

## Article

# Post-Subsidy Solar PV Business Models to Tackle Fuel Poverty in Multi-Occupancy Social Housing

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**Abstract:** UK Feed-in Tariffs created a vibrant business ecosystem for the deployment of decentralised renewable energy technologies while constituting a regressive tax and increasing inequality. Business model innovation spurred by their withdrawal is providing valuable lessons for progressive policy design. Using the case study of solar PV deployment on multi-occupancy social housing, this paper reveals policy, business and organisational challenges that need to be overcome to address fuel poverty and reduce inequality. Suitable ‘export’ and ‘local’ business models were identified through a workshop and subsequently evaluated through qualitative thematic interview analysis. The ‘local’ model compares favourably in terms of production costs and benefits for fuel poor tenants but unfavourably in terms of transaction costs. Both models are considered equally susceptible to changes in policy. Their success hinges upon third party intermediaries, peer-to-peer learning and a supportive policy environment. This paper concludes with a policy recommendation to ensure that energy justice lies at the heart of the UK’s transition to net-zero carbon through the fair distribution of costs and benefits by including specific provisions to protect low-income groups.

**Keywords:** social housing; solar PV; feed-in tariff; community energy; multi-occupancy buildings; fuel poverty; energy justice

## 1. Introduction

Fuel poverty has been identified as a serious energy justice problem in the UK, affecting 11.1% of households in 2016 [1]. Fuel poor households have fuel costs above the national median level, leaving them with a residual income below the official poverty line [2].

Domestic solar photovoltaic (PV) systems can reduce energy bills and create income for fuel poor households through the generation, consumption and export of renewable energy (RE). The UK government has supported growth in the PV sector, most notably through the Feed-in Tariff (FIT). Through the Urban and Rural Community Energy Funds (UCEF/RCEF) and tax reliefs for RE projects, the government has also facilitated the emergence of a vibrant community energy ecosystem [3]. By deploying solar PV systems at the community and household levels, community energy organisations contribute to local decarbonisation and fuel poverty alleviation efforts.

However, many of these incentives have recently been scaled back, increasing financial risk for PV projects [4]. This has complicated the already difficult task of enabling low-income and fuel poor consumers to access the benefits of RE [5]. Supporting policies such as the FIT have also been criticised for failing to provide a fair distribution of benefits to less wealthy socioeconomic groups [6]. As the

FIT is financed through electricity bills and fuel poor households spend a disproportionately large share of their income on energy, the levies that pay for it arguably constitute a regressive tax.

Many low-income families live in social housing, where the prevalence of fuel poverty is higher than average, at 17% [7]. Accessing the benefits of PV is even more difficult under these conditions, as the decision to install panels usually lies with the social landlord (local authority/housing association) and a variety of technical, institutional and financial challenges may dissuade them [8], especially when dealing with multi-occupancy buildings, where legal and organisational difficulties can impede the introduction of PV [9].

However, technological advances and falling costs for PV, the development of supporting technologies, such as smart meters and battery storage, and the growing supportive network of community energy (CE) organisations provide new opportunities for supplying and sharing PV electricity in multi-occupancy buildings [10]. A key enabling factor is the emergence of innovative business models and financing mechanisms for subsidy-free PV projects. This research investigates and compares these emerging models and their capacity to tackle fuel poverty in multi-occupancy social housing schemes.

The key research questions are:

1. Which business models are viable for new PV installations on existing UK multi-occupancy social housing schemes in a post-subsidy environment?
2. Of the models identified, how do they compare in terms of financial viability, transaction costs, benefits to fuel poor tenants and susceptibility to future policy/regulatory changes?
3. How can social landlords effectively implement projects and how can energy policy support this?

This paper is structured as follows: Section 2 introduces the background literature. Section 3 describes the methods used to analyse the data, the results of which are presented in Section 4. Section 5 discusses these results with regards to policy implications.

## 2. Background

Fuel poverty has a range of social, economic and environmental causes, including high energy prices, under-occupancy of homes and low incomes [11,12]. Old, poorly-maintained and energy-inefficient homes are also responsible; the UK has the least efficient housing stock in Europe [13].

As RE technologies become more affordable and efficient, their potential to tackle fuel poverty by reducing energy bills is becoming more apparent [14,15]. PV is well-suited for domestic use and there have been significant advances in system productivity and durability. Installation costs have also dropped considerably due to economies of scale, technological/manufacturing improvements and increased availability of skilled installers [16].

### 2.1. Policy Context and Community Energy

Policies either explicitly or indirectly alleviating UK fuel poverty are mostly concerned with energy demand. These include grants for vulnerable households (Winter Fuel Payment and Warm Home Discount) and for energy efficiency improvements via the Energy Company Obligation (ECO) scheme, the enforcement of minimum energy efficiency standards for privately rented homes, and targets for social housing [8,17,18]. However, their direct impact on fuel poverty is poorly understood due the lack of systematic ways to value multiple benefits in policy evaluations [19]. At the same time there is a widespread absence of clarity, guidance and support regarding social housing [20,21].

