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Wolsink, M.

Publication date
2013

Document Version
Author accepted manuscript

Published in
Energy justice in a changing climate: social equity and low carbon energy

Citation for published version (APA):
Wolsink, M. (2013). Fair distribution of power-generating capacity: justice, microgrids and utilizing the common pool of renewable energy. In K. Bickerstaff, G. Walker, & H. Bulkeley (Eds.), *Energy justice in a changing climate: social equity and low carbon energy* (pp. 116-138). (Just sustainabilities: policy, planning and practice; No. 2). Zed Books.

7 │Fair Distribution of Power Generating Capacity: Justice in Microgrids utilizing the Common Pool of Renewable Energy.

Maarten Wolsink

In : K Bickerstaff, G Walker, H Bulkeley. Energy in a Changing Climate. Social equity and low-carbon energy. Zed Books, London, New York, 2013.

Introduction

Studies of the issues concerning implementation of renewable energy have shown that institutional factors have proved to be the main determinants of renewables' deployment. The institutional constraints will likely affect the next stage of deployment of renewables even more. This phase concerns the integration of renewables into the energy supply system and the enhancement of these sources by the introduction of so-called 'smart grids' to optimize the exploitation of natural resources. These numerous microgrids mark a revolutionary turn our system of energy generation that requires many fundamental changes in the social construction of power supply. In this chapter we will discuss the social construction of such smart electricity grids.

Smart grids facilitate 'distributed generation' (DG), geographically dispersed power generation with renewable sources. Citizens/consumers and other end-users increasingly are becoming co-producers of electricity, and the option to include ‘distributed storage’ (electric vehicles) in the system also promises to enhance this role and creates options to increase of renewables deployment. This way consumers become co-producers , who may optimize the contribution of distributed generation by feeding their renewable energy in a cooperative micro-grid with mutual delivery. This requires a high level of self-governance and general legislation that allows micro-grids and self-governance. However, although such systems fundamentally concern involvement of a community right from the start, and the effective adaptive governance of such systems may be good for renewable energy, self-governance in the ‘common pool’ brings institutional questions of justice - distributive equity and fairness of process - to the fore. These equity and fairness dimensions of new microgrids and self-governance arrangements are explored in combination with the factors that further distributed energy generation.

Starting point: institutions

Implementation of renewable energy schemes has been largely determined by social acceptance issues (Wüstenhagen et al., 2007) with the result that the transformation of the energy supply system into a low-carbon one, strongly based on renewables, is impeded by institutional lock-ins (Unruh, 2002). Institutional factors have proved to be the main determinants of renewables' deployment (Jacobsson and Johnson, 2000). The development of smart grids also suffers from a focus on mere ‘technology’, continuing the neglect of social determinants that create these lock-ins. This chapter investigates the institutional conditions for further deployment of distributed renewable energy sources in microgrid communities and will raise questions about potential injustice and fairness that may emerge as a result of the development of smart grids. It is argued that the creation of micro-grids with substantial amounts of distributed generation − referred to here as ‘DisGenMiGrids’− is a problem of collective action which calls for an institutional theory approach like Common Pool Resources management?(CPR; Dietz et al, 2003). Common Pool Resources “include natural and human-constructed resources in which exclusion of beneficiaries through physical and institutional means is especially costly” (Ostrom et al. 1999: 278). In the case of harvesting renewable energy we are dealing with human-constructed systems. The establishment and the maintenance of such systems in which resources are used and produced requires good governance, which primarily consists of regimes that support and foster co-operation between users and between different levels of regulation. Use, maintenance, monitoring and rules for extraction and contribution to co-production must be institutionalized in a way that these systems are effectively governed, so the use of the resources can be sustained in the long term. For most common-pool resources the difficulty of exclusion is also paramount, and the second component of Common Pools therefore is called ‘subtractability’, meaning that the “exploitation by one user reduces resource availability for others” (Ostrom et al. 1999: 278).

DisGenMiGrids are socio-technical systems that also aim to optimize the exploitation of natural resources. And this must be achieved in a condition of substractability as well, because the space that can be applied for establishing renewable energy generation units and their required infrastructure is limited. Hence, CPR adaptive governance comes to the fore as an obvious concept.

Citizens/consumers and other end-users are increasingly becoming co-producers of electricity, , and the option to include ‘distributed storage’ (electric vehicles) in the system promises to enhance this role because the storage capacity improves the options to balancing local supply and demand and this capacity is under the control of the consumers. The balance between local supply and demand can also be improved when co-producers feed their renewable energy in a cooperative micro-grid with mutual delivery. However, this requires self-governance and regulation that allows micro-grids.

The question of how these new systems are institutionally embedded and socially constructed is relevant for two reasons. First, the prime reason, institutional factors like these are going to be important in the shift towards a low carbon power supply system. Our ability to establish microgrids that locally integrate several renewable sources with each other and with demand is determined by the potential use of space close to end-users and therefore the role of these end-users in these systems becomes very important. Besides this essential space, the secondary relevant ‘institutional’ issue relates to whether establishing microgrids based on high involvement of end-users creating power supply meets certain standards of equity and fairness.

The significance of smart microgrids for distributed generation

Development of low-carbon energies ranks high on policy agendas. With atmospheric CO_2-eq still increasing rapidly, there is an urgent need to switch to low carbon energy sources. The utilization of renewables (sun, wind, geothermal, biomass, marine sources etc.), in particular for generating electricity, has become a pressing issue, and most developed countries have put in place policies to promote renewable energy. At the start of the drafting of such policies, general social acceptance issues were not recognized as important and consequently were largely neglected (Wüstenhagen et al., 2007). Country comparisons have demonstrated that institutional factors are due to this neglect, and as a result the use of renewable energy has been developing rather slowly in most countries (Toke et al., 2008; Fischlein et al., 2010).

