



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Housing retrofit

Citation for published version:

Tingey, M, Webb, J & van der Horst, D 2021, 'Housing retrofit: Six types of local authority energy service models', *Buildings & Cities*, vol. 2, no. 1, pp. 518–532. <https://doi.org/10.5334/bc.104>

Digital Object Identifier (DOI):

[10.5334/bc.104](https://doi.org/10.5334/bc.104)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

Buildings & Cities

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.





Housing retrofit: six types of local authority energy service models

MARGARET TINGEY

JANETTE WEBB

DAN VAN DER HORST

**Author affiliations can be found in the back matter of this article*

SPECIAL COLLECTION:
RETROFITTING AT
SCALE: ACCELERATING
CAPABILITIES FOR
DOMESTIC BUILDING
STOCKS

RESEARCH

]u[ubiquity press

ABSTRACT

Given the ambitious policy target to become net zero carbon by 2050, what role can local authorities play in the decarbonisation of housing? An examination is presented of six local authority energy service models relevant to housing retrofit in Britain. Local authorities have an important role, with local knowledge about housing stock and economic opportunities; they also have relevant planning and governance responsibilities. However, relatively little is known about either the different energy service models adopted for retrofit or their relative effectiveness. Models identified from empirical case study research constitute experimental innovations resulting from constrained finances and competition requirements in public services. They provided (1) energy-efficiency upgrades to public, residential and commercial buildings and/or (2) district heating infrastructure to secure 'upstream' resource efficiencies. Findings show that local initiatives provided different retrofit mixes, with differing potential for effective change. The limitations of current models are considered, along with the policy and market changes needed to empower local authorities to contribute systematically to net zero carbon buildings.

POLICY RELEVANCE

How can British local authorities organise energy-efficiency retrofit in buildings? Six energy service models are identified which deliver on-site energy-efficiency upgrades and/or area-based efficient heating infrastructure. Reductions to energy demand from these models tend to fall short of the radical changes required by UK net zero 2050 goals. Whilst the energy service models provide examples of local innovation and effectiveness, much more ambitious policy is essential to enable a step change in energy service models for retrofit. Policy and regulatory changes are needed: first, to reform the energy retail market to support energy services geared to reducing demand; and second, to empower local authorities and their partners to scale up whole-area retrofitting, including privately owned buildings.

CORRESPONDING AUTHOR:

Margaret Tingey

Department of Sociology,
School of Social and Political
Science, University of Edinburgh,
Edinburgh, UK

margaret.tingey@ed.ac.uk

KEYWORDS:

buildings; energy services; ESCo;
housing; local authority; public
sector; residential; retrofit; UK

TO CITE THIS ARTICLE:

Tingey, M., Webb, J., & van
der Horst, D. (2021). Housing
retrofit: six types of local
authority energy service
models. *Buildings and Cities*,
2(1), pp. 518–532. DOI: [https://
doi.org/10.5334/bc.104](https://doi.org/10.5334/bc.104)

1. INTRODUCTION

The aim of this paper is (1) to understand what types of local authority energy service models have emerged in Britain¹ to improve energy efficiency in buildings and (2) to examine the extent to which these models have the potential to scale up and speed up decarbonisation to achieve net zero carbon targets (2050 for the UK; 2045 for Scotland).

Energy used in buildings currently accounts for a third of UK territorial CO₂ emissions (BEIS 2020), and energy performance of the UK housing stock is poor (Piddington et al. 2020). The integrated technical-economic, social and environmental benefits of investing in energy efficiency are well established (Eyre & Killip 2019), but global and UK investment trends in energy efficiency are moving in the wrong direction (Eurostat 2020; IEA 2019). In 2011, for example, the UK Conservative-Liberal Democrat coalition withdrew all public funding for domestic energy efficiency in England (Webb 2018), and progress stalled (UK Parliament Environmental Audit Committee 2020).

There is significant debate about how to achieve a step change in the pace and scale of energy retrofit of buildings, including recognition that a key challenge is the local variation in building types, tenures, energy needs and existing energy infrastructures (Brown et al. 2018). A common prescription is for locally led strategies, which can also increase political legitimacy and citizen engagement, further increasing potential energy saving (Brown 2018; Hiteva & Sovacool 2017; Pohlmann & Colell 2020). Recent policy in England, Scotland and Wales has acknowledged the role of local authorities and local energy services. The UK government's *The Clean Growth Strategy* (2017), *The Ten Point Plan* (2020) and short-lived Green Homes Grant scheme recognise the benefits of local planning for retrofit. Welsh government focus is on public funding for low-income households under the Arbed programme.² In Scotland, the Energy Efficient Scotland programme places responsibility on local authorities for area-based planning and coordination (Scottish Government 2018), with continuity in public funding for area-based programmes to benefit low-income households (Wade et al. 2020). Many British local authorities have experience of retrofitting social housing and their own corporate estate. They are also responsible for spatial planning and building standards. In principle, this experience and detailed knowledge provides foundations for more ambitious programmes (Tingey & Webb 2020). Progress in Britain to date continues to be derived largely from locally coordinated social housing improvement, governed by housing standards (UK CCC 2019), but with limited support for privately owned homes (Kerr & Winskel 2020).

There is also limited research comparing existing local energy service models and lessons for achieving significant reductions in energy use in buildings. This paper seeks to address this gap and is structured as follows. Section 2 outlines local authority-led retrofitting models identified by research literature, focusing on 'energy service companies'. Section 3 outlines the methods and data sources. Section 4 presents the six types of local operational energy retrofit models identified. Section 5 discusses the suitability of these different models for retrofitting (residential) buildings to accelerate decarbonisation.

2. ENERGY SERVICE MODELS FOR LOCAL AUTHORITY-LED RETROFITTING

In this paper the term 'retrofitting' is used to include improvements both to the building fabric and to resource efficiency from district energy services. Achieving comprehensive retrofit at local authority scale will require innovation in business models to advance from the historical pattern of piecemeal upgrades, which are not always fit for purpose, to neighbourhood action within a planned and prioritised timetable (Wade et al. 2020). The term 'business model' is used in widely varying ways, but in their conceptual review DaSilva & Trkman (2014: 283) give a useful and concise definition on which the present paper relies. They conclude that:

business models represent a specific combination of resources which through transactions generate value for both customers and the organization.

