Urban Energy Club

NIA project report

1st April 2022

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Version control

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Executive Summary

1. Background

There is an increasing need for flexibility in the low voltage (LV) network. Decarbonising the energy sector requires the electrification of heating and transport and the integration of distributed energy resources (DER) including more local renewable generation. A more flexible electricity system can accommodate these technical changes while avoiding costly upgrades.

The potential for a more flexible energy system to increase inequalities has been flagged [1,2]. Those unable to take advantage of new flexibility products and services are at risk of only accessing higher priced electricity or of sacrificing comfort to manage costs[2]. In addition, the commodity price increases of early 2022 have shown how impacted households are by price increases. Local energy markets and community flexibility schemes could potentially reduce exposure of participating households from these price increases.

CommUNITY and Urban Energy Club (UEC) were designed for lower-income groups who may not have the financial resources or capacity to engage with and benefit from a more flexible energy system. The trial explored possible societal benefits of increasing flexibility via community-owned, shared assets. It tested how customers living in blocks of flats could access financial benefits from the provision of flexibility and whether the virtual allocation of assets would support more inclusion. The trial was awarded a regulatory sandbox and ran between 2019 – 2021, led by EDF with Repowering London, UKPN and UCL.

2. Urban Energy Club overview

Urban Energy Club (UEC) provided a 10kW/20kWh communal battery on the roof of a local authority-owned block of flats to deliver LV flexibility services and support collective self-consumption. The battery joined an existing community-owned 37kWp PV array on the building and was integrated into the building's P2P local energy market trial, CommUNITY. A facilitating supplier (EDF) created the CommUNITY platform to virtually connect the assets behind the landlord's meter to residents. Through the P2P platform participating residents received equal allocations of the solar output and battery. They received on bill credits for any solar they consumed, shared or sold to neighbours, as well as a share of the income generated through flexibility services. The platform optimised the use of the battery to increase residents' savings.

Urban Energy Club provides insight into how virtual allocation of communal assets can make the LV flexibility market more inclusive for community energy projects and bring benefits for low-income, disengaged customers.

3. Community engagement insights

The CommUNITY and UEC trial was designed to maximise participation of low income, disengaged energy customers. The **main advantages** of the trial design were:

- No technical barriers to participation
- No financial barriers to participation
- Minimum disruption in the home

- Automatic allocation of equal share of energy benefits (independent of engagement levels or size of demand)

The recruitment process was tailored to the housing estate, with local, specially recruited champions running a face-to-face campaign, providing opportunities for residents to learn about the project, and offering large incentives to join up. This recruitment approach is typical for trials working with disengaged customers, however, uptake was low. Four out of 62 households opted into the trial. This is 6% of all households, and 31% of the EDF customers in the building.

The key limitations to recruitment proved to be the

- the need for non EDF customers to switch supplier to participate
- the requirement for existing EDF customers to actively opt in
- the geographic constraints to participant eligibility (done to provide a sense of community to the local energy market)

In addition, Covid restrictions negatively impacted the recruitment campaign and opportunities to develop a shared awareness of participation. The trial restricted participation to residents of a specific building, with a view to creating a sense of community through the local energy market.

Recommendations for improving uptake

Combining insights from UEC and our rapid realist review of relevant projects, we recommend that organisations developing LV flexibility offers and Network Operators running trials:

➔ Ensure technical and financial barriers to participation are identified and addressed. Smart meter uptake may not be universal and distributional impacts are likely

➔ Consider the ethics of automatically enrolling (with opt out) disengaged customers on to non-punitive trials and / or tariffs offered by their existing supplier

➔ Consider the geographic boundaries of the community alongside the social ties that exist within the area

Further research is needed on barriers to uptake:

⇒ Research the feasibility and benefits of allowing local supply to exist alongside a consumer's standard / grid supplier. Allowing multiple suppliers rather than one facilitating supplier is likely to address the switching barrier to uptake.

4. Societal benefits insights

Using community-owned, communal assets to increase flexibility opens up a variety of societal benefits in addition to the energy system benefits they deliver. The literature suggests such flexibility assets can potentially reduce bills, increase consumer engagement with the transition, support community wealth building and skill development, drive the uptake of renewables, or lower network costs. However, very few trials of shared assets have been conducted. The insights from commUNITY / UEC therefore provide some needed insight into the mechanisms through which benefits can be achieved, as well as indicating challenges. Insights for three types of benefits are summarised here, with more discussed in chapter 3 of the report.

Bill Savings

Communal battery projects deliver bill savings for participating households when they increase the availability of low-price electricity to participants, reduce network charges or earn revenue by providing network services. The magnitude of bill savings will depend factors such as the differential between unit prices of local and grid electricity, battery capacity and number of participants, and household demand profile and correlation to local supply, network charges and flexibility markets.

CommUNITY / UEC delivered bill savings for participating households by:

- working with a facilitating supplier who passed on energy cost savings & flexibility payments to its customers
- using virtual assets and trading platform to equally allocate available solar independent of customer demand or engagement
- using a trading platform to optimise the use of a communal battery to deliver household bill savings

CommUNITY / UEC demonstrated that a local trading system using virtual allocations and optimising for collective self-consumption allows for maximum community savings, while mitigating some of the demand-based inequalities.

However, the costs of the battery and the trading platform were not included in the trial. The battery was not in constrained area and would not have received any flexibility payments outside a trial. In addition, the energy portion of the bill could be affected through the trading, but not the network charges or the other non-energy costs of the consumers' bill.

Consumer engagement with energy markets and low carbon transition

CommUNITY / UEC recruited previously disengaged customers and lead to an increase in engagement of three of the four participants.

Our review of the literature found mixed evidence overall for the potential of shared solar and battery schemes to drive wider and deeper engagement with energy. Their main contribution is to create interactions with potential participants, whether through information provision or ongoing support. In some cases this has translated into activities such as tariff switching, and reported increased confidence in ability to seek information. However, the more substantial impacts, such as in changes in energy-related behaviour and changes in ownership and governance of energy assets are less likely to be achieved without sustained engagement and regulatory support.

Driving uptake of renewables

CommUNITY / UEC allowed a licenced supplier and a community energy group to innovate together and develop a use case for communal batteries with LV flexibility market providing one of the stacked revenue streams. UEC battery delivered flexibility services using only solar electricity, providing broader environmental benefit as well as contributing to lower network costs.

However, the business case for community-owned shared batteries is still uncertain. Most regulatory frameworks do not support community storage, the market is under-developed, battery costs remain high, and there is no added incentive to deliver flexibility with renewables over fossil fuels. Renewables projects are largely driven by the potential to supply on-site demand, rather than communal use or income from delivering flexibility services.

Recommendations & further research on societal benefits

CommUNITY/ UEC was a unique innovation trial that demonstrated the potential to realise broader benefits through community-owned batteries in a specific urban context under trial conditions. We therefore offer limited recommendations, and also highlight new areas of research required.

We recommend that Network Operators:

- ➔ Support collaborations between facilitating suppliers and community-based organisations to innovate LV flexibility services

More research is needed on

- ⇒ use-cases and models of actual revenue stacks for community-owned, shared batteries to build capacity, increase engagement with LV flexibility and support the uptake of renewables
- ⇒ trade-offs between distributing economic benefits via individual bill savings and community funds
- ⇒ effect of changing network charging on the economic benefits of communal batteries and the uptake of renewables by households and communities

5. LV flexibility procurement insights

UEC was designed specifically to deliver flexibility to the DNO while delivering benefits to residents in a multi-apartment building. The trial demonstrated how the technical requirements for procuring LV flexibility from a community-owned battery could be met. The business case, however has not been demonstrated. Changes to LV procurement could improve the economic feasibility of community-owned, shared flex assets.

Current procurement processes do not recognise additional value produced through the provision of flexibility services. Although existing procurement will deliver some social and environmental value (SEV), benefits are currently more likely for those on higher incomes. Adapted or additional procurement processes are needed for wider SEV to be secured. Precedents are offered by:

- Requiring commercial flexibility providers to deliver SEV (similar to Community Benefits Package requirements for wind energy developments in Scotland).
- Providing extensive support and engagement for community groups to develop flexibility assets and engage in the flexibility market (similar to the social Constraint Management Zone trial run by SSEN with NEA, or the Energy Community Aggregator Service outlined by Regen, Carbon Coop & Community Energy Scotland)

Recommendations & further research on procuring LV flexibility

Informed by the Government' Social Value Model for public procurement, we recommend that UK Power Networks and all Network Operators

- ➔ evaluate proposals against the following additional criteria (derived from existing regulatory requirements and UKPN's own commitments):
    - mitigation of vulnerability to (or impacts of) loss of supply;
    - impact on fuel poverty;
    - local community involvement;
    - and contribution to net-zero carbon and other environmental impact reduction.

We propose a model approach to performing such evaluation, and suggest two approaches to administering flexibility procurement for SEV: either by introducing a weighted SEV component to all flexibility tender processes, or having a separate stream of tenders which intentionally set out to deliver SEV to ensure a certain proportion of SEV projects are procured.

More research is needed. Network Operators should:

⇒ Design, pilot and evaluate new processes around flexibility procurement that actively and cost-effectively support the delivery of SEV

6. Scalability and Replicability insights

UEC was an opportunity to pilot a new technical solution to deliver LV flexibility from solar while also delivering bill savings to residents and new business cases for a community-ownership of batteries. The trial proved the technology in the specific context of a local-authority owned apartment block, with a community-owned PV array behind the landlord's meter, separate from the tenants' supply. To understand the scalability and replicability (S&R) of the UEC model, we have carried out analysis that identifies similar buildings (multi-apartment residential with a roof large enough to host a PV array sized for a 20kWh battery) and which are in proximity to substations requiring LV flexibility. This allows us to provide a general approximation for the S&R potential of the UEC flexibility services.

The S&R model found that:

- 28 substations (out of 51) were identified with suitable PV installation capacity potential
- This capacity potential was distributed between one and nine rooftops per substation
- For all but two of these substations the available flexibility capacity exceeds the requested 'sustain' flexibility

Limitations

- The business model determines the system sizing. Systems designed to provide only LV Sustain services are determined by the power and duration parameters of the call and call frequency. Reducing call frequency, minimum power or duration increases the number of qualifying roof-tops per substation
- Lower super output area (LSOA) code is only an estimation of geographical proximity
- No information on the buildings' ownership is available

The financial modelling undertaken to assess the commercial replicability of this typology confirmed the findings in the literature assessment (Section 4. Societal Benefits) in that additional revenue streams and/or cost reductions are required to drive battery deployment at this scale.

- Creating assets to provide network flexibility services, rather than leveraging existing assets, is challenging at a small scale.
- While batteries are unlikely to provide flexibility services on a 'stand alone' basis at this scale, there are opportunities for synergistic development and business models, for example as part of low carbon retrofit projects or local energy supply models.

Recommendations & further research needed

To increase the scalability and replicability, we recommend:

- ➔ Ongoing engagement between UK Power Networks and local stakeholders to raise awareness of opportunities for provision of flexibility services.
- ➔ Allowing LV connected assets to provide HV services will increase the number of sites with the technical potential to flexibility services through the integration of solar PV and batteries.
- ⇒ Further research could consider the potential for SEV criteria with additional financial value to increase the deployment of community owned flexibility assets.

Chapter 1: Introduction

1.1 Flexibility and an equitable energy transition

Decarbonising the energy sector will require the electrification of heating and transport and the integration of distributed energy resources (DER) including more local renewable generation. A key element to ensuring that the electricity net zero transition is achieved at the lowest cost possible is by ensuring maximum utilisation of current infrastructure. A more flexible electricity system can accommodate these changes while avoiding costly upgrades. There is an increasing need for flexibility in the low voltage (LV) network as significant growth in demand (EVs, heat pumps) and inflexible renewables will occur at this voltage level as we transition to Net Zero.

In addition to technical challenges of decarbonisation, there are also regulatory, policy and corporate ambitions for the low carbon transition to deliver social value and be inclusive. The potential for a more flexible energy system to increase inequalities has been flagged [1,2]. Variable pricing, the increasing complexity of smart appliances and controls, the widening range of suppliers and offers, and different abilities to invest in onsite generation and storage are all factors that affect a consumer's ability to access cheaper greener electricity. Flexibility products and services are already appearing in the market in the form of dynamic tariffs or domestic battery storage with charging plans for example. Those unable to take advantage of such flexibility products and services are at risk of only accessing higher priced electricity or of sacrificing comfort to manage costs[2].

Inequalities from increasing flexibility are likely to reinforce the exclusions and distributional impacts that exist in the current energy retail market. Some consumers find it hard to actively engage with the energy market and as a result pay a higher price for their energy[3].

CommUNITY and Urban Energy Club (UEC) were designed for lower-income groups who may not have the financial resources or capacity to engage with and benefit from a more flexible energy system. The trial explored possible societal benefits of increasing flexibility via community-owned assets. It tested how customers living in blocks of flats could access financial benefits from the provision of flexibility and whether the virtual allocation of assets would support more inclusion.

1.2 Urban Energy Club trial description

CommUNITY and UEC were two linked projects which trialled a technical solution and market arrangement designed to mitigate potential inequalities. The aim was to recruit households living in a multi-apartment block into a local energy market that allowed them to collectively trade and share the output of communal PV and battery assets located on the building's roof, owned by a cooperative linked to Repowering London. CommUNITY focused on the P2P market and was designed and led by EDF R&D and Repowering London, with UCL providing social research insight. UEC added a community-scale battery that could increase collective self-consumption and earn revenue on the LV network flexibility market for participating residents. UK Power Networks funded the project through NIA.

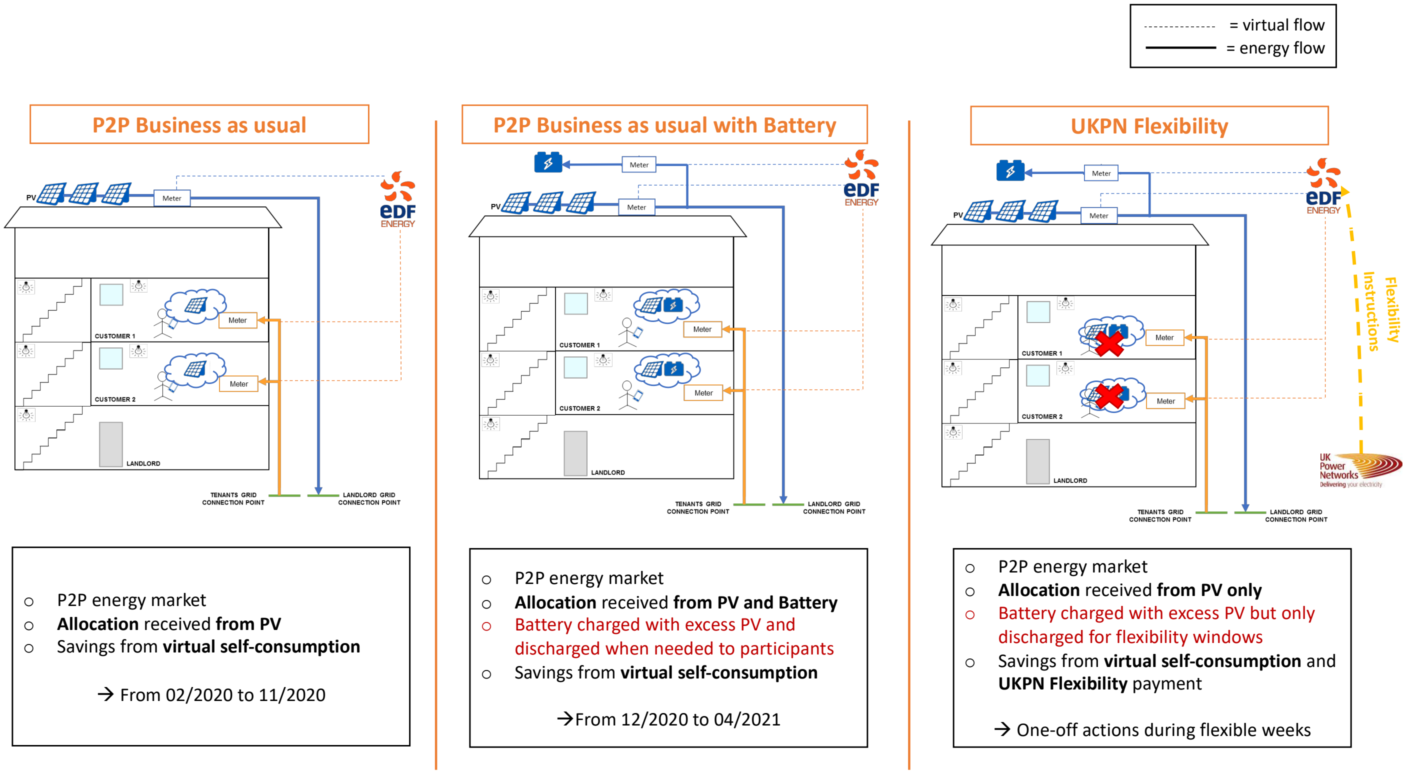


Figure 1 The three trial phases of CommUNITY / UEC (diagram produced by EDF)

EDF Energy is one of the largest energy suppliers in the UK and is interested in the extent that these local offers will support customer acquisition and retention. EDF R&D led the application to Ofgem's innovation link and were granted a sandbox to innovate a local energy market. EDF acted as the umbrella supplier and all participants had to become EDF customers for the duration of the trial to participate in commUNITY and UEC.

Repowering London is a mission driven organisation that works to reduce inequalities and support participation in the energy system. One of Repowering London's first community owned solar PV arrays was located on Elmore House in Brixton; a 37.24kWp PV array owned by Brixton Solar Energy 1. This used future income from a feed-in-tariff to crowd source investment in assets and negotiated with the social landlord to lease roof space and site these assets. The tenants in the building could become investors in the solar PV. In addition the return from the asset was used to fund a community benefit pot for residents and support an outreach and apprentice programme. CommUNITY and Urban Energy Club enabled Repowering London to try out new business cases and explore how local energy markets can be designed to give wider benefits to local communities.

UK Power Networks is the DNO for London and led Urban Energy Club. The trial aim was to understand whether the virtual allocation of shared assets is a more inclusive way of procuring network flexibility from domestic customers. UK Power Networks provided a schedule of flexibility windows, verified the service was delivered and issued payments.

UCL's PACE research group is a multidisciplinary group that investigates the energy demand using social research methods and theories. The groups leads the IEA's Global Observatory on P2P, transactive energy and collective self-consumption, co-ordinating this international research programme. The group was involved in the early design stages of CommUNITY and ran the qualitative research with partners and participants during the trial.

1.3 Background to project & sandbox

The trial took place in Elmore house, a low rise 1960s block owned by Lambeth Council and managed by Loughborough Estate Management Board. Loughborough estate is in a ward which has one of the highest proportions of social rented housing for the borough and the UK (60% social housing, 22% private rented and 16% owner occupation)[4]. It is one of the most ethnically diverse areas of the borough, with the borough's 'highest proportion of Black Caribbean residents, and the highest proportion of Black African residents' [4]. The area also scores highly on multiple indices of deprivation. In 2016 the area was flagged by Lambeth as being the least affluent ward in the borough [4].

Repowering London ran a social survey in 2017 to understand energy issues within the estate and scope the potential for new types of community energy projects. This survey indicated high levels of fuel poverty and low engagement with the energy market. 11 out of 18 respondents had never changed their gas or electricity supplier. The survey also allowed Repowering London to gauge interest in battery projects. Responses indicated that while respondents were interested in smart meters, they were not interested in having a domestic battery inside their flats due to concerns about the space it would take up. A community battery located outside the home therefore offered a more acceptable route.

The project was submitted to OFGEM in 2017 and was granted a sandbox, allowing the partners to create a local energy market for residents in Elmore house (Figure 2).

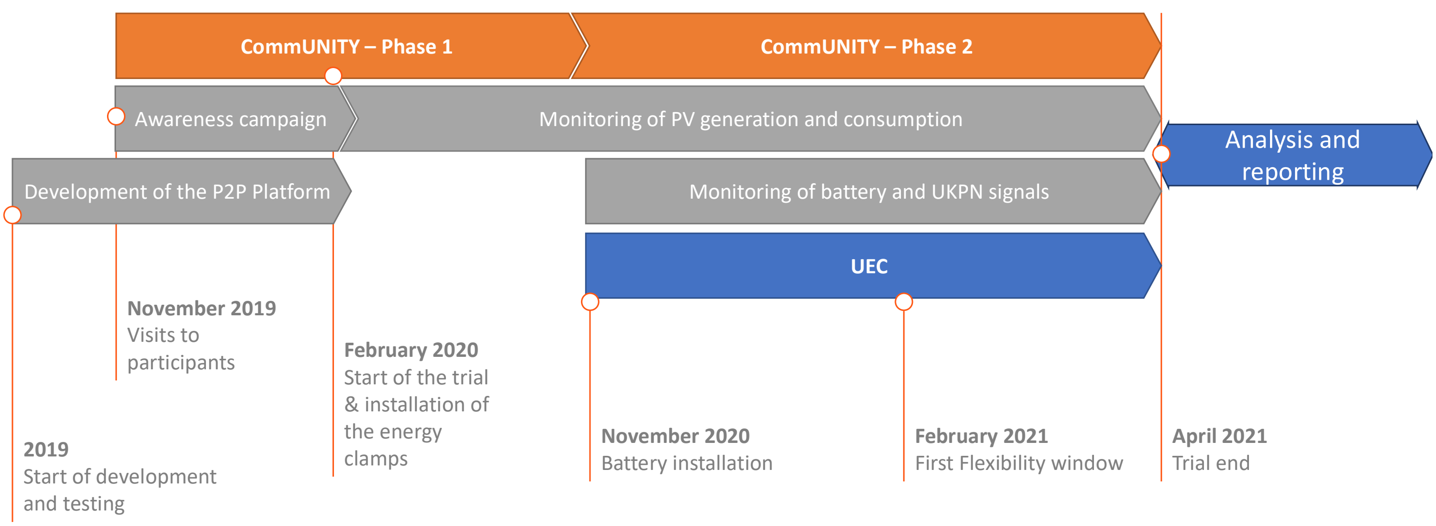


Figure 2: Timeline for CommUNITY and UEC (source: EDF)

1.4 Research during CommUNITY / UEC

UCL was able to monitor the project and provide social research capacity. This included a pre-trial survey at the installation phase which assessed household demographics and their engagement with energy (Appendix 4); a post-trial interview which covered household's experience (Appendix 5), and an interview with the energy champion about the recruitment process (Appendix 6).

EDF monitored household energy use through energy clamps installed in participating households, and engagement with the app. EDF also monitored the PV output and battery performance, iterating their control algorithms to improve battery performance through the trial.

Repowering London provided ongoing support to participants through the trial, giving insight to households' experiences. Repowering London offered support to the prepayment meter (PPM) households when topping up their meters, visiting them to check the first rebates appeared in their accounts. Two participants called Repowering London to discuss the app, and one participant called for help with smart PPM. Repowering London also provided ongoing technical support, providing EDF with the Solar PV generation and export data, and helping to integrate the battery.

