Community solar initiatives in the United States of America: comparisons with – and lessons for – the UK and other European countries

Community solar initiatives in the United States of America: comparisons with – and lessons for – the UK and other European countries

Abstract

Solar energy systems that are increasingly economic with regard to their design, delivery and operating costs, hold the potential to contribute considerably to a nation's energy mix. While solar generation comes in many forms, 'shared solar', or a community-based system with an array size intermediate between a large-field and an individual residential system, offers many advantages that utility-scale projects are not able to deliver. The aim of this paper is to examine the development of shared solar initiatives in the recent history of US energy policy in order to reveal lessons that could be applied to future renewable energy generation in other developed nations including the UK and other European countries. Specifically the paper offers original appraisal of the 'solar gardens' scheme being trialled in Minnesota, drawing on findings from a survey with over 650 respondents representing a range of local renewable energy organizations and their customers. We examine the salience and influence of four key factors, namely: (i) perceived individual benefits; (ii) sources and trustworthiness of information; (iii) location; and (iv) project financing. Taken together the findings contribute understanding on the potential for community solar projects to assist in the transition towards a more sustainable and resilient energy future.

Keywords: Community energy; Shared solar systems; Local energy governance.

1. Introduction

One of the most common criticisms of a renewable energy future is the inability of sources such as wind and solar to replace fossil fuels as the backbone of any reasonably priced power generation system. Such a claim is under increasing challenge. The U.S. National Energy Renewable Laboratory's (NREL's) Renewable Electricity Futures Study, for instance, concluded that "*electricity supply and demand can be balanced in every hour of the year in each region with nearly 80% electricity from renewable resources, including nearly 50% from variable renewable generation*" (NREL, 2012: 3). While no doubt a challenging journey necessitating a range of demand and supply-side solutions, incorporating grid storage, more responsive loads, new transmission and new types of operations vis-à-vis power systems, the report's authors found that "*the abundance and diversity of U.S. renewable energy resources can support multiple combinations of renewable technologies that result in deep reductions in electric sector greenhouse gas emissions and water use*" (NREL, 2012: iii). Similar conclusions were reached by the over 150 authors of *America's Power Plan*, a study overseen by the Energy Foundation and which offered numerous recommendations for working through the multitude of issues involved in the transition to a more sustainable energy future (Harvey and Aggarwal, 2013).

Among the resources likely to hold the greatest potential to aid transformation of the current central station, grid based system of electricity generation and consumption are increasingly economic solar energy systems (Wiser and Dong, 2013). While much attention has been paid to utility-scale projects, one of the most significant challenges to the current system might well be community solar projects with array sizes intermediate between large-field and individual residential or commercial systems. This paper highlights the opportunities and challenges for community solar projects to assist in the transition towards a more sustainable and resilient energy future with findings from a US case study considered in the context of possible lessons for the current and future development of local-level solar electricity generation in the UK and other European countries. Whilst it is acknowledged that some of the lessons emerging from the US research may well have application potential in countries outside the EU (including prominent 'emerging economies' like China and India) for the sake of clarity and tightness of focus in this paper the central point of concentration is on the UK. Increasingly the potential expediency of local-level and community energy/sustainability initiatives in helping to meet legally binding climate targets has been a key feature of UK policy making over the last decade and a half, with a range of policy documents, White Papers and other government communications bearing witness to this – particularly in respect of effective community engagement (for example, DECC, 2009; The Cabinet Office, 2010; DCLG, 2011; HM Government, 2011; HM Government, 2018). This has spawned an ongoing dialogue on extant opportunities, challenges, enabling and inhibiting factors in the fields of current policy analysis and academic inquiry. The current paper contributes fresh insights to this ongoing UK-based debate with some additional evidence discussed and compared in relation to other European countries; specifically Denmark the Republic of Ireland, and Germany. These nations represent geographic and cultural diversity and have all made concerted efforts in terms of policy and practice at various points during the last two decades regarding the design and delivery of effective renewable energy strategies, including solar applications.

It is important to remember that considerable variations in solar irradiance, or insolation, occur both within and between countries. This clearly has potential implications for the applicability of community scale solar at different locations, both in relation to electricity generation capacity and also regarding implications for the efficacy of community pressure and action. So in the UK, for example, the application possibilities for solar in insolation terms are greater in South-West England than in Northern Scotland. In order to give an idea of the magnitude of variation for the five countries described in this paper, Table 1 provides solar insolation figures measured in kWh per square meter per day in a summer month (July) at five disparate locations (North, South, East, West and Central) in each country. The data has been obtained from the 2017 edition of the Solar Electricity Handbook (Boxwell, 2017). From the data shown here the USA and Denmark stand out as having the highest insolation levels at this time of year – but with substantial national variations evident in each case. The UK and Germany share similar but lower level profiles, with Ireland more consistently lower on average across the country in July.

Table 1: Average solar insolation at locations North, South, East, West and central for each case study country in July (measured in average kWh per square meter per day). [Source: Boxwell, 2017]

Location	**Germany**	**UK**	**USA**	**Denmark**	**Republic of Ireland**
North	Hamburg 4.68	Aberdeen 4.31	Saint Paul Minnesota 6.05	Aalborg 6.27	An Longfort 4.21
South	Freiburg 5.48	Exeter 5.28	Houston Texas 5.94	Odense 5.41	Cork 4.61
East	Dresden 4.84	Norwich 4.86	Bangor Maine 5.40	Copenhagen 5.30	Dublin 4.21
West	Dusseldorf 4.78	Swansea 4.71	Los Angeles California 7.54	No data available	Castlebar 4.28
Central	Hanover 4.61	Nottingham 4.50	Bellevue, Nebraska 6.19	Arhus 5.52	Tullamore 4.21

Boxwell, M. (2017) Solar Electricity Handbook - 2017 Edition A simple, practical guide to solar energy - designing and installing photovoltaic solar electric systems. Greenstream Publishing Ltd., London.

We begin by discussing the community-level context, focusing on the opportunities and constraints related to definitions of community energy and mobilization – at the local level – of people individually and collectively in sustainable energy initiatives and sustainability projects more broadly.

2. Background and literature review

2.1 Community energy – concepts, definitions and practices

Recent work by Seyfang et al. (2013) considers the argument that, whilst community organization and mobilization has been offered as an effective delivery mechanism for local level carbon reduction strategies, there are currently inconsistent ways of assessing this approach. Also, and perhaps more importantly, inconsistencies exist in relation to supporting the development of low carbon communities through appropriate regulatory and policy frameworks. They suggest that part of the problem relates to the fact that there is no universal definition of 'community energy'; rather "they encompass a wide range of initiatives such as locally-owned renewable energy generation, community hall refurbishments, collective behaviour change programmes, are claimed to bring additional public engagement benefits to top-down policy initiatives" (Seyfang et al. 2014: 22).In a similar vein, and having observed the diverse range and extent of local-level initiatives identified as so-called ‘community energy projects’, Walker and Devine-Wright (2006) developed an evaluatory grid to assist in providing clarity on the characteristics of a project regarding two principal dimensions. First, dimensions relating to process – Who is the project for? Who owns, operates and manages the project? And second those relating to outcomes – Who actually benefits from the project? How do they benefit; and in what ways are those benefits shared out? The authors highlight that assessing the potential contribution of local and community responses to carbon management and the broader climate challenge requires an understanding of how the processes and outcomes of such endeavours are applied and distributed in practical terms.