In these terms, local authority-led business model innovation for retrofit means combining resources in different ways to create new value streams from efficient resource use. This could include local energy systems' development, as well as building fabric upgrades (Bolton & Hannon 2016). In addition, local authorities may aim to incorporate value streams associated with social welfare, local jobs and social justice (Hiteva & Sovacool 2017). This still leaves unanswered the question of whether certain local authority-led energy service models might prove more suited than others to accelerating building stock retrofit programmes. Brown (2018) provides a starting point for such an appraisal, arguing that scaling up residential retrofit requires business models that can integrate multiple sources of value: first, from comfort, health, aesthetics and guaranteed savings; second, from supply chains focused on an integrated whole-house approach; third, from providing a single point of contact for customers; and lastly, from integrated low-cost financing. Empirical research on the business models in use in local authority-led housing retrofit is however limited, and there is little evidence about the extent to which any current models incorporate some or all of these sources of value.

The impacts of competition requirements and financial austerity on public services have by default resulted in innovation in local authority-led retrofitting models, including variations in outsourcing and partnership working (Murray 2011). This has created a type of experimental innovation that can be used to examine questions about the relative effectiveness of different service models. Experiments encompass municipal 'arm's length' management organisations (ALMOs), commissioning and outsourcing to commercial and third sector contractors, and in-house models, sometimes with ring-fenced funding and 'spend to save' revolving funds (Webb *et al.* 2017). In each model the local authority has differential control over the retrofit enterprise, with most direct influence when there is at least a component of municipal ownership (Berry & King 2019; Hannon & Bolton 2015). Contractors and ALMOs are commonly characterised as energy service companies (ESCOs) (Kindström & Ottosson 2016; Pätäri & Sinkkonen 2014). Unlike energy suppliers who are incentivised to sell units of gas and electricity, ESCOs derive revenues from the delivery of end-use energy services. In principle this orients ESCo business models to energy-efficiency investments. ESCo numbers have been increasing across Europe, with UK growth attributed to public sector clients (Bertoldi & Boza-Kiss 2017; Marino *et al.* 2011) primarily improving public buildings (Nolden & Sorrell 2016). Whether the latter ESCo models can incorporate and scale up residential retrofitting is open to question.

2.1 ESCOS: BUILDING PERFORMANCE OR ENERGY SUPPLY FOCUS

A critical dimension of ESCOs for this paper is their differential prioritisation of retrofit activities, which may result in varying energy-saving potential. A distinction is usually made between energy supply and energy performance ESCOs, which approach energy-efficiency services in different ways (Sorrell 2007).

Performance ESCOs sell an agreed level of final energy (or cost) saving service and focus on improvements to individual buildings and internal systems, prioritising heating equipment, upgrading to more efficient fittings such as light-emitting diode (LED) lighting and digital control systems, insulation and sometimes on-site renewable electricity generation. Local authorities increasingly use 'energy performance contracts' (EPC) to engage ESCOs to undertake upgrades to public buildings and street lighting (Polzin *et al.* 2016a, 2016b). However, these contracts have not routinely led to innovative solutions such as deep retrofit of public buildings (Nolden & Sorrell 2016). The UK trial of the Netherlands *Energiesprong* initiative (Brown 2018) is one of the few examples documented in the literature of a performance ESCo model for achieving net zero energy consumption in (social) housing; its potential role in retrofitting at scale is discussed in Section 4.

In contrast, *supply* ESCOs sell units of energy, with efficiency services variously derived from the provision of shared boilers, combined heat and power (CHP), thermal storage, 'waste' heat recovery and district heating networks (Riahi 2015). These technologies aim to improve conversion efficiency from a primary fuel source, providing decentralised energy to multiple nearby dwellings or buildings. Studies of UK district energy identify a number of public, private and third sector/community-led ESCo models (Hannon & Bolton 2015) with potential suitability for local

authority-led retrofit. Hawkey *et al.* (2013) provided three UK case studies: a municipally owned ESCo serving public, private and residential customers; a private sector-led ESCo primarily serving public sector customers (local authority, university, hospital), and limited social housing; and an independent not-for-profit district heating ESCo serving council-owned social housing, and public buildings. Although publicly owned buildings formed the key anchor loads in each case, building fabric upgrades and network expansion (incorporating different building owners/occupiers) varied in line with ESCo business priorities.

2.2 HYBRID ENERGY SERVICE BUSINESS PRACTICES

The different focus of performance and supply ESCos implies that supply ESCos are less oriented to energy saving. In practice, however, the performance/supply distinction often breaks down: ‘diversification is the norm and [energy service] companies are increasingly combining these approaches’ (Nolden & Sorrell 2016: 1412). For public buildings, this has included combining on-site renewable energy technologies and energy management systems into a single contract, including solar photovoltaic (PV), biomass boilers/CHP and lighting (Nolden & Sorrell 2015). Sometimes termed ‘integrated energy contracting’, this is described as a ‘simpler, less expensive model, whereby demand side and supply side measures are combined’ (Bertoldi & Boza-Kiss 2017: 349).

For housing retrofit, evidence similarly illustrates the lack of a clear-cut distinction between supply and performance ESCos. For example, retrofitting of privately owned apartments in Latvia used an ESCo model blending upgrades to the building fabric, heating and hot water, and control systems (Hiteva & Sovacool 2017); retrofitting of social housing apartment blocks in Glasgow, Scotland, combined fabric upgrades with heat network infrastructure using commercial and housing association funding in a complex contract (Webb *et al.* 2016). Blending of demand and supply-side energy services is thus common, with potential for a ‘whole systems’ efficiency model at a local scale.

2.3 LIMITATIONS OF THE ESCO CONCEPT

These empirical studies illustrate that ESCos typically do not adhere to clear-cut distinctions between supply-side and building performance efficiencies. ESCo practice is hence more nuanced than suggested in theory, with a variety of ownership structures, contract models, supply chain relationships and target buildings, leading to diverse forms of retrofitting. The ESCo model is, therefore, associated in practice with the blurring of boundaries between supply- and demand-side efficiency measures. The generic concept alone may not distinguish effectively between diverse local practices, in principle describing any business providing some form of energy service (*cf.* Roelich *et al.* 2018).

This suggests that the ESCo concept can be extended by using more refined descriptors to differentiate between practice-based energy service models for, in the context of this special issue, retrofitting residential buildings. The potential to accelerate retrofitting through different types of local ESCos is at present unclear, with further empirical research needed. This paper contributes to such research through empirical case studies of local initiatives. These are used to devise a new typology of local authority-led ESCo models and to consider the associated retrofitting opportunities. The analysis uses the terms ‘energy service model’ to distinguish between six models identified and ‘business structure’ to describe the approach to retrofit for each energy service model. The discussion is centred on the suitability of each model for scaling up retrofit of residential buildings.

