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Governing the infrastructure commons: lessons for community energy from common pool resource management

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Governing the infrastructure commons: lessons for community energy from common pool resource management

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Abstract

Community energy projects are making a small but growing contribution to global energy system transformation. However defining this contribution solely in terms of decarbonisation of the energy system underplays the diverse outcomes of community energy projects, which can include fuel poverty alleviation, local economic growth and community resilience. These outcomes can be delivered to the communities themselves but also to the city and nation within which they operate. However, community energy projects face a series of barriers when trying to co-exist with the mainstream, often privatised and liberalised energy market. In this paper we observe that these barriers arise because energy is conceived and governed as a private good, as an interchangeable commodity delivered through national or international supply chains. However, many of the outcomes of energy provision could be considered as public goods or even common goods, which are not suited to governance through market processes. Following analysis of transferrable insights from natural common resource management we argue that more plural approaches to governance of energy, including self-governance, might overcome the under-provision of social and environmental outcomes in a market-based system. In particular we highlight the importance of polycentric governance and the role for cities in facilitating community energy projects and mediating between national and community actors.

Key words: Energy Governance; Infrastructure; Community energy; Polycentricity.

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1 Introduction

It is widely recognised that our energy system must undergo radical change to address pressing environmental and social challenges (GEA 2012). Community energy provision makes a small but growing contribution to the necessary global energy system transformation (Seyfang et al. 2013; Kunze & Becker 2014; van der Schoor & Scholtens 2015). Research undertaken by the UK's Department of Energy and Climate Change has shown that by 2020, community electricity could provide between 0.5 and 3GW of installed capacity, enough to meet the electricity needs of 1 million homes representing between 2.2 and 14% of the total capacity of wind and solar technologies (DECC 2014). Several governments have made specific pledges to increase the contribution of community energy provision by significant margins (DECC 2014; Climate and Energy Fund 2013; ResPublica 2014). Municipalities have a crucial role in facilitating community energy and increasingly recognise the benefit of having greater influence over local energy infrastructure (Core Cities 2013; Hawkey et al. 2014; Späth & Rohracher 2010). This influence includes strategic planning to enable and connect projects (Bale et al. 2012) but also support to build capacity in community groups trying to take part in energy provision.

It is also becoming widely recognised that community energy provision can have benefits beyond simply the management of energy, including fuel poverty alleviation, local economic growth and community resilience (Seyfang et al. 2013; Walker & Devine-Wright 2008; Murphy 2010). The majority of these benefits contribute to national government and municipality goals which should motivate these organisations to reduce barriers to implementation. However, many of these outcomes could be considered as common or public goods or are addressing common pool problems[1], which are not suited to being governed using market processes (Ostrom 2010a). Despite this, energy is currently perceived and governed as a private good using predominantly market-based instruments (Goldthau 2014; Hira et al. 2005). We argue that this is why, despite the well-documented benefits of community energy provision, individual projects face numerous and often overwhelming challenges when trying to develop or maintain initiatives (Roelich et al. 2013).

In this article we first discuss how community energy provision is different to mainstream energy provision. Building on this, and from the perspective that some of the outcomes of energy provision could be considered to be a public or common good, we argue why a different form of governance is required. Subsequently, we discuss transferable insights from common pool resource management that could inform new, more plural approaches to energy system governance. The arguments in this article are globally relevant but are illustrated with evidence from the UK energy system of provision.

2 What makes community energy different?

Community and mainstream energy provision are often considered to be the same system of provision. A system of provision for a good is understood as the integral unity of the economic and social factors that go into its creation and use (Bayliss et al. 2013). Consumption is considered to be part of a chain of activity interlinked with

[1] The definition of which is given in section 3

production processes. We use this concept to enable a more systemic analysis of energy provision. The technology used in community and mainstream energy provision is comparable in nature if not in scale; however, the motivations and modes of operation are substantially different, a crucial point which is discussed in more detail below. This presents challenges for governing two superficially similar but in some way fundamentally different systems of provision, as illustrated below. We consider the energy system of provision to include the technology and business model necessary to deliver a physical 'good' to an end user but also include the system of governance that regulates the physical networks and economic markets necessary for this provision. Technology, business strategies and governance have co-evolved to such an extent that it is difficult (and not advisable) to analyse one without considering the others (Foxon 2011; Verbong & Geels 2010). We understand governance to be a combination of paradigms, institutions and instruments (Kern et al. 2014; Hall 1993) and so discuss all of these aspects of the system of provision.

2.1 Mainstream energy provision

The political paradigm underpinning energy policy has predominantly moved from a state paradigm, where central government controls physical infrastructure, to a liberal market model (Kern et al. 2014; Goldthau 2014). Thus, in most countries, energy is now treated as a commodity (Patterson 2008) and energy provision is, on the whole, operated as a regulated market (Hira et al. 2005). This paradigm change was primarily motivated by the view that the state is inefficient and that creating open, competitive markets is conducive to increased levels of investment, innovation, and lower prices to consumers (Hall et al. 2012; Mitchell 2010; Roelich et al. 2015).

By way of example, energy provision in the UK was fully privatised and partially liberalised in the 1980s. To illustrate this, Figure 1 shows the overarching structure of the electricity system in the UK; electricity is generated (at predominantly centralised, fossil fuel-based facilities), transmitted via the national grid and distributed to customers via regional distribution networks (Bolton 2011). Suppliers buy the electricity generated either through a centralised system or through bilateral contracts with generators. Customers pay a supplier per unit of electricity consumed (plus a standing charge). Gas systems can be divided in the same way but with producers and shippers of gas rather than generators of electricity. Heat provides a contrast to this system both technically and with regard to governance. Heat provision inherently has a limited geographical range, so generation and distribution are usually controlled by the same organisation. In the UK, heat is largely unregulated.