The difficulties of defining what ‘community’ means is a subject that has been extensively deliberated in range of academic literature particularly with regard to the diversity of social organization found within and across different community ‘types’; for example communities of ‘place’, of ‘practice’, of ‘interest’ and so on (Peters et al., 2010). In their paper, Walker and Devine-Wright (2006) discuss those difficulties in an energy project context. It is posited that projects possessing a true community nature would be characterized by a high level of involvement of local people in the planning, setting up and, potentially, the running of the project; with the core benefits arising being distributed locally (e.g. energy generation, providing jobs, contributing to local regeneration or providing an educational resource).

The ability of local action to galvanize collective community activity is, however, seldom a straightforward process; and access to sufficient start-up capital can also be restrictive. In order to investigate such community-oriented challenges in greater depth, Seyfang and her colleagues set in motion a research programme designed to build on three existing surveys – by the Low Carbon Communities Network, Energy Saving Trust, and a Friends of the Earth study of 267 community climate action groups. During the period of June to October 2011, they compiled a database of community energy projects, collated from comprehensive internet based searches and snowball sampling from the personal contacts within the research team. This included "local, regional and national organizations working in climate change, sustainability and sustainable energy issues" (Seyfang et al. 2013: 980). These organizations were subsequently contacted and asked if they would be willing to circulate a link to a web based survey to their members and other organizations that they might be in touch with.

The closed and open questions in the survey incorporated several key themes including: 'structure/organization; 'location' i.e. rural or urban; 'kinds and types of projects' i.e. renewable energy installation, behaviour, or conservation; 'activities'; 'regulation and policy' – a development which they suggest will enable a better understanding of the financial and political backing which is so essential to longer term consolidation for the sector. Data gathered from 337 organizations who took part in this research offered some interesting insights into both the scope and diversity of this sector – insights which Seyfang et al. (2012) strongly suggest need to be embraced more fully by policy makers than they are at present. Amongst findings from survey respondents, 18% argued that major challenges for their organization revolved around lack of time and an over-reliance on volunteers; 31% of respondents who argued that the current lack of funding for this sector was a problem; 26% of the respondents in the survey pointed out that there was a major issue around engaging the wider community in which their project was located; 83% of survey respondents highlighted that the aim of their project was saving energy bills in their community, as opposed to saving carbon; and 73% of respondents suggested that the strength of their organization was underpinned by networking with other community groups and/or other organizations and businesses. Finally, 30% of the survey respondents stressed that effective policy and regulatory frameworks were critical for longer-term success at this level.

The strength of shared links in networks is an opportunity for community groups and grassroots initiatives highlighted by Middlemiss & Parrish (2010), who emphasize that such groups need to draw on multiple capacities, such as personal, organisational and cultural capacity in their activities. They highlight the potential for grassroots initiatives to build community capacity for low-carbon practices. In doing this it is argued that such initiatives are capable, in principle, of breaking current social boundaries by creating new capacity for social change. Forman (2017) adds that grassroots initiatives have the capacity to foster greater energy justice. Community energy is often involved in a wide range of local activities, supporting them to further stimulate local action and deliver more widespread equity gains. Forman additionally underlines the overlap between community energy and issues of local development, local environment, local economy, local culture and social justice (Forman, 2017). This suggests that community energy ownership has much to offer in engendering more widespread equity gains. Considerable work is however required to identify the practices, and material, social and political contributions required for equitable, low-carbon well-being (Simcock & Mullen, 2016).

In relation to demand-side community action initiatives Burchell et al (2014) look, with more balance, beyond their often quoted value and review downsides: referring to NIMBY-ism, the challenges in defining community, power, division, exclusion, conflict and oppression. Interestingly the literature on community-owned *supply* initiatives already reflects these to a large degree. Communities have pointed to the challenges for post-intervention progress (DECC, 2012b) underlining organisational management as critical. Related to this, Burchell et al (2014) review highly varying levels of local trust of project managers, and divisions between local supporters and opponents of initiatives. This signposts the potential for conflict, disagreement, disorder, fracture and failure of such transition. Another downside is the range of quite divergent interests and objectives among commercial and institutional actors (Burchell et al, 2014) and related to this it is imperative that individuals and communities are able to respond to available support in a flexible manner (DECC, 2012).

Wustenagen et al (2007) explain that procedural and distributional justice are important features of community acceptance and engagement of local residents. The findings of Milesecure (2014) in relation to supply-type initiatives support this position stating, for example, that "ownership of the means of energy production seems to have been a key factor in the construction of active consent" (Milesecure, 2014: 46). Key to enabling sustained transition are strategic deliberative processes which "can enhance procedural legitimacy through building trust, increase understanding through social learning, and promote ownership of the decision-making process" (Hajjar & Kozak, 2015: 64). Successful transition in a significant demand-type community-based initiative in Ireland, which enhanced procedural and distributional justice, supports the strategic use of Discourse Based Approaches and co-creation (Carragher, et al. 2018).

2.2 Solar energy nationally and locally in the US and the UK

Arguably one of the critical advantages associated with renewable systems, including scalability and cost avoidance, particularly with regard to the long-distance transmission of mass volumes of electrical energy associated with more 'traditional' transmission networks. Community or 'shared' solar systems capture both of these advantages. Sometimes referred to as a 'solar garden', a facility of this sort is defined by the Interstate Renewable Energy Council as an "*energy generating facility . . . interconnected at the distribution level . . . located in or near a community served by a electricity provider where the electricity generated by the system is credited to the Subscribers to the facility. [The system] may be located either as a stand-alone facility . . . or behind the meter of a participating Subscriber*" (IREC, 2013: p.18).[i] Such a system creates a spatial link between the production and consumption of energy in at least two ways. First, the project can connect subscribers to the array via a local distribution circuit even if a portion of a subscriber's total electrical budget is derived from grid-connected sources (Wiseman and Bronin, 2013). Second, subscribers generally reside within the service territory of a participating utility, within the borders of sponsoring municipality, or within a certain distance from the array or fellow subscribers (Wiedman, 2010).

Unfortunately, as in the case of community wind, the rhetoric of community solar has often outpaced the realities on the ground (Hoffman and High-Pippert, 2007). Tucson Electric Power's Bright Tucson Community Solar program, for example, is a traditional green-pricing program that allows community members to purchase a block of output from a utility or third party-owned solar facility for a fixed fee of $3/month, a cost which is added to their electricity bill; as a result, the program does little to assure a connection between generation and consumption. Another example – Maine's Renewable Energy Pilot Program – is somewhat more conscious of a community connection in that it requires that a generating facility be fifty-one percent locally-owned; on the other hand, the facility can be located anywhere in the state and must be grid-connected. Three recent privately installed installations in Vermont used the term 'community-scale' solely in reference to both the size of the projects, that is, two 150-kilowatt solar farm and a 35kW installation, and the fact that all are designed to serve local public facilities such as police and fire stations. An even weaker version of community solar are so-called *Solarize* programmes or joint purchasing initiatives that allow individual homeowners to realize economies of scale through bulk buying practices. Even with these limitations, the United States remains a useful case study of community solar due to its relatively rapid growth and overall application potential. NREL estimates that (Feldman et al. 2015, 5,6):

[T]he number of shared solar programs has grown from one in 2006 to 41 as of August 2014. These programs span 19 states and collectively have a maximum program size of at least 172 MW. The Solar Electric Power Association (SEPA) and the Interstate Renewable Energy Council (IREC) are also tracking another 16 programs in the planning or proposal stages, which could increase the market's presence of shared solar to 22 states and a maximum program size of at least 1.3 GW.A complex mix of barriers, challenges and opportunities in the move towards more widespread community solar energy has been equally observable in other countries and locations. In the United Kingdom for instance, for most of the 1970s it was concluded that PV was not relevant to the UK context and little funding was therefore provided to help in the technology's establishment, development and application. Advocates of PV pointed out that the methodologies developed for large, centralized power systems worked against the potential of PV to enter mainstream energy markets. Although there was some transitory work on solar cells, PV remained at the margins, limited to the development of niche markets. This situation was further embedded into the UK energy system design once the discovery and opening of North Sea oil and gas removed the growing political and economic concern around energy security (Smith, et al., 2013).