1.5 Evidence review method

In order to evaluate the trial we carried out an evidence review to provide comparisons and draw conclusions about the project's replicability, scalability and potential impact. The full evidence review method is described in Appendix 1. In brief, we specified a range of key search terms associated with shared access to DERs and factors associated with risk of exclusion from conventional flexibility schemes. We used these terms to find academic and non-academic (grey) literature on these topics, which we then screened according to several relevance criteria.

There are few examples of real-world projects similar in most important respects to UEC; that is to say, focusing on access to shared DERs in urban social housing blocks to provide flexibility. However, more trials have been done that are similar in some important respects. For example, that focus on individual access to DERs in a social housing context, or on access to shared DERs not in social housing. While these differences are potentially important for how the findings of such trials might apply to UEC-like projects, we are still able to draw applicable insight from them by using a "realist synthesis" approach. This means that we focused not just on the outcomes of trials (such as a form of societal benefit), but how those outcomes are thought to have come about (the mechanisms), and what it was about the particular context that meant that mechanisms led to those outcomes. We were then able to consider the circumstances under which such mechanisms and outcomes might be most likely to translate to UEC-like projects.

Given this broadened scope we did not attempt to comprehensively identify all relevant trials, but to include enough to look for consistency in context, mechanism and outcomes relationships. The engagement chapter (Chapter 2) focuses on mechanisms identified as support uptake of flexibility products and services. The societal benefits chapter (Chapter 3) focuses on a number of outcomes identified as particularly important to UK Power Networks: the potential of schemes similar to UEC to lower participants' bills, broaden and deepen engagement with the energy transition, and reduce network costs.

1.6 Overview of the report

UEC was a unique trial. It provides an example of how flexibility services can be designed to include low-income groups living in a highly urbanised environment with few behind-the-meter prosumer options open to them. The trial results therefore need to be contextualised. The aims of this report are to:

- Provide the results from the CommUNITY/ UEC trial;
- Contextualise these within a rapid realist literature review to draw insights from relevant and comparable trials;
- Analyse UK Power Network's current LV flexibility procurement process as well as provide examples of using procurement to support projects that deliver social and environmental value as well as network benefits;
- Present our scalability and replicability analysis

The report is structured in the following way. Chapter 2 assesses the recruitment methodology used in the trial, Chapter 3 focuses on the societal benefits that can be achieved by taking this inclusive approach to LV procurement. Chapter 4 reviews existing procurement processes and requirements on network operators in order to analyse how support for these types of projects can be built into procurement. Chapter 5 models the scalability and replicability of UEC by identifying similar buildings with community PV and battery potential that are located close to constrained substations. Our review methods, data analysis and research tools are provided in the appendices.

Chapter 2: Assessment of recruitment methodology

This chapter describes and analyses the recruitment method used for the CommUNITY trial, which was the pathway for consumers to access Urban Energy Club. The project was designed to be inclusive; there were no penalties or economic risk, minimal equipment required to participate (clamp and router) and no requirement to actively engage after opting in to accrue benefits. The recruitment process was also designed to be inclusive; locally recruited and specially trained field officers provided on-site support. Households were provided with independent tariff checks and faced no penalties if they subsequently wished to leave the trial early.

Despite these measures, only 4 of the 13 EDF customer opted in, and none of the 50 non EDF households opted to switch away from their supplier and join the trial. It is therefore useful to evaluate the trial's recruitment process and outcomes in order to understand the extent these types of inclusive, socially-committed offers can overcome traditional barriers to participation and flag any emerging areas of concern.

This chapter addresses the following questions:

- How does the recruitment method used for CommUNITY compare to other methods?
- What should be continued and what needs improvement?
- What were the key advantages and risks from this method?
- What can be unlocked through this method?

To answer these questions we start with a review of the evidence from technology trials run in the UK with Registered Social Landlords as well as shared asset initiatives piloted outside a UK context. We then present CommUNITY's recruitment process highlighting how it was designed in relation to the local context as well as to conform with Ofgem's requirements for customer engagement. We reflect on the advantages and risks of the approach used, areas for improvement and what might be unlocked by this method drawing on key themes within the literature on engaging low-income groups with flex storage projects.

We find that CommUNITY followed standard recruitment protocols; using trained local engagement officers and door knocking to reach all eligible customers. However the requirement to switch suppliers and join EDF proved to be a major barrier to uptake. Evidence from other trials and initiatives suggest that uptake levels could have been improved by widening the pool of eligible households, recruiting from within EDF's customer base and using automatic enrolment. However, these routes may change the broader benefits created through the offer. Regulatory changes that facilitate local energy markets could also positively impact uptake. For example, more participants may have joined the local market if they could have added it as a bolt on, rather than having to change their supplier or supply contract. This approach departs from current consumer-supplier license terms and in doing so opens potential for wider societal benefits, but introduces higher uncertainties.

2.1 Recruitment and engagement evidence review

The evidence reviewed in this section covers technology trials run in the UK with Registered Social Landlords (RSLs) or in stock they own as well as policies and initiatives run outside the UK that have focused on increasing access to shared DERs for low-income households.

The trials in social housing share an approach to recruitment that starts with a selection process to identify eligible households followed by an engagement process run by a trained team of local engagers and then an installation phase often followed by repeat engagement to ensure optimal outcomes for participants and the trial. The incentives are primarily cheaper electricity bills (through self-consumption or optimised energy use), or improved comfort (through a new heating system for example). Any technology is typically grant funded and owned and maintained by the landlord or third-party allowing participants to make bill savings without taking on liabilities. Each of these recruitment steps has implications for the uptake rate and the types of benefits that might be unlocked (Figure 3).

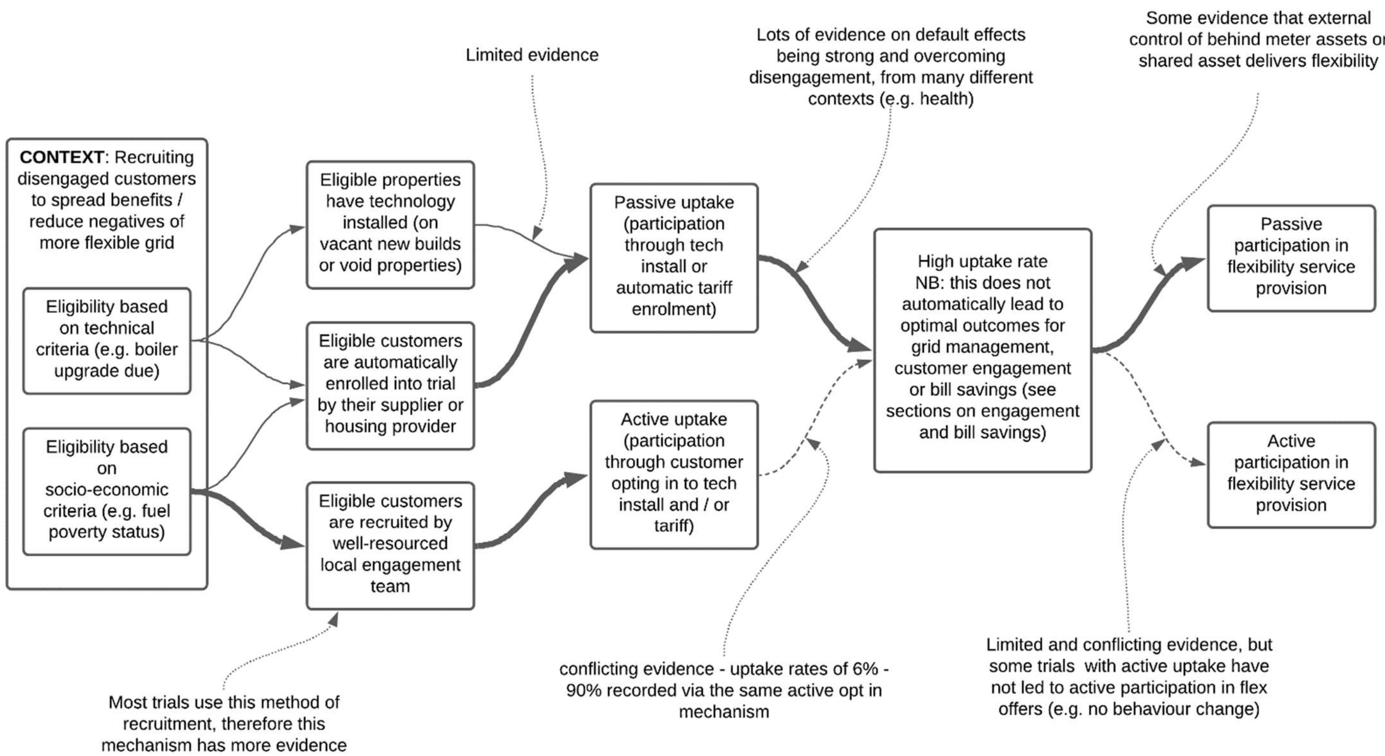


Figure 3: Mechanisms identified in the literature which affect participant recruitment. The bold lines indicate more sources found, the dotted lines indicate conflicting evidence.

The **selection of eligible households** affects how receptive households will be to the offer. Some trials identify the houses that are the most suitable from a technical perspective, working with the DNO, technology provider and / or the housing provider[5]. This increases the potential to produce network effects, but may not be targeted at the most vulnerable or lowest income. Alternatively, the selection can be based on households' socio-economic characteristics or fuel poverty indicators[6], however eligible households may then experience technical constraints or barriers to getting the best outcomes from the project. For example legacy metering and problems with smart meter installation were identified as reasons some participants were disengaged from the trial[7], or failed to get the best savings[8]. Other trials may target fuel poor, but exclude those in debt to their energy supplier[9].

Awareness raising and engagement by tenant liaison officers (TLOs) or project champions are also flagged as an important mechanism. One trial recommended that housing providers' logos are used on all communications finding that households recognise and respond to communications from their landlord, where they ignore communications from energy companies[10]. Face to face engagement has been shown to increase uptake. In the NEDO trial, the housing provider using this mechanism doubled their recruitment rate relative to the other two providers[3]. Multiple visits at different times of the day are recommended and the composition of the engagement team (mixing genders, languages spoken or buddying TLOs with technical experts) also impacts how receptive people are to the offer and uptake rates[7,11].

A related issue is the **ongoing support** needed to get the best outcome. Some trials found they could install the technology, but still struggled to support households switch suppliers or tariffs to get the most benefit from the technology. For example in the DGHP trial, only 8% (34 households) progressed to the optimal outcome of battery with smart ToU tariff[8]. Ongoing support can help reduce the number of dropouts and increase the number of households or units able to respond to ongoing calls for flexibility.

The requirement **to switch tariff or supplier** is a barrier to participation. Some trials avoid this by recruiting from within a supplier's existing customer base, while some behind the meter technology trials do not require households to switch to participate and do not need to work with suppliers to provide bill savings. However even these approaches require a lot of resource to get existing customers to opt in to the trial or move onto an appropriate tariff. Engagement is resource intensive; one supplier recruiting within their own customer base found that a third of the participants needed 4-12 engagements (calls and home visits) before opting in to a non-punitive, no risk DSR offer[7].

Another option is to use an **opt out** mechanism. Overwhelmingly, experimental and field evidence suggests that default effects are strong and persistent i.e., people do not tend to move away from the option that is automatically assigned to them[12]. Opt out frameworks have been successfully leveraged to increase uptake of green tariffs[13–16] [17] and have demonstrated increased willingness to install a smart meter[18]. A heat pump trial in Manchester automatically enrolled households onto DSR events, producing high network impacts often without the household being aware that their domestic heating system was being controlled externally[3].

While highly effective, opt-out defaults are unlikely to deepen consumers' engagement with the energy transition. They also raise issues of informed choice, particularly when targeted at consumers who are typically less engaged in the energy market. It becomes more ethical when we consider that currently consumers who lack the capacity to engage end up on more expensive tariffs. Leveraging opt-out defaults for non-punitive offers, particularly for non-self-selected prosumers and where participants will not incur any financial loss may be acceptable. However, such options would need to be regulated and be supported with strong consumer protection.

A related issue is the **amount of disruption in the home** in terms of equipment being installed. Analysis and evaluations of energy retrofits have shown that disruption in the home can be a significant barrier to participation[19]. This can be mitigated by having good understanding of the residents' lives and priorities, by providing back up services (e.g. offering broadband), using trusted intermediaries and offering appropriate incentives[10]. The use of a communal asset should remove much of the disruption from the home, because the communal asset is installed outside of it.

Table 1: Recruitment processes and outcomes for UK trials in social housing

Project	Household selection and eligibility	Intervention and offer	Recruitment process	Outcome

Energywise (SDRCs[6,7,10])	British Gas customers living in social housing rated EPC C-G, with gas heating. 1352 eligible households targeted	Installation of smart meter & in-home display (some disruption in home) Smart meter costs covered by supplier BAU Offer: bill savings through better energy management Additional incentives: Vouchers, ee kit	(1) Information & invitation using RSL logo (2) Pilot phase with trained team of bilingual field officers (3) roll out: field officers supported by professional recruiters (4) meter installation (5) roll on to DSR trial (6) 2nd round of invitation and door knocking campaign to get active opt in to DSR	538 (40%) smart meters installed 296 rolled on to DSR trial 255 (18%) opt in (but participation per DSR event is less)
Dumfries and Galloway's (DGHP) Domestic Battery Storage Project[8] (project report)	Fuel poverty mapping with RSL 423 eligible households (electric heating, off gas grid)	Tesla Powerwall home batteries (some disruption in home) Battery costs covered by Scottish Government via DNO (SP networks green economy fund). Offer: free battery* and bill savings from cheap imports via TOU tariff.	(1) Information & invitation letter from RSL & warmworks. (2) Home survey (3) battery installation & tariff switching support	133 (31%) opted /able to have a battery (no data on distribution between household refusals and technical ineligibilities). Of these: 34 moved onto a smart ToU tariff 65 kept dual rate tariff 34 remained on a single tariff 'therefore making no battery driven savings' [8]
Together Housing's Solar PV & Storage Pilot Project (website report by contractor[11])	Not available	PV and Tesla Powerwall batteries (some disruption in home & external scaffolding) Tech costs covered by RSL & European Regional Development fund Offer: Bill savings from self-consumption& Free battery and PV array[i]	The recruitment process was 'active' and tailored to individual tenants needs. A tenant liaison officer worked with the installer to educate tenants on the offer. When contracting the installer, the RSL included a requirement that the installer visit each home to explain the technology & offer	"approx. 90%" uptake Initial scepticism was overcome through repeat contact and education.
NEDO[320]	3 RSLs identify 1758 homes due for boiler replacement. Target to recruit 30% of eligible homes	Boiler and wet system replacement (major disruption to home) Heat pumps (HP) and demand response (DR) aggregation system	(1) Long list of homes needing boiler replacements (2) Trained TLO recruitment via letter. (1 RSL ran a door knocking campaign which	550 (31%) HPs installed 103 (6%) installed in void homes (ie no tenant consent required)

* It is not clear if DGHP (the landlord) own the batteries and PV arrays in tenants' homes

i Together Housing (the landlord) own the battery and PV and highlight that they may be able to earn revenue from these assets in the future. They don't specify if this would be from selling electricity to tenants, or capacity to the DNO.

	Void homes included to meet targets	covered by tech partners via government grant Radiators, pipes and broadband covered by Housing associations Offer: new heating system, free broadband for 2 years, free tablet to connect to project portal	delivered 63% uptake rate for their homes) (3) HP and heating system installation (4) automatic enrolment into DR events (opt out)	An additional 159 households opted in, but were technically ineligible DR events were opt out but on average only 5.6% of households actively opted out. Most did not know a DR event was running.

Table 1 describes the trials and shows the different outcomes achieved. All of these social housing trials have tested behind the meter solutions, reflecting the regulatory challenges of working with shared assets in the UK to deliver local energy management. For example, owners of community scale generation or storage assets cannot use public distribution networks to share energy locally with community members, but need to partner with a licensed supplier. The supplier will conform to all industry codes and licence requirements in terms of balancing and settlement. Therefore we have also examined trials and policies from other contexts that have used shared assets to widen access to lower cost renewable energy.

US, Community shared solar schemes (CSS). CSS schemes have been run in the US since 2010.They are designed to overcome financial barriers to participation. They allow consumers to invest in off-site solar farms and receive financial benefits, often via virtual net metering[21]. A review of different recruitment approaches used by projects found there are some common difficulties which relate to consumers' lack of awareness of CSS in general and the role of a third party in consumer - utility relationships. In addition, project developers push potential investors for long contract lengths (20-25yrs) and credit checks which are particularly problematic for low income households. While in theory CSS offers low cost, low risk infrastructure that can reduce costs for low-income households, in practice most schemes target higher income, high energy using customers (households & non-domestic) to reduce financial risks for the developer and minimise risk of payment defaults.

EU, Renewable Energy Communities (REC) & Citizen Energy Communities (CEC[ii]): the EU's 2019 electricity directive requiring rights for RECs and CECs has signalled a positive regulatory framework for community energy and the development of locally owned shared assets. This has led to a wide range of experiments, some examples are outlined below.

In the Netherlands, the GridFlex Heeten trial is **a Citizen Energy Community** trial which includes shared storage and PV generation. All 49 homes behind one transformer are part of collective demand management trial that aims to reduce peaks at the transformer. The homes are part of a new development, some houses have PV and batteries behind their meter, and 24 households have an app that supports them in actively flexing their demand. The price of energy within the community varies relative to the amount transported through the transformer incentivising low import and export. All 49 homes pay the same price for their energy regardless of what assets they have or whether they are part of the active shifting group [23]. The project is a collaboration between the regional network operator, local energy cooperative Endona, as well as technology and research partners. The project is also supported by 'Buurkracht' a capacity building organisation which works explicitly to support communities in energy projects, building on the Netherlands strong tradition of cooperatives. To get all households involved, local energy coop Endona recruited five residents as an

[ii] For full definitions of a Citizen Energy community and Renewable Energy Community refer to the Compile Project report 'Energy Community Definitions' [22]

enthusiastic neighbourhood team who are described as the 'linchpin for success' on the project website (https://gridflex.nl/deelnemers/).

Another EU initiative is the **Consumer Stock Ownership Plan,** developed in the SCORE project. This is designed to specifically engage low income and under-represented groups in collective ownership of renewables, reducing economic barriers to participation. The trials have highlighted incompatibilities between policy areas, specifically the conditions for receiving social care or income support can depend on having no assets or savings and therefore conflict with RE policy which encourages investment or facilitates joint ownership. The SCORE project found that some participants in Italy and Czech Republic refused to become prosumers to avoid any risk to the social support they received [24].

Internationally there is a growing group of **non self-selected prosumers**; people who move into buildings with communal assets already installed. A trial in Sweden tested whether collective self-consumption could be increased within a group of non self-selected prosumers through an information based intervention, but found no impact[25]. However it is going to be increasingly important to understand how to optimise use of flexibility assets installed within households and buildings without the current residents' knowledge or consent. New models of engagement need to be developed. Urban Energy Club is a form of enabling non-self selected prosumers to benefit from shared assets.

2.2 Recruiting households to CommUNITY and Urban Energy Club

Recruitment to CommUNITY followed the typical method for disengaged households in social housing described above. However, through the sandbox Ofgem made two requirements; participants could not be worse off as a result of the trial, and the decision to switch to EDF to participate had to be via an independent tariff check. The savings expected from CommUNITY and UEC could not be communicated as part of an EDF tariff, but only as a subsequent benefit. Figure 4 shows the two recruitment routes led by EDF and Repowering London.

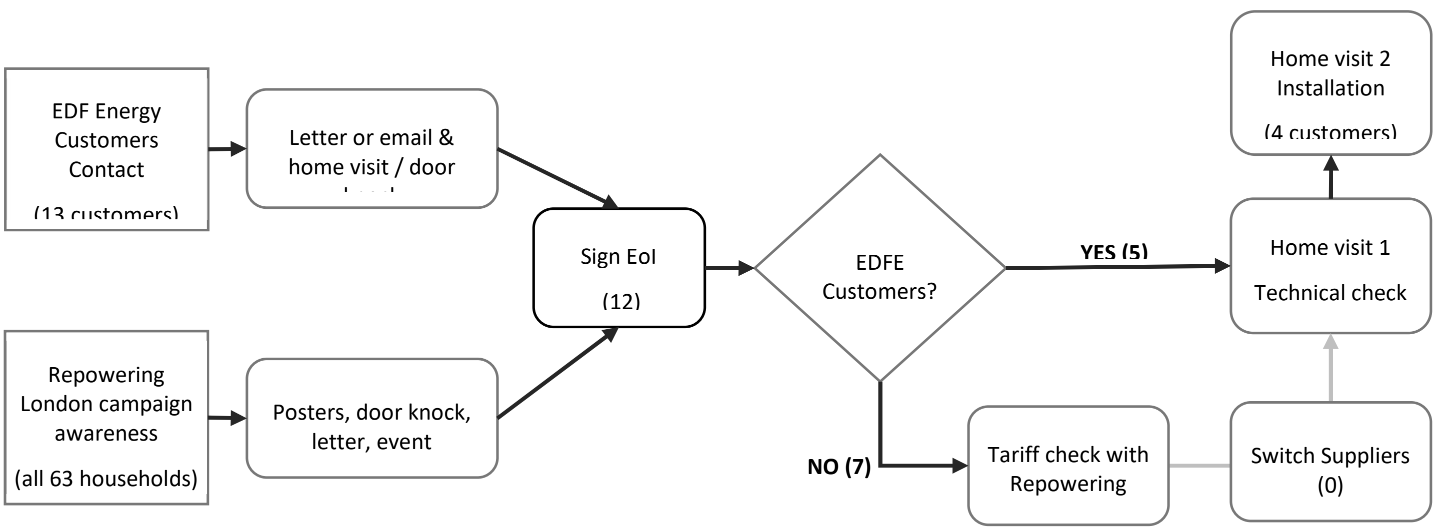


Figure 4: Recruitment paths for CommUNITY

Implementation

Repowering London recruited two energy champions to run the engagement for the project. These champions were local to the area and had previously been involved with the organisation. The champions were trained in technical side of the project and supported in running the engagement. The champions put up posters in communal areas and flyers in every letter box, then ran a door knocking campaign, ensuring each house received door knocks at different times of the day and week. Simultaneously EDF contacted all 13 of its customers via letter and email. Customers were recontacted informing them that EDF representatives would be visiting the estate.

The recruitment message stressed bill savings, but also the potential to use renewable energy and contribute to local residents. The Information sheet (Figure 5) said:

> *"Do you want to make savings on your electricity bill?*
>
> *Do you want to use greener electricity and help out your neighbours at the same time?*
>
> *The CommUNITY Project at Elmore House is for you! "*

The project information sheet explained that bill savings were likely to be 15-20% of usual bills, based on EDF's modelling. In addition, residents were offered £100 as an incentive (£50 at start and £50 at completion) to join. The requirement to switch was explained along with the ability to leave the project and EDF at any time without penalty.

