Taking stock of the local impacts of community owned renewable energy: a review and research agenda Renewable & Sustainable Energy Reviews

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Abstract

A growing literature suggests that community owned renewable energy (CRE) projects have the potential to deliver a range of environmental and local socio-economic benefits. There is relatively little empirical evidence to substantiate this, with few systematic efforts to assess social and environmental impacts or to understand the context in which given impacts arise. In this paper, we review and conceptualise the local impacts commonly cited in the literature and dissect the empirical evidence currently available to support their occurrence. Having assessed the quality of evidence and pinpointed knowledge gaps, we draw on methodological literature to identify approaches necessary to improve our understanding of the local impacts of CRE and explore their patterns of occurrence. We find a lack of robust survey and statistical evidence across all the seven impact categories identified. Of the impacts identified, 'empowerment' and 'access to affordable energy' are found to be the least studied. In addition, several impacts are associated only with specific types of community energy projects. We argue that the paucity of consistent evidence for direct impacts associated with the development processes and direct outcomes of projects suggests that the most substantial local impacts result from medium to long term indirect project outcomes and the investment of project revenues in the local community. As such, collective funding pools and negotiation processes around their distribution towards private versus public goods play a crucial role in determining transformative local impacts of CRE.

Keywords: Community energy, ownership, renewable energy, impact assessment, local impacts, United Kingdom.

1. Introduction

There is growing debate over the role of different ownership models in the renewable energy (RE) transition and the merits and disadvantages of far-reaching civic engagement with energy systems [1-4]. A small but growing number of energy projects in the UK are now wholly or partially owned by self-organised, independent citizen collectives, and 'community energy' is increasingly acknowledged as a distinct subsector in the energy industry. Although community-owned renewable energy (CRE) currently contributes less than 1% of total renewable energy production in the UK, its association with wide-ranging additional economic and social benefits has attracted substantial attention among both academics and policy makers. In addition to empowering communities with the financial resources and autonomy to address local needs, it has been argued that CRE projects, designed and driven by local residents, create platforms for open deliberative processes that restore public engagement in political processes and provide tangible openings for citizen engagement with complex global social and environmental problems [5-9].

Despite this interest, research to date has tended to focus primarily on the factors influencing the uptake and successful implementation of projects, rather than their outcomes [5,10-15]. There is a general assumption that CRE projects deliver local benefits, and a great many studies imply, refer to, or loosely observe these positive outcomes. Yet, very few studies have explicitly assessed the local impacts of CRE. Few formal impact assessment approaches have penetrated research practice thus far so that existing evidence is largely anecdotal.

There is also a lack of robust, systematic monitoring of impacts by the community organisations carrying out CRE projects [16]. This stems from "a tendency within the community sector to focus on 'getting on and doing' rather than on measuring"; a lack of human and financial resources; a lack of technical knowledge and skills; and the lack of "established methodological frameworks" [17]. Despite these challenges, the few impact evaluations that have been carried out demonstrate that evidence can enhance "the group's perception and sense of efficacy and agency", guide activities and serve to mobilise funding [18].

The diversity of CRE projects makes project-level evaluation essential to understanding impacts. The term 'community renewable energy' has been variously understood and interpreted, and encompasses a diversity of technologies, scales of deployment, ownership and organisational structures and degrees of local participation [19-25] (see Table 1). Since the

dominant values, needs and motivations driving CRE projects differ across contexts, the subsequent investment strategies and outcomes also vary considerably [20,21]. A growing literature also emphasises the need to move beyond conceptualisations of 'community' as groups of individuals with homogeneous value priorities, attitudes, and behavioural orientations [26-31], highlighting the significant influence that local social dynamics, management decisions, visioning, leadership and inclusivity can have on project outcomes. If CRE projects do not uniformly engage community members - directly or indirectly as recipients of benefits - it cannot be assumed that they will generate uniformly positive local impacts.

While the 2015 elected UK Government has stated support for community-based renewable energy, they have also endorsed a view that small-scale and Feed-In-Tariff supported RE generation unduly influences consumer energy costs [32,33]. It is unlikely that the UK government will continue to take the acclaimed benefits of CRE as an "article of faith" [20]. To inform and substantiate this debate, there is a need for a clearer understanding of the factors that influence given impacts, how impacts are associated with different types of projects, as well as the development and application of suitable methods for impact assessment.

This paper has three central objectives. The first is to provide a comprehensive review of current knowledge regarding the local impacts of CRE, the conditions in, and processes through which they are generated, building on Rogers *et al*. [34], van der Horst [35] and Callaghan & Williams [36]. Drawing on academic, policy and practitioner literature, we identify, categorise and conceptualise the key impacts most commonly assumed to be generated by CRE projects, and critically review the theoretical grounding and empirical evidence available to support their occurrence. Second, drawing on the current evidence base, we identify knowledge gaps and reflect on appropriate methodological approaches that would be necessary to improve our understanding of the impacts of CRE projects. Our final objective is to identify the conditions and occurrence of specific impacts in relation to different types of community energy projects by systematically collating evidence across case-study based literature.

Informed by several existing characterisations of citizen collectives engaged in energy generation in the UK [19,37-39], we define CRE projects as developments which are wholly or partially owned and managed by constituted (for-, or not-for-, profit) community organisations, established and operating across a geographically defined community. While there are increasingly also community-based supply, storage and demand management projects

in the UK, the majority of projects involve heat or electricity generation. There are approximately 790 active community- organisations that own renewable energy generation installations, representing approximately 105MW operational capacity [25,40]. The largest proportion of CRE organisations in the UK are Scottish local development trusts with projects housed in private limited subsidiaries (41%), followed by energy and other co-operatives (which dominate in England and Northern Ireland) (24%), and community facility or asset holding organisations (7%) (Table 1). The vast majority of projects are wholly community owned (86%), but a minority are shared ownership models (13%), co-owned by community organisations with commercial or public entities (including split equity, shared revenue or flip projects).

Table 1 – Overview of different types of CRE projects and their delivery in the UK (2014) showing and mean and standard deviation of project scale, proportion of projects that are set up by charitable organisations and proportion of shared ownership projects (Source: Own data, Scene Community Energy Database. Classification adapted from ref. [19,24,25,35]).

TYPE OF CRE PROJECT		*DESCRIPTION*	*TECHNOLOGIES*	*SCALE*	*% CHARITABLE*	*% SHARED OWNERSHIP*	*TOTAL CAPACITY*	**Number of projects**
SELF-CONSUMPTION PROJECTS	***COMMUNITY FACILITY PROJECTS***	Charitable organisations building installations primarily supplying heat or power to community facilities, such as churches, recreation centres, community buildings	solar PV, micro-wind, ground/air-source heat pump, solar thermal, woodfuel boilers, (hydro)	μ=14kW σ=19kW	68%	0%	0.98MW	92
	SOCIAL ENTERPRISE – LED MICROGENERATION PROJECTS	Energy provision for residential and facility buildings, serving as additional income generation for local non-governmental organisations providing health, housing, educational or recreational services.	solar thermal, solar PV, ground/air-source heat pump, wind, woodfuel (hydro)	μ=64kW σ=161kW	75%	0%	2.0MW	50
	COMMUNITY-OWNED MICRO-GRIDS	Generation and supply on private wires or grids in remote areas or islands	wind, hydro, solar PV, integrated	μ=91kW σ=78kW	83%	0%	1.1MW	12
	COMMUNITY-OWNED DISTRICT HEAT NETWORKS	Generation and supply of heat (and power)	woodfuel	μ=308kW σ=241kW	50%	0%	1.2MW	4
	LOW CARBON MICRO-GENERATION PROJECTS	Local organisations owning and managing local domestic micro-generation as part of broader carbon mitigation programmes, including ‘Low carbon’ and ‘Transition town’ organisations.	solar PV, solar thermal, ground/air-source heat pumps, micro-wind	μ=19kW σ=34kW	20%	0%	0.13MW	7
ELECTRICITY EXPORT PROJECTS	***GRID INTEGRATED DIRECT SUPPLY***	Direct supply to members of consumer co-operatives. No existing projects in the UK.	wind, hydro	No data	No data	No data	No data	No data
	Custodian *PROJECTS*	Environmental and conservation organisations developing standalone renewable energy installations for grid-export to fund or complement their activities. Includes ‘Low carbon’, ‘Transition town’ organisations, forestry associations and community organisations aiming to keep local natural	hydro-electric, solar PV, woodfuel (solar thermal, heatpumps)	μ= 456kW σ=1099kW	42%	12%	11.9MW	33

		assets under local control or maintain local infrastructure.						
	COMMUNITY DEVELOPMENT PROJECTS	Larger projects exporting electricity to the grid, run by charities and trusts owning privately constituted project entities that house income generating projects and earmark profits to a wide range of development projects	wind, hydro-electric, (solar PV, woodfuel, tidal)	μ=1326kW σ=1837kW	93%	31%	55.7MW	42
	COMMUNITY-OWNED GRID - INTEGRATED MICROGRIDS	Microgeneration and storage units integrated in low voltage networks and interconnected to the upstream network, typically in tandem with demand management strategies. First pilot projects ongoing in the UK.	No data	No data	No data	No data	No data	No data
	Co-operative projects	Larger standalone grid-export or installations directly supplying power to local industry, typically financed through industrial provident societies that offer citizens shares in renewable energy projects, with local, regional or national membership, including crowd sourced projects.	solar PV, wind, hydro-electric, woodfuel (solar thermal, anaerobic digestion)	μ=458kW σ=1000kW	9%	27%	44.9MW	100
	LOCAL LANDOWNER PROJECTS	Local farmers or estate owners collaborating to install projects	No data	No data	No data	No data	No data	No data

2. Methodology

The literature review was conducted through a systematic search for literature using a range of search terms that encompassed overlapping concepts used to describe the phenomena of interest (for example: "[[community or civic or citizen] and [energy or electricity or heat]] and [social cohesion or trust or communication or [[community or shared] identity] or belonging]"). Both UK and international academic studies focusing directly or indirectly on assessing one or more local impacts in relation to community energy were included, as well as grey literature explicitly focusing on assessing one or more impacts, provided these adopted definitions of community energy congruent with the definition adopted in this study.

