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Financing grassroots innovation diffusion pathways: the case of UK community energy

Abstract

Exploring how finance can better support Grassroots Innovations (GIs), community-led solutions for net-zero transitions, we examine finance's role in the case of UK community energy (CE) across three 'diffusion pathways': *niche replication* (growth in the numbers of projects)*, individual scaling* (growth in organisational scale) and *collective diffusion* (confederation of GIs). We examine each through a nationwide survey, interviews and four case studies. We find that while finance currently supports *replication* of small-scale CE projects, the incompatibility between GIs and the wider finance meta-regime inhibits *individual scaling*. The UK CE sector has responded with *collective diffusion*, via business group intermediaries, attracting greater, but still limited, finance. Consequently, for GIs to diffuse effectively they must be supported to translate across both sectoral regimes (e.g. energy) and broader meta-regimes (e.g. finance). This paper contributes to theory on the role of finance in sociotechnical transitions and the role of intermediaries in GIs diffusion.

Keywords

Sociotechnical transitions; Grassroots innovations; Community energy; Intermediaries; Community finance; Finance

1 Introduction

Climate change and sustainable development have never been higher on the global agenda. To tackle them, the high-carbon economy must undergo transformative change. Grassroots Innovations (GIs) offer "promising new ideas and practices" to support this change GIs constitute civil society led sustainable development solutions, which deliver a 'triple bottom line' of economic, social and environmental value, and are built on the principles of local governance and democratic ownership[1] (Hossain, 2018; Monaghan, 2009). Importantly, they are highly 'place-based', offering "solutions that respond to the local situation and the interests and values of the communities involved" (Seyfang and Smith, 2007: 585). Common examples include Community Energy (CE), local currencies and eco-housing cooperatives (Grassroots Innovations, 2019; Hossain, 2018).

GIs "often struggle to scale up and spread beyond small niches" (Grassroots Innovations, 2019), meaning their impact has remained small and their potential underappreciated (Ornetzeder and Rohracher, 2013). GIs therefore often have only a limited impact on transitions, even in areas where they are established, such as CE in the UK. For example, only around 1% of the UK's power comes from CE energy generation (CEE, CES and CEW, 2021).

However, while GIs' impact is often marginal, there is reason to believe they have considerable potential. GIs in the energy sector are marginal in the UK but this need not be the case; as Yildiz (2014) shows, 34.4% of total installed renewable energy capacity in Germany is citizen owned[2]. GIs have an important role in building support for transition. For example, Middlemiss (2011) highlights a powerful role for community based organisations in supporting behavioural change around sustainability. And Warren and McFadyen, (2010) show how community ownership positively affects public attitudes towards renewable technologies. GIs, as "local and non-commercial" initiatives, make interventions more "authentic and trustworthy" easing their implementation (Burchell et al., 2014: 168).

To date, the deepest emissions cuts have been in sectors, like power generation, characterised by large-scale investments from commercial actors rather than smaller scale investments from non-commercial actors (e.g. transport, buildings) (CCC, 2021). Over the coming decades, however, harder to abate "demand-side" sectors will increasingly rely on interventions that challenge deeply engrained behavioural norms, such as opting for active travel, a plant-based diet or shifting the time of use of energy consumption at home (IPCC, 2022). Therefore, the strengths of GIs around building trust and support for change will increasingly be needed. Furthermore, with a strong focus on both environmental sustainability and social justice through democratic governance, GIs could offer a powerful means of ensuring that a transition away from fossil fuels embodies core principles of social justice (Belda-Miquel et al., 2020), i.e. where sustainable development is achieved whilst also ensuring "the benefits of climate change action are shared widely, while the costs do not unfairly burden those least able to pay, or whose livelihoods are directly or indirectly at risk as the economy shifts and changes" (Just Transition Commission, 2021: 13). Thus, despite a lack of diffusion of GIs in the UK to date, as Hossain concludes, drawing on a systematic literature review of 87 articles on GIs, GIs have a "crucial role" in sustainability transitions (Hossain, 2018: 64).

[1] GIs often assume more democratic legal forms like cooperatives, where there is 'one shareholder, one vote', versus the public limited company (PLC) model of 'one share, one vote'.

[2] This figures is based on a narrow definition, which includes the stipulation of over 50% voting rights within the organisations of local citizens. The figure increases to 47% where a broader definition is used, e.g. including municipal ownership.

Understanding the barriers to GIs diffusion is therefore an important task if we are to deliver a just, net-zero transition. While extant literature highlights several barriers to diffusion, e.g. a lack of resources (Middlemiss and Parrish, 2010) or unwillingness within grassroots movements to scale (Seyfang and Smith, 2007), the lack of availability of finance is regularly noted as a key obstacle (Hossain, 2016, 2018). For clarity, in this paper we define finance as unearned inflows of money that are wholly distinct from revenue [redacted], directed by 'financial institutions' and structured by a set of rules (see Section 3). As we argue later in this paper, there are shortcomings in the existing theoretical frameworks for understanding the role of finance in GIs diffusion. Moreover, research that specifically addresses the role of finance in shaping the diffusion of GIs is in short supply. Further, as far as we are aware, the paper is the first to examine the role of finance in what we term *collective diffusion*, diffusion through cooperative business groups.

This paper aims to explore this under-researched topic by examining the role different types and sources of finance have played in the diffusion of CE, taking the UK sector as a case study. In particular, we seek to address the following research question:

> What role has finance played in the diffusion of community energy across three different diffusion pathways: *niche replication, individual scaling* and *collective diffusion*?

This paper proceeds as follows. In Section 2 we draw on the existing literature to outline relevant research on financing of GI diffusion and our contribution to this research agenda. Section 0 presents the paper's analytical framework. Section 4 presents the paper's methodology. Section 5 presents our results, which we discuss further in Section 6. Section 7 highlights the implications of our research. Finally, in Section 8 we conclude by offering a brief summary of our findings.

2 Literature Review

This section reviews the literature on the diffusion of GIs, exploring the relationship between GIs and diffusion pathways (Section 2.1), the roles of finance in GIs diffusion (Section 2.2) and highlighting the role of cooperative business groups as form of intermediary (Section 2.3) notable for its absence in theories of GIs diffusion.

2.1 GIs diffusion pathways

A central concern in the GI literature is how GIs can achieve wide-scale diffusion in order to drive wider societal change (Hargreaves et al., 2013; Hielscher et al., 2011; Seyfang and Longhurst, 2013). To understand how GIs might drive transformational change, many scholars have positioned GIs within the Multi-Level Perspective (MLP), framing it as a form of niche innovation. The MLP is an analytical framework that explains technological transitions as the interplay of dynamics across three different levels: *niche* (small spaces of experimentation)*, regime* (consisting of incumbent actors in established sectors) and *landscape* (deeper, more stable structures, e.g. culture) (Geels, 2002; Markard and Truffer, 2008). Together, these levels exist as part of a nested hierarchy; the landscape being most stable and the niche the least.

More recently, the concept of the *meta-regime* has emerged which, as we shall argue below, offers promise as a means to better understand the role of finance in socio-technical transitions and integrate finance into the MLP. A meta-regime is less stable than the landscape level but given its connectedness across multiple sectoral regimes, it exhibits greater inertia versus the traditional regime (Kanger and Sillak, 2020). Schot and Kanger (2018) define the meta regime as the "rule-sets present in multiple socio-technical systems, coordinating their development and leading to a shared directionality" (2018: 1047). While, as Truffer and Markard (2008) explain, regimes are normally defined at the level of industries or sectors (like energy, transport or food) a meta-regime represents

a common logic embedded across numerous regimes, providing a shared direction of travel across countless socio-technical systems (Kanger and Sillak, 2020). Examples of a meta-regime include global mass production, which coordinated the production of goods in a range of regimes (e.g. food, mobility, and communications) post WWII; and digitalisation (Kanger and Sillak, 2020). Furthermore, a meta-regime's expansive nature means it can even shape landscape structure and dynamics (Kanger and Sillak, 2020).

Positioned within the broader Multi Level Perspective (MLP) framework, scholars have sought to understand the different ways in which GI niches might diffuse (Seyfang and Longhurst, 2016; Smith, 2007), with Seyfang and Haxeltine (2012) presenting three GI diffusion pathways:

- *Replication* – the duplication of multiple, similar scale niche innovations (Boyer, 2015; Seyfang, 2010; Seyfang and Longhurst, 2016);
- *Scaling up* - "enabling constituent projects to grow in scale" (Seyfang and Haxeltine, 2012) and move beyond a small network of committed activists (Boyer, 2015); and
- *Translation*[3] - "adoption of a grassroots practice at higher institutional levels and complementary structural changes in the adopting institution" (Boyer, 2015: 322).

It is important to highlight that successful diffusion may have varied impacts upon a regime. Smith and Raven (2012) frame two types of translation. The first – *fit and conform* - implies little change to the regime, where "the niche innovation is developed in such a way that it fits into and conforms to a relatively unchanged selection environment" (2012: 1030). The second – *stretch and transform* – sees elements of the niche become "institutionalised as new norms and routines in a transformed regime" (2012: 1030) and implies change to the regime and the wider selection environment.

2.2 Grassroots innovations diffusion and finance

Finance is a key barrier to GIs diffusion. For example, taking the case of community energy in the UK, the 2022 state of the Sector report found that financial barriers were a "key issue, specifically a lack of feasibility and/or development funding [and] difficulties raising capital funding" (CES et al., 2022: 7) while "loan rates were a significant barrier to project development" (CES et al., 2022: 14). However, the finance barrier should be seen in the context of other important barriers (Hossain, 2016, 2018). One critical barrier to *scaling up* GIs is that community groups may be unwilling to scale up their initiatives. This is potentially because growing in scale can jeopardise the GI's place-based value proposition, where solutions are tailored to a specific local situation and resonate with that community's interests and values (Seyfang and Smith, 2007). Instead, this place-based solution can be replaced with more impersonal and commercial values (Seyfang and Haxeltine, 2012). Where a willingness to grow exists, a key challenge is to retain an attentiveness to local communities' needs, whilst seeking wider diffusion beyond that local area (Smith et al., 2014).

In the GI literature discussion of finance typically relates to the difficulties GIs face in attaining grants and loans, and the challenges faced securing these due to community groups' lack of skills, knowledge and information about funding and financing opportunities (Hossain, 2018). Here, then, finance is conceptualised as a resource. However, hinting at the deeper processes behind the challenges faced by GI innovators, more recent literature, such as Smith and Stirling (2018), suggests that commercial investors are deterred from GIs because GIs are not motivated by the same

[3] Instead of increasing aggregate grassroots activity, translation relates to the ability of GIs to influence and alter regime practices; more often than not the values and behaviours of incumbent actors. Smith (2007) argues that the grassroots organisations best placed to successfully affect change in regime practices are those intermediately placed - between niche and regime - neither too radical nor too mainstream.

commercial logic. This observation resonates strongly with literature on the financing of environmental entrepreneurship and social enterprise (e.g. Davies et al., 2019); finance challenges persist where "different fundamental logics" exist between conventional investors, who prioritise "yields, security of the investment and accounting liquidity", and entrepreneurs who prioritise environmental or social values (Hörisch, 2015: 637). Supporting this argument, Hall et al. (2016) demonstrate that where the gulf between these logics is reduced, and the traditional commercial logic plays a diminished role in allocating capital, financial systems can play a more supportive role for GIs[4]. They cite the case of the municipality-owned banking system of Germany, which is mandated by the state to support, *inter alia*, energy transitions.

While finance is writ through the MLP, it is rarely dealt with explicitly, nor consistently. Exploring the role of finance in determining the prospects of innovations including GIs is a challenge within socio-technical transitions - specifically the MLP framework - because there is disagreement about how finance is best conceptualised (see **Error! Reference source not found.**).