The role of energy supply in addressing fuel poverty is less well understood. The FIT was introduced in 2010 to promote the uptake of low-carbon electricity generation, by requiring energy suppliers to pay an export and generation tariff to customers with eligible RE installations. The FIT was intended to stimulate an immature RE market and tariff rates consequently declined systematically [22]. However, the FIT was widely considered regressive as it was funded through charges on consumer energy bills but was only accessible to those wealthy enough to afford RE installations [6,22–24]. Of the

£6.5bn raised through policy costs applied to household energy bills (such as the FIT) in 2016, only 17% of the funds were used to support low-income households [25]. The FIT has been replaced by the Smart Export Guarantee (SEG), a scheme requiring large energy suppliers to offer payments to customers who export electricity to the grid, although rates are often variable or very low compared with the FIT [26].

Other UK policies supporting RE have specifically targeted CE projects, in which local communities play an active part in control and/or ownership of supply assets and in reducing fuel poverty [4]. The UK's 2014 Community Energy Strategy aimed for one million homes to be powered by CE generation schemes by 2020 and referred to potential integration with social housing [14]. However, this was scrapped in 2018, at only 6.7% progress towards the target [27]. The UCEF has also been discontinued and RE projects can no longer access 30% tax relief through the Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS). These incentives helped de-risk CE projects and encouraged investment by providing financial support at the early development stages [3]. In the absence of a supportive policy environment, business model innovation plays an increasingly important role in creating new routes to market for sustainable energy supply solutions that help address fuel poverty, especially regarding multi-occupancy buildings.

## 2.2. PV on Social Housing and Multi-Occupancy Buildings

Table 1 provides an overview of common drivers, barriers and opportunities for the uptake of solar PV by social landlords.

**Table 1.** Common drivers, barriers and opportunities for the uptake of solar PV by social landlords.

Drivers	Barriers	Opportunities
Reducing tenants' fuel bills [7,28].	Transaction costs: administering projects, training staff, engaging tenants, establishing relationships with local installers [29,30].	Addressing fuel poverty: social rented sector contains more vulnerable groups than other tenures and 46% of tenants are in the lowest income quintile [31].
Generating FIT income [7,32].	Uncertainty of subsidies, particularly concerning large projects with long lead times [7,8,15].	Innovative financing, raising capital through crowd-funding or shared ownership with intermediaries such as CE groups [14,15,33].
Positive publicity for social landlord [15].	Difficulty of quantifying social and environmental benefits [34].	Improving relationship between tenants and landlord [15].
Improving property Energy Performance Certificates (EPCs) [7,8,35].	Financial risk and difficulty in raising capital [32,36].	Improving living standards and comfort for tenants [7,37].
Reducing carbon emissions [7,35,38,39].	High perceived risk and complexity, lack of success stories [15,40].	Economies of scale: potential for large-scale projects across multiple housing schemes with substantial roof spaces [14,41].
Meeting local planning regulations [20,39].	Ongoing maintenance costs [36,40].	Untapped potential: PV is predominantly found in affluent areas [5,42].

Although there is a large body of literature on the uptake of solar PV by social landlords (see Table 1), relatively few studies or policies highlight the potential supporting intermediary role of CE organisations [14]. Specific issues related to PV projects on multi-occupancy buildings are also not well-studied [9], even though 20% of UK homes are apartments [31].

Multi-occupancy buildings often have complex governance/management structures, which can hinder PV projects. For example, some buildings may have a mixture of social tenants and leaseholders, creating legal issues around co-ownership of the building and often necessitating lengthy consultations with several different parties to approve new installations [43,44].

Another problem is the difficulty of distributing the benefits of a PV installation equally amongst occupants. There are legal and regulatory issues with distributing electricity from a single array

between individually-metered apartments [24,45]. Transferring power from a building-mounted PV system to an apartment inside may incur network charges [9], and there are additional difficulties in allocating free electricity produced by the array between occupants with different usage patterns [43].

### 3. Methodology

A literature review helped identify existing and potential post-subsidy PV project models. As the FIT closed in April 2019 for the general public, and in April 2020 for CE, there were limited resources available that directly related to the new policy landscape, and quantitative analyses of new models were lacking. Therefore, transcript data from a workshop was studied to provide a longitudinal angle to the evolution of business models.

The workshop titled ‘Regulating the Energy Sector: towards Peer-to-Peer Energy?’, involving 30 participants, was held on 13 July 2018 at the University of Bristol. It reviewed the key legislative and regulatory decisions that shape the current energy system in the UK and explored changes necessary to foster growth and stability of peer-to-peer (P2P) trading. In recorded breakout sessions, the workshop attendees discussed the following scenarios: a P2P trading scenario where a large proportion of households and community groups have RE-based generation capacity; a services scenario where businesses and community groups consider providing energy services directly, instead of selling only energy to consumers; a blockchain trading scenario where energy trading takes place on RE trading platforms; and a third party control scenario where control over energy supply and service delivery is ceded to organisations such as price comparison sites, trading platforms or energy service companies.

The attendees, with a background in community energy, innovative business models, decentralised supply, energy policy and technology discussed various current and potential future tensions between, and complementarities among, business models, social and environmental objectives, and policy and regulation. In total, over 10 h of semi-structured qualitative research data was gathered. This data was transcribed and evaluated by clustering data around key topics. Relevant to this research were the key topics of ‘poverty’, ‘business models’, ‘PPA’ (power purchase agreement), ‘contract’ and ‘benefit’.

Workshop data helped identify two emerging supply business models (‘local’ and ‘export’) which promise to deliver social and environmental objectives within the current policy and regulatory environment. The initial frameworks were based on models discussed by workshop participants, with supporting ideas from literature [45,46]. The models were adapted for a multi-occupancy social housing scenario, using findings from other literature, preliminary discussions with industry experts and one of the authors’ prior experiences from working in the sustainability division of a housing association.