However, the miners' strike in 1984 and the gradual reduction of coal in the UK's growing electricity use paved the way for an emerging series of structural shifts in the UK's energy system, culminating in the privatization of the gas and electricity sectors in the late 1980s and the use of predominantly gas-fired electricity for new capacity, providing cheaper energy over the following decade. It was not until 1992 however, when UK PV installed capacity was only 0.1MWp (DECC, 2012a), that the EC/EU THERMIE program supported UK demonstrations for integrated grid-connected PV. By the mid-1990s a UK Technology Foresight panel had rated building-integrated PV as the highest renewable energy opportunity, although the government response remained minimal, instead being seemingly more dedicated to a market paradigm that favoured large scale, centralized, supply.

By the beginning of the 2000s, the growing urgency of climate change and a resumption of worries around energy security saw a political shift towards government being more accepting of the possibilities offered by renewable energy. The Labour government of 1997-2010 introduced a new series of grant programmes designed to help the development of PV. However, the main policy instrument for renewables during this time, the Renewables Obligation (RO), had a price ceiling that was too low to encourage widespread investment in PV (Smith, et al., 2013). All of the schemes were oversubscribed and the funds depleted rapidly, the result being a stop-start dynamic in PV deployment. Significantly, while there was noticeable momentum building for micro-generation during this time, new nuclear capacity resurfaced on the policy agenda as a politically expedient way in which both to reduce the UK's CO_2 emissions and to address growing concerns over gas import restrictions. PV advocates argued for a Feed-In tariff (FIT) to complement the RO by focusing on micro-generation, in return for support on nuclear and offshore wind reforms. The new FIT 'subsidy' received rapid uptake, a result that alarmed the new Conservative-Liberal Democrat government, in turn creating a new round of government cuts. Nonetheless, in May 2012 the national Government announced that their updated Renewable Energy Roadmap would include an explicit focus on solar PV (Smith, et al., 2013).

Despite such variable support, over the last 10-15 years innovative methods of adoption have begun to shape and influence an emerging energy policy landscape that focuses in large part on local and community level applications, with local government having a core role in the design and mobilization of deployment strategies. For instance, the Borough Council of Woking has developed their Oak Tree Programme during this period which provides residents with an opportunity to see for themselves how different energy efficiency measures and installations work, including the role of PV, by transforming an ordinary three bedroom detached house into a low carbon demonstration home (Peters, et al., 2010). The council aimed to recruit 1000 households, each helping others along the pathway towards a 'Low Carbon Home'. It was anticipated that reductions in emissions from household energy use of sixty percent to eighty percent or more would be achievable from a range of practical and effective energy saving measures, supported by simple behavioural changes, an approach to carbon saving that aligns closely with that set out in the UK Carbon Plan (DECC, 2011). A recent study conducted for the British Photovoltaic Association (BPVA) clearly demonstrates that such results are potentially replicable throughout the UK, a finding no doubt encouraged by the variety of initiatives being led by both grassroots groups, cooperative organizations and local authorities despite the many challenges and barriers to such developments[ii] (Kyrke-Smith et al., 2013). In June 2016 it was reported in the national media that for the first time in history solar generation in the UK – across the entire month of May – produced more electricity than coal (with solar producing 1,336 gigawatt hours (GWh) compared with an output of 893GWh from coal) (The Guardian, 2016).

An increase in solar generation alongside the expansion of other renewable generation technologies is observable in several other European countries at various points over the last two decades. Three examples that are diverse with regard to culture and geographical location are Denmark, the Republic of Ireland and Germany; they are discussed in the following section.

2.3 Progress of solar and other renewable energy generation in Denmark, Ireland and Germany

2.3.1 Denmark

Scandinavia provides a number of interesting insights from countries which have developed long-term carbon mitigation strategies, and it has been argued that Denmark, Sweden and Finland are among the world's best at clean technology innovation (Maya-Drysdale and Hansen, 2014). Denmark, in particular, has developed an approach to energy system change which draws on an integrated, grassroots approach to energy generation and consumption. As an exemplar of an effective shift away from the use of fossil fuels (Wang et al., 2017) Denmark exhibits some key renewable energy features:

- It has the largest penetration of decentralized energy in the industrialized world with a record 44% of electricity supply in 2017, 39% of overall energy supply;
- A large percentage of Denmark's energy supply is through wind and a large network of CHP plants where Denmark is a European leader in wind turbine and CHP implementation;
- Denmark demonstrates a high level of government and business support for renewables and CHP, where this foundation has been important in provided a stable environment for decentralized energy since the 1970s;

- Denmark is on track to have 50% renewable energy online by 2050.

Considering the International Energy Agency’s description of Denmark as a world leader in terms of decarbonization, Van der Vleuten and Raven (2006) suggest that historical preconditions provided a ‘seedbed’ for this shift. Marking out the uniqueness of Denmark’s low carbon transition, they describe the ways in which government support of renewables and the shift towards decentralization has involved the deliberate inclusion of smaller urban municipalities, rural cooperatives and community-based interests. As they propose, this has made a potentially difficult transition from the previously centralized energy regime simpler and much more inclusive. This has meant that, over the longer term, a wide variety of Danish stakeholders have had a more personal investment with energy system change, including the encouragement of grassroots knowledge building alongside more specialised expertise, informing an evolving energy system based around different and more innovative ways of delivering heat and power.

As Vase and Tindale (2011: 88) point out, Denmark has demonstrated strategic leadership in how to oversee energy system change, where much of its success in relation to “the ways in which large-scale strategic decisions that have to be made at the national and provincial level’, have been successfully introduced and implemented at the local and community level. For example, they point to the introduction of the Heat Supply Act (and subsequent iterations) in 1979, as a key catalyst for future changes in this sector, which have included bestowing local authorities with a mandate to require commercial premises and households to join district heating networks within a decade of a new network becoming available locally. The Heat Supply Act was also a contributing factor to the emergence of consumer-owned energy co-operatives which began to emerge at this time

– a development that is also ‘a key attribute of the highly successful Danish wind industry’ (Vase and Tindale, 2011: 68).

