A review of business models for decentralised renewable energy projects

Abstract

The diffusion of renewable energy technologies has often been suggested as a means to reduce the emission of greenhouse gases, but emphasis tends to be placed on large scale projects. Adoption of renewable energy at the local level provides opportunities for both distributed energy schemes and domestic micro-generation. However, alternative models of ownership, governance and operation are not well developed. Locally managed energy solutions need to respond to varied end users' requirements to ensure that needs are met, so understanding of different types of end users is a prerequisite to the development of robust business models. This paper presents a review of existing models of decentralised energy generation in which actors such as community groups, energy co-operatives, charities and municipalities participate as owners and co-producers. End users can become involved in the design, development and delivery of energy services in a variety of ways. The focus is active user engagement through co-construction, co-production and co-provision of energy services. The following categories will be reviewed with reference to current understandings of both sustainable entrepreneurship and social enterprise: a) energy service companies (ESCos) as commercial actors that undertake management of these projects b) energy co-operatives and c) municipal energy. This analysis is used to reflect on and refine understanding of the relationship between technical, financial and operational constructs in models of decentralised energy generation which can contribute to social and environmental gains.

Keywords: decentralised renewable energy; Community energy; energy service companies; energy co-operatives; municipal energy

1. Introduction

New approaches to the ownership, management and operation of renewable energy technologies are essential if distributed and on-site micro generation systems are to be widely adopted. However, such alternative business models are not well developed and a good understanding of different types of energy end user is necessary to develop robust models with minimal risks. In developing local energy solutions, it is necessary to recognise variations in demand and usage patterns between specific user groups. This paper aims to review existing business models of decentralised energy generation in which individuals and community organisations participate as co-producers. End users involved in both the production and consumption of energy become prosumers, who enable the integration and optimisation of renewable energy sources into the grid, with the potential to disrupt the traditional utility model (Ellsworth-Krebs and Reid, 2016; Sha and Aiello, 2016). The rise of prosumers is connected to the transformation of energy systems towards more renewable, decentralised and demand responsive smart arrangements (Brown et al., 2020). Decentralised energy is a multi-faceted concept and various terms have been used to describe the same phenomenon such as distributed or dispersed generation, on-site renewables or on-site generation (Devine-Wright and Wiersma, 2013; Judson et al., 2020). According to the UK government definition decentralised energy is not necessarily renewable, although it is characterised by the spatial proximity of energy generation and consumption (DBER, 2008). Energy decentralisation has multiple meanings depending on what is being decentralised: ownership, hardware, knowledge, power or decision-making (Brisbois, 2019; Judson et al., 2020).

The paper examines approaches to active user engagement, co-construction, co-production and co-provision of local, sustainable energy services. The concepts of sustainable entrepreneurship and social enterprise will be employed to develop understanding of the technical, operational and financial constraints involved in management of small-scale energy schemes. End energy users are heterogeneous with different motivations to participate as co-producers in distributed renewable energy schemes. They are broadly categorised into two main groups:

1. *Individuals*: for example, consumers, employees and householders

2. *Civil society groupings & business users*: comprising community groups; large and small firms; service organisations, institutions, local authorities, social and voluntary groups

This article reviews the existing literature on entrepreneurial models for decentralised renewable energy technologies, considering these categories of end users who become renewable energy entrepreneurs. The aim is to elucidate the relationship between social enterprise and sustainable entrepreneurship in decentralised energy models. The following questions are considered:

How do users engage in sustainable entrepreneurship regarding decentralised renewable energy generation? On-site energy generation at the local level is perceived as a form of sustainable entrepreneurship which is driven by diverse motivations and concepts of value. However, this paper will not focus on domestic microgeneration where individual households act as energy producers (see Sauter and Watson, 2007; Allen et al., 2008; Ellsworth-Krebs and Reid, 2016). Instead, the focus lies on community renewable energy initiatives rather than individualistic approaches. Community energy refers to the adoption of sustainable energy schemes (including renewable energy, energy efficiency and energy conservation) in groups and/or on shared property: the groups involved may share geographical location, common interests and participate in the sharing of the benefits and costs of the scheme (Klein and Coffrey, 2016). Community energy bypasses the division between market and state provision (Walker et al., 2007). The role of such community groups is acknowledged in the shift towards more sustainable energy systems (van der Schoor and Soltens, 2015; Koirala et al., 2016).

The next question examines the type of entities (organisational forms) these community groups may form or rely on in order to develop their decentralised energy projects. These entities may apply different business models to ensure the feasibility of their projects and create value.

The paper is structured as follows. Section 2 provides a background to the discussion by examining the related concepts of sustainable entrepreneurship and social enterprise in relation to decentralised renewable energy. Section 3 addresses the role of users as co-producers of energy and the elements of the business models that energy developers can adopt to interact with customers and generate value. Sub-sections 3.1 and 3.2 examine three organisational forms in the area of community energy a) Energy Service Companies (ESCo) b) energy co-operatives and c) municipal energy. Section 4 discusses the potential of these new renewable energy entrepreneurs as they try to integrate in and transform the incumbent energy system. Finally, the conclusion summarises the contributions and raises suggestions for further research.

2. Sustainable Entrepreneurship and Social Enterprise

Sustainable entrepreneurship is an emerging area of research which attempts to explain the activities of small enterprises utilising social and environmental practices in their operation. The definition can include established firms as well as start-ups and not-for-profit enterprises (Greco and de Jong, 2017). As Dean and McMullen (2007) contend such organisations meld financial aims with socio-environmental concerns. Others have referred to these types of organisations as ‘hybrid’ (Ebrahim et al., 2014; Hockerts and Wüstenhagen, 2010; Fellnhofer et al., 2014). One strand of thought focuses on the established characteristics of entrepreneurial activity, how firms recognise and exploit opportunities for profitable activity. For sustainable entrepreneurs, such opportunities contribute social and environmental as well as financial benefits (Hockerts and Wüstenhagen, 2010; Pacheco et al., 2010). The literature is dominated by analysis of entrepreneurship as a small firm activity, thus, emphasises issues such as financing and operations measurement (Juravle and Lewis, 2009; Schaltegger and Wagner, 2011; Hörisch, 2015). However, social entrepreneurship and other co-operative operational models can also be considered, where enterprises actively attempt to minimise negative social or environmental impacts, or to enact positive outcomes (Choi and Gray, 2008; Pascual et al., 2011). The core objectives are, therefore, not solely financial profitability but include a contribution to social or environmental goals (Bell and Stellingwerf, 2012).

Sustainable entrepreneurship is embedded in multiple value systems (institutional logics involving commercial markets, environmental protection and social welfare) as the entrepreneurs aim to create social and environmental value, while maintaining a financially, viable business (Gregori et al., 2019). The concept of sustainable business models addresses how relations between these different forms of value are negotiated by the entrepreneur (Laasch, 2018). Brown et al. (2020) contrast the market value logic, which draws on neoclassical economic concept of rational consumers, to the municipal value logic, which is more rooted in socialist principles and has informed the re-municipalisation of utilities.

Shepherd and Patzelt (2011) also emphasise the importance of cultural sustainability in such entrepreneurial activities. Referring to this idea, Peredo and Chrisman (2006) identify community-based social and sustainable entrepreneurship where local individuals or groups own and run enterprises, based on exploiting opportunities, adapted to and co-existing with local cultural, and sustainability values.

Criado-Gomiset al. (2017) point to the necessary synergy of sustainable entrepreneurship between financial, environmental and social objectives, indicating that conventional indicators of entrepreneurial success may fail to evaluate a holistic approach with the goal of contributing to sustainable development. However, others have identified that internal business strategy and operational business models are as important to success of sustainable enterprises as they are to more conventional firms (Wüstenhagen and Boehnke, 2006; Bocken, 2015).