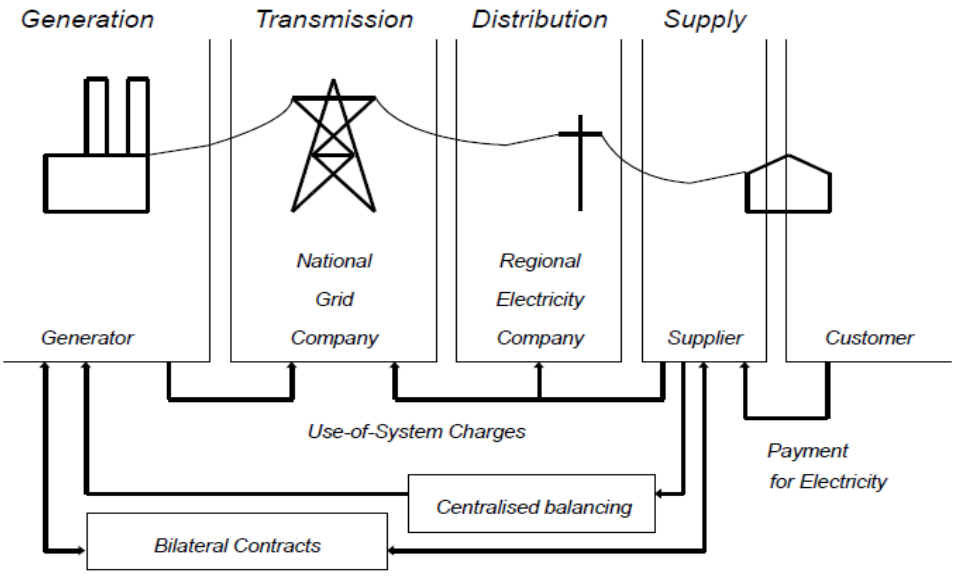

Figure 1: The energy system in the UK (Green 2011 quoted in (Bolton 2011)**)**

Business arrangements in the UK gas and electricity sectors are based on the throughput of energy; the more units of gas or electricity that are sold, the greater a company's revenue (Patterson 2013; Steinberger et al. 2009). In such a privatised system the profit motive is the driving force for private entrepreneurs (Ostrom 2008). As such, both energy generators' and suppliers' interests are in maximising sales and reducing the short-term costs of producing and distributing each unit of energy. This disincentivises the low carbon technology roll out and demand management necessary to achieve environmental and social goals (Roelich et al. 2014).

2.2 Community energy provision

In contrast, community energy provision refers to those activities "where communities (of place or interest) exhibit a high degree of ownership and control [over part of the energy system], as well as benefiting collectively from the outcomes" (Seyfang et al. 2013: 978). Importantly, this includes activities involved in energy generation and supply, but also in managing demand for energy, which is excluded from the mainstream view of the energy system. The motivations for engagement in energy provision differ significantly from the revenue generation driver of mainstream energy provision. A recent survey of community energy in the UK found a diversity of motivations for engagement including environmental and social as well as economic (Seyfang et al. 2013). Interestingly, many projects have multiple motivations for engaging in energy provision (Seyfang et al. 2013).

Many community energy schemes are designed to optimise these social and environmental goals and develop unique business models to manage the creation and appropriation of a wide range of values. Importantly, value created depends on the specific motivations of the communities and the business model they apply depends in turn on the capabilities of the community. So there is a great deal of diversity in what they do, how they go about it and the type of value generated (Seyfang & Smith 2007). In this article we consider these forms of value created through community energy provision to be 'goods' comparable to the energy commodity created in the mainstream system of provision. We present a selection of

the goods in Table 1, which have been documented in research on community energy provision, and group them by the broad area of motivations described above. As we discuss in more detail in section 3.1 these goods display very different properties from the mainstream conception of energy as a commodity.

Table 1: Multiple outcomes of community energy provision (Seyfang et al. 2013; Hall & Roelich 2015)

Area	**Outcomes/goods**
Economic	Competitiveness and economic growth
	Job creation
	Revenue generation
Social	Fuel poverty reduction
	Regeneration
	Skills and education
	Social cohesion
	Fairness e.g. tariff discrepancy
Environmental	Carbon emissions reduction
	Air quality
Self-governance or self determination	Local accountability & control
	Energy independence

Figure 2 highlights some of the key differences between community energy provision (i.e. lower half) and mainstream provision (i.e. upper half), which is solely based on the optimisation of financial value. Although in the mainstream system the energy supply chain creates additional value, in the form of jobs for example, they usually occur outside of the community of end-users paying for the energy. In community energy provision these additional values are not only generated within the community but can be larger and more diverse (i.e. local jobs and environmental benefits). In the mainstream system the community is dependent on the state or wider society for provision of these outcomes, putting a significant burden on the state.