Table 1: Characterisation of finance as artefact, resource, regime and paradigm

Finance characterisation	**Description**
Artefact	As per the MLP, finance is framed as an artefact and a critical part of the physical or tangible socio-technical system (Geels, 2004).
Resource	Aligned with the technology innovation systems (TIS) literature, finance is conceptualised as a resource that can support the maturation and scaling of innovation, much in the same way as skills, infrastructure or technology (Naidoo, 2020).
Socio-technical system and regime	Finance is framed as a stand-alone socio-technical system, governed by its own regime (e.g. Falcone et al., 2018; Geddes and Schmidt, 2020; Ryszawska, 2016); with its own "semi-coherent set of rules" of finance (Geels, 2002: 1260). Finance in this sense has its own identifiable system of actors (e.g. banks), instruments (e.g. loans, shares) and markets (e.g. stock market), which follow and maintain these rules.
Landscape / Paradigm	Finance capitalism constitutes a broader organising paradigm for how the economy functions, based upon a system of capital accumulation; the defining form of social relations in the modern world (Guttmann, 2016; Harvey, 2006; Lapavitsas, 2013)

Where finance has been conceptualised simply as an artefact or resource (Naidoo, 2020) this conceptualisation fails to account for the "semi-coherent set of rules" (Geels, 2002: 1260) embedded in the financial architecture which characterise financial flows. Conceptualising finance as a socio-technical regime in its own right (Falcone et al., 2018; Geddes and Schmidt, 2020; Ryszawska, 2016) benefits from acknowledging those "semi-coherent set of rules" as well as the actors (e.g. banks), along with the instruments (e.g. loans, shares) and markets (e.g. stock market) that follow and maintain these rules. However, it does not capture well the unique power of finance in shaping outcomes across multiple regimes. If finance exists at a higher level than the regime, is it then best conceptualised at the landscape level?

The finance-landscape conceptualisation is perhaps captured best by radical left perspectives of capitalism, where finance is described as a fundamental part of the capitalist paradigm; finance is

[4] The term used is 'civic energy' which includes both municipality and community owned energy ventures.

viewed as a key mechanism for governing capital accumulation, the defining form of social relations in the modern world (Guttmann, 2016; Harvey, 2006; Lapavitsas, 2013). As such, finance is central to capitalism to the extent that the modern social order is often described as finance-led capitalism (Guttmann, 2016). For Feola (2019) sustainability transitions research (STR) shares a similar perspective to these schools of thought in that, within STR, capitalism has been regarded as an aspect of the landscape. However, the author argues that STR differs from a capitalist-critical perspectives in that it considers capitalism as an "implicit given", with the result that the impact of capitalism on transitions has escaped "serious analytical examination" (Feola, 2019: 242). To overcome this, Feola (2019) argues for a rejection of the capitalism-landscape concept within STR, while still arguing for STR to adopt a critical perspective of capitalism.

Opening up a critique of the role of capitalism within MLP is to be welcomed. But it does leave the question unanswered of, if capitalism is not located within the landscape, where should it be located and conceptualised within the MLP? From our perspective, a finance-landscape[5] concept has the benefit of capturing the unique power of finance over other regimes. However, it is limited in its ability to account for varieties of capitalism, including their attendant financial architectures, from country to country (Hall and Soskice, 2001) or over time (Boltanski and Chiapello, 2005). We propose that a better conceptualisation of finance within the MLP would situate finance above the level of the regime but below the level of the landscape. Hence, we suggest that the meta-regime concept is a better fit with the realities of finance (we summarise our argument in Section 3).

2.3 Intermediaries and finance: the unexplored role of cooperative business groups

Intermediary organisations are attributed with a potentially important role in GI diffusion. However, the significant role of intermediaries as providers of finance receives little attention. In the context of GIs, Hargreaves et al. (2013) define intermediaries as:

> "organisations or individuals engaging in work that involves connecting local projects with one another, with the wider world and, through this, helping to generate a shared institutional infrastructure and to support the development of the niche in question" (Hargreaves et al., 2013: 870).

Hargreaves et al. (2013) explain that intermediaries play a variety of roles in supporting GI diffusion: aggregating knowledge; creating and maintaining an institutional infrastructure; coordinating the development of niches (see also Geels and Deuten, 2006). Taken together, intermediaries can be conceptualised as forming a *global niche*, consisting of actors which have some distance from niche projects, but provide support for multiple projects, including finance or knowledge, creating space in which local actors can operate more effectively (Geels and Raven, 2006).

While there is both support for and scepticism about the power of intermediaries in driving diffusion (Boyle et al., 2021; Hargreaves et al., 2013), extant work on their role in diffusion has largely been limited to government departments, NGOs and private sector partners (Hargreaves et al., 2013). This has left one specific form of intermediary, with a considerable potential in financing grassroots movements, under-researched: the cooperative business group.

A business group is defined as "an organisational model in which collections of legally independent firms bounded together with formal and informal ties use collaborative arrangements to enhance their collective welfare" (Colpan and Cuervo-Cazurra, 2018: 2). Business groups are a form of organisational confederation, i.e. a central organisation consisting of smaller formally autonomous

[5] Or perhaps a finance-capitalism-landscape concept.

groups[6] (Einarsson, 2012). They are an especially important feature within the cooperative movement and thus, by implication, GIs. Cooperative business groups are common because a confederation is a reproduction of cooperative logic, of democratic member control, at a higher institutional level (Soegaard, 1994)[7] and because they enable small individual cooperatives to retain a balance between autonomy and the benefits of cooperating over certain functions, e.g. marketing, distribution, or finance[8] (see Battilani and Schröter, 2012).

In these confederations, a central unit shares significant financial and operational interdependencies with the individual units. To provide a concrete example of the importance of the finance function of cooperative business groups, one of the best-known examples is the Mondragon group, headquartered in Spain's Basque Country. It is the world's largest consortium of worker-owned cooperatives (Roche et al., 2018), whose development was coordinated by a bank cooperatively owned by the member SMEs which is recognised as a crucial factor in the group's success (Bajo and Roelants, 2011).

Despite a clear association between cooperatives and GIs, links between GIs and cooperative business groups are rarely made. One exception is Bauwens et al. (2016), who highlight how a business group model has been applied to CE, with the aim of combining resources of multiple individual cooperatives. But as far as we are aware ours is the first attempt to integrate cooperative business groups, which we term 'collective diffusion' in Section 3 into a framework for understanding the role of finance in GIs diffusion in the MLP. Further, drawing the reviewed literature together we identify a critical need for research to explicitly examine the role of finance in supporting GI diffusion pathways and, in particular, the role cooperative business group intermediaries can play in helping attract finance.

3 Analytical Framework

This section outlines our analytical framework, comprised of three core components. First is our framing of: (1) community energy. The second and third elements relate to GIs more broadly: (2) GI diffusion pathways and (3) finance as a form of meta-regime.

In line with Smith et al. (2016) we categorise CE as a GI and adopt it as a case study. We also apply a selection criteria for data collection that adopts Walker's (2011) framing of CE. Here he defines community as a distinct *actor* and *network*; i.e. a coordinated collective of individuals brought together by networks and social relationships. Importantly, we also extend our definition to capture community as *place*, i.e. "a set of social relationships embedded in a particular locality" (2011: 778). However, connections may "extend beyond specifically place-based networks" (2011: 778) and see these networks extend outside a specific town or village.

We also frame community as a *process* and *identity*, where a community project is built on inclusive and collaborative action to deliver on collective interests. Finally, our definition is also sensitive to Walker's community as *scale*, i.e. "above the individual and households, but typically below the level

[6] Federation and confederation are sometimes used interchangeably in the cooperative literature (as is the term second-tier cooperative, second-generation cooperative, i.e. a cooperative of cooperatives). We prefer the term confederation as it better describes the power-structure of cooperative business groups; what distinguishes a confederation from a federation is that in a confederation "the local units have the decisive influence" (Einarsson, 2012: 57).

[7] Note that "Cooperation among Cooperatives" is one of the principles of International Cooperative Alliance (ICA, 2022)

[8] See

of local government" (2011: 778), adopting case studies that are fundamentally 'local' in their operations.

Building on Walker's definition, for the purposes of this study we define a CE project as follows:

> *An energy project initiated through grassroots action, which is wholly or partly-owned, delivered and managed by a community group, and whose mission is to deliver environmental, social and economic value for a specific place.*

Building upon the literature review we propose a new diffusion pathway, namely *collective diffusion*: *diffusion through a cooperative business group*. We should note that here we are expanding upon the concept of a Community Energy Confederation as outlined in our previous paper [redacted]. We acknowledge that diffusion pathways may not be mutually exclusive and CE may diffuse through a combination of these different pathways and could unfold sequentially. For example, *collective diffusion* will likely require elements of *individual scaling* and/or *replication* to have occurred first, so that there are sufficient grassroots actors to form a confederation.

We treat *translation* differently to Seyfang and Haxeltine (2012) and deal with it *not* as a distinct diffusion pathway, but as a critical stage all three of our GI pathways must pass through to affect change at the regime-level rather than a pathway in its own right. Importantly, this sees a two-way relationship between the GI and the regime actors. Here they simultaneously influence one other, potentially resulting in some degree of regime-level change. This change might be minor if the niche *fits and conforms* with the regime, or transformational if it *stretches and transforms* the regime, leading to structural changes in the status quo (Smith and Raven, 2012). It is also important to note that this translation can happen simultaneously across multiple regimes, as we explain in Section **Error! Reference source not found.**, and meta-regimes.

To summarise, the three diffusion pathways that form the basis of our analytical framework are defined below and illustrated in Figure 1, along with the final stage of *translation*:

- ***Niche replication*****:** Growth in the absolute number of GI projects, each of a similar scale;
- ***Individual scaling*****:** Growth in the average scale of individual GI projects;
- ***Collective diffusion*****:** GI projects become connected through intermediaries to form a more cohesive, collective business group (i.e. a form of confederation).
- ***Translation*****:** The end-point for the GI diffusion pathways, comprising a two-way interaction of the niche and the regime, with the potential for regime transformation.

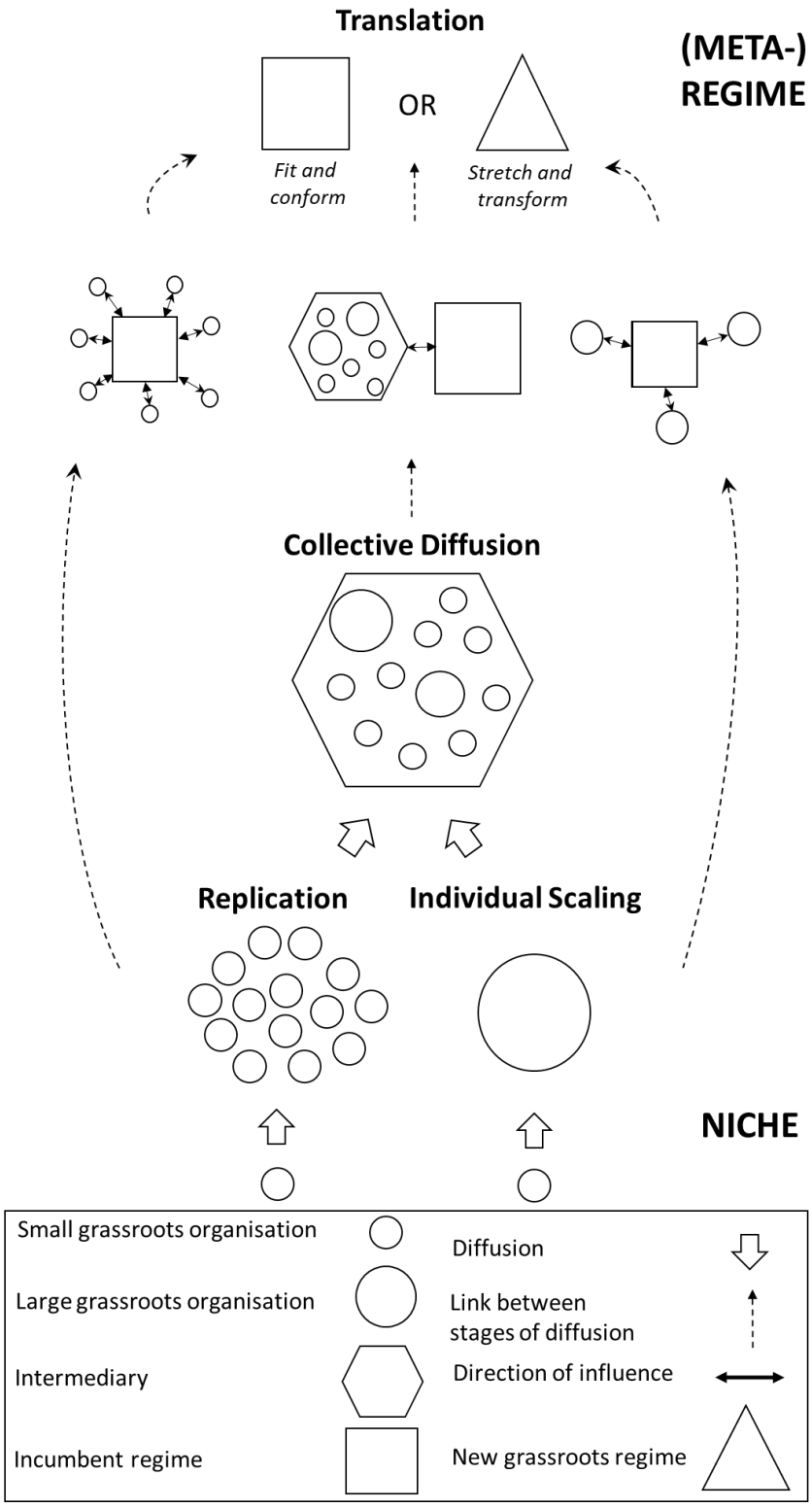


Figure 1 - Three grassroots diffusion pathways and one critical stage (adapted from Seyfang and Haxeltine, 2012)