2.3.2 Republic of Ireland

Under the 2009 Renewable Energy Directive, Ireland is committed to produce at least 16 per cent of all energy consumed from renewable sources by 2020. This will be met by 40 per cent from renewable electricity, 12 per cent from renewable heat and 10 per cent from the renewable transport sector. Electricity from renewables (mostly wind) increased eleven fold from 697 GWh in 1990 to 7,857 GWh in 2015 (SEAI, 2015). Use of renewables in fuels used for electricity generation increased by 18.8% in 2015 (SEAI, 2015). Electricity from solar in 2015 accounted for just 0.01% (SEAI, 2015). Irish policy instruments have not supported solar PV or its community version with a minor exception being the Better Energy Communities programme.

In December 2015, Ireland’s Energy White Paper Ireland’s Transition to a Low Carbon Energy Future 2015-2030 set out over 90 Government actions aimed at low carbon transition. In it, the Government set out several specific actions to engage and empower communities in sustainable energy transition (DCENR 2015). The National Mitigation Plan has further underlined the importance of engaging communities, of community-led projects, and of community ownership in Ireland’s decarbonisation (DCCAE, 2017). It confirms that the sharp decline at a global level in the cost of PV technology has resulted in significant interest in this renewable technology in Europe. The Irish government is currently consulting under the new Renewable Electricity Support Scheme for these technologies and has indicated that support for solar PV is being considered. “Solar PV ….. can empower Irish citizens and communities to take control of the production and consumption of energy” (DCCAE, 2017: 41).

Speculative interest in solar PV has increased due to Government’s discussions on RESS and by 2016 there were over 500 applications submitted to ESB Networks for connection of solar farms, totalling over 4,000MW. This interest is largely from the private sector but community solar interest is represented (EI, 2016). There is currently strong engagement in Ireland with 150 Sustainable Energy Communities registered with SEAI and this could be leveraged to kick start a solar community plan. Given Irelands RE commitments and the low deployment of solar PV and more especially community solar PV our US case study presents a vision for and shines alight on the potential of community solar PV. Given the small size of community solar PV installations, a measured plan, presents no disruption to grid capacity or reliability.

2.3.3 Germany

Germany is an example of a European country that has experienced a vast expansion in the deployment of renewable generation technologies over the last two decades. As Wurster and Hageman (2018) point out this has, to a large extent, been facilitated by a policy framework for sustainable energy transition characterized by financial support in the form of subsidies and the development of an infrastructural network capable of supporting the technologies. The authors do highlight, however, that “significant regional disparities are evident between individual federal states” and that “without the incentive of guaranteed feed-in tariffs for electricity from renewables, the dynamics of expansion would probably be significantly lower” Wurster and Hageman (2018: 610, 618). One region of the country that is able to demonstrate more consistent success in the deployment of community driven PV lies to the southwest, in and around the city of Freiburg im Breisgau. The 'SolarRegion' concept established in Frieburg has its roots in the mid-1970s, when effective resistance against plans for a proposed nuclear power plant near to the city created the need to identify an alternative energy supply system. The central elements of the alternative model incorporated (i) the development of a pro-environmental political culture; (ii) the creation of a pool of expertise and know-how; and (iii) the realisation of strategic opportunities for establishing and progressing energy efficiency and renewable energy technologies (City of Freiburg EPA, 2007).

First adopted in 1986, the Frieburg model features three interlinked strategies. Firstly the principle of energy saving has provided a core focus, through for example improving the thermal efficiency of older buildings with insulation and the application of advanced energy standards for new developments. Secondly, the establishment of efficient energy supply technologies, including co-generation power stations and local combined heat and power plants. Finally the widespread roll out of renewable energy – with solar energy providing the cornerstone of this strategy, but including other technologies such as biomass (City of Freiburg EPA, 2007).

With currently over 10 MW of photovoltaic panels and more than 13,000 m^2 of solar thermal collectors, Freiburg continues to hold a leading position in solar energy applications in Germany. Additionally, it has become a centre of expertise in solar energy technology and applications, forming a major asset for Freiburg as a business location (WWF Global, 2012).

One of the most notable features of the SolarRegion approach progressed in Freiburg is the incorporation of citizens as key stakeholders – emphasizing the importance of social engagement in sustainable energy governance. As critical as the technology and technical knowledge base clearly is, decision makers at the local and federal level were keen to connect with social sustainability principles, respecting the centrality of people – individually and collectively – in creating a sustainable urban environment.

Freiburg’s success in translating a sustainable vision into the range of projects and applications currently on display in and around the city has come about through a unique set of circumstances that – in their entirety – would clearly be very difficult, if not impossible, to replicate. Nevertheless lessons can be drawn and experiences learnt from in order to promote the practical application of renewable energy development within smaller communities. From the perspective of citizens this includes reasonable costs, comfort, and control. From a policy/decision-making standpoint it requires consensus and collaboration. And finally it is important to obtain the interest and involvement of a range of agents from different sectors of society. In terms of the SolarRegion project this has become known as the 'Freiburg mix' – the different motivations of the stakeholders generating momentum [15, 16]. This kind of development could make an important contribution to the transition away from carbon dependency and centralised fossil fuel supply.

In the next section attention is turned to the recently established solar gardens scheme in the northern US state of Minnesota. Findings from a recent questionnaire-based survey with local renewable energy companies and their customers are presented and discussed thematically.

2.2 Minnesota: A Northern US Case Study

A series of policy initiatives recently enacted in the American state of Minnesota included perhaps the most far-reaching community solar legislation found in the United States. In addition to imposing additional renewable energy requirements on the state's utilities, the legislation also requires that at least ten percent of the 1.5 percent [solar] goal has to be realized through solar energy generated by or obtained from solar photovoltaic devices of 20 kilowatts capacity or less (Masterjohn, 2012). The legislation recognized and specifically named solar gardens as the mechanism by which the mandate was to be met. Similar to that found in Colorado, the legislation does not require the electricity generated by the project to be consumed directly by subscribers, but it does mandate that a project "*be designed to offset the energy use of not less than five subscribers in each community solar garden facility of which no single subscriber has more than a 40 percent interest*" (Xcel Energy, 2017: p.3). The legislation also allows public purpose and nonprofit entities to develop and manage a project – and there is no limitation on either the number or cumulative generating capacity of community solar garden facilities. Subscribers must, however, be retail customers of the public utility located in the same county or a county contiguous to where the facility is located (Masterjohn, 2012).

The variety of mechanisms suitable for a solar garden and the multitude of actors potentially involved in an initiative are highlighted in a project currently under development in the state, named 'MN Community Solar'. A small project of forty kilowatts in scale, the initiative involves (i) a Minneapolis-based energy company that created a new division expressly for the purpose of developing solar gardens[iii]; (ii) a merchandising business in Minneapolis that will serve as the host site; (iii) the state's largest city, solar installers and other contractors; and (iv) individual subscribers. Beyond the initial project, the primary aim of MN Community Solar is to bring communities together via workshops and educational outreach in order to identify ideal 'host spots' for the purpose of solar development, and make available the necessary legal, financial and design expertise to enable Minnesotans to benefit from community-based energy options that are both affordable and accessible (SEIA, 2012).