Some countries started research and development programs in the 1970-ies, to achieve diversification –as a response to the 1974 oil crisis – and to reduce air pollution associated with conventional power generation. The 2^{nd} phase of deployment started with the adoption of deployment policies for wind in a small number of countries, e.g. Denmark (in the late 1980-ies) and Germany (from 1991 onwards). Other countries followed with deployment policies, but only in cases with sufficient socio-political acceptance of changes in crucial institutional conditions, this 2nd phase of deployment has become a success. Most developed countries have renewable energy supporting policies now, with currently climate change as the most prominent argument, but huge differences in effectiveness still exist. Deployment of renewable energy is innovation, and breaking the ‘lock-in’s that prevent such innovation (Unruh 2002; Jacobsson and Johnson 2000) requires the understanding of and the will to change crucial 'rules of the game in a society'. This expression is the shortest definition of institutions (North 1990), which are mutually reinforcing patterns of behaviour and thinking, as reflected in formal and informal rules, norms and procedures. These patterns of thinking and behaviour can be recognized within all realms of society, including governance systems. Substantial deployment of renewable energy requires the socio-political and market acceptance of institutional changes like crucial reforms of energy market conditions, empowerment of new actors (which implies disempowerment of incumbents in energy supply) and spatial planning systems that effectively support collaborative planning in renewable energy projects.

In the 2nd phase, the start of deployment of renewable energy like wind and solar power, the new power generating units could be fit-in the existing power supply system rather easy. Institutional constraints, like the dominance of incumbent energy companies and spatial planning policies applying hierarchical methods that create mistrust in collaborative project planning, will likely affect the next stage of deployment of renewables even more, as fitting-in the new sources will increasingly be hard within the existing infrastructure and the existing organization of power supply. The next crucial phase in the deployment of renewable energy concerns the integration of renewables in the energy supply system and the enhancement of these sources by introduction of so-called 'smart grids'. The way existing supply and demand of electrical power are shaped is full of patterns of behaviour of all kinds of actors. These behavioural patterns are based on formal and informal rules that have emerged over time. These institutions have not emerged to further the integration of new energy sources, as their origin lies in the past when there were different conditions, and they were serving different ends. The most essential changes in ways of thinking concern modes of thought that are historically rooted in the competent organisations. This phenomenon is called 'path dependency' and reflects the historical roots of existing institutions (Thelen 1999).

Currently, smart grids are a hot topic, but it is still mainly a buzz-word. Though rapidly gaining attention in the literature and increasingly popular, the ’smart grid’ still lacks a precise definition. In fact, there is no functioning smart grid in existence today. Despite these ambiguities, there is substantial and accelerated technology driven progress towards developing smart grids (Hammons, 2008; Marris, 2008). Technically, smart grids are defined as two networks: one for electricity and a parallel information network for data generated by smart metering devices that monitor, analyse and regulate. The focus is on the power grid, but in practice integration with supply and demand of other energies like heat is also at stake (Lund et al., 2012).

Traditional power plants are large centralized units. Today’s trend is towards much smaller, geographically widely dispersed power generation units. These numerous units situated close to energy consumers are called Distributed Generation (DG; Ackerman et al., 2001). Together with improvements in smart grids that serve efficiency and reliability, a system with a large amount of DG is considered an environmentally friendly alternative to the traditional power supply system (Hammons, 2008). Because DG is made up of a large number of geographically dispersed generation units —that preferably tap renewable energy sources— it is strongly associated with a more environmentally sound type of electricity consumption. Attuning those multiple generation systems situated close to energy consumers to each other and to the variable loads of end-users increasingly requires a ’smart grid’. The most enlightening and comprehensive definition of a smart grid is that it is a ’network of integrated microgrids that monitors and heals itself’ (Marris, 2008). These numerous microgrids (figure 1) mark a revolutionary turn that requires many fundamental changes in the social construction of the socio-technical system (see next paragraph) of the power supply. As outlined by Wolsink (2012a) this is why DG in smart microgrids goes way beyond development of and application of new technologies. A myriad of new assets, but also of new social arrangements must be accepted by numerous social actors, so smart grids must be studied through a social science approach as well.