Social enterprises, however, have a wider focus than traditional entrepreneurship, comprising activities which reinvest surplus into the local community (Local Government Group, 2011). Seyfang (2009) includes community run organisations as social enterprises that contribute to local sustainability objectives, although Aiken et al (2008) indicate the limited knowledge about community-based entrepreneurial activity with regard to asset management. However, Vickers (2010) and Smith and Young (2007) note that social entrepreneurship may take multiple forms, including co-operative forms of organisation, with the aim to enhance local social and environmental outcomes.

However, consideration of the range of organisational forms in local energy management in the discussion that follows will be used to contribute new insights. Community energy is an area of social entrepreneurship where initiatives can be classified according to their objectives, forms of governance and ownership, and inclusion into local or wider social movements (Becker et al., 2017). Community energy entrepreneurship is related to a sense of place (Süsser et al., 2017). The term “associative entrepreneurship” was used to indicate the pluralistic and mutual character of such projects, suggesting that mutualism is a direction in entrepreneurship (Scott Cato et al., 2007).

3. Users as co-producers: business models for decentralised renewable energy

Social acceptance of renewable energy is usually considered in relation to large scale renewable energy projects; yet, user acceptance of micro-generation technologies and decentralised energy requires a different approach. Ruggiero et al. (2014) identify a link between community ownership and support for renewable energy in line with earlier studies. Micro-generation technologies particularly at the domestic level necessitate the active participation of individual households so acceptance can be expressed in the form of attitudes, behaviours and primarily investment (Sauter and Watson, 2007). Decentralised energy generation extends beyond the context of individual households but still it can be argued that it requires more active forms of acceptance on the part of end users.

Insights from the literature on user involvement applied to energy can illuminate how consumers/end users become actively involved in the design, development and delivery of products and services. Sauter and Watson (2007) summarise three approaches to active consumer engagement.

Co-construction involves consumers in the design of new products that take into account their requirements. The concept has mainly been applied to new product development but could be applicable the design of new energy systems.

Co-production. Unlike co-construction, which addresses consumer products, co-production mainly refers to services. The range of customer involvement may vary from passive consumption to active co-production (Fliess and Kleinaltenkamp, 2004). The model of co-production has been applied to the delivery of public services mainly in the United States. The concept of co-production accepts that the skills of so called “consumer producers” complement those of regular producers and are essential in the delivery of services (Lam, 1996). Development studies have examined the role of co-production in the context of irrigation systems, urban infrastructures and primary education.

Co-provision is a more comprehensive term that has also been initially applied to public service provision (Ferris, 1984). According to Ferris co-provision is a more helpful term than co-production since it examines how services can be delivered to end users and not only how they are produced. Van Vliet and Chappels (1999) define co-provision as:

“the provision (including generation, treatment, distribution and consumption) of utility services by a range of new intermediaries (e.g. consumer themselves, other organisations or sub-networks), alongside or intermingled with centrally provided services (e.g. public networks or grid-provision)”.

Hence, co-provision may apply to a service throughout different stages of its supply chain and it can be complementary to more centralised models of provision. Van Vliet (2004) envisions co-provision as one of the possibilities available to consumers choosing among different utility providers in a competitive market. In a liberalised electricity system co-provision becomes an additional option available to end users who may choose to supplement centrally provided energy with their own provision.

The definition by van Vliet and Chappels (2004) recognises that the new intermediaries involved in co-provision may be organisations or sub-networks rather than individual consumers or households. Hence, the question arises regarding what type of entities may undertake this intermediary co-provider role. Community energy could be considered an intermediate form of energy provision: although it is perceived as singular and locally bounded, it is influenced by community , state and private sector actors operating at different scales beyond the local (Creamer et al., 2018) Entities, such as Energy Service Companies, energy co-ops and municipal energy companies will be discussed separately.

In the context of microgeneration technologies Watson (2004) identifies three deployment models that may require active user engagement. These models were devised for individual households rather than for energy communities, yet some of their characteristics regarding the relation between end users and electricity companies can be adapted to the case of decentralised community energy projects.

- The “plug and play” model enables households to gain some independence from their energy supplier. The micro-generation unit is owned and financed by the end user who may export energy into the grid –depending on the nature of reward schemes- or maximise their own consumption of on-site generated electricity and reduce their energy bill.
- Under the “company control” model energy companies use micro-generators to substitute for central power generation as a “virtual power plant”. In this case, the role of consumer is more passive: they provide the site for micro-generator which is owned either by a conventional energy supplier or an Energy Service Company (ESCo). The operation of the unit is driven by the company’s rather than the end user’s needs. For instance, the company uses higher outputs from micro-generation to avoid turning to the wholesale electricity markets.
- Finally, the “community microgrid” model pools together the resources of consumers and institutions in a geographical area. All micro-generation units are connected within the microgrid. End users are involved in two ways: they have control over their microgenerator but also help ensure the supply-demand balance within the microgrid. The microgrid can be partially owned by the consumers so they have an incentive to ensure it operates smoothly.

The following figure maps the models according to company and consumer involvement.

INSERT FIGURE 1 HERE

Figure 1 indicates potential overlaps between the models and the relation between users and energy companies can be more nuanced. In the case of community energy, the plug & play model would require communal ownership of micro-generators possibly in the form of energy co-operatives. The company control model requires less investment and learning on the part of users; however, it primarily serves company needs. Sauter and Watson (2007) argue that the plug & play model is more suitable for early adopters who have a higher understanding of and interest in renewable energy technologies, as well as the capital to finance it. It is likely to have more significant impact on behaviour since consumers seek to recoup their investment and adapt their behaviours according to pricing incentives. On the other hand, they suggest that the company control model can promote micro-generation to more consumers by using the company's knowledge and marketing abilities. Greater company involvement can lend legitimacy to the technology, but behavioural modification is likely to be limited since the consumers are more passive.

The community microgrid model is meant to combine the benefits of company control with greater consumer involvement and partial ownership by the users, but it is more speculative (ibid.). Gui et al (2017) note that community microgrids have a social dimension as they provide sustainable development benefits in community electricity supply and distribution including energy autonomy and improved reliability, retention of economic benefits and job creation, and access to an alternative energy supply to grid electricity. They argue that the optimal ownership and governance structure for microgrids depends on their uncertain, idiosyncratic nature which requires long-term contracting. Four structures are suggested a) community ownership and governance, often noted in remote communities b) utility ownership and governance where the traditional utility can also enable the interface with the national grid c) private ownership and governance, although these investments have high specificity and risk and d) hybrid forms.

Considering that micro-generation and community energy incorporate greater user involvement in the production of electricity and heat it emerges that changes in the business models for energy provision should accompany technological change in order to achieve more sustainable energy production and use. The concept of business model explains how "an organisation creates, delivers and captures value" (Osterwaldeur and Pigneur, 2010, p. 14) by responding to the needs or desires of its customers. Business models are usually discussed in the context of business strategy but their wider implications can also be considered: business models innovation may help the development of new industries (Teece, 2010) or the restructuring of existing ones (Johnson, 2010). The concept of business model may focus on the development of competitive advantage by firms, but they primarily refer to value creation, so they are also applicable to not-for-profit entities. Business models include interconnecting practices which evolve along with their environment (Mason and Spring, 2011) so the choice of a business model for decentralised energy generation may also affect technology selection and user behaviour. Laasch (2018) extends the discussion of business models to partially commercial and non-commercial organisations where the concept of value is driven by more than one institutional logics (commercial, sustainability, government and welfare logics in the case of sustainable business models). Sustainable business models need to balance between the commercial market and the sustainable development logics, which differ in the perception of value, governance and key stakeholders (ibid.)