The information sheet also explained the use of a communal battery in phase 2 of the project.

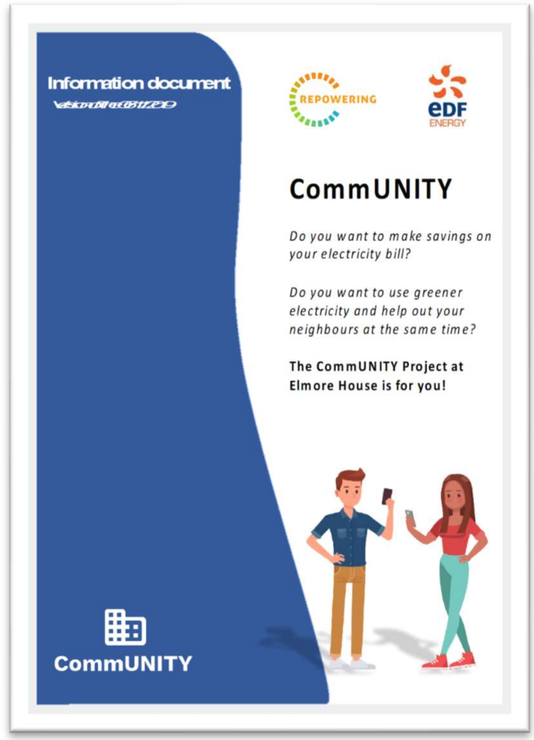


Figure 5: Recruitment brochure for CommUNITY

The process was phased and affected by the COVID19 pandemic. Phase 1 ran between November - December 2019. Phase 2 ran in November 2020 to coincide with the start of UEC, but did not include face to face recruitment activities.

Outcomes

The first phase of recruitment resulted in 12 signed expressions of interest which led to four participating households (Figure 4). Of those that signed EOIs, five were EDF customers and seven were not. One of the EDF customers did not proceed with the home visit and withdrew. Of the seven non-EDF households, three went on to have an independent tariff check with Repowering London but opted not to switch supplier and four chose not to have a tariff check or opt to switch. Recruiting four out of 63 eligible households translates into a 6% success rate. If we remove the requirement to switch, four out of 13 existing EDF customers represents a 30% uptake rate.

In terms of the diversity of the participants, Table 2 shows that three people consenting to the trial were women, in line with the over-representation of women held tenancies in social housing. The ethnic diversity is also in line with that of the local area (Table 2).

Table 2: Gender and ethnic identity of consentees

Gender	3 Women, 1 man
Ethnicity	2 Caribbean, 1 mixed ethnicity, 1 African

Table 3 shows some of the socio-economic characteristics of the participating households. There is a mix of household size and composition and a range of income. In line with local trends, social tenants are the majority and tariff switching is rare.

Table 3: Socio-demographics of participating households

Tenure	Social renter	3
	Owner Occupier	1 (RTB)
	Private renter	0
Household size	1 person 2 people	1 (pensioner) 1 (parent & child)
	3 people	1 (couple & adult child)
	5 people	1 (couple, children, extended family members)
Income	<10k	1
	£11-20k	2
	£21-60k	0
	>£60k	1
Switching history	Never	2
	Rarely (more than 5 years ago)	2
	Occasionally (every 3 – 5 yrs)	0
	Often (every 2 yrs or more)	0

Phase 2 recruitment ran in November 2020, without the door knocking element. Nine EDF customers received a letter from EDF, the other households received a letter from the CommUNITY team. This resulted in one additional expression of interest received in January from a non EdF customer. Given the switching process would take three to four weeks of the nine weeks left for the project, the team decided not to progress this recruitment. The team discussed widening the recruitment base to EDF customers in other buildings in Loughborough estate, but opted not to due to time and budget constraints.

Reasons for saying yes

During phase 1 of the recruitment, we interviewed the energy champion about households' interest in the project. He identified three main reasons; firstly the opportunity to save money, secondly to access green energy and thirdly to support the local community.

We surveyed the participants at the start of the project and all four stated that their primary motivation was 'to save money', with one specifically mentioning the vouchers. The secondary motivations were articulated as:

- interested in giving it a go and not compelled to stay. Can test it out. (ID07)
- interested in sharing with others in the estate (ID12)
- help environment (ID02)

Reasons for saying No

The energy champions did not want to push people on their reasons for declining the offer. However, in the interview one of the energy champions reflected that he heard three reasons:

- A couple of people said they did not want to be involved with EDFE.
- A couple of people said they were happy with their current supplier, particularly when they perceived this to be a green supplier (Octopus & Bulb were mentioned).
- Some said it was too complicated

Eight households signed an expression of interest but did not proceed due to the requirement to switch to EDF Energy.

Other factors

There are often additional factors influencing resident engagement and recruitment outside the residents' own choice. CommUNITY's decision to use energy monitoring clamps and provide a router meant there were no technical reasons preventing interested households from participating. Recruited households had a range of meter and payment types. Two households had prepayment meters, one had a credit meter and paid by cash / cheque, one had a SMETS pay as you go meter. Covid19 affected on the ground recruitment, preventing a second door knocking campaign and removing any possibility to attend neighbourhood events.

In addition, no households moved or switched away from EDF during the project. This meant that there were no drop outs and all participating household were rolled into the UEC phase.

2.3 Discussion

Inclusion was the guiding principle for the recruitment process. Participants could not lose money by signing up and did not have make any long-term commitments in terms either of entering into contracts or changing technology in the home. The recruitment strategy managed to engage four previously disengaged households. The financial benefits (bills savings and vouchers) proved to be the common reason for saying yes. The requirement to switch supplier to join proved to be a major barrier. The engagement process followed standard practice.

What worked

CommUNITY used the building as the selection criteria and included renters and leaseholders who have less prosumer options open to then. By using a battery installed on the roof CommUNITY / UEC avoided any real disruption in the home. Furthermore creating a virtual microgrid with clamps rather than installing smart meters also reduced disruption and meant there were **no technical barriers to participation.** However, clamps would not be used outside a trial context. Once the smart meter roll out is complete, virtual access to a communal asset should be possible. But it is also possible that in the future, the minority of homes without or unable to use a smart meter will include higher than average proportions of low income and vulnerable energy customers, who will then continue to miss out on these offers[8].

There were also **no financial barriers to participation**, however both OPEX and CAPEX of the communal asset were covered in the trial through a combination of grants and sunk R&D costs. This is unlikely to be achieved outside trial conditions and insights from both the US and EU context suggest that when recruitment is linked to investment in the asset, low-income households are likely to face barriers either because project developers view their participation as more financially risky, or because conflicts between policy areas may mean low-income households avoid being asset owners even of shared assets.

What could be improved

There were two decisions that negatively impacted recruitment to the trial

1) **Limiting participation to Elmore House.** A non-wired solution was used therefore there was no technical reason why participation needed to be geographically limited. The decision was taken given current licensing terms, and the need to operate the pilot as 'a complex site with multiple meter points', but also on the assumption that a geographical target might support a sense of community via sharing with immediate neighbours. It also supported the physical / visible link to the infrastructure (both PV array and battery). However, these appear to have been minor factors for opting in and the benefits achieve (see Chapter 3).

2) **Requiring a supplier switch**: CommUNITY required only a minor technical intervention in the home and preference setting in the app, making opt out an option that could be explored. All EDF customers in the building could have been defaulted onto CommUNITY and an engagement process used to further incentivise people to download the app and actively engage in the market. In addition, the UEC part (communal battery plus flex) could have been separated from CommUNITY (P2P market). Communal assets are not behind any one consumer's meter and therefore there is no need to use existing metering and billing processes and the associated supplier license arrangements. All households (including non EDF customers) could have been defaulted into UEC, making them eligible to receive the flex payments. In this scenario, cutting out the supplier would mean the payments had to be distributed by Repowering London or a third party rather than via customers' bills. Other pilots could test models for sharing income from communal batteries that are not reimbursed via consumer bills.

2.4 Conclusions

The key advantages of the CommUNITY & UEC approach to recruitment are:

- No technical barriers to participation
- No financial barriers to participation
- Minimum disruption in the home
- Equal share of energy benefits

Despite this, uptake was poor. **The key limitations to recruitment** proved to be the requirement for existing customers to actively opt in, and the need for non EDF customers to switch supplier participate.

Within existing supplier licence conditions there are two main options that could be used to broaden the number of participants:

1) Recruit within a bigger pool of a single supplier's customers by extending eligibility to a whole estate or neighbourhood.
2) Separate UEC from CommUNITY. Revenue from the battery could be distributed within the estate by Brixton Solar Energy 1 in the same way the income from the PV array is distributed. This is done without involvement of a supplier.
3) Recruit using opt outs. When the majority of homes have a smart meter and suppliers have access to half hourly meter data, there will be an option to automatically enrol households onto local green tariffs. CommUNITY's equal distribution of local renewable energy provides a nonpunitive option and all EDF customers in the building could have been automatically enrolled and invited to opt out. The benefits would have been shared more widely although individual households' bill savings would have decreased. In addition, opt out tariffs raise concerns about reducing agency and may introduce additional exclusions such as those who are not able to get a smart meter installed.

In addition, changes to regulations could offer new opportunities for uptake of these local offers. For example, P379 initially raised the potential for multiple suppliers to supply one meter and explored the option for local energy to be retailed alongside grid energy[26][27]. Uptake of CommUNITY / UEC could have increased if households had the option participate without switching away from their main supplier contract. They could have participated in the local energy market when local energy was available and relied on their existing contract for imports.

Chapter 3: Societal benefit review

Urban Energy Club set out to explore whether giving access to shared distributed energy resources (DER) could widen access to benefits from providing flexibility. In this chapter, we consider the evidence for whether and how this was achieved. We present this discussion in the context of a wider review of evidence on some of the societal benefits that projects of this nature could bring.

3.1. Lowering bills

The first outcome we focused on was the potential for such schemes to deliver lower bills for the participants (Figure 6). This is important for UKPN and other DNOs because the RIIO ED2 they are required to demonstrate actions to minimize the extent to which people are excluded from the benefits of net-zero energy transitions, of which flexibility is a key part. Understanding how savings can come about – particularly for customers in vulnerable situations – is a necessary condition for doing this. Table 4 summarises the context, intervention, mechanism and outcomes for the projects we identified relevant to the outcome of bill saving.

In the studies we identified on trials of access to shared/neighbourhood batteries/PV, and access to individual batteries (sometimes in addition to PV generation) in social housing, we found consistent evidence of bill savings or potential for bill savings, ranging from tens to hundreds of pounds per year. As hypothesised in our programme theory, the primary route to these savings was the battery/PV allowing participants to reduce imports of more expensive grid electricity. In most cases this was by enabling increased self-consumption of PV generation. We found an additional example of a battery project enabling increased consumption of off-peak priced electricity for those on time of use (TOU) tariffs.

Key factors affecting the level of savings were size of battery/PV installation, level of sunlight (due to location or season), and type of tariff the participants were on. Potential for savings is larger when PV/battery installations have larger capacity, when/where it is sunnier, and when participants have access to off-peak electricity rates. Two of the projects we identified involved shared batteries, and two involved batteries in individual homes. One of the shared battery projects (Netherlands) was more directly comparable to the individual battery projects because it assigned a set allocation of battery capacity to each participant. It is indicated that the other shared battery project (White Gum Valley) made no such allocation, instead allowing households to draw on the shared battery as they needed. The report of that project suggests that avoiding partitioning means that better use can be made of the full battery capacity. However, it is likely that higher energy users would disproportionately benefit from such an arrangement, as they would make more use of the battery capacity and access to cheaper power this affords.

Table 4: Selection of projects with an outcome involving bill or grid import impacts, along with details of the context, intervention, and mechanism.

Study	Context	Intervention	Mechanism(s)	Outcome(s)
When top-down meets bottom-up: Is there a collaborative business model for local energy storage?	Social housing in the Netherlands. Participants already renting 8 PV panels each from an energy service company.	Installation of a shared battery with each of 35 participants receiving a 3 kWh share, plus access to a home energy management system.	Battery allowed excess PV generation to be stored and used at other times, reducing need to import from grid. Long track record of collaboration between DSOs and energy cooperatives in the Netherlands may have supported uptake.	Increase in self-consumption of (free) PV generation by average of 69 kWh each. Billing impacts not reported, although tax arrangements in the Netherlands would likely affect this.

Shared solar and battery storage configuration effectiveness for reducing the grid reliance of apartment complexes (see also "Performance of a shared solar and battery storage system in an Australian apartment building")	New build 3 multi-residential apartment buildings at White Gum Valley, Western Australia. Note that the relative sunniness in comparison to UK is an important contextual point.	The blocks were each constructed with a shared battery and PV system, sized and operated to minimise grid imports. No apparent virtual allocation of specific share of battery to individual homes. Each dwelling's imports are sub-metered, and excess generation that cannot be stored is exported to the grid.	Large batteries allowed lots of excess PV generation to be stored and used at other times, reducing need to import from grid. This also permitted substantial additional export. Avoiding strict partitioning of battery may have increased self-sufficiency by optimising use of battery capacity.	Very low grid electricity imports (average of 60% self-sufficiency), especially in summer. Substantial export of electricity to the grid in summer. Billing impacts not reported.
Domestic Battery Storage Project: Dumfries and Galloway Project Report (project report)	Social housing in Scotland, households identified as more likely to be at risk of fuel poverty, off gas grid (with electric heating).	Installation of Tesla Powerwall home batteries in 133 individual homes, analysis available for data on 88. Batteries were managed to charge during off-peak tariff periods where available.	Batteries allowed participants to make more use of off-peak electricity, reducing consumption of peak priced power. Larger savings experienced by those on a dynamic TOU tariff. Savings for flat rate customers were due to them deciding to switch to cheaper tariffs.	Average of 52% of consumption via battery, leading to savings of ~£200-400 per year for those on TOU tariffs. Small average saving (~£20) for those on flat tariffs.
Avonside Renewables Contractor in Together Housing's Innovative Solar PV & Storage Pilot Project (website report).	Social housing in north of England. Mainly bungalows and 3 bedroom houses, some 2 bedroom.	Installation of PV and Tesla Powerwall batteries in 250 homes.	Battery allowed excess PV generation to be stored and used at other times, reducing need to import from grid.	Average £30-50 bill savings in first 3 months of 2020. Combined £31,878 across all tenants Jan-June 2020 compared to average electricity bill for NW England.

While the studies we identified did not provide billing impacts associated with electricity exports, we did find evidence of exports from shared PV/battery systems occurring in the White Gum Valley project. The role of the battery in this case was mainly to *reduce* the level of electricity exported. This is because the level of feed-in tariff in Western Australia is lower than the import rate for grid electricity, meaning that maximising self-consumption is always the economically preferable option. Where variable rate export tariffs are available, or other incentive to export electricity at certain times rather than others, a battery has the potential to enable this and realise this additional value by preferentially exporting at times when payments for exports are highest [28,29].

We did not identify any projects where provision of ancillary services using a shared battery led to customer bill savings. However, as a potential analogy, we identified various examples of shared solar projects where participants received a bill credit proportionate to their share of revenue from power export (e.g. [30,31]). If a similar revenue sharing model were employed for revenue from ancillary services, it is likely that bill savings would result – although there is likely to be some interaction with the amount of power available for self-consumption. Revenues from providing such services could also be placed into a community benefit fund, extending the benefits of the scheme beyond direct participants. There is substantial precedent for this form of community benefit for general renewable energy projects[32]. There is substantial precedent for this form of community benefit for general renewable energy projects[1].

It is important to be clear that the trials we identified did not generally factor capital/operational costs of equipment into their bill savings calculations. Given the scale of savings reported, and current costs of battery/PV installations, payback times would mostly be expected to be quite long had participants been expected to pay for the equipment themselves. Where such assets are paid for by a third party, savings that could be passed on to participants would be expected to be smaller than those reported above to allow the investor to recoup their investment. Third-party financing is also less attractive where paybacks periods are high. Future reductions in technology costs will be important for future project viability. In addition, regulated network charges and taxes impact level of savings achievable through shared assets, particularly if accessed through a public network. While some trials model the impacts on bills that different network charging regimes would make. Other sources note that reducing network charges for those able to use storage to optimise CSC will reduce the tax income and may contribute to higher network charges (and therefore bills) for others [33].

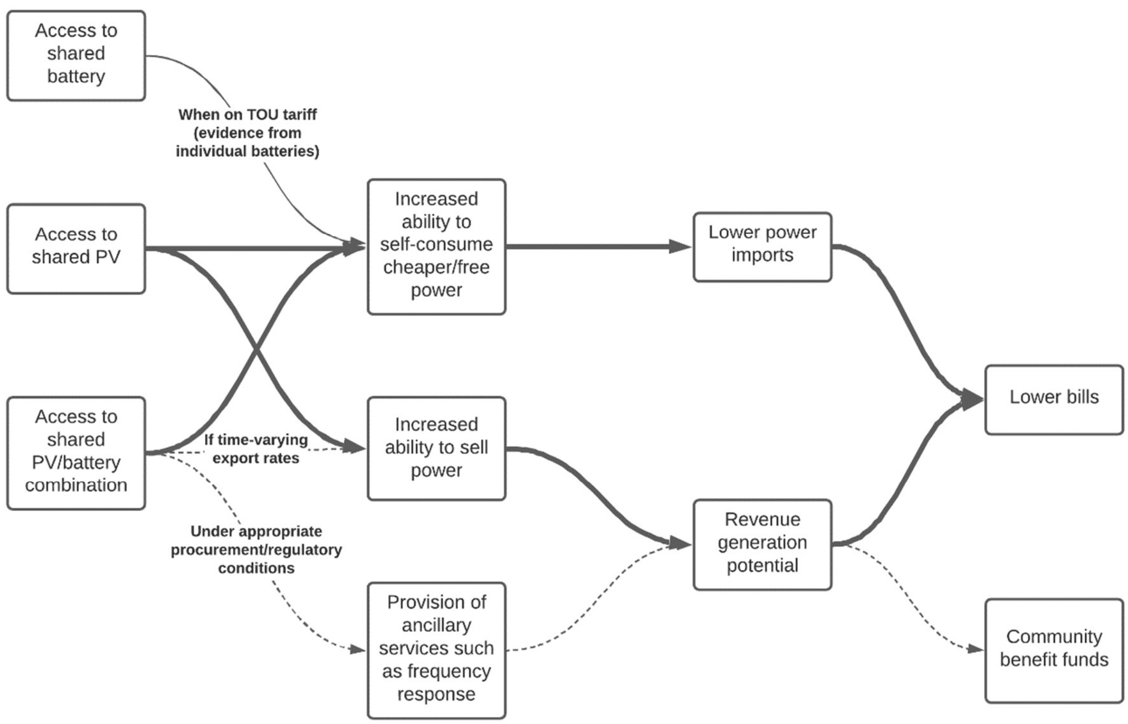


Figure 6: Mechanisms leading to lower bills. Bold arrows represent routes for which we have identified consistent supportive evidence in very similar contexts to UEC. Light solid arrows represent links for which we have identified supportive evidence in quite similar contexts to UEC (with main contextual considerations mentioned). Light dashed arrows show links for which we have identified indirect evidence that this could happen in certain contexts.

3.2. Increased engagement with energy

The second outcome we examined was the possibility of increasing engagement with energy through access to a DER asset (Figure 7). A key aspect of the transition to a smarter, more decentralised energy system is the repositioning of end-users from passive consumers to active, engaged prosumers. Understanding the mechanisms through which this shift can be achieved is important for achieving wider and deeper engagement with the energy transition. We define ‘wider’ engagement with the energy transition as interactions within the realms of the typical consumer-supplier relationship, from those who are not typically engaged in the energy market and may be at risk of being excluded from the benefits of the energy transition. This could manifest, for example, through consumers who had not previously engaged with the energy market switching to a new tariff. We define 'deeper' engagement as engagement that goes beyond the typically passive relationship that consumers have with their energy supplier, becoming a more active participant in the energy system. This could take the form of increased awareness of assets and knowledge of how to optimise one's energy use; a behavioural change towards more self-consumption or off-peak consumption; or even a sense of agency, control, or empowerment over one's energy use. Few of the papers we reviewed discussed engagement in detail, but we have identified some relevant mechanisms to provide insight.

A key mechanism used to drive engagement in these projects was **information provision**, either through leaflets or more comprehensive efforts through home visits and on-going customer support. The desired outcome from this mechanism was deeper engagement, in the form of increased knowledge of the energy system and how to optimise energy behaviours, resulting in either increased self-consumption or flexibility provision, depending on the trial. The EnergyWise trial in particular focused heavily on customer support, providing bi-lingual field officers who were on hand to offer assistance and answer questions. Participants reported an increase in their own ability to seek out knowledge, as well as an increase in their ability to seek out advice within their social networks and having more conversations about energy savings[7,34]. Similarly, several projects in the 'Low-Income Energy Efficiency Project' (LIEEP) involved home visits, and these were the only interventions tested that showed robust evidence for an increase in knowledge. The Alkimos Beach Energy Storage Trial (ABEST) trial in Australia, which involved installing a community battery in a residential beach complex with individually owned solar PV, also featured an "eco-coaching" programme to help participants effectively manage their assets, and, whilst there was a good level of awareness of and interest in the trial, there was no significant increase in knowledge of how the community battery and pricing worked amongst those on the trial compared to those in the control group. This was reportedly due to a lack of easily accessible help and advice. The Domestic Battery Storage project also pointed to the importance of ongoing advice, as, although around two thirds of participants reported high levels of satisfaction with the information provided about the battery, several participants were unable to optimise their energy use or experienced complications.

Notably, increased awareness and knowledge of DER assets and how to optimise energy use did not necessarily translate into behaviour change. In the EnergyWise trial, despite knowledge gains and financial incentives, energy savings were very low; a factor of the low demand that low income households have and the limited ability to flex this. Participants explained that activities such as cooking could not happen at a different time. Similarly, in Uppsala, although participants self-reported a change in their energy use patterns because of being made aware that they could self-consume from their shared solar panels, this shift was not observed in metered electricity data. In this case, there was no financial incentive for self-consumption. In the Domestic Battery Storage project, the combination of the battery with a ToU tariff resulted in larger energy savings than just the battery alone, but only a minority of participants were able to switch tariffs. These projects demonstrate that, for knowledge and awareness to translate into behaviour change, they need to be paired with both the incentive and ability to make those changes.

The projects highlight the different forms that engagement with the energy system can take. From the perspective of DNOs, deeper, more active engagement has value in terms of system operation and balancing. However, this outcome can be achieved through a variety of mechanisms such as behaviour change, automated DSR, investment in communal assets for example. Awareness and knowledge of, or interest in the energy transition may be needed as a first step to achieve these.