The literature pool was then divided according to whether i) the phenomenon of interest was conceptualised as an outcome of CRE projects or ii) conceptualised in another way (for instance as a precondition for success or motivation for participation). Only the prior literature was included for review of evidence. The latter literature was used selectively to place results in context of best-practice approaches to (both theoretically grounded and empirical) impact assessment. Having collated and screened articles for inclusion, each paper was reviewed and evaluated in detail with regard to: 1) statements regarding the occurrence of impacts and underlying processes through which these impacts were generated, 2) context and types of CRE projects analysed in the study, and 3) methodology and quality of evidence. Throughout this process, we added to and adjusted impact categories until we reached a point of saturation where no additional impacts could be identified. Impacts were categorised in such a way that allowed their independent analysis.

Quality of evidence was assessed by assigning papers to indicative ordinal classifications that we developed based on established standards for validity and reliability in qualitative and quantitative approaches to impact assessment (Table 2). The papers reviewed were so methodologically distinct as to require separate quality of evidence frameworks. We identified:

i) Interview-based approaches: used to assess impacts related to complex social phenomena requiring detailed case-study-based analysis, such as social capital development and empowerment;

ii) Survey-based and statistical approaches: used to assess impacts more readily assessed using categorical or numerical data across larger numbers of case studies, such as environmentally benign lifestyles and local acceptance of renewable energy; and

iii) Model-based approaches: currently limited to formalised economic impact assessments at regional level.

We used these results to assess overall quality of evidence and identify methodological recommendations for each impact category identified. Finally, drawing on the strength of evidence, as well as patterns and inconsistencies in the occurrence of impacts emerging from the literature review, we were able to explore the processes that generate local impacts and discuss their occurrence in relation to each other and in relation to generic types of CRE projects (Table 1).

Table 2 – Criteria used to classify quality of evidence, by methodological approach (Source: adapted from ref. [41-44]).

Quality of evidence	Interview-based approaches	Statistical & survey-based approaches	Model-based approaches
Very limited	Source of evidence unclear OR impact referred to in context of participant motivation or expected outcome rather than observed outcomes.		
Limited	Anecdotal evidence based on informal observations by the author, OR deduced from interviews at one specific point in time with up to 2 participants in a single case study. No identifiable validation measures[1] or trail of evidence.	Self-reported evidence collected through a survey with an unrepresentative sample of respondents, across single or multiple case studies, no identifiable measures for internal consistency[2], internal or construct validity[3].	Direct, indirect, and induced impacts, based on hypothetical case studies or scenarios. Off-the-shelf measuring instrument and parameters based on national IO data.
Satisfactory	Clear trail of evidence deduced from interviews at one specific point in time with up to 2 participants per case across 2/3 case studies, OR 3+ participants in a single case study (but no contextual detail).	Cross-sectional survey on an unrepresentative sample across multiple case studies, OR representative sample for a single case study, but with identifiable measures for internal consistency, internal or construct validity.	Direct, indirect, and induced impacts, based on case study data collated from existing literature or expert opinion. Off-the-shelf measuring instrument with parameters based on approximated regionalised IO data.
Good	Clear trail of evidence deduced from interviews with 3+ participants in a single case study, supported by rich detail on context and/or longitudinal observations, OR deduced from interviews with up to 2 participants across more than 3 case studies.	A cross-sectional survey on representative samples across 2+ case studies, with identifiable measures for internal consistency, internal or construct validity.	Direct, indirect, and induced impacts, based on detailed self-reported retrospective data from one case study. IO or SAM data partially survey-based and/or regionalised using empirical regional economy data.
Very good	Clear trail of evidence deduced from interviews with 3+ participants in 2 or 3 case studies, based on a broad	A cross-sectional survey with representative samples across 2+ case studies, with identifiable measures for	Direct, indirect, and induced impacts, based on retrospective data from more than one detailed case study. IO or SAM data survey-based or

[1] Validation techniques include: triangulation, peer review or external audits by other researchers, or checking of data/interpretations with respondents.
[2] Externally obtained data or multiple different survey questions are used to measure the same concept and responses are shown to be consistent.
[3] The causal relationship between project and impact and operationalisation of survey questions are based on exploratory open-ended interviews and/or established theory or evidence.

	evidence base and/or longitudinal observations.	internal consistency, internal or construct validity, with descriptive analysis and significance tests.	regionalised using empirical regional economy data.
Excellent	Clear trail of evidence, based on a systematic enquiry with explicit analysis procedure across 3+ case studies, based on a broad evidence base and longitudinal observations.	Descriptive, inferential and regression analysis based on longitudinal or randomised surveys with representative samples across 3+ case studies, with identifiable measures for internal consistency, internal or construct validity.	Direct, indirect, induced impacts as well as opportunity costs, price changes, and/or amenity effects with confidence intervals, based extended IO or CGE models. IO or SAM data survey-based or regionalised using empirical regional economy data. Based on 3+ case studies across one or more different regions.

3. Scope and conceptualisation of local social, economic and environmental impacts

By focussing on local impacts, we exclude literature pertaining to national effects of distributed generation on for instance the price of electricity, cost of transmission, social inequality [1,28] or on the relative contribution of different renewable energy technologies to greenhouse gas emission reduction targets. Furthermore, we take social impact to incorporate environmental and economic impacts in as far as they are experienced and perceived by a local community. Following established approaches in social impact assessment, social impact concerns all issues related to a planned intervention that "affect or concern people, whether directly or indirectly", which includes anything that is "felt in either a perceptual (cognitive) or a corporeal (bodily, physical) sense" by the community, or an individual or group within the community [45]. As such, the social impacts of a given project are intrinsically related to whether its activities and outcomes concur with local priority values and needs, developed as a result of individual experiences and, in the case of public values, collectively defined and reproduced. CRE projects are variably motivated by a range of different (private and) public values that are contested, negotiated and reproduced through social processes [5,21,29,46], therefore, social impacts cannot be conceptualised in the same way as economic impacts in the form of fixed and measurable stocks of value held by individuals [47]. There may be positive and negative social impacts of CRE that are unrelated to economic gains or losses, for instance related to communitarian and participatory principles or embedding a "different way of living" [20,48]. However, where economic outcomes are pertinent in determining a projects influence on community social fabric and the wellbeing of individuals and families, economic effects of CRE can provide an indication of social impact.

To our knowledge, very few studies have comprehensively investigated social impacts of CRE, but several studies have assessed their economic impact and a number of studies make explicit or implicit reference to one or more social and/or environmental impacts. Both literatures are included in this review with the intention of providing a comprehensive overview of the evidence base for local impacts commonly associated with CRE projects.

4. Local impacts of community energy: a review of existing evidence

In what follows, we review the literature and empirical evidence across the seven broad local impact categories identified.

4.1 Socio-economic regeneration

4.1.1 Overview

There is some evidence that medium to large-scale CRE projects can generate sustained socio-economic benefits that can extend beyond the organisations managing the project. There is also a solid theoretical basis for a more far-reaching notion that, through enabling acquisition of productive assets and stimulating local demand, CRE projects can, under certain conditions, make local and sustained provision of new products and services viable, open up markets for local natural and waste resources, and secure local livelihoods. There is currently relatively little empirical evidence available to support this theory. In several remote rural locations in Scotland and Wales, medium to large scale CRE projects, such as, Gigha, Islay, Eigg and Awel Aman Tawe, have been loosely attributed with contributing towards reversing structural economic decline by diversifying income streams, supporting local industry in terms of training as well as demand stimulus, and enabling provision of (more affordable) essential services [36,49-54]. In some cases, these processes have been associated with repopulation to above critical threshold levels in which rural communities can sustain themselves [50,54,55]. This potential for socio-economic regeneration is not likely to be restricted to the UK, nor to rural areas, since case-study literature documents 'need-based' CRE initiatives that seek to play larger development roles in response to socio-economic deprivation or natural disasters in both rural and (peri-) urban areas elsewhere in the world [56-58].

The existing literature suggests that the extent to which CRE projects are likely to deliver local socioeconomic impacts is highly dependent on several aspects of project management. In particular: the local procurement of material and labour; the allocation of project earnings; and the sourcing of capital.

