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183

Salvatore Ruggiero

People Power

The Role of Civil Society in Renewable Energy Production

JYVÄSKYLÄN YLIOPISTO

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ABSTRACT

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The engagement of civil society actors in energy generation can be defined by the term *community energy*. Community energy initiatives have increased in several countries.

This thesis aims at better understanding how this phenomenon emerges and how it can contribute to the decarbonization of our economy. For this purpose, a multi-level perspective on socio-technical transitions and strategic niche management theory were employed as theoretical lenses. The research material consisted of 75 qualitative interviews, a survey of 26 distributed energy experts, and a panel data study of 66 large electric utilities from various countries. Thematic, narrative, regression and descriptive statistical analysis were utilized to analyse the data collected.

The main findings showed that four main development patterns are triggering the rise of community energy projects. They are: (a) the characteristics of individuals, (b) social needs, (c) economic factors and (d) policy factors. The type of drivers behind community energy development is linked to the possibilities for scaling up the sector. Along with the drivers, some barriers were also identified. These included the resistance of incumbent regime actors to renewable energy diffusion, regulation and, in a few cases, technology performance. Regression analysis and the Granger test for causality showed that this resistance of incumbent energy firms was due to the negative correlation between an increase in renewable energy production and firms' long-term financial performance.

The thesis concluded that community energy could have an important role to play in the ongoing energy transition. Its impact, however, is contingent on the degree of internal niche development and on the ways the community energy niche will engage with important regime actors such as energy companies, governments, and network operators.

This work contributed to better understanding the factors influencing the development of socio-technical niches in the case of non-market driven innovation and the reasons that lead to the locking-up of energy regimes. In the future, researchers should make further attempts to uncover the ways in which regimes can be unlocked and social innovation for sustainability diffused.

Keywords: Community energy, socio-technical niche, transition, renewable energy, distributed energy, Finland

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Jyväskylä, 30 November 2017
Salvatore Ruggiero

FIGURE

TABLE

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I. Ruggiero, S. & Lehkonen, H. 2017. Renewable energy growth and the financial performance of electric utilities: A panel data study. *Journal of Cleaner Production, 142*, 3676–3688.

II. Ruggiero, S., Varho, V. & Rikkonen, P. 2015. Transition to distributed energy generation in Finland: Prospects and barriers. *Energy Policy, 86*, 433–443.

III. Ruggiero, S., Onkila, T. & Kuittinen, V. 2014. Realizing the social acceptance of community renewable energy: A process-outcome analysis of stakeholder influence. *Energy Research & Social Science, 4*, 53–63.

IV. Ruggiero, S., Martiskainen, M. & Onkila, T. 2018. Understanding the Scaling-Up of Community Energy Niches through Strategic Niche Management Theory: Insights from Finland. *Journal of Cleaner Production, 170*, 581–590.

1 INTRODUCTION

1.1 The need for the study

> The Paris Agreement provides momentum and a framework, but those pledges are not enough to bring the planet to the 2 °C trajectory.[1]
>
> …the conclusion really is that economists and environmentalists are on the same side and have both come to the same conclusion: we've got to act now and we don't have much time.[2]

The quotes above aptly reflect the sense of urgency to act on global warming after recent studies (Henley and King, 2017; Rogelj et al., 2016; IEA, 2016a) have found that the pledges made under the Paris Agreement will not be enough to keep global temperatures below the 2°C threshold, which, in fact, may be crossed already by 2030 (Wagner et al., 2016).

The human activity that is contributing the most to the warming of our planet is energy production. The electricity and heat sector accounts for nearly 42% of global CO2 emissions (IEA, 2016b). Considering that by 2040 the demand for electricity is expected to be almost 69% higher than today (IEA, 2016a) due to economic growth especially in non-OECD countries, it is crucial to bring about a rapid transformation of the energy sector.

The energy industry, however, is locked in on fossil fuels and resists a fundamental transformation towards clean energy (Geels, 2014). In addition, although privatization and liberalization were introduced in many countries to increase competition and enhance efficiency, energy generation and distribution are, to date, mostly controlled by a small number of companies (Stagnaro, 2014). Energy provision relies on a centralized production model in which energy is generated by large power plants and distributed through extensive networks to customers. Yet this model is being challenged by the increasing costs

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1 Fatih Birol (2016), Chief Economist of the International Energy Agency
2 Ben Hankamer (2016), Chemistry and Structural Biology Division Director, University of Queensland

associated with the aging of the supply infrastructure, geopolitical instability, and the dramatic expansion of renewable energy (Bouffard and Kirschen, 2008).

Renewable energy production is fundamentally different from fossil fuel energy because it lends itself naturally to a more localised system of energy provision. As a result, a new model of energy production based on distributed energy – that is, localized energy production – is emerging in many countries as a more sustainable approach than centralized energy production based on nuclear and fossil fuels (Alanne and Saari, 2006).

An important aspect of the growth of distributed energy systems is the fact that it is triggering a profound shift in the conventional relationship between people and energy (Mason, 2015). Whereas, in centralized systems, consumers have only a passive role as the endpoint of a top-down system, in distributed energy systems, they have an active one because they can purchase and produce energy at the same time (Watson, 2004; Devine-Wright, 2007). Furthermore, the growth in distributed energy is enabling new actors, such as local communities and citizens, to contribute to the shift to clean energy. The involvement of these civil society members in energy production and saving is referred to as *community energy* (Seyfang et al., 2013).

The development of distributed energy production, along with the rise of new actors, are two of the main change factors currently occurring within the energy sector. They reflect not only a technological shift from fossil fuels to renewable energy technology but also a deeper transformation in societal values.

The emergence of community energy can be positioned in the context of this broader process of change from centralised to distributed energy production taking place in the electricity and heat sector. Its rise is linked to the diffusion of technologies such as solar PV, microturbines, small CHP systems and heat pumps. These technologies have become more affordable, creating the preconditions for localized energy generation and ownership.

The engagement of civil society actors in energy production and conservation is receiving increasing attention from researchers because of the role it may play in helping to unlock the energy sector and in promoting a quicker transition to clean energy (Marechal and Lazaric, 2010). For instance, Geels (2014, p. 17) states:

> An important topic for future research is to better understand the rise of alternative 'Davids', i.e. not just upstream green electricity production technologies (e.g. wind, solar, bio-energy), but also broader socio-technical innovations such as the civil society.

According to one estimation, citizens in the European Union could produce 45% of Europe's electricity demand by 2050 (REScoop, 2017). However, in order to evaluate the role of community energy in contributing to the transition to clean energy, more information is needed on (a) the factors that trigger incumbent energy firms' resistance to renewable energy, and (b) the ways how the community energy sector can scale up and contribute to change the established energy production practices. This thesis seeks to fulfil these two research goals by looking at the rise of community energy through the lens of socio-technical transition literature.

1.2 Key concepts and definitions

The conceptual building blocks of this thesis are distributed energy, community energy, socio-technical niche, regime, transition and scaling-up.

The term *distributed energy* refers to a system relying on small energy conversion units generating energy near to where it is consumed or, ultimately, in buildings that are completely energy self-sufficient (Alanne and Saari, 2006). Thus, Alanne and Saari propose that it can be considered as the opposite of centralized production in which the generation of energy is concentrated in a few large-scale power plants and transported long distances through the electric grid or a heat network.

In the literature, another term often used synonymously with distributed energy is decentralized production. According to Alanne and Saari (2006), however, there is a difference between the terms *decentralized* and *distributed*. Both refer to small-scale production near the consumption point but whereas decentralized systems are not interconnected with a public energy network, distributed systems are. In other words, all the decentralized systems are distributed (relying on small-scale production near to the point of consumption) but not all the distributed systems are necessarily also decentralized (not interconnected to a public network). Consequently, in this thesis I use the term distributed energy instead of decentralized production because the former is broader than the latter.

An important feature of distributed energy systems is the fact that they allow a bidirectional flow of energy. This means that in these systems consumers with generation capacities can take electrical power or heat from an energy network as well as send them back (Nystedt et al., 2006; Alanne and Saari, 2006). Besides generation, distributed energy systems also encompass energy storage and monitoring through smart technologies.

The term *community energy* refers broadly to the involvement of civil society actors such as charities, co-operatives, groups of citizens, and neighbourhood networks (Middlemiss and Parrish, 2010) in energy production and saving (Seyfang et al., 2013; Hoffman and High-Pippert, 2005). Although in recent years the term has been more in vogue, there is no unanimous opinion on what it should mean. Walker and Devine-Wright (2008) tried to determine the key aspects associated with community energy initiatives. They studied several renewable energy projects carried out by local communities in the UK and classified them along two dimensions: outcome and process. The first dimension is connected to the beneficiaries of the project and the second with the participants. Based on these two dimensions, they suggested that ideal community projects are those carried out entirely by local communities and having high levels of citizen participation. Walker and Devine-Wright (2008), however, pointed out that there are different degrees of participation and locally shared benefits in community energy projects. As a result, the definition of community energy is not unambiguous, since a large variety of initiatives can be considered as community projects even if some of them might not have much citizen involvement and provide very few benefits to the local community.

In addition, when we look at the concept of community energy from the point of view of practitioners, its meaning varies according to the place in which it operates. For instance, in the UK the term community energy is used to emphasise the participative aspect of this way of carrying out energy initiatives. Therefore, it relates to what it means to act together as a group and develop energy projects (Martiskainen, 2014). On the other hand, in Germany, the concept of citizens' ownership is so much more prominent than in the UK that the word *Bürgerenergie* ('citizens' energy') is recurrently used (Degenhart and Nestle, 2014). In Finland, where community energy is a relatively new concept, the term *lähienergia*, meaning 'local' or 'nearby' energy, can be found. The use of this particular term indicates the strong geographic focus of this approach in Finland (Martiskainen, 2014), but it does not necessarily indicate citizens' participation or ownership.

Aside from the local variation in meaning, community energy is essentially based on small-scale distributed energy technology. Hence, it is defined in this thesis as citizen involvement in the establishment of distributed energy systems. With the term *citizen involvement*, I do not necessarily imply full community ownership (in some instances citizens and energy companies may co-own energy assets) but at least participation in planning or setting up community energy projects. In contrast, I use the term *distributed energy* to refer to technological configurations that enable citizens to generate energy near where it is needed.

I examine the emergence of community energy in this thesis through the concepts of socio-technical niche and regime. According to a large body of literature, system-changing innovations emerge in niches (Kemp et al., 1998; Geels, 2004). A niche can be understood as a "constellation of culture, practices and structure that deviates from the regime [and] can meet quite specific societal needs, often in unorthodox ways" (van den Bosch and Rotmans, 2008, p. 31). Niches play a fundamental role in system change because they act as protected spaces shielding innovation from market pressures that may inhibit its development. In this study, niches are conceptualized as protected spaces where new renewable energy technologies or practices can be experimented with, but the socio-technological regime constitutes the dominant set of rules and routines that guide the behaviour of actors on how to produce, regulate and use energy (Schot et al., 2016). Since both niches and regimes are shaped by the co-evolution of technology and society, the term *socio-technical* is used to refer to them.

The term *transition* is defined in this thesis as a "gradual, continuous process of change where the structural character of a society (or a complex subsystem of society) transforms" (Rotmans et al., 2001, p. 16). Because transitions do not simply imply a technological transformation but also a societal change in user practices, regulation, infrastructure, beliefs, values and governance, in this case the term socio-technical is also applied (Geels, 2002; Kern and Smith, 2008).

An important concept linked to transitions is the scaling-up of socio-technical niches. Scaling-up in general refers to "moving sustainable practices from experimentation to mainstream" (van den Bosch and Rotmans, 2008, p. 34). In this thesis, I understand it as the process of niche building from local projects to the global niche-level described in Geels and Raven (2006) and Geels and Deuten (2006).

The concepts of socio-technical niche, regime, transition and scaling-up are derived from the transition literature on which the theoretical framework of the study is built. These are discussed in Chapter 2.

In the next section, I summarize some of the prior research on community energy, highlighting the main themes discussed as well as the research gaps that need to be addressed.

1.3 Previous research and the research gaps addressed

As Figure 1 shows, community energy is not a novel concept in the literature. It was discussed already in the 1970s, but it became less prominent in the second half of the following decade. Much of the early research was stimulated by ideas such as small-scale energy development (Schumacher, 1973), soft energy paths (Lovins, 1977) and appropriate technology (Schumacher, 1973; Dunn, 1978).

For instance, in his classic work *Small Is Beautiful: Economics As If People Mattered*, Schumacher (1973) observed that large-scale and centralized energy production is unsustainable and results in an unequal distribution of power. He suggested that an alternative energy paradigm based on decentralized, small-scale and locally autonomous energy solutions relying on renewable sources, should instead be pursued. Such an alternative paradigm should also employ local resources, be appropriate to local culture and practices, and satisfy local wishes and needs (Dunn, 1978).

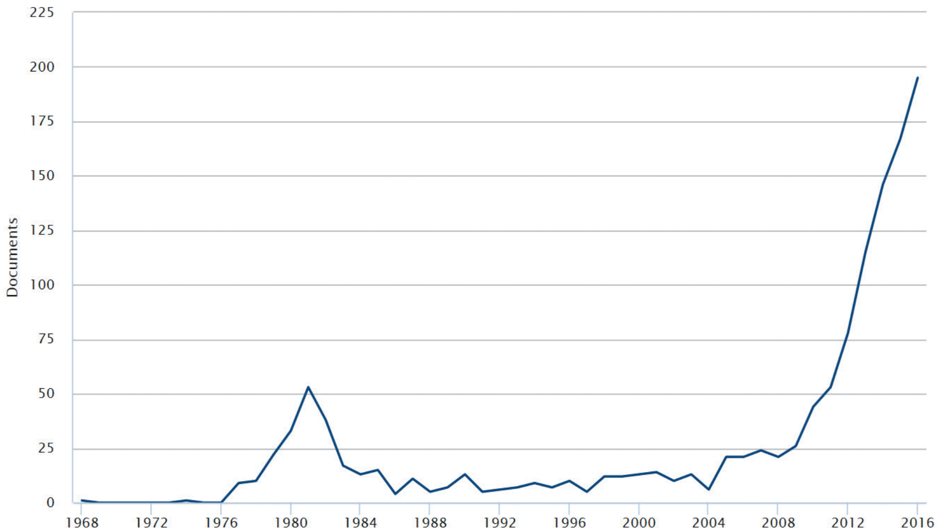

Figure 1 Number of articles, books and book chapters citing the term *community energy* in Scopus by year.

Similarly, Lovins (1977) argued that small-scale energy systems are more beneficial than wide and centralized energy provision networks because they can reduce the costs of energy production and distribution, eliminate the problem of power losses in the grid, and avoid diseconomies of scale due to the need to have back-up capacity to replace large power plants that suddenly fail. In his extensively cited article, “Energy strategy: The road not taken”, Lovins (1977) introduced the concept of *soft energy path* to describe a mix of alternative technologies that are more politically, socially and environmentally attractive than those used in a centralized energy system, which he defines as the *hard path*. In his view, soft technologies use renewable energy, are flexible and match in scale and quality the needs of the end user.

After this first wave of studies that began challenging the established idea of centralized energy production, it was not until the beginning of 2000s that the concept of community energy started to gain renewed interest in the scientific community, especially in the UK.

Some of the more recent literature has dealt with the definition and meaning of community energy (Walker and Devine-Wright, 2008; Walker et al., 2010), aspects related to the development process (Gubbins, 2007) or participation (Hoffman and High-Pippert, 2010). A large group of studies has focused on the drivers and barriers of community energy. For example, Walker et al. (2007) studied the factors that led to the rise of the community energy theme within UK government policies. They concluded that it emerged due to its expected role in stimulating the growth of renewables and its socio-economic benefits to rural areas. Bomberg and McEwen (2012) focused on community energy development in Scotland and found that it was triggered by “structural resources”, which refer to the broad political context in which community energy mobilization develops, and by "symbolic resources", which include less tangible elements such as community identity and autonomy. In a study by Rogers et al. (2012), it was, instead, a shared vision of sustainable development for a particular geographic area to drive community energy development. Seyfang and Smith (2007) discussed the role of grassroots innovation for sustainable development. They suggested that while market-based innovation is driven by profit, grassroots innovation, such as community energy, is triggered by unmet social needs and ideology. Okkonen and Suhonen (2010) studied the case of Finnish energy cooperatives and noted that these initiatives were triggered after the beginning of the 1990s when the heat services, which had traditionally been provided by municipalities, were privatized. In Germany, the drivers of the boom in energy cooperatives are to be found, according to Buchan (2012), in the long and established culture of collective civic action and the anti-nuclear movement.

As for the barriers to community energy development, Bomberg and McEwen (2012) as well as Walker et al. (2007) determined that they were linked to the lack of political and institutional support. Walker et al. (2010) and Rogers et al. (2008) focused more on the internal factors preventing the development of community energy projects and reported that they were associated with a lack of project leadership and community groups' confidence in their abilities.

Another important group of studies has then dealt with the benefits of a community energy approach. Hain et al. (2005) divided them into primary and secondary benefits. In their view, the primary benefits are connected to the possibility that the community approach can contribute to increasing the overall renewable energy capacity while the secondary benefits comprise the positive impact on the grid, voltage stability, generation of stable income and social regeneration. The topic of social and economic regeneration has been discussed at length in the literature. The economic benefits of community energy projects have been illustrated, for example, in Phimister and Roberts (2012) and Li et al. (2013) who suggested that community projects increase household incomes and welfare in rural areas. Social regeneration was described, among others, in Rogers et al. (2008), who found that besides economic benefits local energy projects enhance community cohesion, promote sustainable use of natural resources and bring about societal change.

Finally, a large number of publications have investigated the role of community energy in increasing renewable energy acceptance. Most of this literature has confirmed that a community ownership approach can mitigate local opposition, especially in the case of wind power deployment (Loring, 2007; Zoellner et al., 2008; Warren and McFadyen, 2010; Musall and Kuik, 2011).

When looking at the literature cited above, two key conclusions can be drawn. First, although many authors have highlighted the benefits of a more distributed energy system as well as of community participation in energy production, its role in triggering wider systemic change, that is, a transition to clean energy, has not yet been fully explored. As Figure 2 indicates, the literature that has explicitly linked community energy to the concept of transition is still in its infancy.

Community energy carries a promise of "a better future", but in reality it faces multiple challenges "in simply surviving, let alone growing, replicating and spreading more widely" (Seyfang et al., 2014, p. 25). Transition scholars have suggested that it is because of the resistance to change of the socio-technical regime that alternative renewable energy solutions have not expanded more deeply (Geels, 2014; Schot and Geels, 2008; Kemp, 1994). Regime actors' resistance to renewable energy deployment has been explained in terms of vested interests (Moe, 2010) and perceived risks (Hess, 2015). For instance, van der Schoor and Scholtens (2015) reported that large energy utilities in the Netherlands oppose the expansion of renewables because they fear that renewables can displace fossil fuel–based production. Richter (2013) focused on business model innovation in the electric utility industry and observed that policymakers in Germany following a conservative ideology have tried to protect the traditional business model of utilities based on fossil fuel generation. Geels (2014) stated that policymakers and incumbent energy companies tend to form alliances due to the mutual interests they share. Such alliances aim at protecting the status quo of incumbent regime actors, framing the discussion about the energy transition around the need for green innovation rather than on the phasing out of fossil fuel production.

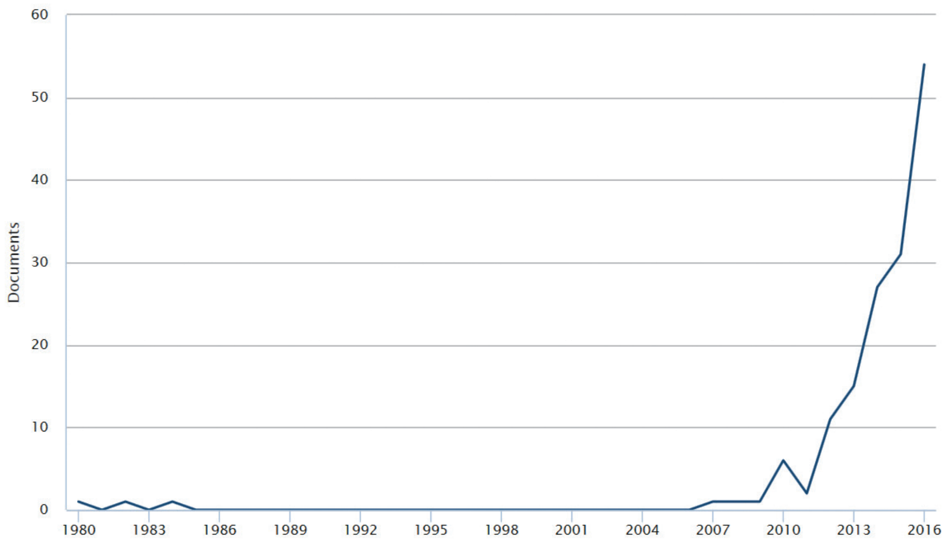

Figure 2 Number of articles, books and book chapters citing the term *community energy* together with the term *transition* in Scopus by year.

Although previous research has highlighted the role of regime actors' vested interests in hindering the deployment of renewable energy, there is a need to better understand the interplay between the expansion of renewable energy and the conventional mode of energy production. In particular, the reasons and specific mechanisms that lead to the opposition of electric utilities to a deeper penetration of renewable energy deserve more attention. This is an important question because a deeper understanding of how incumbent regime actors' opposition to renewable energy is triggered can help in identifying strategies to speed up the energy transition. Therefore, the limited amount of information available on the reasons and specific mechanisms that lead energy companies to oppose the transition to renewable energy is the first research gap addressed by this thesis.