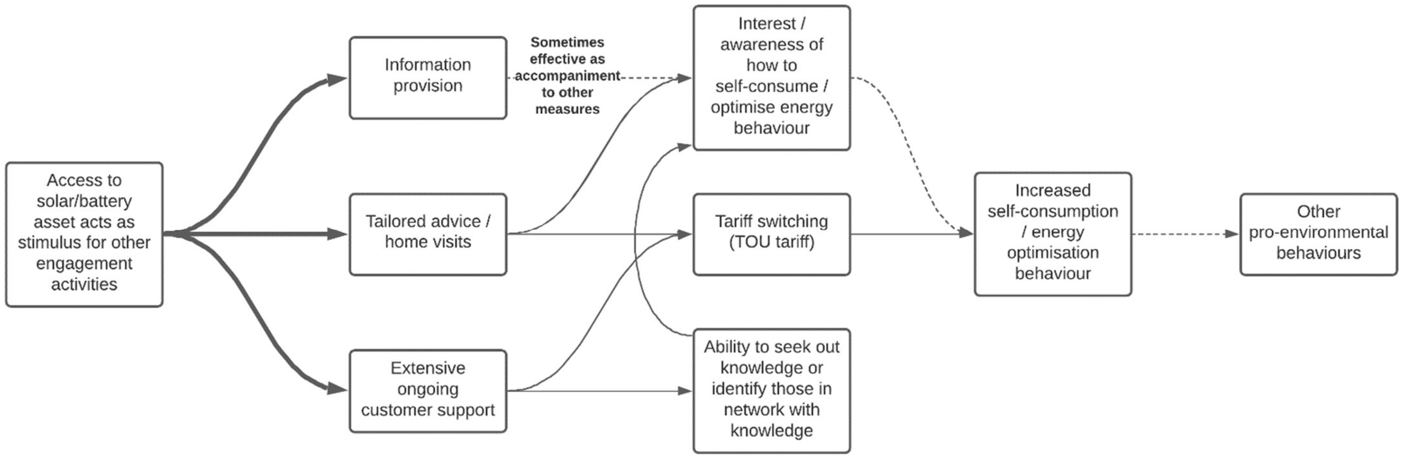


Figure 7: Mechanisms leading to wider and deeper engagement with the energy transition. Bold arrows represent routes for which we have identified consistent supportive evidence in very similar contexts to UEC. Light solid arrows represent links for which we have identified supportive evidence in quite similar contexts to UEC. Light dashed arrows show links for which we have identified indirect evidence that this could happen in certain contexts.

Table 5: Selection of projects with an outcome involving increased engagement with energy, along with details of the context, intervention, and mechanism.

Study	**Context**	**Intervention**	**Mechanism(s)**	**Outcome(s)**
Rising with the sun? Encouraging solar electricity self-consumption among apartment owners in Sweden	54 tenant-owned apartments in Uppsala, Sweden with shared rooftop PV installation of 32.4 kWp. Participants were not low-income. Majority had pre-purchased their apartments before the DER asset was installed, meaning that they were not self-selected prosumers.	Four information leaflets were distributed to apartment owners roughly once a quarter between September 2017 - June 2018. These leaflets informed households that they had become prosumers, how to self-consume, and different reasons for doing so.	Information provision to deliver increased awareness of energy assets, empowerment to make changes to own consumption, leading to changes in energy behaviour and spill-over into other pro-environmental behaviours.	Self-reports indicated that participants believed they had shifted their energy usage to increase self-consumption (increased awareness), however there was no evidence for this in metered data (no behavioural change). There was no evidence that this self-reported shift spilled over into other pro-environmental behaviours.
Domestic Battery Storage Project: Dumfries and Galloway (project report)	423 households in Dumfries and Galloway Housing Partnership (DGHP) between December 2019 and March 2021. Dumfries and Galloway Housing Partnership is Scotland's second largest social landlord with more than 10,000 affordable homes across the regions. Focus on	Installation of individual Tesla Powerwall II (13.5KWh) for homes that met technical requirements. Free and impartial advice on optimal tariff for all households. Total of 133 batteries installed and 205 households referred for tariff advice.	Information and independent advice on alternative tariffs empowering participants to switch to a more optimal tariff. Time of use tariffs combined with battery to encourage consumption of off-peak electricity and self-consumption.	An average of 52% of daily electricity was consumed from the battery, indicating an increase in self-consumption. Approximately half of households referred for advice switched to the ToU tariff. Some households were able to optimise their energy use to take advantage of the battery and ToU tariff. Some households experienced

	households at risk of fuel poverty, off gas grid.			complications or were not able to understand how to optimise their behaviour.
EnergyWise	536 homes occupied by social tenants of either Poplar HARCA or Tower Hamlets Homes with British Gas, living in properties with EPC rating C or below.	Smart meter solutions, energy saving devices. Reduction in energy consumption at peak times was rewarded with generous rebate	Extensive customer support including bi-lingual field officers providing support in person, on the phone, online, in addition to focus groups, newsletters and information tools.	Increased energy social capital, in terms of a higher level of information seeking and identifying people within their networks to seek information from. Very little shift in energy behaviour.
Powershift - The Low-Income Energy Efficiency Project (LIEEP)	Series of projects to engage fuel poor and vulnerable consumers – eight low-income cohorts across 6 states in Australia. 9 Different energy saving initiatives were trialled to reduce energy use or improve well-being	Interventions included home energy visits, major and minor retrofits, energy efficiency information including IHDs, energy efficiency training and workshops, digital engagement, gamification	Home energy visits provided tailored advice for diverse groups; major and minor retrofits provided new technologies or EE improvements; IHDs provided real time information on energy use; EE literature, workshops, and training provided knowledge and ability to promote and engage others; digital engagement and gamification provided stimulating ways of drawing attention to energy usage	Highest improvements were seen in gains in confidence, knowledge, competency and thermal comfort and were measured in trials which combined Home Energy visit (HEV), minor retrofit & IHD (although Knowledge gains were achieved by HEV alone). Others include empowerment, control/self-efficacy, financial control, interest in energy efficiency, positive attitude, financial stress. Digital engagement trials contributed highest positive outcomes for financial control and positive attitude to energy efficiency.
Alkimos Beach Energy Storage Trial (ABEST)	>100 houses in new development in Alkimos Beach, Western Australia with individual PV and shared community scale storage. Participants were not low income.	Energy Smart Home package including rebate for solar PV installation, installation of lithium ion community energy storage system (1.1 MWh), new energy retail products and services, installation of smart meters, behavioural change program to help residents optimise energy usage	Educational program to increase knowledge of smart response program, self-consumption, and benefits of community storage	Self-reported increase in belief of benefits of community storage among those on the trial. No increase in knowledge of DSR in those on the trial compared to those not on the trial. Only 36% of respondents on the trial reported changing their energy use as a result of the trial.

3.3. More affordable Network

The third area of interest was the network savings possible through community battery assets. There were only a handful of studies that were able to demonstrate network impacts and gauge the savings potential

(Table 6). The Brooklyn Queens DSM programme is a commercial project that has used a $2M programme of energy efficiency upgrades and DSR to avoid a $1B network upgrade.

Table 6: Trials identified resulting in reduced network costs, along with details of the context, intervention, and mechanism

Study	Context	Intervention	Mechanism(s)	Outcome(s)
Brooklyn Queens DSM programme	$1B new substation or 52 MW peak load reduction required	Con Edison funded / incentivised a widescale programme. This included a shared asset (CHP in a multi-housing blocks)	$2M programme of EE and DSR	$1B network upgrade (new substation) avoided
DS3[5]	Scenario 1 modelled outcomes in a context of high cost network upgrades that are completely avoided Scenario 2 modelled outcomes in a context of low value network upgrades or when high cost upgrades are only deferred.	Behind the meter / individual household batteries installed in social housing for elderly. 36 households enrolled (27 with pv) (2 with 2 batteries)	The trial tested 2 battery operation modes: Mode 1: Aggregators maximise battery charging for network producing optimum network impacts, but also transferring battery degradation costs to DNO Mode 2: battery optimises between self-consumption and network services.	Network cost reductions from cost-effective behind meter storage (achieved only in scenario 1)
Gridflex Heeten[23,35]	New build neighbourhood share one grid connection. Regulatory sandbox allows network charges to vary according to power imported / exported to the community.	Individual PV and batteries installed in some homes. App to support local demand management.	Collective management of local energy Network charges separated	Minimize the degradation of LV-cables and the transformer

3.4. Broader benefits and contextual factors

The reviewed literature also raised a number of conceptual issues that affect our understanding of the societal benefits achievable and any unintended consequences or conflicts. We briefly discuss these here.

Distributional impacts and risk of being left behind

Research increasingly shows that people and groups have differing opportunities to benefit from providing flexibility. This means that the growing value placed upon flexibility provision is likely to have distributional impacts. Ofgem's RIIO ED-2 methodology recognises this risk, pointing out that:

> "some consumers, especially those in vulnerable situations, may be at risk of being excluded from accessing the benefits and therefore suffer new forms of detriment. For instance, paying for some of the costs associated with the transition of the energy system while being either unlikely or unable to access the associated benefits"[17].

Network requirements for flexibility are spatial and relate to specific locational attributes of the existing infrastructure, renewable energy generation potential of the natural environment and constraints in the built environment. The locational nature of flexibility means the value it produces varies spatially with highly constrained areas placing much higher value on the provision of flexibility.

Relative advantages and disadvantages come in a variety of forms and stem from a range of reasons, but we briefly summarise some of the main ones here. Our aim is to highlight that, while bill savings and engagement are important considerations, they are not only ones and flexibility suppliers should try to give thought to the range of distributional impacts their offerings might have.

Part of the motivation of the UEC project is a recognition that **some groups are relatively less able to participate in flexibility service offerings** by virtue of where they live and their lack of ownership of large flexible loads such as electric vehicles and home batteries. The response in the case of UEC was to partner with a community energy group to develop technical capacity to provide flexibility – here in the form of a shared battery. Such partnership can also help support those who may be less digitally literate to participate in schemes that otherwise would be either inaccessible or opaque to them. However, it should be recognised that not all areas have community energy groups, and not all such groups have the same resources and capacities. Even if well-resourced and motivated groups are present, there may be further reasons why schemes similar in nature to UEC just are not possible – such as whether smart meters have or can be installed in a building[8], or whether the grid is constrained. This means that some population groups are more likely than others to miss out on the benefits of offering flexibility simply by virtue of where they live.

Participating in flexibility services can also impact the way people lead their lives. For example, being on a time of use tariff might prompt people to do certain electricity-intensive activities at some times rather than others. Even approaches that require less direct participant involvement can have lifestyle impacts. For example, automated control of heat pumps for flexibility might have thermal comfort impacts [36], and devices which aim to buffer impacts on energy service delivery (such as thermal stores and batteries) can have variable success depending on their size and other characteristics. Such impacts on comfort, convenience and timing of activities are not necessarily a problem, but they are more likely to be so under certain circumstances. For example, the burden of domestic chore-doing is carried disproportionately by women, who in turn are proportionately more likely to be impacted by pressure to change when tasks are undertaken [37]. Older people and those with disability and chronic illness are more likely to be vulnerable to the effects of temperature variation[38], while those on lower incomes may feel the pressure to make lifestyle compromises more keenly because of financial incentives/penalties[39].

Community vs individual assets

A further consideration is the relative merits of community assets compared to individual assets. Individual assets may create more value for individual owners at a particular point in time, but this value can only be realised at times when those individuals are able to shift their demand and provide flexibility. For DNOs, community assets have the attraction of a simpler management process (also simplifying dispatch, measurement and verification), reduced risk due to the diversity of loads across a pool of participants, and these benefits are likely to be passed down to individuals within that community[33]. For the consumer there are also benefits, with economies of scale leading to reduced capital and operating costs, and no loss of space in the home. Paying for aggregation services for individual assets could reduce benefits for consumers. However, knowledge about community assets is still low. In high-income groups, there does not seem to be an inherent preference for a community asset: in the ABEST trial, 41% of participants not in the trial said that they would prefer to have their own battery than a community battery, with 31% saying they would prefer a community battery. Amongst participants in the trial, this reduced to 33% preferring their own battery, with 27% preferring a community battery. When informed of the cost of installing individual assets, the number of participants on the trial preferring a community asset increased, but those not on the trial were proportionally more unsure. Similarly, no significant difference between preferences for individual and community storage solutions in a series of choice experiments amongst German consumers [40], although there was an assumption that community storage would be more cost effective.

In the context of low-income groups, community assets can address challenges such as the "split-incentive" problem where the owner of a building does not prioritise investments that would benefit the tenants. Community assets can provide benefits to those who would not otherwise have the financial capital to invest. There are additional social benefits that can arise from sharing an asset with others in the local community; for example enhanced community relationships, local jobs, or community development[41]. Profit from community owned assets may contribute towards community benefit funds, leading to further community projects or activities that may result in improved social cohesion.

However, there is a possibility for social tensions to emerge because of community energy projects. Benefits must be divided between participants, raising potential issues around the fair distribution of benefits within the community. When costs and benefits are perceived as being distributed unfairly, this has the potential to result in distrust of the organising body of the project, as well as limiting willingness to engage[42].

3.5. The CommUNITY /UEC approach

CommUNITY and Urban Energy Club tested a new approach to sharing the benefits of renewable energy assets with low-income communities. The ambition was for the pilot to be as inclusive as possible and was designed in reference to the local context which shaped how the potential benefits of the project were interpreted and designed for. For example, the benefit of increasing participation in the energy market was recognised, particularly in an estate where few people seek out the best deals available, but so was the complexity of living on a low income and need to avoid burdening people's time and attention.

When the project was originally planned, the team wanted to run a co-design process in line with best practice for innovating energy services with vulnerable and low income households [1]. However, funding was not secured, and this element was removed. Instead, the team ran a closed design process with Repowering London advocating on behalf of the future participants (closer to user centred design) based on their experience of running projects in the neighbourhood and wider area. Ofgem also set requirements for the project, specifically that no participating household could be financially worse off. In this section we discuss the benefits intended to be realised through the project and how these were designed into the trial.

The overarching societal benefits that were intended to be explored were:

- *Reduce household electricity costs for low income and / or disengaged households*
- *Generate financial benefits from flexibility market for low income households (while minimising the need to flex own consumption or reduce comfort)*
- *Increase access to renewable electricity for low income households and / or disengaged energy customers*

- *Increase engagement in energy markets broadly*
- *Increase awareness in smart local energy systems specifically and develop local capacity*
- *Explore a business model for community energy flex projects/ Test feasibility of storage assets for community energy projects. Promote local uptake of renewables*

Table 7 summarises the mechanisms used to try to deliver the intended benefits and how these mechanisms were shaped by the local context.

Table 7: Mechanisms, context and benefits in the design of CommUNITY /UEC

Local context factored into design	**Mechanisms**	**Benefit /outcome**
Built environment context: Community owned PV array on building Space to add a communal battery Both assets behind landlord supply, non-wired solution required for collective self-consumption. Repowering London has an existing relationship with the housing estate and the landlord Trial context with sandbox: Regulator allows energy costs to be netted but not network costs. Regulator requires that participating households cannot be worse off Regulator requires that collective self-consumption is prioritised over export/import Supplier allows on bill savings for participating customers Community energy group requires that participants must not have to change behaviour to receive rewards R&D test battery algorithm to determine when to make battery available to local CSC market vs. deliver flexibility to UKPN.	collective self-consumption	Reduce household electricity costs for low-income households and / or disengaged energy customers
Built environment context: Assets behind landlord's meter, means battery is charged from PV array, not using grid electricity No grid constraints /no requirement for flexibility Trial context with sandbox: Capital & operation costs of communal battery are covered by trial, not deducted from battery income Regulator requires that participating households cannot be financially penalised.	Income from communal battery delivering LV flexibility passed onto consumers	Generate financial benefits from flexibility market for low-income households and / or disengaged energy customers

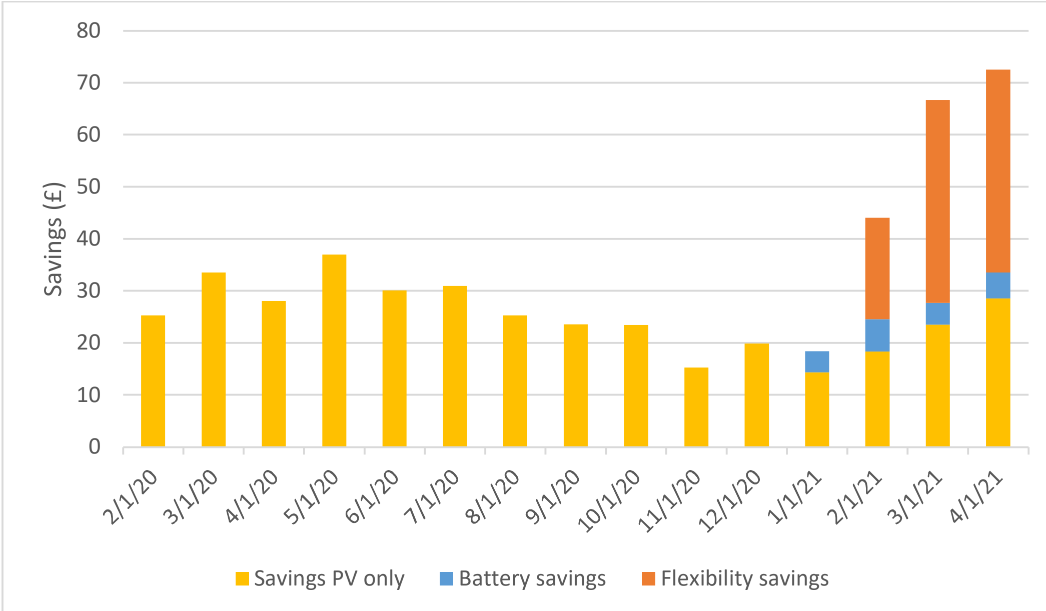
Community energy group requires no impact on household routines or comfort R&D testing battery operation and control algorithm. DNO agrees to reward multiple flexibility windows in an area with no grid constraints.		
Existing PV array on building with communal battery. Control and market algorithms set to equally distribute available PV output and optimise collective self-consumption. Sandbox: Ofgem requirement that no participating household could be worse off. Capital & operational costs of the app are taken on by the supplier, and are not required to be recovered	Virtual micro-grid / app	Increase access to renewable electricity for low-income households and / or disengaged energy customers
Collaboration agreement between supplier and experienced local community energy group	Energy champions	Wider engagement in energy markets
Trained engagement team. R&D team developing the app	Energy champions, App, project communications, and battery installation (visible technology), payments	Increase awareness in smart local energy systems specifically and develop local capacity
Battery funded via a grant	Feasibility of business model of communal solar array with storage	Promote local uptake of renewables

3.6. Results from CommUNITY / UEC

Reduced household electricity costs from collective self-consumption and income from flexibility windows

In the first 12 months 16.7MWh of solar was sold to participating household and resulted in an average 19.5% reduction in electricity costs for each household. The monthly credits varied according to the households' own tariff (which affects the unit rate of the reimbursement) and their demand profile, as well as the amount of solar available and how much each household could use. Figure *8* shows the total households savings achieved in the three different stages of the project (P2P, P2P+battery & Flex – see Figure 1). Households with higher electricity consumption received bigger credits as all households used roughly similar proportions of solar vs. grid electricity.

Figure 8: Total monthly credits for participating households



The battery went live in the market in January 2021 and in the first three months the battery increased collective self- consumption by 440 kWh. Mode 2 (CSC supported by the battery) only ran in January 2021. From February 2021 the battery was also generating income from the flexibility services. The income from providing this service was always higher than the costs avoided through collective self-consumption. Therefore, the battery always prioritised UKPN requests and responded to 18 calls for flexibility. UK Power Networks paid a set price (£19.50) for each flexibility window and the total income (£351.00) was divided equally between the four households. The participants received some of this income as credit during the last three months of the trial and part as a voucher following the end of the trial (Table 8). Households also received two £50 vouchers to incentivise their participation.

Table 8: on bills savings for participating households

	CSC on bills (15 months)	**Flex on bills (3 months)**	**Voucher for flex payment**	**Household income**
Household A	£74.12	£24.35	~£63.40	£10k-20k
Household B	£69.72	£24.35	~£63.40	£10k-20k
Household C	£138.63	£24.35	~£63.40	>£60k
Household D	£113. 87	£24.35	~£63.40	<£10k

In addition, Repowering London signed a PPA with EDF on behalf of the cooperative who owned the solar PV array. Through the PPA 21.4 MWh were sold, earning income for the coop and contributing to the existing community benefit pot.

Increased access to renewable electricity

The CommUNITY app provided a virtual solution to distribute available solar output. Figure 9 shows that households were able to use the majority (59%-94%) of their allocated solar energy. Figure 10 shows that households were typically substituting over 40% of their grid import with local energy, either directly through using their own allocation, or with a contribution from their neighbours. In contrast to other P2P platforms which facilitate price setting or active demand shifting, the platform gave equal shares to all participating household, meaning that their access was secure and did not reduce over time even if they did not engage beyond opting in.

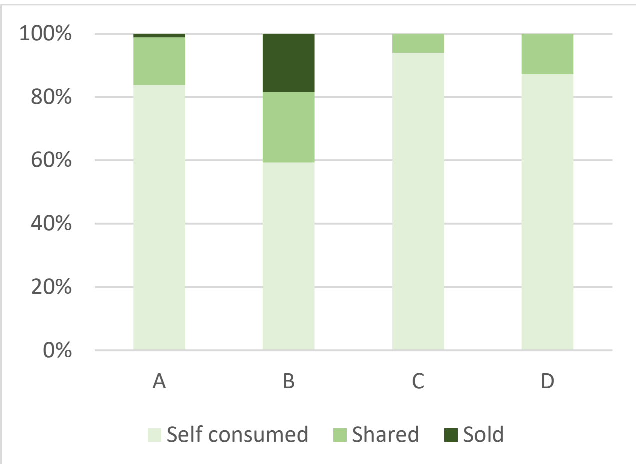


Figure 9: Household use of solar allocation

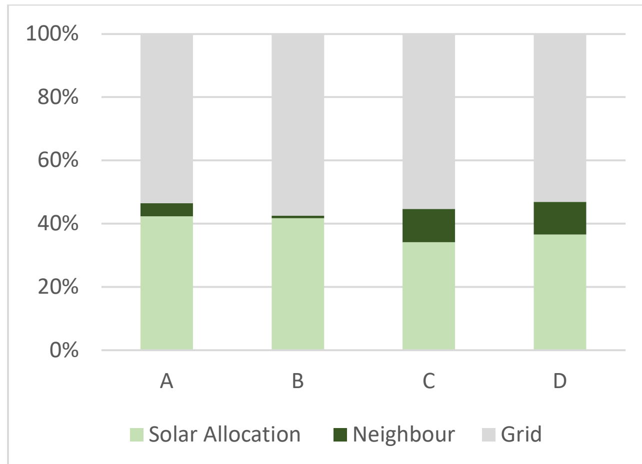


Figure 10: Household Solar Consumption

This approach contrasts to Repowering London's existing model of distributing income from community owned renewables through a community benefit pot. By matching household demand to solar output and working with a supplier to give on-bill savings, arguably this non wired solution allows access to the renewable assets for the participating households.