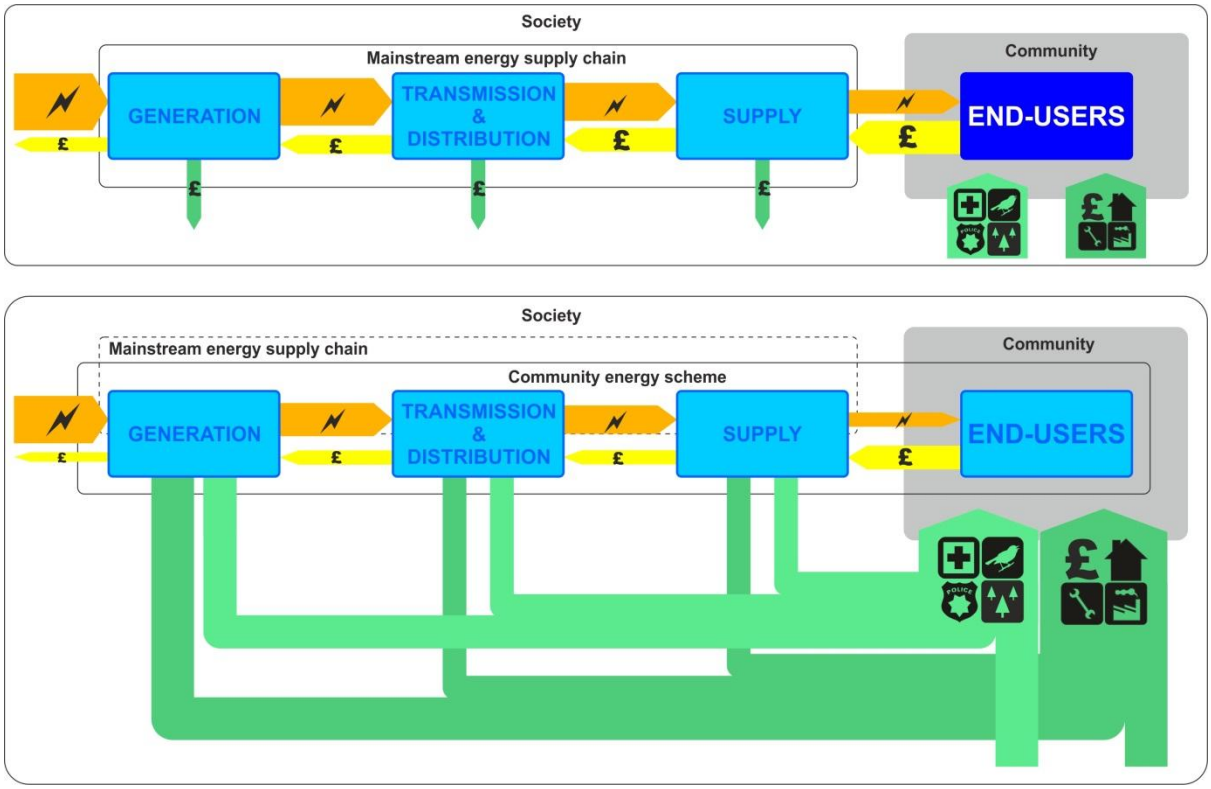

Figure 2: Conceptual representation contrasting value systems between the current UK mainstream energy system (i.e. upper half) and community energy provision (i.e. lower half) (orange arrows indicate energy flows, yellow arrows the corresponding cash flows, additional value flows are indicated in light green for health, environmental and safety benefits, and dark green for economic, employment and general wealth benefits)

Despite these fundamental differences, community energy provision cannot be considered completely separately from the mainstream energy system. Balancing supply and demand locally is very difficult; therefore, community engagement in energy provision rarely covers the whole system of provision. The energy produced from generation activities tends to be fed into the mainstream transmission and distribution system and sold to mainstream suppliers, as indicated by the dotted line in the lower part of Figure 2. This means that community energy inevitably interacts with mainstream governance systems, through network charges and wholesale markets, and is addressed by the same institutions tasked with regulating the profit-oriented mainstream system. It is this interaction that makes it difficult for community energy projects, to compete (or even to survive) (Roelich 2014). As a result of this, community energy actors face a series of barriers and frequently fail to achieve their potential (Seyfang et al. 2013).

2.3 Mainstream energy system governance as a barrier to community energy

The energy system in many countries has been privatised; however, it is still highly regulated. This regulation is necessary to reduce the effects of monopoly control; however, the way that regulation has been implemented presents a series of challenges for community energy provision. These challenges are discussed below

in terms of the representation of energy as a market and the strong regulation of certain parts of the system.

2.3.1 Energy system governance of a market commodity

In mainstream energy provision, the energy system is conceived as a flow of commodity (from generation through distribution and supply to the end-user) and a concomitant flow of money, i.e. as a market (Patterson 2008). As a result policy and regulation is dominated by economic instruments, or requires analysis of financial costs and benefits, to justify implementation of investment or interventions. Supply and demand of energy is currently regulated through an energy market, which is based on marginal cost pricing (Mitchell 2014). The marginal cost system on which the market is based is effective for high marginal cost, continuous production of electricity (such as coal or gas-fired power stations) but breaks down when there is low marginal cost, intermittent energy sources (such as many renewable energy technologies) or if demand were to decrease (Mitchell 2014). Therefore, this form of regulation favours a highly centralised system which prioritises supply over demand management and, by its very design, disincentivises low carbon technology roll out.

The conception of energy as a market commodity, in a neoclassical economic sense, is preoccupied with static allocative efficiency and presumes that only the consumer gets direct utility from energy. In fact the consumer is not the only actor to benefit from energy provision (Wilkinson et al. 2007; Seyfang et al. 2013) and it is not the energy itself that results in utility but the services that energy provision delivers, such as thermal comfort or illumination (Knoeri et al. 2015). Commodification of energy does not recognise or capture any other forms of value or goods (e.g. environmental or social), other than the financial value of the energy commodity. Furthermore it overlooks the fact that the community, local authority and nation in which the energy system is set also derive utility from the way in which the provision of energy is organised.

There is some evidence that the grip of the pro-market paradigm is weakening and policy to explicitly support renewable energy generation and demand management (Kern et al. 2014). However, the persistence of the pro-market perspective alongside emerging perspective of sustainability limits the coherence of resulting policy and institutions (Kern et al 2014). This lack of coherence allows a system focussed almost entirely on financial value to dominate, which favours large, homogenous, profit-oriented organisations and constrains the potential of smaller, diverse organisations focussed on social and environmental value and goods.

2.3.2 Monolithic governance

It is recognised that, despite this conception as a commodity market, the energy system suffers from a number of market failures, such the natural monopoly of the transmission and distribution networks and the potential for exploitation of vulnerable consumers (Hira et al. 2005; RTP Engine Room 2015; Competition & Markets Authority 2015). Therefore, certain parts of the system are strongly regulated to mimic competition and protect consumers (BIS 2011). The main mechanisms for this regulation in the UK are network charge controls and operator licencing. Charges for transmission and distribution of energy through networks can only be made through ‘use of system charges’, which are set on the basis of the volume of electricity or gas moved through the system and on any necessary addition to the asset base to

transmit from new sources or where network reinforcement is required (Hall & Foxon 2014). This approach, where costs for reinforcement are allocated to the 'last-in' presents significant challenges to community energy projects, who cannot move to areas where the grid is less constrained and are unlikely to have significant finance at the early stages of a project (Community Energy Grid Connections Working Group 2014). Regulation of use of system charges is done mainly to reduce prices now, not to enable the systemic change needed to incorporate decentralised energy generation and manage demand (Hall & Foxon 2014).