Second, while there is a plethora of studies focussing on single community energy initiatives, not much attention has been given to how they come to form an emergent sector that can exert influence on the established way of energy provision (Smith et al., 2010). The literature has extensively discussed conventional market-based innovation but, to date, there has been little research on non-market driven innovation such as community energy. In the view of Seyfang and Smith (2007, p. 598), non-market driven innovation has an important role to play and represents a "neglected site of innovation for sustainable development". Thus, more information is needed on how community energy projects develop from the level of local experimentation to the mainstream, in other words, on how they scale up.

The extant theory that seeks to explain how niches emerge against dominant socio-technical regimes has been dominated by a technological perspective that marginalizes the importance of the social side of innovation that, instead, is at the core of community energy (Seyfang and Smith, 2007; Seyfang and Haxeltine, 2012; Hielscher et al., 2013; Seyfang et al., 2014; Smith et al., 2016).

Social innovation driven by civil society members has been conceptualized in different terms. However, one term used in relation to socio-technical transitions and community energy is grassroots innovation. Grassroots innovation can be described as:

> …innovative networks of activists and organizations that lead bottom-up solutions for sustainable development; solutions that respond to the local situation and the interests and values of the communities involved. In contrast to the greening of mainstream business, grassroots initiatives tend to operate in civil society arenas and involve committed activists who experiment with social innovations as well as using greener technologies and techniques". (Seyfang and Smith, 2007, p. 585)

Grassroots innovation is driven by social need and ideology (Seyfang and Smith, 2007). Ideologies promoted by grassroots innovators can often be in sharp contrast with established or mainstream views. This is because these views are supported by alternative values such as market growth vs self-reliant economies (Seyfang and Smith, 2007). Grassroots innovation has been considered an important element for sustainable development (Seyfang and Smith, 2007). However, the factors that contribute to its diffusion have not been sufficiently explored (Seyfang and Longhurst, 2016). In addition, grassroots initiatives often struggle to survive, let alone grow, as an alternative paradigm (Seyfang et al., 2014). Subsequently, the second research gap addressed by this thesis is the limited knowledge on the scaling-up of non-market driven innovation, such as community energy.

After this review of the current literature, in the next section I move on to the aims of this study and state the research questions this thesis seeks to answer.

1.4 The aim and research tasks of the study

In light of the research gaps highlighted above, this thesis aims to better understand the emergence of community energy as a socio-technical niche and the role it can play in the ongoing energy transition. To fulfil this goal, two research objectives were established: (a) to shed more light on the reasons and mechanisms that lead to the resistance of incumbent regime actors to renewable energy penetration; (b) to provide more information on the scaling-up of community energy niches.

To fulfil these objectives, the thesis was divided into two parts. The first part focuses on the socio-technical regime that represents the established set of practices in energy production and dominant way of thinking against which the emergence of a community energy niche occurs. The study focuses on the impact of the expansion of renewable energy on the economic performance of incumbent energy utilities. Subsequently, it explores the benefits and challenges emerging from a less centralized energy production system in which small-scale distributed energy production is promoted.

The research questions addressed in the first part of the thesis are the following:

a) What is the relationship between an increase in renewable energy production and energy companies' profitability?
b) What are the prospects, drivers and barriers of the transition to distributed energy?

The second part of the study focuses specifically on the actors and factors leading to the emergence of community energy as a socio-technical niche. Here the thesis illustrates how community energy stakeholders are involved in project development and the type of roles they can play. It then concentrates on the type of community energy projects that are emerging and the factors that may prevent these initiatives from scaling up.

The research questions answered in the second part of the thesis are:

a) How are stakeholders involved in community energy projects and what role do they play?
b) What type of community energy projects can be found and what factors may influence their scaling-up?

The two research objectives illustrated above were chosen because the role community energy can play in the ongoing energy transition depends not only on its possibilities for internal growth (niche development) but, eventually, also on its ability to contribute to the transformation of the dominant way of energy production. Therefore, studying regime actors' opposition to the growth of new renewable energy practices contributes to better understanding how this process of transformation occurs.

1.5 Geographic scope of the study

The emergence of community energy as a socio-technical niche is considered in a European context, particularly in the case of Finland. Finland is an interesting case because it has strong support for renewables while also endorsing distributed energy generation, but, in contrast with other EU countries leading the renewable energy revolution, it is, to date, still following a traditional, large-scale centralized energy pathway. However, serious concerns have been expressed with regard to the resilience of its centralized energy system. It is these internal tensions combined with a traditional technology- and market-oriented approach that make Finland a fruitful setting for my research. Besides Finland, other countries in the northern part of Europe – including Germany, Ireland, Northern Ireland, Norway, Scotland and Sweden – were included in the study. I chose these countries because the approaches they have taken to distributed energy generation differ from each other and show different degrees of community energy development, thus, giving more breadth to the study.

1.6 The research process

This research originated from my interest in understanding how renewable energy diffusion could be accelerated. In the summer of 2012 I began a systematic review of the literature, focusing on themes such as the barriers to the uptake of renewable energy, its main drivers and new deployment models.

During that same period, I also participated in a two-week international summer school organized by the University of Graz, which had an important impact on how the main idea behind this thesis evolved. The title of that summer school was "Societal energies", and it focused on the societal forces at work in the transition from fossil fuels to renewable energy sources. "Societal energies" consolidated the view in me that, alongside the technological aspect of renewable energy, the societal side also plays an extremely important role. Thereafter, I decided to deepen that subject in this thesis.

Although the research process was planned in my first year, it actually evolved along with my growing understanding and knowledge of the field. Consequently, the research process has ultimately not been straightforward but has instead evolved after each of the four studies included in this dissertation was completed.

The journey began with article III and the need to start to understand who and how was playing a role in the emergence of the community energy approach. Subsequently, I realized that community energy was just one of the many expressions for a wider phenomenon that is being spurred by the growing competiveness of distributed energy technologies. As a result, in article II I wanted to understand the drivers and the factors hindering the expansion of small-scale distributed energy production. It was then, at this journey's halfway point, that I became aware of some underlying assumptions.

Community energy is sometimes prescribed in a rather normative way. Therefore, I wanted to base this research not on the assumption that community energy should be by default the alternative to the current energy paradigm but rather that, based on its limitations, our society needs to consider other options, one of which is a community energy pathway. Consequently, I felt the need to investigate in article I whether, under a centralized energy regime, a significant expansion of renewable energy could be expected. The empirical results supported the position of other authors about regime resistance to change (Geels, 2014). Subsequently, community energy was positioned in the thesis as one option that can be considered to overcome regime inertia to change.

Finally, towards the end of the research, it appeared evident that one of the most important aspects in this field of studies is to find an answer to the question of how small, sometimes fragmented and locally bounded experiences of people getting involved in energy production could become an alternative approach to established energy production practices. For this reason, in article IV I looked into the crucial issues of scaling up community energy niches.

The thesis is presented as one coherent piece of research, but each article has its own story, research design and way in which the research question was derived. The data utilized was collected to meet the research goal of each article. In addition, apart from the case of article I, the data were obtained from research projects in which I had been personally involved and that were connected to the topic of the thesis.

The reflective process that led to the writing of this dissertation was also to a great extent inspired by the numerous research seminars, conferences, summer schools and one long visit to another university abroad that I had during my PhD studies. During these experiences, I received valuable feedback from other researchers and I engaged in discussions that helped me to revise constantly the focus of my research. Many of the ideas and issues discussed during those events were gradually absorbed and integrated into this thesis.

Finally, the review process of each article has been another great source of learning that contributed to the final shape of this dissertation.

I summarize the content and the contribution of each article to the thesis in the following section.

1.7 Summary of the articles and their contribution to the thesis

Table 1 offers a synthetic view of the articles that are included in the thesis. Article I illustrates the relationship between an increase in renewable energy production and the profitability of electric utilities. The results show that, in general, the correlation is negative although partially moderated by the carbon intensity of firms. Thus, a sustained expansion of renewable energy in a centralized energy regime may not necessarily occur due to the implications for the profitability of conventional power plants. Utilities might continue to invest in large-scale renewable energy projects but, in a gradual way, to protect their sunk investments in conventional generation. However, a much more rapid uptake of renewable energy technology is needed to keep in line with the global goal of containing temperature change to 2 °C.

The main implication of the study is that new actors need to be mobilized to promote a wider uptake of renewable energy and avoid lock-in in a situation where fossil fuel production remains the predominant way of energy production and renewable energy continues as a complementary option. In this respect, distributed energy generation, through its ability to mobilize a wider range of actors such as community groups, may represent a solution.

In short, article I contributes to the thesis by answering the question of *why* there is resistance within the energy regime. It also addresses why an alternative model to renewable energy production, such as a community-based approach, would be needed.

Subsequently, article II focusses on the current process of transformation towards distributed energy production occurring within the energy system. Decentralization is taking place due to the profound improvements and cost reductions of small-scale distributed technology. Besides further illustrating the context of the topic investigated, article II identifies the benefits and the challenges that are opening up in the process of transforming the energy system. The results show that a shift to a more distributed system is possible in the next 10 years but the current energy regime does not allow the change to take place. One of the conclusions is that, following on article I, more innovation including new business models should be allowed to develop in order to accelerate the pace of the transition.

In short, article II contributes to answering part of the previous question and the question of *what* possibilities there are and the obstacles that need to be overcome to develop an energy system with more small-scale distributed production, such as in the case of a community-based approach.

After having identified the factors limiting the expansion of renewable energy at the regime level and illustrating the benefits and challenges that might arise from following an alternative pathway based on distributed production, the thesis narrows its focus to the phenomenon of community energy.

Article III uncovers the key stakeholders involved in the establishment of community energy projects and their roles (supportive, hindering or both).

Through a stakeholder analysis, the article identifies the main actors and the ways they contribute to the establishment or non-establishment of community energy projects. This aspect is important in the understanding of how community energy projects emerge and become socially embedded. In short, the article contributes to answering the question of *who* influences the establishment of community energy projects and (partially) how they do so. The paper also helps answer the previous question on the drivers and barriers of the transition to distributed energy.

The emergence of single-community energy projects does not yet constitute an alternative paradigm to an established one. In fact, the literature on strategic niche management suggests that, from local projects a global niche emerges over time. A global niche is the embryonal stage of a new market niche competing with a mainstream market (Geels and Raven, 2006). Article IV provides a deeper understanding of the factors influencing the scaling-up of community energy niches, that is, a protected space where new ways of deploying renewable energy are experimented with.

In short, article IV answers the question of *why* the formation of a community energy niche does or does not occur and partially addresses the issue of who is involved in the scaling-up process. Figure 3 illustrates how each article contributes to the overall structure of the thesis. In Table 2, I illustrate my contribution to the joint articles included in this thesis.

The rest of this dissertation is organized as follows: Chapter 2 addresses the theoretical foundations of the thesis, Chapter 3 examines some methodological considerations, Chapter 4 illustrates the results from the four peer-reviewed articles, and Chapter 5 presents the main conclusions of the study.

Table 1 Overview of the publications included in the thesis.

Article	Focus of the study	Theoretical approach	Data and Methods	Main findings
1) Ruggiero, S. & Lehkonen, H. 2017. Renewable energy growth and the financial performance of electric utilities: A panel data study. *Journal of Cleaner Production, 142*, 3676–3688.	The relationship between an increase in renewable energy production and electric utilities' profitability	Natural resource–based view of the firm (NRBV)	Panel data for 66 electric utilities covering the period 2005–2014 analysed with regression analysis and the Granger causality test	There is a negative correlation between renewable energy increase and firms' short-term as well as long-term financial performance. However, a firm's carbon intensity moderates the relationship
2) Ruggiero, S., Varho, V. & Rikkonen, P. 2015. Transition to distributed energy generation in Finland: Prospects and barriers. *Energy Policy, 86*, 433–443.	The possibilities and challenges of the transition to distributed energy in Finland through 2025	Multi-level perspective (MLP) and transition management (TM) theory	A questionnaire with 26 experts evaluated on a five-step scale plus 15 semi-structured interviews analysed with thematic analysis	A prosperous future scenario for distributed energy in Finland is possible if permit procedures, ease of grid connection, and taxation laws are improved in the electricity sector and new business concepts are introduced in the heat sector.
3) Ruggiero, S., Onkila, T. & Kuittinen, V. 2014. Realizing the social acceptance of community renewable energy: A process-outcome analysis of stakeholder influence. *Energy Research & Social Science, 4*, 53–63.	Stakeholders influencing and influenced by the establishment of community renewable energy projects	Stakeholder theory	41 structured interviews analysed with thematic analysis	Stakeholders assume multiple or even conflicting roles. Key stakeholders are intermediary organizations and local champions.
4) Ruggiero, S., Martiskainen, M. & Onkila, T. 2018. Understanding the Scaling-Up of Community Energy Niches through Strategic Niche Management Theory: Insights from Finland. *Journal of Cleaner Production, 170*, 581–590.	The process leading to the development of a community energy niche	Strategic niche management (SNM) theory	19 semi-structured interviews analysed with narrative and thematic analysis	Three types of community energy projects were identified in the Finnish context. Of these, only projects aiming at broader systemic change appeared willing to scale up. The main factors limiting the scaling-up of the niche include the lack of a clear vision for the sector and of dedicated work by intermediary organizations.

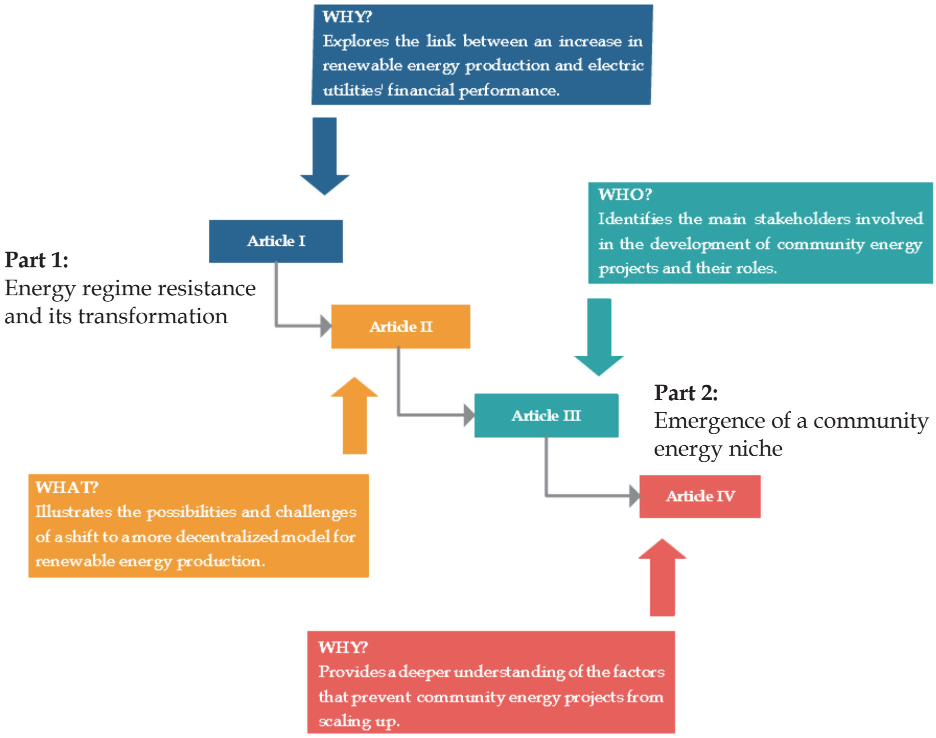

Figure 3 The contribution of each article to the thesis.

Table 2 Main author's contribution to the joint articles.

Article	Main author's contribution to the article	Co-authors' contribution to the article
1) Ruggiero, S. & Lehkonen, H. 2017, Renewable energy growth and the financial performance of electric utilities: A panel data study. *Journal of Cleaner Production, 142*, 3676–3688.	Designed the study, collected the data, created the theoretical framework based on the literature about the link between a firm's environmental performance and profitability, carried out panel data analysis, carried out robustness check on the findings, wrote about 80% of the final manuscript.	Carried out Granger causality test, carried out analysis of variance between developed/developing countries, produced the descriptive statistics, contributed to the interpretation of the results, wrote about 20% of the final manuscript.
2) Ruggiero, S., Varho, V. & Rikkonen, P. 2015. Transition to distributed energy generation in Finland: Prospects and barriers. *Energy Policy, 86*, 433–443.	Designed the study, carried out 15 semi-structured interviews and analysed them with thematic analysis, created the theoretical framework based on the multi-level perspective and transition management theory, wrote about 70% of the final manuscript.	Carried out a survey of 26 distributed energy experts, analysed the findings with descriptive statistics and created a future table, contributed to the interpretation of the findings and description of the energy sector in Finland, wrote about 30% of the final manuscript.
3) Ruggiero, S., Onkila, T. & Kuittinen, V. 2014. Realizing the social acceptance of community renewable energy: A process-outcome analysis of stakeholder influence. *Energy Research & Social Science, 4*, 53–63.	Designed the study, analysed the data with thematic analysis, carried out the review of the literature on community energy projects, interpreted the results, wrote about 80% of the final manuscript.	Brought in the data (the third co-author had access to the SECRE project data and offered it for a joint article), created the theoretical framework based on stakeholder theory, described the data collection process, wrote about 20% of the final manuscript.
4) Ruggiero, S., Martiskainen, M., & Onkila, T. 2018. Understanding the Scaling-Up of Community Energy Niches through Strategic Niche Management Theory: Insights from Finland. *Journal of Cleaner Production, 170*, 581–590.	Designed the study, created the interview guide for the collection of the data, instructed research assistants on how to collect the data, created the theoretical framework based on strategic niche management literature, interpreted the results, wrote about 70% of the final manuscript.	Analysed the data with narrative and thematic analysis, described how the data was analysed, contributed to the conclusions, wrote about 30% of the final manuscript.

2 THEORETICAL FOUNDATIONS

2.1 From firm-level innovation to socio-technical transitions

A large body of research on sustainability-oriented innovation has attempted to explain how new products and processes could avoid environmental degradation while also creating opportunities for businesses. Several approaches have emerged over the years within this strand of literature, including green innovation (Porter and van der Linde, 1995), corporate social responsibility (Porter and Kramer, 2006), industrial ecology (Socolow, 1994), and eco-innovation (Kemp, 2010; Rennings, 2000). These approaches looked at innovation at the firm level or at the sectoral level. However, in the last two decades several scholars, including Rip and Kemp (1998), Kemp et al. (1998), Geels (2002) and Smith et al. (2010) noted that the urge to address sustainability issues calls for the perspective in our understanding of innovation processes to be broadened. In this regard, Smith et al. (2010) has stated:

> Until recently the focus of environmentally oriented innovation studies has remained largely upon innovations to individual goods and services. A greener innovation system may produce more eco-efficient products or services, or even enable industry clusters to develop more closed-loop processes. But the relative improvements they deliver can be undermined by absolute increases in consumption. A need for step-jumps in absolute performance, such as 80% reductions in carbon emissions over the next generation, or factor ten improvements in resource efficiency, implies changes at the level of entire socio-technical systems. (p. 439)

In the literature on sustainability-oriented innovation, these calls have, in recent years, resulted in a gradual broadening of the scope of both the problem and analytical framing (Smith et al., 2010). The former has implied that the focus of sustainability-oriented studies has shifted from cleaner production to the entire system of production and consumption. The latter has led to the development of new analytical frameworks for the study of sustainability-oriented innovation (Smith et al., 2010). These new analytical frameworks (see section 2.2 for more) have widened the focus from the innovation itself to a broader set of systemic issues that may promote or hinder the development of that innovation.

Therefore, scholars in the area of sustainability-oriented innovation have directed their attention to innovation processes at the level of entire socio-technical systems, that is, the systems created for fulfilling societal functions such as transport, energy or food. From this theoretical perspective, achieving sustainability implies a change from an unsustainable socio-technical system to a sustainable one. This process of deep and long-lasting transformation is referred to with various terms, including *system innovation* or *socio-technical transition* (Geels, 2004). In this thesis, I use the latter term to avoid confusion with the term *innovation system* used in the work of Jacobsson and Johnson (2000).

Sustainability transition scholars suggest that transitions not only imply a change of technological aspects but also a change of important societal elements such as user practices, regulation, industrial networks, infrastructure and culture (Geels, 2002) that give them "meaning" and "purpose" (Smith et al 2010, p. 439). For this reason, the term socio-technical transition has been coined to indicate the co-evolution of technology and society (Geels, 2005).

I briefly review in the next section the main theoretical frameworks used to study transitions and those that are of particular interest for this thesis.

2.2 Socio-technical transition studies

Over the last 10 to 15 years, studies referring to the concept of socio-technological transition have increased considerably. A transition can be understood as a process that

> …involves far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural. Transitions involve a broad range of actors and typically unfold over considerable time-spans (e.g., 50 years and more). In the course of_such a transition, new products, services, business models, and organizations emerge, partly complementing and partly substituting for existing ones. Technological and institutional structures change fundamentally, as well as the perceptions of consumers regarding what constitutes a particular service… (Markard et al., 2012, p. 956)

Different approaches have been developed to conceptualize the process by which socio-technical transitions occur. The most important ones include transition management (Kemp et al., 2007; Loorbach, 2007; Rotmans et al., 2001), the multi-level perspective (MLP; Geels, 2002; Geels, 2011; Geels and Schot, 2007), strategic niche management (SNM; Kemp et al., 1998; Raven and Geels, 2010; Schot and Geels, 2008; Smith and Raven, 2012; Smith, 2007), technological innovation systems (Bergek et al., 2008; Jacobsson and Johnson, 2000; Hekkert et al., 2007) and arena of development (Jørgensen, 2012). In this thesis, I use the MLP approach to understand the link between the community energy niche and other levels of change occurring at the meso and macro level. I then rely on SNM to better frame the dynamics occurring at the niche level. I choose these two particular theories for their ability to illustrate change at different levels and for their wide application in other fields. They do have their limitations, however, and I address these in the next sections.