Interviews and workshop proceedings were chosen as the primary qualitative data sources due to the transitional state of the UK’s RE sector brought about by FIT termination. In the absence of quantitative data, analysing insights from industry experts presented the most effective method of answering the key research questions [47].

Interviews were arranged by contacting experts in England, including representatives from CE organisations, local authorities, housing associations and energy suppliers (see Table 2). These contacts were found by searching online for organisations involved in PV projects on social housing or were recommended by other interviewees; three contacts (WR, RM and JC) were also former colleagues of one of the authors.

Interviews lasted approximately 40–60 min and were semi-structured (see Box 1), to avoid pigeon-holing participants and to give them flexibility to expand on certain topics [48]. Interview recordings, transcripts and analysis outputs were kept on a password-protected cloud storage account and deleted on completion of the research. Every interviewee was sent their interview transcript by email and given the opportunity to ask questions and request anonymity.

**Table 2.** Interviewee list.

Interviewee Initials	Job Title	Organisation	Organisation Type
AE	ERDF Project Manager	Bioregional	Environmental consultancy
AF	Resilience Manager	Frome Town Council	Local authority
AN	Project management role	Anonymous	CE organisation
CN	Director	Community Energy South	CE organisation
DT	Renewables Lead	Plymouth Energy Community	CE organisation
DS	Lockleaze Project Lead	Low Carbon Gordano	CE organisation
JC	Energy & Environment Officer	Hyde	Housing association
KE	Director	Brighton & Hove Energy Services Cooperative	CE organisation
LP	Innovation and Strategy Manager	Bristol Energy	Municipal energy supplier
LW	Director	SE2	Environmental consultancy
LE	Community Energy Project Manager	Bristol City Council	Local authority
MW	Energy Innovation Manager	Bioregional	Environmental consultancy
ND	Director	Adecoe	Energy/housing consultancy
RM	Director	SE2	Environmental consultancy
WR	Head of Sustainability	Southern Housing Group	Housing association

**Box 1.** Questionnaire.

1. Following FIT termination, what do you consider viable business models for PV projects aimed at tackling fuel poverty for social housing tenants in multi-occupancy buildings?
2. Between ‘local’ and ‘export’, which do you think:
  - a. Is most financially viable?
  - b. Has higher transaction costs?
  - c. Could provide the greatest benefits for fuel poor tenants?
  - d. Is most susceptible to future changes in policy/regulation?
3. How could social landlords ensure successful project implementation?

Thematic analysis of the qualitative data identified key recurring themes emerging from interviews, using the NVivo software (Version 12, QSR International (UK) Limited, London, UK) and the steps outlined by Braun and Clarke [49]. Recorded interviews were transcribed and codes were created to understand the central themes from responses to questions 2a–d. Paragraphs from transcripts were assigned to one (or more) of these codes on NVivo, excluding comments from the interviewer and those unrelated to the research questions.

#### 4. Results

Four broad post-FIT PV models applicable to multi-occupancy social housing emerged from interviews, but only ‘local’ and ‘export’ were analysed in detail.

Six interviewees raised the option of transferring power from a rooftop PV array on a multi-occupancy social housing scheme directly to participating tenants via a private wire connection or a microgrid, circumventing the distribution grid and the associated network charges [45]. This model was not analysed in detail because legal issues emerge if social landlords wish to sell energy to tenants without involving a licensed supplier [45] and retrofitting additional wiring and submeters is expensive and disruptive. Interview data suggests such models are better suited to new builds.

Four interviewees suggested models based on providing energy efficiency measures/installations and generating income on a ‘pay-as-you-save’ basis, such as the Dutch ‘whole house’ retrofit model, Energiesprong [50]. These were not analysed in depth as many social landlords have already implemented basic efficiency measures, partly through the ECO and Decent Homes programmes [7]. Properties that are still underperforming are often ‘hard to treat’ and, therefore, good candidates for ‘whole house’ retrofits. However, such models (including Energiesprong) are immature in the UK, making projects unaffordable for most social landlords without subsidies [13].

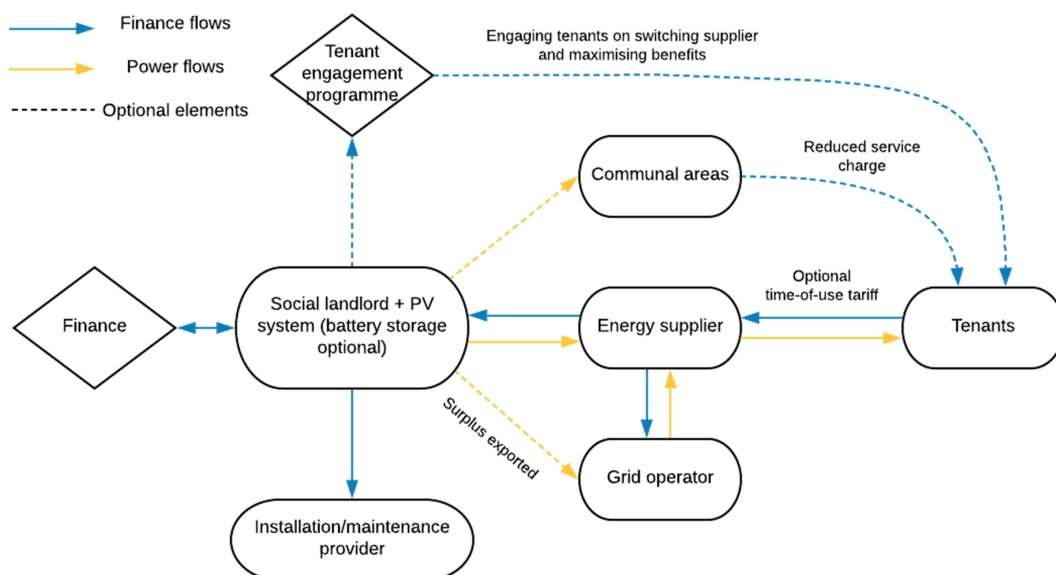
Analysis of the workshop transcript identified model elements that were broadly favoured by participants, which formed the basis of the ‘local’ and ‘export’ models. The ‘local’ model uses concepts of localised generation and supply found in the ‘Lockleaze Loves Solar’ project, whilst the ‘export’