Reflecting on **Error! Reference source not found.**, and how finance is conceptualized in terms of characteristics and its level of operation, we frame finance as situated somewhere between an economic paradigm (existing at the landscape level) and the socio-technical regime. We also view finance as its own stand-alone sector, home to its own actors, institutions, networks etc. The key difference however being that it exerts an influence that extends across many other sectors, by

dictating the 'rules of the game' regarding financial flows and thus shaping the structure and behaviour of other socio-technical regimes.

In this context, we situate finance at the level of the *meta-regime* (see Section 2.1). Drawing on the discussion of meta-regimes above, a finance meta-regime concept accommodates the "rule-sets" (2018: 1047) finance imposes in multiple socio-technical systems and its ability to shape landscape structure and dynamics (Kanger and Sillak, 2020). However, at the same time it is sufficiently distinct from the concept of the landscape to ensure that finance not be considered an "implicit given" (Feola, 2019: 242); a monolith whose immutable rules are near impossible to overcome. Hence, it allows for sufficient variation to enable the concept to also accommodate the many varieties of capitalism and financial structures which accompany them. In this context, we posit that an innovation may, on the face of it, possess a strong overall fit with a particular sectoral regime but will struggle for wider adoption if it fails to also fit with the guiding principles of the finance meta-regime.

4 Data and Methodology

Our mixed methods approach involved a number of steps. Firstly, to obtain a broad picture of the sector, we undertook a UK-wide survey. Drawing on lists of organisations accessed from Community Energy England (for England and Wales) and SCENE consultancy (for Scotland), as well as internet searches and sector events attendees, we identified 280 CE organisations in the UK and contacted them. Of these, 83 responded and 48 completed our survey, providing detailed project finances on 145 projects and business model data. Secondly, during 2018, we undertook 14 in-depth semi-structured interviews focussing on sectoral level developments with leading figures in the UK's CE sector, including policymakers, civil servants, activists, financiers, leaders of CE intermediary organisations, and legal experts (see Appendix A). These were built upon a further set of 18 interviews with individuals directly involved with establishing and running CE organisations, as well as those playing a supporting role such as investors, policy makers, and NGOs (see Appendix A).

Thirdly, this data was supplemented with sectoral level reports, produced by NGOs, government departments and CE intermediaries, such as company accounts, share offers, presentations, etc.

Drawing these different streams of data together we constructed four in-depth case studies of locality-focussed CE organisations, to explore at an organisational level how financing decisions are made and how they affected individual CE organisations:

- Brighton and Hove Energy Services Company (BHESCo) [redacted];
- Edinburgh Community Solar Cooperative (ECSC) [redacted];
- Green Energy Mull (GEM) [redacted]; and
- Gwent Energy CIC [redacted]

Fourthly, we undertook a case study of Energy4All to illustrate *collective diffusion* (Section 5.4). This built upon the interviews and documentary evidence cited above, plus an analysis of 32 CE share offers that have raised £34.5m since 1997, spread across 29 discrete energy projects and 18 cooperatives.

Finally, in 2018-19 four workshops with practitioners and stakeholders across the UK were undertaken to produce a long-term vision of a thriving CE sector and identify steps needed to realise the vision [redacted][9].

[9] An abridged version of the survey data and analysis is reproduced in Appendix F for the reviewers.

For the survey data we undertook cross-sectional analysis of organisational performance and finances, exploring, *inter alia*, the costs of finance for different financial instruments, controlling for the quantity of finance obtained, and the dependence of projects finances on price support (e.g. the FiT). A detailed account of survey data and analysis is provided in a previous paper [redacted]. Thematic analysis (Braun and Clarke, 2012) of qualitative data was carried out using NVIVo software. Investigator triangulation and data triangulation (Archibald, 2016; Denzin, 2017) were deployed, reducing researcher bias and improving the validity of findings. Case study reports were reviewed by leading representatives of the case study organisations, reducing factual errors, lessening misunderstandings and providing additional comment and insights.

5 Results: The role of finance in the diffusion of community energy

In the following sections we examine the role different types and sources of finance have played in the diffusion of CE across three different diffusion pathways: *niche replication* (Section 5.2)*, individual scaling* (Section 5.3)*, collective diffusion* (Section 5.4); and one critical stage: translation (Section 5.5). Before we do this, in Section 5.1 we present a brief overview of how CE is financed in the UK to provide context so that the following sections can be more easily understood.

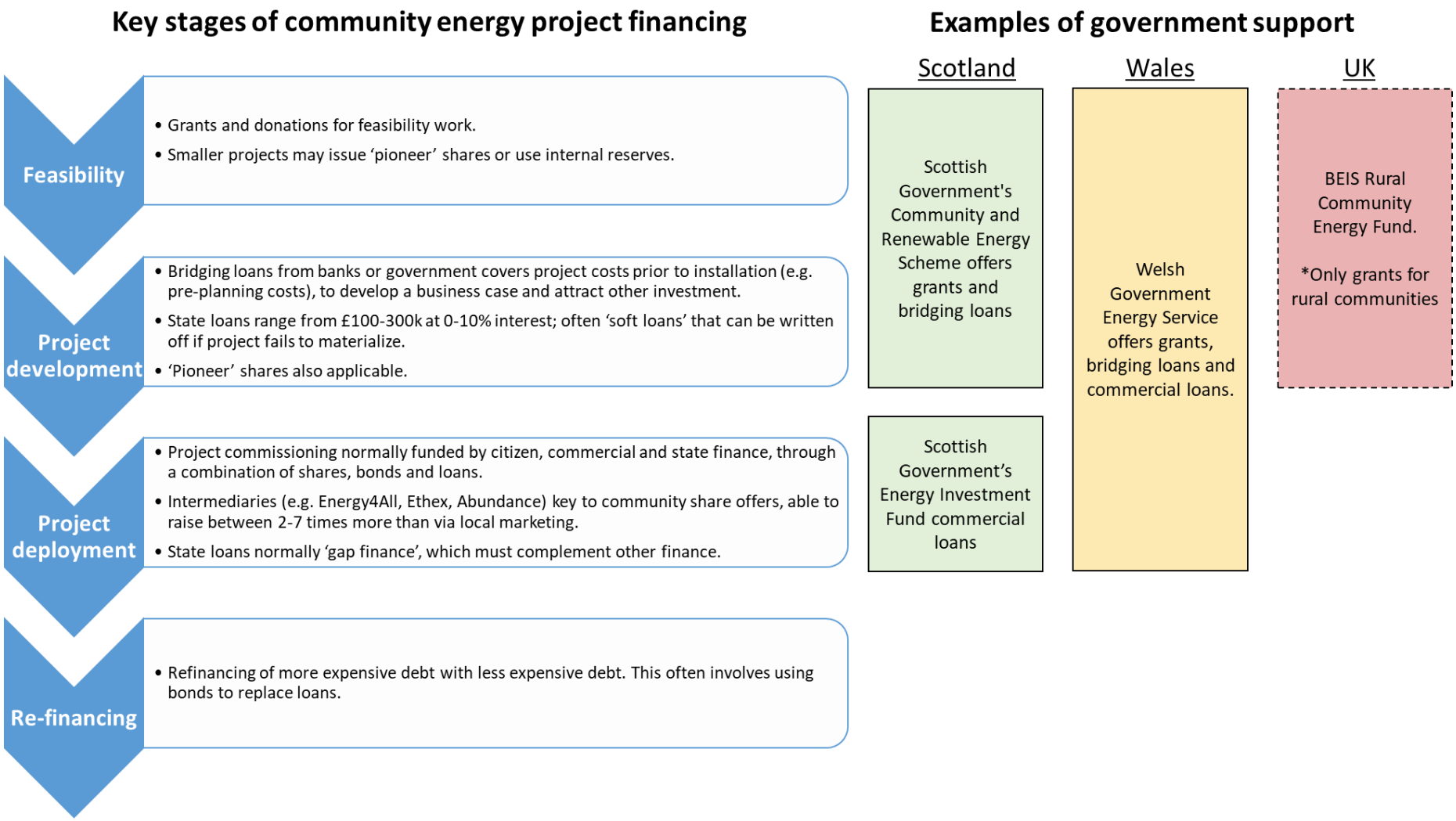
5.1 Overview of the finance of community energy

CE has drawn down a variety of different types of repayable finance but these can largely be categorised as either *community shares*, *loans* or *bonds* (Appendix B). Community shares are the most common form of finance in the CE sector [redacted] and constitute a form of equity issued by cooperative societies. Their popularity is in large part attributed to their affordability, with community share representing the cheapest form of finance available to the sector, with an average interest rate of 4.6% (see Appendix B). These shares are raised either via direct marketing, or through national energy-specific or generic community share platforms, synonymous with crowd sourcing (Appendix C), each carrying their own benefit in terms of cost (i.e. interest rate) and size of funds raised per share offer [redacted]. Another important factor is that they perform an important democratic function – critical to GIs - by creating membership of the cooperative on a “one member, one vote” basis (I9).

Despite these advantages, community shares do not represent the largest source of CE finance. Our survey identified that of a total of £42.8m of repayable finance, the bulk of this was invested via loans (£21.1m) and community shares (£18.8m), with £2.8m raised via bonds. These loans were sourced from a variety of sources, the majority being was from commercial lenders (69%) and public bodies (23%), although the cheapest finance was loans from directors, which were interest-free and accounted for £0.45m of lending (see Appendix D). However, the largest individual sums raised per project were achieved via bonds (£923,000), followed by loans (£556,304) and then shares (£209,370) (see Appendix B).

Different types of finance are appropriate to different stages of CE project development, from feasibility through to refinancing (Figure 4). Whilst (community) shares, loans and bonds are pivotal to later stage project deployment, it is soft loans and non-repayable finance such as grants and donations that are most critical to the earlier, higher risk, stages of project development.

Figure 2: Community energy finance chain and associated government support



Source: authors' own research

Importantly, this finance chain has until recently sat alongside two flagship subsidies that have provided long-term price guarantee schemes to incentive deployment of small-scale, decentralised renewable energy generation: the Feed-in Tariff (FiT) and Renewable heat incentive (RHI) (Table 2).