3. Methodology

The research involved the administration of questionnaire surveys designed to elicit the views of local residents on community solar initiatives. It was intended that this would contribute to improved understanding of the issues associated with the creation of viable community solar initiatives. Two surveys, using the same questionnaire instrument, were conducted in late 2013 and early 2014, with a total of 537 respondents. A further survey with a revised instrument was administered in the autumn of 2014, with 131 respondents. The surveys were administered online, with the electronic link being sent to individuals on distribution lists maintained by a range of private and non-profit partner organizations including Fresh Energy, MN Community Solar, Clean Energy Resource Teams (CERTs), Minnesota Interfaith Power and Light, Minnesota Renewable Energy Society (MRES), the

Izaak Walton League (Midwest Office), and the Colorado State University Extension Service.

A follow-up request was sent a week after the initial request. Survey response rates varied by organization, but remained in the range of 10 to 15 percent. While the individuals who responded to these surveys represent a broad mix of respondents, including those displaying certain affinities such as religious or environmental concerns, they are not representative of the general population.[iv] Rather, given their membership in organizations that advocate on behalf of green energy options and work to involve individuals in environmentally beneficial energy activities and programmes, it is reasonable to assume that respondents would be early adopters and hence, particularly receptive to programs perceived to advance their environmental values (Rogers, 1995). This would, of course, be problematic if these findings were to serve as a guidepost for the creation of messages with appeal to the general public. However, given that awareness and knowledge of shared solar initiatives is minimal amongst the general public, marketers and developers must make their appeals to precisely the sorts of individuals who responded to this survey, at least if they are to follow the well-worn path of innovation and diffusion characteristic of most emerging technologies (Berkowitz, 1996; Rice, 2009; Rogers, 1995; Weatherford, 1982).

The surveys themselves aimed to provide useful information on the critical question of 'what are the key factors that might affect an individual's decision to participate in a community solar initiative?' Three categories of motivating factors were specified, including:

1. Personal factors such as the ability to use cutting edge technology, the opportunity to achieve energy independence, and personal economic benefit.
2. 'Local', though socially distant, factors including generalized environmental benefits of shared solar, perceived local energy use, and whether or not Minnesota or Colorado companies would build and/or maintain the system; and
3. Considerations relevant to the community-building benefits of such systems, namely, the opportunity to partner with either neighbours or members of a particular affinity group such as a faith community or business association.

These factors feed into the thematic structure within which key findings from the surveys will now be presented and discussed.

4. Results and discussion

4.1 Perceived individual benefits

The individual benefits of shared solar are clearly important and influential in the adoption decision. An overwhelming majority of respondents rated both energy independence (85 percent) and personal economic benefit (75 percent) as important determinants of their decision to participate in a community solar initiative. Respondents also expressed strong interest in both general environmental benefits (92 percent) and a vague sense of 'community benefit' that is associated with a shared solar project. Indeed, clear majorities of respondents are motivated, at least to some extent, by the prospect of bringing home the benefits of shared solar, either in the form of locally produced energy that would also be locally consumed (79 percent) or by having Minnesota or Colorado companies, presumably employing Minnesota or Colorado residents, build and/or maintain the technology (78 percent).

As for the community-building opportunities embedded in a shared solar initiative, survey results indicate that the appeal of local benefits is bound up with an *abstract* rather than *specific* sense of community. That is, instead of seeing community solar as an opportunity for higher levels of civic engagement or public partnering, even those early potential adopters are not highly motivated by the community-building opportunities represented by shared solar. While many respondents do seem eager to work with their neighbours (63 percent) or members of an affinity group (45 percent), most respondents place more importance on personal economic benefit than community-building opportunities.

4.2 Sources and trustworthiness of information

Another aspect of the survey dealt with an issue of long-standing interest to researchers in this field, namely, the trustworthiness of information offered by various sources. Prior research has shown that peers and near-peers are often the most trusted source of information when it comes to the diffusion of new technologies or practices; conversely, distant and/or expert-dominated sources of information are the least trusted sources (Hoffman and High-Pippert, 2010). These survey results reinforce these conclusions. Thus, individuals representing either an investor-owned utility or a local installer are burdened by a heavy dose of suspicion. Spokespersons from a cooperative or municipal utility fare somewhat better in terms of trustworthiness. And while respondents may not express much of a desire to work directly with neighbours or affinity groups, they nonetheless trust, more than any other source, the information they receive from neighbours and affinity group members.[v]

4.3 The importance of location

Location is a critical feature of any community solar project, beginning with the question of whether to select a location within or outside of the geographic borders of a subscriber's community. In the former, proximity between the location of the project and the location of the subscribers may create a greater sense of ownership at both the individual and community level. This, in turn, may encourage participation by providing a sense of shared community benefit that can be extended to one's neighbours with minimal effort. Proximity may also encourage the use of social assets such as local schools, churches, mosques or synagogues as project sites. Indeed, even if the structures or sites associated with these institutions are not suitable as project sites, an array of formal community-based organizations, as well more informal groups such as book clubs, garden clubs, and so on, can serve as potentially valuable recruitment centers by developers or aggregators seeking subscribers to a community solar project (Hoffman and High-Pippert 2007, 2010).

Alternatively, subscribers may be located some distance from the site upon which the panels are located. Such an arrangement could allow a subscriber to act upon highly individualistic motives, including environmental or economic agendas, while avoiding unwanted or minimally attractive requirements for social engagement. Developers may also find distance between subscribers and projects beneficial in that it expands the scope of potential sites beyond those proximate to specific communities or neighbourhoods. However, increasing the physical distance between a community and the actual project site may inhibit the use of social assets as recruitment centers while weakening the social capital appeal of a solar garden.

In order to understand the significance of place in the participation decision, Minnesota respondents were asked to consider projects located both inside and outside of their community and/or neighbourhood, and there were a number of differences regarding projects located inside versus outside of a community. First, respondents were generally more concerned about affinity, and whether the community solar project is owned or operated by their membership organization, when the project is viewed as inside of their community (35 percent); there was less of a connection to group membership when the project is located outside of their community (25 percent). Second, respondents were also much more sensitive about the nature of spatially-proximate projects. Thus, while none of the proximity factors were generally ranked as being very important, respondents were nonetheless much more likely to be relatively indifferent to the project site, the size of the project, the distance to one's residence and the visibility of the project from the street if the project was outside of their immediate neighbourhood or community.

The question of location was further refined by asking about a variety of potential host sites. Again, Minnesota respondents were asked to consider projects located both inside and outside of their community; Colorado respondents were not asked to distinguish amongst projects on this basis. Similar to the general locational issues discussed above, responses were distinguishable on the basis of whether projects are located inside or outside of one's own community. Within their own communities, respondents expressed relatively stronger preferences for negative assets such as brownfield sites being turned into something productive (66 percent) and for projects located on highly visible social assets such as school roofs (68 percent) or church roofs (51 percent). This finding offers the strong possibility of using important neighbourhood or public assets as a means of securing acceptance of and/or participation in a project.

4.4 Project financing

A preference for something does not, of course, necessarily translate into a willingness to pay for that preference, a fact clearly demonstrated by survey respondents. Thus, even though strong preferences were expressed for projects located on a brownfield site or on a school roof, an overwhelming percentage of respondents indicated that they would be unwilling to pay any greater amount for a project no matter the nature of the site. The single exception to this general unwillingness to pay for preferred locations of sites concerned projects that guaranteed access to low-income households. While a 12 percent of respondents indicated willingness to pay a modest premium, they were overwhelmed by those indicating that they would pay only slightly more (34 percent) and, in most cases, by those unwilling to pay any additional amount (53 percent).