3. METHODS

The typology is derived from 31 case studies of British local authority-led energy-efficiency initiatives. A total of 28 case studies are from a pre-existing database of 40 case studies; each comprises in-depth semi-structured interviews with local officers, business case documents and descriptive statistics from an online questionnaire (Webb *et al.* 2017). All interviews were audio-recorded and transcribed. The remaining three cases are from the academic and grey

literature and rely on documentary analysis. Data were originally collected between December 2015 and June 2016, and updated during 2019–20 by searching council websites for new or revised business case and project documents. There were no consistent data on intended and actual energy performance for all cases; anticipated energy savings were usually based on UK Standard Assessment Procedure (SAP) models for dwellings.³ Confidentiality agreements associated with the interviews and online survey mean that these data are unavailable for secondary analysis.⁴

The original database of 40 case studies (Webb et al. 2017) was constructed to examine in depth a range of UK local authority energy initiatives developed by authorities active in energy and carbon management. The sample of 40 cases was derived from research mapping of 458 local authority energy projects. It was designed to represent different scales of authorities (single tier, district, unitary and county) across England, Scotland, Wales and Northern Ireland, focusing on those with a published energy and carbon plan and at least one energy project. The selection criteria are fully explained in Webb et al. (2017). Some of the 40 cases were not directly concerned with energy-efficiency retrofit. Hence, the subset of 28 cases used in this paper are those that represent forms of (1) building and heating upgrades, including lighting and energy management systems; and (2) district energy development utilising ‘waste’ heat, gas CHP, district heating and thermal storage. As noted above, an additional three cases were derived from the academic and grey literature and were used to extend the case studies to further types of efficiency initiatives, notably energy performance contracting in social housing.

This enables a wide range of retrofit activities to be represented in a typology derived principally from original empirical research. It is, however, unsuited to tracing the impact of local advice services on retrofit, which is therefore outside the scope of analysis. Supplementary file 1 in the supplemental data online details the case studies. While the sample cannot be claimed to be representative of all local retrofit models, they are nevertheless a significant foundation for analysis.

Six energy service models were derived from the 31 case studies (**Table 1**), providing a broader analysis of local authority energy retrofit models than a focus on single types of ESCo. The approach also has parallels with categorisations of local energy businesses distinguishing between public, private and third sector models (e.g. Hannon & Bolton 2015), degree of local authority control (e.g. Berry & King 2019), and governance models for municipal retrofitting (e.g. Polzin et al. 2016a). The resulting typology is presented in section 4, using brief examples of cases to illustrate each energy service model.

4. AN EMPIRICAL TYPOLOGY OF LOCAL ENERGY SERVICE MODELS

Energy retrofit service models adopted by local authorities ranged from investing in municipal in-house resources to creating independent local enterprises and long-term contracting with commercial utilities. **Table 1** describes each model and identifies: sectoral control, business structure, ownership, types of retrofitting initiatives prioritised, and degree of local authority control over retrofit.

4.1 MUNICIPAL IN-HOUSE

Under the municipal in-house energy service model (10 cases), retrofits were directly managed by the local authority, which procured local and non-local installers, including operation and maintenance contractors, for projects. The model was used for a wide range of retrofits, including corporate building upgrades and social housing, and establishing new, efficient heat supply to serve residential, commercial and/or public sector buildings. Funding and financing models were similarly varied, including ring-fenced grant funding from government and the European Union (EU), blended finance from housing revenues, ‘spend to save’ loan and revolving funds.

Table 1: Six identified energy service models for locally managed energy retrofit.

Notes: ^aOn-site building upgrades: including insulation, glazing, efficient lighting, on-site heating and energy management systems. Efficient infrastructure: including utilising sources of ‘waste’ heat, combined heat and power (CHP), district heating and thermal storage.

EPC = Energy Performance Certificate; JV = joint venture; LA = local authority; SPV = special purpose vehicle.

ENERGY SERVICE MODEL	SECTORAL OWNERSHIP	BUSINESS STRUCTURE	OWNERSHIP UNDER THE BUSINESS STRUCTURE	RETROFITTING ACTIVITY ^a	DEGREE OF LA CONTROL IN RETROFITTING	CASES
Municipal In-house Model	Public	Energy retrofit directly provided by the LA	In-house owned on council balance sheet	Building upgrades; efficient infrastructure	High: the LA decides the approach to local retrofit	10
Energy Performance Contractor Model	Private	Corporate estate: the LA procures the company to retrofit corporate buildings under a guaranteed EPC	EPC: LA owned buildings; the EPC governs the energy-saving requirements	Building upgrades	Low-medium: the LA can propose target buildings and preferred measures, but the contractor typically selects the types of installed measures, with preferred technologies matching expertise	5
		Social housing: whole-house deep retrofit model with a long-term performance payment structure	<i>Energiesprong</i> : social landlord property owner; long-term performance contract replaces kWh energy bills	Building upgrades	Low: <i>Energiesprong</i> : Netherlands model of off-site construction methods with a predetermined focus on fabric-first whole-house measures	1
Municipal District Energy Company Model	Public	LA-owned local business for district energy development	LA-owned independent company structure; some assets may be retained on the LA’s balance sheet	Efficient infrastructure	High: as company owner, the LA can decide on network development	5
Local Third Sector Business Model	Third	Independent local organisations delivering energy-efficiency projects and services	Multiple community and social enterprise ownership structures; asset ownership mixed between building owners and third sector business depending on the project	Mostly building upgrades; some efficient infrastructure	Low-medium: third sector organisations primarily decide the approach and priorities for local retrofit, with some LA input	5
District Energy Concession Contract Model		LA procures a private sector company through a long-term concession contract to finance, build, own and operate district energy	Off-balance sheet; infrastructure paid for through the concession contract	Efficient infrastructure		
	Private	Variation: commercial-SPV: established as a company wholly owned by the private sector concession holder			Low: the LA has scope regarding buildings connected in the initial phases, but little control over expansion for area-based low-carbon heat provision	2
	Public-private	Variation: commercial JV: the LA has a partial ownership stake in the local business; it contributes finance with ongoing control			Low-medium: under a commercial JV, the LA aims to have ongoing input through an ownership stake	1
Municipal Energy Utility Model	Public	LA-owned licenced gas and electricity supply retail company	LA-owned independent company structure; energy-efficiency measures funded by the utility	Building upgrades	Medium-high: as a shareholder the LA can encourage work with local organisations to fund local retrofit and ameliorate fuel poverty	2

Beyond the corporate estate, in-house models suited council priorities for affordable heat and warm homes. Notably, in social housing this model demonstrated potential for neighbourhood whole-building retrofit, aided by local authority ownership and associated responsibility for properties. In Dundee Council, a £15 million retrofit initiative replaced ageing electric storage heating with combined heat network and external insulation for around 1100 council-owned social housing properties (primarily multistorey blocks). The council assessed this combined retrofit approach as providing more efficient energy services for these homes compared with simply renewing the electric storage heating.