Table 2: UK long-term price guarantee schemes

Policy	Key characteristics	Period
Feed-in Tariff (FiT)	Paid for between 20-25 years for each kWh of renewable power generated (below a certain capacity), plus export tariff for supply to grid.	2010–2019
Renewable heat incentive (RHI)	As above but no export tariff, seven year term and only for renewable heat.	2014–2022

Appendix E outlines how a combination of the FiT and RHI accounted for between 10% and 79% of the total revenue across our four case studies. The discontinuation of the FiT in 2019 and significant reductions to some tariffs available through the Renewable Heat Incentive (e.g. non-domestic biomass) have presented a major challenge to CE groups. It is important to note that these price guarantee schemes have traditionally provided much of the revenue needed to repay interest on finance. For the 101 projects in our survey that received a price guarantee, we found that removing these guarantees entirely would see only 22% continue to generate a surplus, versus 92% of projects in 2018 [redacted].

Another important subsidy was investment tax relief via the Enterprise Investment Scheme (EIS) and Enterprise Investment Scheme (SEIS), which allowed investors to reduce their tax liability by between 30% and 50% of the value of the shares they buy, up to a total investment of £150,000 (REACH, 2021). However, in 2015, this was discontinued for CE organisations, and was excluded from their successor, the Social Investment Tax Relief (SITR) (CEE, 2019).

5.2 Niche replication

In terms of community finance, community shares are the dominant means of financing the bulk of smaller scale projects and play a leading role in the *replication* of small-scale CE projects. CE projects whose CAPEX is below £200,000, cover 90% of their upfront costs through community shares, whilst projects up to £1.5m saw only about half of their CAPEX covered by shares [redacted]. However, in a similar fashion to share raising via national platforms and intermediaries (e.g. Energy4All, see Section 5.4.1), locally marketed share offers can also result in investment being drawn in from outside of the local community. As the case of GEM illustrates, only "*two thirds of those investors are pretty much from on the island [of Mull] or from people with close associations with the island*" (I21). Whilst not always the case, this can run the risk of diluting the community's degree of autonomy.

Community Finance extended beyond shares to include loans and to a lesser extent bonds (Appendix A). Appendix D illustrates how over £628,000 in community loans was sourced across 15 projects, from a combination of citizens and directors of community groups. Whilst these were on average relatively small loans (ranging from £19,436 to £75,475), the weighted average rate of interest for citizen loans was low at 5.2% and interest-free from directors. One respondent from Gwent Energy CIC pointed to how this funding could be relatively easily sourced too:

> "*I spoke for about five minutes and it took us about 15 seconds to write down the names of people who were offering to lend us about £15,000 … That's the model we've used thereafter*." (I15)

State support is critical to the helping CE organisations raise finance for their projects, especially long-term price guarantees like the FiT and RHI (Section 5.1). However, these have now been discontinued or are scheduled to end shortly. The FiT's replacement – the Smart Export Guarantee – represents a much less lucrative subsidy[10]. What remains are policies designed to support utility-scale generation projects, which are the reserve of multi-national companies, such as the Contracts for Difference (CfD). BHESCo, which was the least reliant on revenue payments out of our four case studies (Appendix E), no longer believed it could offer the same attractive terms that helped it secure over £500,000 in community share finance by 2018 (I25). The removal of tax-relief for investment in CE cooperatives had a similarly damaging impact (Section 5.1). Together, these interventions have undermined the business case for CE and therefore hindered CE groups' ability to draw in mainstream finance.

The state has also provided small sums available for feasibility studies and project development, the public sector aides the proliferation of small CE enterprises (Figure 2). State agencies provide funding at the earliest and riskiest stages when communities have no assets and when high risks prevent private sector lending (I2). Grants and unsecured 'project-success-contingent' loans (i.e. soft loans) protect individual members of the community from risking their own wealth to access capital (I5).

We identified little evidence of commercial finance supporting replication of small-scale CE projects. Instead, commercial finance has focused on larger scale projects (Section 5.3).

5.3 Individual scaling

In terms of community finance, community shares on average yielded no more than £209,370 per share issue and £739,731 per organisation (Appendix A) suggesting they are limited in their ability to provide finance for larger-scale projects. Importantly, however, community groups have achieved larger share raises via nationwide platforms versus local marketing. Here, innovative 'alternative finance' platforms that have emerged outside of the traditional financial system, such as Ethex or Crowdfunder, delivered on average seven times more share investment than local marketing alone (the sums are £706,984 and £98,802 respectively (Appendix C). Similarly, energy-specific marketing via intermediaries like Energy4All yielded larger share raises too (Section 5.4.1 for detail). This highlights how the way in which shares are raised has an important bearing on their potential to support larger-scale projects.

Whilst typically used to date for refinancing purposes (I7; I9), bonds were actively being explored by BHESCo as a means of raising funds for a much larger district heating scheme. Given they offer more secure returns, a clear end-date for (re)payment and potential tax relief (e.g. Innovative Finance ISAs) versus shares, they are thought to potentially appeal to a different kind of investor and bring in an additional finance stream that could unlock larger, more costly projects (I28).

In terms of public finance, price guarantees (see Section 5.1 and 5.2) are an important intervention for individual scaling, with the withdrawal of this support also damaging for larger scale CE projects.

Loans, underwritten by the state, are an important means of financing individual scaling. These offer sizeable investment, with the weighted average value of public loans £690,000 – roughly half the £1.46m available from commercial sources (Appendix D). Concerns were however raised by participants about these state loans being move expensive versus other loans. At almost 8% interest,

[10] Significant decline in tariff value during the 2010s prior to scrapping in 2019. Replaced by the 'export only' Smart Export Guarantee in 2020, which offers much lower tariffs per kWh.

public loans were 2 percentage points higher on average versus commercial loans and almost 3 points higher versus citizen and third sector loans.

Taking the example of GEM, to deliver its 400 kW run of river hydro scheme, it accessed a £434,000 fixed-rate loan from Scottish Government via its Energy Investment Fund (EIF) at 7% interest but a cheaper £500,000 variable rate loan from the ethical lender Charity Bank at 5.25% [redacted].

These high interest rates have often meant projects were simply not financially viable: "these projects are not working with bank finance at six, seven, eight per cent" (I2). The high interest rates associated with state lending can largely be attributed to state lenders inability to offer finance at a rate that would undercut private lenders, in case it distorts competition. Loans from individual citizens, Directors and other third-sector organisations are not constrained by the same rules and can thus offer finance below the average market-rate.

In terms of private finance, commercial loans are already helping community projects to achieve scale, helping communities raise on average £1.46m per loan, at a weighted average interest rate of 5.8% (Appendix D). This is a significant sum of finance, and surprisingly at a rate only marginally higher than that offered via citizen or third sector loans (Table 3). There was also one case of a commercial bond, raised by Triodos for a community wind farm, totally £1.75m.

Superficially, debt finance appears to be the ideal solution for scaling-up CE beyond community shares. However, it is problematic for a number of reasons. First, it implies an erosion of community logic; taking on expensive debt from banks means that CE projects risk becoming "all about servicing that loan and not about generating community engagement" (I17). Community groups may also fear that, as banks secure the loan with company assets as a condition for lending, "the bank could then end up owning the project and not the community" (I4).

Second, most commercial banks are disinterested by community ventures (I1, I12). They were often unfamiliar with niche social enterprise legal structures (I12) and projects were also "of a scale that's not interesting to the banks" (I1).

Where commercial finance has been forthcoming, this has typically been sourced from "a very limited pool of lenders" (I12), who understand the sector, in particular ethical investors like Thrive, Close Brothers, Social and Sustainable Capital, Charity Bank, Pure Leapfrog and Abundance. These are described as "ethically focussed" lenders (I12), who concentrate investment in projects with clear ethical and/or environmental goals. Importantly however, our case studies of BHESCo [redacted] and Green Energy Mull [redacted] revealed how these ethical investors shared a similar appetite for scale compared to the larger institutional lenders: "we were actually too small for Triodos. They were looking at £2m plus schemes" (I21).

Some CE activists resisted approaching these 'ethical' lenders banks, because they still operated with a commercial ethos that they felt undermined their community's autonomy (I25). Examples of included these lenders' preference for debt seniority, using community assets as collateral and the diversion of surplus revenue away from the community, as interest payments (I17; I29).

Equity investment (e.g. shares) is also problematic for commercial investors. First, withdrawable shares are less attractive to commercial investors given they cannot be traded with third parties and cannot increase in value (Community Shares Unit, 2019) (Appendix A). Second, commercial investors may be deterred because withdrawable shares offer insufficient legal security (I18). Whilst, the Financial Services Ombudsman (FSO) settles disputes between sellers and purchasers of ordinary shares, it plays no part in regulating withdrawable shares. Third, withdrawable shares have a cap of

£100,000 on individual investment, limiting the scope for significant commercial investment (Community Shares Unit, 2019). Fourth, because of fiduciary duty to shareholders, it is debateable whether commercial firms are able to invest in withdrawable shares (Sandberg, 2011). The lack of sizeable commercial investment is symptomatic of a poor fit between CE and the wider finance meta-regime.

5.4 Collective diffusion

One of the most mature examples of CE collective diffusion is encapsulated by the work of the Energy4All group of cooperatives. Energy4All was founded in 2002 by Baywind Energy Cooperative, the UK's first community wind farm co-operative (established in 1996), to encourage the diffusion of CE across the UK. It has become one of the leading CE intermediary organisations and has a membership of 28 independent renewable-energy co-operatives, together with 13,250 individual members (Energy4All, 2021a).

It derives its income from the services it offers cooperatives, including managing project development, construction, operations and most importantly for this paper, finance (Energy4All, 2014, 2019) (Figure 3). For example, ECSC have a ten-year contract with Energy4All, who is paid an annual fee of 9% of turnover for its management, administration and secretarial services (ECSC, 2015). Aligned with the principles of GI, any surpluses are only used to develop the business (Energy4All, 2020).

Energy4All is owned by the cooperatives to which it provides services, affording them control over how the business is governed[11]. Conversely, its member co-ops typically agree to include an Energy4All representative on their boards. As well as providing them with a 'voice' through co-ownership, as a shareholder, individual co-ops also have 'exit power' (Hirschmann, 1970), being under no obligation to receive services from Energy4All. Tying this together, Figure 3 illustrates Energy4All's focus on a virtuous cycle of project development:

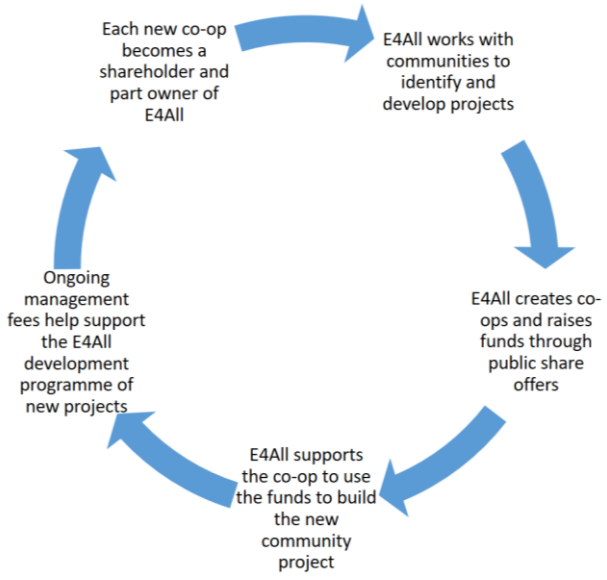


Figure 3: The Energy4All Development Model (Energy4All, 2021b)

[11] 30 shares at the nominal sum of £1, each is owned by one of the 20 cooperatives serviced by the company, with the remaining shares split between Baywind Energy Cooperative (3 shares), another cooperative which was an early project for Energy4All (2 shares) and Enegy4All's five directors (Mutuals Public Register, 2018; Energy4All, 2021b).

Energy4All has both a direct and indirect influence on CE organisations' ability to finance their activities.