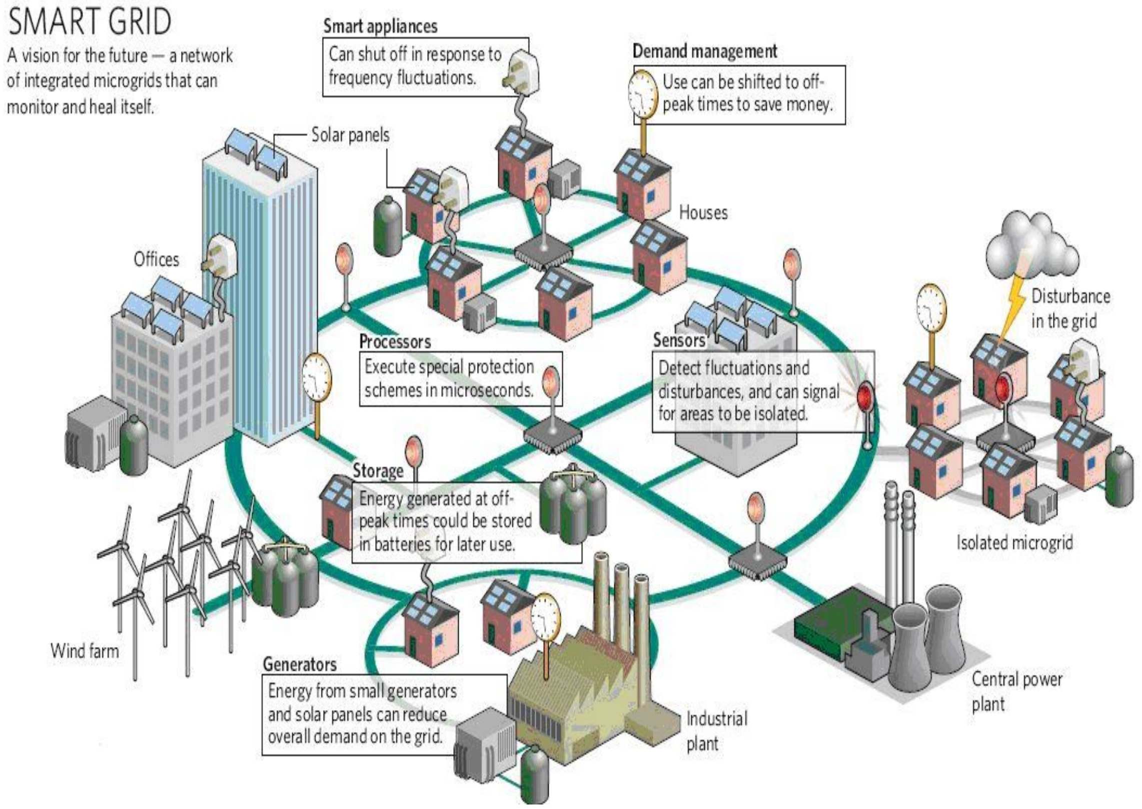

Figure 1. "A network of integrated microgrids that can monitor and heal itself" (Marris 2008 p.570).

Beyond all the technology development that is still required to establish smart microgrids, important questions remain about the social dimensions and characteristics of DisGenMiGrids. What are the social factors that create opportunities for DisGenMiGrids; and how can institutional constraints that impede the creation of such microgrids be addressed? Central to Marris' definition of smartgrids is the recognition of fully changed principles for organizing energy generation and distribution. There will no longer be one centralized public power grid, but many different 'microgrids', in which energy flows from different sources, regulated and fine-tuned to local demand within the same microgrid. With the on-going splintering of central power grids, there is already a move towards 'Distributed Generation' but there are also several developments towards local adaptive demand and 'distributed storage' capacity. For example, an important new development relates to the social choices made about options for reloading plug-in electric vehicles within DisGenMiGrids (e.g., at home or the work place). This can become a significant factor in advancing the deployment of renewable energy (Lund and Kempton, 2008; Andersen et al., 2009), but this development is determined by the behaviour of many actors. The social choices made by consumers and by other actors, particularly those in the transport sector, with regard to the development and use of electric cars (see “Future developments”), will have significant consequences for renewables in microgrids.

Smart grid innovation

The overall question of smart grid innovation is a fundamental one about the social acceptability of all social choices that must be made for the social construction of DisGenMiGrids. As elaborated in the following sections, establishing microgrids and implementation of renewables is a problem of collective action. Doing so requires forms of self-governance, and institutional conditions that allow such adaptive self-governance (Ostrom, 1999; Wolsink, 2012a).

Many persistent misconceptions exist on the importance and complexity of social acceptance of renewable energy innovation. For example, the geographical space required for all infrastructure needed to achieve a shift towards a low-carbon energy system, with limited environmental impact, is highly underestimated. In fact, in policy realms there is little awareness of key aspects of renewable power generation. For example, centralized, large-scale developments (e.g., offshore wind, desert solar power etc.) can only provide a limited amount of all the renewable energy needed for satisfying current energy demand – and in a relatively unreliable and inefficient fashion. All space, particularly at close distance to the energy use, should also be utilized if we want to cover all of our huge energy demand through renewable sources (MacKay, 2009). To increase the acceptability of using that space, a good match between energy systems and communities is crucial (Walker and Devine-Wright, 2008), and the integration of renewables in DisGenMiGrids is thus essential for further deployment.

Beyond the technological characterization of buildings, power generating infrastructure, sensors, processors and storage, all potential participants in microgrids shown in Fig.1 are social actors. Their participation in creating the microgrid and constructing and utilizing renewable energy generating facilities is an essential building block in the innovation process. However, the characteristics of participants, their behaviour and their preferences are not known. Their willingness to support innovation by participating in the new power supply system is questionable, as smart grids imply a drastic departure from the current, predominantly centralized power supply systems.

Innovation is, by definition, a change of ideas that is manifested in products, processes, or organizational units being successfully applied in practice. Innovation is not merely the introduction of new technology, but rather of a socio-technical system (STS) (Geels, 2004; Jacobsson and Bergek, 2004). DisGenMiGrids are socio-technical systems, characterized by the active management of both information and energy flows, and by the community in which members cooperate to construct the microgrid and to manage it. Such cooperating communities should replace the existing social characteristics of the energy supply system. This requires new 'patterns of social practices and thinking‘. This expression is the short definition of institutions (North, 1990 p.4). These patterns of practice and thinking are manifested in the organization of the energy sector as well as other related sectors. They can also be found in regulation, standardization, existing infrastructure, and in existing patterns of thinking (‘belief systems’, or ‘discourses’). Such belief systems concern all aspects of existing power supply systems, for example their (un-)reliability; beliefs about the new DG energy sources, for example their variability (or ‘intermittency’; Devine-Wright and Devine-Wright, 2006); and beliefs about the public interest which the system is supposed to serve, for example ‘reliable supply’, ‘sustainability’, and price.