4.1.2 Local procurement

Opportunities for socio-economic regeneration are derived primarily from investment of long-term project revenues into diverse and locally appropriate community benefits [5,36,50], or in economic terms the indirect and induced impacts derived from project earnings [55,59,60]. The construction, operation and maintenance of any RE project also generates jobs and income directly and indirectly, for example, in the form of local project expenditures, property tax, or land lease payments, and the resulting knock-on household expenditures [61]. However, even though community projects are more likely to source locally than commercial projects [36,62], the proportion of total economic benefits of CRE derived from local sourcing of labour, (engineering, design, legal) services, materials, or auxiliary components associated with project development, is small compared to that derived from project earnings [55,59,60,63-65] (Table 3). While this finding depends to an extent on the local economic structure, labour force and capacity to develop intermediate input supply industries over time [66], it has been widely observed and attributed to the lack of both local supply and sustained demand for the skills required for construction and operation of energy installations in rural areas [36,65,67-69] (see 4.2 below). Local sourcing was observed to be common in small-scale Scottish community facility projects [36] and Welsh hydro projects [17,62], but less prevalent for larger scale hydro [17], and neither practical nor strategic in medium-scale wind [36]. Local intermediate inputs in project development are often not accounted for on the basis of being equivalent to commercial projects for wind energy in rural Scotland and USA [59-61,63] (Table 3). Bioenergy technologies stand apart from other renewable technologies in requiring high local intermediate inputs during operational phase [35,70].

4.1.3 Earnings allocation

The potential for socio-economic regeneration is likely to be limited to medium or large -scale CRE projects, since these projects generate sizable revenue streams that can be strategically allocated to improve public amenities and infrastructure, or to complement or diversify existing local economic activity. A number of regional economic impact studies, from both the UK and USA, demonstrate that (potential) regional stimulus generated from local ownership (of wind, biofuel and hydro installations) vastly outweighs that generated from commercial (or 'absentee') ownership. This holds even when accounting for varying levels of community payments (‘community benefits’) or local sourcing of intermediate inputs [59,60,63,65,70,71]. Throughout this literature, there has been little consideration of how different types of organisations involved in CRE allocate project earnings to private or public goods locally, or

how and to what extent this influences hard and soft indicators for local development, including employment and income multiplier effects. Although it is difficult to compare economic impact studies directly[4] and draw conclusive inferences as to how project earnings allocation influences employment and income multipliers, an overview of studies and their assumptions is nevertheless instructive.

Of the studies that explicitly treat local economic impacts from project earnings, both Okkonen & Lehtonen [55] and Entwistle *et al*. [64] show that local economic impact is highest where earnings are invested in most labour-intensive sectors, such as social services, which tend to exhibit high local spending rates (Table 3). Both these analyses assume fixed prices, wages and input coefficients and zero displacement of existing economic activity, known to generate upper bound impact estimates at regional level [43,60]. In what is the only regional computable general equilibrium (CGE) application in this field, Phimister & Roberts [60] show that a net increase in household income follows from the capital investment of project earnings in the agricultural or rural public sector but not when allocated directly to consumption, because households tend to invest or purchase from outside the region. Furthermore, investment in the rural public sector results in the largest GDP impact and increase in rural non-farm household income, demonstrating that community development projects have tangible redistributive properties (Table 3).

All Scottish studies assume that project earnings are held by charitable trusts or social enterprises and spent on public goods and services, suggesting that pooling profits for investment in public goods may be a relatively unique characteristic of CRE in Scotland but broadly not representative of CRE elsewhere (Table 3). Case-study-based evidence from Scotland and Wales furthermore suggests that local investment has taken place in a broad range of public goods including health and social care, housing, culture and heritage, local services and amenities, education, sport and recreation, forestry, recycling, energy efficiency, or further renewable energy projects [36,48,72]. However, case studies in this literature are often explicitly selected on the basis of public benefits and there is currently no basis on which to estimate their representativeness of the sector. In contrast, the majority of US-based studies are

[4] Results of regional economic impact studies depend on the scope of the regional economy analysed, its production base, labour structure and level of local economic connectivity, implicit assumptions regarding labour, resource and capital constraints and ability of markets to clear in response to changes in demand, the ability to account for displacement effects [63] and non-market transfers [59], as well as country, (state) and date- specific costs of capital, inputs and renewable energy support that influence project cost structure. See Loveridge (2004) and Rey (2016) for a detailed discussion on comparability of economic impact studies [43,44].

based on an assumption that projects reinvest in the finance sector or in renewable energy after servicing debt or paying out shareholder dividend, following similar observations of energy co-operatives in Germany (Table 3) [73]. In these cases, based on the evidence reviewed here, project earnings would be spent on substantially less local private goods and services, to the detriment of overall local value added. Nevertheless, there is anecdotal evidence that CRE projects can indirectly provide a degree of public benefit merely by complementing household and municipal income, sustaining livelihoods in the face of decline of dominant local industries and, through enhancing overall economy purchasing power, making places more livable [17,58,74].

4.1.4 Local capital investment

Other than the extent of local intermediate inputs, the absolute value and allocation of project earnings, a final factor determining the potential for local socio-economic regeneration is the extent to which capital is locally sourced. Entwistle *et al*. [64] compare third order multipliers across three types of CRE projects, drawing on detailed cost structure data associated with each business model. They show that sourcing capital locally through co-operative shares can reduce the overall cost of capital, increase net project earnings, and contribute directly to household income of co-operative members. The co-operative share model increases total local GDP impacts by 35% compared to CRE projects relying on commercial debt (Table 3).

Table 3- *Overview* of economic impact assessments of community energy, showing methodological approach as well as income, employment and amenity impacts for project development and operational periods. All figures adjusted for inflation and converted to 2014 GBP.

Study	Location	Local economy data (year)	Project data	Project technology, size	CRE project type	Method	Displacement effects	Project earnings allocated to…	Amenity effects	Jobs (p/MW)		GDP impacts (GBP p/MW)	
										Development	Operations (annual)	Development	Operations (annual)
Allan et al. (2011) [59]	Shetland Isle, Scotland	Council/ island (surveyed bottom-up) (2003)	Self-reported ex-ante (2003)	Wind 600MW	Shared ownership with community development project	SAM	NA	public spending as per local government expenditures	NA	NA	1.4	NA	223.6k
						IO	NA	NA	NA	NA	0.1	NA	172.7k
Bere et al. (2015) [17]	Wales	Region (regionalized from national dataset)	Self-reported ex-post (2014)	Hydro 99kW	Unspecified	IO	NA	mix of educational, community retail, recreational activities, refurbishment and low carbon investment.	Tourism	12		300k	
				Hydro 499kW	Unspecified	IO	NA	mix of educational, community retail, recreational activities, refurbishment and low carbon investment.	Tourism	6.5		200k	
Entwistle et al. (2014) [64]	Tiree, Scotland	Island (Surveyed bottom-up)	Self-reported ex-post, hypothetical (2013)	Wind 900kW	Community development	LM3	NA	Tiree community trust staff and projects	NA	NA	NA	13.3k	727.4k
					Energy co-operative (export)	LM3	NA	shareholder investors, Tiree community trust staff and projects	NA	NA	NA	13.3k	985.1k
					Energy co-operative (direct supply)	LM3	NA	Tiree community trust staff and projects	NA	NA	NA	13.3k	1036.9k
Kildegaard & Myers-Kuykindall (2006) [63]	Big Stone County, Minnesota	County (Regionalized from national	Hypothetical scenarios (2006)	Wind 10.5 MW	Unspecified	IO	NA	unspecified	NA	NA	0.8-1.3	NA	43.4k - 85.5k

		dataset) (2003)											
Lantz & Tegen (2009) [65]	Minnesota; Texas	State (Regionalized from national dataset)	Self-reported retrospective (2008)	Wind 9*1.7MW	Collective landowner	IO	NA	state finance sector	NA	4	0.6	299k	52.7k
				Wind 10MW	Shared ownership with (wind flip)	IO	NA	state finance sector	NA	5.7	0.4	490.6k	37.4k
				Wind 15MW	Shared ownership with (wind flip)	IO	NA	state finance sector	NA	6.1	0.3	443.2k	21.4k
Okkonen & Lehtonen (2016) [55]	Western Isles, Scotland	Council (national dataset)	Self-reported retrospective (2016)	Wind 27.6MW	Community development project	IO	NA	community business development	NA	2.1	3.4	49.5k	55.1k
								social services	NA	2.1	3.9	49.5k	89.1k
								infrastructure and communications	NA	2.1	3.0	49.5k	61.5k
Phimister & Roberts (2012) [60]	Aberdeen & Aberdeenshire, Scotland	Region (regionalized from national dataset & surveyed bottom-up) (2005)	Self-reported retrospective	Wind 300MW	Collective landowner project	CGE	Yes	increased farm household consumption	NA	NA	NA	NA	267.5k
						SAM	NA		NA	NA	NA	NA	351.4k
						CGE	Yes	capital investment in the agricultural sector	NA	NA	NA	NA	314.3k
					Community development project	CGE	Yes	increased consumption via non-profit institutions	NA	NA	NA	NA	266.2k
						SAM	NA		NA	NA	NA	NA	410.1k
						CGE	Yes	capital investment in rural public sector	NA	NA	NA	NA	318.8k
Torgerson et al. (2006) [61]	Utamilla, Oregon	County (Regionalized from national dataset) (2005)	Hypothetical scenarios	Wind 5MW	Unspecified	IO	NA	energy projects as per expenditures of local utility sector.	NA	NA	0.5	NA	111.7k

4.2 Knowledge & skills development

4.2.1 Overview

There is considerable evidence that active participation in CRE projects can facilitate the development of knowledge and skills across a range of areas, including organisational management and leadership, project management, problem-solving, teamwork, community consultation and engagement, marketing and communication, business development, project finance and fundraising, law, as well as technical capacity around renewable energy technology and energy efficiency [17,31,36,50,62,72,75-78]. In addition to fostering new learning, there is also evidence that CRE projects can help draw out and utilise latent knowledge, skills and capacities existing within communities [46,77,79]. Characterisations of the community energy sector as a whole suggest that community capacity building has variably taken place; while some community organisations have been dissolved following project failure, a number of community organisations throughout the UK have replicated projects, implemented larger more ambitious projects, and/or have become intermediaries facilitating community energy projects across the region or country [25]. There is limited evidence, however, of the degree to which knowledge and skills have increased throughout the wider community, beyond the individuals that actively lead and manage projects – or that the community has benefited from the increased skills of these project leaders.