The model also has potential to encompass whole-area integration of energy-efficient infrastructure, incorporating multiple building types/tenures and improving overall system efficiencies. In Islington, the Bunhill energy network uses conventional gas-fired CHP alongside thermal storage, and now also a heat pump to recover heat from London Underground. Developed in two phases since 2012 (Islington Council 2020), the network serves 1350 homes, two leisure centres, two office blocks and a school. There is further potential to connect existing homes and new-build housing, and mixed-use development in future phases.

4.2 ENERGY PERFORMANCE CONTRACTORS

Under an EPC, the contractor is obliged to deliver a preset level of either energy (kWh) or financial (£) savings (depending on contract structure) from retrofitting. This ‘guaranteed’ contract allocates the main financial risk to the contractor, who in turn retrofits an agreed set of buildings. This energy service model involved local, national and international contractors. Whilst the municipal in-house model targeted a range of buildings and retrofitting activities, energy performance contractors addressed only one type of public, commercial or residential buildings in a single contract. They also focused on building upgrades and on-site services, rather than combining these with area-based efficient infrastructure. Consequently, there was no integration of ‘waste’ heat sources in this model.

In most cases (five) the local authority procured an external specialist to retrofit public buildings; only one case targeted social housing through a performance model. In public buildings, the highest energy users had relatively conservative building upgrades securing typically around 15–20% reduction, sometimes also including on-site heat and electricity generation. Conversely in social housing, a UK *Energiesprong* trial focused on major reductions to energy demand through a performance-based approach, treating the building as a system and including consideration of aesthetics and comfort (Brown 2018). In this whole-house deep retrofit, the building envelope is prioritised. Unlike performance contracts retrofitting public buildings, homes were highly insulated, providing around 80% reduction in energy demand. On-site renewables meet the residual demand, with batteries to provide grid flexibility in some homes (Friedler & Kumar 2019).

A total of 155 Nottingham City Homes properties were being retrofitted (2017–20), alongside five Moat Housing Association homes in Maldon (Energiesprong UK 2019a, 2019b). Additionally, blocks of flats in Nottingham were retrofitted as part of an EU-funded demonstrator project ‘Mustbe0’ (a total of 415 flats in the UK, Germany, France and the Netherlands). This is showcasing the *Energiesprong* model adapted to apartment blocks (Interreg North-West Europe 2020). *Energiesprong* had high unit costs of around £75,000 per property for the Nottingham City Homes pilot, and was supported by EU European Regional Development Fund (ERDF), Horizon 2020 and Interreg grants. A long-term performance-based payment plan recoups capital expenditure and installation costs; residents pay for energy services, rather than a bill based on kWh usage. This was estimated at £600 per year in the Nottingham pilot. The model is targeted at social landlords with large housing stock and is intended to use scale and bulk ordering through offsite mass manufacture of materials to reduce unit costs to a target £35,000 based on 5000 retrofits per year (Friedler & Kumar 2019: 15).

4.3 MUNICIPAL DISTRICT ENERGY COMPANIES

Municipal district energy companies (five cases) were owned by a local authority, but had a separate legal structure, financial management and accounting. There was no single blueprint

for company structure. Depending on local authority priorities, companies included holding and operating structures, or used other subsidiaries to create boundaries between aspects of the business. The local authority could also decide to retain ownership of certain assets (e.g. energy centre and network assets) ‘in-house’ and use the company primarily for customer operations.

With a core focus on district energy infrastructure, this energy service model appeared more restricted in retrofit activities compared with the previous two models. There was less attention on upgrading the thermal fabric of buildings. Instead, the focus was on supplying energy-efficient heat and sometimes power to clusters of buildings. Key heat network anchor loads were existing public buildings, housing and new-build developments on regeneration sites.

In Sutton (*Sutton Decentralised Energy Network*) and Enfield (*Energetik*), new-build privately owned and social housing, and mixed-use developments were the first buildings connecting. Consequently, they were expected to have higher energy performance standards. The goal in both cases was to decarbonise the heat for already more efficient buildings, including using heat from energy from waste plants under construction (Beddington Lane for Sutton; Edmonton Park for Enfield). Subsequently networks would be extended to serve larger areas of the borough, connecting existing buildings.

Whilst Enfield and Sutton prioritised new build developments in first phases, Bridgend Council plans to focus on connecting existing buildings to district heating. In Caerau, a mine water heat network with a heat pump (approximately £10 million) is intended to serve up to 800 residential buildings (300–400 planned for phase 1), community buildings and a school (Bridgend County Borough Council 2020). Analysis by the Energy Technologies Institute (ETI) (2018: 50–51) identified district heating as the preferable retrofit technology compared with individual heat pumps, due to the age (pre-1914) and density of properties. In Bridgend itself, around 10,000 potential homes have been identified as suitable to connect to district heating as the most cost-effective route to decarbonisation (Energy Systems Catapult (ESC) 2019). Residential energy-efficiency programmes, however, have largely focused on other areas of the borough (ESC 2019: 44), suggesting little synergy with the municipal district energy company model to date.

4.4 LOCAL THIRD SECTOR BUSINESSES

Local third sector energy service businesses (five cases) had multiple forms of enterprise ownership, including community interest companies, industrial and provident societies, community benefit societies, and companies limited by guarantee. All had a close relationship with the local authority. In this model, organisations were either the outcome of cross-sector partnerships between the local authority and existing community groups, or responded to council priorities to establish independent third sector energy services organisations.

In contrast to the municipal district energy company model, local third sector businesses provided more diverse retrofit. This spanned both small and larger scale building fabric upgrades, new heating infrastructure, and local retrofit supply chains. Two businesses were established as energy services organisations (Aberdeen Heat and Power (AHP), YES Energy Solutions (YES)) but delivered different services; three (Low Carbon Hub, Plymouth Energy Community, Bath and West Community Energy) were cooperative enterprises focused primarily on solar PV and securing long-term income. These also incorporated some fabric efficiency retrofit. Illustrating the flexibility of this model, of the latter group of energy cooperatives, Plymouth Energy Community, a social enterprise established by Plymouth City Council in 2013, is in the early stages of developing a subsidiary to focus on community-led zero carbon housing.