5.4.1 Direct influence on finance

Energy4All exhibits considerable success in sourcing finance. It is often thought of "*fundamentally, [as] an investor community*" (I10). Up to June 2020 Energy4All had raised over £81m in debt and equity across its 26 energy cooperatives[12], equating to approximately £3.1m raised per organisation (Energy4All, 2020). The core of its finance model revolves around community shares. Since 1997, it has raised £34.5m in community shares to deliver 845 MW of renewable generation capacity, equivalent to an average £1.2m of community share raised per project and £1.9m per organisation.

The scale of investment raised per project compares very well against other means of raising community share finance. For example, Energy4All was able to raise 11 times more on average per project versus a local marketing approach and 69% more versus general share raising platforms (e.g. Ethex) [redacted]. Energy4All has also been very successful at securing considerable amounts of capital, with two out of three of its share offer campaigns either meeting or exceeding the targeted share value. However, this also means that Energy4All has fallen short of meeting the targeted amount of share finance for a third of prospective projects, meaning alternative sources are required.

One such avenue is Energy4All's supported loans, primarily through three routes:

1. Its investment arm - the Energy Prospects Cooperative (EPC) - which provides mainly short-term loans for early stage project development;
2. B2B loans from its cooperative member organisations;
3. Overseeing issuance of public loan notes.

The cost of the finance raised by Energy4All was however more expensive versus other avenues. The expected[13] share interest over the lifetime of Energy4All projects was on average 5.71%, versus an average of 4.25% for local marketing 4.33% for general platforms. This means that for an average raise of £1.19m, an additional 1.4%[14] would equate to an additional £17,400 in interest in the first year. This constitutes a significant increase for small non-profit organisations. It also makes the interest rate more expensive versus most forms of loan, even commercial (Appendix D). It is important to note, however, that all but one of the 15 share offers since 2016 were 5% or lower.

Unlike generalist UK-wide platforms (e.g. Ethex), which are equally open to investment from outside the community as to locals, Energy4All first markets its offer to the local community and only if this fails to raise the required amount, does it take the offer to its larger network [redacted; Energy4All, 2019). For example, the case of ECSC points to how 80% of the shareholders and around 70% of the £1.5m share capital was sourced locally, i.e. Edinburgh, by Energy4All (I17).

This points to the trade-off faced by CE organisations, where they can raise greater sums of share finance but often only if investment is secured from outside the local area and at higher cost. This in turn can erode the community's degree of control and ability to retain profits locally, with (higher) share dividends leaving the local area. As one interviewee explained, where insufficient sums are raised locally "*it's the investor community, which is … not necessarily geographically associated with*

[12] This excludes the Energy Prospects fund.
[13] This is the interest rate E4A expected to pay to its investors, as outlined in its share offers. The actual return on investment may have differed.
[14] The difference between 5.7% and 4.3%.

the project, that's … benefiting largely from the scheme" (I10). On the other hand, we might also recognise that where Energy4All are a decisive factor in enabling the scheme to be realised, there would be no community benefit whatsoever without Energy4All involvement.

Rumbling Bridge Community Hydro's £3.4m 500 kW project was Energy4All's largest project that did not source debt finance from outside Energy4All's investor network (Rumbling Bridge Community Hydro Society, 2018). Typically though, the Energy4All model was insufficient to independently finance the largest CE projects alone and consequently investment was drawn in from outside its investor network. For example, Energy4All's largest project - Westmill Wind Farm Co-operative – saw Energy4All raise £4.6m to deliver a 6.5 MW wind farm but £3.8m of this was a loan from the Co-operative Bank[15] (Co-op Energy, 2011; Mutuals Public Register, 2019). Similarly, as part of its move to become the sole community owner of the 6.9 MW Mean Moor wind Farm, the High Winds Cooperative secured a £3.5m refinancing loan from Triodos Bank (High Winds Community Energy Society, 2020). This last example points to how an Energy4All cooperative, with the support of commercial debt finance, was able to raise sufficient sums to 'buy-out' a commercial energy project, rather than establishing their own.

5.4.2 Indirect influence on finance

Indirectly, Energy4All acts as a reservoir of sector-specific knowledge and experience for project development, which individual start-ups are unlikely to possess but can still access via Energy4All. This strong track-record and expertise lends communities legitimacy and helps to de-risk projects; both of which are critical to convincing investors to invest. In the case of ECSC, Energy4All's input was pivotal to persuading the local council to support a services contract with ECSC to deliver (then) the largest community-owned solar farm in Scotland (I17).

By situating itself as the hub to the broader business group, Energy4All plays a critical role in facilitating knowledge exchange between these cooperatives about 'best practice' business models and finance mechanisms to support CE. In effect, Energy4All has been refining its special purpose vehicle (SPV) cooperative model since the formation of Baywind in 1996 and subsequent ventures, like ECSC, were very much built on a proven formula of CE, built on a cooperative models and financed primarily by community shares [redacted]. As such, Energy4All offers a powerful mix of "*industry experience, community involvement, ethical investment and business acumen*" (Energy4All, 2019).

One important critique of this model, however, is that communities can become highly dependent on Energy4All, for both energy sector and financial expertise (I4, 19). It also relies heavily on these community groups being sufficiently experienced to be able to critique what Energy4All was recommending (I20).

5.5 Translation of GI principles to the finance meta-regime

The growth of sustainable and ethical finance is seen by some CE practitioners (I7; I29) as evidence of a growing alignment between the finance meta-regime and the underlying grassroots principles of GIs such as CE. Thrive Renewables (established by Triodos Bank in 1994) or Close Brothers, are good examples of the trend towards more sustainable, ethical investment funds. However, despite some optimism amongst practitioners that money divested from fossil fuels will flow into low-carbon decentralised energy (I7; I29), CE organisations have yet to become major beneficiaries of ethical finance.

[15] The interest rate charged on the loan is not disclosed.

Instead, we find a fundamental mismatch between the prevailing logic of the finance meta-regime and the investment needs of CE groups. First, as is evident in Section 5.3 and Appendix D, CE organisations continue to struggle to secure sizeable sums of commercial investment from institutional investors, such as through debt finance. The largest commercial loan for CE we identified was a £10m loan to Point and Sandwick Trust for a windfarm on Lewis, although this was something of an outlier and remains very small compared to the loans on offer for utility scale renewable projects (e.g. offshore wind).

Second, the qualities that make investment in fossil fuel companies attractive to mainstream commercial investors, including liquidity, scale and high returns on investment (RoI) (Ritchie and Dowlatabadi, 2015), are not normally associated with the CE sector. Instead of prioritising liquidity, communities prize patient capital, supplied by a local and engaged population. Community shares have become highly popular amongst communities because they satisfy these needs as they cannot be sold to third parties but only bought back by the co-op or BenCom at face value (i.e. no capital gain) (I9). Consequently, commercial investors will often feel that withdrawable shares are "*too illiquid [and/or] too long term*" (I7).

Turning to scale and the return on investment, CE projects are normally associated with the scale of local communities (i.e. small) and returns are tempered by the prioritisation of social and environmental benefits, captured for instance by the reallocation of profits via community benefit funds. With a focus on the former (scale), one practitioner puts it, "*it's not very easy for [pension managers] to … invest … fifty million in community energy, even if they wanted to*" (I13).

Third, the ethos of most CE groups, especially BenComs and cooperatives, is that control is distributed equally across the community, by adopting a 'one shareholder, one vote' model. However, commercial investors investing large sums will invariably demand control commensurate with the size of their investment and thus "*expect more than one vote*" (I11). If the community did relinquish equity to a commercial investor, possibly even majority control, this would undermine the CE objectives of increasing local autonomy and retaining financial flows locally.

Fourth, even though the public sector has intervened, introducing new rule sets into the finance meta-regime to support small scale development, thus far this has been insufficient to drive widespread diffusion of CE. The devolved administrations in Scotland and Wales have moved to address a shortage of capital investment for small scale ventures (Figure 2). In Scotland, for example, the Scottish Government-backed Energy Investment Fund operates as a secondary lender to supply small sums of capital and de-risk investment for private banks [redacted]. Conversely, smaller scale projects receive limited finance support from UK government.

Between 2012, when the UK-Government's Green Investment Bank (GIB) was established, and 2017, when it was privatised, the GIB had made little meaningful investment in community owned energy projects and "*not addressed the problems which community energy schemes have in accessing finance*" (House of Commons Environmental Audit Committee, 2014: 27). Again the small-scale nature of CE was blamed by the then Chief Executive of the GIB: "*It is very difficult to do that in chunks of £1 million or £2 million for a community project; we have to invest that in chunks of £25 million and above*" (House of Commons Environmental Audit Committee, 2014: 27). One practitioner explains that government "*likes us but they don't take us seriously because we're small fry*" (I9), fuelling a positive feedback cycle that perpetuates the small-scale nature of CE.

6 Discussion

In the discussion we highlight four key findings: (1) the different mixes of finance applicable to different diffusion pathways; (2) the role of collective diffusion in financing GI diffusion; (3) how different diffusion pathways interact with one another; and (4) the limits of alternative finance in driving diffusion.

6.1 Different finance for different diffusion pathways

CE projects take something of a pragmatic *bricolage* approach to finance, drawing on different types of finance to deliver projects. The result is that different forms of finance play varying roles across the three different diffusion pathways. *Replication* can take place almost exclusively through provision of community finance (e.g. shares), albeit normally underpinned by public sector subsidy (e.g. FiT). *Individual scaling* however is much more reliant on larger-scale public (e.g. gap funding) and private (e.g. commercial loans) sector finance to achieve scale. *Collective diffusion* is open to all three sources of finance but to date has relied largely on a niche-based investment network built around nationwide citizen crowd-sourcing and B2B loans from other cooperatives.

Echoing earlier work (Boyer, 2015; Seyfang and Smith, 2007), CE groups were also highly dependent on earlier stage public sector investment and subsidies, with a focus on de-risking projects, often through provision of soft loans, gap funding, tax breaks and long-term revenue payments (e.g. FiTs). However, much of this support has been removed of late (Section 5.1), most notably the FiT, rendering many traditional generation-oriented CE projects uneconomic and dissuading private and community investors from investing.

We also find that different types and sources of finance are inter-linked and typically rely upon and even unlock each other. For example, government 'gap funding' loans normally require majority match funding from the private sector, whilst community shares are normally raised post-feasibility studies, typically funded by government grants. In this context, we find the GI finance chain is both highly inter-connected and thus susceptible to disruption, where the removal of a single form of finance can have a cascade effect, which can be devastating to GI diffusion.

6.2 Collective diffusion: the third diffusion pathway

This paper makes a novel contribution to the literature on GI diffusion pathways by introducing a new pathway: *collective diffusion*. As evidenced by the case of Energy4All and UK community energy, we find business group intermediaries have both a direct and indirect influence on GI finance.

Directly, *collective diffusion* builds a larger network of investors to ensure larger scale projects can secure finance. The network of niche-to-niche financial support (e.g. loans between business group cooperatives), coupled with crowd-sourced citizen investment, has driven a virtuous cycle of project development that has enabled the CE sector to steadily diffuse.

Indirectly, these business groups play a key role in de-risking grassroots projects and making them more appealing to investors, by providing: a) a network to exchange best-practice between communities; b) access to a strong track record of project development; and c) consolidating administration services to offer economies of scale (Bauwens et al., 2016). Furthermore, having focal point intermediaries like Energy4All, who orchestrate the *collective diffusion*, means that a single organisation is able to construct a strong track-record and reputation for deploying GI projects versus a community doing this for the very first time. This is critical to instilling confidence in investors and securing finance.

Also important, is the fact that *collective diffusion* can support *individual scale-up* in a way that resists the erosion of community autonomy. Here the CE business group can grow, whilst the ultimate authority is retained by local communities. This is integral to the value proposition of grassroots action. As such, it offers one potential solution to the challenge common in GIs of balancing attention to localities, while simultaneously creating wider impact (Smith et al., 2014).

Finally, we note an interesting development whereby the *collective diffusion* pathway has enabled communities to buy-out projects that were originally established by commercial developers (Section 5.4.1). This offers some evidence of the GI niche making inroads into the wider commercial energy and finance regime, and potentially eroding the prevailing finance logic.