model involves power purchase agreements (PPAs) discussed in the workshop. These models are comparatively more bounded than ‘pay-as-you-save’ business models while requiring less dedicated infrastructure than private wire/microgrid solutions.

#### 4.1. ‘Local’

‘Local’ involves the sale of power generated by a PV system to tenants living inside the building (see Figure 1). UK regulator Ofgem’s (Office of Gas and Electricity Markets) current ‘supplier hub’ model means that consumers must buy energy from a licensed energy supplier [51]. Consequently, this model requires participating tenants to switch to a partner energy supplier to purchase energy generated on-site. In reality, tenants would receive electricity from a variety of sources from the grid as normal, but the energy supplier would offer a specialised tariff to these tenants. This may be a time-of-use tariff, which varies in price depending on the PV system output. Excess electricity demand which cannot be matched by the system would be sold to tenants (probably at a higher price) by the supplier [45]. Surplus generated electricity would be exported to the grid for little or no financial return, so maximising on-site self-consumption is important for this model’s success [35].



**Figure 1.** ‘Local’ flowchart, adapted from ‘Figure 15: Typical self-consumption business model’ in Dunlop and Roesch [45]. Additions of tenant engagement, powering communal areas and time-of-use tariffs derived from interview and workshop data.

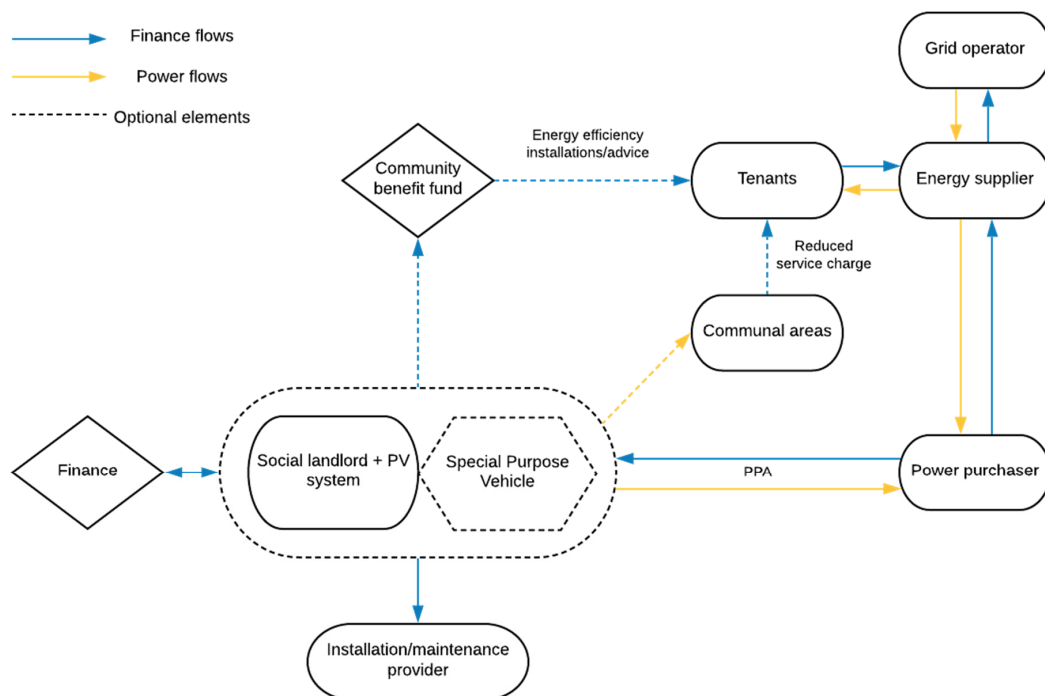
Optional elements could be added to maximise self-consumption of generated electricity:

- A tenant engagement programme could convince tenants to switch to the partner energy supplier and help them understand how to adapt their energy usage to maximise their benefit from cheap electricity. For example, energy prices would fall on a sunny day when PV output is high, so encouraging tenants to run household appliances during these times would help them to save money. ‘Smart’ appliances could be scheduled to turn on automatically when generation output is high [52].
- A private wire connection from the PV system to the communal electricity circuit (which may power the communal lighting, heating, security systems and lifts) helps to maximise on-site consumption and avoid grid charges [45]. Savings made here could reduce the tenants’ service charge.
- Battery storage could be integrated to store energy generated on-site at times of high supply and low demand. This could power communal facilities or be used by residents at times of high demand.