Demonstrating an alternative trajectory to the cooperatives in this energy service model, YES began as a municipal in-house service in Kirklees Council, which created Yorkshire Energy Services in 2000. In 2009, the business became a community interest company (CIC) focused on energy-efficiency upgrades to social housing. Based in the North of England, it now has a national network of local installers. YES business operations have evolved over time, now providing both domestic and business energy efficiency, and working with energy suppliers using the Energy Company Obligation (ECO) to retrofit housing energy-efficiency measures (YES Energy Solutions 2019).

AHP, established in 2002, exemplifies further adaptability for retrofitting within the third sector model. It is a company limited by guarantee, insulating social housing tower blocks, removing inefficient electric storage heating and providing low-carbon district heating. Like YES and Plymouth Energy Community, it has a close association with the council: the 1999 Affordable Warmth Strategy aimed to ameliorate fuel poverty among council tenants, and was a key factor in the decision to create AHP as an independent, not-for-profit organisation (Webb 2015). The company works mainly under city council contracts for area-based improvements to social housing and development of district energy networks (AHP 2020a, 2020b).

AHP demonstrates the potential for the third sector energy service model to support whole-area integration of energy-efficient infrastructure with ‘waste’ heat sources (as exemplified by the in-house and municipal district energy company models). It intends to take heat from a planned energy from waste plant (Aberdeen City Council 2020) to serve residents in Torry and city centre buildings.

4.5 DISTRICT ENERGY CONCESSION CONTRACTS

Concession contracts (commercial special purpose vehicle (SPV) and commercial joint venture (JV)) (three cases) represent an energy service model based on a long-term contract (up to 40 years) between the local authority, sometimes with other public sector organisations, and a commercial energy utility. In these cases, the contractor was the UK arm of an international energy business. Concession contracts were established when local political appetite for public investment in district energy was limited (Hawkey *et al.* 2013). The model resulted in the creation of a commercial SPV (Birmingham and Leicester), or a commercial JV (Newcastle) to finance, own and operate district energy networks serving specified buildings.

Commercial SPVs were established as local companies wholly owned by the private sector concession holder. In the commercial JV, the local authority had an ownership stake, contributed some finance and hence had more ongoing control. In both variants, long-term supply contracts guarantee recovery of capital investment.

Both commercial and JV SPVs were developing (and in Leicester also renewing) district energy infrastructure to serve a predefined mix of public and commercial buildings. As this model was restricted to district energy (rather than a wider range of retrofit activities), it is more bounded, similar to the municipal district energy model, but with less focus on residential customers. Of the three concession contract cases, Leicester (commercial SPV) was the only example with a significant (social) housing dimension. Leicester District Energy Company was established in 2010 with around £14 million investment from Engie to develop gas CHP and heat networks serving Leicester University campus and around 30 council buildings. £1 million in energy supplier funding was used to upgrade 1980s’ heat networks serving around 3000 social housing tenants. This revived Leicester’s in-house model proposal (about £22 million) from the early 2000s, which had aimed to upgrade and extend existing district heating, but perceptions of political risk led to its abandonment.

In the concession contract energy service model, local authorities anticipated expansion of networks into area-based schemes. In the two more established cases this has been largely unmet to date, leading to claims that the concession contractor is ‘cherry picking’ heat loads to maximise profit; connections to social housing were perceived as less profitable. In both Leicester and Birmingham, residential customers were restricted to those specified in the initial contract. By co-financing with Engie, Newcastle council aims to secure a stake in continued expansion of networks. Since the JV was announced only at the end of 2018, no conclusions can yet be drawn about its trajectory.

4.6 MUNICIPAL ENERGY UTILITIES

Municipal energy utilities (two cases) are licenced retail companies serving domestic and non-domestic customers across the British retail gas and electricity market. Robin Hood Energy (Nottingham City Council) and Bristol Energy (Bristol City Council) were established in 2015 with

the council as sole shareholder. However, in 2020 both councils decided to sell the respective utilities (e.g. Bristol City Council 2020), citing financial difficulties and leaving large debts.⁵

As energy retailers, retrofit was not their core business. The main route for energy retailers to reduce demand in residential properties is via the regulated ECO, which requires suppliers with over a threshold number of customers (200,000 in 2019–20; 150,000 in 2020–21) to fund retrofit. Both municipal utilities were ECO suppliers (Ofgem 2021) and worked with local organisations on fuel poverty and energy-efficiency programmes. Both councils also provided energy-efficiency programmes and hence were not reliant on this utility model for retrofitting.

Bristol Energy also tested a domestic ‘heat as a service’ tariff with the ESC. This aimed to reduce customers’ energy demand through enhanced digital control of home heating, using a tariff selling ‘warm hours’ rather than units of gas and electricity (ESC 2020). Interventions used sensors to test scope for savings from greater spatial (room-by-room) and temporal (hour-by-hour) control. In principle, such service contracts should result in retail suppliers offering housing retrofit when this provides higher revenues than selling units of energy. Such tariffs would, however, require long-term contracts between customers and supplier to guarantee pay back of retrofit costs.

5. DISCUSSION

UK climate protection goals include net zero emissions from building stock. The analysis of local energy service models, arising from experimental innovations associated with austerity and competition in public services, assessed their potential to contribute to such ambitious goals. Findings reveal that different local energy service models influenced the types and prioritisation of work, adaptability to local goals, and energy-saving strategies. Case studies also revealed diversity of activity, even within the same energy service model. The models appear differentially suited to scaling up the pace and scale of residential retrofit, with the third sector model emerging as particularly flexible and adaptable, although all are at present limited in scale and ambition and there are little data on actual, rather than modelled, energy savings.

5.1 MODELS TO ACCELERATE BUILDING ENERGY EFFICIENCY

In-house, energy performance and third sector energy service models entailed forms of flexibility that could support faster residential retrofit, with supportive public policy and finance. In-house models conferred flexibility by channelling and blending funding from local authority capital programmes; maintenance budgets; revolving energy/carbon funds; public borrowing and grants; and energy supplier ECO budgets. Third sector enterprises were responsive to diverse energy-efficiency retrofitting, although there were not yet examples of a comprehensive, planned whole-house/whole-area approach. In addition, the UK trial of the *Energiesprong* performance contract model exemplified a radical approach to whole-house retrofit for net zero emissions in (social) housing. Opportunities for increasing the pace and scale using the model require suitable housing stock for bulk ordering prefabricated materials to capture cost reductions and faster installation.