Starting from the perspective of social acceptance, with the concept of institutions at its centre, the general question about the social construction of future power supply based n renewables can be divided into several specific questions. For example: what are the institutional conditions that determine the creation of DisGenMiGrids? Other questions concern which institutional conditions will enable optimal application of renewables in microgrid communities, and how spatial planning and decision-making about infrastructure may affect the creation of DisGenMiGrids. One of the main unrecognized and underestimated factors in the neglect of social acceptance of renewables innovation is the fact that almost all acceptances by all actors are conditional: for example conditions concerning the distribution of costs and benefits, the sites for building the infrastructure, the control over the installations, the consequences for tariffs, etc. Therefore an essential question for establishing DisGenMiGrids also concerns the geographical and institutional conditions various actors are willing to accept such changes - and do policies allow them:

– to install renewables' generating units;
– to cooperate in a DisGenMiGrid and mutually exchange energy, regulated by smart metering;
– to adapt their energy behaviour, shaping demand patterns that match the supply of renewables;
– to accept these new configurations and infrastructure of power supply;
– to accept the institutional arrangements that are required to create and maintain DisGenMiGrids.

Acceptance of institutional change for energy innovation

Public acceptance –aggregated individual preferences– is a very poor proxy for social acceptance (Wolsink, 2012b). Similarly, the construction of smart grids and the application of renewables is not simply a matter of individual choice. The major shift in the way the power supply is organized is determined by institutional change. The dominant approach in consumer choices, as seen in most Demand-Side-Management studies regarding energy consumption, may be characterized as the 'ABC- account of social change' (attitude, behaviour, choice). This rules out historic path dependencies and it does not reveal relevant social practices, and related infrastructures and institutions (Shove 2010). Similarly, the way policies try to address the social acceptance of renewables seems equally dependent on this limited vocabulary. This is the reason why the topic of acceptance is poorly understood among policymakers and developers alike. This is also why most problems with social acceptance of innovation in renewables are found in the first of three dimensions in social acceptance: socio-political acceptance (Fig.2).

Socio-political acceptance concerns the abilities of policy makers, governmental agencies and other key stakeholders alike, to craft policies and to create frameworks that help to establish conducive conditions for implementing innovations. However, in practice it is often more problematic, as the institutional changes needed for rapid deployment are resisted by key stakeholders and policymakers (bottom Fig.2).

Figure 2:Three dimensions of social acceptance of renewable energy innovations (Wüstenhagen et al. 2007; Wolsink, 2013, p.11).

Socio-political acceptance of the institutional changes is needed for creating supportive market conditions, and also for furthering collective action at the community level (Sovacool and Lakshmi Ratan, 2012). Market and community acceptance are both essential for the emergence of DisGenMiGrids. As is the case in the stagnant deployment of renewables (Sovacool, 2009; Breukers and Wolsink, 2007), socio-political acceptance could also turn out to be the main barrier for utilizing high potential acceptance in the other two dimensions. DisGenMiGrids run counter to today's highly centralized power grids. For example Fig.1 only shows a peripheral 'central' power plant. The existing organizations in power supply, with their highly centralized infrastructure and their centralized way of operating and thinking will institutionally impede socio-political acceptance. Regarding innovation in any sector, the close connection between the sector's incumbents and policymakers induces strong inertia and retards the innovation processes (Walker, 2000). According to Lund (2010) – for example, among many others– this phenomenon also applies to renewable energy. Based on 12 case studies he concludes that alternatives, representing radical technological change, have to come from outside organisations representing the existing technologies, where existing incumbents may even make efforts to eliminate alternatives from decision-making processes (Lund, 2010, p.4008).

The other two dimensions of social acceptance (community and market acceptance; Fig.2) concern the decisions about installation of power generating units, or about willingness to take part in investing in such installations. The introduction of DisGenMiGrids completely changes the picture of market acceptance relations between incumbents, new firms, consumers, and authorities (Fig.2, 2nd level) as investment decisions shift to communities. These decisions must be taken at the micro-level, provisionally by actors in the category of 'prime-movers' who are crucial for the deployment of renewable energy (Jacobsson and Johnsson, 2000). These actors, however, have to deal with often suffocating institutional frameworks. At this level the transaction costs of the required collective action are important. The problems with implementation of renewables have shown that high transaction costs are principally determined by institutional conditions and policies at the national level. In terms of justice, the procedures and legal conditions -for example in spatial planning, grid access, access to subsidies etc.- may create problems of lack of recognition, according to Schlosberg (2004; also see section "Justice as fairness" below) one of the three essential components of environmental justice. The important role of consumers for establishing renewables' capacity should be recognised in policy, as well as within the existing energy supply sector. Lack of such recognition may easily result in constraints to the abilities to exploit the local options for establishing renewables' capacity. For microgrids, a crucial issue is how the institutional frameworks can be changed in order to create optimal conditions for positive decisions -investments and siting - at the meso level of communities. The social costs not only concern transaction costs for individual investors, they also concern changes in the mutual position of consumers and the related distributions of costs and benefits. As consumers may also become producers, some become involved in production while others remain consumers only. How does this affect their social relations and equity?