Collective diffusion does, however, have some important drawbacks. First, where the necessary sum of project capital cannot be raised from the local community alone, finance will normally be sourced from outside the local area, undermining autonomy and leading financial surplus to leave the locality. Second, we note how reliance on a third party – such as Energy4All - can undermine a community's own capacity building efforts (e.g. skills, knowledge) (Section 5.4.2). Third, the model, as applied to date for CE in the UK, does also still align with many of the principles of the traditional finance meta-regime, by promising a relatively attractive interest rate (~4%) and thus potential for financial gain. Fourth, the case of UK CE points to how attractive finance via *collective diffusion*, as well as the other two pathways, has been highly reliant on long-term revenue payments (e.g. FiT, RHI) and it remains to be seen whether Energy4All's model will remain viable now these have been discontinued. Finally, despite the successes of *collective diffusion* (e.g. Energy4All), and the emergent trend of ethical finance, GIs are now reaching the limits of finance available through community, public and private sources.

Through a combination of investor networks and human capital, then, *collective diffusion* provides considerable support for GI diffusion, while working to minimise a weakening of GI logic. However, it does still involve some erosion of that logic, by aligning itself with elements of the dominant finance regime logic (e.g. transfer of autonomy, focus on investor return on investment), whilst still not lending GIs sufficient scale to enable them to access the much greater sums of institutional finance.

6.3 Combinations of diffusion pathways

The three GI diffusion pathways are not mutually exclusive. Instead, they can blend into one another, with hybrid configurations of these pathways emerging. In the case of *collective diffusion*, we note that the emergence of intermediaries and business groups like Energy4All succeeded through a combination of initial *replication* and *individual scaling* efforts. In simple terms, there was already a critical mass of CE organisations, mostly small-scale energy cooperatives that had struggled to scale-up individually[16]. There was therefore the necessary network of actors and understanding of a 'gap in the market', for a business group to form.

Even so, there is likely to be a sequential nature to these pathways, with *replication* likely the first pathway deployed, followed by *individual scaling* and then *collective diffusion*. The extent to which latter stage pathways (e.g. *collective diffusion*) are implemented will likely depend on the success of earlier stage pathways (e.g. *replication*). If early niches are able to endure, *collective diffusion* may emerge as a means to help niches navigate the regime by creating a more supportive infrastructure to support individual GIs (i.e. Energy4All's investor network). Thus, while Bauwens et al. (2016) find that collective action is a reactive strategy, designed to overcome challenges faced by individual

[16] In economics these spill over benefits of sufficient 'critical mass' of activity are known as agglomeration externalities (Devereux et al., 2007).

actors within the sector, *collective diffusion* may also constitute a more proactive strategy, aimed at providing greater infrastructure to support niche activities.

6.4 The finance meta-regime and the financial 'glass ceiling'

Our work expands upon previous literature that has concentrated on single-regime and/or single-technology frameworks (Seyfang and Longhurst, 2016), to highlight how GIs have to 'fight on multiple fronts' to either *stretch and transform* or *fit and conform* across different regimes.

On the one hand, GIs must identify a strong fit with their sectoral regime - energy in the case of CE - in order to secure customers, forge partnerships and generate income. On the other, it must also achieve a strong fit with the wider finance meta-regime, to attract sufficient sums of affordable finance from non-energy sector specific investors to deliver their projects.

To some extent there are likely to be synergies between the meta-regime and regime, considering they have co-evolved and are now strongly intertwined. This means a GI may be tackling regimes with similar characteristics to the meta-regime. For example, the current centralised and liberalised energy regime prioritises many of the same principles as the centralised and liberalised finance regime, i.e. scale, return on investment and replicability.

Even so, in the case of CE, we find a GI niche that is increasingly aligned with the objectives of the energy regime, with its growing focus on net-zero carbon future and a just transition, whilst at the same time struggling to achieve compatibility with the wider finance meta-regime. In this sense, a GI may share a relatively strong fit with the sectoral regime but not the meta-regime.

In this context, we find that CE has rarely struggled to source small to moderate sums of finance for energy projects via 'alternative finance', such as citizen crowd-sourcing, government loans or ethical lenders. Notwithstanding some estimates of vast untapped potential of 'alternative finance' (Pons-Seres de Brauwer and Cohen, 2020), this has not unlocked the step-change in finance that GIs demand to become wide-spread. This is largely because the bulk of capital is held by large financial institutions, targeting large-scale, profitable and replicable projects. This world-view is fundamentally at odds with the principles of GIs. This dynamic stymies the flow of finance and subsequent GI diffusion, meaning they struggle to *translate* GI principles into the regime. Consequently, the traditional finance logic goes unchecked and perpetuates itself, fuelling a positive feedback that locks out the financing of large-scale GI projects.

GIs, such as CE, are thus caught in a bind and face two options for scale-up. The first, is that they wait in the hope that the finance meta-regime reconfigures through a combination of niche and landscape pressures - in a way that sees it look to structurally re-align around GI principles (i.e. *stretch and transform*) (Section **Error! Reference source not found.**). Considering how tied up this meta-regime is in the architecture of all sectors and how intertwined it is with the prevailing orthodoxy of capitalism, this type of transformation will meet fierce resistance. The second, is that GIs should look to change their own characteristics and improve their fit with the prevailing selection environment of the finance regime, (i.e. *fit and conform)*. However, echoing Seyfang and Haxeltine (2012) and Smith et al. (2016), championing scale, profit and replicability over delivering bespoke solutions that deliver economic, environmental and social value for local communities runs the risk of undermining the very principles the GI organisation was established to champion. Doing so can undermine its connection with 'community as place' (Walker, 2011) and with it the unique value propositions GIs offer.

There is little evidence of the translation of GI principles to the status-quo and thus of a *stretch and transform* scenario, where the regime is transforming in line with niche innovations. Neither is there

much evidence of CE adopting a *fit and conform* approach to regime integration. CE projects continue to exhibit the guiding principles of GIs and have done little to fundamentally re-design their business models to offer a more attractive investment proposition to traditional investors, who seek liquidity, return on investment and scale. Instead, CE finds itself 'caught in the middle'. Here it continues to rely on finance from alternative investment channels, primarily citizen 'crowd sourcing' and ethical investors but also seeks to achieve greater scale and efficiencies via *collective diffusion*.

Collective diffusion, via business group confederations, has helped communities to raise larger sums of finance and scale-up, whilst retaining the essence of what a GI offers. Even so, this approach has yet to see communities achieve a step-change in the level of finance secured. In effect, *collective diffusion* has raised the 'glass ceiling' for GI investment but has not removed it, with clear limits on the scale of finance that can be secured. This will instead require broader structural change in the finance meta-regime via targeted top-down interventions but also bottom-up innovations (Section **Error! Reference source not found.**).

6.5 The applicability of our findings and analytical framework

This paper has operated on three levels of abstraction: 1) GIs in general, 2) CE as one example of GIs and 3) financing CE in the UK, our case study. Our framework and findings have focused on CE in the UK, showing how the UK's finance meta-regime has shaped the fortunes of CE groups and presents a 'glass ceiling' for CE innovators who seek to scale their organisations. What we have not yet addressed is to what extent our framework and findings are applicable to CE outside the UK or GIs more generally.

Regarding CE outside the UK, in our literature review we argue that the finance meta-regime concept, by being positioned at a less stable level than the landscape, is better able to accommodate the variety of financial architecture that exists from place-to-place or time-to-time. Our findings in relation to the variation in finance available across the UK, as a result of devolution in Scotland and Wales, therefore provide support for the greater applicability of a finance meta-regime concept over that of the landscape. The meta-regime concept appears yet more applicable when we consider international comparisons, where yet greater variation is evident. We noted previously that Hall et al. (2016) attribute the markedly greater success of citizen energy in Germany compared to the UK to the different financial systems of the two respective countries. Finance and its different 'rule sets' are a key factor in determining the success of community energy in Germany in comparison to the UK, or, to a lesser extent, in Scotland or Wales in comparison to England. Here the meta-regime concept within the MLP framework provides a lens through which this variety can be more clearly conceptualised.

Regarding GIs more generally, our framework and findings chime especially with work which describes an incompatibility between mainstream commercial finance and other values, such as social good or environmental protection (Hörisch, 2015). This implies a whole range of innovators are hampered by an unaccommodating finance meta-regime. And, in fact, there is evidence for this. Davies et al. (2019), for example, conclude that for social enterprises, "financial constraints are consistently the most difficult barrier to overcome" (2019: 1617). The implications of our findings and framework, therefore, extend well beyond CE to other GIs and social enterprises more generally.

Focusing again on GIs, we find that some GIs are likely to be impacted more than others. Like Davies et al. (2019) details regarding social enterprises, we find that the greatest financial challenges arise when capital for growth or development is sought. Thus, GIs for which larger quantities of capital are necessary for growth are likely to be those most badly constrained. CE is a prime example of GIs

which are capital intensive. Others include GIs focused on other expensive assets, such as those associated with housing, e.g. eco-housing, or waste management facilities. Yet while our research suggests barriers to GIs stemming from a fundamental mismatch in values, it offers a chink of light; unlike landscapes, meta-regimes are not "implicit givens" (Feola, 2019: 242), they are highly variable and can be shaped to be more aligned to sustainably transitions, as Germany's example shows in Hall et al. (2016).

7 Implications for policy makers, practitioners and researchers

Our research has a number of implications for practitioners and policy makers (Section 7.1) and recommendations for future research (Section 7.2).

7.1 Policy and practice

For GIs to attract significant levels of commercial finance, there is need for 'top-down' changes to the finance meta-regime.

First, GIs are having to achieve fitness across multiple regimes and 'fight on multiple fronts'; both the sectoral regime (e.g. energy, food, transport) and a cross-cutting meta-regime (e.g. finance, legal). Incompatibility with either of these will stymie attempts at diffusion. Therefore, sector specific interventions will likely prove insufficient (e.g. energy policies and regulation) for meaningful GI scale-up. Instead, we must simultaneously look to implement complementary changes to both the sectoral regime and the wider meta-regime(s) if GIs are to prosper. For CE this might involve stipulating that energy suppliers supply a specific share of their power from local sources (*sectoral* intervention), whilst also offering tax breaks for investment and low-interest public loans for community owned organisations (*finance* intervention).

Second, the financial system would need to be restructured in such a way that both reflects and supports grassroots values, most notably the prioritisation of democratic ownership, not-for-profit and a triple bottom-line. Examples of policy interventions might include the establishment of municipality-owned banks (Hall et al., 2016) and member-led financial institutions, such as credit unions. Yet, given the scale of finance required for transition and the urgency of the problem (Aglietta et al., 2015), stronger state intervention is likely needed. This could take the form of central bank guidance to commercial banks for delivery of 'just transition' projects (e.g. like China's 'window guidance' approach (Dikau and Volz, 2021)), alongside targeted support for GIs, such as subsidies (e.g. grants, community FiT) or interest-free loans from national investment banks. The fossil fuel divestment trend, for example from pension funds, could also provide GIs with a boon and see significant sums of previously locked up investment become targeted at sustainable and ethical projects. Finally, concerted support for ethical finance amongst incumbent finance institutions will yield larger sums of GI finance. Examples include the Financing a Just Transition Alliance, which brings together over 40 banks (e.g. HSBC, Barclays) and investors to "translate the growing commitment to a just transition across the financial sector into real world impact" (LSE, 2021).

On the assumption that *fit and conform* with the traditional finance regime would largely undermine GI principles (Section 6.4), we consider how 'bottom-up' niche-level actions could help to increase the flow of finance for GIs beyond the large, incumbent financiers. To achieve this, GIs could form new alliances with smaller-scale and locally focused lenders, which also exhibit some of the same GI design principles (e.g. not-for-profit, member owned), such as credit unions, mutuals or building societies.