Two types of project financing were considered in the survey: (i) lump-sum or up-front financing that requires a subscriber to front the developer an amount of money with a specified pay-back period; and (ii) a pay-as-you-go method that, depending upon the terms of the contract, allows a subscriber to 'opt-out' after a given period of time. In the former, the most important contingency is the number of years a subscriber will accept as a condition of participation; in the latter, the percent change in a subscriber's bill is the controlling factor. Our survey results clearly demonstrate the importance of a relatively quick pay-back period in the participation decision, as a majority of respondents indicate a very strong interest in a project with a payback of ten years or less (76 percent), with interest dropping off as the payback period extends to between 11 and 15 years (37 percent) and further into the future. A similar finding is evident with regard to the required changes in bills when using the pay-as-you-go method.[vi] An individual's interest in a community solar project decreases smoothly and markedly with the prospect of rising monthly bills.

4.5 Lessons from the US with relevance for community solar development in the UK and other European countries

Despite the challenges around community driven PV in the US, there are promising signs that policy makers are beginning to recognize shared solar programmes as an important bridge between the committed individual and utility-scale systems. The U.S. Department of Energy's *Sunshot* programme, for instance, identifies three types of community solar initiatives, namely: utility-sponsored projects; initiatives sponsored by special-purpose entities; and initiatives organized and implemented by nonprofit organizations.

Programmes are distinguished by such factors as who owns the array, how it is financed, who is the 'host', the subscriber profile and those factors providing the motivation for participation on the part of subscribers, and the long-term strategy of the sponsor. At the present time, at least eight American states have authorized the development of utility-sponsored programs while a number of others also allow special-purpose entity and nonprofit entities to develop shared solar resources (DOE, 2012).

There are a number of factors driving these policy developments, one of the most important being that community solar initiatives accord with much of what is known about how best to motivate individuals to adopt more sustainable, pro-environmental behaviours. This has become a core focus for academic inquiry in recent times, principally through the methods and techniques of socio-technical transitions and 'practice theory' (e.g. Firth, et al., 2008; Shove, 2012). Shove and Walker, for instance, argue that embracing and encouraging the transition to more sustainable lifestyle practices requires an appreciation "*of how patterns and practices of daily life interrelate, erode and reinforce each other*" (Shove and Walker, 2011). They make the argument that placing too much emphasis on the agency of innovation in reducing a household's electricity consumption through, for instance, the purchase and use of a new, highly efficient appliance, is likely to miss the salience of behavioural and human factors that undoubtedly play a pivotal function in the establishment and durability of more environmentally 'sustainable' and less carbon intensive lifestyle practices.

The potential expediency of community-based action in accelerating the uptake of behavioural and lifestyle change has, in recent times, provided another key focus for academics, practitioners and policy makers interested in establishing pragmatic approaches for transitioning economies towards more sustainable, resilient energy futures (Peters, et al., 2010; Hoffman, et al., 2013; Peters, et al., 2013). This emphasis on collective, local-level action has arguably arisen, in part, from the growing body of evidence indicating that individuals are not currently consistently willing and/or able to take personal action on climate change 'in isolation' (Norton and Leaman, 2004; Lorenzi, et al., 2007; Spence, et al., 2011). In the UK, for example, although there is generally a high level of awareness of environmental issues, concern about the threat of climate change remains a relatively low priority for a large portion of the public and has in fact declined in perceived significance in recent years. This 'value-action gap' has been further complicated by a slight increase in skepticism on the issues of impact severity and human influence (Spence, et al., 2011).

Community energy, including shared solar projects could well play a critical part in reversing these trends and in doing so generate public support for the broader task of investment in and construction of new energy infrastructure in the UK. The positive experiences around resident engagement in community solar and other renewable technologies in both Germany and Denmark noted earlier would seem to support this and point to substantial opportunities for expanding participation through existing social assets and civic organizations. In terms of community solar, candidate organizations can range from informal gatherings such as neighborhood block clubs, local reading or garden clubs, groups of stay-at-home mothers or fathers, or even residents of a single apartment block or the occupants of an office building. More formal organizations such as schools, churches, Scout troops or local Chambers of Commerce can also serve as viable breeding grounds for a community solar initiative. As Hannah Masterjohn notes "*schools and places of worship make ideal shared solar hosts for numerous reasons. They are likely to have suitable sites for solar generation, and come with built-in pools of potential subscribers in students' parents and parishioners. They also represent an educational opportunity to introduce people who might not otherwise be interested to the benefits of solar energy*" (Masterjohn, 2012: p. 1).

While community-based solar projects no doubt offer significant opportunities for accelerating and sustaining higher levels of public participation in energy-related decisions, they can also deliver economic benefits to individual subscribers. For instance, one of the more significant barriers faced by households when installing a rooftop PV system relate to the so-called *soft costs*, or those associated with local permitting and inspection requirements. According to a recent study carried out at the Lawrence Berkeley National Labs, streamlining such requirements could cut the cost of a 2011 residential solar project by five to thirteen percent (at $6.00 per watt) and as much as forty percent in the near future (NREL, 2012). While community solar initiatives themselves may not induce local governments to re-design their processes, it would allow individuals to avoid personally entangling themselves in these issues, thus reducing the opportunity costs required of individuals who might otherwise be dissuaded from investing in a stand-alone residential system (Wiser and Dong, 2013). According to the 2012 National Solar Survey results, Americans, at least, are likely to be predisposed to appreciate such benefits. Eighty-five percent of registered voters responded that they have a favorable view of solar energy, while ninety two percent of registered voters responded that it is important for the United States to develop and use solar power. At the same time, however, registered voters also expressed concerns regarding the affordability and practicality of solar energy, factors that could perhaps be more easily addressed with community solar rather than residential solar projects (SEIA, 2012).

Similar advantages accrue on the utility side of the meter in that a community solar programme aggregates the intentions of multiple parties who might otherwise invest in stand-alone systems. Rather than managing a host of interconnections and individual meters, the utility can deal with a single party who is responsible for a single array that requires one interconnection and, in some cases, a single bill, the latter depending upon who administers the economic benefits to be allocated amongst subscribers.

Finally, community solar represents a unique opportunity for countries expanding market penetration in well-suited physical settings across the nation. Cities, for example, with their configurations of tall and unevenly spaced buildings and other structures, are not particularly amenable to a technology that requires the smooth and steady flow of air across a turbine blade. Conversely, the proliferation of large flat surfaces that characterize many urban spaces (incorporating 'big-box' retailers and other commercial spaces), translates into numerous siting opportunities for arrays of all sizes. The fact that some of these structures might be shaded or may be improperly oriented is not an insurmountable barrier given the plentitude of sites generally available.

5. Conclusions and policy implications

This paper has examined opportunities and challenges associated with the potential for community level solar PV, and associated social mechanisms of support, to contribute more substantially to a sustainable energy generation mix into the future. Considering the broader barriers and challenges in the UK, and the opportunities which have marked out the emergence and progress of renewable energy in Denmark, Ireland and Germany – and in particular community driven solar PV in Minnesota – the paper highlights the ways in which successful community level projects can be developed in relation to a marketing strategy which prioritizes participation, engagement and social norms around ideals of community membership.