Energy Local have used a similar model to create a localised cooperative in Bethesda, North Wales, involving a hydropower scheme, over 100 households and Co-operative Energy as the partner supplier. Initial surveys indicate reductions on electricity bills of 19–29%, depending on how well households match their consumption to local generation. [53].

#### 4.2. ‘Export’

‘Export’ involves the sale of electricity generated by a PV system to a different building/organisation, rather than to the building’s occupants (see Figure 2). The buyer should have a high energy demand, for example a residential block, university, hospital or utility provider, such as a rail network or water company [54]. The transaction is carried out via a PPA, which is an often long-term contract between the generator and buyer [45]. Power transfer can be achieved by a private wire connection if the buyer is geographically close to the social housing scheme, or via an intermediary energy supplier, who purchases power from the social landlord and sells it to the buyer on a specialised tariff that links the price with the PV system output (known as a sleeved PPA) [10].



**Figure 2.** ‘Export’ flowchart adapted from ‘Figure 23: Typical onsite private wire PPA business model structure’ in Dunlop and Roesch [45]. Additions of community benefit fund, powering communal areas and tenant benefits derived from interview and workshop data.

Tenants do not directly benefit from power generated on-site. Instead, profits from energy sales are directed into a community benefit fund (CBF), which could be used to install energy efficiency measures, upgrade insulation or provide energy advice to tenants [3]. Additionally, the PV system could power communal facilities (as with ‘local’) and reduce tenants’ service charges.

‘Export’ could utilise a special purpose vehicle (SPV) to reduce transaction costs associated with negotiating the PPA. These are companies created for a specific financial transaction [45]. They are time-consuming to establish, but can be used repeatedly for similar transactions/projects. SPVs allow multiple organisations to work in partnership and hold assets separately from stakeholders, therefore minimising the risk to investors [7].

A similar model is being used in the ‘Riding Sunbeams’ project, which is investigating the potential for PV to power the UK’s rail network. Power can be sold from multiple PV installations to Network

Rail using PPAs. The model is expected to operate subsidy-free, generate a CBF, reduce the Southern Region's traction electricity bill by 4% and reduce CO<sub>2</sub> emissions by 13% [55].

#### 4.3. Thematic Analysis of 'Local' and 'Export'

Tables 3–5 compare the key themes identified for 'local' and 'export' through analysis of interview transcripts.

**Table 3.** Financial viability themes for both models from interview transcript analysis.

Financial Viability Themes	'Local' Model	'Export' Model
Supply contract length	<ul style="list-style-type: none"> <li>Consumer protection regulations mean that tenants could leave supply contracts after a year, representing a significant risk.</li> <li>If electricity prices are low enough a certain proportion of tenants are likely to remain on-supply. However, this depends on them feeling engaged with the project and understanding how to adapt their energy usage [15,38].</li> <li><i>"Ofgem will at some point review this prioritisation of consumer choice, because it goes against the possibility of getting long-term contracts necessary to secure investment to develop renewable energy projects"—CN.</i></li> </ul>	<ul style="list-style-type: none"> <li>Typical PPA contracts are around a decade long and consequently offer more financial certainty [46].</li> <li>Long contracts could become a disadvantage, as buyers could relocate, alter their power demand or go bankrupt, and policy changes could facilitate new and more profitable business models [45].</li> <li>Ensuring contracts cover as many eventualities as possible and are signed with well-established buyers would help mitigate risk [46].</li> </ul>
Economies of scale	<ul style="list-style-type: none"> <li>The larger the project, the more individual tenants need to be engaged.</li> <li><i>"The problem with the local model is that complexity rises proportionately to scale, whereas with the PPA model it's the opposite"—CN.</i></li> </ul>	<ul style="list-style-type: none"> <li>'Export' may only be viable for large projects, as it is not worth negotiating a complex PPA for a low-value, low-power exchange.</li> <li>Fortunately, multi-occupancy buildings often have large roof spaces and social landlords often have multiple suitable schemes [15].</li> <li>Social landlords could sell power from PV systems across multiple schemes via a single PPA using 'virtual power plant' platforms which aggregate multiple generation sources [56].</li> </ul>
Battery storage	<ul style="list-style-type: none"> <li>Battery storage could enhance financial viability through increased on-site power consumption.</li> <li>Capital costs would rise, and indoor battery installations can cause disruption and encroachment on living space.</li> <li><i>"The storage part is key. If you can get high on-site consumption you can make solar work in terms of a business case quite easily...you could buy a larger battery and have it for a whole apartment block"—DT.</i></li> </ul>	<ul style="list-style-type: none"> <li>Battery storage is only necessary if there is surplus power generation.</li> <li>Surplus could be avoided by finding a power purchaser with power requirements that closely align with times of peak generation or that greatly exceed the power being generated.</li> </ul>
Smart meter difficulties	<ul style="list-style-type: none"> <li>Standard SMETS1/2 smart meters may not support half-hourly settlements and generation metering aspects of 'local' [10].</li> <li>Paying for the installation of export or advanced smart meters may be necessary, although planned upgrades to existing smart meters could resolve this.</li> </ul>	Theme not applicable for this model.