Table 9: Demand and household composition

	Total demand	**Large loads**	**Household composition**
Household A	2938.6 kWh	WM	One adult (retired)
Household B	2338.8 kWh	WM	One adult and one child
Household C	3914.1 kWh	WM	Three adults (couple and adult child)
Household D	3653.2 kWh	Electric oven, WM, DW	Two adults and three school age children (extended family)

Table 9 shows that Household C had three working age adults and was in the highest income bracket (>£60k). They also had high demand which meant they were able to consistently use most of their allocation and in effect contributed least to collective pot of energy while receiving the biggest proportion from the pot (11%). This household benefitted from being able to use more of the cheaper renewable energy available locally. By contrast Household B has a lower demand, and lower income (one working age adult and a school age child). The CommUNITY platform meant that households with smaller loads unable to use all of their allocation are able to share or sell this, not only reducing their own power imports but also earning income from their unused allocation. The actual bill savings depend on their own tariffs and the price they pay for imports. In this context, households with high demand stand to be able to make bigger reductions, and this reflects that the biggest environmental and network impacts come via changing the biggest consumers. However, the equal allocation model also allows for smaller consumers to benefit financially.

Increased engagement in the energy transition

In line with section 3.2 above, we examine two different forms of engagement: wider (previously disengaged consumers becoming more engaged with the energy market) and deeper (consumers challenging the typical unidirectional consumer – supplier relationship and becoming active in the energy transition).

We use switching tariff or supplier as a proxy for **wider engagement** and therefore argue that the project did widen engagement for a limited number. The mechanism for delivering this outcome was the collaboration with Repowering London and their team of local energy champions and trained advisors. As a result of the trial engagement process three non-EDF households arranged an independent tariff check with Repowering London and four EDF households opted into the project. These four were 'disengaged consumers' in that none had switched tariff in the preceding five years, and two had never switched (Table 3). They opted into the project, taking a first step towards engaging as a consumer. Repowering London then asked EDF to call participating households to discuss tariffs and offer to switch participants away from their SVT and onto the best available tariff. Two households remember being contacted, but were unable to switch at the time. They discussed their intention to switch suppliers once the trial was complete and they had received their bonuses. Three households described Repowering London and the Energy Champion in particular as a trusted source of information to whom they would turn for support for interacting with the energy market. One participant, however, was sceptical of all energy companies, seeing them as 'money making schemes'. She included Repowering London in this category and when discussing future intentions to switch she said she was someone who would rather do it herself than turn to an intermediary for support.

In terms of **deeper engagement**, we hoped the trial would increase awareness in smart local energy systems specifically and develop local capacity. The project provided a number of mechanisms to do this (see Table 7), but in interview it seemed the credits to household accounts was the most salient mechanism. All four found the app hard to engage with and two did not open project emails. But all households noticed the credits and found this the most important benefit of the project.

Three households noticed their reimbursements changing from month to month and going up towards the end of the project (when the battery was installed), but they attributed these changes to various things. Only one participant (Participant A) was able to clearly **identify the battery** as having made a difference to the monthly rebates. This participant read project materials, but was also active in seeking support from the energy champion to help her understanding. One household (Participant C) did not notice a change in monthly savings. He felt the credits were about £10-15 a month, but had not checked to see if he had been credited on his quarterly bill. Coincidently he had come out to watch the battery installation and had discussed what was happening with the energy champion at the time, but by the end of the project he was not able to describe what the project was about clearly in interview. The other two participants noticed their credit changing and vaguely attributed this to changes in how sunny the month was.

The ability to **share with neighbours** was identified as a positive aspect by three of the participants. Two had opted to share with the group as way of making a positive contribution to the local community. One of these (Participant D) had tried to get a friend in the local area to join the project, but the inclusion criteria (limited to one building) meant this could not happen. Instead the community contribution was experienced in broad and vague terms. People did not know the other households involved, and they did not know the door numbers listed on the app. The trial had not been designed to use a snowball approach of neighbours inviting neighbours and COVID restrictions meant the research team could not run events to introduce participants to one another. None of the participants had tried to associate the door numbers with the actual flats in the building or the people living there. Only one participant showed an interest in trying to sell to specific households, despite not knowing who they were. She found this aspect the most engaging, but lost interest when she was not able to see the details of how much she had sold to whom or how much she had earnt from this activity. The other three households did not engage with this aspect of the app, mainly setting to share at the project start and leaving it at that.

The project did give a sense of making **a positive contribution to the environment** for three of the households. This was also discussed in broad terms, one participant explaining that it was like 'recycling' in that it's a system that allows everyone to make a small contribution to a bigger environmental good. The participants were also generally supportive of more local solar and battery projects, but this was seen as something the council should be doing rather than groups of residents. The project therefore helped people feel they were making a contribution to the low carbon transition, but did not lead to a deeper questioning of the roles and responsibilities for energy consumers, communities or companies in this transition.

Local uptake of renewables

However the capacity to deliver local energy also resides with organisations like Repowering London, not only with individual consumers opting in. From this perspective the innovation project did allow Repowering London to build capacity and provides insight into ways that social justice can be factored into the design of smart local energy systems. Numbers of new community rooftop solar projects have sharply decreased with removal of the Feed in Tariff. Collective Self Consumption (CSC) and flex services offer two income streams for local renewable energy projects that could **support local uptake of renewables.** Currently projects based on selling capacity to DNOs as in the model of Urban Energy Club are not economically viable because of the difficulty in getting an aggregator to take on one relatively small asset. The CSC aspect is also not feasible given the high cost of the battery, the regulatory constraints on selling energy locally and the inability to reduce network charges, however the project has demonstrated the capacity of a community energy group to deliver the project. The business case for communal batteries may improve in the future if technology costs fall and revenues from different markets can be stacked. The trial has also indicated that mission driven organisations are able to operate flexibility assets to produce targeted and context sensitive social benefits. The following chapter discusses this issue in terms of inclusive procurement.

3.7. Discussion

Bill savings

Bill savings were the major benefit of the project from the participants' perspective. These savings were achieved through the ability to collectively self-consume cheaper power. The trial context was key to realising these savings. It removed the capital and operational costs of the battery and the platform solution developed to facilitate the local energy market and the optimisation of the battery. It also removed some regulatory constraints and allowed virtual netting of energy costs. This is not possible in the UK under current regulations, although evidence from the US suggests this policy can be used to deliver bill savings to low income households when targeted for these groups[43].

Further bill savings could be achieved for participants if the UK changes the network charging model to one where costs reflect the distance the power travels. The GridFlex Heeten project has showed the possibility to use this mechanism to reduce bills for groups who all share one connection point.

The flexibility revenue generated through the battery offers an additional mechanism to reduce costs. This is independent of household consumption therefore can be distributed in different ways; equally between participating households (option taken in UEC); proportionally relative to household income or directed to a community benefit pot in the way that income generated from the rooftop PV array is currently. There are trade-offs between these different options. The first and second options demonstrate the tension between equal vs. equitable distribution of benefits but maintains the virtual link between energy asset and lower bills. The third option converts the value from the energy asset into income which can be used by a wider group of people for a wider set of benefits but breaks this link.

This mechanism of flex income leading to lower bills is also affected by the trial context. Again, the absence of capex and opex increased the amount of revenue passed on to households. More importantly though, the trial context shaped the distribution of revenue. In UEC, the algorithm controlling the battery operation set the battery to charge with excess solar and not reduce the participating households' allocation. Before accepting a call for flexibility, the algorithm also evaluated whether household savings would increase more through responding, or more through CSC. The operation of the battery therefore always prioritised household savings. In a non-trial context, a commercial battery owner / operator may prioritise revenue generation over collective self-consumption, reducing the energy available to participants and negatively impacting their ability to consume cheaper electricity.

By charging the battery only with the PV the flexibility service delivered was low carbon / zero emissions. The trial proved it was possible to provide this zero-emission flexibility. Currently there are no incentive mechanism to support or prioritise low carbon flex. This negatively affects the ability for community energy groups / mission driven organisations to develop flex assets.

These kind of tensions and trade-offs demonstrate a potential benefit to having an organization like Repowering London owning and operating a shared battery on behalf of the community co-located with the asset.

Broader engagement

The project had limited success in engaging households. The offer of local energy encourages seven out of 62 households take the first step to engage, opting in or having a tariff check. Two of the participating households then associated changes to the electricity bills with the communal assets and one participant did engage more deeply and showed interested in the transition and understanding the impact the battery made to household savings. The savings were the main mechanism for delivering this outcome. The potential to make a saving encouraged people to express interest initially in the project and the credit participants received made the infrastructure visible to them. The project therefore adds some evidence about the importance of the intermediary stages shown in Figure 7 that link communal infrastructure to engagement.

The trial also raises a question about the trade-off between the amount of resource required to get this level of engagement, particularly given the reduced number of households who were then able to access the financial benefits of the shared assets. Can this be justified if this connection to the battery does not lead to a deeper engagement with the transition or understanding of energy? It would be appropriate to explore lower cost options based on opt out mechanisms for non-self-selected prosumers and investigate the extent this route does or does not generate broader engagement.

When considering broader engagement with the transition, however, it is also important to acknowledge that innovation projects of this type can help build the capacity of CEC organisations like Repowering London, who in turn can bring the technologies involved to a wider audience. Repowering London had the opportunity to test the feasibility of a new business model and gain new technical skills by working with the battery manufacturers and EDF's technical team. Their associated coop 'Brixton Solar Energy 1' received the battery at the end of the CommUNITY trial which is now being used to generate income and provide additional revenue for the community benefit pot.

In the UK, the current policy context and energy market regulations are not supportive of community energy groups. In the EU, the requirement to allow CECs and RECs encourages capacity building of local groups. In the UK, local energy solutions are being implemented with a focus commercial outcomes less of societal ones, leading some scholars to caution that this reduces the ability for the transition to be achieved [44].

A more affordable network

In the trial, the revenue from the flexibility payments was significant for the participating households, however outside trial conditions this level of income would not be achievable. The substation did not require flexibility services, the flex windows were artificially scheduled to provide many income generating opportunities, and the capital and operation costs for using the battery were not included. The project was not designed to explore if this was a cost-effective solution for managing network costs. It is however useful to investigate the extent that community-owned storage assets could be viable and produce benefits for both the network and the local residents. This theoretical potential is explored in Chapter 5.

3.8. Conclusions

Based on the evidence we reviewed and the outcomes of CommUNITY, we expect that communal battery **projects can deliver bill savings** for participating households when they increase the availability of low-price electricity to participants. For example, this could be allowing them to use more electricity from onsite generation or at off-peak rates than would otherwise be then case. The magnitude of bill savings will depend on factors such as:

- the price differential between locally produced energy and a customer's tariff
- battery capacity and number of participants, with a higher ratio of capacity to participants leading to higher savings
- household demand profile and correlation to local supply. Allowing all participants unlimited access to the battery (rather than a limited share) is likely to maximise total savings as the full battery capacity can be capitalised on, but high electricity users will save disproportionately more. A local trading system using virtual allocations and optimising for collective self-consumption should allow for maximum community savings, while mitigating some of the demand-based inequalities.
- the type of network that connects the household to the asset and the associated charges or taxes. Wired and non-wired solutions have been used to deliver bill savings, however non-wired solutions using public networks are more highly affected by regulations and likely to incur higher costs and limited savings outside of a trial context. If network charges are changed there will be potential for bill savings to be achieved through non-energy cost reductions as well.

Bill savings and economic benefits are also affected by the ownership of the asset and business model used to create returns. Shared batteries can earn revenue from export of low-price electricity at higher export prices, or provision of other flexibility services. These services impact the availability of storage for collective self-consumption and affect the share of flex income versus bill savings participants will receive. Community-owned schemes may choose to distribute any flex income through non-bill mechanisms such as community funds, or via bills by working with a licensed supplier. Changes in regulations may allow for local energy and flexibility services to be retailed along with a customer's main supply contract. Changes in network charging structures may mean the use of local renewable energy delivers bill savings via non-energy cost reductions. Changes in procuring flexibility from renewable-only assets or socially-oriented projects could increase the value of these projects and support the business case for developing them.

We found **mixed evidence overall for the potential of shared solar/battery schemes to drive wider and deeper engagement** with energy. Their main contribution is that they provide a prompt for interaction with potential participants, whether through information provision or through ongoing support. In some cases, this has translated into activities such as tariff switching, and reported increased confidence in ability to seek information. However, the more substantial impacts, such as changes to energy-related behaviour and changes in ownership and governance of energy assets are less likely to be achieved.

There is potentially some tension between approaches to financial benefits and engagement. The lowest risk/resource approach for such projects is likely to be avoiding recruitment altogether and distributing revenue benefits from providing flexibility in the form of community funds or automatically enrolling groups onto local energy tariffs. This minimises the opportunities to build engagement, since recruitment and support are not required. Alternatively, if participants are sought, then there is potential to build both engagement and further bill savings. However, this requires substantially more in terms of resource commitment, and may still yield limited success. It is more likely to be successful in a regulatory and policy context which sees consumer engagement and innovation as fundamental to a successful transition.

In addition, design decisions taken shaped the social interactions created through the market. For example, the project opted to use the building as the 'community'. An alternative would have been to allow existing social groups in the estate to influence participation, for example, participants to bring interested neighbours into the trial. The app identified people by their door number, but this was not meaningful for residents who could not connect the number to the flat in the building, or the household living there. Covid prevented the team from running events on the ground, which could have built more awareness in the building of who was in the trial and how to get involved.

Chapter 4: LV flexibility procurement

In this chapter we consider how DNOs such as UK Power Networks might go about procuring flexibility with additional social and environmental value (SEV). We begin by briefly recapping UK Power Networks' existing flexibility procurement process and exploring the kinds of SEV procured services may already deliver. We then turn to examine the learnings from work on other procurement processes intended to promote SEV in flexibility and energy more generally. Based on this, and informed by the Government's new Social Value Model, we propose a number of recommendations and considerations for procuring flexibility that promotes SEV.

4.1 Overview of UKPN and wider DNO flexibility procurement

Great Britain's distribution network operators (DNO) are increasingly taking on electricity distribution system operation (DSO) responsibilities. Amongst these is contribution to more active management of systems through the procurement of flexibility services. UK Power Networks released its first invitation to tender (ITT) for flexibility services in 2019, with further rounds of procurement later that year and in 2020 and 2021.

In its most recent ITT, UK Power Networks set out to procure three services:

- "Secure": A service where providers commit to being available (i.e., on standby) to provide flexibility during specific service windows. The service is activated closer to real-time to deliver flexibility when needed e.g., 1 hour ahead of required flexibility delivery. Providers are paid availability (£/MW/h) and utilisation (£/MWh) fees.
- "Sustain": A service which is scheduled either a month- or week-ahead of time. Providers are paid a fixed service fee (£/kW/year). Service mainly procured to address constraints on the LV network.
- "Dynamic": An optional service activated to deliver flexibility when needed closer to real-time. Providers are paid utilisation fees.

LV connected projects can participate across all three products, but for the purposes of this project, the community battery was dispatched by UKPN under the Sustain product due to the advanced notice provided and simplified payment structure.

Potential flexibility providers (FP) can identify areas in which these services are required using the Piclo Flex platform, and tender accordingly. FPs must show that their solution can meet a number of technical requirements, including: having the capability to turn up/down the required amount, being electrically connected to the constrained network asset, being able to receive and act on instructions, and permitting metering at sufficient detail. The tenders are scored against these criteria and, subject to additional financial checks, contracts awarded. Fee payment levels are set pay UKPN, and do not vary between service areas. FPs are dispatched in a merit order based on their cost. Other DNOs have procured flexibility services through a similar approach.

4.2 Social/environmental value and UKPN's flexibility portfolio as a result of previous tenders

Following its 2021 ITT, UK Power Networks procured flexibility services from providers as listed in Table 10.

Table 10: Providers of flexibility procured in UKPN's 2021 ITT, showing the main technology employed to provide flexibility, and whether it was procured under the low voltage (LV) or high voltage (HV) stream.

Flex Provider	Main Technology Type	Service (HV/LV)

AMP Energy Services Limited	Gensets	HV
Bankenergi limited	DSR	HV
Cambridgeshire County Council	DSR	HV
Conrad Energy Limited	Gensets	HV
Electric Miles Ltd	EVs	LV/HV
ev.energy	EVs	LV/HV
Gridimp Ltd.	Commercial DSR	HV
Just Charging Ltd	EVs	HV
Octopus Energy	EVs	LV/HV
Ohme Operations UK Ltd	EVs	LV/HV
Orange Power Ltd	DSR	HV
Tesla Motors Netherlands B.V.	Domestic batteries	HV
GRIDSERVE Sustainable Energy Ltd	Large scale batteries	HV
Lightsource Labs Holdings Limited	Domestic batteries	LV
ENGIE	Gensets	HV
Kaluza Ltd	EVs	HV
Green Energy Options (geo) Ltd	Domestic batteries	HV

As can be seen in Table 10, UK Power Networks' flexibility tenders attract a variety of technologies. A significant number of providers procured through the LV stream offer flexibility through smart charging of electric vehicles (EVs). Payment for flexibility services provided through smart charging of EVs has a range of social and environmental implications. The offer of payment for providing flexibility through smart charging reduces the cost of charging, and therefore of ownership, of an EV. For illustrative purposes, the website rightcharge.co.uk estimates that smart charging to take advantage of electricity tariffs designed for EVs could save the average EV driver £240 per year. By making EV ownership more affordable, payment for EV-derived flexibility could therefore make EV ownership more accessible to drivers with a broader range of incomes. However, according to a 2019 report, more than half of ultra-low emission vehicles in the UK were owned by the 20% top earning households, while the lowest earning 20% of households owned just 4%[45]. More broadly, 89% of owner occupiers own at least one car or van while 46% of social renters do (ONS). While flexibility-related savings could help improve the uptake and ownership distribution of EVs, currently most of the ownership savings are likely to benefit households in higher income brackets. For the same reason, such routes to providing flexibility also present limited opportunity to widen engagement with energy in general.

Unlocking flexibility from EVs has other important social and environmental implications that should not be overlooked. EVs do not burn fuel, and therefore do not create nitrogen oxides (NOx) or some other harmful air pollutants (although they do still contribute to particulate emissions). Because traffic pollution has been shown to be worse in areas with more poorer households[46], reducing it by increasing the proportion of EVs is likely to have disproportionately large health benefits in such areas[47]. Running an EV also emits less carbon than a petrol or diesel vehicle, meaning they contribute less to climate change. While this benefits everyone, it is especially important for those groups who are likely to be less resilient to its impacts, such as those living on low incomes. Smart charging can help cut EV carbon emissions even further where charging is set to coincide with low carbon intensity electricity on the grid (such as when outputs from renewable generators are high). While this is not the explicit intent of the flexibility services procured by DNOs, the evening peak period often coincides with higher carbon intensity as fossil generators are turned up to meet higher demand. By reducing EV charging during these periods, smart charging can further support climate mitigation.

In summary, flexibility procured by UK Power Networks can support a range of social and environmental benefits. However, under current arrangements the opportunity to derive direct economic benefits will tend to be restricted to higher income groups. As set out in the Introduction, DNOs have increasing responsibility to support vulnerable customers. Additionally, UK Power Networks has a stated aim to strengthen links with the communities that it serves. UKPN therefore needs to explore the trade-offs between hosting a solution-agnostic tender process and one that actively supports technologies and business models that deliver SEV. The next sub-section explores other existing or proposed approaches that aim to address these goals.

4.3 Evidence on processes used to procure flexibility with social and environmental value

Recognition of social value, including that attached to communities, has a long precedent in energy-related procurement. The actual level of direct community involvement can vary, from simply receiving payments to provide community benefits, to being integral to the delivery of the procured solution. The Scottish Government's requirement for community benefits of offshore energy projects mainly illustrates the former[48]. Developers of projects seeking permission to proceed should prepare a Community Benefits Package considering questions such as how the communities intended to benefit will be defined, how they will be engaged with, and how any benefits will be implemented. Case studies demonstrate that benefits often take the form of community funds, financed through project revenues, with aims such as supporting regeneration, providing community services, and local business support.

One approach to securing more community involvement in providing flexibility is to support communities and their representatives in developing their capacity to do so. An example of a programme which set out to do this is the Social Constraint Management Zone (SCMZ) project run by SSEN with National Energy Action (NEA). It trialled whether support to form partnerships with flexibility providers, combined with seed funding for project development, could make it easier and more attractive for communities to tender to provide flexibility services. While successful in attracting small volumes of flexibility, SSEN concluded that for such an approach to be economically sustainable the level of support delivered to communities would need to be substantially decreased (or the efficiency of providing it improved). There were also challenges around how to fund the technologies required to provide despatchable flexibility. There is an expectation that as technology costs fall and familiarity with flexibility services increases both of these challenges may diminish. Alternative funding sources may also need to be sought or developed, perhaps recognising and valuing the wider benefits that community approaches can bring (see chapter 3).

Initiatives such as SCMZ are not the only ones aimed at supporting communities to help unlock flexibility. The not-for-profit organisation Regen has a workstream focused on this challenge, and has produced advice for both communities and system operators on how to overcome it[49]. Their report identifies 13 barriers that prevent communities from participating in flexibility markets, along with measures those procuring flexibility can take to overcome them. The full menu of options (pp27-29 of the Regen report) merits careful reading, but in brief, the main themes are directly relevant to procurement processes are as follows:

- Promote opportunities widely and early through networks likely to be accessed by community groups.

- Explain opportunities clearly, using framings that are likely to be relevant to community projects (such as climate change and revenue opportunities) and avoiding jargon.
- Offer longer contracts to reduce risk for community groups.
- Make the tender process itself as straightforward as possible, with clear (standard) terms and conditions, and avoiding criteria that may exclude community groups (such as high levels of indemnity insurance).
- A range of other suggestions related to supporting capacity building in community groups.

The UEC project also provides us with useful insight into procurement of flexibility with aims to deliver wider SEV. As discussed in detail in previous chapters, the project successfully demonstrated operation of a neighbourhood battery to provide flexibility services. However, despite extensive recruitment efforts within the relevant community, interest was limited. This meant that direct financial benefits only accrued to a very small number of residents. This highlights a risk around delivery of SEV for projects of this nature. As proposed in the sub-section below, attention should be paid in any future procurement process to how this kind of risk is anticipated and mitigated. In this case, as suggested above, more optimal distribution of benefits could perhaps have been achieved via a community fund.