To protect customers from exploitation, the energy economic regulator in the UK, Ofgem, has developed a series of licences, codes and standards that transmission, distribution and supply companies must comply with in order to operate different parts of the energy system[2]. This works well for large organisations that engage with the energy system in a traditional way but is an overwhelming burden for smaller organisations and is not able to accommodate the diversity of alternative forms of operation. Furthermore, customer protection is promoted through restrictions on contract length, meaning suppliers can't lock customers into unsuitable contracts and to promote competition. However, this means suppliers can't form long-term relationships, which might be required to encourage roll out of low carbon technologies.

Both network and supplier regulation have evolved around the mainstream mode of operation and severely restrict diversity in how energy is provided, putting community energy provision at a significant disadvantage (Roelich 2014).

3 Why do we need a different form of governance?

Section 2 summarised some of the key differences between mainstream and community energy provision and outlined how the current form of governance presents barriers to alternative forms of operation. This section proposes a theoretical explanation underpinning these differences, and the unsupportive nature of the current form of governance.

3.1 Multiple outcomes of energy provision as a common pool problem

One way of understanding the barriers faced by community energy is to consider the type of 'good' created by each system of provision. If we consider the commodity of energy in isolation to its mode of provision then it could be argued that it is a private good; it is excludable (energy companies can prevent those that have not paid for it from using the good) and rivalrous (each unit of energy generated can only be used once). However, there is a nascent body of work arguing that many of the outcomes of infrastructure provision could be more appropriately defined as a common good or public good and the challenges faced in its provision are similar to common pool problems (Little 2005; Künneke & Finger 2009; Goldthau 2014). Both common goods and public goods are described as non-excludable, where it is difficult or undesirable to prevent access to a particular good, for example a public park. Common goods are also rivalrous, where the use of a unit of good by one consumer precludes benefit from another consumer using the same unit of good, for example extraction of wood from an area of forestry. Energy infrastructure is often described through property rights whether it is private or common. However, few of the social and

[2] https://www.ofgem.gov.uk/licences-codes-and-standards

environmental outcomes described in section 2 have defined property rights therefore classification requires more detailed consideration.

One of the principle arguments for this case for energy is that the provision of energy creates a far wider range of outcomes or 'goods' than just kWh of electricity or therms of gas (Wilkinson et al. 2007) as outlined above. Some of these goods are provided to the end user, such as thermal comfort, hygiene and illumination (also called energy services) (Knoeri et al. 2015), and might be excludable, as such. However, it has been argued that a minimum provision of energy services are essential to human development (United Nations General Assembly 2011). Therefore it could be argued that these goods should not be excludable to enable this development, and that some of these goods could be considered to be common or public goods.

Furthermore, many of the goods created through energy provision are conferred to organisations other than the end-user of the energy. For example, fuel poverty alleviation can improve the health and wellbeing of residents and reduce the burden on municipalities and health services. Because of the systemic nature of these goods it is difficult, or impossible, to assign them to individual users reinforcing their non-excludability. Fuel poverty alleviation also displays a degree of rivalrousness, particularly where it involves investment in properties to reduce the fuel consumption. In this case, the investment in the property creates the good of fuel poverty alleviation which can only be used by the householder to reduce their own fuel poverty. The challenge of attribution is a typical problem associated with common goods (Künneke & Finger 2009) and presents problems when determining who pays and who receives benefit from energy provision.

A further challenge of common goods is the requirement for collective action, the inputs and efforts of multiple individuals, to achieve sustainable outcomes (Ostrom 2010b). In natural resource common good problems, lack of collective action leads to over-exploitation and depletion of a finite stock of resource, a phenomenon known as the tragedy of the commons (Hardin 1968) or to under-provision and depletion of respective infrastructure hindering resource flows (e.g. Baur et al. 2014). In energy provision, lack of collective action could mean that certain goods are under-provisioned (for example potential social and environmental benefits are not exploited). For example, community development and local economic growth are unlikely to occur if the community itself is not involved in energy provision (Walker et al. 2010; Walker & Devine-Wright 2008).

Energy provision in community energy schemes provides a range of goods in addition to energy itself with differing degrees of common pool-ness and facing different degrees of common pool problems. However, community energy provision is more likely to provide those goods, such as climate change mitigation and community development (Seyfang et al. 2013), which exhibit the features of common pool problems most strongly. This indicates that the current approach to governance, based on the premise that energy is a private good, is flawed and in isolation will under-provide many of the potential benefits of community energy provision.

3.2 Governance of common pool problems

When Hardin first introduced the notion of the tragedy of the commons he claimed that only two state-established institutional arrangements - centralized government and private property - could effectively manage common goods in the long-run, and

he presumed that common good users were unable to solve common good problems themselves (Hardin 1968; Costanza 1987). However, decades worth of work by Ostrom and colleagues has shown that sustainable common pool resource management is possible at a local level.

In light of the global trend towards privatisation and liberalisation of energy provision (Hira 2004) there is increasing reliance on private property rights, and market-based governance. This presents a number of challenges to common pool governance and community energy provision. The economic instruments which dominate current energy policy are effective if stocks and flows of goods are predictable, if the number of users or producers is low and if regulated users or producers are homogenous (Dolsak 2000). It could be argued that these conditions hold for the current highly centralised, supply-oriented system of energy provision but if we are to move to a more renewable, decentralised system, that fully engages actors such as community energy providers and includes significant demand management, they most certainly do not hold. Firstly, the diversity of goods produced by different projects at different scales, and the dynamic nature of goods, which change as the priorities of groups changes, makes stock and flows very difficult to predict. Secondly, there are thousands of producers (compared to the six energy companies that dominate the UK market today). Finally, producers all vary dramatically in motivations and capabilities so are highly heterogenous. Therefore, market instruments are unlikely to be effective for governance of community energy provision.

Ostrom and colleagues argued that in some cases, self-governance could be more effective than state or market control because it was better able to address the issues of diversity and change. They argue that the creation and distribution of value can be managed more effectively based on local knowledge about priorities and capabilities. However, it has been found that self-governance of common good problems is effective only when a specific set of conditions hold (Ostrom 2009). These conditions include the ability to monitor resources; moderate rates of change of key system variables; interaction to increase trust and lower the cost of monitoring; low cost of excluding outsiders; and users' support of monitoring and rule enforcement.