**Table 4.** Transaction cost themes for both models from interview transcript analysis.

Transaction Cost Themes	'Local' Model	'Export' Model
Tenant engagement	<ul style="list-style-type: none"> <li>Allocating/training staff to encourage tenants to switch energy supplier and adapt their energy usage would incur transaction costs [32].</li> <li>Widespread reluctance to switch energy suppliers [27], and low-income customers may be particularly less inclined to do so [57].</li> <li>Time-of-use tariffs would also need explaining, although low-income tenants are more likely to be at home during daytime hours and are therefore well-suited to maximising the benefits of such tariffs [2].</li> <li><i>"If residents need to change supplier, they're going to want to know how much less they will pay. Start bringing in time-of-use tariffs and people may lose interest because it's too complicated"—JC.</i></li> </ul>	Theme not applicable for this model.



Table 4. Cont.

Transaction Cost Themes	‘Local’ Model	‘Export’ Model
Number of parties involved	<ul style="list-style-type: none"> <li>Social landlords may enter contracts with many tenants, an energy supplier and intermediaries (such as CE organisations) within a single project.</li> <li>Maintaining relationships with so many stakeholders would require considerable staff time and incur transaction costs [15].</li> </ul>	<ul style="list-style-type: none"> <li>Straightforward relationship of selling power to a single buyer.</li> <li>Less time-consuming and complicated than selling power to multiple tenants, incurring lower transaction costs.</li> <li><i>“Export is easier because you don’t have to sign on the customers”—KE.</i></li> </ul>
Supply contract complexity	Theme not applicable for this model.	<ul style="list-style-type: none"> <li>Specific expertise needed to broker good value PPAs as contracts are complicated and prices set in various ways (e.g., fixed and tracker PPAs) [10,45].</li> <li>Social landlords are unlikely to be familiar with negotiating PPAs, although SPVs and P2P trading platforms could simplify and automate the process.</li> <li><i>“If you’re good at negotiating partnerships and brokering deals with the private sector then maybe you look that way. A template contract would make it more reassuring”—LW.</i></li> </ul>
Integrating electricity bills into service charges	<ul style="list-style-type: none"> <li>Avoid tenant engagement and short contract problems by including electricity bills in tenants’ service charges.</li> <li>Convincing tenants to sign new tenancy contracts and managing billing may be challenging [7].</li> <li>Option better suited to new builds, where the terms can be included in the initial tenancy contracts.</li> </ul>	Theme not applicable for this model.

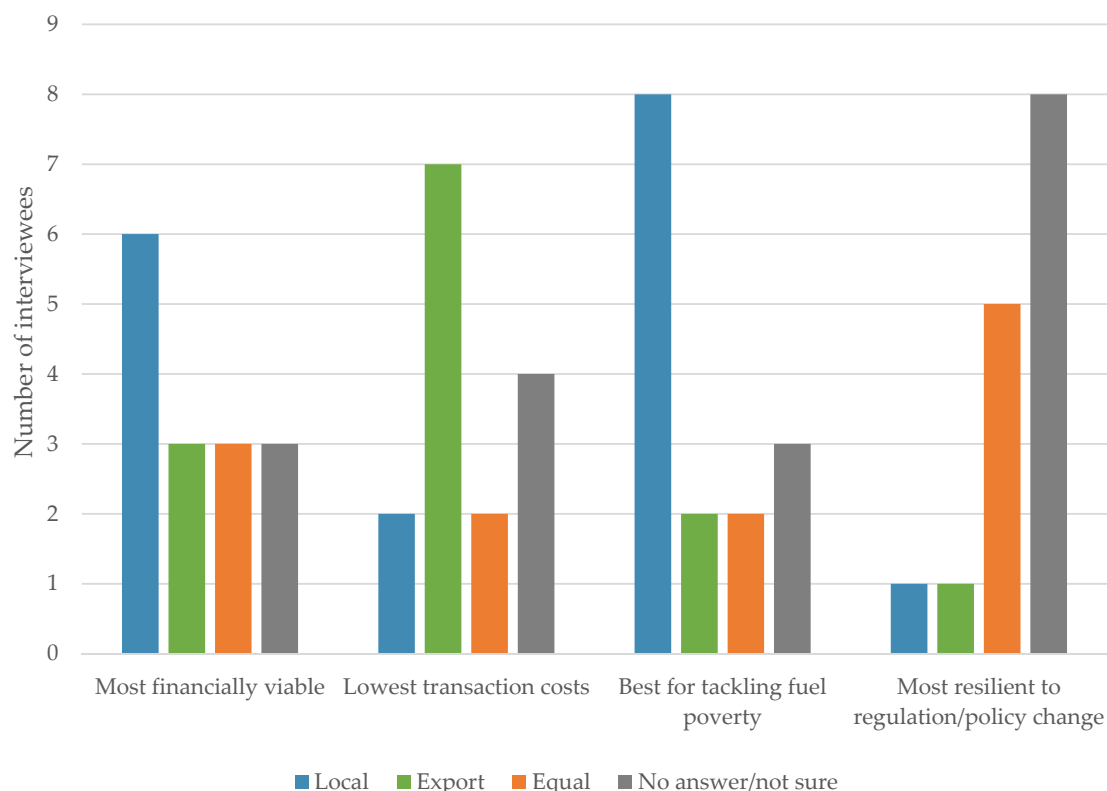
Table 5. Tenant benefit themes for both models from interview transcript analysis.