The literature identifies four key characteristics of business models: value proposition, customer interface, infrastructure and revenue model (Richter, 2012). The value proposition refers to the offering to the customer (products and services). Customer interface describes the interaction with customers while infrastructure includes the company's assets and the activities that create value. Finally, the revenue model addresses the feasibility of the business model by accounting for revenues and costs (Osterwalder and Pigneur,2010 cited in Richter, 2012).

Richter (2012) distinguishes between utility-side and customer-side renewable energy business models. Utility-side business models refer to larger renewable energy installations than microgeneration while customer-side business models are more pertinent to the level of household micro-generation and community energy. In customer-side business model the generation of renewable energy takes place in the customer's premises, but the company's value proposition may vary. The company's involvement can range from consulting services to a complete package that includes financing, ownership and operations of the energy generation by the company. Hence, customer-side business models run the gamut from Watson's (2004) plug & play model to company control model.

Below it is described how the four elements of a customer-side business model can be structured (Richter, 2012):

Arguably, utilities should shift their *value proposition* from providers of energy as a commodity to comprehensive energy solution providers. For instance, the New Jersey Public Service Electric & Gas Company provides customer loans for the installation of photovoltaics which can be repaid in the form of energy certificates as the installations produce solar energy. Austin Energy in Texas aims to offer a fixed fee service where the customer would get the energy they need for a fixed fee provided they made their roof available for photovoltaics.

Customer interface: improving the customer interface required market research to identify the distinct needs of different user groups and offering them customised packages. Better exchange of information is required between the utility and the customers, for instance in the form of smart metering. However, the customisation of packages may increase transaction costs.

The management of *infrastructure* would require substantial change as large scale power stations will be partly replaced by decentralised infrastructure for energy generation. Partnerships with providers of renewable energy equipment can be included in the business model so that the utility itself will not be responsible for maintenance.

Revenue model: under the prevailing business models increase in energy consumption leads to more profits for the utilities. Arguably, this is the greatest obstacle for utilities to invest in decentralised energy and energy demand reduction. Three approaches to pricing are possible for a feasible revenue model:

- *Decoupling sales volume and revenue* entails separating the recovery of fixed costs from the amount of electricity sold. It has had limited use as a regulatory tool. Decoupling has been criticised in that it protects the utility's interests rather than passing on benefits to the users.
- *Dynamic pricing* entails the use of flexible rather than fixed prices for units of energy. The prices are meant to reflect changes in the wholesale electricity prices. Peak and off-leak rates are a common form of dynamic pricing. At a more extreme form prices would be constantly adjusted according to demand and consumers would receive these price signals to adjust their consumption.
- *Flat rate tariffs* charge a set price regardless of the energy consumed. Their application would require careful management of energy demand. The utility would enter into a partnership with the consumers who would agree to install energy efficiency measures. The flat rate could depend on dwelling size with a maximum usage limit.

The aforementioned pricing methods are options available to for-profit utilities, still even not-for-profit entities need to consider their pricing in relation to their cost structure. The sources of revenue may vary according to the type of technology. For instance, firms in the German micro Combined Heat and Power sectors are more likely to gain revenue from the sale and maintenance of equipment (89% and 69% respectively) than from contracting services (15% of firms) (Boehnke and Wüstenghagen, 2007). Unlike photovoltaics firms CHP providers were more likely to offer financing services while a minority of CHP firms also supplied the fuel (ibid.).

The following sections discuss business models for the adoption of micro-generation in the context of community energy considering the nature of organisations involved. The ESCo model is pertinent as it is a popular choice by UK local authorities. Municipal energy and energy co-operatives are also discussed as models for managing renewable energy which are more established in other countries.

3.1 The energy service company model (ESCo)

An ESCo is an organisation that provides energy services (illumination, heating or transport) in the form of an energy service contract (Bolton and Hannon, 2016). ESCos provide energy solutions including energy conservation, energy infrastructure outsourcing and power generation (Wagner, 2010). They introduce energy efficiency measures following detailed analysis of a property and its energy needs. The resulting savings may be used to pay back the initial investment or reinvested to achieve further improvements. An ESCo may be responsible to pay the difference if the project savings do not recoup the initial investment (ibid.). ESCos are separate Energy Service Provider Companies (ESPC) who provide a similar range of services for a fixed fee: unlike ESCos ESPCs do not take any risks and they do not guarantee the energy savings (ibid.). However, different contracting forms can co-exist in the energy services market (Boza-Kiss et al., 2019).

Wagner (2010) regards the liberalisation of the electricity and gas market and the pressures to address climate change as the main drivers of ESCos in the EU. Ürge-Vorsatz et al. (2007) note that the model has more than a hundred-year history in Europe, but it was revived in the United States during the oil crisis in the 1970s. Table provides some data regarding the ESCo market across the EU. The data refer to energy efficiency services and energy services along with ESCos.

INSERT table 1 here

ESCo contracts can refer to either energy performance contracting or to energy supply contracting (Sorrell, 2007). Energy performance contracting refer to the provision of the final energy service (such as light or heat), which is what the customer wants from the use of energy. In this model ESCos are responsible for providing a certain standard of service (e.g. stable room temperature) at a cost. The ESCo has control over the secondary conversion equipment at the building scale (e.g. type of radiators and heat exchangers in the heating system) and it can also manage the demand for the final service through behavioural change. This control over the energy conversion and distribution processes allows the ESCo to provide energy at a lower cost than a typical utility (ibid.).

On the other hand, energy supply contracting operates upstream in the energy supply chain. ESCos using such contracts provide energy streams to the end consumers that have already been converted (e.g. in a boiler or CHP plant) and the end user is charged per unit of usable energy (Sorrell, 2007) or a fixed price for a defined standard of energy service (Marino et al., 2011). Under energy supply contracts ESCos control the primary conversion equipment and they can reduce production costs through technical and operational efficiency (Sorrell, 2007).

The value proposition of the ESCo business model is that the customer can fulfil their energy needs at a lower cost than the bills of an energy utility.

The following graph compares the operational focus of energy utilities and the two different forms of energy contracting undertaken by ESCos.

INSERT FIGURE 2 HERE

Utilities provide gas that has not undergone any conversion process to useable forms of energy and they have no control over how efficiently the end users will convert gas. Grid electricity results from primary conversion processes usually in fossil fuel powered centralised plants. ESCos control the conversion processes at a smaller, decentralised scale. The proximity of energy conversion facilities to consumption means the ESCos are a good choice for CHP/ district heating schemes as the residual heat from energy conversion processes can be distributed to the sites of consumption (Bolton and Hannon, 2016). Unlike energy utilities ESCos typically lock users into long term contracts (20-30 years) (Fawkes, 2007). These types of contracts provide them with the security that high up-front investments will be recouped (Martino et al. 2011). Yet, long term contract may act as a disincentive to consumers as they limit flexibility.

There are different ways to allocate the benefits from realised energy saving between the ESCo and the customer. Three financing options are usually available (Wagner, 2010):

- Customer financing: the customers invests their own resources but the energy savings are guaranteed by the ESCo
- ESCo financing

- Third party financing (debt): in this case either the ESCo or the client may take on the debt.

The financial position of the ESCo and the credit worthiness of the customer influence the choice of financing: third party financing usually allows for higher investment. Lack of familiarity of the national banking system with the business model may limit access to third party financing. The allocation of risk between ESCo and client depends on the type of contract: in a guaranteed savings scheme the ESCo takes on the performance risk. When ESCo guarantees the savings from energy efficiency will benefit the customer, customers usually take on the financing risk. On the other hand, a shared saving scheme divides the benefits from improved energy efficiency according to a pre-defined percentage. In the case of shared savings schemes, financing costs are more likely to be shared (Wagner, 2010). Pearce and Miller (2011) provide an example of Penn State University that used a self-funded guaranteed service scheme to improve energy efficiency: they argue that university facilities management can benefit from the additional expertise of ESCos. Even where debt financing is used the benefits from lower utility bills can help service the debt.