The community and collective action perspective

The territorial acceptability of decisions on energy infrastructure is strongly determined by the connections between the energy system and the community in which it is sited. This acceptability may be particularly low in cases of 'exogenous and invasive projects that are disconnected from the socio-economic and environmental local context' (Bagliani et al., 2010). As DG is located close to end users, the literature on the deployment of renewables shows the importance of securing a good fit between the energy schemes and host communities (Walker and Devine-Wright, 2008). This can be achieved by means of collaborative ways of decision-making and by effective involvement and participation in the management and/or ownership of the new energy systems (Toke et al., 2008; Wolsink, 2012b). Projects initiated by community outsiders (e.g. energy companies) are much more likely to face resistance by the community. Solid commitment in implementation of renewable energies requires trust among the relevant actors, and the lack of recognition and the ignorance of how to establish and maintain such trust is the main reason why renewable energy policies have been ineffective in most countries. Community members must have strong conviction that the new energy system will serve their benefit as well as that the organization that is facilitating this process will act in their best interest. ’Trusting social relationships support and enable cooperation, communication and commitment such that projects can be developed and technologies installed in ways that are locally appropriate, consensual rather than divisive, and with collective benefits to the fore’ (Walker et al., 2010, p.2657). With this trust many people are willing to invest in renewables, even without immediately optimizing their personal financial gains. However, they do prefer to invest on their own terms and not being obstructed by regulatory conditions imposed by grid managers and power distributing companies, the likely preferred condition being ‘plug-and-play’ (Sauter and Watson, 2007; Wolsink, 2012a). This implies that property and ownership regimes for the various assets in DisGenMiGrids therefore become an important issue concerning trust and social acceptance.

Within the broader approach of the DisGenMiGrid as a social-technical system this question is not only about formal ownership, but about different kinds of property. For governance regimes within common pools systems, Schlager and Ostrom (1992) have developed four distinctive types of property rights: ‘owner’; ‘proprietor’ (unlike owner, without the option to alienate the good from others); ’claimant’- without the proprietors’ rights of exclusion; and ‘authorized user’ - without the claimant’s rights of management. These different types of property rights include all goods that determine the access to the resource. The important point here is that the access for one may be dependent upon the property rights of others, for example when buildings or trees are owned that can harm the free flow of resource (wind or solar radiation) to generating energy units for others. ‘Access’ can be defined as the right to benefit from things, or more broadly as the ability to derive benefits from things. Following this definition, access is about a bundle of powers rather than the narrower notion of property as a "bundle of rights." (Ribot and Peluso, 2003). Within newly emerging microgrids, who will hold these powers and how are they distributed within the community, and among different communities? This is a real issue of distributive justice as well as of fairness of process. These issues are formulated as questions, because there are not many answers yet.

Justice as fairness

The socio-technical system of renewable power generation within a smart microgrid requires high levels of involvement of energy end-users. However, the participation of those users in the new system will probably be unequal, as the participation might require investments that cannot be made by all. The obvious variable determining the options for investments is financial capital, but equally important may be the amount of space that users can offer for installing renewable’s capacity and ‘harvesting’ the energy to supply to the microgrid.

So neither the costs nor the benefits of participating in microgrid developments will be distributed equally, which immediately leads to questions of equity. The establishment of DisGenMiGrids is an environmental issue, and therefore it has consequences related to environmental justice. When we try to assess these justice issues related to smart microgrids and distributed generation, that is largely in the hands of all kinds of end-users, we start where almost all reflections on justice start. Rawls (1972) proposes two principles of justice “First: each person is to have an equal right to the most extensive basic liberty compatible with a similar liberty for others. Second: social and economic inequalities are to be arranged so that they are both (a) reasonably expected to be everyone’s advantage, and (b) attached to positions and offices open to all”. (Rawls, 1972, p.60). Together with the “principle of fairness” for individuals, this leads to priority rules for institutional as well as individual principles. According to Rawls (1972, p.108) these aspects of fairness imply “priority rules for assigning weights when principles conflict”. In the case of

DisGenMigrids, for example, this means that general justice needs rules that assign priority to either rights of individuals to generate their own power, and rights for consumers to get a reliable amount of electricity the need for living but who are not in a position to generate that power themselves.

"Justice as fairness" is the issue of how the basic structure is shaped in a scheme of institutions that creates a fair, efficient and productive system of social cooperation that can be maintained over time. Contrasting this with "the very different problem of how a bundle of commodities is to be distributed, or allocated, among various individuals whose particular needs, desires, and preferences are known to us, and who have not cooperated in any way to produce those commodities" …. "is the problem of allocative justice". (Rawls, 2001, p.50).

This allocative justice resembles fairness in the process of decision making as it is recognized as a crucial dimension in the concept of environmental justice. Within this framework, currently three dimensions are recognized. The original concept focused on distributive justice (Capek, 1993) but soon a broader conceptualization emerged (Young, 1990; Fraser, 2000). Two dimensions were added. The first is so-called 'procedural justice' with a focus on decision-making and participation (Schlosberg, 2004). Usually the focus is upon inequalities and injustices in the distribution of environmental quality, but in his conceptual elaboration of environmental justice Schlosberg joins Harvey (1996) with emphasizing that "the achievement of environmental justice will come only with confronting the fundamental underlying processes (and their associated power structures, social relations, institutional configurations, discourses, and belief systems) that generate social injustices (Schlosberg, 2004, p.534). Eventually, Schlosberg distinguishes three dimensions: distributional justice, procedural justice, and the 'interactional' dimension of 'justice as recognition'. The latter refers to the fundamental human need that feelings of dignity and integrity are supported by the treatment by others (Hanneth, 1992), which also applies to the support of such feelings by institutional conditions, for example the recognition of the fundamental stakes that people hold in decisions about energy supply.

DisGenMiGrids for all?