Tenant Benefit Themes	‘Local’ Model	‘Export’ Model
How do tenants benefit	<ul style="list-style-type: none"> <li>Tenants have reduced electricity bills as soon as they join the new tariff, leaving them with more disposable income.</li> <li><i>“The local model directly translates into savings for tenants”—JC.</i></li> </ul>	<ul style="list-style-type: none"> <li>CBF could be spent on interventions to reduce tenant’s energy bills, such as LED lighting, draught-proofing, improved insulation, new heating systems and energy/budgeting advice provision.</li> <li>CBF could be easily misallocated without appropriate ring-fencing and management.</li> <li><i>“Ensure the community fund does something meaningful and doesn’t get eaten up in administration fees, which does happen sometimes”—LP.</i></li> </ul>
Scale of benefits	<ul style="list-style-type: none"> <li>Savings depend on PV system performance, tariff pricing and ability of tenants to adapt their energy usage [15]. However, subsidy cuts have made it difficult to give on-site customers a discounted tariff [58].</li> <li>Energy generation/efficiency installations can result in tenants increasing their energy usage: a ‘rebound effect’ [41,59].</li> </ul>	<ul style="list-style-type: none"> <li>Tight margins may lead to small or non-existent CBFs. The amount that CE organisations raised for CBFs varies greatly, with some raising below £10,000 and others raising over £50,000 [3].</li> <li>Larger CBFs are often raised by well-established CE organisations, supporting the argument for social landlords to engage experienced intermediaries.</li> <li>Social landlords may focus on repaying loans for project capital costs, causing a time lag of several years before tenants benefit from a CBF [7].</li> <li><i>“The margins are tighter than before, so that community benefit pot isn’t going to be as large”—DT.</i></li> </ul>
Social equity	<ul style="list-style-type: none"> <li>Occupants of buildings unsuitable for PV installation may be left at a disadvantage. However, ‘local’ does not necessarily exclude non-residents: Energy Local Clubs accept anyone in their specific geographical location.</li> </ul>	<ul style="list-style-type: none"> <li>CBFs enable equal sharing of benefits amongst a community rather than between tenants fortunate enough to live in a building with PV installed [60].</li> <li>CBFs could be added to a wider fuel poverty fund managed by the social landlord and spent on efficiency upgrades for buildings with low EPC ratings, damp/condensation issues or high prevalence of fuel poverty.</li> <li><i>“Efficient buildings with solar panels have already got relatively low costs, they could use that benefit to help older buildings without solar panels . . . Target buildings with the lowest EPC band and residents with real financial difficulties”—WR.</i></li> </ul>
Community empowerment	<ul style="list-style-type: none"> <li>Community-building impacts such as job creation and upskilling (if tenants are involved in installation/management).</li> <li>Empowerment through participation in local energy generation and improved social cohesion through involvement in a shared project [5,36,61,62].</li> <li>Improving tenants’ environmental awareness and encouraging behaviour change.</li> </ul>	<ul style="list-style-type: none"> <li>‘Export’ could offer community-building impacts, although tenants may be less interested in getting involved if electricity is being sold to a third party.</li> <li><i>“Creating stronger and more resilient communities...It’s the whole value of building community around a shared project”—AN.</i></li> </ul>

## 5. Discussion

Figure 3 shows that six interviewees considered ‘local’ more financially viable than ‘export’, while an equal number were unsure or thought both were equal. This could be explained by concerns

about tight margins in ‘export’ and the difficulty of brokering good value PPAs without subsidies (see Tables 3 and 4). However, many interviewees thought the financial viability of ‘export’ would improve with economies of scale and when PPA frameworks and SPVs become more established (see Table 3). Short contracts with tenants and smart metering issues could impact the financial viability of ‘local’, but interviewees presented solutions to these issues and thought battery storage would improve prospects (see Table 3).



**Figure 3.** Interviewee responses to questions 2a–d comparing ‘local’ and ‘export’ models.

Seven interviewees thought ‘export’ would have lower transaction costs than ‘local’ because of the simpler relationship of PPAs with a single power buyer and the potential use of SPVs and P2P trading (see Table 4). Only two interviewees stated a preference for ‘local’ on this subject. This can be attributed to the time-consuming task of engaging tenants in ‘local’, although interviewees pointed out that these issues are easier to tackle in new builds (see Table 4).

Eight interviewees viewed ‘local’ as offering superior potential benefits to fuel poor tenants, as it directly reduces tenants’ electricity bills and offers wider community and educational benefits relating to involvement in local energy generation that may be harder to achieve through ‘export’, where tenants do not directly engage with RE generation (see Table 5). The variety of potential uses for a CBF and the fact that funds could be spread equally in a community or directed to those in most need were overshadowed by concerns that the CBF could be too small for a significant impact, misspent or lost in administrative costs (see Table 5).

Thirteen interviewees indicated that both models were equally susceptible to changes in policy/regulation or that they were unsure, as both are subject to similar regulatory/policy requirements [45].

### 5.1. The Need for Case-by-Case Analysis

Analysis has identified benefits and disadvantages of both models, although it indicates that each model is appropriate in different scenarios.

As ‘local’ is reliant on high levels of self-consumption and tenants adapting their energy usage behaviour, it may be best implemented in housing schemes where occupants are at home during the daytime (see Table 4). These could be sheltered housing for elderly residents, care homes or schemes with high numbers of unemployed residents [15,37]. Another suitable scenario is properties with electric heating such as heat pumps. Immersion heaters and new storage heater technologies can also be used in conjunction with domestic PV systems to charge up when PV output is high [63].

‘Export’ may be best suited to larger schemes, schemes located near potential large-scale power consumers or a mass rollout of PV across a social landlord’s stock, where engaging numerous tenants could incur high transaction costs (see Table 4). Current PPA models are most commonly used on large commercial projects or solar farms, while domestic and small commercial projects tend to use self-consumption models [46].