4.2.2 Active participation in projects

In a survey of 84 community facility and development projects in Scotland, 65% of the groups believed that their committee had learnt new skills through developing a CRE project [50]. In a study of 11 CRE projects in Scotland, van der Horst found that projects that require ongoing local management have the greatest potential to build local capacity through skills development, with biomass projects, which require substantial operational maintenance, identified as the strongest example [35]. In cases where the RE technologies had been "bolted on" to other local development projects to meet funding criteria, using "fit and forget" technologies which do not require significant levels of ongoing local participation (such as solar panels or a wind turbine), local knowledge and skills were less likely to be generated [35]. There is also evidence that the majority of learning that takes place within projects is by the leaders of the projects, who invest much time and effort to gain the information and expertise

required to make the project a success [62,77]. As such, while the development of CRE projects has been found to increase local capacity, this is precarious and fragile, and can be lost with the departure of certain key individuals [62].

4.2.3 It takes capacity to build capacity

The initiation of CRE from the bottom up is more likely to occur in places where there is significant pre-existing knowledge and skills, and this has been recognised an important precondition for success. In cases where communities lack certain skills and knowledge, this has been observed to hinder development of a CRE project [38,80-82]. There is evidence that community organisations often lack essential skills and competencies, such as technical, financial, legal, and business management, and that projects are often championed by inexperienced members of the community [38]. Similarly, Rogers *et al*. find that, while the idea of community renewable energy may be popular, local residents felt that they lacked the requisite skills to make it viable [83]. It has been suggested that a key challenge for policymakers and CRE support organisations is to assist those communities that are interested in CRE but do not currently have the sufficient capacity to initiate a project [82]. In addition, Middlemiss and Parish demonstrate that variably established community organisations can be empowered by projects by designing and building projects around the different personal, organizational, and cultural latent capacities held within their communities [84].

Typically, project delivery rests on a small number of local project champions with particular skills and competencies [38]. If participation in CRE is more accessible to individuals who have higher levels of education relative to other members of the community, CRE projects may be serving to widen local inequality gaps [1,85,86]. Bird *et al*. suggest that a lack of basic knowledge and understanding regarding energy issues within the wider community can act as a barrier to CRE projects having greater impact, as this lack of awareness prevents a greater number of local people from getting involved [87]. In addition, the availability of funding and other financial resources can play a crucial role in developing community capacity. Therefore, it should not be assumed that capacity automatically materialises with the initiation of a CRE project [88]. Community organizations developing CRE projects may need to plan for the delivery of basic training and awareness programmes prior to seeking widespread local engagement.

4.2.4 Role of intermediaries

Whilst local project participants are likely to build knowledge, skills and capacity through CRE, there is a limit to the level of expertise that community members can be expected to gain through developing a project. Several studies have demonstrated the importance of leveraging the professional knowledge and experience of intermediary organisations in supporting communities to deliver CRE projects [38,53,77,89], and intermediary organisations have been found to have a particularly crucial function in facilitating knowledge exchange and local capacity building [38]. Martiskainen has directly observed the role of intermediaries in the learning processes of CRE organisations found that intermediaries translate and aggregate project-level learning, and share that with other CRE groups [77]. In addition, the intermediary actors themselves gained knowledge and skills through their role in the process of supporting CRE projects, suggesting that these impacts extend beyond local project participants.

4.3 Social capital

4.3.1 Overview

Social capital facilitates the collective articulation of shared visions and the values that underpin them, fosters the perception of shared identity, and increases the availability of information and knowledge among community members [55,64,90], giving individuals the "confidence to invest in collective activities, knowing that others will also do so" [91,92]. Strong local interpersonal networks and trust are widely cited as both a precondition [5,14,38,50,51,56,79,94-100] and a potential outcome [35,50,75,79,101,102] of CRE projects. These two roles are not often made distinct within the literature. This reflects a longstanding theoretical debate on the challenge of distinguishing between the sources of social capital and its benefits [103,104].

In this section, we attempt to disentangle the evidence to determine the extent to which social capital has been demonstrated as an outcome of CRE.

4.3.2 Social capital as a precondition

A recent study in Germany found that stated willingness to participate in community energy projects correlated with perceived inclusion in local social networks characterised by trust and perceptions of shared identity, a finding thought to explain the relatively rural distribution of CRE projects [94]. Similarly, based on observations with 100 CRE projects in Scotland, the

invocation of shared place-based identity was observed to serve as a proxy for shared aspirations and values and to underpin the trust, communication, and norms of reciprocity required to overcome the complexities involved in mobilising CRE projects [14]. This concurs with a well-documented correlation between social capital and the emergence of shared visions, resource mobilisation and community initiatives [90,106].

'Bridging' or 'linking' social capital has not been explicitly analysed in the context of the relationship between CRE organisations and state and market institutions. However, many studies have observed the substantial role of trusted social networks with intermediaries and local authorities in connecting, knowledge brokering, facilitating and lobbying on behalf of CRE projects [12,13,18,36,38,56,76,89,107-110]. Several authors have suggested that the integration of community energy support programmes within existing networks and institutions for rural development and land use has contributed to the rapid uptake of CRE in Scotland [35,49,51,111]. Strong interpersonal connections and trust have also been conceptualised as a precondition for CRE projects to generate awareness raising, interpersonal learning and fostering of norms around environmentally oriented behaviour change and energy poverty alleviation [18,34,35,36,56,112,113] (see 4.5 and 4.6 below).

There is also evidence that some CRE organisations have notable gaps in their social networks that prevent them from effectively reaching a wider public and scaling up their activities. For example, one study from south west England found that CRE groups particularly lacked connections to households, other non-energy groups, and the wider public, as well as having low levels of connectivity to national stakeholders, such as commercial energy companies and UK Government [87]. The authors suggest that this 'low connectivity' is likely to have a negative effect on the groups' ability to communicate with, and influence, a wider audience, as well as reducing their opportunities to leverage funding.

Taken together, there is substantial evidence supporting the notion that social capital is a precondition for participation and for specific or positive project outcomes, although this evidence tends to frame the concept of social capital relatively superficially and remains largely disconnected from the rich theoretical literature on social capital and collective action in environmental and commons governance.

4.3.3 Social capital as an outcome

The notion that social capital is (re)produced through CRE projects is less well studied and the evidence is more variable than its role in facilitating successful CRE projects. That this

phenomenon can occur is in line with theoretical and empirical research outside of the field of community energy that has described the emergence of new organisational forms, networks, and improved network quality that can arise from interpersonal interaction in collective action processes [104,114-117]. Arguably the most robust relevant study of social capital as an outcome of CRE is an assessment of the social impact of two UK community hydropower schemes [17]. Specifically selected for their far-reaching community engagement, Bere *et al*. find that approximately as many community members surveyed were ambivalent as were positive about the impact that the projects had had on local bonding social capital. There is little empirical evidence beyond this study. There is self-reported survey-based evidence from Scotland which suggests that, for some groups, CRE projects resulted in additional members (23%), a broader membership base (35%) and increased awareness and support for organisation activities (54%) [50]. There are also studies that identify expectations of increased interaction and unification amongst project participants as a driver of CRE, or that do not substantiate claims of strengthened social capital [76,101]. Finally, several studies provide anecdotal evidence for cases in which fuel savings enabled additional events and classes in a community facility, suggesting that CRE projects may indirectly generate social capital through community engagement processes that are enabled by longer term financial returns from projects [35,36,50,118].

4.3.4 Preconditions for positive impact on social capital

When considering impacts on social capital in any context, it is important to acknowledge that "human interaction can [also] diminish social capital" [106]. While there is little methodical analysis of social dynamics and intra-community conflict characterising (failed or struggling) projects, there is ample indication that CRE projects, being participatory, complex, time consuming and sometimes controversial projects, can expose conflicting interests and be divisive [15,17,38,96,112,119]. This happens in particular where there are low degrees of trust [112] or different motivations for engagement [119]. Projects can expose conflicting stakeholder interests and priority values that shape attitudes, beliefs, preferences and behaviours [51,95], often involving opposing hedonic landscape versus biospheric values or communitarian versus private values [29,119-121]. Walker *et al*. provide the most robust study of relevance, in which they examine ex-post the relationship between trust in project organisers and perceived community contribution and togetherness as a result of projects across six English and Welsh case studies [112]. The results reveal large discrepancies between projects in terms of the impact on local social relations – some positive, some neutral and some

negative, with results from one collective landowner-led case study suggesting that the project had served to erode social cohesion [112]. Finally, a cross-sectional survey across 84 projects of different types in Germany showed that even if projects generate trust among the wider community, project membership does largely not include lower income groups or women, suggesting projects tend to build on existing local social networks rather than expand them [102]. Taken together, this suggests that the factors distinguishing projects with positive and negative impacts on social capital are the obtrusiveness of technology, the unequitable distribution of costs and benefits and the degree of broad and deep engagement in the project process [112].