The analysis of the different financing schemes and contract types suggest that the ESCo model is not easily scalable as each project needs to be examined in its own merits: typically newer ESCos do not have the financial funds for equity financing but the customer is more likely to undertake the financing risks if the savings are guaranteed (Wagner, 2010). Wagner also suggests that energy service contracting is not an attractive industry and that the main motivation of industry actors is to increase the sales of their existing product line to a new customer base. In fact, a number of ESCos are owned by energy equipment companies such as Honeywell.

ESCos face different challenges according to the type of customer: the residential sector is more neglected since many residential building owners lack an awareness of the benefits and the business model is further complicated in the case of multiple occupancy buildings or rented accommodation (Ürge-Vorsatz et al., 2007). The majority of EU ESCo projects target the public sector as it is considered a more reliable customer (Bertoldi et al. 2006). Vine's (2005) review also identifies that most ESCos do not target the residential sector. Bertoldi et al. (2006) suggest that the public sector can set the example in disseminating good practice through demonstration projects while the standardisation of contracts can encourage market growth. Boza-Kiss et al. (2019) note that the EU market has grown substantially but it is still characterised by a wider variety of supplier compared to customers. Energy performance contracting is becoming more prominent form of contracting (ibid.).

In conclusion, ESCos provide a range of skills and experience useful to micro-generation projects, but the feasibility of this business model depends on reliable financing and the sharing of risk and benefits between the ESCo and the client.

3.2 Community owned renewable energy: energy co-operatives and municipal ownership of utilities

There has been some interest in energy solutions that rely more directly on participation of social enterprises that may have less of an emphasis on financial solvency for their survival: a decentralised energy community could bring together local residents, commercial organisations and the public sector as a not-for-profit entity but the involvement of commercial organisations may hinder this goal. ESCos are commercial profit seeking companies; hence there are limits in their involvement in a not-for-profit entity. It is not clear whether a not-for-profit ESCo can be established, possibly in the form of a demonstration project. Energy utilities are also profit-seeking organisations since the liberalisation and privatisation of the energy market. This section examines what forms the consumer ownership of community energy may take. Energy co-operatives are discussed as not-for profit business model for renewable energy. Municipal energy constitutes another option.

A review by Walker (2008) remarks that a number of renewable energy projects in the UK carry the community label although many are operated by local authorities or entrepreneurs under conventional organisational arrangements. Community ownership entails that the community has financial investment or managerial control in the project even if it may collaborate with commercial organisations (ibid.). Olsen and Skytte (2002) discuss consumer ownership in the electricity markets in the form of energy co-operatives or municipal energy and they argue that this option has been neglected since World War 2.

Walker (2008) identified the following models and legal structures for community ownership:

- Co-operatives where individuals become members and own shares in the project
- Community charities: these are usually charities that manage some community buildings while they may also have a trading arm to finance the charitable activities
- Development trusts: more common in Scotland, they represent the community's interests in revenue generating schemes
- Community organisation with shares in a commercial project. For example, the community may own some wind turbines in a wind energy park.

Becker et al. (2017) remark that there is a multiplicity of legal ownership forms for or non-profit and not-only-for-profit organisations in renewable energy: the legal forms are instrumental in including the social values and the participation of stakeholders into decision making. Seyfang et al. (2013) included informal groups, charitable incorporated organisations, charitable social enterprises and limited companies with social purposes in their survey of UK community energy. As the organisations evolve, they may choose more formal structure (van der Schoor and Soltens, 2015).

Walker (2008) also distinguishes between communities of interest and communities of locality: in the latter case the benefits from community ownership reach everyone in the community even if they have not sought active involvement in the project as in a share-owning scheme. One advantage of communal ownership in renewable energy projects is that the negative externalities from their operations can be mitigated if the community has some controlling stake (Morse, 2000).

It is argued the principles of the co-operative movement are intrinsically embedded with sustainability principles, specifically when addressing the social dimensions of sustainability (Dale et al., 2013), so co-operatives are better placed than companies to achieve sustainable energy transition (Huybrecths and Haugh, 2017). The co-operative principles include voluntary and open membership, democratic governance and economic participation by the members. The perception of sustainability among co-operatives is closely linked to the concept of community (Dale et al., 2013).

In the traditional co-operative model in the 19th to early 20th century co-operatives were run for the benefit of their members either in a fully mutual role (all customers were members) or partially mutual (Mori, 2013). The late 20th century saw the introduction of energy co-operatives that operate more broadly in the public benefit (ibid.). Currently, the most common form of energy co-operatives is where a group of people gather with capital to invest in an energy generation scheme entering into a feed in tariff agreement with an energy retailer who also guarantees preferential supply tariffs to the co-operative’s members (Willis and Willis, 2012).

Debor (2014) examines the impact of renewable energy production co-operatives on the decentralisation of the energy system in Germany. There is evidence that a decentralised energy system managed by small firms is the preferred option of German consumers. Energy co-operatives appear more attuned to local energy needs that may be neglected by other organisations. Along with the aforementioned principles of the co-operative movement, the business models favoured by co-operatives tend to include local energy production, closer links between user and producers and the engagement of civil society in the energy system. Co-operatives may operate at different stages of the electricity value chain, but most German Energy co-operatives focus on renewable energy production. 91 % of 942 co-operatives were set-up after 2006 driven by the increased interest in renewable energy and a change in legislation that allowed for easier set-up of co-operatives. Investment by energy co-operatives has also increased, although most remain small to medium size enterprises in terms of revenue.

The German experience indicates that legal frameworks can enable the development of not-for-profit energy groups. On the other hand, national preferences over the structure of the energy system may also play a role, as German citizens prefer a decentralised system (Hall et al., 2013). The challenges faced by energy co-operatives involve the maintenance of their memberships and availability of capital for investment (Debor, 2014).

Greenpeace energy is an example of a successful energy co-operative in Berlin (Müller and Rommel, 2010). It is not affiliated with the namesake NGO although it was set up by Greenpeace members and has permission to use the name. 20% of the co-operative’s customers are also members thus enabling the integration of production and consumption. Most members are highly educated with an interest in environmental issues. The members have highlighted the changes in legal framework as a factor that has enabled the co-operative’s growth. The authors also argue that electricity co-operatives can reduce information asymmetries between users and producers in the electricity market.

Mori (2013) addresses the Italian experience with energy co-operatives and identifies that most co-operatives were set up from scratch to provide electricity services rather than take over a pre-existing organisation. Historically, co-operatives were rural and small scale co-owned either by their customers or by the suppliers of some energy input. In their purer form, as with US rural energy co-operatives, all customers were members. Yet, a different model is necessary for the transformation of the current electricity system: the development of medium to large co-operatives in urban setting. Walker (2008) also mentions that urban implementation of community renewables may require new models and could be integrated into regional regeneration initiatives. 71% of Italian energy co-operatives were established before the nationalisation of electricity in Italy and in 2009 27 co-operatives ran district heating schemes: only few co-operatives were founded after liberalisation (Mori, 2013).

The prevalence of community ownership varies by country with Denmark leading in consumer owned energy. Unlike most European energy systems, the Danish system has relied on power stations and energy grids which were established and owned by consumers and municipalities (Olsen and Skytte, 2002). Co-operatives and municipal energy were both established at the turn of the 19th century (ibid.; Mori, 2013). Drawing on theories regarding contracts costs and the costs of ownership, Olsen and Skytte (2013) argue that consumer ownership is an efficient organisational form for the management of the electricity market. Customers of energy co-operatives in Denmark automatically become member and used to share the liabilities. Joint stock companies and independent partnerships are additional legal forms for the management of community energy. Consumer ownership may be more efficient when the customer base is more homogeneous, hence why rural electricity co-operatives set up by farmers have been more widespread than urban ones (Hansmann, 1996). Despite the importance of co-operatives in the Danish energy system, most members now regard themselves as customers rather than as joint owners (Olsen and Skytte, 2002).