2.2.1 The multi-level perspective (MLP)

The MLP was proposed by Rip and Kemp (1998) and subsequently further elaborated by Geels (2002) and other authors (Verbong and Geels, 2007; Geels, 2005; Smith et al., 2005). Originally, it was based on evolutionary theory but later on was broadened to include neo-institutional theory.

One of the main reasons, as stated by Geels (2006), for the development of this analytical framework, was the observation that environmental problems such as climate change are deeply rooted in societal structures and activities. Therefore, Geels suggests that to solve these problems we need to broaden the analytical focus from product or process innovation to system innovation.

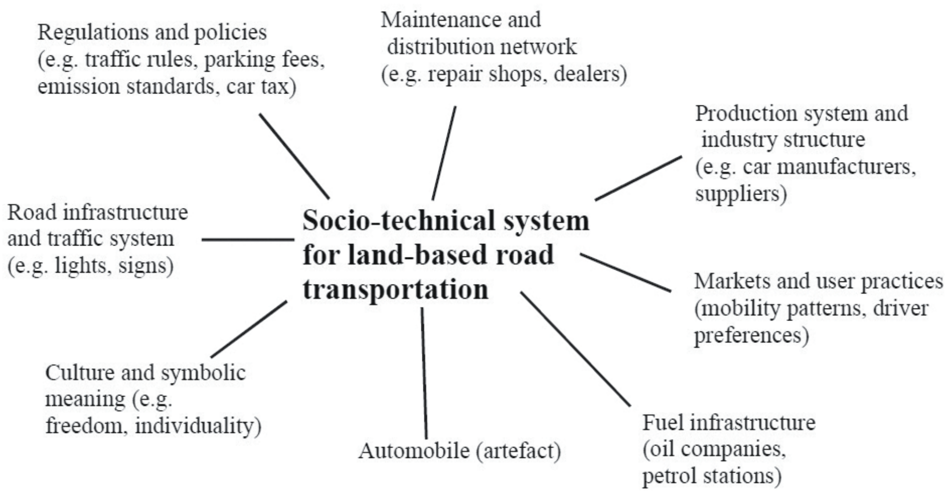

Figure 4 Illustration of socio-technical transport system (Geels, 2002).

According to Geels (2002), system innovations are much broader than product innovations because they involve changes in policy, user practices, infrastructure, industry structures and symbolic meaning. In other words, a shift towards sustainability cannot just be associated to technological substitution, but it also needs to contemplate societal transformation. For this reason, the MLP conceptualizes system change as a major shift from one socio-technical system to another.

To illustrate the nature of socio-technical systems, Geels (2002) uses the example of the socio-technical system built around the automobile (Figure 4). It includes not just the automobile as an artefact but numerous other elements linked to it, such as the road and fuel infrastructure, traffic rules, the network of dealers and repair shops, drivers' preferences, as well as the symbolic meanings associated with the automobile (Geels, 2002). Socio-technical systems are created and reinforced by the actions and routines of human actors who are embedded in their social groups. To illustrate this point with the previous example of the automobile, embedded actors include road-planning authorities, insurance companies, the lobbies of car manufacturers and oil companies, and so on (Geels, 2002, 2004).

Building on both evolutionary economy and institutional theory, the MLP argues that socio-technical systems stabilize due to the emergence of regimes. However, while regimes provide stability to socio-technical systems they are affected by inertia, lock-in, and path dependency (Unruh, 2000). Starting from this important point, the MLP seeks to understand how transitions to new socio-technical systems occur.

According to the MLP, socio-technical changes take place at multiple levels: macro, meso, and micro (Geels, 2002; Rip and Kemp, 1998). The macro level corresponds to the landscape, the meso level to the socio-technical regime, and the micro level to the socio-technical niche. Rather than ontological realities, these layers represent different levels of analysis at which the dynamics of sustainability transitions can be analysed. Originally they were conceptualized as a nested hierarchy (i.e. embedded in each other), but this view was later dropped (Geels, 2011).

The landscape level consists of those material and immaterial elements that sustain society, including political ideologies, demography, the macro economy and the natural environment (Rip and Kemp, 1998). This represents the external environment that influences the interaction between niches and socio-technical regimes (Geels, 2011). An example of a landscape factor is climate change that influences the interaction between the existing energy regime based on fossil fuels and the emergence of a clean technology niche (Kern and Smith, 2008).

The socio-technical regime level is at the core of the MLP. It is defined as the "semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems" (Geels, 2011, p. 27). Regime rules do more than just determine the actions a regime carries out, as they also "configure" its actors. This means that the rules characterizing a regime not only determine favourable institutional arrangements and regulations but also the routines, shared beliefs, capabilities, lifestyles and practices that regime actors have (Geels, 2011).

Socio-technical regimes are formed over a long period of time by the interaction of various forces, including technology, industry, science, culture and policy (Geels, 2011; Smith, 2007). Regimes exist to fulfil a certain societal function related to a human need such as mobility, food or energy (Holtz et al., 2008). Although regimes are not static, they tend to stability and become locked in through path-dependency (Unruh, 2000). Using the example of electric generation in the United States, Unruh (2000) describes how this process of lock-in takes place. Scale economies and improving learning curves driven by government incentives reinforce the existing patterns of energy provision. As energy provision becomes more reliable, the price of electricity goes down, thereby stimulating consumption. Consequently, the government needs to approve the construction of new power plants to meet the increasing demand. The pattern illustrated above generates a self-reinforcing mechanism that locks in the technological and institutional domains. Due to such lock-in mechanisms, it becomes difficult to change the development trajectory of incumbent socio-technical regimes even when in the case of climate change there is evidence of the risks for society (Unruh, 2000).

Another danger of lock-in connected to incumbent regimes can also occur at the beginning of a transition when one option is deemed as the best one while other alternatives are still developing (Kemp et al., 2007). As a result, that particular option becomes the dominant one, leading the entire system to be locked into a suboptimal solution. This may happen for instance with certain forms of renewable energy that might not be completely sustainable (e.g. biofuels) or suboptimal when compared to other technologies. To overcome this risk, Kemp et al. (2005) suggest adopting a portfolio of options rather than devoting all the efforts to one single option. Socio-technical regimes tend to retain a condition of stability but can experience internal tensions under the pressure of the changes at the landscape level.

The niche level refers to protected spaces where new practices and technologies are experimented with. Within these protected spaces, specific societal needs can be met in new and "unorthodox" ways (van den Bosch and Rotmans, 2008, p. 31). Niche novelties deliver distinctive benefits that cannot be provided by the established technologies (Schot and Geels, 2008) and for which niche customers are available to pay more (Levinthal, 1998; Malerba et al., 2007). The novelties emerging at the niche level can be a technical innovation, but also a new form of governance or a new practice (See more about niches in section 2.2.2).

The interaction between niches and socio-technical regimes is another important aspect of the MLP and has been studied by several authors (Kemp et al., 1998; Geels, 2004, 2011). These authors are particularly concerned with the interaction between an emergent socio-technical niche and a regime. However, this part of the literature does not cover the processes by which a niche, or to be more precise a "global niche" (Schot and Geels, 2008), develops. This is in the focus of SNM that is discussed in section 2.2.2.

Returning to questions of how an emerging niche interacts with a socio-technical regime, Smith (2007) observes that this interaction is continuous and leads to the mutual redefinition of their position. Smith (2007) also identified three interaction mechanisms. The first occurs when unsustainable practices in a regime determine the creation of a niche in which experiments try to demonstrate or learn how to implement sustainable solutions. The second occurs as a mutual adjustment between niche and regime when the latter tries to absorb the lessons learned by the former and the former tries to adapt to the latter. The third mechanism represents a sort of cooperation between the niche and the main regime actors by which both try to remove those constrains that impede each other's operations. Smith (2007) recognises that the transfer of new practices from the niche to the regime and vice versa does not happen directly but it requires a process of translation, that is, adaptation. More recent research has further elaborated niche-regime interaction. For instance, Elzen et al. (2012) proposed the concept of anchoring. They used this term to indicate that the connection of a niche to the regime is less stable than what is often thought. For Elzen et al. (2012), the concept of anchoring suggests two things. First, in the niche-regime interaction it is some specific social or technical aspect of a niche that becomes linked up to the existing structures and institutions. Second, the anchoring of a novelty does not necessarily always take place in the regime but can occur also in niches.

As Figure 5 indicates, the MLP shows that shifts in socio-technical systems occur when: (a) there is pressure from the landscape, (b) socio-technical regimes have become instable and open for change, and (c) innovation at the niche level is available and sufficiently developed (Geels, 2002). When these three conditions manifest, innovation from niches begins to spread gradually to mainstream markets. In these markets, the niche innovation can exist as an add-on or hybrid form before completely replacing the old technology (Geels, 2002). Therefore, transitions do not happen as a sudden change from one socio-technical system to another but take place through a gradual process of adaptation. In this process, Geels (2002) highlights the importance of what he calls cascade dynamics: the fact that once an element of a socio-technical regime changes it triggers a cascade effect on other elements.

The original conceptualization of the MLP was later amended because of its strong bias towards a bottom-up change model, in which path-breaking innovation diffuses from niches to socio-technical regimes. To overcome this bias, Geels and Schot (2007) have proposed a fourfold typology of transition pathways to illustrate how transition processes can unfold. These pathways are derived from the variation of timing of multi-level interactions, and the context and the type of multi-level interactions (Geels, 2011). The first transition pathway is called *transformation* and is characterized by gradual change caused by regime actors. It is a form of internal renewal of a socio-technical regime enacted by pressure from social movements and public opinion. The second transition pathway is *reconfiguration*. In this case, an innovation is very well diffused at the niche level and when the regime is put under pressure it begins to adopt some of the practices existing in the niches. This pathway also includes a form of internal renewal of the regime, but the difference with the previous one is that it follows an interaction between the socio-technical regime and the niche. The third pathway is *technological substitution*. In this transition pathway, niche actors compete with the regime and when, due to pressures from the landscape, a new window of opportunities opens, the new technology gradually replaces the old one. The fourth transition pathway is called *de-alignment and alignment*. This is a more intense processes of transformation in which the regime goes through several shocks, creating uncertainty about the future of the system. During the period of uncertainty, different technologies are experimented with at the niche level but eventually only one option becomes dominant, leading to a profound transformation of the system.

Although the MLP is widely applied, it has been criticized in several ways. Some of the most important limitations of this approach include the difficulties in operationalizing the concept of regime (Berkhout et al., 2004), a predominant focus on how to promote niche innovation along with less attention on how to discontinue incumbent regimes (Geels, 2014), and a lack of conceptualization of the role of power and politics (Avelino and Rotmans, 2009).

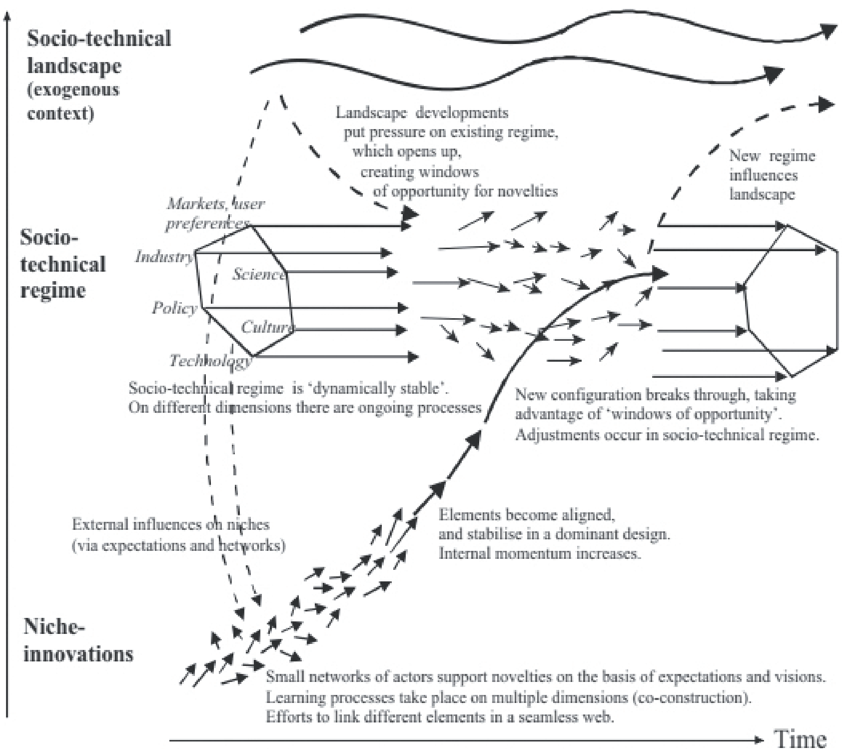

Figure 5 Multi-level perspective on transitions (Geels, 2011).

The first criticism calls for more operationalization and delineation in the concept of regime. Geels (2011) responds to this criticism admitting that there is often in studies adopting a MLP approach a tendency to use the concept of system as the equivalent of regime. He points out the following important difference:

> System then refers to tangible and measurable elements (such as artefacts, market shares, infrastructure, regulations, consumption patterns, public opinion), whereas regimes refer to intangible and underlying deep structures (such as engineering beliefs, heuristics, rules of thumb, routines, standardized ways of doing things, policy paradigms, visions, promises, social expectations and norms). So 'regime' is an interpretive analytical concept that invites the analyst to investigate what lies underneath the activities of actors who reproduce system elements (p. 31).

Geels (2011) views the problem of delineation as a normal problem of establishing the boundaries of the study and suggests that one should "first demarcate her object of analysis and then operationalize the analytical levels" (p. 31). However, the large degree of freedom in operationalizing the socio-technical regime level of the MLP may lead to inconsistencies and difficulties in comparing different studies.

The second criticism calls for more attention to the ways incumbent socio-technological regimes can be discontinued. Although Geels (2011) responded to the bottom-up change model bias with the concept of transition pathways, many authors continue focusing on the ways innovation can be fostered at the niche level rather than focusing on how regime resistance can be neutralized. In this regard, Geels (2014, p. 17) states:

> So, rather than following the normal 'David versus Goliath' storyline, in which heroic green innovations overthrow the giant, this new agenda would shift the analytical agenda to better understand how 'Goliath' can be weakened, eroded and destabilized, to enhance the chances of green David.

Recently, some scholars have begun addressing the issue of how socio-technical regimes can be destabilised, and they have proposed that this process requires more economic and socio-political pressures (Turnheim and Geels, 2013). In order to increase pressure on regime actors, new policy mixes are needed to replace dominant regime rules and provide support to new actors and technologies (Kivimaa and Kern, 2016).

The last criticism has been expressed by those authors who find that the MLP does not account for the important role of power struggle and politics. Shove and Walker (2007) pointed out that the MLP lacks a reflexive and politically informed appreciation of how socio-technical systems are socially constructed. Meadowcroft (2009) says that politics are reflected on all the levels of the MLP. At the landscape level, international treaties determine long-term trends while at the socio-technological regime level, regulation and policy contribute to establish and reinforce the practices and cognitive rules followed by regime actors. At the niche level, government programmes create protected spaces for innovation. Meadowcroft views changes in socio-technical systems for addressing major environmental problems as political issues because they relate to long-term human wellbeing. He argues that because politics play an important role they deserve more attention from those scholars interested in understanding sustainability transitions.

Besides these specific criticisms of the MLP, there are other important and more general concerns, one of which lies at the heart of the concept of sustainability transition: the definition of sustainability itself. In the MLP as well as in the transition literature, sustainability is the ultimate goal but fundamental questions such as what is sustainability and who defines it remain unaddressed.

Bearing in mind the limitations discussed above, I use the MLP approach in this thesis as a general framework to understand the process of destabilization of the energy generation regime triggered by the rise of distributed energy as well as to study the growth of a community energy niche. An MLP approach is necessary because understanding the growth of the community energy niche requires not only the consideration of the internal processes of niche formation (I study this part in light of SNM, see next section) but also the interaction between the niche, the socio-technical regime and the landscape, that is changes occurring at the macro, meso and micro level.

On the macro level, regulatory changes at the national as well as the EU level have promoted the liberalization of the energy sector and increased competition on the energy markets. In addition, policy mechanisms and renewable energy targets (including the goals of international treaties such as the Paris agreement) are further promoting changes at the landscape level that increase pressure on incumbent energy firms. At the micro level, niches experimenting with new socio-technological configurations for distributed energy nurtured over the years by subsidies and integration policies are identified. At the meso level, I distinguish incumbent energy companies, their established practices and the cognitive rules guiding them.

An important shortcoming of the MLP is the fact that it comes without a theoretical micro-foundation illustrating actor behaviour. This means that the MLP is not able to explicate the driving forces of sustainability-oriented innovation for key regime actors such as incumbent firms. To overcome this limitation, in this thesis I used, along with the MLP, the natural resource–based view of the firm (Hart, 1995, 1997). According to this theory, firms that deal proactively with environmental issues develop organizational capabilities that can lead to acquiring a competitive advantage. Therefore, firms tend to integrate environmental issues into their strategy due to the business opportunities that might be seized (Hart and Dowell, 2011). This approach also implies that firms are able to evolve towards sustainability through a unique, inimitable set of organizational capabilities.

The natural resource–based view of the firm and the MLP complement each other in the theoretical framework of this thesis. The first illustrates the drivers of sustainability-oriented innovation at the firm level while the second highlights the importance of systemic thinking for a shift in organizational capabilities, in other words, firms acquire the required organizational capabilities to address sustainability challenges by getting involved with a broad range of actors and networks.

2.2.2 Strategic niche management (SNM)

SNM emerged around the time when the MLP was first formulated by Rip and Kemp (1998). It began by addressing the problem of why promising sustainable technologies such as the electric car would not spread (Kemp et al., 1998). The approach was initially inspired by historical case studies showing that, in many instances, successful innovations started as a technological niche and eventually overturned a dominant regime (Schot and Geels, 2008).

Similarly to the scholars supporting the MLP, SNM advocates maintain that existing socio-technical regimes are locked in and, thus, innovations that have important benefits for society do not spread (Kemp et al., 1998). They also observe that sustainable innovations do not have a market niche in which they can develop. Therefore, SNM emerged as an approach that focuses on creating protected spaces where path-breaking innovations can temporally be shielded by market pressures (Schot and Geels, 2008).

Examples of how protected spaces for sustainability innovations can be created include public policies such as subsidies, investment grants or tax exemptions for renewable energy technologies. These protected spaces are referred to as niches. In the literature there is no clear definition of niche, but it can be understood as:

> …a (local) constellation of culture, practices and structure that deviates from the regime (or dominant culture, practices and structure). A niche is relatively powerless in comparison to the regime, but can meet quite specific societal needs, often in unorthodox ways. (van den Bosch and Rotmans, 2008, p. 31)

Once niches are created, they can be used as testbeds for learning and building new social networks so that the innovation can improve, diffuse and eventually even replace dominant regime practices (Smith and Raven, 2012).

The niches shielding innovations from regime pressures discussed in SNM are different from market niches. In line with Smith et al. (2016), in this thesis I apply the term *socio-technical niche* to distinguish them from market niches. Socio-technical niches are proto-markets and generally exist before market niches (Kemp, et al. 2001). Socio-technical niches are less stable and need some forms of protection. With time, however, this protection can be removed to let them mature into market niches that are able to survive on their own (Smith and Raven, 2012).

The literature has illustrated two main ways in which socio-technical niches are created: passive and active shielding (Schot and Geels, 2008). Passive shielding takes place unintentionally and generally refers to pre-existing niches that emerged due to special conditions, such as in the case of solar PV installations in off-grid locations (Schot and Geels, 2008). Active shielding, instead, is a deliberate strategy to establish technology incubators and can emerge as a result of innovation policies in the form of demonstration or pilot projects (Smith and Raven, 2012).

Besides the process of establishing protective spaces to shield innovations from market selection pressures, three other important aspects connected to niche development have been discussed in the literature. They include niche nurturing (Kemp et al. 1998), scaling-up, and empowerment (Smith and Raven, 2012). Niche nurturing consists of three important processes: shaping of expectations, learning, and building of actor networks (Schot and Geels, 2008).

The shaping of expectations is a fundamental step in niche development because expectations from projects are initially inconsistent, but when a niche matures, they become more crystallized, substantiated by the results from the projects, and shared by numerous actors (Schot and Geels, 2008). Positive expectations justify the need for the temporary protection of niches and provide direction for learning. Future visions and expectations are also important because they attract other actors contributing to the expansion of niches (Schot and Geels, 2012; Schot and Geels, 2008).

Learning is another important process of niche nurturing because it helps in refining and adjusting the visions and expectations through the experiences gained from the projects. Learning, however, to be useful to the growth of the niche should not just be limited to the accumulation of facts and data (i.e. first-order learning) but should also stimulate a change in cognitive framing and assumptions which is referred to as second-order learning (Schot and Geels, 2008).

The last important step in niche nurturing is the building of social networks. While learning contributes to the vertical growth of niches, the building of social networks contributes to the horizontal growth of the niche. In order to be effective, networking needs to create broad networks in which actors commit substantial resources (Raven et al., 2016).