4.4 Increased local support for renewable energy

4.4.1 Overview

There is strong evidence that community ownership can have a positive impact on local support for renewable energy technologies. Specifically, initiatives emerging from within trusted networks built on a credible premise of local public benefits are less likely to trigger opposition based on notions of 'fairness' around the distribution of costs and benefits of renewable energy projects [79,97,122]. Warren & McFadyen draw on comparative survey-based data from local residents in South West Scotland to compare public attitudes to wind development in two nearby regions exposed to community versus commercially owned wind farms [123]. They demonstrate that while arguments underlying attitudes were not substantively different across the two groups, positive perceptions associated with local ownership resulted in lower weights being attached to concerns around intermittency, visual impact and bird strikes. A similar study assessed comparative public support for renewable energy across groups exposed to a partially (20%) community-owned wind farm and a wholly commercially owned wind farm in southeast Germany, showing that community co-ownership of wind energy led to a higher level of local support and less negative evaluations of shadow flicker, noise, and visual impacts [124]. In both studies, community co-ownership was correlated with a more positive attitude towards wind energy in general. Finally, in a systematic study based on 18 case studies in Wales, England and Denmark, McLaren-Loring finds a positive correlation between high levels of community engagement, ownership and project leadership on the one hand and public acceptance on the other, but also observed cases in which public acceptance existed despite an absence of far-reaching community engagement [97].

At the macro-level, various country and regional comparative studies have noted a positive correlation between high degrees of local ownership and/or participation in planning processes on the one hand, and public support for wind power on the other [125-128]. This suggests that the effect of community ownership on public support for renewable energy may be cumulative and manifest itself in higher overall deployment rates.

4.4.2 Trust, past experience and perceptions of place

It is important to place these results in the context of our understanding of what underlies local opposition versus support for renewable energy more generally [129,130]. Psychological ownership of projects resulting from perceptions of 'being part of' [19] and 'having the option to influence' [51,97,131] projects appear influential in determining whether renewable energy projects act to enhance or disrupt psychological place attachment and place-based conceptions of identity. 'Being part of' is more important in stigmatised areas where energy projects are perceived to improve the image of the area, while 'having the option to influence' aspects over siting and design is likely to be more important in areas where landscape characteristics are an integral part of self-identity [130]. These socio-psychological perceptions in turn dominate and colour objective arguments for and against renewable energy developments, including environmental, noise impacts and local material benefits [129,130,132,133]. In this context, trust, which is frequently cited as a precondition of local support for renewable energy [4,51,79,122,134], represents a resource established and maintained through social interaction on the basis of common interest that enables residents to assume that project managers will act in their best interests without the need to become personally involved. The mixed results in both Walker et al's and McLaren-Loring's studies indicate that trust in project leadership can to a degree substitute for far-reaching community engagement in generating local support for renewable energy [97,112], in addition to familiarity and positive experience with renewable energy technology [38,130].

4.5 Energy literacy & environmentally benign lifestyles

4.5.1 Overview

There is a rich theoretical basis to support the notion that CRE projects have the potential to bring otherwise distant and ambiguous global environmental issues into the realm of 'conscious awareness' and every day practices. However, beyond changes in energy consumption practices, there has been little empirical work done on the direct or indirect environmental

impacts of CRE projects, with available evidence largely limited to low carbon microgeneration projects. While there is systematic, quantitative and primary evidence with regards to the factors determining improved energy literacy and adoption of energy saving and load-shifting measures in response to domestic renewable energy installations [135-139] there is no equivalent literature assessing such impacts in community-level self-consumption installations.

Anecdotal evidence suggests that collectively defined rules to manage demand in capacity-constrained community-owned micro-grids have proven effective in capping consumption of connected households in some projects [75,140] but not others [141]. However, micro-grid projects, as well as some community facility projects and microgeneration projects in the UK, have thus far been implemented in localities where there is a need to increase overall energy consumption at lower per unit cost [34]. As such, depending on the capacity installed, its vulnerability to seasonal fluctuations in resource availability, the nature of back-up power and growth in demand, these projects may or may not result in net emission reductions even where they (partially) replace diesel generators or oil boilers [34,35,140]. Similarly, while community-owned district heat or CHP is its infancy and its impacts on user energy consumption behaviour are undocumented, it provides a unique behavioural context in that unplanned heat demand reduction by users can act to reduce overall efficiency and carbon emission savings [142,143]. In what follows we summarise available conceptual evidence and evidence from community microgeneration projects to explore the conditions in which community energy might generate positive environmental impacts.

4.5.2 Theory and conceptual evidence

Current literature on environmental behavioural change implies that local collective initiatives may have distinct advantages over initiatives targeting individuals because they can overcome tendencies of individuals to believe they cannot influence the problem and to reject and externalise responsibilities to act [117,144-146]. More recent behavioural models and accumulating evidence on the drivers underlying environmentally oriented behaviour change both suggest that community projects can leverage a universal human tendency to model behaviour on those around us and a moral obligation to act in support of intra-group solidarity at regional scale [144,147,148]. Such behavioural responses have been shown to trump behavioural responses to factual knowledge about global environmental problems [149-152], suggesting environmentally oriented behavioural change is more likely to arise from projects that have been designed to address pertinent local public issues and create locally relevant co-

benefits. For example, while CRE projects were found not to impact awareness of climate change amongst participants across six case studies in England and Wales, they were found to be strongly embedded in more immediate local needs, such as replacing a school boiler, refurbishing a village hall, or providing an alternative income stream for local farmers [112].

Where they are embedded in enabling regional and national policy frameworks, intelligently designed community projects may go some way to creating a sub-context in which incentives inherent to price, infrastructure, information and socio-cultural context are better aligned [46,113,145,148,153]. If environmental attitudes and behaviour are shaped in part by socio-cultural factors and reproduced through local social relationships, community-based projects could present practical and locally-specific fora for the renegotiation of "what constitutes appropriate levels of consumption" [144,146,154]. Furthermore, because they are rooted in person to person relationships, community projects can enable experimentation and embedding of new environmental practices in a way that can take "account of the socio-cultural ways in which opinions are formed", personalising information and support in a way that top-down measures cannot achieve [30,83,93,146,147,155,156]. For example, there is ample secondary evidence that meetings, events, practical demonstrations and regional feasibility planning based on local connections and personal ties serve to motivate and support individuals to engage with energy issues, discover and alleviate concerns around measures they can take through knowledge sharing and ideas development [18,76,93,101,153,156,157].

4.5.3 Mission, project framing and levels of engagement

Few studies have methodologically assessed the medium to long term environmental impacts that materialise as a direct result of community-based renewable energy, but available evidence overwhelmingly suggests that it does not on its own deliver substantial progress on environmental indicators [158]. Among community-based carbon mitigation projects more generally, active participation rates in first time projects are typically less than 50% and resulting behaviour change tends to be dominated by small low-impact and low-cost behaviours, with less than 20% of households taking more extensive behavioural measures [113,118,156]. A systematic study of community-based low carbon micro-generation projects in Oxfordshire finds that a small proportion of individuals involved undertook significant energy reductions and that measures were largely limited to low cost interventions [18]. In a survey of 25 individuals across two community hydropower case studies, up to 65% of respondents claimed reduced energy consumption and 26% stated that they had installed domestic microgeneration systems as a result of the CRE project (although the authors note

that the survey suffered from self-selection bias) [17]. In both cases, measurable success in electricity and carbon reduction at community level arose as a result of multiple sequential initiatives circumscribed by project funding and spanning over a period of years [17,18].

A number of studies have observed environmentally-oriented behaviour change within core project co-ordinating teams, thought to result from high levels of perceived ownership, high degrees of engagement and the adoption of role model behaviour, where environmental objectives are sometimes adopted along the way to further champion a project [5,34,113,159]. Middlemiss observed that environmentally-oriented behavioural change may be more likely to occur as a result of community projects that actively engage their members and that target lifestyle, as opposed to specific activities, and most impactful for participants without previous exposure to sustainability discourse [113]. In a longitudinal mixed analysis of energy consumption behaviour across 88 households partaking in six community-based low carbon microgeneration projects, Gupta & Barnfield show that physical interventions without complementary behaviour-oriented support from a local community organisation often resulted in negative behavioural impacts such as increased energy intensive behaviour, use of additional appliances, or failure to adapt behaviour to suit low carbon technologies [160]. Van der Horst also points to the high level of user understanding required for environmental benefits of microgeneration to materialise, and the need for effective user handholding and feedback [35]. Detailed community-led microgeneration case studies suggest that when project promotion and recruitment rests on individual economic benefits rather than social collective moral obligations to act on climate change, they are unlikely to prevent rebound effects or produce beneficial environmental change [34,159]. This is because discourse around individual benefits does not open up what are taboo discussions around reconfiguring consumption behaviour for "low carbon living" within and beyond the household, nor encourage participants to identify with and take ownership of environmental behavioural objectives [34,159].