Conversely, the municipal energy utility model was limited in ability to advance energy efficiency. Although the municipal utilities differed from commercial suppliers by prioritising social welfare and carbon reduction by working with local organisations, their primary business was selling units of energy, not reducing energy use. Financial losses, leading to council decisions to sell the companies, suggest that in current retail markets, there is little opportunity to adapt this business model for scaling or accelerating residential retrofitting. While local authorities in countries such as Germany frequently own successful integrated municipal utility companies (Roelich et al. 2014), this option is marginalised in current British energy market structures.

5.2 BUSINESS MODELS TO ACCELERATE LOCAL ENERGY-EFFICIENT INFRASTRUCTURE

For new district heating infrastructure, in-house, municipal and third sector energy service models were most adaptable to scaling up for residential retrofit. These models illustrated area-based

extension of district energy, securing economies of scale by incorporating residential retrofit in a local systems approach. For municipal and third sector energy service models, an independent, but close, working relationship with the local authority enabled ring-fenced finance for area-based developments. Conversely, the concession contract model was associated with ‘island’ systems, geared to larger buildings and higher rates of financial return, rather than connecting the greatest number of buildings to maximise energy and carbon saving (Bush *et al.* 2019). Complex procurement processes, contract negotiations and legal costs associated with the concession model also slowed developments and increased costs (Tingey 2020). Further research is needed to understand whether a local authority ownership stake in a commercial JV contract creates opportunities for integrating energy-efficiency upgrades in housing with district energy infrastructure.

5.3 THE PROBLEM OF CONFIGURING DEMAND REDUCTION AS A VIABLE BUSINESS IN THE UK

All energy service models in this paper’s typology exemplify the challenges of configuring viable business models to reduce energy use, illustrating the continuing difficulties of such a business proposition (Kindström & Ottosson 2016). Public policies to stimulate a market for comprehensive energy-efficiency retrofit services remain under-developed (Brown *et al.* 2018; Eyre & Killip 2019). Most of the local case studies were relatively early-stage businesses operating at the margins of the mainstream (centralised) supply market.

Some of these innovative energy service models nevertheless prefigure options for upgrade of the whole building stock and retrofit for low carbon heat networks where appropriate. Municipal in-house and third sector models are distinctive examples of integrated retrofit. In-house models avoided the costs and time required to set up a separate local enterprise, and conferred direct control over projects, but can be subject to disruption when, for example, political control changes following local elections. Third sector models in this sense provide a degree of resilience and continuity for progress across the authority area, as in the case of AHP. At present, social housing is the priority building stock, but there is potential for local authorities to coordinate retrofit offers for private housing estates built to common standards in neighbouring areas. This would require supportive and stable public policy for housing retrofit and clean heating, backed by regulatory standards, and a route to low-cost financing for owners. In the UK, the latter could be provided by a public agency such as the National Infrastructure Bank planned for launch in 2021.

6. CONCLUSIONS

Six types of UK local authority energy service models were identified and assessed for low carbon retrofit of buildings, using 31 case studies, for their potential in scaling and accelerating energy-efficiency improvements. The models represent local authority-led innovation in difficult circumstances associated with budget cuts, competing priorities and limited powers. There are nevertheless local successes, particularly in social housing and council buildings, where varying resources were combined to create viable projects, incorporating value for social welfare, local jobs and social justice. These are critical sectors, but none of the models was extending any significant services to homeowners, and only 17.7 % of UK homes are social rented (Piddington *et al.* 2020).

Initial answers were provided to the question of whether certain local authority-led energy service models are more suited than others to accelerating building stock retrofit programmes. None of these models can fully integrate the multiple sources of value proposed by Brown (2018) from guaranteed savings to supply chains focused on an integrated approach and low-cost financing. The findings indicate the severe constraints on local energy-efficiency business models in UK market and policy environments. These two interrelated areas urgently require change. Energy retail markets need reshaping to incentivise demand reduction and local authorities need to be empowered for integrated area-based approaches to energy efficiency across building sectors and ownership. The innovations observed in local authority energy service models provide starting points for an ambitious approach. Energy-efficiency retrofitting is likely to be more effective in a

locally informed and planned approach. Local authorities need resources to develop and coordinate programmes, as well as using public estate and housing stock to anchor district heating systems. Despite limitations, local authority business model experiments have generated unique expertise and information which are essential for managing large-scale building retrofit for low energy requirements and clean heating.

NOTES

- 1 Northern Ireland is excluded from this study. The suspension of the Assembly in 2017 stalled activity in this area and therefore there were insufficient data. The Assembly was reconvened in 2020.
- 2 See <https://www.arbedambyth.wales/eng/home.html/>.
- 3 See <https://www.bregroup.com/sap/>.
- 4 An associated database of 458 UK local authority energy projects is, however, available from the UK Energy Research Centre (UKERC) Energy Data Centre, <https://doi.org/10.5286/ukerc.edc.000005/>.
- 5 Together Energy acquired Bristol Energy's residential customers and brand for £14 million in September 2020; Robin Hood Energy's customers were transferred to British Gas in October 2020 and the company ceased trading and went into administration in January 2021.

ACKNOWLEDGEMENTS

An earlier version of this paper was presented at the Local Energy Systems in National and International Contexts conference, Oxford, UK, April 2019. The authors thank the editors and reviewers whose comments helped improve the paper.

AUTHOR AFFILIATIONS

Margaret Tingey  orcid.org/0000-0001-7668-4208

Department of Sociology, School of Social and Political Science, University of Edinburgh, Edinburgh, UK

Janette Webb  orcid.org/0000-0001-8295-346X

Department of Sociology, School of Social and Political Science, University of Edinburgh, Edinburgh, UK

Dan van der Horst  orcid.org/0000-0002-9454-9664

School of Geosciences, University of Edinburgh, Edinburgh, UK

COMPETING INTERESTS

The authors have no competing interests to declare.

FUNDING

The authors gratefully acknowledge support from the UK Research and Innovation through the Centre for Research into Energy Demand Solutions (grant reference number EP/R 035288/1).

SUPPLEMENTAL DATA

Cases used to generate the typology are provided in supplemental data online, which can be accessed at: <https://doi.org/10.5334/bc.104.s1>

REFERENCES

Aberdeen City Council. (2020). *NESS Energy Project*. <http://nessenergy.co.uk/>

AHP. (2020a). Aberdeen Heat & Power key facts. Aberdeen Heat and Power (AHP). Unpublished.

AHP. (2020b). Aberdeen Heat & Power Ltd: Supplementary Note to Scottish Parliament Economy Committee. Aberdeen Heat and Power (AHP). Unpublished.