These conditions rarely occur spontaneously, but it is possible to enable them through the creation of institution. In this sense we mean norms and rules, not organisations, although an organisation might form to devise and implement these rules. These institutions themselves have a series of overarching requirements (Ostrom 1990; National Research Council 2002; Dietz et al. 2003) including:

- Institutional variety – governance should employ mixtures of locally relevant institutional types.
- Design principles – which describe general principles that can be used to develop effective local institutions, rather than attempting to define universally relevant institutional rules; and
- Polycentric governance - Nested allocation of authority is required to allow for adaptive governance at multiple levels.

4 Insights from Common Pool Problem Management

In this section we review these key insights from common good management to evaluate transferrable lessons for community energy provision that might contribute to the development of more supportive governance arrangements.

4.1 Institutional variety: There are no panaceas

Ostrom and colleagues argue that "*Providing and producing public goods and common-pool resources at local, regional, national and international levels require different institutions than open, competitive markets or highly centralized governmental institutions"* (Ostrom 2008). A key insight from the literature on governance of natural resources is that there is no single blueprint of a governance system for common pool problem management because context is so important (Ostrom et al. 2007). Rather, a mixture of institutional types should be used (e.g., hierarchies, markets, and community self- governance) that employ a variety of decision rules to change incentives, increase information, monitor use, and induce compliance (Dietz et al. 2003). Furthermore, the institutions within these types should be locally-relevant to respond to the diversity of local motivations and capabilities.

The way that privatisation and liberalisation have happened in the energy sector puts community energy at a disadvantage because it assumes all providers are the same and that only one type of good is created. In this way it applies a market-led panacea, which has also been described as a pro-market paradigm (Kern et al 2014). The sole reliance on market-based governance has reinforced the dominance of incumbent operators, excluded community energy providers and as a result has undermined the ability of actors surrounding the energy system to address issues like climate change and fuel poverty.

No single form of ownership, be it private, government or community, uniformly succeeds in effective management of common goods (Dietz et al. 2003). The complexity of socio-technical systems, like energy, means that management from one central authority or point is too difficult (Künneke & Finger 2009). Therefore, multiple forms of authority are needed to deal with this complexity. We do not suggest that all energy provision should or could be self-governed; it is likely that there will always be a place for private and state actors in energy provision and self-governance will need to operate as part of a more plural, integrated system of governance. However, the current system of energy governance needs to change to become more flexible, allowing different actors to co-exist in the energy provision system and to encourage the provision of multiple outcomes.

4.2 Design principles, not standardisation

Motivated by the need for institutional diversity, Ostrom developed design principles for institutions for effective self-governance of common pool resources (Ostrom 1990). These include principles which cover:

- **Providing information** – to support monitoring of the value and good created. This is a major challenge for institutions because local and easily captured value (such as financial value) must be balanced against diffuse and hard to capture values (such as community development).
- **Dealing with conflict** – to deal with differences in power and values.

- **Inducing rule compliance** – so people who comply don't suffer from people not complying.
- **Adapting to change** – because fixed rules are likely to fail because they place too much confidence in the current state of knowledge.
- **Participation** – particularly by people that might benefit but who are outside the system. Provides improved information and the trust in it that is essential for information to be used effectively, builds social capital, and can allow for change and deal with inevitable conflicts well enough to produce consensus on governance rules (Dietz et al. 2003)

The principles were updated by Cox et al (2010) to reflect insights from 20 years of application and are strongly supported by empirical evidence. These principles avoid standardisation and encourage development of locally relevant rules to appropriate and distribute value including monitoring rule compliance and sanctioning non-compliance.

The rejection of standardisation in favour of principles guiding the design of locally relevant institutions strongly supports the findings of Hargreaves et al (2013) that context and resources available to community energy project vary so much that best practice guidance and standardisation are of limited value. To date the design principles have not been applied to energy provision and, therefore, require an analysis of relevance. For example; the clearly defined boundary of resources is crucial to natural resource management, where a finite stock has to be preserved. In contrast, community energy provision is more concerned with maximising value to the community and ensuring its fair distribution, so the importance of the boundary is more difficult to establish. An initial analysis of the relevance of the design principles to self-governance of energy provision is presented in Table 2. This analysis presents a first attempt to articulate some principles for self-governance of energy provision, based on evidence gathered in previous research and a limited review of literature. We recognise that some principles are more transferrable than others and indicate where this is the case below.

Table 2: Relevance of Ostrom's design principles to community energy provision

Design principle	Relevance to community energy provision	Examples
1A. *User Boundaries*: Clear and locally understood boundaries between legitimate users and nonusers are present.	Control of access to outcomes of community energy provision is an essential precursor of efficient system management and fair distribution of costs and benefits. Furthermore, benefitting without contributing to the cost of provision, either through user charges or contribution to construction costs, increases cost to legitimate users.	The reduction in network congestion created by off-grid energy provision or demand management can significantly reduce network reinforcement costs but distribution companies do not compensate such projects and there is little evidence to suggest time of use tariffs in isolation incentivise demand management.
1B. *Resource Boundaries*: Clear boundaries that separate a specific common-pool resource from a larger social-ecological system are present.	In natural resource systems the resource is a physical input, however, for energy, the resource is more like a process or activity which results in an outcome. Limits on the process can result in under-provisioning of a good. It can be difficult to define who is involved in the process and therefore attribution of value is even more complex than in natural systems and boundaries more fuzzy.	Some outcomes like community development and local economic growth, are affected by local authority spatial planning and national government investment as well as by community energy provision, so it is hard to define exactly which process or actors led to the production of the good.
2A. *Congruence with Local Conditions*: Appropriation and provision rules are congruent with local social and environmental conditions.	It is important that the scope of energy provision (focus on generation, supply or demand management?) the means of provision (type of technology) and the way it is provided (what is charged for and how?) reflect the needs of local users and the capabilities of communities and individuals engaged in energy provision.	The charging system for heat at a social housing development was a fixed monthly cost, because the majority of users had low and fixed levels of income and needed certainty about monthly costs.
2B. *Appropriation and Provision*: Appropriation rules are congruent with provision rules; the distribution of costs is proportional to the distribution of benefits.	Payment mechanisms are needed that capture the benefits of non-monetary value and compensate operators appropriately for delivery of these benefits. This might be a challenge when benefits accrue to those outside the defined user boundaries. In this case, some form of government subsidy might be required to support schemes contributing to national or long-term goals.	Many benefits, such as such as reduction of global emission levels, contribute to national government targets.