Together this suggests that environmentally-oriented lifestyle changes beyond core project management teams are limited to projects with explicit environmental mission statements that use renewable energy projects to fund or complement community-wide measures to encourage 'sustainable behaviour'. Furthermore, energy literacy and consumption behaviour can improve in self-consumption projects characterised by high levels of active user engagement if energy demand was not initially constrained and the installation is correctly sized.

4.6 Access to affordable energy

4.6.1 Overview

For a minority of CRE projects, energy access and affordability is a primary motivation for pursuing projects. A 2012 survey in Scotland suggested that 15% out of 97 CRE projects were initiated to lower energy costs, while 3% aimed to increase the availability or reliability of electricity supply [161]. Among the public, more affordable access to energy is also the most common motivation for wanting to invest in community projects in the UK [157]. However, community energy, and microgeneration more generally, are not central pillars of policy frameworks addressing access and affordability of energy in the UK, which have necessarily focussed on support schemes for energy efficiency measures and winter payments for low income vulnerable households [162,163]. Consequently, even though residential cost of energy and fuel poverty is heavily analysed and monitored in the UK, there is currently very limited research on the effect of CRE on the affordability of energy or relevant indicators such as energy performance, changes in disposable income, thermal comfort of buildings, or mental and physical health of residents involved in projects.

There is anecdotal evidence that self-consumption projects can facilitate access to affordable heat or electricity where the cost of alternative fuels is relatively high [164,165], typically in off-gas and/or off-electricity-grid remote locations [35,140,166] or locations that have ample low-cost woodfuel supply [167,168]. Such conditions can make community micro-grids and facility projects the most financially attractive option available [36,50,140,166]. The literature indicates that there are several preconditions for CRE projects to deliver more affordable energy for local community members, related to project financing, enabling behaviour change as well as the feasibility of direct supply models.

4.6.2 Project financing models

Several authors have argued that the upfront capital costs of projects currently necessitates that community organisations shoulder these costs on behalf of the wider community if they are to service energy poor consumers [140,162,169]. As a result, historically, these organisations have either had access to grants or loan programmes, or be well-established social enterprises with primary revenues from another form of economic activity, such as housing. More recently, community organisations are using more innovative financing approaches to circumvent placing upfront capital costs on community members. For instance, the Brighton and Hove Energy Services Co-operative have started utilising pay-as-you-save models to

recuperate costs from end users gradually over time. In addition, an increasing number of community organisations are beginning to recuperate earnings of past CRE projects, and there is ample evidence of earnings allocation to energy efficiency or microgeneration projects [40,46], such that CRE projects may indirectly generate more affordable access to energy.

4.6.3 Behaviour change

Savings on energy bills in the context of residential microgeneration of heat or electricity are known to be highly dependent on household characteristics. This includes initial consumption levels, demand profile, as well as the ability to engage with the technology and adapt consumption behaviour to optimise on cost-efficiency in the context of local import, export and generation tariffs [35,136,139,170]. Energy savings are generally only observed in a small proportion of households, often those with high initial energy consumption and low prior energy literacy [136,139,170]. There are few direct investigations into whether local community owned and managed projects can increase the proportion of households that experience monetary savings from these installations. Available literature does suggest that community organisations are well placed as intermediaries to overcome existing problems around suboptimal installation, and lack of user- specific information and feedback, which helps to achieve optimal use of microgeneration installations and reduce energy consumption more generally [18,136,160,171]. Community organisations are likely to be more trusted and accessible than government or industry representatives, and are able to use local knowledge to facilitate tailored technology-choice, better quality installation, and deliver better and longer-term user engagement through locally appropriate information, training, and after-sales services. As such, for CRE projects to have an impact on affordability of energy, an emphasis on community engagement and support services is likely to be key.

4.6.4 Direct supply

Due to current regulations and administrative costs, there are very few examples of CRE projects supplying electricity directly to the local community. In exceptional cases, through private wires or in partnership with commercial organisations that are able to meet licensing requirements around electricity distribution and supply, CRE organisations are able to sell electricity directly to their members at lower (wholesale) prices than (retail) prices from an alternative distribution network operator [64,172]. Current examples in the UK are limited to cases where CRE organisations can identify and connect with matching demand in the vicinity of the site [64], with projects increasingly seeking innovative ways to match local renewable

energy generation with local heat and power demand[173]. While direct supply from CRE is still an emerging area in the UK, there exist grid-exporting consumer co-operatives in both Sweden [172] and the Netherlands [174] that pay out shareholder returns in the form of monthly reductions on electricity bills through net accounting, and are marketed on the basis of guaranteed increased affordability of electricity for both urban and rural co-operative members.

4.7 Empowerment

4.7.1 Overview

Community empowerment is a contested concept and can be understood as both a process and an outcome [175]. An empowered community, as an outcome, has been described as one in which people feel that they have a voice that is listened to, are involved in processes that affect them, and can themselves initiate action to make desired changes [176]. The World Health Organisation defines the process of community empowerment as "the process of enabling communities to increase control over their lives, the process by which they increase their assets and attributes and build capacities to gain access, partners, networks and/or a voice, in order to gain control" [177]. Facilitating community empowerment is therefore intimately interlinked with, and dependent upon, development of social capital and community capacity, and is therefore best viewed as an overarching outcome of successful projects. It is often assumed that full or co-ownership of renewable energy production assets is intrinsically empowering for communities [51]. It has been suggested that, by bringing together groups of people with a common purpose, local energy projects empower communities to collectively change their social, economic and technical contexts [46], as well as a medium to negotiate the opportunities, constraints and risks associated with the contemporary transition to renewable energy [102]. Given the illusiveness of empowerment as a concept however, there is very limited research that has explicitly attempted to assess the impact of CRE on community empowerment.

Through interviews with members of 21 ‘community-related renewables projects’ in Scotland, Callaghan & Williams found some evidence to suggest that community ownership of renewable energy assets can lead to increased community confidence and empowerment, however, the authors highlight that this impact is difficult to quantify [36]. While CRE projects have been described as bringing "feelings of community pride, strength and empowerment" to the people involved [76], there is no evidence substantiating this conclusion. Similarly, based

on a large survey of the socio-economic status and attitudes of members across different project types in Germany, Radtke finds that CRE initiatives tend to involve largely well-educated males with good incomes and individuals "who already have an affinity to specific ways of participating in groups, political parties and organisations" [102]. This suggests that the degree to which previously powerless individuals may be empowered through CRE is limited to a small section of society.

4.7.2 Structural barriers

There is evidence from studies of community-based initiatives similar to CRE that, under certain circumstances, there can be negative implications when overly high expectations are placed on community development initiatives. Specifically, the expectation for communities to take responsibility to deliver solutions for structural demographic or socio-economic problems that may be beyond their capacity, in particular without access to sufficient support, may lead to disillusionment and powerlessness. For example, a case study of the impact of a community development initiative in rural Australia found that the combination of the 'self-help' model of community development, the decline of government assistance, and social and economic changes such as declining population and the ageing of the volunteer 'workforce', was disempowering rather than enabling [178]. If insufficient account is taken of the complex inter-relationships that already exist in a community, community development projects can create dislocation in local networks and place pressure on finite individual and community resources. A similar study of a scheme established to build capacity in 'less-resourced' communities in Scotland found that, although empowerment can take place on an individual basis, this does not necessarily translate to 'community empowerment' [86]. Specifically, it is typically the 'usual suspects' within communities that are empowered, and these individuals may not always receptive to ideas from other community members, causing disagreements locally[86]. Orientation of leadership towards wider community engagement has been found to play a large role in determining to what extent community members beyond project co-ordinating teams can take ownership of a project and its success [83]. At worst, a project can entrench local power structures and make individuals less likely to participate in future [86]. Empowerment can therefore not take place in absence of the inclusive capacity building processes that enable community members to participate in projects [86].

5. Quality of evidence across impact categories and project types

Appendix A lists all studies reviewed with respect to quality of evidence for the seven impacts identified. Overall, the current evidence base supporting these seven impact categories is relatively weak and demonstrates considerable variability across case studies. Impacts are often referred to loosely in order to justify the relevance of research, suggesting that evidence available may be biased towards positive impacts. The nature of evidence for impacts of community energy is dominated by qualitative interview based studies, reflecting the dominance of case-study-based analysis in the field (Figure 1). Least studied impacts are empowerment and access to affordable energy, followed by energy literacy and environmentally benign lifestyles and social capital, with lack of robust qualitative evidence for socio-economic regeneration. There is a lack of robust survey and statistical evidence across all impacts.

Considering the distribution of evidence across different types of community projects, a large proportion of the literature does not distinguish between different project types or provide sufficient context for project types to be deduced from the analysis. However, it is clear that energy co-operatives and shared ownership projects of any kind are relatively understudied in the context of project impacts, as are rarer project types such as community owned district heat networks and community-owned microgrids. The majority of studies investigating environmental behavioural change have analysed low carbon microgeneration projects, while evidence on socio-economic regeneration is largely limited to community development projects in Scotland.