The three processes described above take place within the niche and thus are often referred to as internal niche development (Geels and Raven, 2006). Originally internal niche development used to be evaluated at the level of individual projects (Schot and Geels, 2012). Somewhat later, however, alongside this concept of local development the concept of global niche was introduced (Geels and Deuten, 2006). Figure 6 shows how a global niche emerges out of local projects. The accumulation of local experiments over time can gradually trigger the rise of an "emerging community" or "field", that is, of a global niche (Geels and Raven, 2006). In this process of development from local experiments to a global niche, Geels and Raven argue, rules and institutions are initially diffuse, broad and unstable but with time they become more articulated, specific and stable. With the development of a global niche, expectations about a particular technology tend to become more articulated and homogeneous (Smith and Raven, 2012).

According to Geels and Raven (2006), the journey from local experiments to global niche does not happen automatically but requires the dedicated work of intermediary organizations. Hargreaves et al. (2013, p. 870) have defined intermediary actors operating specifically in the domain of grassroots innovation as

> …organisations or individuals engaging in work that involves connecting local projects with one another, with the wider world and, through this, helping to generate a shared institutional infrastructure and to support the development of the niche in question.

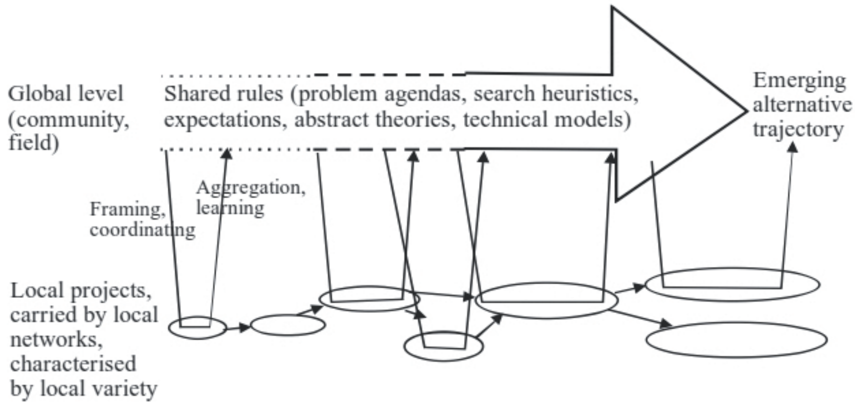

Figure 6 Emergence of a global niche from local projects (Geels and Raven, 2006).

These organizations promote aggregation of knowledge, creation of institutional infrastructures, coordination and framing action (Bird and Barnes, 2014). Aggregation of knowledge is obtained by extrapolating knowledge from local projects and aggregating it at the level of the global niche to then transfer it back to the local projects (Geels and Raven, 2006). Examples of aggregation activities include standardization, codification, model building and the formulation of best practices (Geels and Deuten, 2006). Geels and Deuten further suggest that intermediary organizations also foster networking and the dissemination of information through conferences, workshops, technical journals, newsletters and other channels. Alongside carrying out activities that stimulate internal niche development, intermediary organizations can also have an important role in regime destabilization (Kivimaa, 2014).

An important element of SNM theory linked to niche development is the scaling-up of niches. Scaling-up refers broadly to "moving sustainable practices from experimentation to mainstream" (van den Bosch and Rotmans, 2008, p. 34). This process is understood in at least two different ways. Those authors following a MLP or transition management view see it as the process by which niche practices become embedded in a regime. On the other hand, SNM scholars understand it as the process of development from local projects to the global niche, which in turn can influence the regime (Hoogma et al., 2002; Schot and Geels, 2008; Smith and Raven, 2012). In this thesis, I adopt the latter conceptualization of scaling-up. In literature, this conceptualization of scaling-up is also known as "broadening" (van den Bosch and Rotmans, 2008) or "accumulation" (Naber et al., 2017). According to Hoogma et al. (2002, p. 51), the typical activities for scaling up sustainability experiments into a niche include the following:

> …the dissemination of information, the extension of the network of actors and stakeholders, the involvement of competing parties in the network, the setting up of partner experiments, or a modification of the regulatory and political framework facilitating the establishment of new, similar experiments.

In recent years, SNM scholars have begun focusing on the ways niches compete with incumbent regimes. In Smith and Raven (2012), this process is called niche empowerment and is essentially about the issue, illustrated in section 2.2.1, of how niche and regime interact. They identified two main strategies to achieve niche empowerment: *fit and conform* and *stretch and transform*. In the first strategy, niche advocates aim to demonstrate that the niche innovation can be perfectly integrated into the existing regime without bringing too much change to existing markets, institutions, infrastructures and base knowledge (Raven et al., 2016). In the second strategy, they aim to change the rules of the game by reforming institutions and setting new norms for sustainability (Smith and Raven, 2012).

In both strategies, niche actors use narratives as powerful political devices to promote their cause. According to Smith and Raven (2012, p. 1034) the main themes of such narratives include (a) positive expectations about the future of the innovation advocated justifying the demand for more favourable conditions, (b) claims for niche friendly institutional reforms or claims of competitiveness with mainstream solutions, and (c) statements that challenge the regime and emphasize opportunities arising from alternative solutions, such as the promised role of solar PV technology in mitigating climate change and addressing energy security.

I use SNM because it complements the MLP by providing information about the internal mechanisms that lead to the rise of a community energy niche which, then, under concurrent factors at the landscape level may contribute to influence and change the socio-technical regime towards a more sustainable way of energy production. These mechanisms can be called internal niche dynamics.

As with the MLP, the SNM approach has also received several criticisms. One important point that is of interest for this thesis is the fact that the SNM approach has a predominant focus on technology. Although SNM refers to socio-technical innovation, its "social" aspect has been overlooked. This is an important limitation because social factors are as important as technical factors in sustainability transitions (Smith et al., 2010). For instance, Hegger et al. (2007) point out that because the real challenge in sustainability transitions is more in dealing with the complexity of the social reality rather than in technological improvement, the focus of niche experimentation should be on "concepts" and "guiding principles" (p. 741). Recognizing the role of the societal forces at play in sustainability transition would ultimately broaden the current innovation processes that, according to Hegger et al. (2007,) are "dominated by engineers" (p. 743).

Therefore, when utilizing the SNM approach in the context of community energy – which is a form of grassroots innovation (Seyfang and Smith, 2007) focusing less on technology and more on the social solutions that can be found to address climate change – there are some limitations (Hargreaves et al. 2013). SNM starts from the assumption that path-breaking innovations develop in niches and that these can be scaled up through the dedicated work of intermediary organizations (Schot and Geels, 2008). However, community energy initiatives are driven by less market-oriented motives than other forms of innovation (Hargreaves et al., 2013). This often implies that community energy initiatives do not necessarily aspire to grow or scale up, as SNM would advocate (Hargreaves et al., 2013; Seyfang and Longhurst, 2013).

Hence, there is a tension between the non-market motives of community energy and the main argument of SNM that protective spaces are created to allow new socio-technological configurations to gradually develop in market niches which are then able to compete against regimes. Some authors (Seyfang and Haxeltine 2012; Seyfang et al., 2014 and Smith et al., 2016) have begun addressing this tension, but it remains relatively unclear how non-market-based innovation can grow beyond the limits of protected spaces. This is fundamentally a question of better understanding how socio-technological niches scale up, in other words, how they develop and gain wider influence (Smith et al., 2010).

Another important limitation of the SNM literature with regard to the topic of how niches scale-up is the fact that the role of specific actors influencing this process has been insufficiently explored, especially in the context of community energy initiatives. SNM offers no tools to identify who really plays an important role or really counts in scaling up. To overcome this limitation, I use, along with SNM, stakeholder theory.

The original argument of stakeholder theory was that managers need to take into account all those groups or individuals who can affect or are affected by the activities of an organization (Freeman, 1984). These actors are called stakeholders. Their stake can be simply an interest, a right or be based on ownership (Carroll, 1993). An interest deals with situations when a person or group will be affected by a decision. A right can be based on either legal rights (a person or group has a legal claim to be treated in a certain way or to have a particular right protected) or moral rights (when a person or group thinks it has a moral right to be treated in a certain way or to have a particular right protected). Examples of moral rights include fairness, justice and equity. Different aspects including stakeholder definition and salience, stakeholder actions and responses or firm performance have been discussed in the literature (Laplume et al., 2008). In this thesis, my focus is on the aspect of stakeholder theory concerned with how stakeholders influence organizations.

The application of stakeholder theory along with SNM aided me in better understanding who the main actors involved in community energy projects are and how they influence these initiatives as well as how they are influenced by them. The theory allowed me to identify some of the key factors involved in the social acceptance of community energy projects.

2.3 Summary of the theory used

In synthesis, the theoretical framework of this thesis is built on the MLP (Geels, 2002; 2011; Geels and Schot, 2007) and SNM theory (Kemp et al., 1998; Raven and Geels, 2010; Schot and Geels, 2008; Smith and Raven, 2012; Smith, 2007). The first is utilized to frame the overall context in which the rise of community energy niches is occurring – the ongoing transition to sustainable energy. The socio-technical regime constitutes the backdrop against which the emergence of community energy is seen. This represents the established practices and cognitive rules that the actors operating in the socio-technical system of energy production follow. This first part of the theoretical framework has then been integrated with the natural resource–based view of the firm (Hart, 1995, 1997) to understand the reasons that may push regime actors to promote the energy transition.

The second theory, SNM, is then applied to study the dynamics of niche development in more detail. In particular, this thesis is informed by the concepts of niche nurturing and scaling-up (Schot and Geels, 2008). Niche nurturing was defined as the process by which protective spaces develop through articulation of expectations, networking and learning (Schot and Geels, 2008). The scaling-up of niches, was, instead, defined as the process by which local initiatives develop into a (global) niche, that is, an emerging field or sector (Geels and Raven, 2006; Geels and Deuten, 2006; Schot and Geels, 2008). As with the MLP, I also tried to overcome some of the limitations of SNM by integrating it with other theories. I applied descriptive stakeholder theory (Freeman, 1984; Carroll, 1993) to SNM to identify those stakeholders that influence and are influenced by community energy development and understand how their roles are linked to the various interests that they have at stake in niche development.

3 METHODOLOGICAL CONSIDERATIONS

3.1 Ontological and epistemological assumptions

Kuhn (1962) adapts the term *paradigm* to indicate a disciplinary matrix including commitments, beliefs, values, methods and outlooks that are shared across a certain discipline. It represents the general worldview or perspective guiding the researcher's mind. According to Guba (1990), a paradigm consists of three parts: (a) an ontology that deals with the nature of reality, (b) an epistemology that determines what is knowable and who can know it, and (c) a methodology concerned with how one can obtain knowledge.

In the philosophy of science, there are two dominant ontological paradigms, realism and constructivism, to which two main epistemological positions are often linked: positivism and interpretivism. According to the first ontology, the world is external (Carson et al., 1988) and, thus, reality can be objectively known in spite of the researcher's perspective or beliefs (Hudson and Ozanne, 1988). The goal of positivist enquiry is to make generalizations that are both time- and context-free.

Positivism was criticized and subsequently amended by the supporters of post-positivism, who accept the fact that the background, knowledge and beliefs of the researcher can influence what is observed and that reality can only be imperfectly known (Guba and Lincoln, 1998). Post-positivists, in Guba and Lincoln's view, share with positivists the view that there is only one reality and objective truth, but they concede that knowledge is based on provisional conjectures. Therefore, with time existing claims can be refined or abandoned. Positivist and post-positivist ontologies favour quantitative methods such as statistical and mathematical analysis to uncover the specific causes of events (Carson et al., 2001).

The second ontology instead believes that the reality is not one but multiple and, above all, relative (Hudson and Ozanne, 1988). Contrary to the previous view, the knowledge acquired through interpretivism is socially constructed (Carson et al., 2001) or perceived (Berger and Luckman, 2011; Hirschman, 1985). Interpretivist researchers use a more personal and flexible approach (Carson et al., 2001) and aim at interpreting the meanings of human interaction (Neuman, 2000; Hudson and Ozanne, 1988). Interpretivists focus on understanding the motives, meanings, reasons and other subjective experiences, which are always relative to the time and context in which they are considered (Hudson and Ozanne, 1988; Neuman, 2000). Both respondents and researchers contribute to co-create knowledge, which is not absolute but often permeated by ideological and political values (Rouse, 1996). Therefore, in the interpretivist approach qualitative methods such as participant observation, in-depth interviews or focus groups are favoured.

The term *constructivism* is often used interchangeably with constructionism or social constructionism. However, there is an important difference between the two. The first is more concerned with how individuals mentally construct the world they experience through cognitive processes. The second is less concerned with the meaning-making of individuals and focuses on how social phenomena are constructed through language and shared meanings (Berger and Luckman, 1966). In other words, while the first has its focus on the meaning-making activities of single individuals, the second looks at the collective or social generation of meaning (Crotty, 1998).

In article I, I relied on a post-positivist view. This position determined the methodological choices I made including the research questions, the data collection and analysis as well as the type of results that were obtained. In articles II (at least partially), III and IV, I carried out the research from a social constructionism point of view although I do not take a strict stance, that is, a completely relativist position in which I believe that there are only multiple realities and that they are all meaningful (Burningham and Cooper, 1999). This is because, in my view, despite the fact that the phenomenon of community energy has some features that are shared among many practitioners in different countries, it is mainly a socially constructed phenomenon heavily dependent on the type of context in which it emerges. Table 3 summarizes the ontological and epistemological positions assumed in each article included in this thesis.

Table 3 Ontological and epistemological assumptions of each article.

Article	Ontological assumptions	Epistemological assumptions
I	Realism	Post-positivism
II	Social Constructionism	Interpretivism
III	Social Constructionism	Interpretivism
IV	Social Constructionism	Interpretivism

3.2 Methodological choices

The research conducted in this thesis follows a mixed methods approach. According to Creswell et al. (2003), *mixed methods* implies the integration of quantitative and qualitative data collection and analysis in a single study. I chose this methodological approach because the theoretical lenses I use imply the combination of different paradigms and levels of analysis (Geels et al., 2016; Geels, 2010). Moreover, I use a mixed methods approach to better deal with the complexity of community energy as a socio-technical phenomenon.

The research followed what Creswell (2012) calls an exploratory sequential mixed methods design. This design involves collecting data in an iterative process in which the data gathered in one phase contributes to the data gathered in the following one. Therefore, the quantitative and qualitative datasets available were connected rather than merged (Creswell, 2012). The results concerning the resistance of Finnish electric utilities to the expansion of renewable energy identified in article II was subsequently tested through a larger sample of electric utilities from 26 different countries in article I. Thus, article I builds on article II. The same design was also applied within article II where the first qualitative interviews were conducted and then followed by a survey with 27 distributed energy experts.

Although the thesis employs a mixed methods approach, the qualitative approach has a greater weight. To illustrate this I use the qualitative-quantitative continuum created by Johnson et al. (2007) and illustrated in Figure 7. If pure mixed methods exist between pure qualitative and quantitative research, the approach followed in this thesis is between pure qualitative research and pure mixed methods (the left side of the continuum).

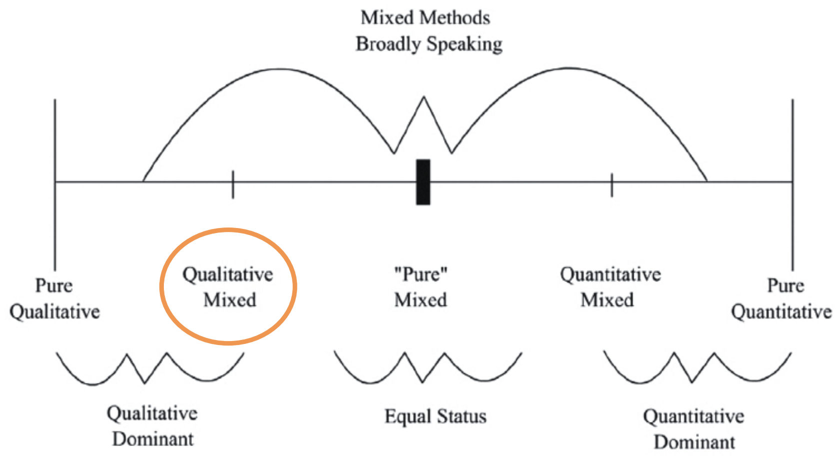

Figure 7 Illustration of mixed methods in relation to qualitative and quantitative research (Johnson et al., 2007).

The higher weight of qualitative research in the thesis was substantially due to the nature of the phenomenon being examined: community energy. This is an extremely variegated phenomenon, the emergence of which cannot easily be explored with a purely quantitative approach but requires a finer analysis of the context in which it emerges.

To answer the first research question, the data were obtained by pooling multiple observations concerning environmental and economic variables for the same set of energy firms over a period of 10 years. This type of longitudinal data collection is known in econometrics as panel data. A panel data design was chosen to increase variability and reduce collinearity (Baltagi, 2001). The data used to answer the last three research questions of the thesis were, instead, collected through both quantitative means (a survey) and qualitative interviews. Interviews were used because they provide insights into the experiences, opinions and ways people perceive their lived world (Kvale, 2007). See section 3.3 for more details on the research materials and analysis techniques employed in this study.

3.3 Research material and its analysis

The research material of this thesis consists of three distinct datasets. The first includes about 450 panel data observations (article I), the second 75 qualitative interviews (articles II, III and IV), and the third a questionnaire directed at 26 experts (article II).

The first dataset was built from different data sources including Datastream, IEA's energy policy database and REN21 reports. It includes firm-level data concerning 66 large electric utilities from 26 countries covering a period of 10 years (2005–2014).

The second dataset consisted of 75 qualitative interviews conducted between 2012 and 2016 in Finland, Scotland, Germany, Northern Ireland, Sweden, Ireland, and Norway. The majority of these interviews (41) were structured whereas the rest (34) were semi-structured. The duration of the interviews ranged between a minimum of 37 minutes to a maximum of 2 hours. The number of interviews for each country can be found in Table 4 whereas the number of each actor type is shown in Table 5. Altogether, the number of community energy projects studied through the interviews with various actor types was 50.

In line with Firmin (2012), structured interviews were used to allow comparison among different types of community energy projects in different contexts. On the other hand, semi-structured interviewing was applied to obtain more flexibility and let new themes emerge from the conversations with the interviewees. In both the structured and semi-structured interviews, the interviewees were selected based on their level of experience and relevance to the study topic.

To secure heterogeneity, a maximum variation sampling method (Patton, 2002) was applied in the selection of the informants. The interviewees were mostly citizens involved in community energy projects, energy industry representatives, experts in the field of renewable energy, energy companies' managers, representatives of national and regional authorities, and intermediary organizations.

Table 4 Number of interviews for each country.

Country/Region	Number of Interviews
Finland	39
Scotland	24
Germany	6
N. Ireland	2
Sweden	2
Ireland	1
Norway	1
Total	**75**

Table 5 Number of interviews for each actor type.

Actor type	Number of Interviews
Community energy leaders	38
Public institutions (e.g. universities, ministries, state agencies)	16
Companies	13
Intermediary organizations	5
Lobbying organizations	3
Total	**75**

The purpose of the interviews was to derive interpretations rather than facts or laws (Holstein and Gubrium, 1995; Holstein and Gubrium, 2011). In order to enhance the process of interpretation, almost all of the interviews (68) were recorded and subsequently transcribed verbatim. Of the remaining seven, field notes were made.

The last dataset was employed to complement the information from the semi-structured interviews utilized in article II. It consisted of the responses to a questionnaire with a scale-based evaluation focusing on 50 change factors in the distributed energy sector given by 26 experts from Finland. In accordance with Amara (1981), the respondents were asked to express a preferred and a probable future view for the year 2025 as well as a valuation of importance for each change factor. Preferred and probable futures were expressed on a five-step scale of -2…+2, where -2 referred to a substantial decrease from the present level, 0 referred to no changes to the present level, and +2 referred to a substantial increase from the present level. The importance of each change factor was then estimated on a scale of 1–5. The panel of experts selected covered various areas of expertise and renewable energy sources.

In illustrating the research materials of the thesis, I have kept the qualitative interviews and the survey separate because, although they share some similarities, they are profoundly different epistemologically. Qualitative interviews follow a constructionist view in which the interviewees and the interviewer are both active meaning-makers. In surveys, the approach tends more to positivism, in which interviewing is experienced as a passive means for retrieving information (Holstein and Gubrium, 1995; Holstein and Gubrium, 2011).

Because the three datasets employed were different in nature, diverse techniques were utilized to analyse them. For the panel data, a regression analysis with both a fixed and random effects estimator model was run. These two estimator models have advantages as well as drawbacks.

The fixed effects estimator model considers each individual in the panel as a group and focuses on the change occurring within each group. Consequently, it provides precise estimates about how much on overage the dependent variable changes when the independent variable of the individuals in the panel changes. Its main strength is that one can control for all unmeasured variables and produce accurate estimates for variables that vary over time. On the other hand, it is less efficient compared to the random effects model in using the data because observations with no within-individuals change are not included in the estimate (Hsiao, 1986). The random effects estimator model also allows the estimation of coefficients for variables that do not change over time such as sex or race. However, the estimation is based on the strong assumption that the unmeasured time-constant variables are independent of the measured variables (Baltagi, 2001), which may not always be the case.

Some researchers have argued that one estimation model is superior to the other. In truth, they simply report on different aspects of the data and can be used to answer different types of questions. Therefore, in line with Petersen (2004), in this thesis I reported the results obtained under both fixed and random effects estimation models.