Design principle	Relevance to community energy provision	Examples
3. *Collective Choice Arrangements*: Most individuals affected by a resource regime are authorized to participate in making and modifying rules.	Engaging end-users in determining appropriate institutional arrangements is important to ensure that value delivered by the infrastructure scheme remains relevant to the end users. Participation of end-users has also been shown to increase acceptance and support for infrastructure project (Walker & Devine-Wright 2008).	One way this could manifest itself is through increasing participation in determination of project objectives and in tariff setting (to include payment for social value).
4A. *Monitoring Users*: Individuals who are accountable to or are the users monitor the appropriation and provision levels of the users.	Mechanisms may be required to encourage better matching of demand (appropriation) and supply (provision). This might include incentives for demand reduction at certain times (such as time of use tariffs) or contractual agreements to manage peak demand (similar to those currently used to curtail load in industry) (Ofgem 2010).	An example of this is energy provision on the Isle of Eigg. All users are subject to a 5kW cap per day and are provided with smart meters to monitor usage (Yadoo et al. 2011). Further voluntary measures are used to encourage users to reduce their demand when generation from renewable resources are running low, including a 'traffic light' system indicating when generation is low.
4B. *Monitoring the Resource*: Individuals who are accountable to or are the users monitor the condition of the resource.	Mechanisms are required to determine whether the scheme is delivering on the locally-relevant objectives, including financial, environmental and social objectives.	Many projects claim to have environmental and social motivations for engaging in energy provision but do not monitor whether these aspirations are delivered, which can result in under-provision.
5. *Graduated Sanctions*: Sanctions for rule violations start very low but become stronger if a user repeatedly violates a rule.	Sanctions need to be in place in the event that either the supplier or user breaks agreements about provision or appropriation. These need to be more comprehensive and specific than current supplier agreement which simply list the conditions for payment, metering, data management, supplier transfer and the conditions under which energy may be cut off (Ofgem 2014).	The energy security of the Isle of Eigg is dependent on matching generation and demand locally. A combination of forms of sanction is used to enforce mandatory caps and voluntary measures. Service performance contracts (using e.g. thermal comfort) as the basis for agreements and sanctions, incentivising resource efficiency.

Design principle	Relevance to community energy provision	Examples
6. *Conflict Resolution Mechanisms*: Rapid, low cost, local arenas exist for resolving conflicts among users or with officials.	Procedures are required to hold providers to account but which are specific to the institutions developed. This could increase the burden on national regulators to monitor conflict resolution. However, it is possible that the creation of locally relevant procedures could prevent complaints escalating to the stage at which intervention is required.	In the UK a free Ombudsman Service is available to help settle customer complaints in a fair and unbiased way. This is not currently available to community energy providers, but could be.
7. *Minimal Recognition of Rights*: The rights of local users to make their own rules are recognized by the government.	This means that the goals and execution of regulation, and in particular economic regulation, must change to allow local definition and management of value along with local arrangements for customer protection.	Regulators in the United States recognise that municipalities with different motivations to private companies, require different regulatory instruments.
8. *Nested Enterprises*: When a common-pool resource is closely connected to a larger social-ecological system, governance activities are organized in multiple nested layers.	The connection between governance of local system and rules for governance of wider infrastructure systems needs to be recognised and articulated. This is also true for the connection between local infrastructure and national infrastructure systems.	It is not always possible to use all energy produced locally, therefore it is usually necessary to connect to the distribution networks and energy markets. Regulatory processes which govern these national systems should not penalise smaller scale actors nor overlook the additional outcomes they create.

4.3 Polycentric governance and the role of municipalities

Polycentric governance connotes multiple centres of decision making/governing authorities that are independent and make rules within their specific domain, but which interact productively. In successful polycentric governance actors at different scales *"take each other into account in competitive relationships, enter into various contractual or cooperative undertakings or have recourse to central mechanisms to resolve conflicts…"* (Ostrom et al. 1961 p831). As such, governance operates more effective and as a system and include mechanisms for mutual monitoring, learning and adaptation of better strategies over time (Ostrom 2010b).

In order to develop institutions appropriate to the creation and distribution of locally relevant value, community energy providers must be supported and enabled by the national system and by local government, which can authorise local control, help it, hinder it or over-ride it (Dietz et al. 2003). Furthermore, communities do not set all the rules that affect energy provision, for example they may rely on electricity distribution systems which are regulated by national government and must be a licenced supplier to sell energy directly. Therefore, self-governance cannot happen in isolation of governance at other scales (Ostrom 2012) and a more polycentric approach to governance is required.

In this article, we have argued that national level governance is hindering and overriding institutional diversity of community energy provision, because it is so locked-in to the pro-market paradigm (Mitchell & Woodman 2010; Mitchell 2010; Kern & Mitchell 2010). It is clear that national governance needs to change to enable local rule setting and access to system components, such as electricity network, which are outside the control of community providers. A more plural approach to governance is needed to overcome the under-provision of social and environmental outcomes from energy provision.

There is emerging awareness of the important role of local government in supporting community energy provision and facilitating development of appropriate institutions (Bale et al. 2012; Core Cities 2013; Platt et al. 2014). Intermediary organisations, including those supported by municipalities, are crucial to building capacity in community energy provision but, in the face of severe human and financial resource constraints, this role tends to be limited to diffusing generic lessons about context-specific projects (Hargreaves et al. 2013). This kind of support is limited in its effectiveness because of the challenge of defining best practice when the motivations, capabilities and approaches to community energy provisions vary so dramatically between projects. This could be addressed to some extent by structuring support around the design principles, rather than around best practice, to recognise and enable institutional diversity.

Municipalities can also provide more direct support to community energy providers by acting as an intermediary between local rules and national rules. A recent example of this is the attempt by the Greater London Authority (GLA) to set up a supply licence and to directly supply local customers using energy generated locally, providing a more cost effective route to market, without having to comply with extremely complex licencing requirements (Greater London Authority 2013). Other authorities are trying to engage in smart grid infrastructure to enable more local generation and demand management (Hall & Foxon 2014).