Alternatively, drawing on the Mondragon example, the CE sector might explore establishing its own dedicated bank, owned and run by member groups (and so an alternative model of sourcing finance

through *collective diffusion*). Such a bank could leverage deposits to further scale investment in the sector, avoiding the problem of surpluses being extracted from CE projects by a network of private investors. Another action is to broaden the remit of GI intermediaries involved in the *collective diffusion* pathway (e.g. Energy4All) to other sectors. This could see finance flow across sectoral boundaries, rather than just within them. Finally, experimenting with business models that are more resilient to the reduction or removal of subsidies, such as the Pay-As-You-Save [redacted], might make finance easier to secure in the absence of state support.

7.2 Future research

Future research could usefully explore the adoption of the *collective diffusion* pathway in other countries' energy sectors and other sectors more broadly. Research is also needed to examine whether the meta-regime concept can help identify other areas that might need to be restructured if GIs are to achieve transformation of the individual socio-technical regimes within which they are currently struggling. One clear candidate is the legal meta-regime, which clearly intersects across all other sectors but like finance, possesses its own guiding logic depending on the national context. The intersections between meta-regimes (e.g. finance and legal), and how they impact upon GIs would also benefit from greater academic attention.

As highlighted in Section 6.4, there are question marks about whether GIs – like CE – are fundamentally unsuited to scaling-up. There is a pressing need for further research that interrogates the business models and value propositions of GIs, to better understand the ways in which scale can fortify or undermine GIs' value proposition for local communities. Insights here could in turn help to identify whether finance should be targeting the *replication* of a much greater number of small-scale GI organisations versus *individual scaling.*

Finally, we noted in our introduction that GIs are a potentially positive force for a just transition. Further to this, we suggest that there is potential in terms of delivering a just transition by restructuring the financial system in a way that better supports GIs. For example, a transition towards a finance system with a far stronger role for community-owned banks, such as credit unions (as suggested in the previous section), would mean not only greater support for GIs but also that greater returns on investment would accrue to local community actors, rather than private (high net worth) individuals. However, whilst our paper examines the ways that finance helps or hinders GIs diffusion along different pathways, we have not focused on: 1) which pathways (or combinations of pathways) offer the greatest synergies with a just transition; nor 2) the best ways to finance these pathway to maximise their impact on social justice. Hence, there is a role for future research to explicitly address these two important issues.

8 Conclusions

Taking the case of UK community energy (CE), this paper has sought to understand how GIs are financed and the critical role finance plays across three different grassroots innovation (GI) diffusion pathways: *niche replication, individually scale-up* and *collective diffusion.*

Across all pathways, CE groups took a pragmatic *bricolage* approach to securing finance, essentially securing a wide range of finance as and when it became available. Even so, different types and sources of finance suit different stages of GI project development (e.g. public for feasibility and private for deployment). Taken as a whole, these different types of finance form an inter-connected and delicate finance chain, where earlier types of finance unlock other forms later on, typically by de-risking the project. Consequently, removing a single link could prove catastrophic to GI project delivery and wider niche scale-up. Furthermore, we find that the lucrative public subsidies, like the

FiT, have underpinned inward investment from both citizens and the private sector. Their absence seriously threatens the viability of the established model for financing CE.

Finance also plays a variety of roles across different GI diffusion pathways. We find that there is a relative abundance of finance available for CE groups to scale-up via *niche replication*, that boosts the absolute number of GI projects, each of a similar scale. This has mostly been via a combination of community shares (equity) and loans (debt) from the state and ethical investors. Where CE groups have struggled however is in securing finance to *individually scale-up* and deliver increasingly larger projects. This is primarily because the bulk of finance resides with institutional investors, who target large-scale, profit generating projects, which are not the focus of community groups, who instead focus on creating value in a much broader sense (economic, environmental and social) for a specific local community

A third GI diffusion pathway has emerged in response to this predicament: *collective diffusion*. This is where GI projects become connected through intermediaries to form a more cohesive, collective business group, with a view to access larger sums of democratic finance. Our case of Energy4All points to how this approach has enabled CE groups to access more finance versus operating independently, via an investor network of citizens and other cooperatives. Indirectly, it offers investors and customers a more compelling offer by relying on single, experienced intermediary to capture both greater economies of scale and legitimacy.

Despite this innovation, CE is still unable to access the large-scale institutional investment, necessary for it to become widespread. Whilst *collective diffusion* has raised the potential sums of finance individual CE groups can access, it has done so at the cost of the loss of local control and benefit. And CE groups are still limited in the sums of finance they can raise (maximum ~£5m), due to an incompatibility with the finance meta-regime. This lack of scale feeds into a negative feedback cycle, whereby the GI remains niche and is unable to apply pressure on the wider regime to its advantage.

To capture significantly more commercial finance, GIs would need to adapt their business model to ensure a stronger fit with the finance status quo (e.g. scale, profit, investor control etc.) but in doing so, would likely betray the very GI principles they were founded on (e.g. local impact, not-for-profit, democratic control, etc.). To enable GIs such as CE to break out of their niches, the finance meta-regime requires restructuring, and while GIs are driving some of this 'from below' (e.g. supply and demand for ethical finance), intervention 'from above' by the state could accelerate and enlarge the scope for GI adoption and wider sustainability transitions.

Within the current finance structures in the UK, GIs are having to achieve fitness across multiple regimes and 'fight on multiple fronts'; both the sectoral regime (e.g. energy, food, transport) and a cross-cutting meta-regime (e.g. finance, legal). Incompatibility with either of these will stymie attempts to scale-up. Therefore, for widespread diffusion to occur, sector specific interventions will likely prove insufficient (e.g. energy policies and regulation). Instead, we must also look to meta-regime(s), which operate at a higher level of abstraction, to make complimentary changes that will enable GIs to prosper.

Let us conclude this paper with some brief reflections on the role of finance of GIs pathways on just transitions, which we highlighted in the introduction as being central to the GIs movement. We suggest that there is much to gain in terms of reducing social inequalities from restructuring the financial system in such a way as that it better supports GIs. For example, a transition towards a community bank-based finance model, would mean that return on investment accrues to community organisations, rather than private (high net worth) individuals. Still, evidence from

Germany suggests that greater community and municipality banking will not be enough . The impact on struggling communities could be further enhanced if low-income neighbourhoods were prioritised as hosts for these new finance institutions, bringing new jobs and income. Further, these institutions could be mandated to prioritise investment not only in GIs but in GIs in low-income areas. GIs-friendly financial institutions could reinforce established GIs' commitments to just transition, for example by including investment terms which stipulate how a minimum portion of surpluses might be directed towards low-income or other excluded groups. Related to collective diffusion, investment terms should anchor or establish not just community organisations but also intermediary organisations - with their higher-skilled and well paid employment - in low-income areas, i.e. investment being dependent on intermediaries basing their operations in areas where well paid employment is scarce. There is also a role for window guidance and financial regulation, imposing sanctions against finance organisations who cannot demonstrate how investments promote sustainability, alleviate hardship and promote equality. Once we accept the logic that low risk, large scale and high return on investment are not the primary factors which should determine the allocation of financial resources within a society, space is created for deliberation about what other values should determine financial flows. This can serve to support GIs but also a just transition.

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Appendix A - List of interviewees

Code	Position	Type of org.	Date
I1	Renewables manager	Energy supplier	30.7.18
I2	Manager	Government energy department	30.8.18
I3	Independent consultant	Energy consultancy	26.7.18
I4	Project Officer	Community energy intermediary	20.7.18
I5	Energy Systems Manager	Delivery body for government funds	2.8.18
I6	Energy Specialist	Non-departmental public body for enterprise	2.8.18
I7	Investment Manager	Social investment organisation	9.8.18
I8	Director	Social investment company	9.8.18
I9	Director	Community energy association	10.8.18
I10	Political advisor / CE campaigner	Environmental charity	13.8.18
I11	Director	Renewable energy developer	17.8.18
I12	Partner in law firm	Law firm	30.8.18
I13	CE campaigner	Environmental charity	4.9.18
I14	Director	Government energy specialist	18.9.18
I15	Director	Community energy organisation	7.9.18
I16	Environmental activist	Environmental community organisation	29.9.18
I17	Project Officer	Community energy intermediary	11.9.18
I18	Board member / former councillor	Community energy organisation	3.10.18
I19	Board member	Community energy organisation	23.10.18
I20	Manager	Environmental community organisation	19.11.18
I21	Director	Community energy organisation	11.10.18
I22	Director	Community organisation	18.10.18
I23	Research and Development Engineer	Distribution Network Operator	1.11.18
I24	Energy Strategy Manager	Distribution Network Operator	1.11.18
I25	Director	Community energy organisation	12.10.18
I26	Non-executive director	Community energy organisation	25.10.18
I27	Director	Community energy intermediary	26.8.18
I28	Director	Social investment platform	6.11.18
I29	Director	Community energy organisation	3.9.18
I30	Project Officer	Community energy organisation	8.10.18
I31	Business Development Manager	Social investment platform	27.9.18
I32	Project manager	Community energy organisation	8.10.18

Appendix B - Common sources of repayable UK community energy finance

Mechanism	Issuer	Term and repayment.	Securitisation	Transferability	Governance	Notes	Average interest rate of finance per instrument[17]	Total finance raised	Average finance raised per project	Average finance raised per organisation
Loans	'Ethical' investors (e.g. Thrive Renewables, Charity Bank, Close Brothers, government programmes (see Figure 4), state-backed funders (e.g. Scottish Investment Bank) or loans from local organisations and individuals[18].	A fixed, regular and legally enforceable payment schedule against both principal and interest. Penalties incurred for defaulting payments.	Banks loans are typically secured against the community assets.	N/A	Lenders do not get voting rights, but may have various 'charges', i.e. rights, over the assets of the company if it is unable to meet payments.	Intermediaries can (e.g. Energy4All) offer loans through their investor community; typically other community organisations. Early-stage project loans from the state may be 'soft' and thus be written off if project fails to deliver. State-backed lenders can also act as a junior lender, unlike institutional investors who are normally the senior lender.	4.2% (n=38)[19]	£21,139,575	£556,304	£1,006,646 (n=21)

[17] Data extracted from survey presented in [redacted].

[18] Community organisations may also issue loans to members of the local community [redacted]. However, these loans cannot be offered publicly and only to members of a Common Interest Group, e.g. a group of local people associated with the organisation. Given onerous financial regulations, these loans are rare (ibid).

[19] Number of loans we know the interest rate of, from our survey.

Community shares	Shares issued by co-operatives or a Community Benefit Society (BenCom). Marketed either directly by community group or via intermediaries, such as general online platforms (Ethex, Crowdfunder, Abundance) and energy intermediaries (Energy4All).	Shareholders paid interest (not fixed), and capital repaid, typically over 20 years. Repayments decided annually by board of directors and subject to AGM approval. Provides cooperative with flexibility in terms of timing and level of repayments.	Unsecured	Shares are *withdrawable* and not *transferrable*. The coop or BenCom will buy back at face value (i.e. no capital gain), subject to funds and cannot be sold to third parties.	Shareholders become members and attain voting rights, normally on a 'one member, one vote' basis.	Inexpensive Cheaper to issue versus transferrable shares because of lower regulatory compliance: approximately £700 versus £10,000 per share offer (I12; I20).	4.6% (n=90)	£18,843,284	£209,370	£739,731 (n=25)
Bonds and Debentures	Borrower issues bonds or debentures, through broker or direct to individuals on an online platform.	Legally enforceable, regular and fixed interest payments over the 'term' of the bond; principal repaid at 'maturity'. Term is typically 5 – 20 years.	Bonds secured against company assets. Debenture secured against company revenue (deemed less secure).	Can be traded with a third party but sale nor price are guaranteed. Investment tied up for the full term of agreement, so investor unable to access it.	Do not give holders a vote in the business.	To date, bonds typically used more as a means of refinancing, to replace more expensive bank loan liabilities, once a project is generating predictable revenue (I7; I9). Bonds can be eligible for tax	5% (n=3)	£2,769,000	£923,000	£923,000 (n=3)

						relief (through Innovative Finance ISAs).				