It is anticipated that the results from the survey discussed in this paper could offer some useful evidence and potential guidance to policy makers, marketers and developers seeking to progress the future expansion of solar generation in the residential market of the UK and other European nations. Whilst financial factors proved to be of great importance in affecting how early adopters in Minnesota conceptualized community solar projects, it was also the case that these programmes were able to generate a broader dialogue around the perceived environmental and social benefits of such local-level initiatives. Whilst there was a rather low degree of importance attached to 'community' *per se* as a locational variable, respondents were nonetheless attracted to the idea of using local assets as project sites. When combined with a personal environmental agenda or the realization that personal economic benefits are possible and are available through participation, it is clear that such a strong combination of factors could be enough to move an individual to become a subscriber or at least more amenable to the idea of solar PV in such a setting.

Principles embedded into the community driven 'solar garden' initiatives presented in this paper are potentially relevant in relation to continued expansion of solar PV in the UK and elsewhere in Europe. For example, divergence from current EU models which have traditionally tended to prioritize economic incentives as a driver of consumer change, to models that incorporate and mobilize the role of more socially-based influences on behaviour would be very worthwhile as a way forward for policy makers and practitioners. This renewed local and community level focus would have the potential to link more clearly and effectively the roles of ‘place’, ‘social identity’ and ‘community’ in a viable and resilient energy future. In the UK, for example, latent questions around ‘energy citizenship’ – that is, those of participation and engagement – certainly provide an important and potentially exciting avenue for further exploration building on the evidence base provided by Seyfang et al., (2013) and this paper, amongst others.

Whilst small scale and culturally specific, the Minnesota experience nonetheless proffers some salutary lessons which might be drawn upon in understanding the conditions necessary for enabling effective engagement in the broader establishment of community based solar projects (whilst not forgetting the potential implications around insolation variations noted at the beginning of the paper). While it would be naïve to think that people will abandon any concern with personal gain in deciding whether or not to subscribe to community solar projects, our findings suggest that ideas around ‘community’ and ‘sense of place’, while not directly influencing participation, may yet play an important role in connecting with citizens in the progression and expansion of local-level renewable energy generation schemes over the next two decades at least.

Acknowledgements

The vision for this paper – and writing of an original version – was led by Professor Steven M. Hoffman who sadly passed away in November 2015. We respectfully dedicate it to his memory and rightfully list him as co-author.

REFERENCES

Berkowitz, B. (1996) Personal and community sustainability. *American Journal of Community Psychology*. Vol. 24 (4) 441-459

Boxwell, M. (2017) *Solar Electricity Handbook - 2017 Edition A simple, practical guide to solar energy - designing and installing photovoltaic solar electric systems.* Greenstream Publishing Ltd., London.

Burchell, K., Rettie, R. and Roberts, T.C. (2014) Community, the very idea!: perspectives of participants in a demand-side community energy project. *People, Place and Policy*, 8, 3, 168-179.

Carragher, V., O'Regan, B., Peters, M. & Moles, (2018) Novel resource saving interventions: the case of modelling and storytelling, *Local Environment,* 23:5, 518-535.

The Guardian, (2016) The Guardian newspaper. *UK solar eclipses coal power over month for first time*. Article by D Carrington, published 7th June 2016. Available online:

https://www.theguardian.com/environment/2016/jun/07/solar-sets-british-record-for-may-producing-more-electricity-than-coal (accessed 09/09/2016)

City of Freiburg Environmental Protection Agency, (2007) *Solar Region Freiburg.* Freiburg, Germany.

DCCAE, (2017) National Mitigation Plan. Department of Communications, Energy and Natural Resources, Dublin. Available at https://www.dccae.gov.ie/documents/National%20Mitigation%20Plan%202017.pdf (accessed 09/05/2017).

DCENR, (2015) Ireland's Transition to a Low Carbon Energy Future 2015-2030. Department of Communications, Energy and Natural Resources, Dublin. Available at http://www.dccae.gov.ie/en-ie/energy/publications/Documents/2/Energy%20White%20Paper%20-%20Dec%202015.pdf (accessed 09/05/2017).

DECC (2009), *The UK Low Carbon Transition Plan: National Strategy for Climate and Energy*, Department of Energy and Climate Change: London, UK and The Stationary Office: Norwich, UK, July 2009.

DECC (2011) *The Carbon Plan: Delivering our low-carbon future, Part 2: Our strategy to achieve carbon budgets*. Department of Energy and Climate Change, London

DECC, (2012a) Digest of United Kingdom Energy Statistics (DUKES). Department of Energy and Climate Change, London (2012)

DECC, (2012b) *Low Carbon Communities Challenge: Evaluation Report*. Department of Energy and Climate Change (London).

EI, 2016. Solar energy could provide a bright future for Ireland's 2020 targets. Engineers Ireland Journal, available at: http://www.engineersjournal.ie/2016/12/13/solar-energy-ireland-2020-targets/ (accessed 09/05/2017).

Environmental Energy Technologies Division, Berkeley, California (2013). Available online: http://emp.lbl.gov/sites/all/files/lbnl-6140e.pdf (accessed August 25, 2017)

Feldman, D., Brockway, A., Ulrich, E., Margolis, R., 2015. Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation. NREL/TP-6A20-63892. National Renewable Energy Laboratory, Golden, Colorado.

Firth, S., Lomas, K., Wright, A., and Wall, R. (2008) Identifying trends in the use of domestic appliances from household electricity consumption measurements. *Energy and Buildings.* Vol. 40 926–936

Forman, A. (2017) Energy justice at the end of the wire: Enacting community energy and equity in Wales. *Energy Policy*, 107, 649–657.

Hajjar, R. and Kozak, R.A. (2015) Exploring public perceptions of forest adaptation strategies in Western Canada: Implications for policy-makers. *Forest Policy and Economics*, 61, 59–69.

Harvey, H., and Aggarwal, S. (2013) *America's Power Plan*. Available online: http://americaspowerplan.com/site/wp-content/uploads/2013/09/APP-REPORT_FULL.pdf (accessed August 25, 2017)

HM Government (2018) *A Green Future: Our 25 Year Plan to Improve the Environment*. Department for Environment, Food and Rural Affairs, London.

Hoffman, S.M., and High-Pippert, A. (2007) Beyond the Rhetoric: Distributed Technologies and Political Engagement. *Proceedings of the 7th International Summer Academy on Technology Studies. Transforming the Energy System: The Role of Institutions,* *Interests & Ideas.* The Inter-University Research Centre for Technology, Work and Culture (IFZ), Graz, Austria

Hoffman, S.M., and High-Pippert, A. (2010) From private lives to collective action: recruitment and participation incentives for a community energy program. *Energy Policy, Special Section: Carbon Reduction at a Community Scale.* Mulugetta, Y., Jackson, T., and van der Horst, D., (eds.). Vol. 38 (12), 7567-74

Hoffman, S.M., Fudge, S., Pawlisch, L., High-Pippert, A., Peters, M., and Haskard, J. (2013) Public values and community energy: lessons from the US and UK. *Sustainability*. Vol. 5 (4) 1747-1763

Interstate Renewable Energy Council (IREC), (2013) *Model Rules for Shared Renewable Energy Programs.* Latham, New York

Kyrke-Smith, H., Blomfield, P., Crockart, M., and Munt, T. (2013) *Constituency Voices: realizing the potential of community energy.* The Green Alliance Trust, London

Lorenzi, I., Nicholson-Cole, S., and Whitmarsh, L. (2007) Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change.* Vol. 17 445–45

Masterjohn, H. (2012) Bringing Solar to the Masses: Community Shared Solar Gains Popularity Nationwide. *Renewable Energy World*. Available online: http://www.renewableenergyworld.com/rea/news/article/2012/04/bringing-solar-to-the-masses-community-shared-solar-gains-popularity-nationwide (Accessed August 25, 2017).