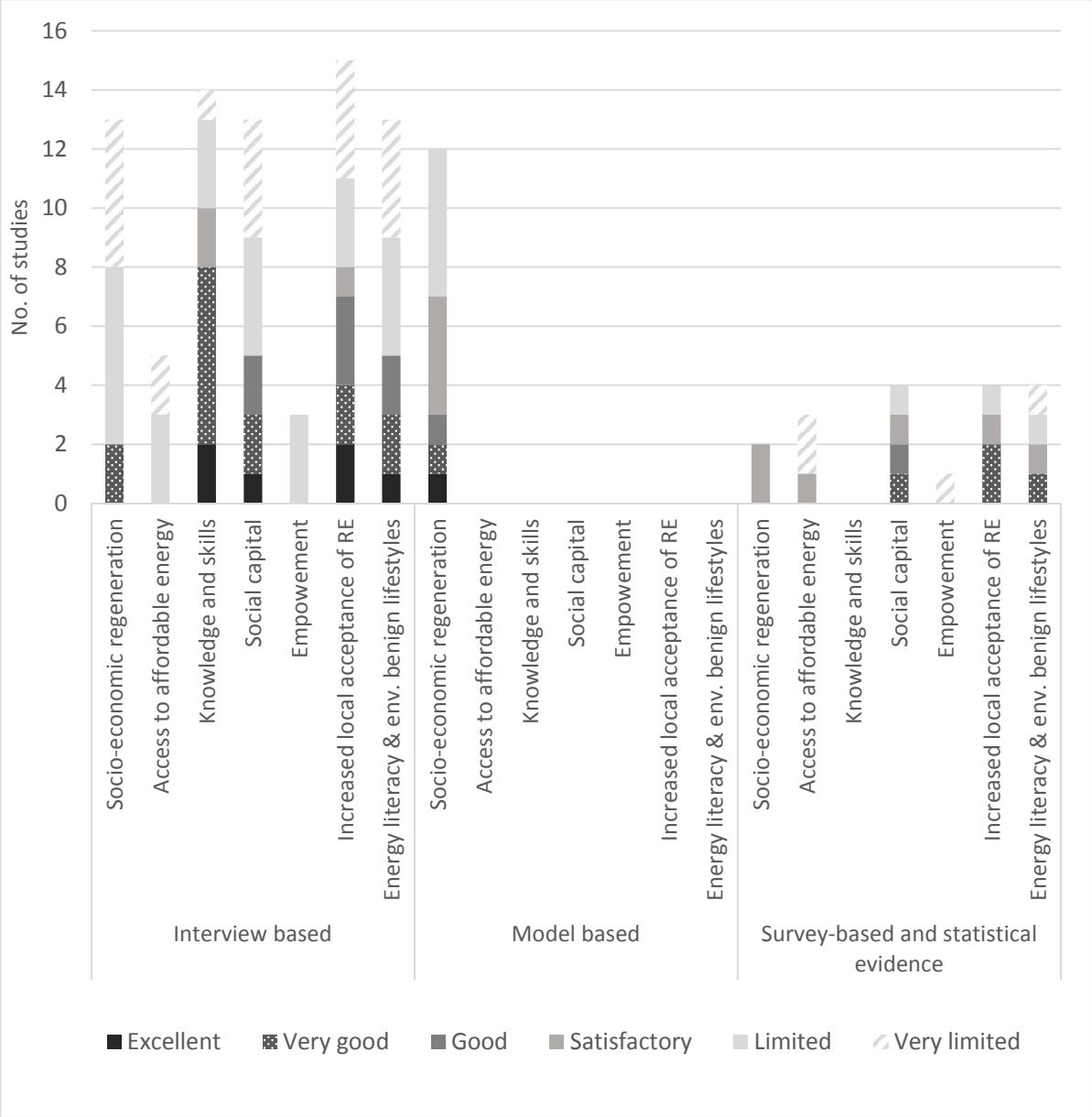

Figure 1 - Summary of quality of evidence for interview-, survey- and model-based literature on the impacts of community energy.

6. Discussion

Having conceptualised impacts associated with CRE in the literature and reviewed quality of evidence, in what follows we summarise the conditions under which given impacts are generated and explore whether we can deduce patterns in the occurrence of impacts across different types of projects, based on the literature reviewed (Section 6.1). Finally, we identify knowledge gaps, highlight research priorities, and provide methodological recommendations (Section 6.2).

6.1 Emerging patterns in the occurrence of impacts

Despite shortcomings, the available evidence enables an initial exploration of the nature and occurrence of specific impacts in relation to different types of CRE projects and in relation to two defining dimensions that have been widely used to distinguish CRE projects from commercial projects – namely, 'processes' versus 'outcomes' [19,21].

Impacts that are predominantly associated with the process of project development and direct outcomes of a project can be distinguished from those that are generally associated with indirect and longer-term transformative processes that are mediated through the local investment of project revenues (Figure 2). Within the literature, access to affordable energy, knowledge and skills development, social capital, increased acceptance of RE technologies, and energy literacy are more closely associated with project processes and direct outcomes (Figure 2). In contrast, empowerment, socio-economic regeneration and environmentally benign lifestyles appear to be longer term, indirect impacts that depend on the generation and allocation of project revenues and subsequent community activities, which may or may not result from given CRE projects (Figure 2).

Inclusive engagement

Across the literature, there is evidence that all of the impacts we have identified are to some degree dependent on inclusively managed project processes, corroborating 'inclusive process' as a defining feature of what distinguishes community from commercial projects [20] (Figure 2). In particular, the evidence suggests that the degree of effective, early and wide community engagement determines whether a CRE project will have a positive impact on social capital. While some projects depend on community engagement by design, for instance those aimed at diffusion of technologies or environmental measures across the wider community [31,34], a number of studies have observed that inclusive 'community building' processes are not seen as a priority or objective for all CRE organisations [21,22,29,31]. Hence community organisations are not always motivated to undertake early and extensive community engagement [21,22].

In all cases reviewed, active community participation was motivated by perceived public and collective benefits, and sustained through a sense of social and civic gratification [5,36,83,112,118,179,180]. As such, the development of social capital is likely to be as much a function of local need as a group's organisational mission and culture. Collective action

initiated to address systemic market and state failure around the provision of warm homes or electricity or other goods or services necessitates broad community support and can serve to overshadow and unify conflicting interests, while broad community support may be less pertinent where basic needs are met.

CRE projects are typically co-ordinated by small core teams whose motivation and leadership style heavily influence social capital development [5,34,35,56,112].The literature suggests that CRE leaders who see themselves as part of local protest movements against a unified cause are more likely to engage in community building than those who are less ideologically driven [31,157,181]. In certain contexts, stakeholder conflict around a local issue has itself been the impetus for inclusive community building efforts [104]. In settings characterised by uncertainty, conflicting opinions or conflicting interests, leadership that "fosters notions of learning through failure, 'constructive controversy', depersonalises politics and accepts value differences", is more likely to facilitate social capital development than leadership that stifles and excludes discerning voices [34,104,182,183]. Given an impetus for inclusivity, other factors that may influence choices around community engagement and consequent social capital impacts of CRE projects are state incentives and resources available for broad-based civil society groups, including physical space [12,184,185].

In addition to its critical role in developing social capital, there is unequivocal evidence to suggest that increased local support for renewable energy is more likely to emerge from inclusively managed projects. Exposure to and psychological ownership of renewable energy installations determines whether they come to represent tangible and symbolic manifestations of shared identity and success [14,123,130] as opposed to a threat to self-identity or to positive emotional attachment with a locality [129]. There is also clear evidence of a direct correlation between social capital and socio-economic regeneration, since, irrespective of how project revenues are allocated locally, local multiplier effects are higher in contexts where there is connectivity, relational trading and mutual loyalty between local firms and residents such that goods and services are locally purchased [66,186]. Several studies have demonstrated that the development of local skills and knowledge depends on active participation in CRE projects [30,62,95]. Therefore, project management processes that include the wider community are essential if these impacts to be felt beyond the few individuals comprising the core team.

Type of project

A number of impacts were found to be associated with specific types of community energy projects but not others. For example, while the social and economic benefits of provision of access to more affordable and reliable heat or electricity through CRE projects are likely to be substantial, they apply only to those self-consumption projects in the UK where the cost of energy alternatives is relatively high, and where an organisation is able to raise capital and invest on behalf of the wider community, and/or can distribute and supply heat and electricity to local residents directly (Figure 2).

Similarly, based on the evidence presented here, energy literacy and environmental behavioural impacts are most likely to arise from self-consumption projects characterised by high levels of active user engagement and projects with explicit environmental mission statements that use renewable energy projects to fund or complement community-wide measures to encourage 'sustainable behaviour' more broadly. At least 13% of all community organisations involved in heat or power generation are known to have explicit environmental mission statements [25], using generation projects as flagship demonstration projects and investing earnings in local energy efficiency measures, bulk purchasing schemes, and environmental projects in gardening, waste, or transport domains potentially generating indirect environmental impacts at household and community level [17,18,38,46,48,187]. Outside of these organisations and self-consumption projects in which wider community members necessarily interact with renewable energy technology by design, there is currently little evidence that projects directly induce community-wide behaviour change through prompting reflection on links between personal behaviour, energy consumption, and energy generation.