As outlined above community energy provision has the potential to contribute to municipality goals, such as climate mitigation, economic development and fuel poverty alleviation. Communities predominantly, and understandably, focus on the specific community goals and could miss the potential to contribute to bigger-picture municipal and national challenges (Berkhout et al. 2003). It is important that municipalities have an opportunity to connect community energy provision with municipal and national goals to maximise the contribution of community provision (Leach et al. 2012).

These ideas represent aspects of the theory of poly-centric governance which "facilitate achieving benefits at multiple scales as well as experimentation and learning from experience with diverse policies" (Ostrom 2010b). Our research highlights the key role of municipalities in facilitating polycentric governance at the intermediate level between communities and national government. Nevertheless, further work is needed to articulate the specific implications of polycentric governance for energy provision.

5 Conclusions

Urgent and radical transformation of our energy system is required to address the pressing environmental and social challenges of climate change and fuel poverty. Community energy provision could play an important role in this transformation because it is more likely to prioritise social and environmental outcomes over financial goals. Despite this, the current focus of regulation on financial value and market mechanisms creates a series of seemingly impenetrable barriers to a significant contribution from community energy actors. In this article we argue that the majority of the goods resulting from community energy provision are more like common goods than private goods. The challenge of attributing the outcomes of community energy provision to individual actors, the challenge of excluding end-users from goods that are fundamental to their development and the need for collective action contribute to this designation as goods which are more common than private. As a result community energy groups struggle to proliferate, or even survive in a system dominated by a pro-market paradigm and social and environmental goods are under-provisioned.

There is an extensive body of research demonstrating the limits to state- and market-governance of common goods in isolation. The diversity of goods produced by different projects, at different scales; the dynamic nature of goods, which change as the priorities of groups changes and; the number of potential producers all conspire to reduce the effectiveness of market-based instruments in isolation. This article argues that a more plural approach to governance, which includes and enables self-governance is necessary and can result in more effective production and more equitable distribution of social and environmental outcomes.

Research on the management of natural common goods (such as fish and forests) provides a series of insights that could inform more effective self-governance and reduce the barriers to community energy provision. This includes the need for institutional diversity across market, state and community governance, and for diversity within community governance. This indicates the need for institutional design principles, rather than best practice. A series of principles for the monitoring of goods, development and enforcement of rules has been widely tested in natural resource governance and has relevance to governance of energy provision. In this article the relevance of these

principles are discussed in the context of community energy provision. In order to develop more robust recommendations these initial principles would benefit from more detailed analysis and empirical evidence. Once updated to reflect the specific challenges of energy provision, the design principles could be used to adapt local and national governance to be more supportive of the development of locally-relevant institutions. We don't suggest that all energy provision should be self-governed, but that national and local governance should enable community energy provision to operate *in parallel* with private provision.

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7 References

BIS, 2011. *Principles for Economic Regulation*.

Bale, C.S.E. et al., 2012. Strategic energy planning within local authorities in the UK: A study of the city of Leeds. *Energy Policy*, 48, pp.242-251.

Baur, I., Liechti, K. & Binder, C.R., 2014. Why do individuals behave differently in commons dilemmas? The case of alpine farmers using common property pastures in. *International Journal of the Commons*, 8(2), pp.657-685.

Bayliss, K., Fine, B. & Robertson, M., 2013. From Financialisation to Consumption: The systems of provision approach applied to housing and water.

Berkhout, F., Leach, M. & Scoones, I., 2003. *Negotiating environmental change: new perspectives from social science*, Cheltenham: Elgar.

Bolton, R., 2011. *Socio-Technical Transitions and Infrastructure Networks: the cases of electricity and heat distribution in the UK*. PhD Thesis. University of Leeds.

Climate and Energy Fund, 2013. *Climate and Energy Model Regions: An Austrian blueprint for a successful bottom-up approach in the field of climate change and energy*.

Community Energy Grid Connections Working Group, 2014. *Community Energy Grid Connections Report to Secretary of State*.

Competition & Markets Authority, 2015. *Energy market investigation. Updated issues statement*.

Core Cities, 2013. *Core Cities Growth Prospectus Policies Step 6 : Power Up the Cities*.

Costanza, R., 1987. Social Traps and Environmental Policy: Why do problems persist when there are technical solutions available? *BioScience*, 37(6), pp.407-412.

DECC, 2014. *Community Energy Strategy: Full Report*.

Dietz, T., Ostrom, E. & Stern, P.C., 2003. The Struggle to Govern the Commons. *Science*, 302, pp.1907-1912.

Dolsak, N., 2000. *Marketable permits: Managing local, regional and global commons*. PhD Thesis. Indiana University.

Foxon, T.J., 2011. A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecological Economics*, 70(12), pp.2258-2267.

GEA, 2012. *Global Energy Assessment - Towards a Sustainable Future*, Cambridge: Cambridge University Press and the International Institute for Applied Systems Analysis.

Goldthau, A., 2014. Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research & Social Science*, 1, pp.134-140.

Greater London Authority, 2013. Licence Lite. *london.gov.uk*. Available at: http://www.london.gov.uk/priorities/environment/tackling-climate-change/energy-supply/licence-lite [Accessed December 31, 2013].

Hall, 1993. Policy Paradigms, Social Learning, and the State: The Case of Economic Policymaking in Britain. *Comparative Politics*, 25(3), pp.275-296.

Hall, J.W. et al., 2012. *A Fast Track Analysis of strategies for infrastructure provision in Great Britain: Technical report*, Oxford.

Hall, S. & Foxon, T.J., 2014. Values in the Smart Grid: The co-evolving political economy of smart distribution. *Energy Policy*, 74, pp.600-609.

Hall, S. & Roelich, K., 2015. *Local Electricity Supply: Opportunities, archetypes and outcomes*.

Hardin, G., 1968. The tragedy of the commons. *Science*, 162, pp.1243-1248.

Hargreaves, T. et al., 2013. Grassroots innovations in community energy: The role of intermediaries in niche development. *Global Environmental Change*, 23(5), pp.868-880.