Maximising the use of PV to power communal facilities inside the housing scheme would be beneficial for the implementation of both models, as suggested by six interviewees. Therefore, both models are well suited to large buildings with high communal power demand, such as those with lifts, mechanical ventilation and heat recovery systems, advanced security systems and electric heaters in communal areas [45].

### 5.2. Recommendations for Social Landlords

There are various ways social landlords could improve prospects for PV projects on their housing stock. Firstly, support from third party intermediaries such as local CE groups, energy agencies/consultancies, local authorities and energy suppliers has been identified as an important enabler of successful PV projects on social housing [14,15,34,61]. CE organisations often have the expertise and motivation needed to enable successful PV projects [14,34,64]. Their trusted community connections make them well placed to assist with tenant engagement, which is particularly useful if there is a lack of trust between tenants and the social landlord [65]. Failing to involve tenants can lead to their losing interest, misunderstanding the new technology and failing to realise its potential benefits [38,39,61].

Engaging intermediaries can also unlock new finance options [66]. For example, CE organisations are often experienced in raising money through community share offers or crowd-funding [36]. Their position as organisations with community/environmental objectives can also attract support from social/environmental impact investors [67].

Social landlords should collaborate to share technical knowledge and best practice, encourage P2P learning and pool resources such as document/project frameworks [5]. ‘Umbrella’ organisations could assist by creating a national RE forum for social landlords [28]. Social landlords should also train their frontline staff on advising tenants on getting the best from new and existing PV systems [7].

Finally, integrating robust monitoring of CO<sub>2</sub> savings, financial benefits to tenants and wider community benefits into future projects would provide evidence on the benefits of small-scale RE projects and bolster the case for government support [60]. Installing smart generation/export meters would enable accurate monitoring of project performance, and could also benefit tenants [8].

### 5.3. Policy Implications

Standing charges for all network users are under review and regulators need to strike a fine balance between the even distribution of costs and facilitating investment in distributed RE and storage technology [68]. Changes to the ‘supplier hub’ model are also being considered, as it may hinder innovation (such as P2P trading) and RE diffusion [51]. Enabling buying and selling electricity locally, rather than through a licenced supplier, is also being considered (see the 2020 Local Electricity Bill). This has the potential to reduce transaction costs for both models, as the need to engage intermediary energy suppliers currently represents an obligatory financial and logistical hurdle for both. The SEG is variable and not guaranteed, and conveys a minimal and equal advantage to both models presented here.

The alternative is to incentivise consumers to reduce their electricity demand, for example via time-of-use tariffs. To ensure vulnerable groups can benefit, specialised reduced tariffs could be offered to the most deprived areas, as measured by the Index of Multiple Deprivation. To allow households that cannot afford solar PV, electric vehicles and battery storage to benefit from time-of-use tariffs, subsidies could be provided to low-income households for installing energy-efficient smart appliances and heating systems that automatically power up when electricity prices are low [69]. These could include smart washing machines, fridge-freezers, electric immersion heater timers and night storage heaters [52]. Such demand response and flexibility can also benefit network operators, which might provide an additional source of income if these can be aggregated [70].

Support for CE to help tackle fuel poverty could be expanded by reinstating EIS and SEIS [3]. Reinstating the UCEF could be particularly beneficial for projects on multi-occupancy social housing schemes, which are commonly found in urban areas. These, however, would not address the legal barriers to supplying occupants with energy generated on-site [24].

To make a real difference to fuel poor households, and especially those in multi-occupancy social housing, ownership of (remote) generation assets could be transferred through ‘buy as you use’ arrangements. So instead of hemorrhaging money, households would become asset owners through their expenditure (similar to a mortgage). Energy policymakers and regulators could enable such models by simplifying complex billing arrangements in return for a right to curtail any export to the grid. This can ensure that additional RE generation capacity can be installed to address fuel poverty without overloading local grid infrastructures.

Upgrading, draught proofing and insulating the building fabric of homes needs to be prioritised and closely coordinated with the installation, operation and management of sustainable and affordable heating systems. Cash grant schemes such as Winter Fuel Payments and the Warm Home Discount help ease the pressure on certain fuel poor households but do not tackle the root problem.

Bearing in mind rising inequalities, any support schemes need to apply the ability-to-pay principle by funding policy costs through general taxation or taxes on businesses to help reduce the financial burden on the less wealthy [71]. It is estimated that transitioning to a general taxation approach for funding energy subsidies would decrease costs for 70% of UK households [25].

The UK’s Renewable Heat Incentive is an example of such a policy paid for through general taxation. Targeting such policies at (multi-occupancy) social housing could reduce energy expenditure through lower energy bill levies and modern heating systems. In their absence, the continuous funding of energy efficiency improvements through the ECO scheme, whilst making such improvements mandatory for social landlords (by extending MEES to apply to social housing, for example), can ensure that even the lowest-earning households would be able to afford to heat their homes and live comfortably.

Ultimately, there is a need for greater institutional commitment to fuel poverty alleviation measures which acknowledge and incorporate the financial, social and environmental value of energy saving and local supply. ‘Local’ and ‘export’ have emerging potential and could be combined with pay-as-you-save models and grid flexibility services to benefit vulnerable groups. However, a shift towards a more cooperative and collaborative form of energy governance is required to realise their full commercial potential and contribute to the development of more sustainable and just energy systems.

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