2 Adapted from {redacted]

Appendix C - Community shares by marketing mechanism

Marketing mechanism	Count (no. share issues)	Total raised	Mean raised per share offer	Mean interest rate weighted by size of loan
General online platforms	9	£6,362,856	£706,984	4.94%
Energy specific intermediaries	38	£7,881,930	£207,419	4.38%
Local	43	£4,598,498	£106,942	4.36%
Total	**90**	**£18,843,284**	**£209,370**	4.57%

NOTE: Table shows data from a UK wide survey from 145 CE projects run by 48 CE organisations conducted in 2017/18

Appendix D - Community energy loans by source, count, value and interest rate

Source of loan	Count	Amount	Average raised per loan	Mean interest rate weighted by size of loan[20]
public	7	£4,827,000	£689,571	7.9%
commercial	10	£14,624,800	£1,462,480	5.8%
third sector	6	£1,060,000	£176,666	5.5%
citizen	9	£174,925	£19,436	5.2%
directors	6	£452,850	£75,475	0%
total	**38**	**£21,139,575**	**£556,304**	**6.1%**

NOTE: Table shows data from a UK wide survey from 145 CE projects run by 48 CE organisations conducted in 2017/18

Appendix E – Case study revenue payment income as a share of turnover for financial year 2017/18

Organisation	Revenue payment subsidy income	Turnover (year end 2018)	Share of revenue	Source
GEM	£191,252 (FiT)	£242,366	79%	(GEM, 2019)
ECSC	£129,242 (FiT)	£215,474	60%	Survey
Gwent Energy CIC	£40,000 (FiT and RHI)	£100,000	40%	I15
BHESCo	£27,625 (FiT and RHI)	£281,146	10%	(BHESCo, 2019)

[20] Calculation for weighting: [(size of loan 1 * interest rate of loan 1) + (size of loan 2 * interest rate of loan 2) etc. to loan n] ÷ [sum of sizes of all loans]

Appendix F - Survey design and data collection (for reviewers)

[This is an abridged version of what we have published elsewhere but which we have been unable to reference in this anonymised version our paper without compromising the anonymity of the review. It is presented here for the benefit of the reviewers]

The survey questionnaire covered characteristics of community energy organizations, and of the projects they run. With regard to organizations, it included the legal structure, annual turnover, numbers of paid staff and volunteers, and numbers of members. In relation to each project, topics included energy activities (including electricity or heat generation and energy efficiency), ownership (sole or partnership type), financing (for example, details of each instrument type, value, terms), resources employed (including sites, technical, financial and legal services, general administration), costs (operating and financing), revenues (values and sources), value propositions (a range of economic, social and environmental propositions), customers (for example, types and rates paid) and other beneficiaries.

These categories were based on the Business Model Canvas approach to analysing business models, adjusted to take account of the project's particular interest in financing mechanisms, and the characteristics of the community energy sector as the project team understood it.

Pre-set multiple choice formats were used as far as possible to facilitate data coding and quantitative analysis. Some free-text qualitative questions were also included, particularly in relation to organizations' future plans.

The questionnaire was piloted in October/November 2017 with three community energy organizations. Only minor changes were made after the pilot process, and the pilot data form part of the survey dataset analysed in this paper. The full survey was launched in November 2017 and closed in May 2018.

The survey was available to complete online or by telephone interview with the project team. Two methods of completing the survey were offered because the team were conscious that community energy is a heavily surveyed sector. Allowing research participants to choose the most convenient participation method ensured the survey achieved sufficient responses for a meaningful quantitative data analysis, while also reducing the administrative burden on research participants. Ideally, we would use only one method of data collection, because using different methods may affect the quality of the data. Although we attempted to minimize this concern by ensuring that the online and telephone data followed a standardized framework, we cannot rule out that inconsistent data collection methods have resulted in measurement error in our data. This is a limitation of the study.

In total the researchers contacted 280 organizations, of which 83 responded and 48 completed the survey, providing data on 145 projects. Not all projects are included in all the analysis presented here. Complete data were not available for some projects, limiting the kinds of analysis that could be performed. Further, some projects were classified as 'stalled or on hold', and so by their nature did not have complete data. Data were collected on an additional eight projects using published accounts and reports only. These data were included to provide greater coverage of the hydro, wind and solar ground-mount technologies, but are not otherwise used in the analysis.

Performance and financial analysis

This paper uses data collected for a single year of project operation. Therefore, we provide a cross-sectional analysis that involves looking at the sector at a moment in time rather than assessing how it changes over time. It is particularly important to bear this in mind for the project performance characteristics: because generation, revenue and operating costs may vary considerably from one year to the next, these data may not be representative of project performance in other years.

Although data were collected between November 2017 and May 2018, as noted above, the data do not relate to the performance of projects during the months the survey was open. Rather, organizations reported data that relate to a 12-month period, more specifically, the most recent financial year for which data on the project were available. As the data measure project performance over a 12-month period, they will reflect project performance over a sustained period of time rather than during an individual month or season of the year. Furthermore, we do not typically expect that community energy projects will vary that much in terms of their performance from one year to the next, especially in a systematic way (such that variations over time would not average out across projects when performing statistical tests, for example, when performing *t*-tests of means). Nonetheless, we cannot be sure that information during one 12-month period is representative of a different 12-month period. This is an issue with any cross-sectional dataset.

The absence of data with a time dimension means we also do not aim to assess performance over the lifetime of a project, for example, by measuring the internal rate of return. Likewise, we analyse costs in terms of cost per unit of kW h of generation rather than the LCOE.

To better understand the importance of financing characteristics for community energy projects, we explore whether there is a statistical relationship between the interest rate (cost of finance) and the instrument type. We are particularly interested in comparing community shares with loans because the majority of community energy projects are financed using these instruments. (Grants are also a common source of finance but do not charge interest.) To do this we first note that the mean interest rates for community shares and loans in our sample are 4.58% and 5.58%, respectively. The difference in means is 1.01 percentage points. Performing a *t*-test on the equality of the mean rates, we find that the means are statistically different at the 1% significance level (*t*-statistic of 3.03). Thus, community shares charge on average a statistically lower interest rate than loans.

A comparison of means may, however, be misleading because the size of the finance obtained and the financing term (duration) may also influence the interest rate. We therefore compare the difference in interest rate between community shares and loans while holding these other characteristics constant. We do this by estimating a linear regression model. We proceed by defining three dummy variables that capture the instrument type:

CommunityShare = 1 if the financing instrument is community shares, and CommunityShare = 0 if it is not community shares.

Bonds = 1 if the financing instrument is bonds, and Bonds = 0 if it is not bonds.

Loans = 1 if the financing instrument is loans, and Loans = 0 if it is not loans.

Although all three instrument types are included in our model, we need to include only two of these three dummy variables in the regression equation. We choose to include the CommunityShare and Bonds dummy variables. Therefore, Loans is the base group (or benchmark or omitted group) and is the group against which comparisons are made. We choose loans as the base group because we are

especially interested in looking at the difference in interest rate between community shares and loans.

We then estimate the linear regression model given by equation:

$$\mathrm{IR}_i = \beta_1 + \beta_2 \mathrm{CommunityShare}_i + \beta_3 \mathrm{Bonds}_i + \beta_4 \mathrm{Size}_i + \beta_5 \mathrm{Duration}_i + \epsilon_i$$

where the dependent variable IR is the financing interest rate of financing source *i*. IR is a continuous variable that can take non-integer values. CommunityShare and Bonds are defined above. As explained previously, we compare how these financing instruments are associated with the interest rate relative to the omitted category, which is loans. In this equation we also include the variables Size and Duration to control for the size and duration of the financing instrument, respectively. Size is defined as the monetary value of the financing source (in £ millions) and Duration is a dummy variable equal to 1 if the finance term is 240 months or more, or indefinite/not specified, and 0 if a relatively short-term duration (less than 240 months). β_1 to β_5 are coefficients to be estimated. Finally, ϵ is an error term. We estimate regression equation using ordinary least squares.

Each observation on financing source *i* belongs to an organization that may use one or more sources of finance for its community energy project(s). Outcomes for different financing sources within organizations are likely to be correlated. As we cannot assume that the error term is independently distributed within organizations, we cluster standard errors at the organization level.

In our equation, the continuous variables (IR and Size) enter in levels. An alternative approach that allows for a non-linear relationship between the dependent and explanatory variables is to enter the continuous variables in logarithms. We find our results are robust if we use a logarithmic functional form (the results are available on request). However, here we present the results with variables in levels because in this case the coefficients have a percentage point interpretation.

We now present the results from the estimation of regression. Here we report the estimated coefficients with cluster-robust standard errors in parentheses. For each estimated coefficient, we also report the *t*-statistic that we calculate to test the null hypothesis that the population coefficient equals zero.

We find, *β*^1 = 5.124(0.585) and *t*-statistic = 8.76, *β*^2 = −2.016(0.706) and *t*-statistic = –2.85, *β*^3 = −0.653(0.667) and *t*-statistic = –0.98, *β*^4 = 0.185(0.091) and *t*-statistic = 2.02, and *β*^5 = 1.452(0.777) and *t*-statistic = 1.87. Finally, the *R*-squared from the regression is 0.2457 and there are 118 observations.

The estimated coefficient for the dummy variable CommunityShare (–2.016) indicates that there is a difference in the interest rate between community shares and loans of 2.016 percentage points on average in our sample while holding constant the size and duration of the finance. The *t*-statistic indicates that this difference is statistically significant at the 1% level. To put this finding into perspective, the average size of an individual financial instrument (that is, a single loan or share issue) in the regression sample is about £306,000. Therefore, for the average project, the annual interest payment for the first year would be on average lower by £6,168.96 (2.016% of £306,000) if financed by community shares rather than loans. This does not take into account compound interest and repayments in later years of a project; it is simply intended to illustrate what the interest rate differential between loans and community shares means, in terms of actual amounts a community

energy project might pay in interest on the initial principal sum. In the paper, the figures given are rounded for greater readability: thus, we mention a “2 percentage points” difference in interest rates and an average repayment differential of “about £6,200”.

We also find that projects financed by bonds do not have an interest rate that is significantly different from loans. In addition, we find that instruments that have a longer duration and larger value have higher interest rates on average.

We investigate whether these results are sensitive to outliers. We do not find any evidence of observations with large estimated residuals that may affect the estimates. We also investigate the distribution of the dependent and explanatory variables by inspecting the raw data and by using a leverage-versus-squared-residual plot. From this analysis we identify two observations with large leverage on the estimated coefficients due to outlying values for the explanatory variables. However, our central findings on the difference in the interest rate between community shares and loans are robust to dropping these observations from the analysis. Therefore, they do not affect our conclusions.

The impact of the removal of price guarantee schemes is calculated by simply subtracting all price guarantee scheme revenue (FITs, RHI or RO) from total project revenue, project by project, for the single year of revenue data that we collected. It is important to note that, for the FITs, projects retain the tariff rate for which they initially qualified for the rest of their lifetime, including an inflation adjustment; unlike the RO, the FITs is not subject to annual variations in price due to market conditions. The RO scheme revenues are affected by year-to-year market variation, but this variation is not itself affected by the scheme being closed to new entrants. Therefore, the data do not only reflect the performance of community energy under the tariff rates available to new projects at the time of data collection.

This analysis allows an appreciation of the extent to which actual projects are reliant on price scheme revenues. There is no consideration for how projects might have been designed if the schemes had not been available, which is a more complex question. Therefore, these results do not in themselves show that it would be impossible to design a future project to make a financial surplus without a price guarantee scheme; nor, given that we have just one year’s data, do they test the ‘viability' of a project over its lifetime.

To investigate whether different types of customers pay different rates for community-generated energy, we calculate mean rates paid by the four different types of customer (energy companies, other private sector, public sector, community and third sector). We find that the mean rates differ, with the mean rate lowest for energy companies and highest for public sector customers. Performing a *t*-test on the equality of the mean rates paid by energy companies and public sector organizations, we find that the means are statistically different at the 1% significance level (*t*-statistic of 3.69).