Heras-Saizarbitoria et al. (2018) discuss the Spanish experience of energy co-operatives as an example of a country with limited history in this area noting the variations in the dissemination of energy co-operatives across European countries. The earlier wave of co-operatives founded in late 19th /early 20th century mostly disappeared after the civil war. The re-emergence of co-operatives is linked to the economic crisis and are influenced by the communitarian traditions in regions such as the Basque Country and Catalonia.

Due to the local nature of energy co-operatives it is difficult to identify how successful examples could be scaled up. This is indicated in cases from the Netherlands (Hufen and Koppenjan, 2015). There are systemic factors accounting for the differences in the diffusion of the energy co-operative organisational form across European countries such as the nature of the electricity grid and the structure of the electricity mark: lack of a financial infrastructure, limited access to knowledge and networks, and lack of appropriate regulation (Mignon and Rüdinger, 2018). The nature of scaling activities that co-operatives engage in are also dependent on their institutional logic: co-operatives with a mutual interest focus were more likely to engage in scaling up activities (growth), while those with a more general interest orientation were more likely to scale-out by increasing their range of services or scale-deep by improving the quality of processes (Bauwens et al., 2019).

Municipal energy is an example of public ownership of energy utilities while co-operatives focus on consumer ownership (Mori, 2013). Ironically, many contemporary large energy producers had started as municipally run small firms (van der Schoor and Soltens, 2015). Municipal ownership stakes in renewable energy projects can be part of a wider municipal energy plan (ibid.). Roelich et al. (2018) noted that municipalities in the UK are increasingly involved in the management of aspects of the energy system; yet, their primary motivation is to deliver place-specific outcomes and essential services rather than provide low-cost energy. Hence, the municipal energy projects are heavily influenced by the unique characteristics of each city. Policy changes in the UK have obstructed the further development of municipal energy. In Germany Hall et al. (2013) have noted a return towards municipally owned energy utilities (stadtwerke) since the mid-2000s which involves both the establishment of new municipally run companies and the return of energy concessions -mostly in distribution networks- to municipal ownership. This shift is supported by public opinion as demonstrated in local referenda.

In the UK municipal energy has been partially revived in recent years due to concerns on fuel poverty and rising energy costs (Heatherington, 2013). Woking council runs the Thameswey plant. Tralee in Ireland operates a district heating scheme where residents accumulate energy credits over the summer months which they “spend” when they need heating in winter (ibid.). The successful implementation of municipal district heating schemes requires investments both on the supply (power plants) and on the demand side (improved insulation) (Rolfsman, 2004). In practice, the boundaries between commercial and municipal forms of organisation may be blurred. For example, Themeswey, Energy Ltd is run as an ESCo co-owned by Woking Council and Xergi, a Danish CHP operator (Hannon and Bolton, 2015). The company runs two CHP schemes in Woking and has more than 170 commercial and domestic clients (ibid.). UK local authorities have engaged with ESCos either by setting up their own “arms-length” ESCo, granting a contract to a private ESCo or supporting a community ESCo, which may have different legal forms (ibid.)

To summarise, community and consumer owned forms of energy have a long history in Europe and it is likely that recent technological and policy developments will further promote their growth. Change in the threshold for small-scale generators to enter the supply market would act as a market incentive (Walker, 2008). In addition, developers may be drawn to co-ownership initiatives in order to gain the acceptance of local communities (ibid.). Considering that community heat is more technically complex that electricity the engagement of communities in renewable heat will require added support from local authorities (DECC, 2014).

4. Discussion: who are the decentralised energy entrepreneurs?

The foregoing discussion indicates that there is potential to migrate from a centralised model of energy provision to a more decentralised energy system (Judson et al., 2020). However, if such a situation is to become mainstream there must be active attempts made to ensure that the large energy companies allow new arrangements to emerge at a local level. As pointed out in the literature, sustainable entrepreneurship as a business form can only exist where there are genuine opportunities to gain financially from participation in the ownership of generative energy technology.

Sustainable entrepreneurship is more likely to occur where there is community or other groups interested in taking ownership of energy generation. The role of intermediary organisations can be instrumental in enabling knowledge transfer as in the case of Scotland (Ruggiero et al., 2014). Although decentralised energy projects can emerge in different institutional environments, factors such as community spirit, a co-operative traditions and local norms of responsibility can enable these projects (Wirth, 2014).The question of who the end users of generated electricity are becomes more complicated as generation becomes more distributed.

Organisations engaging in decentralised energy generation vary significantly in their motivation. Wiersma and Devine Wright (2014) note that the sector of the lead project actor has an impact on their motivation, with actors drawn from the community sector being less interested in financial rewards. Fuel poverty is noted as a key driver, though not by private sector actors. Community energy companies have a variety of motives beyond financial return, which are related with their identification to the locality such as protecting the environment and securing energy supply (Holstenkamp and Kahla, 2016). The varied motivations are associated with their engagement in different value logics.

Arising from this discussion it appears that novel operational arrangements will be necessary to manage local schemes. However, the indications are that governance arrangements will take place via a coalition of local commercial and non-commercial groups or through the activities of local authorities. Currently, there is little evidence to suggest that individual users will play a key role. There is some consensus, however, that the prevailing national, regional or local context for energy provision will exert some influence on the type of arrangements that find an acceptable 'fit' with consumers.

This discussion raises issues relating to how we understand sustainable entrepreneurship and social enterprise in the area of renewable energy provision and use. It is also pertinent to consider whether these two organisational forms would support or oppose each other's objectives in a local market, begging the question of whether the relative size and power of local authorities can distort opportunities. A related issue is whether small entrepreneurial firms can retain an independent presence in the market given the tendency for energy to be dominated by large, sometimes transnational, companies. The question of how to remain solvent as a sustainable energy entrepreneur is not yet clear given the early stage of technology adoption and, at least in the UK, lack of stable enabling policy. Currently, there are examples of business operations in ownership and maintenance of equipment, and in the provision of energy services, although the latter appear more widespread and tested. However, the preference of ESCos for long term contracts could provide a barrier to further development, particular with householders, retaining a niche in multi-occupancy buildings. In addition to sustainable entrepreneurship, the opportunities for social enterprise are worth considering, as there are examples of consumer and community owned renewable energy technologies. These arrangements include both third sector organisation and various co-operative organisational forms. The latter seeks to provide energy to a membership group at a lower cost, while promoting sustainable generation. Their fate, however, appears to depend on both regulatory environment and consumer preference. In addition, the available examples of co-operatives indicated the need to attract knowledgeable individuals to participate at local energy providers. However, this form of energy provision, where individuals take control is quite underdeveloped in the UK and appears to depend predominantly on local conditions and motivations. Increasingly, energy co-operatives may have to liaise with commercial partners as they face internal deficits and legal concerns (de Bakker et al., 2020). The development of these links would be consistent with the hybrid nature of co-operatives as an organisational form seeking to gain legitimacy (Huybrechts and Haugh, 2017). Municipal energy, as a form of local ownership appears to be more likely to emerge as the UK 'style' of co-operative organisation. However, local councils also experiment with commercial forms to manage their energy activities such as arms-length ESCos (Hannon and Bolton, 2015).