The interviews' transcripts (both structured and semi-structured) were processed with thematic and narrative analysis. Thematic analysis can be defined as an exploratory approach in which sections of text from, for example, interview transcripts, field notes or documents are coded according to whether they appear to contribute to an emerging theme (Boyatzis, 1998; Braun and Clarke, 2006). The main difference in using this approach between structured and semi-structured interviews was that the former contained only a minor degree of freedom to deviate from the topics in the interview guide, and the latter allowed more room for other themes to emerge from the interview (Thomas, 2006). The first step of the analysis was to identify emerging patterns in the data and give them a code, a label that described what theme that segment of text concerned. These codes were then brought together to see how they could form a sub-theme and eventually an overarching theme. Once the overarching themes emerged, they were reviewed and refined according to the principle of "internal homogeneity" and "external heterogeneity" (Patton, 2002, p. 465) to test their stability. Table 6 shows an example from article III of how the overarching themes were created.

Though thematic analysis can be a powerful technique to make sense of qualitative data, it also has some important limitations. One of the main criticisms concerns its interpretative nature, the way it relies on the interpretation of others' actions through the understanding of the researcher (Boyatzis, 1998). Braun and Clarke (2006) also pointed out that thematic investigation can be reduced to a mere descriptive endeavour if not used in an existing theoretical framework giving ground for the analytical claims made. In addition, they also found that, compared to other qualitative methods such as narrative analysis, this mode of investigation is not able to highlight consistencies or contradictions through the account given by the interviewees that might be revealing.

Some interview transcripts were then processed with narrative analysis. This data analysis method was utilized with the belief that narratives are about human action and experience (Eriksson and Kovalainen, 2008). The focus was on the substance of stories rather than on the activity of storytelling. Therefore, the interview transcripts were analysed to identify similarities and differences between the accounts given by the interviewees (Gubrium and Holstein, 2009). The accounts given by the interviewees that shared similar aspects linked to niche development theory were grouped under the same category and then summarized in short abstracts illustrating different types of community energy projects.

The responses to the questionnaire directed at the panel of distributed energy experts was analysed with descriptive statistics to create a futures table. The mean and standard deviation of the top five change factors in both the preferred and probable future views were calculated. The means of the preferred views represented a future image named *Prosperity* whereas the means of the probable views represented a future view called *Steady growth*. In addition, a third future image called *Stagnation* was introduced to represent a dystopian future – a view that was the opposite of the Prosperity view. The main limitation of this third dataset was mainly the small number of respondents. Although the sector is not too big in the context of Finland, a larger sample would have had more statistical power. While survey data can be a powerful source of information to arrive at general conclusions, it can be biased by the type of sampling procedure adopted. This issue was avoided here by increasing as much as possible the variety of renewable energy sources and related expertise in the panel of experts surveyed.

The data collection and analysis methods employed in each article followed different types of reasoning. In article I, I applied deductive reasoning because the aim of the research was to test the validity of the natural resource–based view of the firm in the context of the electric utility industry switching to renewable energy. Therefore, in this case the data were collected and analysed to see if that link between increased environmental performance and financial outcomes could be confirmed. In article II, III and IV, I then used inductive reasoning. As a result, in these articles I remained open to various possibilities and explored the data to find emerging patterns and themes that could lead to generalizations. In my view, an inductive approach was needed in order not to become locked into assumptions that would limit the exploration of the research questions. Table 7 shows a summary of the research material and the ways it was collected and analysed.

Table 6 Examples of the coding frame with associated stakeholders categories utilized in article III

Stakeholder	Theme	Subtheme	Sample quotations
Government	Available funding Difficulties in accessing funding Unsteady regulatory framework	 Feed-in tariff	*"Availability of grants for such projects", "The change to feed-in tariff rules has stalled the whole industry for 18 months", "Funding planning process, initially recommended for refusal, a very hard and difficult time for the board personally"*
Energy supplier	High energy price	Fuel poverty Energy costs	*"…increasing price of oil and bills. Couldn't afford to keep going on paying these bills", "The fact that the residents wanted affordable heat, we have fuel poverty within the development…"*
Local businesses	Opposition	Competition	*"Some opposition from local business community, saw them as competition"*
People living near installations	Opposition	Impact on health due to noise Affected value of the landscape	*"Some resistance around wind turbines and the aesthetics of the site, nervousness around noise issues from immediate neighbours"*

Table 7 Details of how the data were collected and analysed

Article	What is included in the sample?	How were the data collected?	Who collected the data?	When were the data collected?	How were the data analysed?	What type of reasoning was applied?
I	66 international electric utilities from 26 countries	Retrieved from Datastream, IEA, REN21 databases	The main author	January–October 2015	Regression analysis	Deductive
II	43 experts in distributed energy from Finland	Semi-structured interviews/ Expert survey	All the authors	August 2013–March 2015	Thematic/ Descriptive statistical analysis	Inductive
III	41 people involved in community energy projects mainly from the Nordic countries	Structured interviews	Research project members	September 2012–May 2013	Thematic analysis	Inductive
IV	13 people involved in community energy projects and 11 Experts in local energy development from Finland	Semi-structured interviews	Research project members	March–June 2016	Thematic/ narrative analysis	Inductive

4 RESULTS

4.1 What is the relationship between an increase in renewable energy production and energy companies' profitability?

In capitalist economies, the main goal of an enterprise is profitability. Thus, incumbent energy companies can increase their investments in renewable energy if they see ways to improve their profitability or develop a competitive advantage. Based on this line of reasoning, article I looked into the link between the expansion of renewable energy at the firm as well as the country level, and three different indicators of firm performance.

The study relied on a panel of 66 large electric utilities from 26 countries covering the period 2005–2014. A regression analysis for panel data plus the Granger causality test were run to explore both the level of correlation and possible causality links (in the sense of Granger causality) between an increase in renewable energy production and firms' profitability. The results showed that under two different estimation models (fixed and random effects) the correlation between renewable energy production and all three profitability indicators was consistently negative though the level of significance did vary. The Granger causality test then revealed that an increase in renewable energy production Granger caused a decrease in Tobin's *q*, which was used as a proxy for a firm's long-term profitability. In synthesis, the study showed strong evidence of a negative relationship between an increase in renewable energy production and long-term profitability when the latter was measured at the firm level as well as at the country level. However, at the firm level and for at least one of the three performance indicators, this relationship was moderated by the level of the firms' carbon intensity. So, for firms with very high carbon intensity (i.e. a high reliance on fossil fuel–based production), an increase in renewable energy production was positive up to a certain point. Once a certain level of carbon decrease was reached, the relationship again became negative.

The findings also showed a negative time trend indicating that the economic underperformance of the electric utilities studied can be imputed, in part, also to unfavorable conditions that may include a stagnant demand for electricity, overcapacity, nuclear phase-outs in some countries and the financial crisis that struck Europe in 2007.

The robustness check confirmed the presence of a negative relationship between renewable energy growth and profitability at the firm level. In addition, it also revealed (although only in one estimation model) that firms operating in countries that have not adopted a feed-in tariff scheme and that rely on a quota obligation system/renewable portfolio standards had better short-term performance than firms operating in countries without these.

A confirmation of the main results of article I can be found in article II, although this study was limited to the context of Finland. Some of the interviews with the managers of the main energy companies in the country revealed that there was deep concern about the negative effects of a rapid expansion of renewable energy such as the one happening in Germany.

> I don't think that in Finland they will go in the same direction as in Germany, because it has really bad influences on the whole society. It's the… really big power plants losing the revenues [which is a problem] because these power plants in Finland are mostly municipally owned and they are the biggest source of money for the city.

Another interesting confirmation of the findings from article I can be found again in article II with regard to the resistance by incumbent energy companies to the introduction of a feed-in tariff. In article II, it was found that the energy industry representatives opposed the introduction of a feed-in tariff in Finland, basing their opposition on arguments such as unfair distribution of benefits and high administrative costs.

> We don't like subsidizing because it must be… business must be always, you know, market-based. And the prices must be market-based. We are selling to our customers, at the market prices and, of course, what we are paying to our customers is also based on market prices.

Article I shows that the concern of firms is due to the fact that feed-in tariff schemes negatively affect the profitability of conventional power plants. The finding concerning the opposition to feed-in tariffs in Finland is supported by the main results on electric utilities' profitability showed in article I. Feed-in tariffs have, to date, been the most powerful policy mechanism in promoting the diffusion of renewable energy (Couture and Gagnon, 2010), which in turn affects the long-term profitability of conventional generation.

4.2 What are the prospects, drivers and barriers of the transition to distributed energy?

Article II focused on analysing the prospects, drivers and barriers of the transition to distributed energy production. The study was conducted in Finland and consequently the results cannot be generalized, although similarities might exist with other countries that have highly centralized energy systems. The research material consisted of a questionnaire directed at 26 distributed energy experts and 15 semi-structured interviews with representatives of energy companies, Finnish institutions and various associations. The data from the semi-structured interviews were analysed with thematic analysis while those obtained through the questionnaire with descriptive statistics.

The study identified the future paths that a transition to distributed energy may take in Finland in the mid-term, that is, over the next decade. Additionally, it also illustrates the drivers and barriers that are involved in this process of change. The results show a difference between what the experts expected to happen in the future and what they preferred to happen. The preferred future view is called Prosperity while the expected future is called Steady growth.

In a Prosperity future view, the share of distributed energy production would be significant, but it would not entirely replace centralized energy production. From a technological point of view, solar PV would play a fundamental role. One of the most interesting findings of this first future view was that the experts did not expect a widespread diffusion of distributed energy technology to be triggered by traditional financial policy instruments such as feed-in tariffs but rather by regulatory changes, R&D funding and harmonization of procedures. This was in contrast with Scotland, where more financial help through a feed-in tariff was sought for distributed energy production.

In the Steady growth future view, the pace of the change is much slower that in Prosperity. In this future view, both economic instruments and regulatory changes are limited, which prevents the diffusion of new business concepts and the growth of technology manufacturers. The second future view shows that experts expect growth in distributed energy production in any case. They see it not as a question of will the distributed energy sector grow, but as a question of how fast it will grow.

Another important finding of the study was that the panel of experts did not expect energy cooperatives to be one of the top five change factors in the distributed energy sector in Finland. This was a surprising result considering the country's long tradition of cooperatives.

The second part of the study dealt with the drivers behind the adoption of distributed energy generation and the barriers that hinder its diffusion. The question of the drivers and barriers to the growth of the distributed energy sector was also partly answered by article III. Based on the findings of article II and III, the drivers of distributed energy innovation have been grouped here in four larger categories: characteristics of individuals, social need, economic factors, and policy factors (see Table 8). The first category includes one or more characteristics of the people adopting distributed energy solutions. Examples of such characteristics are willingness to pay more for green energy, values, ideology or skills and competences. The second category is linked to projects that were triggered by a particular social need, such as, for example, the need to address the lack of access to the electric grid or energy poverty. The third category includes economic factors pushing towards distributed energy. Examples include energy saving or opportunities related to new business concepts (see section 5.2.5 in article II). The fourth category includes policy drivers such as investment support for heat pumps, fossil fuel taxation and R&D for smart grids.

Table 8 Drivers and barriers of community energy development.

Drivers	**Barriers**
Characteristics of individuals • Willingness to pay more for green electricity • Skills and competencies • Values (e.g. environmentalism, entrepreneurism, volunteerism) • Attributes (e.g. active, determined, hands-on) • Ideology *Social need* • Lack of access to the heat network in rural areas • Energy poverty *Economic factors* • Energy saving • Market opportunities for companies • New business concepts *Policy factors* • Investment support • Fossil fuel taxation • R&D on smart grids	*Regulation* • Reliability and quality of supply of wood pellets • Construction codes • Drilling regulation • Lack of standardized procedures for grid interconnection • Taxation • Variability and complexity of building permit procedures *Financing* • Feed-in tariff • Lack of trade schemes for excess heat • Low buy-back rates for electricity *Incumbents' resistance* • Concerns for grid stability • Low price of electricity • Concerns for the profitability of municipal power plants *Technology performance* • Increased operation costs • Issues related to metering

The business concepts identified as drivers of distributed energy were the turn-key model, facilitator model, utility-side solar PV model, and joint purchase model. In the first model a utility provides a turn-key solution to its customers. This includes not only the generation equipment but also installation, connection to the grid and the possibility to sell the surplus electricity to the utility. In the second model, a utility acts as a facilitator for local energy producers selling their surplus energy to the grid. The producer determines the final price while the facilitator charges a small fee for the service offered. The third model was developed to give access to distributed energy to those utilities' customers who, for instance, do not have a suitable roof for PV panels or who do not want to get directly involved in energy production but are willing to pay a fixed amount of money to receive a certain quantity of distributed energy monthly. The fourth model aims at reducing the costs of distributed energy generation equipment through large collective orders. Most of the equipment purchased is then installed at private dwellings.

Similarly to the drivers, the barriers listed in article II and III that prevent the diffusion of distributed energy can be grouped into four larger categories. They are regulation, financing, incumbents' resistance, and technology performance (Table 8). The first category includes construction codes, drilling regulation, lack of standardized procedures for grid connection, low buy-back rates, taxation, and the variability and complexity of building permit procedures. The second includes the lack of financing schemes to promote the growth of the sector, as was the case in Finland, which lacks a feed-in tariff for small-scale distributed energy. The third refers to the building of narratives by regime actors around concerns for grid stability and the profitability of conventional power plants as well as market failure associated with low energy prices. Finally, technology performance includes those factors that are related to the overall performance of technologies for distributed energy production.

4.3 How are stakeholders involved in community energy projects and what role do they play?

Article III identified the key stakeholders and the role they play in community energy projects. The research material was obtained from an international research project called SECRE that looked at the role of social enterprises in community renewable energy deployment in countries in the northern part of Europe. It consisted of 53 cases of community energy projects, 41 of which became relevant for the study. The cases were from Scotland, Finland, Northern Ireland, Ireland, Norway, Sweden, and Germany. Different ownership models were included as well as various renewable energy sources. For each project, a structured interview dealing with 12 specific themes related to project development was conducted. The data were analysed with thematic analysis.

The results showed that stakeholders' influence on community energy projects could be distinguished on three different levels: macro, intercommunity and intracommunity. At the macro level, the key stakeholders were the government, energy suppliers, the network operator and commercial developers. These actors were the most powerful in setting the "rules of the game". In the language of the MLP, they are the regime actors who can help community energy initiatives to grow but also the ones that can hinder them. For instance, governments can provide funding for community-led initiatives, but they can also slow down their development when sufficient information is not provided or when there are policy inconsistencies.

A crucial finding of this study in regards to funding was that a large number of projects were able to self-finance or to provide at least the front capital to start the project. This finding illustrated that, in contrast to the conventional wisdom, community energy can also thrive on internal resources or at least do not necessarily depend of government subsidies.

Energy suppliers (i.e. incumbent energy companies) were seen as one of the actors indirectly triggering community energy initiatives. This was due to the steep increases in energy prices registered across most of the countries in which the projects were carried out. These actors were often also the network operators. Network operators had predominantly a negative role because, in some cases, they delayed the process of grid connection or increased the connection fee to deter further community projects. This finding is consistent with the results of article II, which focused specifically on the case of Finland and are in line with the implications derived from article I.

Commercial developers were direct competitors of community energy projects. However, these stakeholders were also providing interesting examples of hybrid models of ownership with local communities. Co-ownership of renewable energy projects was a model well diffused in Scotland, providing an example of how regime actors can cooperate with enthusiastic niche innovators to foster renewable energy deployment.

The second level of influence identified was the intercommunity level. Here the two most relevant stakeholders were nearby communities and intermediary organizations. This level of stakeholder influence corresponds to what is called, in the language of SNM, the global niche. The analysis highlighted how activities such as networking, exchange of know-how, the crystallization of expectations as well as the dedicated work of intermediary organizations contributed to establish a new field of practice in the renewable energy development domain. With regard to the latter stakeholder, one important finding was that there was a large variety of intermediary organizations that emerged in response to different type of stimuli. They ranged from organizations that had been purposely set up to support community energy projects, such as Community Energy Scotland, to state agencies or ministerial departments that provided ad hoc support to the initiatives, such as in the case of the Sustainable Energy Authority of Ireland or the Finnish Environment Institute (SYKE). Intermediary organizations were external to the projects and provided support with funding applications and feasibility plans, examples of best practices from other communities, and brokerage services between community groups and technology suppliers.

The third level of influence identified was the intracommunity level. This corresponds to the level of local experiments as described both in transition management studies and in the SNM approach. Within this sphere, the most influential actors were the local community at large, local businesses and people living near an installation as well as project champions.

Table 9 Stakeholders and their roles in community energy projects development (adapted from article III).

Level	Stakeholder	PROCESS: Supportive	PROCESS: Hindering	OUTCOME: Beneficiary	OUTCOME: Harmed
Macro	Government	Available funding Feed-in tariff	Difficulties in accessing funding Unsteady policy framework	Increased RE capacity	
	Energy supplier	High energy price			Lost market share
	Network operator	Lack of energy infrastructures (indirect)	Delayed connection to the network	Network connection fee	Affected grid stability
	Commercial developers	Interest to cooperate	Interest to compete	Income from partnerships Enhanced reputation	
Inter	Nearby communities	Shared knowledge and experience		Shared knowledge and experience	
	Intermediary organizations	Advice and guidance			
Intracommunity	Local community (at large)	Availability of resources Community ownership General positive attitude	Skepticism Lack of trust	Economic development Self-sufficiency Identity Sustainability Start-up capital	Shattered community cohesion Generation curtailments
	Local businesses	New business opportunities	Opposition	Income from new business opportunities	Competition
	People living near installations		Opposition		Impact on health due to noise Affected value of the landscape
	Local champions	Skills and competences Individual values	Lack of skills and competences	Learning Income from co-ops	

Apart from a few cases in which local businesses and people living close to an installation were dissatisfied, in most of the cases the community in which a project was developed was supportive. This was due to the outcome of the projects that contributed to local economic development, self-sufficiency, community identity and sustainability. One interesting finding regarding how the profits of the projects were used was the fact that in half of the cases the revenues were reinvested in the community for social or environmental purposes. In some cases, they were even used to fund new renewable energy projects.

Project champions were a group of stakeholders that emerged separately from the local community at large. These were those people who had a prominent role in starting, endorsing or carrying out a project. They became involved with the projects for three main reasons: they wanted to support an initiative as a volunteer; they wanted to act for the environment; or they wanted to demonstrate the viability of particular renewable energy solutions through experiments. The most important result regarding this group of stakeholders was that besides their strong supportive role their lack of competences in carrying out complex energy projects slowed down, in some cases, project development. This finding was also confirmed by article IV in which it was found that some projects (e.g. cost reduction projects) lack the necessary know-how to carry out a renewable energy project and try to acquire new skills from other initiatives sometimes also outside the community energy niche.

The study contributed a framework illustrating the key stakeholders and their respective stakes both during the process of development and after a community energy project has been completed. At the time when the study was conducted, it was probably the first that used stakeholder theory in the context of community energy. It revealed that stakeholders do not influence community energy projects by simply opposing or supporting them but can actually have both roles at the same time. Additionally, it also showed that stakeholders' views of community energy initiatives are not fixed but can change according to the development phase of a project and the type of stakes they hold. The framework proposed in article III is presented in Table 9.

4.4 What type of community energy projects can be found and what factors may influence their scaling-up?

Article IV applied SNM theory to better understand the type of community energy projects that can be found and factors that influence their scaling-up. The data were collected from Finland, so the results cannot be generalized even though similar issues might exist in other countries. The research material consisted of 19 semi-structured interviews with two groups of interviewees. The first group included community energy project leaders whereas the second representatives of various expert organizations and institutions involved in the community energy sector in Finland. Some examples of this latter category of interviewees encompassed research institutes, ministries, funding and regulatory agencies. The first set of interviews was processed with narrative analysis while the second with thematic analysis.

Based on the narrative analysis of interviews with project actors, a typology of community energy projects was created. Three different categories of projects were identified: cost reduction, technical expertise and system change projects. Each category of project differed in terms of expectations, networking and learning. The main motivation of the first category of projects was cost savings. Their scope was limited to a very small geographic area and learning happened in external networks. These projects showed a lack of interest in scaling-up.

The second group of projects was strongly based on the technical expertise of some of their key actors, which often was the starting point for a project. The initiatives, also in this case were again limited to very small geographic areas. Their main objective was to capitalize on their pre-existing know-how to fulfil some specific need or interest. Technical expertise projects were less focused on learning in external networks but shared a lack of interest in scaling-up with the previous group of initiatives. The third group of projects aimed at promoting the growth of certain renewable energy technologies or knowledge about renewable energy production. The most intense learning and networking activities between community projects were found in this last category of projects, which was also the only group of initiatives clearly aiming at scaling up. These projects were also strongly based on key actors' existing know-how, yet contrary to the previous initiatives they were based on open networks that were not limited to small geographical locations but constituted what Walker et al. (2010) defined as a "community of interest".

The results from the thematic analysis revealed then that a lack of clear vision for the niche was one of the main hindrances. Such a lack was evidenced by the absence of national policy support for community energy projects, the continuing discussion among experts about what community energy should mean and look like in the Finnish context, and uncertainties regarding how to best arrange project ownership and responsibilities.

A lack of vision or of expectations for a community energy niche in Finland was also found in article II. In that study experts expressed their preferred and expected future views for distributed energy. It was found that among the new business concepts that are expected to change the market in Finland, energy cooperatives were not among the top five models mentioned.

Joint ownership of renewable energy installations is a recurrent feature of community energy in many countries. However, the findings of article IV indicated that in Finland it is relatively rare to jointly own production means. Thus, besides the nature of the projects (cost reduction, technical expertise or system change), cultural factors may also prevent the scaling-up of community energy initiatives.

On the other hand, it was also found that local communities that have a strong background of cohesion and activism might get involved in community energy projects more easily. This point is supported by the results of article III where it was found that the existence of a collaboration network between small villages in Sweden started in the 1980s favoured the exchange of experiences related to renewable energy production.