Maya-Drysdale, D. and Hansen, K. (2014) *100% renewable energy systems in the Scandinavian Region*. Research report from Aalborg University Copenhagen. Available online: http://www.energyplan.eu/wp-content/uploads/2014/06/Master-Thesis-2014-Dave-and-Kenneth.pdf (Accessed June 4, 2018).

Middlemiss, L. and Parrish, B.D. (2010) Building capacity for low-carbon communities: The role of Grassroots initiatives. Energy Policy, 38, 7559–7566.

Milescure-2050, (2014) *Deliverable 2.2: Report on comparative analysis*. Milescure-2050 (available at www.milesecure2050.eu).

National Renewable Energy Laboratory (NERL), (2012) Renewable Electricity Futures Study. Edited by Hand, M.M.; Baldwin, S.; DeMeo, E.; Reilly, J.M.; Mai, T.; Arent, D.; Porro, G.; Meshek, M.; Sandor, D. 4 vols. NREL/TP-6A20-52409. Golden, CO: National Renewable Energy Laboratory.

Norton, A. and, Leaman J. (2004) *The Day After Tomorrow: public opinion on climate change*. MORI Social Research Institute, London

Peters, M., Fudge, S., and Jackson, T., (eds), (2010) *Low carbon communities: imaginative approaches to combating climate change locally*. Edward Elgar Ltd, Cheltenham

Peters, M., Fudge, S., and Hoffman. S.M. (2013) The persistent challenge of encouraging public participation in the low-carbon transition. *Carbon Management*. Vol 4 (4) 373-375

Rice, R. (2009) Diffusion of innovations: integration and media-related extension of this communication keyword. Paper presented at the annual meeting of the International Communications Association. Chicago (2009)

Rogers, E.M. (1995) *Diffusion of innovations.* New York, Free Press

SEAI, 2015. Renewable electricity in Ireland. A report by the Sustainable Energy Authority of Ireland available at http://www.seai.ie/resources/publications/Renewable-Electricity-in-Ireland-2015.pdf (accessed 09/05/2017).

Simcock, N. and Mullen, C. (2016) Energy demand for everyday mobility and domestic life: Exploring the justice implications. *Energy Research & Social Science*, 18, 1–6.

Seyfang, G., Park, J.J., and Smith, A. (2013) A thousand flowers blooming? An examination of community energy in the UK. *Energy Policy.* Vol 61 977-989

Seyfang, G., Hielscherb, S., Hargreaves, T., Martiskainenb, M. and Smith, A. (2014) A grassroots sustainable energy niche? Reflections on community energy in the UK. *Environmental Innovation and Societal Transitions.* Vol 13 21-44

Shove, E., and Walker, G. (2011) Governing transitions in the sustainability of everyday life. *Research Policy.* Vol 39 471–476

Shove, E. (2012) The shadowy side of innovation: unmaking and sustainability. *Technological Analysis & Strategic Management.* Vol 24 (4) 363-375

Smith, A., Kern, F., Roven, R., and Verhees, B. (2013) Spaces for sustainable innovation: Solar photovoltaic electricity in the UK. *Technological Forecasting and Social Change.* Vol 81 115-130.

Solar Energy Industries Association (SEIA), (2012) *America Votes Solar: National Solar Survey 2012*. Available online: http://www.seia.org/research-resources/america-votes-solar-national-solar-survey-2012 (accessed August 25, 2017)

Spence, A., Poortinga, W., Butler, C., and Pidgeon, N. (2011) Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change*. Vol 1 46–49

United States Department of Energy (DOE), (2012) A Guide to Community Shared Solar: Utility, Private and Nonprofit Project Development. Washington, DC

Van der Vleuten, E. and Raven, R. (2006) Lock-in and change: Distributed generation in Denmark in a long-term perspective. *Energy Policy*, Vol 34 (18) 3739-3748

Vaze, P. and Tindale S. (2011) *Repowering Communities: Small-Scale Solutions for Large-Scale Energy Problems*. Earthscan, Oxford, UK

Walker, G. and Devine-Wright, P. (2007), 'Community renewable energy: What should it mean?' *Energy Policy*, 36, 497-500

Wang, J., Zong, Y., You, S. and Træholt, C. (2017) A review of Danish integrated multi-energy system flexibility options for high wind power penetration. *Clean Energy*, Vol 1 (1) 23–35

Weatherford, M.S. (1982) Interpersonal networks and political behavior. *American Journal of Political Science*. Vol 26 (1) 117-143

Wiedman, J. (2010) *Community Renewable Model Program Rules*. Interstate Renewable Energy Council, Latham

Wiseman, H., and Bronin, S. (2013) Community-Scale Renewable Energy. *San Diego Journal of Climate and Energy Law.* Vol 14 (1) 1-29

Wiser, R., and Dong, C. (2013) *The Impact of City-level Permitting Processes on Residential Photovoltaic Installation Prices and Development Times: An Empirical Analysis of Solar Systems in California Cities.* Ernest Orlando Lawrence, Berkeley National Laboratory, California. Available online: http://emp.lbl.gov/sites/all/files/lbnl-6140e.pdf (accessed August 25, 2017).

Wustenhagen, R., Wolsink, M. and Burer, M.J., 2007. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy,* 35, 2683–2691.

WWF Global (2012) *Freiburg Solar Region – solar focus feeds local economy.* WWF News and Stories, 2012. Available online: http://wwf.panda.org/wwf_news/?204416 (Accessed 04 January, 2017).

Xcel Energy, (2017) SolarRewards Community Subscriber Frequently Asked Questions Information Sheet, Colorado. Xcel Energy Inc., Minnesota. Available online: https://www.xcelenergy.com/staticfiles/xe-responsive/Programs%20and%20Rebates/Residential/CO-Solar-Rewards-Community-Subscriber-FAQ.pdf (Accesed 10 December, 2017).

---

[i] The term 'subscriber' or 'participant' rather than 'shareholder' is used in deference to the U.S. tax code and regulations administered by the Securities and Exchange Commission.

[ii] See bpva.org.uk/Press-Release-Details/12.

[iii] The new division is appropriately named MN Community Solar.

[iv] For example, survey respondents in both Minnesota and Colorado were more likely to report higher ownership rates of electric vehicles than typical Americans. Survey respondents were also economically advantaged, with almost one-third reporting annual household incomes of more than $100,000.

[v] Sixty percent of respondents identified individuals representing an investor-owned utility as not trustworthy, while 32 percent of respondents identified local installers in that same manner. Thirty-four percent of respondents identified spokespersons from a cooperative or municipal utility as not trustworthy. Respondents considered neighbours and affinity group members to be the most trustworthy sources of information, at 65 percent and 78 percent, respectively.

[vi] When the payback period extends to between 16 and 20 years, 14 percent of respondents remain very interested in a project. These downward trends extend to 5 percent of respondents after 21-25 years and 3 percent of respondents after 26-30 years.