5. Conclusion

Decentralised renewable energy projects are a good example of an area where new business models have emerged. There are opportunities for both sustainable entrepreneurship and social enterprise to develop, which include both individual and civil society groups. However, the paper did not address the role of individual households as renewable energy entrepreneurs, instead, focusing on the organisational forms of ESCos and energy co-operatives. These types of organisations act as entrepreneurs in the field of renewable energy generation. Early demonstrations can be found of both for profit and not for profit examples across a range of activities from technology ownership to service management. However, it is not yet clear which of the deployed business models will prove to be both persistent and successful. Business models for user generated energy will be affected significantly by the removal of subsidies and technological trends such as smart metering and electric vehicle integration in the grid (Brown et al., 2019) while the reduction in battery prices will also affect business models as it allows for easier local storage (McKenna, 2018). However, there are encouraging trends to suggest that the small-scale flexibility of micro-generation could enable much wider social participation in finding local solutions to the issue of sustainable energy. In particular, this review has identified three areas for further study, to identify trends and outcomes.

Firstly, there is a need to examine how community participation in co-operative initiatives can be promoted and nurtured. Different characteristics of communities such as urban or rural location may require different approaches. Although many members only engage with their energy co-operative as customers, there may be potential to further engage member in the governance of their energy co-operative and decision making.

Secondly, the development of a regulatory framework and policy support to encourage the emergence of sustainable entrepreneurs in the renewable energy sector requires further examination. Such a research avenue would be particularly pertinent regarding the role of local authorities as renewable energy entrepreneurs and the policy measures to support municipal energy.

Decentralised energy initiatives occur at the local level, hence they are situated in a geographical context. A further question that arises concerns to what extent such initiatives can act as demonstration projects and to what extent learning can be transferable across decentralised, community energy projects. Earlier evidence in the case of London (Coles et al, 2016) suggested only limited knowledge sharing among microgeneration projects.

As technologies and local energy policies develop, opportunities for community-based initiatives will increase and a range of business models will play a key role in these emerging systems.

References

Aiken, M., Cairns, B., & Thake, S. (2008). *Community Ownership and Management of Assets.* York: Joseph Rowntree Foundation.

Allen, S. R., Hammond, G. P., & McManus, M. C. (2008). Prospects for and barriers to domestic micro-generation: A United Kingdom perspective. *Applied energy*, 85(6), 528-544. https://doi.org/10.1016/j.apenergy.2007.09.006

Bauwens, T., Huybrechts, B., & Dufays, F. (2019). Understanding the diverse scaling strategies of social enterprises as hybrid organizations: The case of renewable energy cooperatives. *Organization & Environment*, 1086026619837126. https://doi.org/10.1177/1086026619837126

Becker, S., Kunze, C., & Vancea, M. (2017). Community energy and social entrepreneurship: Addressing purpose, organisation and embeddedness of renewable energy projects. *Journal of Cleaner Production*, 147, 25-36. https://doi.org/10.1016/j.jclepro.2017.01.048

Bell, J.F., & Stellingwerf, J.J. (2012). *Sustainable entrepreneurship: the motivations and challenges of sustainable entrepreneurs in the renewable energy industry*. Unpublished MA Thesis, Jönköping International Business School, Jönköping, Sweden.

Bertoldi, P., Rezessy, S., & Vine, E. (2006). Energy service companies in European countries: Current status and a strategy to foster their development. *Energy Policy*, 34(14), 1818-1832. https://doi.org/10.1016/j.enpol.2005.01.010

Bocken, N., Short, S., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, 42-56. https://doi.org/10.1016/j.jclepro.2013.11.039

Boehnke, J., & Wüstenghagen, R. (2007). *Business models for distributed energy technologies: evidence from German clean tech firms.* Academy of Management 2007 Annual Meeting, Philadelphia.

Bolton, R., & Hannon, M. (2016). Governing sustainability transitions through business model innovation: Towards a systems understanding. *Research Policy*, 45(9), 1731-1742. https://doi.org/10.1016/j.respol.2016.05.003

Boza-Kiss, B., Toleikyté, A., & Bertoldi, P. (2019). *Energy Service Market in the EU - Status review and recommendations 2019*. Scientific and Technical Report. European ESCO Market Reports series. EUR 29979 EN, European Commission, Luxembourg, doi:10.2760/768, JRC118815.

Brisbois, M. C. (2019). Powershifts: a framework for assessing the growing impact of decentralized ownership of energy transitions on political decision-making. *Energy Research & Social Science*, 50, 151-161. https://doi.org/10.1016/j.erss.2018.12.003

Brown, D., Hall, S., & Davis, M. E. (2019). Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK. *Energy Policy*, 135, 110984. https://doi.org/10.1016/j.enpol.2019.110984

Brown, D., Hall, S., & Davis, M. E. (2020). What is prosumerism for? Exploring the normative dimensions of decentralised energy transitions. *Energy Research & Social Science*, 66, 101475. https://doi.org/10.1016/j.erss.2020.101475

Choi, E., & Gray, R. (2008). The venture development processes of "sustainable" entrepreneurs. *Management Research News*. 31(8), 558-569. https://doi.org/10.1108/01409170810892127

Coles, A. M., Piterou, A., & Genus, A. (2016). Sustainable energy projects and the community: Mapping single-building use of microgeneration technologies in London. *Urban Studies*, 53(9), 1869-1884. https://doi.org/10.1177/0042098015581575

Creamer, E., Eadson, W., van Veelen, B., Pinker, A., Tingey, M., Braunholtz-Speight, T., ... & Lacey-Barnacle, M. (2018). Community energy: Entanglements of community, state, and private sector. *Geography compass*, 12(7), e12378. https://doi.org/10.1111/gec3.12378

Criado-Gomis, A., Cervera-Taulet, A., & Iniesta-Bonillo, M.-A. (2017). Sustainable entrepreneurial orientation: A business strategic approach for sustainable development. *Sustainability*, 9(9), 1667. https://doi.org/10.3390/su9091667

Dale, A., Duguid, F., Garcia Lamarca, M., Hough, P., Tyson, P., Foon, R., Newell, R., & Herbert, Y. (2013). *Co-operatives and sustainability: an investigation into the relationship*. International Co-operative Alliance. Available from https://www.ica.coop/sites/default/files/attachments/Sustainability%20Scan%202013-12-17%20EN_0.pdf

de Bakker, M., Lagendijk, A., & Wiering, M. (2020). Cooperatives, incumbency, or market hybridity: New alliances in the Dutch energy provision. *Energy Research & Social Science*, 61, 101345.https://doi.org/10.1016/j.erss.2019.101345

Dean, T.J., & McMullen, J.S. (2007). Toward a theory of sustainable entrepreneurship: reducing environmental degradation through entrepreneurial action. *Journal of Business Venturing,* 22(1), 50-76. doi:10.1016/j.jbusvent.2005.09.003

Debor, S. (2014). *The socio-economic power of renewable energy production cooperatives in Germany: Results of an empirical assessment.* Wuppertal Papers, No. 187. http://nbn-resolving.de/urn:nbn:de:bsz:wup4-opus-53644

DECC (2014). *Community Energy Strategy: Full Report*. Department of Environment and Climate Change. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/275163/20140126Community_Energy_Strategy.pdf

Department of Business, Enterprise and Regulatory Reform (2008). *UK renewable energy strategy – consultation.* London: BERR.