Studies of renewables' implementation indicate significant justice factors, particularly associated with the community perspective. Translated to DisGenMiGrids this knowledge can be formulated in many issues related to all three justice dimensions.

The perceived equity and fairness issues associated with the energy systems.

When we consider equity and fairness combined as an umbrella for all of Schlosberg's environmental justice dimensions, the important factors as perceived by community members are:

- The ownership of the assets in the energy system. This concerns equipment like the power generating units; the transmission infrastructure within the microgrid; the smart meters etc.
- All aspects of distributive justice in 'ownership' of resources and benefits. On the one hand this is about access for any participant to options of generating power with renewable sources, but on the other hand also the access to supplied energy yields and the associated economic benefits.
- The perceived fairness of the process of decision-making about anything related to the infrastructure that is opening up or closing down opportunities for participating in the establishment of distributed generation in microgrids. In terms of environmental justice, this is a combination of 'procedural' and 'interactional' justice.
- Openness of decision-making processes: access to all information available, as well as access to the arena of decision making.
- Institutional constraints on participation in decision-making as a result of policies and regulation. Some such constrains are paradoxically associated with the legitimization of spatial planning decisions as created by legal procedures. Such procedures often reduce the options for adaptive governance, as they legitimize powers exercised by higher tiers of government. For all kinds of siting decisions, for example, this mainly concerns hierarchical and procedural rules within planning legislation. In several countries these options have been limited during the last decade by national governments with the introduction of so-called 'speed up' legislation relying on the argument of 'streamlining' decision making (Cowell and Owens, 2006; Wolsink, 2003).

The level of trust/distrust and the conditions that may create such (dis)trust.

The collective action required for the establishment of a microgrid, renewable energy generation capacity, and a system of mutual supply and demand of power, requires trust.

- Mutual trust among the community members that cooperate in a microgrid.
- Trust in the investors in the new energy system. These can possibly be investors from within the community itself, but also optionally outsiders investing in it. Most previous research on renewables suggests that trust in community outsider's investments is generally not high; when it is associated with energy companies it is particularly low (Walker and Devine-Wright, 2008). The key issue here is the role(s) for such actors that would be considered as fair and trustworthy by the participants in microgrids.
- The level of trust in actors managing and regulating the system, again either from within the microgrid community or from outside the community. Here the role of public grid managers in the microgrid is a key issue, in particular when the grid infrastructure within the microgrid is still owned by a public grid manager.
- Trust in authorities who may have procedural powers in decision-making about how the microgrid is managed and how the electricity is generated and distributed.
- Trust in national authorities and their policies. Governments have created the regulatory frameworks that set important conditions for operating microgrids and distributed generation, and the regulations have a strong component of institutional path dependency as they mainly support the centralized model of power supply. These regulations are a strong building block of the institutional lock-in (Unruh, 2002; Lehmann et al., 2012).
- Trust in the amount of support or obstruction created by procedures and legal frameworks. Many legal obstructions may exist for establishing microgrids, for generating power and providing the energy not only to oneself but to others within the microgrid. The existence of such obstructions depends upon existing national legislation, which is an essential building stone of the institutional lock-in for energy innovation.

The match between identity characteristics of the community and the energy system.

The identity of the community is determined by a wide variety of variables. Many of those can be relevant for establishing a good fit with the new energy system. In order to achieve such new systems with large amounts of renewables the existing identities of communities should be recognized as extremely relevant. Hence, the recognition (3rd dimension of justice) of the importance of that identity is at stake, as well as the recognition that the best way to achieve a good match between the identity and the new system is to let the members of the community define that identity themselves. In fact this is why self-governance in CPR management is so important, as it creates the opportunity to shape the new system according to the identity that the community members know better than anyone else.

- The physical identity of landscape and environment, which includes variables determining the geomorphology, the character of the soil, and diverse variables related to wildlife and biodiversity, such as flora, fauna, and water.
- The symbolic meaning of the landscape and environment factors, as similar characteristics in different places can have varying significance for the members of communities, due to historic and cultural values.
- The socio-economic composition of the community, which is an important factor in the characteristics of energy demand as well as the capacity and the willingness to invest in energy innovation and self-supply.
- The community members' identities, with a huge variety of socio-cultural factors and life styles.

Renewable energy: a Common Pool natural resource

The identity factors of the community are connected to the location as well as to the profile of people in the community. Place attachment to a particular location, and the symbolic values held by the people, play a significant role in shaping people’s responses to any proposed changes to their surroundings (Devine-Wright, 2009). The identity of the actors in the community is important in determining such variables as the possibilities for installing new renewable energy generating capacity (rooftops, farmland, underground etc.) as well as patterns and flexibility of electricity consumption (including the potential of using electric cars and recharging them with renewables in the microgrid). However, the identity of the partners in the DisGenMiGrid may be varied to such a degree that their contribution to the establishment of the microgrid may also be very different. This unequal contribution has immediate consequences for what distribution of the benefits among these partners is perceived as equitable and fair.

All actors in electricity production and consumption will play entirely different roles. All actors can become co-producers, but co-production must be supported by institutions. 'Citizens are an important co-producer. If they are treated as unimportant or irrelevant, they reduce their efforts substantially' (Ostrom, 2010, p.10). This relates to the recognition issue in the justice concept, but this observation is also in line with the recognition that a DisGenMiGrid is a socio-technical system that must be classified as a Common Pool Resource (Sauter and Watson, 2007; Wolsink, 2012a). Common-pool resources (CPR's) are characterized by difficulty of exclusion and substractability of resource units. CPR studies show that simple governance strategies that are applied in the name of efficiency that rely on imposed markets, or on centralized command and control, tend to fail - which is in line with the failing governance of renewables implementation in many countries. CPRs ask for high institutional variety (Dietz et al., 2003) and that is why the establishment of DisGenMiGrids requires adaptive governance based on institutional variety and a high level of self-governance.