Local economic stimulus generated from CRE projects increases as a result of locally sourcing finance and intermediate inputs, as well as strategic investment of earnings in local public or private capital (rather than to consumption and leakage out of the local economy) (Figure 2). Indirect economic impacts will accrue to communities able to tap into sustained regional demand for renewable energy by developing capacity to supply intermediate products and services over time. Earnings should be allocated towards the (rural) public sector in order to maximise a projects redistributive effects [60]. However, CRE projects do not generate profits or allocate them towards local public goods or private incomes equally and there is still a lack of understanding of how this interacts with local economic structure to influence tangible (income, employment) and less tangible regeneration effects.

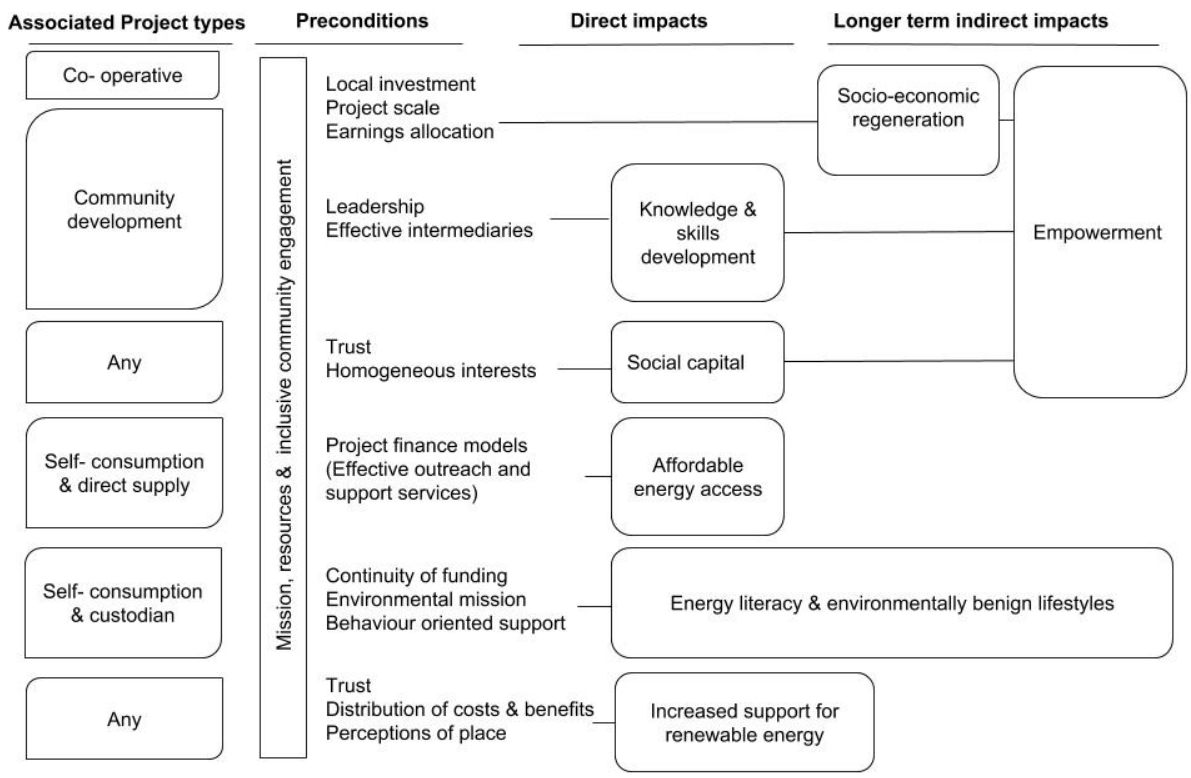

Figure 2 – Summary of direct impacts from project development and longer term indirect impacts, showing preconditions and indicative associated project types.

6.2 Research priorities & methodological recommendations

The results suggest that evidence underpinning social impacts of community energy to date is fragmented and to variable degree based on either loose anecdotal observations, conflation of stated motivations of participants with project outcomes and policy rhetoric. With the exception of increased support for local renewable energy, research into social and environmental impacts lacks systematic inquiry; few studies have explicitly defined and deployed transparent analysis procedures that draw on a representative evidence base.

The current lack of evidence across impact categories identified stems primarily from the complexity involved in attempting to assess many of the social behavioural phenomena and a lack of longitudinal studies. For example, our understanding of social capital development, capacity building and empowerment would benefit from long term comparative studies to track the emergent development of social networks in which CRE organisations are embedded. This would enable observation of the variable degrees to which they succeed to secure voluntary participants, develop moral obligations and incentives among members to contribute time and resources, expand internal and external networks, and overcome conflict and detrimental

divisions that make or break a project. Analysing environmental behavioural impacts systematically across different types of community energy projects over timeframes spanning spin-off and follow-up activities would help to identify the key characteristics of projects that do and do not successfully engage the wider community in gradual cultural and behavioural reconfiguration processes around consumption.

While there is evidence demonstrating the presence of local economic multiplier effects for both medium and small-scale wind and hydro projects respectively, there is a lack of understanding as to how representative these projects are for the community energy sector as a whole, as well as how they relate to less tangible social aspects of regeneration. Existing sociological literature is largely limited to anecdotal evidence on (intended) allocation of project revenues based on one-time interviews with local residents and project participants and cannot demonstrate links between CRE and the character of local and regional development pathways in terms of employment, income and productivity, social inequality and living standards. There are to our knowledge no studies that have: systematically analysed the role of local renewable energy projects in supporting a medium to long-term transformation towards more multi-functional, diversified and 'resilient' rural or urban economies; analysed the influence of patterns of earnings allocation towards local private or public goods across different regions; or assessed the factors characterising localities that do and do not possess the endogenous development potential required to capitalise on CRE projects.

One step removed from analysing project impact on the economic opportunities and well-being of local residents, the most conclusive studies are based on input-output, social accounting matrix and regional CGE models that have estimated local economic stimulus resulting from construction and operation of wind and hydro-power installations within a region [17,55,59-61,63-65]. These approaches variably account for project-associated earnings expenditures and displacement effects. Bottom-up survey-based data collection approaches in combination with meticulous regionalization of sectoral economic datasets is necessary to overcome the difficulties in accounting for locally specific production functions, economic interlinkages and non-market transfers. This would enable the development of more fine-grained local social accounting matrices, as well as capture unique project financial structures that are relevant in the assessment of socio-economic regeneration impacts of CRE projects [59,64,186,188]. Regional comparisons using the same analytical approach would help to explain how regionally divergent project finance structures, resources, labour, skills and assets shape the ability of CRE projects to develop sustained economic activity that can complement regional

core functionalities and address locally pertinent state and market failures. Data-driven, mixed and longitudinal approaches would be necessary to assess less tangible longer-term development outcomes, including cultural or natural amenity effects, information spillovers and external scale economies, for instance by mapping economic functionalities over time [189], using structural path analysis [190] and/or integration with econometric models [44].

Finally, current evidence on improved access to affordable energy is limited to the differences in the cost of energy before and after a project. Given public interest in solutions aimed at increased affordability of energy, there is scope for more in-depth evaluations of how different types of CRE projects perform in terms of a broader range of indicators including the reach and inclusivity of projects, socio-economic status of participants, impacts on disposable income and, where relevant, energy performance and thermal comfort in partaking households.

7. Conclusions

Community energy projects are widely thought to be associated with positive local impacts. This review has demonstrated how the diversity of CRE projects in the UK inevitably leads to significant differences in projects' ability to deliver given social, environmental and economic impacts. The processes through which CRE projects lead to positive local impacts are not well understood. With the exception of increased local acceptance of renewable energy, there is a paucity of consistent evidence for local impacts associated with project development processes and direct outcomes. Overall, the evidence suggests that the most substantial local impacts are associated with indirect project outcomes and investment of project revenues in the local community.

Projects are characterised by different community needs and objectives, variably drawing on private and public values, which ultimately influences their local impacts. We suggest that where CRE was a response to structural socio-economic decline or global environmental problems that are perceived as beyond the agency of individuals, it is motivated and designed to fill gaps in essential public goods, services and amenities. This necessitates a 'public good approach' that is characteristic of community development projects in Scotland, and of community facility projects throughout the UK, as well as some projects run by social enterprises and energy co-operatives. In contrast, where CRE was driven by (financial and/or environmental) objectives that do not extend beyond renewable energy projects, it led to business models designed primarily to generate returns for membership-based investors. In

addition, small-scale facility projects and projects primarily designed to provide access to more affordable energy are not likely to generate substantial earnings such that their local impacts are largely limited to those associated with project development processes and direct outcomes.

Finally, the case studies reviewed here suggest that the pursuit of public social and environmental values is fundamentally correlated with inclusive and place-based collective management processes that are built on social capital, such that CRE projects characterised by high degrees of social capital are more likely to be oriented to public social, socio-economic or environmental problems. Only these projects involve negotiation and enforcement of public value priorities and social norms that are, by definition, based on local person-person relationships. For such 'public good' projects, the success and inclusivity of this negotiation process is likely to determine how effectively project earnings are translated into more far-reaching local impacts. On this basis, collective funding pools, and the negotiation of their distribution towards private versus public goods, appear to play a crucial role in determining the extent to which CRE projects deliver transformative local impacts.

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