Hawkey, D., Tingey, M. & Webb, J., 2014. *Local Engagement in Energy System Development: Present Practice, Future Need and Pathways to 2050*.

Hira, A., Huxtable, D. & Leger, A., 2005. Deregulation and Participation : An International Survey of Participation in Electricity Regulation. *Governance An International Journal of Policy and Administration*, 18(1), pp.53-88.

Kern, F. & Mitchell, C., 2010. Policy Paradigms as part of the landscape: How do policy paradigms influence attempts to govern transitions? In *14th IRSPM Conference, Berne, Switzerland, 7-9th April 2010*. pp. 1-18.

Kern, F., Kuzemko, C. & Mitchell, C., 2014. Measuring and explaining policy paradigm change: The case of UK energy policy. *Policy & Politics*, 42(4), pp.513-530.

Knoeri, C., Steinberger, J.K. & Roelich, K., 2015. End-user centred infrastructure operation: Towards integrated infrastructure service delivery. *Journal of Cleaner Production*, pp.1-20.

Kunze, C. & Becker, S., 2014. *Energy democracy in Europe. A survey and outlook*, Brussels.

Künneke, R. & Finger, M., 2009. The governance of infrastructures as common pool resources. In *Workshop on the Workshop (WOW4)*. Bloomington, pp. 1-24.

Leach, M. et al., 2012. Transforming Innovation for Sustainability. *Ecology and Society*, 17(2).

Little, R.G., 2005. Tending the infrastructure commons: ensuring the sustainability of our vital public systems. *Structure and Infrastructure Engineering*, 1(4), pp.263 - 270.

Mitchell, C., 2014. Change and Inertia in the UK Energy System - getting our institutions and governance right. EPG working paper 1403.

Mitchell, C., 2010. *The political economy of sustainable energy*, Palgrave Macmillan.

Mitchell, C. & Woodman, B., 2010. Towards trust in regulation - moving to a public value regulation. *Energy Policy*, 38, pp.2644-2651.

Murphy, J., 2010. *At the edge: community ownership, climate change and energy in Scotland*.

National Research Council, 2002. *The Drama of the Commons* E. Ostrom et al., eds., National Academy Press.

Ofgem, 2010. *Demand Side Response: A discussion paper*.

Ofgem, 2014. *Standard conditions of electricity supply licence*.

Ostrom, E., 2012. Polycentric systems: Multilevel governance involving a diversity of organisations. In E. Brousseau et al., eds. *Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms*. Oxford Scholarship Online, pp. 1-20.

Ostrom, E., 2010a. Beyond Markets and States: Polycentric Governance of Complex Economic Systems. *American Economic Review*, 100, pp.1-33.

Ostrom, E., 2010b. Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, 20(4), pp.550-557.

Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. *Science*, 325, pp.419-422.

Ostrom, E., 2008. Polycentric systems as one approach for solving collective- action problems. , pp.1-22. Available at SSRN: http://ssrn.com/abstract=1304697

Ostrom, E., 1990. *Governing the commons: the evolution of institutions for collective action*, Cambridge University Press.

Ostrom, E., Janssen, M.A. & Anderies, J.M., 2007. Going beyond panaceas. *Proceedings of the National Academy of Sciences*, 104(39), pp.15176-15178.

Ostrom, V. et al., 1961. The Organisation of Government in Metropolitan Areas: A Theoretical Inquiry. *American Political Science Review*, 55(4), pp.831-842.

Patterson, W., 2013. Beyond The Fire Age. , pp.1-13. Available at http://www.waltpatterson.org/beyondfire.pdf

Patterson, W., 2008. Managing Energy: Rethinking the Fundamentals. Managing Energy Wrong. Energy, Environment and Resource Governance Working Paper One

Platt, R. et al., 2014. *City Energy: A new powerhouse for Britain*, IPPR.

RTP Engine Room, 2015. *Distributing Power. A transition to a civic energy future*.

ResPublica, 2014. *Creating Local Energy Economies: Lessons from Germany*.

Roelich, K., 2014. *Physical and institutional challenges of infrastructure transitions: constraints and potential solutions*. PhD Thesis. University of Leeds.

Roelich, K. et al., 2015. Towards resource-efficient and service-oriented integrated infrastructure operation. *Technological Forecasting & Social Change*, 92, pp.40-52.

Roelich, K. et al., 2013. The role of governance in accelerating transition towards more integrated, service-oriented infrastructure operation. In *Theorising Governance Change for a Sustainable Economy*. London, pp. 1-18.

van der Schoor, T. & Scholtens, B., 2015. Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews*, 43, pp.666-675.

Seyfang, G. & Smith, 2007. Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*, 16(4), pp.584-603.

Seyfang, G., Jin, J. & Smith, A., 2013. A thousand flowers blooming? An examination of community energy in the UK. *Energy Policy*, 61, pp.977-989.

Späth, P. & Rohracher, H., 2010. “Energy regions”: The transformative power of regional discourses on socio-technical futures. *Research Policy*, 39, pp.449-458.

Steinberger, J.K., van Niel, J. & Bourg, D., 2009. Profiting from negawatts: Reducing absolute consumption and emissions through a performance-based energy economy. *Energy Policy*, 37(1), pp.361-370.

United Nations General Assembly, 2011. *Sustainable Energy for All - Note by the Secretary General*.

Verbong, G.P.J. & Geels, F.W., 2010. Exploring sustainability transitions in the electricity sector with socio-technical pathways. *Technological Forecasting and Social Change*, 77(8), pp.1214-1221.

Walker & Devine-Wright, P., 2008. Community renewable energy: What should it mean? *Energy Policy*, 36, pp.497-500.

Walker et al., 2010. Trust and community: Exploring the meanings, contexts and dynamics of community renewable energy. *Energy Policy*, 38(6), pp.2655-2663.

Wilkinson, P., Smith, K.R. & Haines, A., 2007. Energy and Health 1: A global perspective on energy: health effects and injustices. *The Lancet*, 370, pp.965-78.

Yadoo, A., Gormally, A. & Cruickshank, H., 2011. Low-carbon off-grid electrification for rural areas in the United Kingdom: Lessons from the developing world. *Energy Policy*, 39(10), pp.6400-6407.