As DisGenMiGrids will become a significant cornerstone in the power supply system, a properly designed common pool resource management approach - adaptive management - should provoke societal initiatives for investment in distributed generation. The presumption that a shift towards low carbon energy provision is needed requires such initiatives, but an important follow-up question is what the social consequences of this development may be. The rules and norms studied in institutional CPR research include penalties imposed by formal and informal authorities for non-compliance. Norms are social prescriptions for compliance without formal or informal consequences (Ostrom, 2005). In CPR literature there is some attention paid to environmental equity (Pero and Smith, 2008; Smith and McDonough, 2001) but there has also been a critique that economic and political trade-offs are overemphasized, and that the research question about institutional conditions for environmental governance should be reformulated as a justice question (Paavola, 2007). The considerations are significant to generating power with renewables in microgrids. From studies on CPR's and renewables' implementation, the following factors have come to the fore as essential for adaptive governance (Dietz et al., 2003; Ostrom, 1999; Wolsink, 2012a).

● *System boundaries:* What constitutes a 'community'? Walker (2011) recognized such various meanings of community as (1) identity (2) an actor (3) as scale (4) a network, and (5) as a process. The definition of a community is complex, but in this case the socio-technical system is formed by all potential participants in the microgrid. Some factors that determine the feasibility of the system, but also the options to establish justice within it, are the appropriate size, the relationship between the microgrid and the public grid, and the space that is used for the power generation and the power supply infrastructure.

● *Ownership and control* of the various assets of distributed generation and the microgrid (Brown et al., 2010). Who owns the power generating units, all different types of sensors and regulating units (smart meters), the grid infrastructure, the sites where all these assets are located, and possible storage capacity? First of all, this is a matter of who has invested in these assets, but also of the location. For PV panels on rooftops, a clear model is that they are owned by the homeowners, but this model may become more complex when not all rooftops of participants are equally available for efficient generation, or when districts consist primarily of rental housing. Other partners in- or outside the microgrid, like ESCOs (energy service companies) or housing associations, may participate in investing in these assets. Eventually, financial actors like banks will play a significant role as well.

● *Management:* Ownership does not necessarily equal management, as specialized actors, for example ESCOs or new bodies created by the community, may become important. In fact the emergence of such new actors is essential for innovation (Jacobsson and Johnsson, 2000). Obviously, engineering capabilities are essential in building microgrids and installing renewable energy generating units, but these can be outsourced to different types of companies. The issue eventually is who decides about the allocation of control over assets, which companies are enabled and under what conditions. Crucial is who controls the smart meters and hence, who can use the data generated by all the sensors and for what purpose. The microgrid-model assumes that the application of the smart meters as well as the data is primarily used to optimize the production and demand within the microgrid community.

● *Access rules*: The resource, renewable energy, is free, but the space needed to build the infrastructure for generation as well as distribution is limited. How can the availability of land, rooftops, and resource rights be regulated in the community? In particular the rights to catch the sun and wind are complex and far from yet crystallized (Vermeylen, 2010). Important for the establishment of microgrids, and optimal conditions for citizens to become co-producers, are a wide variety of opportunities for self-governance that are not restricted by uniform regulations (Dietz et al., 2003).

● *General standardization/regulation:* Mutual delivery to neighbouring consumers (currently legally blocked in most countries) and standardization of equipment, e.g. *"plug-and-play"* for solar panels (Sauter and Watson, 2007) require regulation at higher levels. Simultaneously adaptive governance in CPRs requires strong limits on interferences by central authorities, utilities, (public) grid managers, and tax agencies (Wolsink, 2012a). Some general principles of recognition and procedural justice may ask for general frameworks that create options for participants that cannot contribute with essential resources - e.g. finances, space for siting generating units - to become part of the microgrid community. They may not be in a position to contribute to the production of the common good but allocative justice would mean that they nevertheless should have rights to participate (Rawls, 2001). At the same time, general principles of regulation must be available to create frames of self-governance that avoid free-ridership, which would imply that participants that are in a position to contribute can be enforced to do so.

● *Compliance rules:* What can be the architecture of internal regulation? This issue includes the regulation of energy flows, of information flows, of financial transactions regulated in the internal tariff system, as well as simple and easy rules for joining a microgrid community - for all kinds of actors. The right to co-produce and to deliver power to the microgrid, and the right to cover demand with internally produced power asks for an internal system of self-governance that is tailor-made to create an optimal match with the geographical identity of the microgrid community.

Future developments

Obviously the framework of energy regulation is among the primary institutions and practices that determine whether DisGenMiGrids will further renewables' deployment. However, there are other relevant domains such as transport –e.g. with regards to infrastructure for vehicle-to-grid V2G development –see below– and spatial planning with regards to land use for infrastructure and housing with high relevance for ownership and management issues. In particular the energy framework aims to establish a harmonized regulatory platform, consisting of European energy efficiency Directives as well as the EU Member States' national legislative and regulatory conditions to secure and enforce the energy supply in Europe.