The UEC project was a trial and was not developed through a standard competitive tender process. Nevertheless, the Repowering London team support the Regen recommendations and add a number of further observations on how to make flexibility procurement workable for community organisations. Procurement for social/environmental value should be designed to be as open as possible to different solutions, while meeting the necessary technical requirements. Echoing Regen's recommendations, minimum capacity thresholds for flexibility should be kept as low as possible to minimise the barrier to entry for smaller projects which may still have significant social value. The process of engagement with social delivery partners should be an ongoing one where possible, ensuring that awareness remains high (and spreads) about the potential to get involved in – and generate revenue from – flexibility projects.

UEC was delivered through a collaboration of more than one organisation, and Repowering London suggest that community/industry partnerships would likely be a standard arrangement for delivery of social value projects. There is already substantial precedent for this in the development of solar/wind power joint ventures. Once the commercial benefits of such arrangements were clearly demonstrated through early projects, they became common. Therefore, for a similar approach to work in flexibility provision, projects will not only have to work commercially for the partners involved, but communication of successful and widely replicable examples will need to be effective. This could be supported through the use of illustrative case studies.

Such communication could be particularly useful in highlighting the kinds of projects that are most likely to be practical for community energy groups to get involved in delivering. For example, one approach to unlocking flexibility in social housing blocks could be through some third-party control of domestic appliances. However, this raises challenges such as high engagement costs, and local reputational risks associated with perceived poor performance or damage of appliances. A project like UEC, however, relied on a single asset, ultimately under ownership of the community energy group, and over which they had full control. Benefits are still delivered to the community through bill discounts (or alternatively they could go towards a community fund), and it still provides an opportunity for increased engagement (although see discussion in Chapter 3).

4.4 Considerations for implementing social value in procurement

It is clear from the above discussion that a substantial part of procuring flexibility that delivers SEV is building and unlocking capacity of stakeholders (such as community energy groups). While the challenges involved in this are highlighted by the SCMZ project, guidance on good practice is available – such as that provided by Regen, and the reflections from Repowering London. However, it is also important that the procurement process itself is designed in such a way as to allow projects that deliver SEV to be recognised, evaluated and, if appropriate, supported. Building on the above evidence and recommendations, this section presents more specific considerations for how flexibility procurement for social/environmental value might be conducted. We set out some specific suggestions for what tender processes might assess, and how social/environmental value might be weighted and evaluated.

Since the Public Services (Social Value) Act came into force in 2013, organisations involved in procurement using public funds have had to consider how their procurement processes can support delivery of wider social, economic and environmental value. While DNOs are not subject to this legislation, their incentives increasingly include similar objectives (as set out in the Introduction). There is therefore potential to learn and draw directly from the considerable work that has been done on building social value into procurement in the public sector.

In the wake of the Covid-19 pandemic, the government introduced new, detailed guidance on how to capture social value in procurement in the form of the Social Value Model (SVM). It came into effect in January 2021. The model sets out in detail the forms of social value that should be targeted, and how they can be integrated into tender processes. Other social value frameworks are also available, such as the National Themes Outcomes Measures framework available at the Social Value Portal. This provides an extremely wide-ranging and detailed way for organisations to develop, evaluate, and describe their own social and environmental performance. Some organisations, such as Brighton & Hove (local authority), have developed their own frameworks. As far as possible, reusing existing frameworks is desirable because it supports consistency and efficiency. We focus on the SVM because of its expected (widely mandated) broad level of uptake, relevance, relative parsimony, and recency. The following sub-sections draw on this guidance and suggest how it might be translated for use in the context of procuring flexibility in LV networks.

What to assess

A DNO's responsibilities in respect of social value follow directly from requirements placed on them by the regulator and their own mission commitments. As set out in the Introduction, the main areas of responsibility of commitment in respect of SEV are as follows:

- From RIIO-ED-1:
  - "Social Obligations: Companies will do more to help vulnerable customers, particularly during power interruptions".
  - "Environmental: Companies must reduce their carbon emissions and other environmental impacts".
- From RIIO ED-2:
  - "Vulnerability to a loss of supply"
  - "Being in, or at risk of, fuel poverty"
  - "Risk of being left behind by the energy system transition towards Net Zero"
  - "Decarbonise networks, reduce the wider impact of network activity on the environment and support the transition to a sustainable low carbon energy system"
- From UK Power Network's own commitments:
  - "Strengthening links with the local communities we serve"

On this basis, we identify four main areas where assessment of SEV could potentially focus:

1. Mitigation of vulnerability to (or impacts of) loss of supply.
2. Impact on fuel poverty.
3. Local community involvement.
4. Contribution to net-zero carbon and other environmental impact reduction.

The SVM sets out a range of themes under which it considers social value should be delivered, including: supporting COVID-19 recovery, tackling economic inequality, fighting climate change, equal opportunity, and wellbeing [50]. There is some overlap between these (or their subcategories), and the criteria of interest identified above for DNOs; especially "fighting climate change" and the subcategory "wellbeing: improve community integration". Re-using these themes directly or in slightly amended form would be ideal because the Social Value Model has already developed model evaluation questions, award criteria, response guidance and reporting metrics for them (see[50]). These could also be used as a model to create similar material for the two topics not covered in the SVM. Table 11 presents a summary of the main award criteria falling under each category (either drawn from the SVM directly or proposed).

Table 11: Main award criteria

Category	Activities that...	Source
Mitigation of vulnerability to (or impacts of) loss of supply	• Demonstrably reduce the potential for and duration of loss of supply, particularly to users in situations of vulnerability. • Contribute to improved support for users (particular those in vulnerable situations) when supply is lost.	Proposed
Impact on fuel poverty	• Lead to reduced prevalence and severity of fuel poverty by reducing bills and/or energy use (while maintaining acceptable service quality), or otherwise supporting those in fuel poverty to minimise its impacts.	Proposed
Improve community integration	• Demonstrate collaboration with users and communities in the codesign and delivery of the contract to support strong integrated communities. • Influence staff, suppliers, customers and communities through the delivery of the contract to support strong, integrated communities.	Social Value Model summary, Appendix A, Action Note PPN 06/20
Fighting climate change	• Deliver additional environmental benefits in the performance of the contract including working towards net zero greenhouse gas emissions. • Influence staff, suppliers, customers and communities through the delivery of the contract to support environmental protection and improvement.	Social Value Model summary, Appendix A, Action Note PPN 06/20

Approach to evaluation

The SVM provides model evaluation questions along with guidance on how evaluation can be conducted. Box 1 shows a model evaluation question, which is the same for both topics "fighting climate change" and "wellbeing: improve community integration". Consideration may also be given to including additional requests for consideration/mitigation of risks and negative impacts and supporting evidence for claims.

Box 1 Model evaluation question

Using a maximum of [insert number] characters describe the commitment your organisation will make to ensure that opportunities under the contract deliver the Policy Outcome and Model Award Criteria. Please include:

- your 'Method Statement', stating how you will achieve this and how your commitment meets the Award Criteria, and
- a timed project plan and process, including how you will implement your commitment and by when. Also, how you will monitor, measure and report on your commitments/the impact of your proposals. You should include but not be limited to:
    - timed action plan
    - use of metrics
    - tools/processes used to gather data
    - reporting
    - feedback and improvement
    - transparency

As identified in in the Social Constraint Management Zone project discussed in section 4.3 above, care is needed to ensure that the language and requirements of the tender are clear. This is because they will potentially be used by organisations which are less familiar with going through tender processes, such as small community groups. Regarding scoring, a standard approach of grading each criterion on a scale from 0-5 is likely to be appropriate. An example scoring framework is provided on pp13-14 of the SVM guidance[51].

Weighting

The SVM mandates a minimum 10% weighting to be placed on social value in scoring tenders. This balances clear signalling of the importance placed on social value against the risk of significantly impacting competition by excluding too many potential bidders[iii]. If DNOs decided to adopt this approach, then all bidders would be required to make a case for delivery of social value, whether or not this was originally part of their model. The effect of this would be to increase consideration of social value by all bidders, potentially driving increased social value delivery. However, as outlined above, many of the existing services procured by UKPN would already be able to make some case for delivery of wider SEV. The differentiation potential for projects with a particular emphasis on social value would therefore be comparatively limited. In this case, consideration

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[iii] This required can be adjusted if pre-market engagement suggests this impact would be too significant.

should be given to whether specific forms of value or activity (such as direct involvement by community organisations) should form part of the assessment.

An alternative approach is to work in a similar way to the Social Constraint Management Zone initiative described above, where a separate stream of tenders is invited specifically for projects which set out to deliver additional SEV. In such a case the weighting for SEV criteria would likely exceed the 10% minimum threshold in the SVM – while still requiring the technical requirements to be met. This approach would make it easier to procure a desired proportion of projects offering additional SEV, since they would not be competing directly against standard projects.

4.5 Summary

While UK Power Networks' last round of flexibility procurement is likely to deliver some social and environmental value (SEV), user benefits are likely to be mainly for those on higher incomes. Adapted or additional procurement processes are likely to be necessary if wider SEV is to be secured. There is precedent for procurement for SEV within energy, such as Community Benefits Package requirements for wind energy developments in Scotland, and the Social Constraint Management Zone trial run by SSEN with NEA. The latter, based around extensive support and engagement with community groups to deliver flexibility, demonstrated that while limited amounts of flexibility can be successfully delivered along with wider SEV, this currently requires significant resourcing. Repowering London, one of the UEC partners, see scope for this challenge to diminish as the solutions which work become better know. The organisation Regen has provided helpful guidance on how procuring flexibility can be made easier for community groups. Continued research and piloting are necessary in this area to identify and support effective approaches.

Informed by the Government' Social Value Model for public procurement, we suggest approaches to administrating flexibility procurement for SEV. This includes proposed areas for evaluation, or: mitigation of vulnerability to (or impacts of) loss of supply; impact on fuel poverty; local community involvement; and contribution to net-zero carbon and other environmental impact reduction. We provide an example tender question and discuss trade-offs on how to weight the value placed on SEV in evaluation of tenders. Evaluating projects which intentionally set out to deliver SEV as part of a separate stream of tenders would have the advantage of more easily allowing a certain proportion of SEV projects to be procured. Alternatively, introducing an SEV component to all flexibility procurement would incentivise all bidders to place greater emphasis of SEV delivery.

Chapter 5: Scalability and Replicability analysis:

This chapter looks at the scalability and replicability (S&R) potential of UEC pilot project. The chapter highlights some of the particularities of UEC model design boundary conditions which are also adopted for the S&R assessment. For the analysis we draw from various datasets and aim to provide a general approximation for the S&R potential of the UEC flexibility services. It is important to note that this is an analysis of the technical potential for scalability and replicability of the project. It is not a statistical generalisation of the findings. The numbers of participants and the specifics of the case make any statistical generalisation impossible.

5.1 Need for new flexibility capacity

As highlighted in Chapter 4.1, UKPN procures three types of flexibility, namely 'Sustain', 'Dynamic' and 'Secure'. As directed by UKPN, this analysis only addresses the 'Sustain' flexibility service. The 'Sustain' service is procured for constraints on the low voltage network in specific scheduled delivery windows. Sellers receive a single fixed annual procurement fee and opt in to providing flexibility on a month-ahead or week-ahead basis[52].

UKPN publishes yearly updates on the procurement requirements of flexibility and provides information on the required and predicted flexibility demand for the years ahead[iv]. Figure 11 below shows the flexibility requirements for LV-zones for the flexibility category 'Sustain' in the UKPN operation area for both winter and summer. For the 61 substations that require flexibility in the winter an average of 525h annually per substation is requested. For six substations in the summer an average of 1222h annually per substations is requested[53]. The data shows that flexibility capacity requirements are expected to rise over the coming years. This demand will have to be met by additional flexibility resources located in the LV-networks.

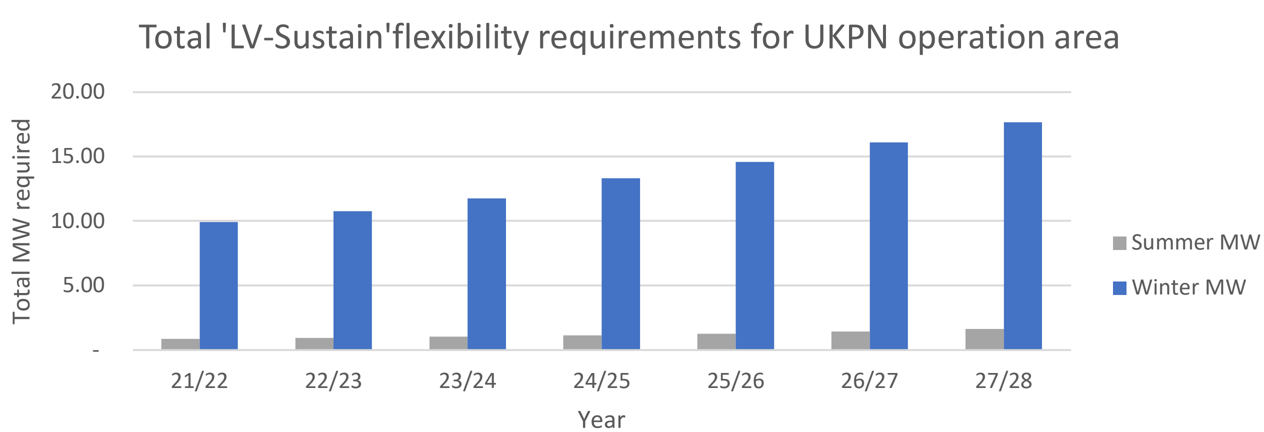

Figure 11 UKPN LV-Zones 'Sustain' (21/22-27/28) (Source: EDF)

UKPN operation areas are divided into three distribution networks namely, South Power Network (SPN), East Power Network (EPN) and London Power Network (LPN). All LV-flexibility zones for the 'Sustain' flexibility have historically fallen within the LPN zone and are mainly within residential areas[v].

[iv] https://smartgrid.ukpowernetworks.co.uk/flexibility-hub/
[v] https://dgmap.ukpowernetworks.co.uk/

Electricity flexibility in predominantly residential areas will come primarily from large load devices such as electric vehicles (EVs) and heat pumps (HP) as highlighted in Chapter 4.2. However, for highly urbanised and dense areas with the dwelling stock mainly consisting of multi-apartment blocks, it can be assumed that the uptake of EVs will be limited, therefore different sources for flexibility procurement need to be identified. On the other hand, considering an area with a mixture of multi-apartment blocks with and without EVs, those with EVs would be mainly responsible for the additional constraint on the grid due to the increasing load. If the resulting increased costs of balancing are to be equally distributed across end-users (as is the case today), then access to the benefits of providing flexibility should likewise be equally distributed across all end-users. Identifying a different source of flexibility could help to provide balancing services where EVs are not the main reason of constraints, and could provide opportunities for residents to participate in the flexibility market for those that cannot fall back on devices with demand side response (DSR) capacity.

The UEC project set out to test the provision of flexibility in constraint areas with little adoption of EVs and maximise utilisation of distributed generation. As discussed in Chapter 4.1 UK Power Networks currently uses a solution-agnostic procurement process, equally valuing any provision of flexibility. The goal of the project was to test how customers living in blocks of flats could access financial benefits from flexibility services and whether the virtual allocation of assets would contribute to a more inclusive flexibility provision.

5.2 UEC pilot design

To test flexibility services multi-apartment buildings could provide, a 10kW/20kWh battery by StorTera was installed on the roof of Elmore house and connected to the existing 37kW peak (kWp) PV array on the building's rooftop. During the UEC project the battery would be charged with excess PV energy and only discharged for flexibility services in agreed flexibility windows. A visual representation of the platform architecture can be seen in Figure 12.

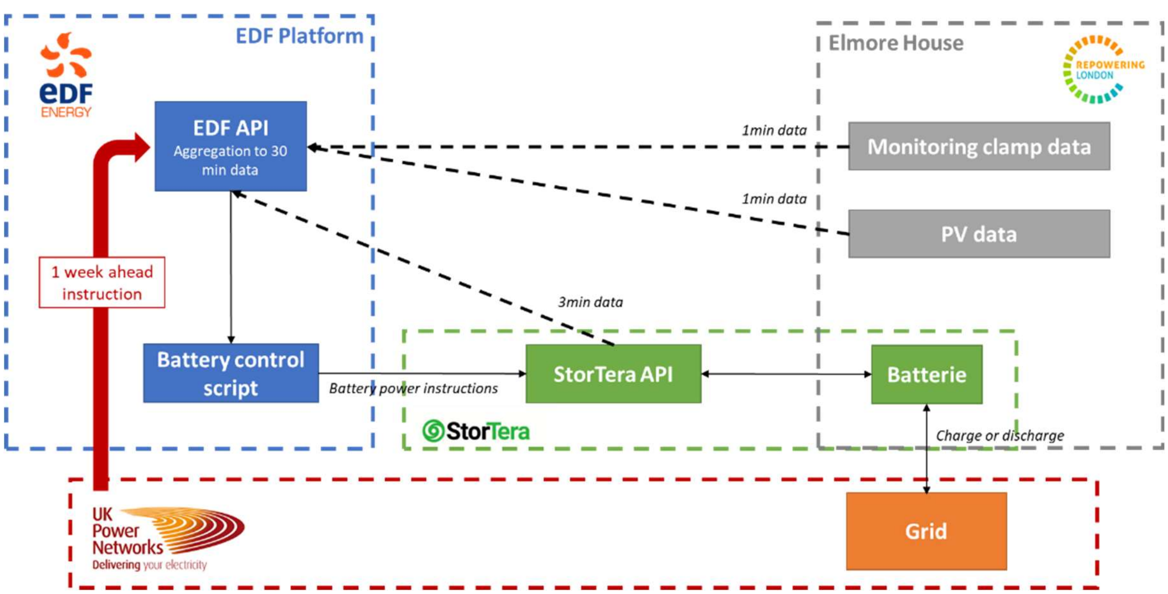

Figure 12: CommUNITY & UEC - External platform architecture (Source: EDF)

A battery control system was designed to receive signals from UKPN for a scheduled flexibility window. The flexibility windows were scheduled in advance by UKPN and shared with EDF. Two to three flexibility windows per week over two months were taken into consideration. Whether or not flexibility was provided was based on data from the previous week, which provided information on how many days it takes to charge the battery. The following charging timeline has been established prior to providing flexibility services and had a duration of two weeks (see Figure 13).

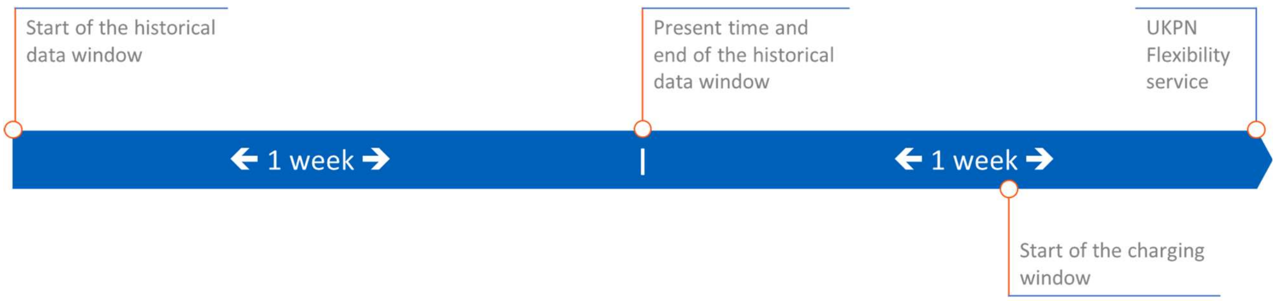

Figure 13: Battery charging timeline (Source: EDF)

One week prior to the flexibility window a request was sent out by UKPN. The battery charging and discharging was based on an optimization method whereby the arbitrage between the UKPN payment and the participants' cost opportunity was based on the previous week's weather and load profiles. Using charging data from the previous week under consideration of the current Status of Charge (SoC), a date was calculated for the second week when charging process would start. If a flexibility window was accepted the optimal time to start charging was calculated. As soon as the battery enters the charging phase no solar energy from the battery was allocated to the participants. For the battery to participate in a flexibility window the following criteria had to be present:

1. The battery needs to be fully charged at the beginning of the flexibility window
2. The flexibility service payment must be higher than predicted savings from charging the battery
3. The battery needs to discharge at almost full power (9kW) for at least 30 min and up to 2 hours.

To handle the flexibility windows a dataflow process has been established. The three actors involved in this process are UKPN, EDF and StorTera. First, EDF receives raw data from the StorTera API, which includes information on phase currents, voltages, SoC, and temperature. Second, an algorithm processes the data and converts it into variables to decide which control signals need to be sent to the battery. The battery can switch between normal behaviour, meaning providing solar energy to the participants in the market or to provide flexibility. UK Power Networks sets the flexibility window and settles with EDF after the service is provided. The success of the flexibility service delivered was evaluated against two success rates:

1. The minimum time of flexibility provided needs to be more than 30 min and take place in one of the dedicated flexibility windows, daytime (11:30-13:00) or evening (17:00-20:00).
2. Comparison between the actual energy provided and the expected/requested energy for a specific time period

Table 12 shows the flexibility windows scheduled by UKPN and their success rates. Due to a lack of time for the battery to recharge after the flexibility period some flexibility windows were not met. This issue has been resolved towards the second half of the project by reducing the number of flexibility windows per week from 3 to 2 or 1.

Table 12: Flexibility windows scheduled by UK Power Networks for UEC (Source: EDF)

Flexibility window number	Date	Time	Acceptance	Power (kW)	Agreed duration (h)	Success rate 1	Success rate 2
1	23-Feb	P.M.	YES	9	2	100%	63%
2	26-Feb	P.M.	YES	9	2	100%	84%
3	03-Mar	P.M.	YES	9	2	100%	68%
4	04-Mar	P.M.	NO	-	-	-	-
5	05-Mar	P.M.	YES	9	2	100%	58%
6	10-Mar	A.M.	YES	9	1.5	100%	82%
7	11-Mar	A.M.	NO	-	-	-	-
8	12-Mar	A.M.	YES	9	1.5	100%	94%
9	15-Mar	P.M.	YES	9	2	100%	88%
10	16-Mar	A.M.	NO	-	-	-	-
11	17-Mar	P.M.	YES	9	2	100%	97%
12	22-Mar	A.M.	YES	9	1.5	100%	100%
13	23-Mar	P.M.	NO	-	-	-	-
14	24-Mar	A.M.	YES	9	1.5	100%	76%
15	30-Mar	A.M.	YES	9	1.5	100%	76%
16	01-Apr	A.M.	YES	9	1.5	100%	97%
17	09-Apr	P.M.	YES	9	2	100%	82%
18	14-Apr	P.M.	YES	9	2	100%	85%
19	16-Apr	A.M.	YES	9	2	100%	50%
20	23-Apr	P.M.	YES	9	1.5	100%	74%
21	28-Apr	P.M.	YES	9	2	100%	70%
22	30-Apr	A.M.	YES	9	1.5	100%	88%

Nevertheless, the conclusion drawn by EDF is that using the battery to generate revenue from flexibility services exceeds participants' savings from self-consumption. With the battery providing two flexibility services on average per weak being the most feasible to constantly provide flexibility services while not delivering energy to participants (see Chapter 3.6 Figure 8).