The interviews with the experts also revealed that while there were some intermediary organizations operating in the Finnish community energy sector, their activities were not following an overall strategy deliberately seeking to promote the growth of the sector. Their operations were more ad hoc than strategic. Thus, questions remained about their role and how they could better support the sector by offering brokering service to communities that, for example, needed to deal with network operators. The study also indicated that in the case of Finland, where community energy projects have a strong local rootedness, regional intermediaries carrying out aggregation and lobbying activities could be better placed to support the development of the community energy niche than national ones are.

4.5 Integrated model of the results

Figure 8 shows a model that integrates the results from all the articles of this thesis. The figure was originally presented in article III but here it has been expanded following the insights gained from the studies that followed it and the growth of my understanding of community energy.

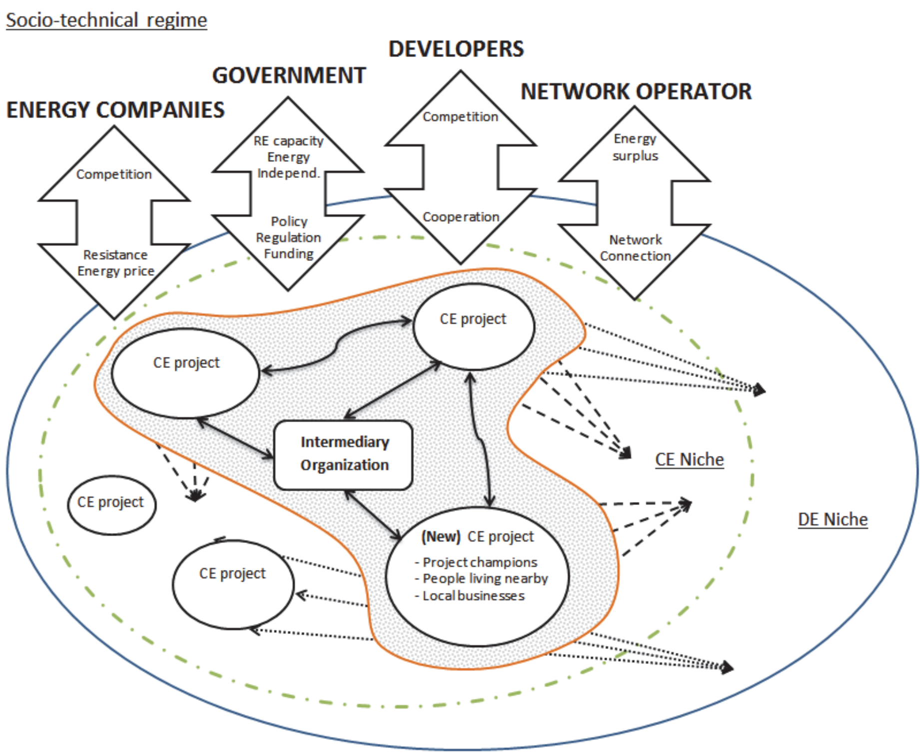

Figure 8 Integrated view of the results.

The lower part of Figure 8 shows two circles. The blue one represents the overall distributed energy (DE) niche while the green one represents the community energy (CE) niche. The line demarcating the community energy niche is dashed to express the idea that the definition of community energy is not set in stone but changes according to the background in which community energy is analysed. I located the community energy niche inside the wider distributed energy niche because, in my view, the community energy niche is a sub-sector of the wider distributed energy sector. These two niches are related and the main difference between them is in what Seyfang and Smith (2007) call market-based innovation vs grassroots innovation. The first type of innovation applies more in general to the wider distributed energy niche whereas the second is most particular to the community energy niche – in which the driving force may not necessarily always be profit.

Within the community energy niche (the green dashed line) several community energy initiatives can be found. However, not all of them are automatically networking and learning from each other. Community energy niches may include projects that are more interlinked and ready to scale up as well as projects that are less active. In article IV, the ones that were ready for scale-up were called system change projects. They form the nucleus of an emerging community energy niche. Along with them, there are other initiatives that are not interested in expanding but remain focused on addressing one particular social need or exploiting some existing resources (e.g. know-how or natural resources) in a specific geographic area. Examples of the latter type of initiatives are the cost-reduction and technical expertise projects discussed in article IV.

To represent the idea of a niche nucleus, I demarcated the area where the projects are more interconnected with an orange line. As SNM niche theory predicts, when local projects start to network and learn from each other through the dedicated work of intermediaries (Geels and Deuten, 2006; Schot and Geels, 2008; Smith and Raven, 2012) a global niche starts to emerge. Based on the findings of this thesis, I propose that it is the nucleus of more active and interlinked projects that contributes to the emergence of a global niche. In other words, not all the projects may have a role in the rise of a global niche. Some of them may, for example, contribute to the formation of multiple niches or have no role whatsoever in niche building. This expands the established view that with the accumulation of multiple projects over time a new socio-technological trajectory can emerge (Geels and Raven, 2006). I represent the fact that the niche nucleus informs and is informed by the global niche (Geels and Raven, 2006) with dashed arrows pointing from the projects in the nucleus area to the community niche area. Some of the community energy projects, however, are not linking up with the emerging community energy niche but with other actors and initiatives in the wider DE niche (the blue circle). This argument is consistent with the "twin-track" mechanism illustrated in Seyfang et al. (2014). These authors found that community energy projects shared knowledge and information with other projects from other niches. Therefore, they demonstrate that, contrary to SNM prescriptions, there is nonlinearity in the process of niche formation from local projects to the global niche.

The application of descriptive stakeholder theory aided the analysis of niche development by showing the main actors and their stakes in this process. Apart from intermediary organizations, the most important actors operating at the level of local projects are project champions: the real drivers behind the initiatives, people living nearby installations, and local businesses. The latter two stakeholders are relevant players contributing to niche development through the acceptance of community energy projects. Niche actors are active both at the intracommunity and intercommunity level. Their area of influence is represented in the first case (intracommunity) with smaller circles and in the second (intercommunity) with a rectangle.

Along with the actors operating at the niche level, there are also actors from the socio-technical regime interacting with the niche. These are represented with double arrows.

Energy companies set the energy price. The energy price was an important factor triggering community energy development when it increases. Community energy initiatives focusing on generation compete with incumbent energy companies. These offer resistance to community energy development (article III) and to the penetration of renewable energy in general (article I). However, the process that leads to resistance is not automatic nor is it so that energy companies are necessarily against the expansion of renewable energy. Instead, these incumbent regime actors may react when a certain threshold is passed and the profitability of their conventional investment is threatened.

Government is another important regime actor involved in community energy development. Government sets the policy agenda for local energy production as well as the funding schemes necessary to stimulate growth and the regulative framework, all of which can hinder or favour the diffusion of community-driven initiatives. The community energy sector, for its part, can contribute to meet capacity and energy independence goals at the national level.

In addition to energy companies, various energy developers are also active players. These can engage with local communities and pursue collaboration (article III) through, for example, joint ownership or they can simply compete for good renewable energy sites. Network operators are crucial actors because they provide access to the network. They take in surplus energy from community projects and need to balance the network constantly. Handling energy surpluses, however, raises two main issues which are connected to how clean energy should be valorized (e.g. through net-metering schemes) and its impact on the network. The electric grid was not designed to accommodate bidirectional flows of energy but, with the expansion of the distributed energy niche, the issue of grid stability becomes of central importance.

The drivers and the barriers of local initiatives can be found in Table 8. Some of the drivers apply to the initiatives happening in the entire distributed energy sector whereas some of them are more specific to the community energy niche. Examples of drivers that are more specific to the community energy niche are actors' values, such as volunteerism. These values reflect the non-market motives often encountered in this field. As for the barriers, the first two categories in Table 8 – incumbent's resistance and regulation – are linked to the socio-technological regime whereas the last category, technology performance, can be ascribed to the niche level where some technologies have yet to reach their full maturity.

When the focus is on the overall community energy niche, there are other factors that contribute to its expansion. First, a clear vision for the sector needs to emerge. Such a vision is stronger when it is linked to the possible achievement of wider goals such as increasing renewable energy capacity or energy efficiency. Another element is the dedicated work of intermediary organizations, which, especially in the early stage of niche development, might be better situated to promote niche development if operating at the regional level.

Along with the importance of a clear vision and the dedicated work of intermediaries that had been already discussed in niche literature (Hargreaves et al. 2013; Seyfang and Longhurst, 2013), this study pointed out that certain characteristics of projects, namely their attitude to networking with other projects and scaling-up, are relevant drivers as well. In addition, exogenous elements such as a background of cohesion (Seyfang et al., 2013) and mutualism also contribute to niche development.

5 DISCUSSION AND CONCLUSIONS

5.1 Discussion

This thesis aimed at increasing our understanding about how community energy emerges as a socio-technical niche and its role in the context of the ongoing energy transition. To fulfil this goal, two research objectives were established. In this chapter, I discuss their relevance and implications in light of the theoretical framework adopted in this thesis. I then conclude with some final remarks, an evaluation of the research and directions for future studies.

5.1.1 Incumbent regime actors resistance

The first research objective of this thesis was to shed more light on the reasons and mechanisms that lead to the resistance of incumbent regime actors to renewable energy penetration. Studying them is extremely important because, as Geels (2014) and Smith et al. (2010) have noted, our understanding of how socio-technical regimes can be unlocked is limited. This is now needed as much as new knowledge on the dynamics of niche growth is.

The results of this thesis showed through two different datasets and research methods (article I and II) that economic performance is an important factor. The expansion of renewable energy beyond a certain limit affects the economic prospects of conventional generation, diminishing, in turn, the profitability of incumbent energy companies. This finding contributes to an explanation of why large energy companies tend to invest in renewable energy gradually and, partially, of why there is regime inertia to change. Confirmation of the economic performance argument can be found in two important reports focusing on global investments and trends in the renewable energy industry: the first by the Frankfurt School-UNEP published in 2015 and the second by the REN21 network published in 2016.

> More generally, utilities have been re-examining their priorities in the light of the rise of renewables and the strain on their business models. Many of them have cut back sharply on capital spending, including investment in renewables, to protect balance sheets and credit ratings. (Frankfurt School-UNEP Centre, 2015, p. 39)

> The rapid growth of renewable power generation created both challenges and opportunities in 2015. In countries where electricity consumption is expanding, both renewable energy and fossil fuel generation are being deployed to meet growing demand. In countries with slow or negative growth in electricity consumption (e.g., several OECD countries), renewable energy is increasingly displacing existing generation and disrupting traditional energy markets and business models. In response to this competition, some incumbents are pushing back against supportive renewable power policies or adapting their business models by restructuring, consolidating or splitting. (REN21, 2016, p. 34)

When reflecting on the findings relative to regime actors' resistance to renewable energy penetration in light of the MLP, there are some interesting points for discussion. First, both neo-Schumpeterian innovation studies and industrial economics support the idea that economic performance problems as well as new market entrants are an indicator of regime destabilization (Turnheim and Geels, 2013). Therefore, resistance to the penetration of renewables and to community energy development can be understood as a sign that regime destabilization is underway. Continued problems of economic performance can lead actors to question the viability of the regime leading to loss of commitment of key actors and further destabilization. However, according to Steen and Weaver (2017), incumbent energy companies are not passive towards the changes occurring in their industry, as they are trying to develop new corporate strategies to respond to the transition processes. For instance, they found that utility companies in Norway have recognized the emerging opportunities and have diversified their activities to capture value in new market niches. The findings of this thesis are in line with Steen and Weaver (2017) as in Article II it was found that utility companies in Finland are developing new business models, such as the turnkey or utility-side solar PV model to take advantage of the opportunities created by distributed energy generation.

Second, incumbent firms' resistance to renewable energy should not be considered as a default quality of regime actors. As Geels (2014, p. 3) has observed, many transition scholars often look at regimes as "monolithic barriers to be overcome". The results of the thesis show that this resistance might not be triggered automatically but depends on the extent to which the expansion of the renewable energy market erodes profit margins of conventional generation. In addition, firms' resistance might be stronger in mature markets where overcapacity and a declining energy demand in combination with the expansion of renewable energy may contribute even more to the loss of profitability. Therefore, one crucial point in the near future will be to achieve a balance between the need for a swift uptake of clean energy and the profitability of still perfectly functioning power plants running on transition fuels such as natural gas. Finding answers to this question also means finding answers to the question of how to increase the support of powerful incumbent regime actors for the transformation of the energy system.

The application of the natural resource–based view of the firm showed that incumbent firms can be motivated through the possible competitive advantages that could be gained (Hart, 1995). Competitive advantage, however, is a distinct concept from economic performance (Ma, 2000). Firms may have a competitive advantage, for instance in terms of better alignment with their external environment, even without it leading to a superior financial performance. The competitive advantage of a firm is about creating better value for the customer than the competitors (Ma, 2000). Thus, a more active participation of regime actors in the energy transition can be triggered by showing the benefits in terms of possible competitive advantage. However, this requires efforts in overcoming short-term thinking, a focus on linking profits to the creation of social value and development of new business models for distributed energy generation.

Involving powerful regime actors in the energy transition is needed as much as setting targets and incentives for renewable energy is. This argument echoes Geels and Schot's (2007) idea of different transition pathways, which show that transitions are not necessarily always about small Davids defeating a gigantic Goliath. According to them, transitions can take place in different ways, including via gradual internal renewal of regimes. This might be the case, at least for countries such as Finland, where most of the power plants are owned by local municipalities, which make a large share of their income from power and heat generation. The threat of losing municipal income may lead regime actors in contexts such as Finland to promote an internal renewal of the regime rather that allowing new entrants to displace incumbent companies.

Regime actors may also decide to open up to community energy niches. This possibility, according to Geels and Schot (2007), would represent a reconfiguration pathway or, according to Smith (2007), the establishment of collaboration models between niche and regime. This thesis illustrated some examples of how this alternative process of regime unlock could happen. Article II, for instance, presented the facilitator model. Through this collaboration model, incumbent energy companies can help small community energy producers to place their energy surpluses on the retail market, leaving them the possibility to set the price and charging them a small commission. The diffusion of this model, however, will depend on the type of companies adopting it. Utilities that focus on energy sales might be keener on adopting this model than those focusing mainly on generation. Another example of how regime and niche actors can collaborate was presented in article III, which illustrated a joint venture model for investments in wind power. This was seen as an effective solution to involve local communities in renewable energy projects led by commercial developers. The main benefit of this model is that it removes the economic risk to inexperienced community groups while offering commercial developers the possibility to establish wind power projects in areas where people could otherwise resist these initiatives.

5.1.2 Scaling-up of community energy niches

The second research objective of the thesis was to provide more information on the scaling-up of community energy niches. This part of the study began with the exploration of the drivers of community energy initiatives. As discussed earlier, they can be classified into four broad categories: characteristics of individuals, social needs, economic factors, and policy factors (Table 8). While the last three categories have been extensively discussed in the literature (Walker et al., 2007; Bomberg and McEwen, 2012; Hain et al., 2005; Phimister and Roberts, 2012; Li et al., 2013), the first one has received less attention in the context of transition studies. The characteristics of the individuals promoting community energy initiatives and, in particular, their values are crucial foundational elements in understanding the broader mechanisms of niche development in the community energy field. The important implication here is that community energy initiatives may not respond well to policies that aim at scaling them up with the same mechanisms employed in commercial projects. In this respect, Seyfang et al. (2014, p. 41) observe:

> …rather than forcing projects to become businesses to compete and survive, a broader understanding of the value of such initiatives (recognising diversity, value-plurality, and non-monetary outcomes) might approach the sector differently and support their multiple activities and goals in other ways.

Consequently, in transition studies, the role of individuals' values and their relationship with the broader processes of change occurring at the socio-technical regime level needs to be further elaborated.

One of the characteristics of individuals driving community energy development that emerged in this study was a tendency towards entrepreneurism. The results of article III showed that people involved in local community energy projects shared a feeling of owning crucial resources that they wanted to exploit in order to promote socio-economic development and sustainability in their neighbourhoods. This casts a new light on community energy development, which has been regarded as a phenomenon thriving on state subsidies and being spurred by people in need or activists. In this study, it emerged that in some communities grassroots innovators feel they have important natural and social resources that they want to exploit as a means of promoting local development. However, there are differences in how such resources are distributed and how they are eventually utilized. For instance, some communities may have both good renewable energy sources and the technical skills to exploit them whereas other may only have the former and have more difficulties in setting up energy projects. In any case, the fact that some communities feel that they have resources that can be better utilised indicates the presence of an entrepreneurial mind-set behind grassroots innovations such as community energy. This expands on what is currently known about how grassroots innovation is driven mainly by people's ideology and needs (Seyfang and Smith, 2007). An important implication of this finding is that there are potential renewable energy resources as well as social resources that are still untapped or limitlessly reached by current policies.

When considering the drivers of community energy projects illustrated in Table 8 on in the context of the countries studied, different national development patterns or a combination of them can be discerned. For example, community energy development in Germany was strongly triggered by individual characteristics, such as ideology, and strong policy inducement. On the other hand, in rural areas of Sweden, Finland and Norway, although individual characteristics were important to some extent, a social need–driven development pattern prevailed. In the case of Scotland, instead, it was a combination of social needs and individual characteristics driving development.

How different development patterns lead to different ways of niche scaling-up is an interesting question that deserves further attention. This study speculated that those community energy projects driven by social need might not necessarily be able or willing to scale up. These projects had their focus on finding a solution to a specific problem in limited geographical areas and were less interlinked with other community energy initiatives. On the contrary, the projects that were following an ideology of broader societal change had more networking and sharing of experiences. Hence, the assumption in SNM that local projects can scale up with the dedicated work of intermediary organizations (Geels and Raven, 2006) appears to be not so straightforward in the case of community-led initiatives, and it might depend on the type of drivers behind the projects. This is in line with Seyfang and Smith (2007), Seyfang et al. (2014) and Hargreaves et al. (2013), who found that not all the community energy projects wish to expand.

Besides the drivers, this study showed that there are also important antecedents of community energy development that play a role in the scaling-up process. In article IV these were called exogenous factors and include cultural aspects, the specific context in which community energy develops (e.g. a rural or urbanized area) and the characteristics of community groups. Cultural aspects might affect the diffusion of community energy projects. This was the case with community energy initiatives in Finland where the local culture did not favour the shared ownership of production means, which was experienced as a factor inhibiting the development of community energy. The specific context in which community projects develop may also have a relevant role in the scaling-up process. This point is supported also by Feola and Nunes (2014), Feola and Butt (2017) and Seyfang and Longhurst (2016), who stated that the characteristics of the geographical location in which grassroots innovation takes place play a crucial role in the diffusion process. For instance, Feola and Butt (2017) found that the long history of left-wing politics, the presence of social entrepreneurism and environmental awareness may have favoured the diffusion of the Transition Towns Network and solidarity purchasing groups in central Italy. As for the characteristics of community groups, some are more active than others in local development activities or exhibit a higher degree of cohesion (Martiskainen, 2017; Seyfang et al., 2013). This was shown as an important precursor of community energy development in the case of some community energy projects in Sweden. Based on these findings, the scaling-up of community energy projects appears to be less linear than the process illustrated in SNM literature.

In addition to the drivers and antecedents, this thesis has also identified some of the barriers to the scaling-up of community energy projects. They have been organized into four groups: regulation, financing, incumbents' resistance and technology performance. Some of these factors had already been discussed in the previous literature. For example, Bomberg and McEwen (2012) as well as Walker et al. (2007) have discussed the role of the political framework while Rogers et al. (2008) has addressed the lack of institutional support. Other factors, such as incumbents' resistance, were further elucidated in this work in the context of socio-technical transition literature.

Along with the factors involved in the scaling-up of local projects, this thesis also identified the factors involved in the scaling-up of the community energy niche (Schot and Geels, 2008; Smith and Raven, 2012). In this regard, intermediary organizations play an important part, yet these have varying roles in different countries. They emerged in various organizational forms and had various missions with some more linked to the public sector (state agencies, ministries, etc.) and other to the private or social sector. In more mature community energy niches, such as in Scotland, they were well established. In less mature niches, like in the case of Finland, their number and strategic activity were, however, far less visible. This point supports the extant theory that intermediary organizations play a pivotal role in promoting internal niche development (Geels and Raven, 2006; Geels and Deuten, 2006).

Other factors driving community energy development at the global niche level included visions and expectations for the sector. It was revealed that as predicted by SNM theory (Schot and Geels 2008; Smith and Raven, 2012) future visions and articulation of expectations are important elements promoting the growth of community energy niches. As Geels (2012, p. 472) states:

> Niches gain momentum if visions (and expectations) become more precise and more broadly accepted, if the alignment of various learning processes results in a stable configuration ('dominant design'), and if social networks become bigger (especially the participation of powerful actors may add legitimacy and bring more resources into niches).

When discussing the future possibilities of distributed energy technologies, it was found that many of those technologies that had a promising future (according to the view of the experts) had also contributed to the emergence of socio-technical niches (e.g. heat pump or biomass gasification in the case of Finland). On the other hand, when business concepts were discussed with experts in Finland, a cooperative model for renewable energy production was not expected to play an important role despite its importance in other sectors. Consequently, in general it appears that the formation of a global niche in the community energy domain follows growth mechanisms like those described in SNM theory. Nevertheless, it remains unclear how exactly expectations form, what external factors influence them and how they diffuse. To illustrate, in Finland there is a strong tradition of civic activism. It could, therefore, be assumed that this characteristic would also emerge in the energy sector but, to date, it has not. One possible reason proposed in this thesis (article II) was that the lack of a sense of urgency in the institutions for speeding up the energy transition may prevent innovations emerging in other sectors from being adopted in the energy domain. This points again to the importance of intermediary organizations in supporting the broadening of the community energy niche. One of the typical activities favouring the broadening of niches is repeating and linking an innovation to other domains.