The institutional frameworks within these other domains include legislation, knowledge frameworks and organizational structures. They all show patterns that are shaped by norms and values that are relevant for the implementation of smart grids and DG, according to the institutional categories that are distinguished in Ostrom's theory of CPRs (Ostrom, 1999, 2010; Dietz et al., 2003). These are norms and values concerning ownership relations, for example the regulatory conditions between existing and future license holders of local energy distribution networks, local production capacity, and all other assets in DisGenMiGrids (e.g. smart metering devices). Crucially in the current policy frame there are basically two possible paths of development. Policies might either enhance the autonomy of cooperating end-users to further their options to install renewable DG by managing their local generation and use (hence, to create their DisGenMiGrid), or they might further the construction of smart-metering and smart regulation of energy use primarily aiming for increased surveillance of consumers by energy companies. The latter option is in line with centralized goals, usually not DG, and may be associated with values representing a 'technocratic fix'. The first option provides a wider scope of possibilities for applying renewables in DG (Hammons, 2008).

In policy this cooperation choice is hardly recognized, while the incumbents in the energy sector are heading for maintaining the centralized option. Indeed, current policies seem to opt for heavy infrastructure and centralized scenarios. This is illustrated by discussions about 'intelligent grids' and developed scenario's - see for example in the UK Ofgem/LENS (www.ofgem.

gov.uk/LENS), though a striking suggestion from the latter scenario-study is that the DG and microgrid scenario requires far less investment in heavy infrastructure such as high voltage transmission and large scale generation, than the centralized scenarios.

Closely linked to the centralization-decentralization debate is the issue of authority with regard to ‘smart applications’. This concerns the access and use of data generated from ’smart metering’: are they collected primarily for energy providers and/or grid managers, or primarily for consumers/’prosumers’ balancing their own energy demand and supply? This involves the system services’ access to the distribution network, which is currently a particular responsibility, allocated exclusively to national transmission system operators. The functions required for smart grids may prove problematic for distribution systems operators at the local level.

A crucial issue in centralization, with strong relevance for justice, is tariffs. In all frameworks for smart grids tariffs are considered the key element of demand response, and tariffs systems are a major element in how current centralization has been established (Houthakker, 1951). Existing systems of demand management are usually based on static time-of-day variability, with occasionally options for fees for switching-off loads during peak demands. In smart grids the variability of tariffs will sharply increase. Tariffs may become increasingly variable in height and timing once adequate two-way smart meters and load control devices have been developed. For acceptance the important issue is who will control this variability and for what purpose. The two basic paths of development are likely to show large differences for acceptance, as the continuation of centralized power supply will also imply centralized control. Tariffs systems with variability aiming at optimizing deployment and utilization of renewables would imply control within the microgrid community. In both cases, however, there is a strong justice dimension to demand response. “Any type of tariff or direct control will affect people differently according to their ability and willingness to change daily routines, adopt new technology, invest in efficiency measures or participate more actively in energy markets” (Darby and McKenna, 2012, p.767) Microgrid optimization implies invoicing and settlement of energy supply: between various local (market) actors, between the microgrid community and the individual members, and between microgrid communities and public grid managers, and with authorities. An interesting topic, with huge relevance for the feasibility of renewables deployment and mutual supply of power within microgrids will be the systems that are implemented for taxing energy flows and how they affect tariffs.

CPR theory explains why institutional arrangements addressing questions of collective action in managing CPR's and of social acceptance must be complex, redundant, and nested in many layers (Dietz et al., 2003). In power supply, currently the layer of national institutions and “installed base” of existing infrastructure is dominant, but for adaptive management directed at efficient use of natural resources the shape, management and decision-making about the infrastructure in which the microgrids must become integrated must be reconsidered (Marris, 2008). This primarily concerns decisions on the structure and infrastructure of power supply, but it also includes structures and infrastructure in related domains. In smart grid development this concerns IT for example, but new directions in transport infrastructure and in the transport sector also become particularly important.

Electric cars create extra load and storage capacity in households (Anderson et al., 2009; Lund and Kempton, 2008). This vehicle-to-grid (V2G) application increases the feasibility of renewables and microgrids. Currently electric vehicles are recharged with the 'dirty mix' of public power generation. Recharged by renewables in DisGenMiGrids they would reduce transport GHG emissions significantly. Furthermore, flexibility in time-of-loading is inherent in the energy storage of the cars. This enhances the opportunities for smart applications of renewables. The aggregated load of V2G is important for levelling demand and supply imbalances by means of absorption of power - ’regulation down’- as well as the provision of power - ‘regulation up’ (Green et al., 2011).

However, the institutional question with regards to transport is whether these opportunities will actually be utilized to promote DisGenMiGrids. What kind of infrastructure will be developed for recharging cars: will consumers be recognized as important co-producers and will the storage techniques in cars and support recharging at home and at the working place –in the case their employer is also connected to a microgrid? Or will they be shaped to fit to large on-the-road recharging stations? The latter seems to match with existing infrastructure and ‘patterns of organization and thinking’, but it would reinforce the institutional lock-in for power supply innovation. This institutional inertia may easily impede individual citizens to use this opportunity for their own benefit and to further co-production of power and in this sense receive due recognition as important actors in DisGenMiGrids.

The significance of the identification of lock-ins for infrastructure more broadly, and of ways to avoid them or address them, are crucial for all decisions that will be significant for deployment of renewables and justice issues within new systems of power supply. As with power supply, desired transport infrastructure also suffers from the lack of social acceptance and obsolete institutions, and not so much technical issues that are holding back their implementation (Bannister, 2008). In transport, overcoming barriers to implementation of V2G infrastructure also requires innovation addressing social as well as technological dimensions. The interconnectedness of all the infrastructures as well as the structure of the sectors behind these infrastructures, combined with the issues of justice as fairness that are associated with the decisions that must be taken, are the perfect examples of increasing complexity in the future systems of power supply.

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