Devine-Wright, P., & Wiersma, B. (2013). Opening up the "local" to analysis: exploring the spatiality of UK urban decentralised energy initiatives. *Local Environment*, 18(10), 1099-1116. https://doi.org/10.1080/13549839.2012.754742

Ebrahim, A., Battilana, J., & Mair, J. (2014). The governance of social enterprises: Mission drift and accountability challenges in hybrid organizations. *Research in Organizational Behaviour*. 34, 81-100. https://doi.org/10.1016/j.riob.2014.09.001

Ellsworth-Krebs, K., & Reid, L. (2016). Conceptualising energy prosumption: Exploring energy production, consumption and microgeneration in Scotland, UK. Environment and Planning A: Economy and Space, 48(10), 1988-2005. https://doi.org/10.1177/0308518X16649182

Fellnhofer, K., Kraus, S., & Bouncken, R. (2014). The current state of research on sustainable entrepreneurship. *International Journal of Business Research*, 14(3), 163-172. http://dx.doi.org/10.18374/IJBR-14-3.11

Ferris, J. M. (1984). Coprovision: Citizen time and money donations in public service provision. *Public Administration Review*, 324-333. https://www.jstor.org/stable/976078

Fliess, S., & Kleinaltenkamp, M. (2004). Blueprinting the service company, managing service processes efficiently. *Journal of Business Research*, 57(4), 392–404. https://doi.org/10.1016/S0148-2963(02)00273-4

Gibbs, D. (2006). Sustainability entrepreneurs, ecopreneurs and the development of a sustainable economy. *Greener Management International*, 55, 63-78. https://www.jstor.org/stable/greemanainte.55.63

Greco, A., & de Jong, G. (2017). *Sustainable entrepreneurship: definitions, themes and research gaps.* Centre for Sustainable Entrepreneurship, Working paper 1706, University of Groningen.

Gregori, P., Wdowiak, M. A., Schwarz, E. J., & Holzmann, P. (2019). Exploring value creation in sustainable entrepreneurship: Insights from the institutional logics perspective and the business model lens. *Sustainability*, 11(9), 2505.https://doi.org/10.3390/su11092505

Gui, E. M., Diesendorf, M., & MacGill, I. (2017). Distributed energy infrastructure paradigm: Community microgrids in a new institutional economics context. *Renewable and Sustainable Energy Reviews*, 72, 1355-1365.https://doi.org/10.1016/j.rser.2016.10.047

Hall, D., Lobina, E., & Terhorst, P. (2013). Re-municipalisation in the early twenty-first century: water in France and energy in Germany. *International review of applied economics*, 27(2), 193-214. https://doi.org/10.1080/02692171.2012.754844

Hannon, M. J., & Bolton, R. (2015). UK Local Authority engagement with the Energy Service Company (ESCo) model: Key characteristics, benefits, limitations and considerations. *Energy Policy*, 78, 198-212. https://doi.org/10.1016/j.enpol.2014.11.016

Hannon, M.J., Foxon, T.J., & Gale, W.F. (2015). 'Demand pull'government policies to support Product-Service System activity: the case of Energy Service Companies (ESCos) in the UK. *Journal of Cleaner Production*, 108, 900-915. https://doi.org/10.1016/j.jclepro.2015.05.082

Hansmann, H. (1996).*The Ownership of Enterprise*. Cambridge, MA: Harvard University Press.

Heatherington, P. (2013, 4 December). Councils generate own power to take on the big six energy firms. *The Guardian.* Retrieved from https://www.theguardian.com/society/2013/dec/04/councils-generate-own-power-big-six-energy-fuel-poverty

Heras-Saizarbitoria, I., Sáez, L., Allur, E., & Morandeira, J. (2018). The emergence of renewable energy cooperatives in Spain: A review. *Renewable and Sustainable Energy Reviews*, 94, 1036-1043. https://doi.org/10.1016/j.rser.2018.06.049

Hockerts, K., & Wüstenhagen, R. (2010). Greening Goliaths versus emerging Davids: theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. *Journal of Business Venturing*, 25(5), 481-492. https://doi.org/10.1016/j.jbusvent.2009.07.005

Holstenkamp, L., & Kahla, F. (2016). What are community energy companies trying to accomplish? An empirical investigation of investment motives in the German case. *Energy Policy*, 97, 112-122. https://doi.org/10.1016/j.enpol.2016.07.010

Hörisch, J. (2015). The role of sustainable entrepreneurship in sustainability transitions: a conceptual synthesis against the background of the multi-level perspective. *Administrative Sciences*, 5(4), 286-300. https://doi.org/10.3390/admsci5040286

Hufen, J. A. M., & Koppenjan, J. F. M. (2015). Local renewable energy cooperatives: revolution in disguise? *Energy, Sustainability and Society*, 5(1), 1-14. https://doi.org/10.1186/s13705-015-0046-8

Huybrechts, B., & Haugh, H. (2018). The Roles of Networks in institutionalizing new hybrid organizational forms: Insights from the European Renewable Energy Cooperative Network. Organization Studies, 39(8), 1085-1108. https://doi.org/10.1177/0170840617717097

Johnson, M. (2010). Seizing the White Space: Business Model Innovation for Growth and Renewal. Boston: Harvard Business Press

Judson, E., Fitch-Roy, O., Pownall, T., Bray, R., Poulter, H., Soutar, I., ... & Mitchell, C. (2020). The centre cannot (always) hold: Examining pathways towards energy system de-centralisation. *Renewable and Sustainable Energy Reviews*, 118, 109499. https://doi.org/10.1016/j.rser.2019.109499

Juravale, C., & Lewis, A. (2009). The role of championship in the mainstream of sustainable investment (SI): what can we learn from SI pioneers in the United Kingdom? *Organisational Environment*, 22 (1), 75-98. https://doi.org/10.1177/1086026609333341

Klein, S. J., & Coffey, S. (2016). Building a sustainable energy future, one community at a time. *Renewable and Sustainable Energy Reviews*, 60, 867-880. https://doi.org/10.1016/j.rser.2016.01.129

Koirala, B. P., Koliou, E., Friege, J., Hakvoort, R. A., & Herder, P. M. (2016). Energetic communities for community energy: A review of key issues and trends shaping integrated community energy systems. *Renewable and Sustainable Energy Reviews*, 56, 722-744. https://doi.org/10.1016/j.rser.2015.11.080

Laasch, O. (2018). Beyond the purely commercial business model: Organizational value logics and the heterogeneity of sustainability business models. *Long Range Planning*, 51(1), 158-183. https://doi.org/10.1016/j.lrp.2017.09.002

Lam, W. (1996). Institutional design of public agencies and co-production: a study of irrigation associations in Taiwan. *World Development* 24 (6), 1039–1054. https://doi.org/10.1016/0305-750X(96)00020-4

Mason, K., & Spring, M. (2011). The sites and practices of business models. *Industrial Marketing Management*, 40**,** 1032-1041. https://doi.org/10.1016/j.indmarman.2011.06.032

McKenna, R. (2018). The double-edged sword of decentralized energy autonomy. *Energy Policy*, 113, 747-750. https://doi.org/10.1016/j.enpol.2017.11.033

Mignon, I., & Rüdinger, A. (2016). The impact of systemic factors on the deployment of cooperative projects within renewable electricity production–An international comparison. *Renewable and sustainable energy reviews*, 65, 478-488.https://doi.org/10.1016/j.rser.2016.07.026

Mori, P.A. (2013). Customer ownership of public utilities: new wine in old bottles. *Journal of Entrepreneurial and Organisational Diversity*, 2 (1), 54-74. Available at https://ssrn.com/abstract=2305942

Morse, L. B. (2000). A case for water utilities as cooperatives and the UK experience. *Annals of Public and Cooperative Economics*, 71(3), 467–495. https://doi.org/10.1111/1467-8292.00149

Müller, J., & Rommel, J. (2010). Is there a future role for urban electricity cooperatives? the case of Greenpeace Energy. Advances in Energy Studies, Barcelona.

Olsen, O.J., & Skytte, K. (2002). Consumer ownership in liberalized electricity markets: the case of Denmark. *Annals of Public and Cooperative Economics*, 73(1), 69–88. https://doi.org/10.1111/1467-8292.00186

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. Hoboken: Wiley Desktop Editions.