Considerations

The timeframes in between the different flexibility windows are dependent on the status of charge (SoC) of the battery. Energy production in the summer months is higher than in the winter months, hence the time to achieve a full SoC is less than in the winter. A look at the generation data from the PV array in Elmore house shows, that 70% of the total energy is produced between March and September while 30% of the energy are produced in the months October till February (see Figure 14 and Figure 15), therefore more time in between the flexibility windows in the winter has to be taken into consideration compared to the summer.

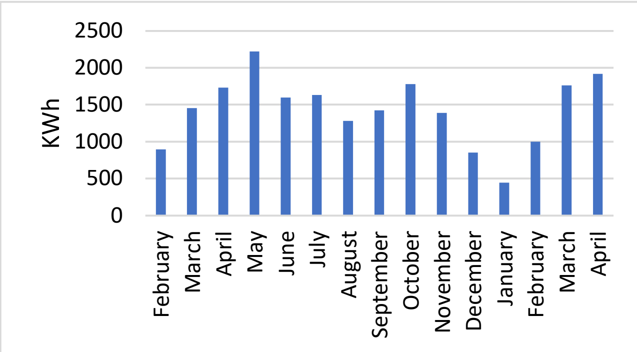

Figure 14: Cumulated generation (Source: EDF)

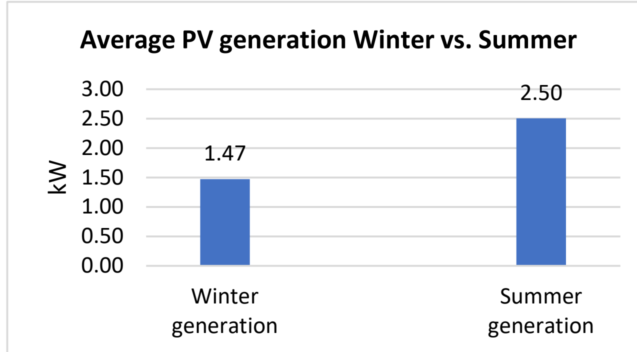

Figure 15: Average PV generation in Winter vs. Summer (Source: EDF)

5.3 **Methodology**

To assess the S&R potential of the UEC project, the goal of the analysis is twofold. Firstly, it is important to identify suitable sites or buildings near substations requiring flexibility services where the UEC project could be replicated. Those buildings should exhibit similar socio-technical characteristics to those of Elmore house. Secondly, it is necessary to understand the scale of flexibility those sites could provide. While the results of the analysis only provide a rough estimation of the S&R potential, they provide insights into the adjustments needed for future market uptake. The following datasets were used to provide a broad approximation of the S&R potential of the UEC project:

- The London Building Stock Model (LBSM)[vi] is a tool developed by the UCL Energy Institute to provide insights into energy efficiency of buildings across London. It contains detailed information on every building in London and whether or not they have PV installed[54];
- The Appendix 6[vii] (revenue ranges) from the UKPN Flexibility Services Tender Jan-21 providing detailed information on UKPN's LV-flexibility zones and the associated revenue ranges[52];
- The DG-Mapping tool[viii], an online platform provided by UKPN that provides approximate location for HV network poles and cables as well as LV-substations for London[55];

Scalability and replication were based on identifying buildings with similar characteristics to those of Elmore house - a multi-apartment social housing unit with PV roof-top space. While we did not find any data that could provide information on each of these three aspects, the LBSM database was used to extract information on low- to mid-rise buildings that met the following criteria:

1. Domestic and non-domestic occupancy (domestic occupancy dominant)
2. Pure domestic occupancy with 10 or more households
3. Pure domestic occupancy between 1 to 10 households

The building data used in our analysis is presented aggregating individual premises into "self-contained units" (SCUs). One building block can consist of multiple SCUs. Where this is the case, the data we have on each SCU in the same block has been aggregated, as all SCUs share the same rooftop of one block. To establish which blocks will be included in the replicability analysis of this study boundary conditions are set that define

[vi] https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/london-building-stock-model
[vii] https://smartgrid.ukpowernetworks.co.uk/wp-content/uploads/2020/11/Appendix-6-Revenue-Ranges_v1.0.xlsx
[viii] https://dgmap.ukpowernetworks.co.uk/site/?q=home

inclusion and exclusion parameters for each SCU. It is important to highlight that while UKPN operates the EPN, LPN and SPN areas, the LBSM represents data for the 33 boroughs in the Greater London Authority (GLA)[ix]. This limitation was acceptable as all constrained networks in the UKPN operation area lie within LPN - and most of the LPN overlaps with the GLA area.

To understand the replicability and scalability potential of the UEC project we mapped the LBSM data onto the UKPN constrained substations requiring 'sustain' flexibility, to assess the flexibility potential for each area using Lower Layer Super Output Area (LSOA)[x] codes.

While LSOA codes for the LBSM dataset were available, the LSOA codes for constrained LV substations for the Appendix 6 dataset had to be extracted manually by identifying substations postcodes using the DG-Mapping Tool. Out of the 59 substations purchasing flexibility services in 2020/2021, seven substations could not be identified in the DG-Mapping Tool or were lying outside the Greater London Authority Area and were therefore excluded in the analysis.

Defining Boundary conditions

The results are sensitive to the model parameters defined in the analysis. This is important, as useful business models of battery-based flexibility services may exist that lie outside the scope of this analysis. The aim of this analysis was to replicate the CommUNITY/UEC system configuration so that has set the parameters for this study. The study parameters are outlined below, a discussion of the limitations is found in section 5.5.

Modelling parameters were set to replicate the CommUNITY/UEC configuration. As highlighted in the flexibility procurement statement by UKPN[52] the minimum requirement to participate in the flexibility tender is to deliver a minimum power capacity of 10kW for at least 30 min. We assumed a power-to-energy ratio (P/E-ratio) of 0.5 producing a minimum battery energy capacity of 20kWh. This ratio is dependent on the technical specifications of each battery and varies across battery manufacturers. To determine a suitable battery size for a given PV-array size, the MSC Battery Standard[56] was used. Battery size is determined by the intended use and the size of the PV array. As shown in Figure 10, the CommUNITY/UEC battery use case was to maximise self-consumption between UKPN LV sustain constraint management calls.

While the MSC guidelines recommend sizing batteries for 730 battery charging cycles a year (two a day). As one of the assumptions of the CommUNITY/UEC project was that only energy from the 37 kWpPV array would be used, we changed this to one cycle per day or 365 cycles per year. This assumes the battery is charged from the PV during the day and discharged in the evening to meet self-consumption or sustain flexibility requirements through renewable energy. This assumes that under ideal conditions the battery would be fully charged and discharged once per day. was used, which assumes a best-case scenario, meaning the battery would be able to fully charge and discharge once a day. Other approximations to calculate a suitable PV battery system can be found in literature[57]. Various factors play and important role when designing the optimal system size. Amongst others the efficiency of the PV array, the combination of use-cases for the battery, purpose such as increase self-consumption, provide flexibility services or a combination of both, the load behaviour of the users or clients, the generation curve, etc.

[ix] https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/london-building-stock-model

[x] Super Output Areas were designed by ONS to improve the reporting of small area statistics. LSOAs are groups of 1000 – 4000 population. See www.ons.gov.uk for more detail.

5.4 **Results**

Figure 16 and Figure 17 show the overall potential of data extracted from the LBSM by kWh and kWp installation with 11% efficiency. As expected, most of the potential installation capacities fall within the smaller ranges, meaning that there are large numbers of smaller rooftops and smaller numbers of larger rooftops on which to install PVs.

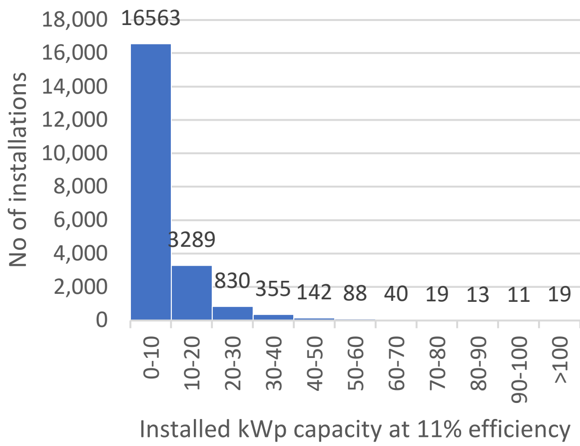

Figure 16: Estimated kWp of PV system for buildings with selected characteristics limited to GLA

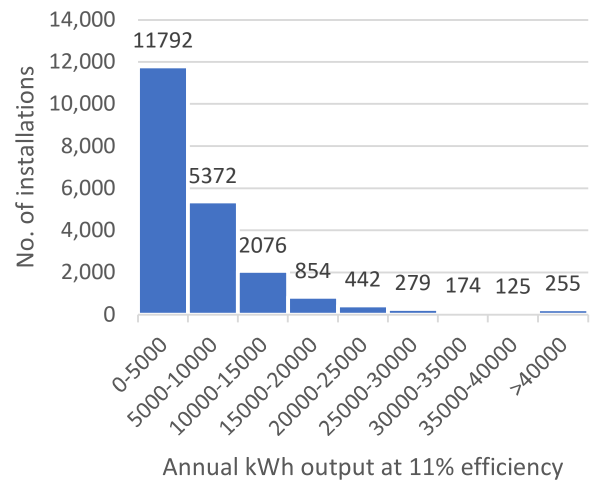

Figure 17: Estimated annual kWh PV output for buildings with selected characteristics limited to GLA

As highlighted above, UKPN publishes yearly updates on the procurement requirements of flexibility and provides information on the required and predicted flexibility demand for the years ahead on the flexibility hub website[xi]. Figure 18 show the flexibility requirements for LV-zones for the flexibility category ‘sustain’ in the UKPN operation area for the winter seasons of 2021/2022 for each substation. The energy requirement is calculated from the indicated power and the ‘indicative hours of utilisation’ per annum.

[xi] https://smartgrid.ukpowernetworks.co.uk/flexibility-hub/

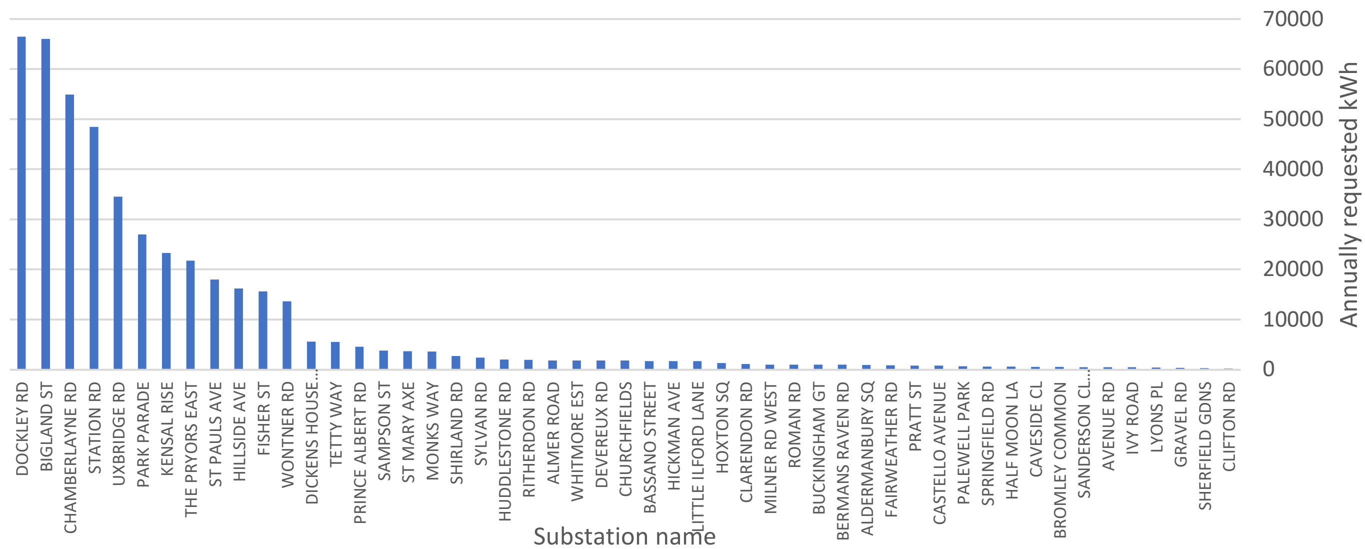

Figure 18: Flexibility demand per substation for LV-'Sustain' product (2021/2022)

Figure 18 shows that the flexibility demand varies significantly between substations, with the highest demand lying mainly within the London metropolitan area. Applying the parameters highlighted in the methods section we find that of the 52 constraint LV- substations, only 28 substations were identified with had suitable PV installation capacity potential (see Table 13). This means that around half (28) of the constrained substations could have all their ‘LV sustain’ flexibility capacity needs met from PV and battery combinations installed on between one and nine buildings near each substation that match the CommUNITY/UEC profile. Table 17 in Appendix 3 displays buildings that could deploy a battery power rating of more than 10kW. While in some cases due to the available capacity of the PV array battery sizes rise above current residential and commercial/industrial standards, these solely indicate that an installation of a battery above 10kW would be feasible without specifying the final installation capacity as this would depend on multiple factors such as the final PV array size, the main trading purpose, etc.

Table 13: Substations with requested energy and no of buildings with potential capacity

Substation name	Requested energy in kWh	No. of Buildings with flexibility capacity
AVENUE RD	450	3
BIGLAND ST	66000	2
CASTELLO AVENUE	750	2
CLARENDON RD	1100	2
CLIFTON RD	200	1
DEVONPORT	2250	1
DOCKLEY RD	66500	7
FAIRWEATHER RD	850	2
FISHER ST	15600	1
HICKMAN AVE	1700	1
HILLSIDE AVE	16150	1
HOXTON SQ	1300	9
HUDDLESTONE RD	2000	2
IVY ROAD	450	6
KENSAL RISE	23250	6
LITTLE ILFORD LANE	1700	2

LUXBOROUGH	250	2
PRATT ST	800	2
PRINCE ALBERT RD	4550	1
RITHERDON RD	1950	4
SANDERSON CL CARROL CL	450	1
SHIRLAND RD	2700	2
SPRINGFIELD RD	600	1
ST MARY AXE	3650	1
ST PAULS AVE	18000	3
STATION RD	48450	4
SYLVAN RD	2400	3
UXBRIDGE RD	34500	2

5.5 **Limitations**

The results of this analysis present a rough estimate of the S&R potential of UEC type projects however do provide insights into the adaptability of such flexibility procurement in the future. The analysis is subject to various limitations:

- The battery use-case determines the battery size which in turn determines the size of the PV array required which then determines the number of buildings with the necessary roof space. For LV sustain events (power provision of a specified level over a fixed duration), the frequency of events strongly determines the system size. Dropping the number of charge-discharge cycles from 360 (once per day) to 52 (once per week) significantly reduces the PV array size needed, but also eliminates the system's capacity to provide self-consumption.
- The approach used to map the flexibility requirements to the LBSM databased was based on the LSOA code. Although it is likely that a building located in the same LSOA as a substation could be connected to the substation, this is not guaranteed.
- The limitations and assumptions made in the LBSM data influence the validity of the model results. The model uses LiDAR data to measure distances and estimate the electricity generation potential. The developers of the model stress that while the model is based on the best available data and most realistic assumptions, prior site-specific studies need to be conducted to receive a realistic estimation of the installation potential[xii].
- Physical conditions of the roof for the PV installation, availability of space for the battery installation, metering infrastructure and others can impact the actual realistic installation potential.
- Insufficient information is available on the ownership of buildings, more specifically data on the ownership that can be combined with the datasets used in this model. Distinguishing between social and non-social housing units could allow better identification of realistic business opportunities.

5.6 **Discussion**

The UEC project aim was to assess the potential for obtaining flexibility from consumers without access to flexibility from EV fleets and heat pumps. This opens up access to flexibility markets, reducing redistributive disbenefits and potentially reducing inequities in future flexibility scenarios. The goal of this analysis was to assess the scalability and replicability potential of flexibility provides such as procured from the Elmore house

[xii] Details of the model can be found at: https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/london-solar-opportunity-map

as part of the CommUNITY and UEC project - i.e.: blocks of flats operated as social housing units with a solar PV array and a battery that can deliver the flexibility service as outlined in the UKPN LV-'Sustain' flexibility tender.

Making use of multiple datasets the analysis has shown that out of the 52 identifiable substations currently looking to procure LV sustain flexibility services, 28 would be near buildings broadly matching those in CommUNITY/UEC suitable for providing such services. While our results are only estimates, it shows clearly that the number and applicability of properties is strongly driven by the battery use-case. Where this use-case includes participating in LV sustain flexibility scheme, UK Power Networks has the capacity to alter the frequency of events, and this directly influences which properties can participate. The developed Pivot-Excel table as part of this analysis is attached into this report (see Appendix 2) and can be used for further intended scalability and replicability analysis. With the information provided and the inclusion of additional data such as the buildings' tenure further analysis can be conducted to identify the real installation potential for UKPN and energy community organisations.

While these results are not specific enough to provide detailed next steps for the development of future flexibility procurement options from social housing units, partly due to the necessarily limited scope of the CommUNITY pilot project and the simplifications necessary to implement UEC, they do highlight important factors that need to be taken into consideration for future pilot and trial studies to improve the informative value and lessons learned from such experiments as they will prove effective in accelerating the uptake of such flexibility solutions.

5.7 Financial modelling of network services from community-scale batteries integrated with solar PV

Repowering London have undertaken financial analysis to assess the commercial replicability of the physical typology used in the UEC project, i.e. a community-scale solar PV installation and battery, both connected at LV behind the same MPAN, and able to export electricity to the local distribution network. The P2P platform facilitated by EDF during the CommUNITY trial has not been included in the analysis as it is not yet commercially available.

The model assumes that no grid electricity is imported to charge the battery with 'grid' electricity, as although this is a technical possibility it would require additional commercial arrangements that are not typical for solar pv projects at this scale. The model also assumes that the electricity generated by the solar PV installation is sold through a 'flat rate' export PPA, and that the revenue arising is ringfenced for the financing of the solar PV installation and operating costs- and is not used to finance the battery. This means that the model is suitable for assessing the potential for retrofitting batteries to operational solar PV installations with pre-existing financing arrangement (as was the case for UEC).

The revenue streams considered for the battery financing are DUoS payments passed through to generators as 'embedded benefits' under export PPA contracts; and the payments for UK Power Networks' 'Sustain' flexibility product (which was used for the battery technical testing under UEC). 2021 values were used for the DUoS and Sustain payments. DUoS payments are volumetric (£/kWh), while the Sustain payments are based on capacity (£/kW). They provide distinct commercial services and can in principle be combined.

The battery operation would be optimised to maximise export during 'red band' DUoS periods, as well as Sustain delivery windows. The DUoS windows are fixed annually in advance through the DNO's Charging and Methodology Statement; the Sustain windows are notified one month ahead of dispatch. Using a 20kW solar PV installation and 10kW/20kWh battery, the model found combined annual revenues of £800-1200. Taking an average price of £650/kWh for batteries in this size range provides a simple payback of 12 years, which is longer than typical battery warranties of 10 years. Moving to a 6 year payback as the benchmark for viability would require a 50% reduction in battery installation costs, including labour.

These results suggest that LV flexibility services and DUoS payments are unlikely to be sufficient to drive the deployment of batteries at this scale under current battery market prices. On the revenue side, further research could consider the integration of other LV and HV flexibility services and national ancillary services; arbitrage of imported grid electricity; the value created by P2P trading arrangements for collective self-consumption; and additional financial incentives for flexibility services that provide increased social and environmental value.

Appendix 1: Review method

Our review approach employed systematic literature review methods to maximize the likelihood that relevant evidence is captured. The initial question for this review, in line with the scope of work, was: *According to existing evidence, have models of shared ownership and virtual assets increased participation in a more flexible energy system by excluded groups*? We interpret 'excluded groups' according to the categories identified by UK Power Networks: Low income, in energy poverty, not engaged in energy markets, living in blocks of flats. We interpret 'participation in a flexible energy system' in terms of consenting to a technology trial, or a supplier / community energy offer for a variable supply of low carbon energy from a shared or virtual asset. For example, participating in a smart local energy market, or a neighbourhood battery project.

In a less formalized way, we also used the review to collect evidence on a) the experience of participating, e.g., reported satisfaction, stated co-benefits, percentage of participants who recommend the project / offer; and b) any new forms of exclusion or inequalities. We expected a qualitative overview of such findings to allow insight into how the use of shared & virtual assets overcomes barriers to inclusion or redistributes benefits – while always being aware of the risks of bias inherent in such assessment (driven, for example, by selection bias in trial recruitment). The review process proceeded as follows.

Step 1: Search and screening

To identify findings on flexibility delivered through shared and virtual assets, we generated keywords for automated searches. The keywords are in three broad categories: those that refer to project type, those that refer to characteristics of excluded groups, and those that refer to building type. Table 14 shows the target words/phrases.

Table 14: Concepts and search terms we planned to use in conducting the search, with example search string for use in Scopus. Note: terms in grey were initially included but found to be too restrictive, so main searches were run using only the "project type" terms

	Project type	**Consumer group**	**Building type**
Concept	Virtual energy community Virtual micro grid Community energy storage Neighbourhood / community / communal battery Local energy market LV DSR	Fuel poor Low income Disengaged / hard to reach consumers	Multi-occupancy buildings Apartment block Block of flats (Social) housing estate
Search term	"virtual micro-grid" "virtual microgrid" "community battery" "community storage" "local energy"	"fuel poor" "poverty" "low income" "disengaged consumer*' "hard to reach consumer*" "hard-to-reach-consumer*"	"multi-occupancy" "multi occupancy" "apartment*" "housing estate"

Example search string
(TITLE-ABS-KEY (“virtual micro grid” OR ”virtual microgrid” OR “community battery” OR “community storage” OR “local energy”) AND TITLE-ABS-KEY ("fuel poor" OR "poverty" OR "low income" OR "disengaged consumer*" OR "hard to reach customer*" OR "hard-to-reach-customer*") AND TITLE-ABS-KEY ("multi-occupancy" OR "multi occupancy" OR "apartment*"))

The following bibliographic databases were then searched:

- Scopus
- Web of Science (all databases)

We also ran google searches based on the above search terms to find grey literature and project documentations. We engaged with UKPN, Repowering London and parties in the GO P2P network to elicit suggestions for other material to screen for inclusion. In particular

- Evidence from LCNF, NIA & NIC projects (if not yet online)
- Trials that have not involved a DNO (eg community energy projects, projects in the GOP2P network).
- Specific technology trials
- Counterfactuals (eg current types of assets being used to provide flex services to UKPN)
- Option to extend to DLC or ToU tarifs / broader flex offers? Tbc. Depending on amount of evidence on shared assets.