5.2 Contributions of the overall thesis

This thesis makes a number of important theoretical, empirical and methodological contributions. With regard to theoretical contributions, in line with Hargreaves et al. (2013) and Seyfang et al. (2014), the findings of this study contradict the established idea that niches emerge out of a linear process according to which the accumulation of local projects leads to the formation of a global niche over time (Geels and Raven, 2006). This linear mechanism is less evident in the community energy field where there is more diversity with projects often being informed by and informing other initiatives in the broader distributed energy niche. Moreover, the scaling-up of niches in the community energy sector is dependent on the characteristics of projects because not all of them are interested in scaling-up. This point is consistent with the distinction that Seyfang and Smith (2007) make between "simple niches" and "strategic niches".

The thesis makes a further theoretical contribution by combining the MLP and SNM with other theories. In the first part of the study, a bridge between the natural resource–based view of the firm and the MLP is established. The first theory has its analytical focus on the process of change of an individual organization towards sustainability and the implications that this might have for the performance of that organization. The second, in contrast, is a heuristic framework utilized to understand changes in socio-technical systems. Therefore, where the first is concerned mainly with how corporate activities can be greened, the second looks in a systemic way at how the fulfilment of societal functions (e.g. energy provision) can be transformed to become more sustainable. Linking these two approaches has provided some new insights about how regime resistance to clean energy could be mitigated. Moreover, it enriched the MLP in offering a theoretical foundation for the micro-determinants of change at the level of the socio-technical regime. Similarly, in the second part of the study stakeholder theory was used to increase the understanding of SNM about the role and influence of powerful actors in the process of niche development. Stakeholder theory allowed a deeper analysis of the actors and their respective interests, showing how the interplay of these contributes to the co-construction of the social acceptance of socio-technical niches. The resulting stakeholders' map, reported here in Table 9, is of particular relevance to policymakers because it shows how the various actors involved in community energy development may benefit or be harmed by energy transition.

The thesis has also re-contextualized SNM theory in the context of community energy. The specialty of the community energy sector is in its predominant focus on the social dimension of sustainability innovation rather than on technology. Thus, studying the sector through the lens SNM theory, which has traditionally focused mainly on technology (Hegger et al., 2007), contributes to expanding this approach into the under-researched area of social innovation for sustainability. In general, SNM theory also seems to apply to the community energy sector, but some tensions exist in terms of the factors that lead to the scaling up of niches. This thesis showed that the characteristics of community groups, cultural aspects and the specific context in which community energy develops are relevant in the scaling-up process.

As for empirical contributions, the thesis has provided, through novel data, more details about the motives related to the resistance of incumbent regime actors to emerging sustainability innovations. The resistance of incumbent firms is linked to the loss of long-term economic performance of conventional fossil fuel technology. Moreover, incumbents' resistance does not necessarily exist ex-ante but may manifest when a certain critical point in firms' profitability is reached. This brings into focus new questions connected with the impacts of socio-technical transformation, such as how to account for the loss of profitability of still perfectly functioning infrastructures. In other words, though it is certainly acceptable to discuss how to deploy more renewable energy in the context of energy transition, we also need to discuss what should be done with the existing energy generation infrastructure.

The study has also identified new forms of business models that incumbent energy utilities are developing in response to the diffusion of distributed energy. This was the case with the facilitator and utility-side solar PV models illustrated in article II. The facilitator model is, in particular, a rather unique example of how incumbent energy firms can actually collaborate with niche actors in co-creating value from local renewable energy projects.

Additionally, the thesis has highlighted the importance of actors' values in niche creation and the broader context of socio-technical transitions. This finding signals the need to make more attempts to better evaluate the role of political fights and power struggles in transition studies and is coherent with recent works that take a user-centric view on socio-technical change (see e.g. Schot et al., 2016).

Concerning methodological contributions, the research undertaken in this thesis has followed a mixed methods approach in which quantitative and qualitative methods were combined. This is in contrast with most of the research conducted in the community energy field, which has mainly adopted a qualitative approach. Moreover, in the qualitative part of the thesis a novel combination of techniques merging thematic and narrative analysis was introduced. Ultimately, the research design adopted contributed to a deeper understanding of the emergence of community energy, strengthening the quality of the research via between-method triangulation.

5.3 Practical implications and policy recommendations

The results of this study have three main implications. First, as the expansion of renewable energy can contribute to a loss of profit from conventional energy generation, incumbent energy firms may, in the near future, promote only gradual investments in clean energy production. If the goal of governments is to keep in line with the 2 °C goal, solutions need to be found to avoid incumbent resistance to renewable energy deployment. Such solutions imply a discussion about how to effectively combine the phasing out of fossil fuels with the expansion of clean energy production in a way to minimize regime actors' resistance. Large utility investment continues to be crucial in achieving the volume of investment that contributes to generating scale economies and further driving down the costs of technology. But to avoid the risk of remaining locked in a fossil energy paradigm, the promotion of alternative modes of renewable energy deployment needs to be encouraged. A community energy approach can be a solution to speed up the energy transition due to the possibilities that are offered by distributed energy technology and, more in general, the unhindered power of civil society. However, regulative changes aiming at removing barriers that prevent grid connection, standardization of building permits, promotion of priority access and dispatch, and full access to balancing markets need to be introduced. Furthermore, a clear and stable legislative framework should be promoted. This framework should reduce the complexity and risks of citizen investments in renewable energy as well as create a level playing field between small energy producers and incumbent firms.

Second, a community energy approach is not something that can be simply copy-pasted from other contexts. It has strong cultural foundations that might not necessarily be shared across countries. Therefore, much adaptation work and flexibility is required when working with this approach. Although the definition of community energy entails the strong participation of civil society members, hybrid forms may also be promoted in some countries, for example, with the participation of municipalities or local businesses. Whatever the ownership models are adopted, community energy should represent a way to redistribute the benefits of renewable energy locally. Future energy policies could aim to create tools that are more effective in supporting the informed choices of consumers who want to be certain that they are purchasing locally produced renewable energy. An example of a green label scheme that can be adapted to promote community energy projects is the Guarantee of Origin (GO) mechanism.

Third, since different development patterns drive community energy initiatives, a careful analysis of these underlying motives needs to be carried out before attempting to apply SNM as a policy tool to scale up the sector. Many community energy projects are interested only in finding solutions to local problems. However, once these have been found, project participants may not be interested in sharing their experiences or in lobbying to promote their approach. Therefore, such a role should be delegated to intermediary organizations that, besides promoting networking and the sharing of learning, should also build robust narratives to promote the growth of the sector and lobby for it (Hargreaves et al., 2013; Smith and Raven, 2012). Such narratives need to be appealing and incorporate legitimate expectations and clear visions for the sector.

5.4 Concluding remarks

The overall aim of this thesis was to better understand the emergence of community energy and its possible role in the context of the ongoing energy transition. I looked at this phenomenon through the lens of socio-technical transition literature and, in particular, of the MLP and SNM theory. Through this theoretical background I framed the emergence of community energy as an alternative socio-technical niche, that is, as a set of practices and structures aiming at meeting specific societal needs in a way that deviates from the established ones. To fulfil the research goal a mixed-methods study with a prevalence of qualitative data was designed. In total, 75 qualitative interviews including 50 different cases of community energy projects from various countries were carried out. In addition, a survey of 26 experts from Finland and a panel data study of 66 large electric utilities from 26 countries were conducted. The data were analysed with different methods including thematic, narrative, regression and descriptive statistical analysis.

The results showed that community energy follows four main development patterns that can be linked to the characteristics of individuals, social needs, economic factors, and policy factors. These patterns changed according to the countries investigated with a predominance of some in certain contexts and the coexistence of others in other countries. Actors' values are important drivers behind community energy initiatives and, therefore, adopting policies applied in commercial projects may not be effective in this sector. The intrinsic nature of the drivers of community energy development is linked to the possibilities to scale up niches.

Although community energy appeared as a vibrant sector in some of the countries investigated, incumbent regime actors have put up strong resistance to renewable energy diffusion, regulation and, in a few cases, technology performance, all of which have prevented this approach from growing further.

All in all, the growth of community energy seems to follow a mechanism similar to the one illustrated in SNM theory, but there are some inconsistencies with this theory. First, not all of the projects are interested in being part of a global niche. This means that SNM can be applied selectively to, for example, a cluster of more active initiatives that have in mind a more general view for societal change. Second, while SNM illustrates a linear process of niche formation with local projects informing the global niche and vice versa, community energy niches seem to exchange experiences and learning with a multitude of other niches, a mechanism similar to the twin-track concept illustrated in Seyfang et al. (2014). Third, the applicability of SNM seems to be contingent on exogenous factors such as the cultural background or the level of activism that a community historically has had prior to renewable energy development.

From a MLP point of view, the opposition of regime actors to the diffusion of renewable energy can be seen as an important window of opportunity for the community energy niche. In fact, if incumbent energy firms continue to invest gradually to preserve their sunk investments in conventional generation, more renewable energy will be needed and, therefore, a community-driven approach can play a role in filling the gap. Moreover, community energy can have an important role to play in the following ways: (a) increasing pressure on incumbent regime actors to accelerate the shift to clean energy sources, (b) contributing to mobilizing precious societal and monetary resources for supporting this epochal transformation, (c) creating opportunities for socio-economic development, (d) raising awareness of climate change (second-order learning).

However, the magnitude of its impact depends on the degree of internal niche development and on the ways the niche can interact with important regime actors (Figure 8). As for the first element, it is of fundamental importance that a vision for the sector crystalizes and that intermediary organizations promote networking and learning between projects as described by SNM. Crystallization of the vision does not mean homogeneity of technology and practices. On the contrary, it must include diversity and adaptation to local needs. What needs to clearly emerge is, thus, a vision that includes civil society as an important actor for renewable energy deployment.

With regard to the second element, a community energy niche can play an important part if it is able to engage with energy companies, government, commercial developers, and network operators at the regime level. To counterbalance the dominant paradigm of centralized energy production based on fossil fuels, it needs to develop strong narratives (Smith and Raven, 2012) around the possibilities that it can create for local development, community resilience, energy self-sufficiency, local acceptance and fairness. Yet this alone will not suffice if other factors at the landscape level do not put enough pressure on the energy regime. At the same time, it also needs to lobby government for changes in regulations and funding schemes by highlighting how it can contribute to energy security and increased renewable energy capacity (Hargreaves et al., 2013).

The degree to which community energy can contribute to decarbonization can also depend on its ability to forge alliances with other energy market entrants such as commercial developers. Both community energy and the initiatives of other new entrants can apply further pressure on incumbent firms to accelerate the pace of the energy transition. Commercial developers need to collaborate with local community groups because renewable energy generation requires much more land than fossil fuel production. Therefore, collaboration is crucial in avoiding local resistance to clean energy development. Ultimately, the role of community energy as well as the renewable energy industry in general is linked to the efforts of network operators to reinforce and modernize the distribution network and, consequently, to the possibilities that there will be to feed in high amounts of fluctuating energy from renewable sources.

It remains to be seen how long the resistance shown to community energy in some regions will continue. However, in other regions there has been slow but steady progress towards a transformation in the energy system that will lead to a lower carbon future. Such progress suggests that change triggered by civil society actors is possible.

5.5 Quality considerations and limitations of the research

This section presents an evaluation of the study. I focus on two crucial aspects: quality considerations and the limitations of the research.

As discussed in Chapter 3, this thesis employed a mixed methods approach to offer a more comprehensive account of the emergence of community energy niches. According to O'Cathain (2010), there are three different ways to evaluate quality in mixed methods research: the generic research approach, the individual components approach, and the mixed methods approach.

The first approach utilizes general evaluation tools that can be deployed across all study designs. While very practical, this approach is too generalist and fails to account for quality issues that might be specifically pertinent to mixed methods studies. The second approach focusses on evaluating separately the quantitative and qualitative parts. The main argument for adopting this approach is that, according to some scholars, different paradigms imply different types of research methods. Therefore, the qualitative and quantitative parts are evaluated according to their respective quality criteria. However, some researchers have rejected the idea that methods are necessarily linked to paradigms and that consequently methods need to be separated (Bryman, 1988). The individual components approach, although useful in evaluating the qualitative and quantitative components of a study, does not consider the fact that mixed methods research is not just the sum of qualitative and quantitative parts but an integrated research design in which inferences are drawn beyond the limits of each specific method (O'Cathain, 2010).

The mixed methods approach tries to offer an evaluation framework that is tailor-made to assess mixed methods research. For example, O'Cathain (2010) building on Tashakkori and Teddlie (2008), proposes a framework that scrutinizes quality in eight domains: planning, design, data, interpretative rigor, inference transferability, reporting, synthesizability, and utility. The main challenge of this framework, as O'Cathain (2010) concedes, is that it has too many criteria. Moreover, although it offers a way to handle mixed methods research as a distinct research method (neither qualitative nor quantitative), it does not solve the problem of how to evaluate the individual components.

As observed, the three approaches discussed above have both strengths and limitations. In light of this and the fact that I do not use pure mixed methods but a qualitatively dominant design, I follow Bryman (2006) who suggests that the quality criteria associated with the dominant method can be used to assess both components of the study. In addition, since the role of the less dominant component in a study is not subject to quality assessment when its aim is only to support the dominant component (O'Cathain, 2010), I focus here only on the evaluation of the qualitative part of the study.

Quality criteria for qualitative research have been widely discussed and remain somewhat contentious. In line with Lincoln and Guba (1985), I used credibility, confirmability, transferability and dependability as my set of quality criteria for this thesis.

The credibility criterion refers to the degree qualitative research offers a true or credible picture of the phenomenon investigated. Some techniques suggested by Lincoln and Guba (1985) to achieve credibility are prolonged engagement, triangulation, debriefing and peer scrutiny. Prolonged engagement refers to spending sufficient time in the field to become familiar and understand the phenomenon of interest. During my doctoral studies, I have been in contact with a number of community energy projects in several countries and spoken to a range of people including experts, policymakers and local champions. Moreover, I have visited community energy projects both in Finland and abroad on more than one occasion.

With regard to triangulation, in the view of Flick (2011) this can be achieved in three ways: data triangulation, investigator triangulation, and theory triangulation. The first type aims at combining data drawn from different sources, people, times or places. The second is characterized by the use of different observers or interviewers in data collection to reduce the subjective influences of individual researchers. The third is obtained by looking at the same data through more than one set of theoretical lenses. Flick (2011) also states that triangulation can mean methodological triangulation. Methodological triangulation is achieved when employing different methods within the same research tradition (within-method triangulation) or combining different methods from different research traditions, that is, quantitative and qualitative (between-method triangulation). The research undertaken in this thesis has relied on data triangulation as well as on methodological triangulation.

Debriefing and peer scrutiny refer to the frequent discussion of the research results and procedures with superiors or steering groups. Debriefing sessions are important moments because they contribute to expanding the researcher's vision. While completing my research, I have had many occasions to discuss the findings and research procedures with supervisors, colleagues and other academics. Their views have helped me to see my underlying assumptions and become more detached from my work.

Credibility is, for Lincoln and Guba (1985), the most important quality criterion and it also applies to the collection of data and their analysis. The selection of the participants for this study has been in line with Patton (2002) in choosing people with different experiences and expertise in order to address the research question from a variety of perspectives. In analysing the data, which consist predominantly of interviews, I have tried to be as transparent as possible. For instance, to illustrate how I identified similarities and differences between the various categories that emerged from the thematic or narrative analysis, I have presented representative quotations from the transcribed text of the interviews.

According to Lincoln and Guba (1985), transferability is about whether the findings can be transferred to other contexts or people. The transferability criterion has received criticism from several authors, who dispute that the findings of qualitative research are specific to certain settings or a small group of people and thus cannot be generalized (Erlandson et al., 1993). Other authors believe that while the latter point is true, the specific cases identified through qualitative research can be an example of a broader group (Denscombe, 1998). In dealing with transferability, I again followed Lincoln and Guba (1985), who advised researchers to provide rich descriptions (*thick description*) of the context and research procedures of the study and to leave transferability judgments to the reader.

Dependability deals with the consistency of the findings. It is an important criterion for judging how to deal with changes in the phenomenon investigated as well as changes in the research design due to, for instance, a researcher's expanding insight. In a positivistic paradigm the underlying assumption is that there is stability in the social world and thus inquiry can be logically repeated. However, this position is problematic for qualitative research, which assumes instead that the social world is being constantly constructed. For example, Graneheim and Lundman (2004, p. 110) say:

> …interviewing and observing is an evolving process during which interviewers and observers acquire new insights into the phenomenon of study that can subsequently influence follow-up questions or narrow the focus for observation.

Therefore, dependability in qualitative research is about finding ways to take into account the changing conditions appearing in the context of the research and the study design. Following Lincoln and Guba (1985), I addressed dependability issues in this study by using some of the techniques already used for credibility (i.e. prolonged engagement and triangulation). In addition, I have strived to make the research processes clear and asked colleagues, supervisors and other experts to check the research plan and its implementation.

Confirmability in qualitative research is the corresponding concept to objectivity in quantitative studies. This criterion helps ensure the neutrality of the researcher and that the findings reflect the experiences and ideas of the informants rather than the bias or interest of the researcher (Lincoln and Guba, 1985). In this study, this criterion was addressed, first of all, by the type of reasoning used in data analysis, which was predominantly inductive. This approach let the data "speak" rather than them being used as a testing ground for previously existing concepts. Another way to deal with confirmability was again the use of multiple methods that helped me to reveal possible biases. In addition, as described by Lincoln and Guba (1985) whenever possible I made important research materials including raw data, thematic categories and quantitative summaries of data available to co-authors, reviewers or supervisors. Finally, I have tried to achieve confirmability by always justifying the choice of one particular method when another would have been available and describing the weaknesses in the techniques that were actually employed.

Although this study was designed to match the quality criteria illustrated above, it has limitations. First, as illustrated in Chapter 1, the scope of the research is restricted to some regions of the Nordic countries and in particular Finland. This poses restrictions to the applicability of the findings to countries in other contexts, such as in southern Europe. Unfortunately, this was a constraint I had to deal with from the beginning of my PhD studies due to the limited resources and time available. Second, in the qualitative part of the study I applied a maximum variation sampling method to secure heterogeneity (Patton, 2002). However, this approach has presented some challenges. One of them is that the results have, perhaps, lost some of their contextual background for the sake of scope. Furthermore, my sample favoured developed countries and their more mature electricity markets in the quantitative part of the study. This has limited the findings concerning the link between renewable energy growth and profitability to this context. Third, my understanding of the topic evolved over the period of my PhD studies. The journey has not been straightforward and, therefore, some early works could have been framed in a different way to better capture the phenomenon investigated in the thesis.

5.6 Directions for future studies

Smith et al. (2010) pointed out that the socio-technical approach to transitions needs to give more attention to how regimes can be unlocked and niches develop. This thesis attempted to help fill these important gaps. However, there are many aspects that require further investigation. For instance, in continuing to address the ways regimes can be unlocked, more attempts should be made to identify business models that promote collaboration between regime and niche actors. So research should address questions such as which business models can encourage energy regime actors to collaborate with niche advocates in fostering the energy transition? How can sustainable practices developed in community energy niches be incorporated in regimes?

From the perspective of niche development, it emerged in this study that contextual factors such as a sense of community and the motives behind the initiatives are fundamental if we are to better understand the role of community energy in the broader context of the energy transition. In this respect, Seyfang and Haxeltine (2012, p. 396) wrote:

> …what is required, then, is an understanding of how identity, belonging, purpose, and sense of community underlie niche growth and the evolution of goals and priorities over time.

Accordingly, more qualitative research should explore the links between endogenous factors, values and niche development. An important question is, for example, how the presence of pre-existing linkages or shared development patterns between communities can facilitate renewable energy deployment. Answering this question also helps to address the contingencies of SNM as a policy tool.

Another important aspect of SNM theory that could be investigated by future studies is its link with social acceptance. In the concept of niche nurturing, there is an underlying assumption about the social acceptance of certain alternative socio-technical solutions. Based on the results of this thesis, which showed that in some instances community energy–driven initiatives have also faced local opposition, the topic of social acceptance needs to be unpacked in the SNM literature. Social acceptance is fundamental to the expansion of niches as much as the sharing experiences and knowledge. More attention in the future needs to be given to the question of how social acceptance forms and comes about in socio-technical niches.

This argument points towards of what some authors have recently pointed out (Smith and Raven, 2012; Shove and Walker, 2007) regarding how the socio-technical perspective on transitions lacks a view on power struggles. By integrating stakeholder theory that identifies the actors and their interest involved in the establishment of community projects, this thesis was a first step in the direction of better understanding the problem of social acceptance of community energy niches.

One of the main implications of this study is that community energy cannot, due to its contextual and cultural rootedness, be automatically transplanted from one country to another. Therefore, a significant amount of adaptation and translation work is needed when working with this approach. Future research should clarify which aspects of community energy are more easily transplanted and which are less so. This is a crucial question that stands at the heart of the concept of scaling-up.

Finally, the socio-technical perspective on transitions is no longer the only perspective available. Other theoretical approaches have been developed and might help to illuminate aspects related to the diffusion of community-driven initiatives. In this regard, future research could (a) study the role of community energy in changing established practices through the lenses of theory of practice (Røpke, 2009; Shove and Walker, 2010), and (b) address the tensions between actors involved in community energy development at the local and national level through the lens of arena of development (Jørgensen 2012; Valderrama Pineda and Jørgensen 2016).