- BEIS.** (2020). *Final UK greenhouse gas emissions national statistics: 1990 to 2018—Statistical summary*. Department for Business, Energy and Industrial Strategy (BEIS).
- Berry, T., & King, M.** (2019). Governance models and low carbon thermal networks. Paper presented at the UKERC Local Energy Systems in National and International Contexts Conference, Oxford, UK, 24–25 April 2019. <https://ukerc.ac.uk/news/watch-ukerc-annual-conference-2019>; and <https://ukerc.ac.uk/news/ukerc-annual-conference>
- Bertoldi, P., & Boza-Kiss, B.** (2017). Analysis of barriers and drivers for the development of the ESCO markets in Europe. *Energy Policy*, 107, 345–355. DOI: <https://doi.org/10.1016/j.enpol.2017.04.023>
- Bolton, R., & Hannon, M.** (2016). Governing sustainability transitions through business model innovation: Towards a systems understanding. *Research Policy*, 45(9), 1731–1742. DOI: <https://doi.org/10.1016/j.respol.2016.05.003>
- Bridgend County Borough Council.** (2020, July 17). *Investigation work continues on innovative Caerau Local Heat Scheme*. <https://www.bridgend.gov.uk/news/investigation-work-continues-on-innovative-caerau-local-heat-scheme/>
- Bristol City Council.** (2020, June 3). Cabinet agrees sale of Bristol Energy. [news.bristol.gov.uk](https://www.bristol.gov.uk/news/cabinet-agrees-sale-of-bristol-energy/)
- Brown, D.** (2018). Business models for residential retrofit in the UK: A critical assessment of five key archetypes. *Energy Efficiency*, 11(6), 1497–1517. DOI: <https://doi.org/10.1007/s12053-018-9629-5>
- Brown, D., Kivimaa, P., Rosenow, J., & Martiskainen, M.** (2018). Overcoming the systemic challenges of retrofitting residential buildings in the United Kingdom: A Herculean task? In *Transitions in energy efficiency and demand: The emergence, diffusion and impact of low-carbon innovation* (pp. 110–130). DOI: <https://doi.org/10.4324/9781351127264>
- Bush, R., Hawkey, D., & Webb, J.** (2019). *Meeting strategic challenges of UK district heating: Research briefing and practitioner resources* (Vol. 12). University of Edinburgh. <https://heatandthecity.org.uk/resource/meeting-the-strategic-challenges-of-uk-district-heating-research-briefing-and-practitioner-resources/>
- DaSilva, C. M., & Trkman, P.** (2014). Business model: What it is and what it is not. *Long Range Planning*, 47(6), 379–389. DOI: <https://doi.org/10.1016/j.lrp.2013.08.004>
- Energiesprong UK.** (2019a). *New pilot helps optimise the Energiesprong solution for Nottingham rollout to 155 homes*. <https://www.energiesprong.uk/newspage/new-pilot-helps-optimise-the-energiesprong-solution-for-nottingham-rollout-to-155-homes>
- Energiesprong UK.** (2019b). *Projects: Maldon*. <https://www.energiesprong.uk/projects/vlijmen>
- ESC.** (2019). *SSH Phase 2 D37/D38: Smart Energy Plan—Bridgend County Borough Council*. Bridgend County Borough Council/Energy Systems Catapult (ESC).
- ESC.** (2020, July). *Bristol Energy heat as a service trial*. Energy Systems Catapult (ESC). <https://es.catapult.org.uk/case-studies/bristol-energy-heat-as-a-service-trial/>
- ETI.** (2018). *Bridgend Local Area Energy Strategy*. Energy Technologies Institute (ETI)/Energy Systems Catapult.
- Eurostat.** (2020, February 4). *Energy consumption in 2018: Primary and final energy consumption still 5% and 3% away from 2020 targets*. <https://ec.europa.eu/eurostat/documents/2995521/10341545/8-04022020-BP-EN.pdf>
- Eyre, N., & Killip, G.** (Eds.) (2019). *Shifting the focus: Energy demand in a net-zero carbon UK*. CREDS. <https://www.creds.ac.uk/publications/shifting-the-focus-energy-demand-in-a-net-zero-carbon-uk/>
- Friedler, C., & Kumar, C.** (2019). *Reinventing retrofit: How to scale up home energy efficiency in the UK*. Green Alliance.
- Hannon, M. J., & Bolton, R.** (2015). UK local authority engagement with the Energy Service Company (ESCO) model: Key characteristics, benefits, limitations and considerations. *Energy Policy*, 78, 198–212. DOI: <https://doi.org/10.1016/j.enpol.2014.11.016>
- Hawkey, D., Webb, J., & Winskel, M.** (2013). Organisation and governance of urban energy systems: District heating and cooling in the UK. *Journal of Cleaner Production*, 50, 22–31. DOI: <https://doi.org/10.1016/j.jclepro.2012.11.018>
- Hiteva, R., & Sovacool, B.** (2017). Harnessing social innovation for energy justice: A business model perspective. *Energy Policy*, 107, 631–639. DOI: <https://doi.org/10.1016/j.enpol.2017.03.056>
- IEA.** (2019). *World energy investment 2019*. International Energy Agency (IEA). [iea.org/wei2019](https://www.iea.org/wei2019)
- Interreg North-West Europe.** (2020). *Mustbe0: Desirable, warm, affordable homes for life*. <https://www.nweurope.eu/projects/project-search/mustbe0-multi-storey-building-e-0-refurbishment/>
- Islington Council.** (2020). *Bunhill Heat and Power Network*. Islington Council. <https://www.energyadvice.islington.gov.uk/wp-content/uploads/2020/03/Bunhill-Heat-and-Power-Network-brochure.pdf>
- Kerr, N., & Winskel, M.** (2020). Household investment in home energy retrofit: A review of the evidence on effective public policy design for privately owned homes. *Renewable and Sustainable Energy Reviews*, 123, 109778. DOI: <https://doi.org/10.1016/j.rser.2020.109778>