Bibliographic database searches were be recorded and are reported in Table 15.

Table 15: Results of the bibliographic database searches

Database	**String**	**Date**	**Hits**
Scopus 1	TITLE-ABS-KEY ("virtual micro-grid*" OR "virtual microgrid*" OR "community batter*" OR "community storage" OR "community microgrid*" OR "shar* batter*" OR "shar* photovoltaic*" OR "shar* der" OR "shar* pv" OR "shar* solar" OR "shar* distributed energy" OR "shar* decentrali* energy" OR "neighbo* batter*")	24/5/2021	493
Scopus 2	TITLE-ABS-KEY ("neighbo* energy") AND (LIMIT-TO (SUBJAREA , "ENER"))	24/5/2021	48
Web of Science 1	TS=("virtual micro-grid*" OR "virtual microgrid*" OR "community batter*" OR "community storage" OR "community microgrid*" OR "shar* batter*" OR "shar* photovoltaic*" OR "shar* der" OR "shar* pv" OR "shar* solar" OR "shar* distributed energy" OR "shar* decentrali* energy" OR "neighbo* batter*") Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.	25/5/2021	365
Web of Science 2	TS=("neighbo* energy") Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.	25/5/2021	184

Potential sources were saved to reference management software (Mendeley). Results were screened according to the criteria in Table 16. Screening was initially be conducted in parallel by two screeners until high levels of agreement are reached; subsequent screening was by a single screener. Screening and extraction were conducted in Microsoft Excel.

Table 16: Inclusion and exclusion criteria for attractiveness review screening.

Include if source	**Exclude if source**
Is in English	Is not in English
Reports findings from empirical research or evaluation.	Does not report empirical results (e.g., includes only modelled benefits).
Reports research designed to understand inclusion / participation, social benefits or distributional impacts of relevant types of projects and flexibility offers (ie shared or virtual assets) in a residential context.	Does not report research on participation, social benefits or distributional impacts (for example, focuses only on technical design and operation).
Reports on research relevant to task 2a (TBC)	
Reports on network benefits	
Is focused on the domestic sector or community buildings	Is focused on the non-domestic sector industrial sector without shared ownership
Access to shared assets	Individual prosumer assets only (NB Following pilot searches and discussion with UKPN, we decided not to exclude on this criterion in cases that dealt with households in potentially vulnerable situations).

The list of final documents for inclusion was reviewed following screening. If we or our partners (UKPN, Repowering) were aware of any publications which are not present and which we believe should be, we checked if they were included in the original review and if not, passed them through screening as above.

<u>Step 2: Extraction</u>

All **primary empirical** sources included following screening were coded for the following key characteristics:

- geographical location of study
- date of deployment
- type of study
- type(s) of technology / LV DSR offers tested
- organization(s) administering the study
- organization(s) offering (or framed as offering) the virtual / shared assets or flex offer
- characteristics of group / consumers receiving the offer / intervention
    - Income level
    - Fuel poverty status
    - Level of engagement with energy market
    - Other protected characteristics e.g., ethnicity, health, disability?
- type(s) of outcome(s) measured by the intervention
- reported outcome(s), key interpretations and main conclusions

Extraction was conducted by a single reviewer and the extracted information reviewed by project team members for quality assurance.

Step 3: Synthesis

A summary table was compiled showing outcome measures relating to participation by different groups to different types of virtual/shared assets or local flex offers. There were few examples of real-world projects similar in most important respects to UEC; that is to say, focusing on access to shared DERs in urban social housing blocks to provide flexibility. However, more trials have been done that are similar in some important respects. For example, that focus on individual access to DERs in a social housing context, or on access to shared DERs not in social housing. While these differences are potentially important for how the findings of such trials might apply to UEC-like projects, we were still able to draw applicable insight from them by using a “realist synthesis” approach.

Realist approaches focus not just on the outcome of an activity (such as a form of societal benefit), but how that outcome is thought to have come about (the mechanism), and what it was about the particular context that meant that mechanism led to that outcome. As an illustrative example, a social media campaign (activity) might succeed in getting high turnout at an engagement event (outcome) by promoting electronic word of mouth through repeated sharing (mechanism), when many of the intended attendees have access to the relevant social media sites, are in each other’s networks, and live nearby (context). If the context were different and access to social media was low, the electronic word of mouth mechanism would be less likely to work, changing the outcome (such as how many and which people attend the event). The approach lets us answer the question “what works, for whom, in what circumstances, how?”. Importantly for this report, it also provided us with a way of thinking about how transferable evidence is likely to be from one context to another.

An important part of the realist approach is the development of a provisional description of the kinds of outcomes, mechanisms and contexts you expect to be relevant. This is based on prior knowledge, pre-reading, and discussion, and is sometimes known as a “programme theory”. It is helpful because once this has been done, it allows you to decide where to look for evidence of comparable mechanisms, if such evidence is lacking in your direct area of interest. Figure 19 shows the initial programme theory that we constructed for a shared battery scheme. In discussion with UKPN, we identified a number of main outcomes of interest (indicated by blue notes): how access to a shared battery might be thought to lead to bill savings for participants, broader/deeper engagement with energy in general, and network cost savings.

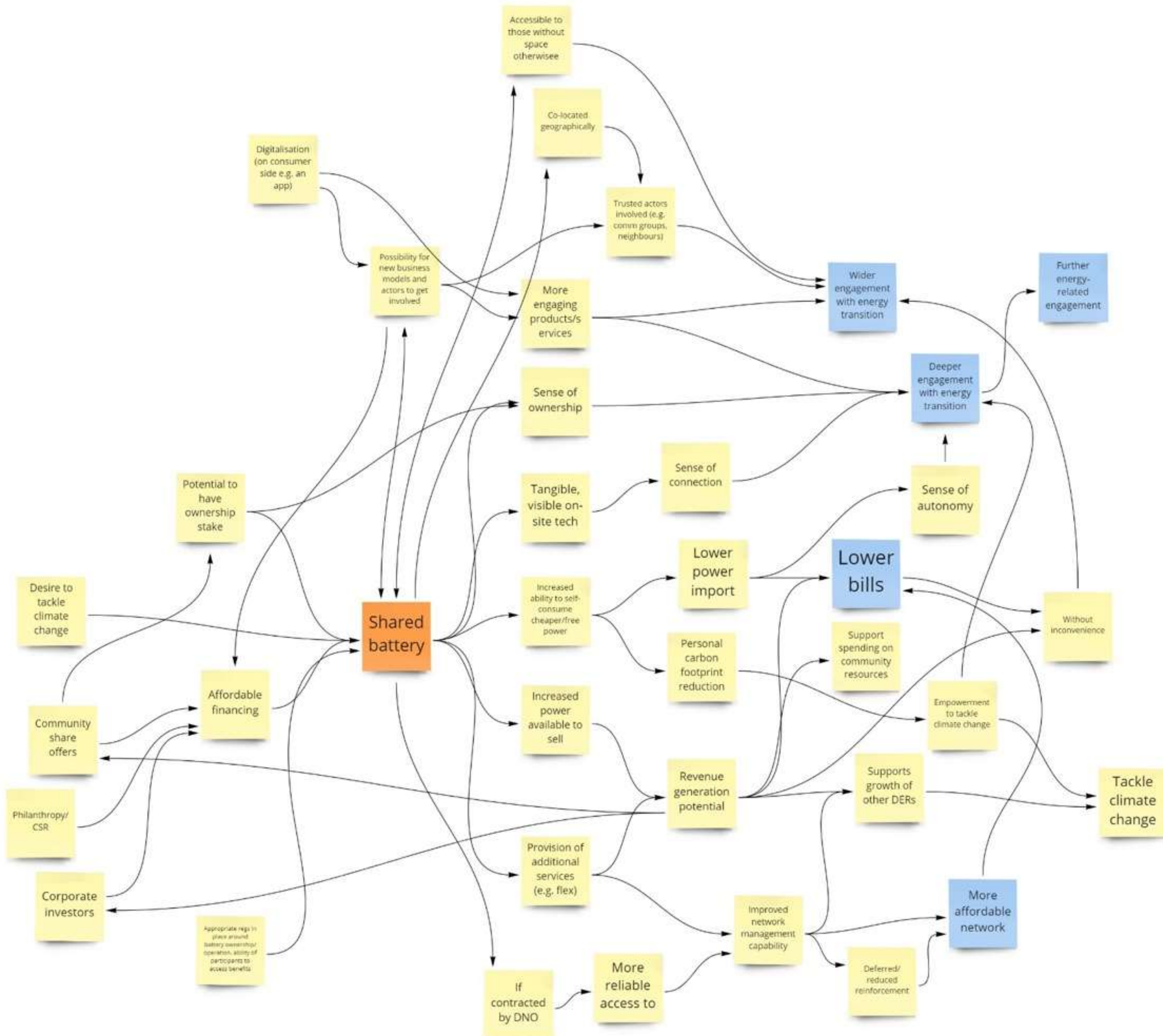

Figure 19 Programme theory used for the evidence review

Our initial review work identified very few trials that contained all the elements we were looking for; that is, access to shared DERs, in the context of urban social housing blocks, in comparable European locations. We therefore expanded our search to include trials that included some of these elements, such as access to shared DERs of any kind in the UK, or individual DERs in social housing contexts, and in any country. Given this broadened scope we did not attempt to comprehensively identify all such trials, but to include enough to look for consistency in context, mechanism and outcomes relationships. We extracted information on key contextual points, mechanisms, and outcomes into an Excel spreadsheet and used this to inform narrative syntheses for each of the key outcomes of interest.

Appendix 2: UK Power Network substation flexibility requirements & buildings with capacity to host a 10kW battery

Table 17: Estimation of Buildings able to provide a minimum power capacity of 10kW located in close geographical proximity to the substations

Station name	Requested energy in kWh	Available capacity in kWp (η=11%)	Sum of available energy in kWh (η=11%)	Approximated battery capacity in kWh	Approximated power rating of battery in kW
		18,68	16659,67	45,64	22,82
AVENUE RD	450	19,01	15851,03	43,43	21,71
		8,91	7946,91	21,77	10,89
		17,47	15976,89	43,77	21,89
BIGLAND ST	66000	58,87	51938,81	142,30	71,15
		10,57	9344,99	25,60	12,80
CASTELLO AVENUE	750	12,91	11886,04	32,56	16,28
		10,96	9118,63	24,98	12,49
CLARENDON RD	1100	14,89	13473,45	36,91	18,46
CLIFTON RD	200	20,17	19146,19	52,46	26,23
DEVONPORT	2250	15,18	13630,69	37,34	18,67
		12,78	11574,24	31,71	15,86
		13,26	12286,41	33,66	16,83
		14,53	12884,91	35,30	17,65
		38,16	39798,31	109,04	54,52
		52,76	53120,32	145,54	72,77
		80,81	72196,71	197,80	98,90
DOCKLEY RD	66500	153,17	156565,76	428,95	214,47
		9,42	8507,45	23,31	11,65
FAIRWEATHER RD	850	9,52	8839,59	24,22	12,11
FISHER ST	15600	9,80	8216,65	22,51	11,26
HICKMAN AVE	1700	12,04	9971,09	27,32	13,66
HILLSIDE AVE	16150	8,51	8278,13	22,68	11,34
		11,19	10806,90	29,61	14,80
		12,93	10618,84	29,09	14,55
		16,71	14859,75	40,71	20,36
		17,40	16211,19	44,41	22,21
		19,33	17143,01	46,97	23,48
		22,28	19223,73	52,67	26,33
		22,48	21256,06	58,24	29,12
		54,72	47183,51	129,27	64,63
HOXTON SQ	1300	56,27	49255,20	134,95	67,47
		18,40	16293,16	44,64	22,32
HUDDLESTONE RD	2000	26,84	23855,57	65,36	32,68
		10,43	9588,52	26,27	13,13
		11,10	9753,24	26,72	13,36
		12,53	11626,09	31,85	15,93
		14,24	11693,48	32,04	16,02
		21,98	20470,82	56,08	28,04
IVY ROAD	450	121,79	111477,85	305,42	152,71
		8,31	7768,75	21,28	10,64
		9,51	8958,14	24,54	12,27
		9,68	9252,21	25,35	12,67
		14,07	13344,92	36,56	18,28
		15,00	13757,20	37,69	18,85
KENSAL RISE	23250	20,22	17851,53	48,91	24,45
		9,95	8779,51	24,05	12,03
LITTLE ILFORD LANE	1700	11,11	9624,60	26,37	13,18
LUXBOROUGH	250	23,15	19409,02	53,18	26,59

		23,92	20300,64	55,62	27,81
		10,36	9049,55	24,79	12,40
PRATT ST	800	20,41	18432,78	50,50	25,25
PRINCE ALBERT RD	4550	8,94	8143,28	22,31	11,16
		7,77	7324,30	20,07	10,03
		11,69	10709,16	29,34	14,67
		23,73	21238,88	58,19	29,09
RITHERDON RD	1950	33,37	30286,43	82,98	41,49
SANDERSON CL CARROL CL	450	16,43	14968,61	41,01	20,50
		11,08	10206,25	27,96	13,98
SHIRLAND RD	2700	11,42	10965,13	30,04	15,02
SPRINGFIELD RD	600	13,21	11349,85	31,10	15,55
ST MARY AXE	3650	12,72	10882,71	29,82	14,91
		10,77	9789,04	26,82	13,41
		21,66	19226,78	52,68	26,34
ST PAULS AVE	18000	25,79	23328,33	63,91	31,96
		9,93	8500,81	23,29	11,64
		11,56	10783,61	29,54	14,77
		13,57	12218,60	33,48	16,74
STATION RD	48450	25,25	23834,60	65,30	32,65
		10,53	9784,96	26,81	13,40
		20,23	17849,41	48,90	24,45
SYLVAN RD	2400	24,27	21738,30	59,56	29,78
		8,35	7362,91	20,17	10,09
UXBRIDGE RD	34500	10,24	9630,00	26,38	13,19

Appendix 3: Survey for participants at Installation

Participant ID number_______________

Installation visit – participant survey

Thank you for agreeing to take part in CommuNITY. This survey has some questions about you, your home, others in your household and your energy use. The CommUNITY representative will fill this in with you. It should take about 10 minutes.

About your home & household

1.	When did you move into this flat roughly?	
2.	Do you have any of these electric appliances?	☐ Electric shower ☐ Dishwasher ☐ Electric hob ☐ Washing machine ☐ Electric oven ☐ Tumble dryer ☐ Electric heaters
3.	How many people live in your home?	
4.	On weekdays are you and your household?	☐ Mainly in during the day ☐ Mainly out during the day ☐ Sometimes in or out during the day
5.	Do you rent or own your home?	☐ We rent from Lambeth / Housing Association ☐ We rent privately ☐ We own our home outright (RTB Y/N) ☐ We own our home with a mortgage (RTB Y/N)
6.	What is your age?	☐18 to 24 ☐60 to 80 ☐25 to 39 ☐80 plus ☐40 to 59

About managing your energy costs at home

7.	Are you the person who normally pays the electricity bill / tops up the electricity meter?	☐ Yes ☐ No
7a.	If no, who is:	
8	Is there anything you do at home to reduce how much you spend on electricity?	☐ Yes ☐ No ☐ Not sure

8a.	If yes, what kind of things do you do?	
9	How often do you or anyone in your household compare and / or switch energy tariffs and suppliers?	☐ Never ☐ This was the first time ☐ Rarely (over 5 years) ☐ Occasionaly (every 3 – 5 years) ☐ Often (every 2 years or more often)
10.	What is your household's income (before tax)?	☐ < 10k ☐ £41-50k ☐ £11-20k ☐ £51-60k ☐ £21-30k ☐ >£60k ☐ £31-40k

About you & your community

11.	Are you involved in any local community groups?	☐ Yes ☐ No
12.	If yes, which ones?	
13.	Did you know about the solar panels on Elmore house before we spoke to you about CommUNITY?	☐ Yes ☐ No
14.	If yes, have you or your household been involved in the project in any of these ways?	☐ Invested in the solar panels ☐ Used or helped with the Community fund ☐ Contacted Repowering London for energy advice ☐ Contacted Repowering London about training ☐ Other (please specify ____________________ ____)
15.	Are you	☐ Female ☐ Male ☐ Prefer not to say
16.	What is your ethnic group? (Provide government list of 18 groups)	

About CommUNITY

17.	Has the CommUNITY project been clearly explained to you?	☐ Yes ☐ No
18.	Why do you want to take part in it? (If you have more than one reason please rank them 1,2,3,4)	☐ Use renewable electricity ☐ Save money on electricity costs ☐ Buy local electricity ☐ Support my estate ☐ Try out new technology ☐ Receive vouchers ☐ Not sure
19.	Are there any other reasons you want to take part?	
20.	Do you have any concerns?	
21.	Do you want Repowering London to send you any published results and reports?	☐ Yes ☐ No
22.	Do you want your real name to be used in any publications using my data?	☐ Yes ☐ No

Setting preferences

CommUNITY rep to take notes on conversation with participant

Ease of use:
Note down any issues or questions
Setting preferences:
What decisions do people make and why?
Understanding energy consumption:
Are people interested in getting neighbours involved? Any awareness that the more people who join, the less they'll earn? Any interest in how to maximise own gain through Demand shifting etc.

Any other points?

UK government list of ethnic groups (USE THIS SO SEPERATELY MARK RESPONSE)

White	
1	English / Welsh / Scottish / Northern Irish / British
2	Irish
3	Gypsy or Irish Traveller
4	Any other White background
Mixed / Multiple ethnic groups	
5	White and Black Caribbean
6	White and Black African
7	White and Asian
8	Any other Mixed / Multiple ethnic background
Asian / Asian British	
9	Indian
10	Pakistani
11	Bangladeshi
12	Chinese
13	Any other Asian background
Black / African / Caribbean / Black British	
14	African
15	Caribbean
16	Any other Black / African / Caribbean background
Other ethnic group	
17	Arab
18	Any other ethnic group

Appendix 4: Interview proforma for participants - Final Feedback

- **Motivation to sign up**, *expectations and did the project deliver on them?*

Can I start at the beginning, what was it about the project that interested you? Why did you decide to sign up?

Have you had any major changes to your home and routines?

How many people are living at home [incl. age and gender], has this changed?

Has covid affected how much time you & your household spend at home? Any big new appliances?

- **Installation process and kit:** [find out / confirm meter type & bill payment method]

Back last February we came to install a clamp and a router. Have these worked ok? Any problems or concerns with having this kit in your home?

Can I check what type of meter you have?

- **Credits**

Were you able to receive the credits ok?

Do you know roughly how much credit you got? [*prompt on whether they felt this was a lot / appropriate / not much]*

Did you notice it varying month to month [*prompt on why – e.g., sunny weather, arrival of battery, change of tariff*].

- **Experience of app**:

We also downloaded an app onto your phone. How did you find the app? Roughly how often did you use it during the project?

Did you decide to share or sell your surplus at the start? Did you then change? [*prompt on how they interpret the share, sell options, why they picked them, when they changed them*]

Who did you decide to share or sell to? [*prompt on community vs. door number, do you know the other flts in the project?].*

Did anyone else in the family help you use the app or use it themselves? Was your family interested in the app? Would anyone else have liked to have it?

Do you still have it on your phone? [prompt to open app] Can you show me the bits you found most interesting or useful?

How do you understand these charts / options / visualisations?

- **Experience of the project**: *did they feel well supported by Repowering London and/ or EDF?*

Did you receive the monthly statements about your credits? Was there anything that you found interesting or surprising? Expected or unexpected?

Did you get texts about the credits?

Did you get any other bits of information? [eg covid letter, battery letter, tariff switch] *Did they notice the battery installation?*

Did you change tariff?

Did you know where to turn if you had questions? And did you have questions? How well were they sorted out? *did you feel you could get support from Repowering London and/ or EDF?*

Now I'd like to discuss broader project outcomes:

- **Overall positives or negatives**

It would be great if you could tell me what the project meant to you and your household.

- What was the best / worst thing about the project?
- Would you want it to continue?
- Would you recommend this project to friends and family?
- What do you wish you'd known at the start / recruitment?

- **Energy salience** and sense of control over household use and associated costs.

Do you think the project has changed how you think about energy? [prompt how so?]

- Did participating lead to any changes in household's electricity use and / or tariff?
- Any increase in understanding of renewable energy use & role of storage?
- Any change in use corelated to weather (i.e., try to do more when it's sunnier).

- **Contribution to community**:

Do you think the project has changed how you think about the building, neighbours or your community?

- did participating give a sense of contributing to the local community?
- At the start no one knew the door numbers, did this change?
- Any conversations with neighbours or friends and family about the project, the app, the savings.

- **Energy justice & inclusive transition**:

Do you think the project has changed how you think about your energy company and / or Repowering? Or energy companies more generally?

- Did it make you think about green / renewable energy?
- Would you go to Repowering London in future either for their?
- Would you like more local energy options? Provided by whom?
- Would you switch suppliers? Or want to stay with EDF?

- Any more understanding of & confidence in switching?
- Any more interest in community energy/ BES1 / Repowering London now?
- Any change in perspective about their supplier / EDF?

Did you have your own questions and concerns – did you know where to turn to?

Who would you go to for support on the project, and energy more generally?

At the start you said you were interested in the project because of xxx. Do you feel you got what you expected from the project?

Last question: Anything you'd have done differently or want us to improve on?

- improvements of app / project / p2p trading / local use of renewable energy

Appendix 5: Interview proforma for Community Champion – Trial recruitment

This is the first interview which is about recruitment. The point is to understand:

- What people think of the project and why they say yes or no
- How your own knowledge of the area is being used
- Feedback on content of survey

Content

1) Own relationship to the neighbourhood and Repowering London
2) Strategy for recruitment
3) Experiences of recruitment
4) Own perceptions of the trial and what it offers to the residents of Elmore house
5) Review draft survey

Own relationship to the neighbourhood and Repowering London.

- Can you start by telling me about Elmore House – is it a place that you know well?
- When did you hear about repowering? And what made you get involved?
- When did you hear about CommUNITY and what made you get involved?

Strategy for recruitment

- What was your first approach?
- Any particular knowledge or contacts that you are drawing on to open doors?
- How have your organised your time? How have things changed?
- When does Fran support you?

Experiences of recruitment (reflect on social identity – ei gender, ethnicity, tenure, life stage)

- Who is saying yes? Can you talk me through the process of getting the 11 EOIs
- Who is signing up? Can you talk me through the process of getting the first T&Cs signed?
- Who is saying no? Can you talk me through the first withdrawal?
- In general, What interests residents about CommUNITY?
- What will encourage residents to sign up?
- What do residents want from p2p energy?
- What prevents residents from signing up or causes them to drop out?

own perceptions of the trial and what it offers to the residents of Elmore house

- What interested you in this role?
- What do you see as the point of the project?
- What would a successful outcome be from your perspective?

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