Pacheco, D.F., Dean, T. J., & Payne, D.S. (2010). Escaping the green prison: entrepreneurship and the creation of opportunities for sustainable development. *Journal of Business Venturing*, 25(5), 464-480. https://doi.org/10.1016/j.jbusvent.2009.07.006

Pascual, O.,Klink, A.V., & Grisales, J.A.R (2011). Create impact! Handbook for sustainable entrepreneurship, enviro–innovators in sustainability. Available at: http://www.scpcentre.org/fileadmin/content/files/6_Resources/1_Publications_pdfs/60_Creating_impact_full.pdf

Pearce, J.M., & Miller, L.L. (2006). Energy service companies as a component of a comprehensive university sustainability strategy. *International Journal of Sustainability in Higher Education*, 7(1), 16-33. https://doi.org/10.1108/14676370610639227

Peredo, A.M. & Chrisman, J .J. (2006).Toward a theory of community-based enterprise. *Academy of Management Review*, 31, 309-328. https://doi.org/10.5465/amr.2006.20208683

Richter, M. (2012). Utilities' business models for renewable energy: A review. *Renewable and Sustainable Energy Reviews*, 16(5), 2483-2493. https://doi.org/10.1016/j.rser.2012.01.072

Roelich, K., Bale, C. S., Turner, B., & Neall, R. (2018). Institutional pathways to municipal energy companies in the UK: Realising co-benefits to mitigate climate change in cities. *Journal of Cleaner Production*, 182, 727-736. https://doi.org/10.1016/j.jclepro.2018.02.002

Rolfsman, B. (2004). Optimal supply and demand investments in municipal energy systems. *Energy Conversion and Management*, 45(4), 595-611. https://doi.org/10.1016/S0196-8904(03)00174-2

Ruggiero, S., Onkila, T., & Kuittinen, V. (2014). Realizing the social acceptance of community renewable energy: A process-outcome analysis of stakeholder influence. *Energy research & social science, 4*, 53-63. https://doi.org/10.1016/j.erss.2014.09.001

Sauter, R., & Watson, J. (2007). Strategies for the deployment of micro-generation: implications for social acceptance. *Energy Policy*, 35(5), 2770-2779. https://doi.org/10.1016/j.enpol.2006.12.006

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: categories and interactions. *Business Strategy and the Environment*, 20 (4), 222-237. https://doi.org/10.1002/bse.682

Scott Cato, M., Arthur, L., Smith, R., & Keenoy, T. (2007). Entrepreneurial energy: associative entrepreneurship in the renewable energy sector in Wales. *Available at SSRN 1970251*. http://dx.doi.org/10.2139/ssrn.1970251

Seyfang, G. (2009). *The new economics of sustainable consumption*. Basingstoke: Palgrave.

Seyfang, G., Park, J. J., & Smith, A. (2013). A thousand flowers blooming? An examination of community energy in the UK. Energy policy, 61, 977-989. https://doi.org/10.1016/j.eist.2014.04.004

Sha, A., & Aiello, M. (2016). A novel strategy for optimising decentralised energy exchange for prosumers. *Energies*, 9(7), 554. https://doi.org/10.3390/en9070554

Shepherd, D.A., & Patzelt, H. (2011). The new field of sustainable entrepreneurship: *Entrepreneurship Theory and Practice*, 35(1), 137-163. https://doi.org/10.1111/j.1540-6520.2010.00426.x

Smith, G. & Young, S. (2007). *Social economy and the environment*. Paper at the conference Social Economy: Towards a Worldwide Perspective, Leuven, June.

Smith, G. (2007). Green citizenship and the social economy. *Environmental Politics*, 14(2), 273-289. https://doi.org/10.1080/09644010500055175

Sorrell, S. (2007). The economics of energy service contracts. *Energy Policy*, *35*(1), 507-521. https://doi.org/10.1016/j.enpol.2005.12.009

Teece, D.J. (2010). Business models, business strategy and innovation. *Long Range Planning*, 43, 172-194. https://doi.org/10.1016/j.lrp.2009.07.003

Ürge-Vorsatz, D., Köppel, S., Liang, C., Kiss, B., Nair, G.G. & Celikyilmaz, G (2007). *An Assessment of Energy Service Companies (ESCos) Worldwide*, London: World Energy Council.

Van Der Schoor, T., & Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews*, 43, 666-675. https://doi.org/10.1016/j.rser.2014.10.089

Van Der Schoor, T., & Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and sustainable energy reviews*, 43, 666-675. https://doi.org/10.1016/j.rser.2014.10.089

Van Vliet, B. (2004). Shifting scales of infrastructure provision In Southerton, D., Chappells, H., & Van Vliet, B. (Eds.) *Sustainable Consumption: The Implications of Changing Infrastructures of Provision (pp-67-80)*. Cheltenham: Edward Elgar.

Van Vliet, B., & Chappells, H. (1999). *The Co-provision of Utility Services: Resources, New Technologies & Consumers*. Reader distributed for the Consumption, Everyday Life and Sustainability Summer School, Lancaster University.

Vickers, I. (2010). *Social enterprise and the environment: a review of the literature*. Third Sector Research Centre Working Paper 22.

Vine, E. (2005). An international survey of the energy service company (ESCo) industry. *Energy Policy*, 33(5), 691-704. https://doi.org/10.1016/j.enpol.2003.09.014

Wagner, L. (2010). *Energy Service Companies (ESCo) (research note)*. Moro Associates. Available at www.moraassociates.com/reports/1002%20ESCO.pdf

Walker, G. (2008). What are the barriers and incentives for community-owned means of energy production and use? *Energy Policy*, 36(12), 4401-4405. https://doi.org/10.1016/j.enpol.2008.09.032

Walker, G., Hunter, S., Devine-Wright, P., Evans, B., & Fay, H. (2007). Harnessing community energies: explaining and evaluating community-based localism in renewable energy policy in the UK. *Global Environmental Politics*, 7(2), 64-82. https://doi.org/10.1162/glep.2007.7.2.64

Watson, J. Sauter, P., Bahaj, B., James P., Myers, L., Wing, R. (2008). Domestic microgeneration: Economic, regulatory and policy issues. *Energy Policy*, 36: 3095-3106. https://doi.org/10.1016/j.enpol.2008.04.028

Wiersma, B., & Devine-Wright, P. (2014). Decentralising energy: comparing the drivers and influencers of projects led by public, private, community and third sector actors. *Contemporary Social Science*, 9(4), 456-470. https://doi.org/10.1080/21582041.2014.981757

Willis, R., Willis, J. (2012). *Co-operative Renewable Energy in the UK*. Manchester: Co-operatives UK.

Wirth, S. (2014). Communities matter: Institutional preconditions for community renewable energy. *Energy Policy*, 70, 236-246. https://doi.org/10.1016/j.enpol.2014.03.021

Wüstenhagen, R., & Boenke, J. (2006). Business models for sustainable energy In Andersen, M., & Tukker, A. Proceedings of the workshop of the Sustainable Consumption Research Exchange (SCORE) network: prospectives on radical changes to sustainable consumption and production (pp. 253-258), 20-21 April, Copenhagen Denmark, pp. 253-258.

Table 1: ESCo markets across selected countries (Boza-Kiss et al. 2019)

		Number of ESCos					
	Establishment of first ESCo	2007	2010	2013	2015	2018	Market value (2018 in euros)
France	1800's /1937	3 (100)	10+100	350	300	45	13.5 billion (EnS); 40-60 million (EnPC)
Germany	1990-1995		250-500	500-550	ca. 500	560 (EnS);	9 billion (EnS);

						138 (EnPC)	7.7 billion (EnPC)
UK	1966	20-24	20	30-50	>50	136 (EES); 62 (ESCOs);	108.3 million
Italy	early 1980s	15-25	50 (100)	50-100	200-300	1500 (EnS); 340 (ESCo)	2 billion

Figure legends

Figure 1 Deployment model for microgeneration technologies (Sauter and Watson, 2007 p. 2774)

Figure 2: Adapted from Sorrell (2007) in Hannon et al. (2015, p. 902)