- Kindström, D., & Ottosson, M.** (2016). Local and regional energy companies offering energy services: Key activities and implications for the business model. *Applied Energy*, 171, 491–500. DOI: <https://doi.org/10.1016/j.apenergy.2016.03.092>
- Marino, A., Bertoldi, P., Rezessy, S., & Boza-Kiss, B.** (2011). A snapshot of the European energy service market in 2010 and policy recommendations to foster a further market development. *Energy Policy*, 39(10), 6190–6198. DOI: <https://doi.org/10.1016/j.enpol.2011.07.019>
- Murray, J. G.** (2011). Third sector commissioning and English local government procurement. *Public Money and Management*, 31(4), 279–286. DOI: <https://doi.org/10.1080/09540962.2011.586241>
- Nolden, C., & Sorrell, S.** (2015). The role of energy service contracting in delivering energy efficiency measures for local authorities in the UK. *Paper presented at the eceee Summer Study Proceedings* (pp. 515–525). https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2015/3-local-action/the-role-of-energy-service-contracting-in-delivering-energy-efficiency-measures-for-local-authorities-in-the-uk/
- Nolden, C., & Sorrell, S.** (2016). The UK market for energy service contracts in 2014–2015. *Energy Efficiency*, 9(6), 1405–1420. DOI: <https://doi.org/10.1007/s12053-016-9430-2>
- Ofgem.** (2021). *Eco supplier contact details*. <https://www.ofgem.gov.uk/environmental-programmes/eco/contacts-guidance-and-resources/eco-supplier-contact-details>
- Pätäri, S., & Sinkkonen, K.** (2014). Energy service companies and energy performance contracting: Is there a need to renew the business model? Insights from a Delphi study. *Journal of Cleaner Production*, 66, 264–271. DOI: <https://doi.org/10.1016/j.jclepro.2013.10.017>
- Piddington, J., Nicol, S., Garrett, H., & Custard, M.** (2020). *The housing stock of the United Kingdom* (No. PEN02). BRE Trust. https://files.bregroup.com/bretrust/The-Housing-Stock-of-the-United-Kingdom_Report_BRE-Trust.pdf
- Pohlmann, A., & Colell, A.** (2020). Distributing power: Community energy movements claiming the grid in Berlin and Hamburg. *Utilities Policy*, 65, 101066. DOI: <https://doi.org/10.1016/j.jup.2020.101066>
- Polzin, F., von Flotow, P., & Nolden, C.** (2016a). Modes of governance for municipal energy efficiency services—The case of LED street lighting in Germany. *Journal of Cleaner Production*, 139, 133–145. DOI: <https://doi.org/10.1016/j.jclepro.2016.07.100>
- Polzin, F., von Flotow, P., & Nolden, C.** (2016b). What encourages local authorities to engage with energy performance contracting for retrofitting? Evidence from German municipalities. *Energy Policy*, 94, 317–330. DOI: <https://doi.org/10.1016/j.enpol.2016.03.049>
- Riahi, L.** (2015). *District energy in cities: Unlocking the potential of energy efficiency and renewable energy*. United Nations Environment Programme (UNEP).
- Roelich, K., Bale, C. S. E., Turner, B., & Neal, R.** (2018). Institutional pathways to municipal energy companies in the UK: Realising co-benefits to mitigate climate change in cities. *Journal of Cleaner Production*, 182, 727–736. DOI: <https://doi.org/10.1016/j.jclepro.2018.02.002>
- Roelich, K., Knoeri, C., Steinberger, J. K., Varga, L., Blythe, P. T., Butler, D., et al.** (2014). Towards resource-efficient and service-oriented integrated infrastructure operation. *Technical Forecasting & Social Change*, 92, 40–52. DOI: <https://doi.org/10.1016/j.techfore.2014.11.008>
- Scottish Government.** (2018). *Energy Efficient Scotland*. Scottish Government. <http://www.gov.scot/Publications/2018/05/1462/downloads>
- Sorrell, S.** (2007). The economics of energy service contracts. *Energy Policy*, 35(1), 507–521. DOI: <https://doi.org/10.1016/j.enpol.2005.12.009>
- Tingey, M.** (2020, November 23). *Local governance of energy initiatives: Struggles in assembling value*. University of Edinburgh.
- Tingey, M., & Webb, J.** (2020). Governance institutions and prospects for local energy innovation: Laggards and leaders among UK local authorities. *Energy Policy*, 138, 111211. DOI: <https://doi.org/10.1016/j.enpol.2019.111211>
- UK CCC.** (2019). *UK housing: Fit for the future?* UK Committee on Climate Change (CCC). <https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/>
- UK Government.** (2017). *The clean growth strategy: Leading the way to a low carbon future*. UK Government. <https://www.gov.uk/government/publications/clean-growth-strategy>
- UK Government.** (2020). *The ten point plan for a green industrial revolution*. UK Government. <https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution>
- UK Parliament Environmental Audit Committee.** (2020, May 18). *New inquiry: Energy efficiency of existing homes*. UK Parliament. <https://committees.parliament.uk/work/309/energy-efficiency-of-existing-homes/news/114729/new-inquiry-energy-efficiency-of-existing-homes/>
- Wade, F., Bush, R., & Webb, J.** (2020). Emerging linked ecologies for a national scale retrofitting programme: The role of local authorities and delivery partners. *Energy Policy*, 137, 111179. DOI: <https://doi.org/10.1016/j.enpol.2019.111179>

- Webb, J.** (2015). Improving innovation in UK urban district heating: The convergence of social and environmental agendas in Aberdeen. *Energy Policy*, 78, 265–272. DOI: <https://doi.org/10.1016/j.enpol.2014.12.003>
- Webb, J.** (2018). The challenge of effective energy efficiency policy in the United Kingdom. In *Transitions in energy efficiency and demand: The emergence, diffusion and impact of low-carbon innovation* (pp. 195–214). Routledge. DOI: <https://doi.org/10.4324/9781351127264>
- Webb, J., Hawkey, D., McCrone, D., & Tingey, M.** (2016). House, home and transforming energy in a cold climate. *Families, Relationships and Societies*, 5(3), 411–429. DOI: <https://doi.org/10.1332/204674316X14758447787663>
- Webb, J., Tingey, M., & Hawkey, D.** (2017). *What we know about local authority engagement in UK energy systems: Ambitions, activities, business structures & ways forward*. UK Energy Research Centre (UKERC) and Energy Technologies Institute (ETI).
- YES Energy Solutions.** (2019). *CIC report 2018–2019*. YES Energy Solutions. <https://www.yesenergysolutions.co.uk/about/company-reports>

TO CITE THIS ARTICLE:

Tingey, M., Webb, J., & van der Horst, D. (2021). Housing retrofit: six types of local authority energy service models. *Buildings and Cities*, 2(1), pp. 518–532. DOI: <https://doi.org/10.5334/bc.104>

Submitted: 21 January 2021

Accepted: 16 May 2021

Published: 23 June 2021

COPYRIGHT:

© 2021 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.

Buildings and Cities is a peer-reviewed open access journal published by Ubiquity Press.