YHTEENVETO (SUMMARY)

Yhteisöenergiaa – kansalaisyhteiskunnan rooli uusiutuvan energian tuotannossa

Väitöskirjan tarkoituksena on tarkastella uudenlaista, paikallisten energiamuotojen kehittämiseen liittyvää kansalaistoimintaa sekä sen roolia siirryttäessä vähähiiliseen yhteiskuntaan. Termillä *yhteisöenergia* viitataan kansalaisaktiivisuuteen perustuviin yhä enenevässä määrin toteutettaviin energian tuotanto- ja säästöhankkeisiin. Muutosta käsittelevän kirjallisuuden perusteella yhteisöenergia käsitteellistetään sosiotekniseksi lokeroksi (niche) eli suojatuksi tilaksi, jossa energiayrittäjät ja tuottajakuluttajat testaavat uusiutuvan energian teknologioita ja käytäntöjä. Yhteisöenergialokeroiden syntyä tarkastellaan energian tuotannon, sääntelyn ja kulutuksen tämänhetkisten käytäntöjen ja rutiinien kontekstissa. Tätä monimutkaista sääntöjen ja rutiinien joukkoa muutostutkijat kutsuvat *sosiotekniseksi regiimiksi*.

Väitöskirjan tutkimusmateriaali koostui kolmesta eri aineistosta. Ensimmäisen niistä muodostivat noin 450 havaintoa paneeliaineistosta (artikkeli I), toisen 75 laadullista haastattelua (artikkelit II, III ja IV) ja kolmannen 26 asiantuntijalle suunnattu kyselylomake (artikkeli II). Ensimmäiseen aineistoon kuuluivat yritystason tiedot 66 suuresta sähkölaitoksesta 26 maassa 10 vuoden ajalta (2005–2014). Toinen aineisto koostui 75 laadullisesta haastattelusta, jotka tehtiin vuosina 2012–2016 Suomessa, Skotlannissa, Saksassa, Pohjois-Irlannissa, Ruotsissa, Irlannissa ja Norjassa. Haastateltavat olivat yhteisöenergia-alan toimijoita, julkisia laitoksia, yrityksiä sekä välittäjä- ja lobbausorganisaatioita. Kolmas aineisto käsitti 26 suomalaisen asiantuntijan vastaukset asteikkopohjaiseen kyselyyn, joka keskittyi 50 muutostekijään hajautetulla energiantuotantosektorilla. Ensimmäistä aineistoa analysoitiin regressioanalyysillä käyttäen sekä kiinteiden että satunnaisvaikutusten arviointimalleja. Toisen aineiston analysoinnissa käytettiin temaattista ja narratiivista analyysiä, kolmannen analysoinnissa kuvailevaa tilastotiedettä.

Väitöskirjan tulokset on julkaistu neljässä vertaisarvioidussa artikkelissa, joihin johdantoessee perustuu. Artikkelissa I keskityttiin uusiutuvan energian tuotannonlisäyksen ja sähkölaitosten kannattavuuden väliseen suhteeseen. Tarkastelu osoitti, että uusiutuvan energian lisäys yli tietyn rajan vaikuttaa perinteisen tuotannon pitkän aikavälin näkymiin. Tutkittujen sähkölaitosten heikon tuottavuuden ei kuitenkaan katsottu johtuvan vain uusiutuvan energian tuotannon kasvusta vaan myös muista epäsuotuisista tekijöistä, kuten paikallaan polkevasta sähkön kysynnästä, liikakapasiteetista, ydinvoiman vaiheittaisesta alasajosta joissakin maissa ja Eurooppaa vuonna 2007 koetelleesta talouskriisistä. Yksi artikkelin I tärkeimmistä johtopäätöksistä oli, että keskitetyssä energiajärjestelmässä ei välttämättä tapahdu jatkuvaa uusiutuvan energian lisäystä johtuen seurauksista perinteisten voimalaitosten pitkän aikavälin tuottavuudelle. Laitokset saattavat jatkaa investointeja laajoihin uusiutuvan energian hankkeisiin, mutta vain vähitellen, jotta turvaavat investointinsa. Siksi on aktivoita-

va uusia toimijoita edistämään uusiutuvan energian kattavampaa talteenottoa sekä estämään jähmettymistä tilanteeseen, jossa fossiilisen polttoaineen tuotanto on vallitseva energiantuotantotapa ja uusiutuva energia vain sitä täydentävä vaihtoehto.

Artikkelissa II tarkasteltiin hajautettuun energiantuotantoon siirtymisen nykytilaa Suomen energiajärjestelmässä. Tulosten mukaan siirtyminen hajautetumpaan järjestelmään on mahdollista ensi vuosikymmenellä, mutta siirtymistä hidastavat sääntely, rahoituskysymykset, energiahallinnon toimijoiden vastustus ja joissakin tapauksissa teknologiaan liittyvät haasteet. Sekä lämmitys- että sähkösektorille on ilmaantunut merkittäviä sosioteknisiä erikoisaloja, joilla testataan hajautettuja energiaratkaisuja, mutta lämpöpumppuja lukuun ottamatta nykyiset toimintapolitiikat eivät niitä yleensä tue. Vakiintuneetkin energiayhtiöt kehittävät uusia liiketoimintamalleja voidakseen hyödyntää hajautetun energiantuotannon tarjoamia mahdollisuuksia, mutta pääasiassa sähkösektorilla, kun taas lämmityssektorilla havaittiin vain vähän innovaatiotoimintaa. Sekä artikkelin I että artikkelin II tärkeimpiä johtopäätöksiä oli, että siirtymän nopeuttamiseksi innovaatioiden (esimerkiksi uusien liiketoimintamallien) kehittämiseen tulisi panostaa enemmän.

Artikkelissa III määriteltiin yhteisöenergiaprojektien tärkeimmät sidosryhmät ja niiden roolit seitsemällä alueella Keski- ja Pohjois-Euroopassa. Tutkimuksessa tarkasteltiin myös sitä, olivatko yhteisöenergiaprojektien tulokset suotuisia vai epäsuotuisia määritellyille sidosryhmille. Sidosryhmät vaikuttivat yhteisöenergian kehittämiseen kolmella eri tasolla: makrotasolla, yhteisöjen välisellä ja yhteisön sisäisellä tasolla. Makrotason avainsidosryhmiä olivat hallitus, energian toimittajat, sähköverkko-operaattorit ja kaupallisesti toimivat rakennuttajat. Kaksi merkittävintä yhteisöjen välisellä tasolla vaikuttavaa sidosryhmää olivat lähiyhteisöt ja välittäjäorganisaatiot. Yhteisön sisäisen tason toimijoista vaikutusvaltaisimpia olivat paikallisyhteisö kokonaisuudessaan, paikalliset yritykset ja laitoksen läheisyydessä asuvat ihmiset sekä hankkeen puolestapuhujat. Päätelmänä oli, että sidosryhmät eivät vaikuta yhteisöenergiahankkeisiin joko vastustamalla tai kannattamalla niitä, vaan niillä voi olla yhtä aikaa molemmat roolit. Tutkimus myös osoitti, että sidosryhmien näkemykset yhteisöenergiahankkeista eivät ole muuttumattomia vaan voivat vaihdella projektin kehitysvaiheen ja sidosryhmän panostustyypin mukaan.

Artikkelissa IV yksilöitiin nousevia yhteisöenergiaprojektityyppejä sekä tekijöitä, jotka vaikuttavat niiden yleistymiseen Suomessa. Tulokset toivat esiin kolme projektityyppiä, joissa keskeinen tekijä on joko kustannusten alentaminen, teknologinen asiantuntemus tai systeemimuutos. Kustannusten alentamiseen liittyvien projektien edellytyksenä on ulkoinen tuki, ja ne pyrkivät luomaan edullisia paikallisia ratkaisuja, mutta laajentuminen ei ole niiden tavoitteena. Teknologiseen asiantuntemukseen perustuvien projektien lähtökohtana on avaintoimijoiden osaaminen, mutta ympäristösyyt ovat niissä yhtä tärkeitä. Näillä projekteilla on paikallinen fokus, eivätkä nekään pyri laajentumaan. Systeemimuutosprojektit taas pyrkivät luomaan uuden energiantuottamistavan, joka edistäisi yhteiskunnallista muutosta. Ne eivät ole tiukasti sidottuja tiettyyn paikkaan ja pyrkivät laajentumaan. Paikallisten projektien välillä havaittiin kokemusten ja oppimisen jakamisen mahdollistavia verkostoja, jotka olivat kuitenkin laajentumisen näkökulmasta vähäisiä. Juuri systeemimuutosprojekteissa nähtiin kuitenkin eniten verkostoitumista, oppimista ja kiinnostusta laajentumiseen. Artikkeli IV osoitti myös, että laajentumisprosessissa on merkitystä yhteisöryhmien erityispiirteillä, kulttuuritekijöillä ja sillä kontekstilla, jossa yhteisöenergiaa kehitetään. Yhteisöenergiahankkeiden laajentumista jarruttavat lisäksi yksittäisten hankkeiden ulkopuoliset tekijät, kuten puutteellinen käsitys sektorista ja yhteisöenergian mahdollisesta merkityksestä Suomessa. Sitä paitsi harva organisaatio on omistautunut kehittämään tätä sektoria, ja epäsuotuisat poliittiset linjaukset ja sääntelyjärjestelmä lisäävät esteitä entisestään.

Väitöskirjan neljän artikkelin tulosten perusteella yhteisöenergian kehittämisessä voidaan havaita neljä pääasiallista mallia, jotka ovat yhteydessä yksilöiden ominaisuuksiin, sosiaalisiin tarpeisiin, taloudellisiin tekijöihin ja politiikkaan. Yhteisöenergialla voi olla tärkeä tehtävä energia-alan murroksessa, koska sillä voidaan (a) lisätä painetta vallanpitäjiä kohtaan, jotta he nopeuttaisivat siirtymistä puhtaisiin energianlähteisiin, (b) mobilisoida yhteiskunnallisia ja taloudellisia resursseja edistämään vähähiiliseen tuotantoon siirtymistä, (c) luoda mahdollisuuksia sosioekonomiseen kehitykseen ja (d) lisätä tietoisuutta ilmastonmuutoksesta (toisen tason oppiminen).

Yhteisöenergian vaikuttavuus riippuu kuitenkin kahdesta tekijästä: sektorin sisäisen lokeroitumisen määrästä ja siitä, miten kukin lokero (niche) voi olla vuorovaikutuksessa vallanpitäjien kanssa. Ensiksi mainitun tekijän suhteen on olennaisen tärkeää, että mielikuvaa sektorista selkeytetään ja että välittäjäorganisaatiot edistävät hankkeiden välistä verkostoitumista ja oppimista. Yhteisöenergiaan liitetyn mielikuvan selkeyttäminen ei tarkoita teknologioiden ja käytäntöjen homogeenisuutta. Päinvastoin, siihen tulee kuulua monimuotoisuutta ja paikallisten tarpeiden huomiointia. Tarvitaankin epäilemättä visiota, jossa kansalaisyhteiskunnalla on merkittävä rooli uusiutuvan energian käyttöönotossa.

Arvioitaessa toista osatekijää eli vuorovaikutusta vallanpitäjien kanssa, kapea yhteisöenergiasektori voi olla merkittävä tekijä, jos se pystyy toimimaan yhdessä energiayhtiöiden, hallituksen, rakennuttajien ja sähköverkko-operaattoreiden kanssa järjestelmätasolla. Vallitsevan keskitetyn, fossiilisiin polttoaineisiin perustuvan energiantuotantoparadigman vastapainoksi tulee kehittää vahvoja narratiiveja mahdollisuuksista lisätä paikallista kehittämistä, yhteisön selviytymiskykyä, energiaomavaraisuutta, paikallista hyväksyntää ja oikeudenmukaisuutta. Samalla on yritettävä vaikuttaa hallitukseen, jotta se muuttaisi säännöksiä ja rahoitusjärjestelmiä, korostaen lisääntyvää energiaturvallisuutta ja uusiutuvan energiantuotannon kapasiteettia.

Yhteisöenergian rooli vähähiiliseen talouteen siirtymisessä riippuu myös sen kyvystä luoda yhteyksiä muihin energiamarkkinoiden toimijoihin, esimerkiksi rakennuttajiin. Sekä yhteisöenergialla että muiden uusien tulokkaiden hankkeilla voidaan lisätä perinteisten yritysten painetta vauhdittaa energiamurrosta. Pohjimmiltaan yhteisöenergian ja koko uusiutuvaa energiaa tuottavan alan rooli kytkeytyy sähköverkko-operaattoreiden pyrkimyksiin vahvistaa ja modernisoida jakeluverkostoa, ja sen seurauksena mahdollisuuksiin ammentaa suuria määriä energiaa saatavuudeltaan vaihtelevista uusiutuvista energianlähteistä.

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ORIGINAL PAPERS

I

RENEWABLE ENERGY GROWTH AND THE FINANCIAL PERFORMANCE OF ELECTRIC UTILITIES: A PANEL DATA STUDY

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Renewable energy growth and the financial performance of electric utilities: A panel data study

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ABSTRACT

Electric utilities are under pressure to increase clean energy production. Although the adoption of renewable energy can improve the utilities' environmental performance, a fundamental question is if it also pays in economic terms. Building on the natural-resource-based view of the firm, we answer this question using two data analysis methods. First, we carry out a regression analysis of panel data from 66 large electric utilities covering the period 2005–2014, applying both a fixed and random effects estimator. Subsequently, we use the Granger causality test to explore possible causality links. Our results show a negative correlation at the firm level between renewable energy increase and short-term as well as long-term financial performance. More specifically, we find that an increase in renewable energy penetration Granger-causes a reduction of long-term performance. However, the results also show that a firm's carbon intensity moderates the relationship. When the focus is on the country level, we find that an increase in renewable power penetration is also negatively correlated to long-term firm performance, which might be explained by the combined effect of low power demand and overcapacity in developed economies. We conclude that the concept of organizational ambidexterity may supplement the natural-resource-based view of the firm for a better understanding of the relationship between an increase in renewable power and a firm's profitability.

1. Introduction

The Paris Agreement signed in 2015 may pave the way for a major transformation of the present energy provision system to renewable energy (IEA, 2016; UN, 2016). Electric utilities play a fundamental role in this process of change because they represent the backbone of the power supply infrastructure. However, even though the adoption of renewable energy can be seen as a way to improve environmental performance (EP), a fundamental question is if it also pays in economic terms. This is a timely question in light of the fact that, since 2011, large utilities have significantly reduced their capital expenditures on renewables (Frankfurt School–UNEP Centre/BNEF, 2015).

The discussion about whether an increase in renewable energy capacity may affect the financial performance (FP) of electric utilities can be seen as a part of the broader debate about corporate environmentalism and its profitability. Indeed, despite more than two decades of research, the question of if it pays to be green is far from settled. A slight majority of the studies indicate a positive relationship between EP and FP whereas the rest show either a negative or a neutral relationship (Albertini, 2013). Authors supporting a natural-resource-based view (NRBV) of the firm have argued that firms can attain a competitive advantage or superior performance by implementing proactive environmental strategies (Hart, 1995). Such strategies lead to the development of capabilities that have implications for a firm's performance in terms of lower costs, improved reputation, and strategic alignment with ongoing changes in the business environment (Aragón-Correa and Sharma, 2003).

Much of the literature stemming from the NRBV has mainly explored the greening of firms and its impact on performance (Hart and Dowell, 2011). To date, however, there is still little research focusing on firms that adopt a so-called beyond-greening strategy. Beyond-greening strategies address sustainability and include the adoption of clean technology (Hart, 1997, 2007). But in the domain of clean technology, it is unclear if firms can maintain a competitive advantage (Hart and Dowell, 2011). Thus, the first contribution of this study is to test if the NRBV of firms, which supports a positive link between a proactive environmental strategy and a firm's

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performance, is also valid in the context of a clean technology such as renewable energy.

Second, researchers have begun to suggest that rather than addressing the question in terms of whether it pays to be green, it would be more fruitful to shift the focus of the discussion to *when*, – i.e., under which circumstances – it may pay to be green (Bernicchi and King, 2007; Dixon–Fowler et al., 2012; King and Lenox, 2001; Orsato, 2009). Previous research (Hart and Ahuja, 1996) has shown that the improvement of EP has a higher impact on FP for heavy polluters than it does for firms that pollute less. This implies that electric utilities with high carbon intensity should benefit more from an increase in renewable energy production than utilities with already very low carbon intensity. The second contribution of this paper is to further move the debate from *if* to *when* it might be fruitful for a firm to improve its EP by examining the role of carbon intensity as a moderator of the renewable energy–profitability relationship.

In order to fill the two gaps identified above, we first carried out regression analysis of an unbalanced panel of 66 large electric utilities over the period 2005–2014 to evaluate the correlation between an increase in renewable energy production and firm performance. Then we applied the Granger causality test to explore possible causality links. The research questions we addressed can be formulated as follows: Does an increase in renewable energy production lead to higher FP for electric utilities? Does a firm's carbon intensity moderate the relationship?

The rest of this article is organized as follows: in section 2 we present a summary of the main literature and the NRBV approach, in section 3 we briefly discuss the electric utilities context, in section 4 we illustrate our data and methods, and in section 5 we present the findings. In section 6 we discuss our results and draw some conclusions.

2. Theoretical framework

2.1. A summary of the does it pay to be green? literature

Over the last two decades a number of studies have focused on the relationship between corporate EP and FP. The results of this research are contradictory. According to a meta-analysis carried out by Albertini (2013) that included 52 studies over a 35-year period, a slight majority of studies have shown that better EP is positively correlated to a firm's FP. Some of these studies include Sen et al. (2015), Clarkson et al. (2011), Zeng et al. (2010), Hart and Ahuja (1996), Wagner and Schaltegger (2004), King and Lenox (2001), Konar and Cohen (2001) and Russo and Fouts (1997). On the other hand, an almost equal number of papers have found that the relationship is neutral, or perhaps even negative (e.g., Cohen et al., 1997; Cordeiro and Sarkis, 1997; Filbeck and Gorman, 2004; Graves and Waddock, 1999; Hassel et al., 2005; Morris, 1997; Sueyoshi and Goto, 2009; Telle, 2006).

Early research in the field was dominated by the traditional economic trade-off view, according to which enhancing EP implies extra costs for a firm, costs that in turn might hurt its FP. Thus, companies need to make a trade-off between acting to reduce their environmental burden and maintaining good FP. Some authors who have brought forth this view include Haveman and Christiansen (1981), Jaggi and Freedman (1992), Walley and Whitehead (1994), Portney (1994), Levy (1995) and Palmer et al. (1995). Later, the view that better EP can instead create opportunities for both increased revenues and lower costs has been proposed. Some of the most notable supporters of this second view are Porter and van der Linde (1995), Hart (1995, 1997) and Reinhardt (1999). They have indicated that increased revenues can stem from better access to certain markets, product differentiation and selling clean technology whereas lower costs may be achieved through better relationships with external stakeholders (Ambec and Lanoie, 2008). In addition, Aragon-Correa (1998) and Hart (1995) have suggested that EP improvements may also lead to strong organizational and management capabilities and enhance a firm's legitimacy.

An important set of studies within the large body of literature summarized above has also focused on the direction of the relationship between EP and FP. For instance, Earnhart and Lizal (2006) and McGuire et al. (1988) have posited that, instead of EP acting on FP, it might be that FP influences EP. Companies with a good FP may have a surplus of financial resources, called “slack resources” by Waddock and Graves (1997), which they can invest to improve their EP when external pressure increases.

Along with the proponents of a link between FP and EP, the literature also contains studies that suggest a bidirectional relationship between the two variables. Some examples include the extensively cited work of Hart and Ahuja (1996) and more recent papers such as those of Makni et al. (2009), Surroca et al. (2010) or Carrión–Flores and Innes (2010). According to these authors companies with slack resources tend to improve their EP, which in turn increases FP that again can lead to further improvements of EP. In other words, the relationship between EP and FP would move from the first to the second and from the second to the first, creating what Hart and Ahuja (1996, p. 36) have called a “virtuous circle”.

Because research about the relationship between EP and FP has led to contrasting results, some authors have concentrated on methodological issues in studying the relationships between the two variables. Three main methodological approaches have been employed to explore the EP–FP relationship: (a) portfolio analyses, (b) event studies and (c) long-term studies using regression analysis (Ambec and Lanoie, 2008). The first method consists of comparing the economic performance of portfolios that include companies with high EP against those including companies with no environmental features. The main limit of these studies is the fact that FP depends heavily on a firm's fund management ability. Event studies aim at investigating the effects of environmental events, generally negative, on areas such as stock market performance. Although this approach can identify a clear causal relationship in the days soon after the negative event, it is difficult to evaluate the specific effects of such an event over the long term. The last approach, the one used in this study, relies on regression analysis to investigate the relationship between various companies' characteristics over a certain period of time. Studies based on regression analysis may appear to be the most suitable ones for exploring the EP–EF link (Ambec and Lanoie, 2008), but they show a lack of consistency in operationalizing both the independent and dependent variable (i.e., EP and FP) and often overlook the important role of control variables (Telle, 2006). In the next section we discuss this lack of consistency in operationalizing EP and FP variables.

Finally, researchers have also explored the link between companies with different types of environmental strategies and their FP. One of the most important contributions in this context was the NRBV proposed by Hart (1995), which is discussed in more detail below. The main argument justifying this research strand is the fact that the link between the competitive advantage of the firm and the environmental strategy depends on the form of environmental improvement under consideration (Hart and Dowell, 2011).

2.1.1. Lack of consistency in operationalizing EP and FP

Most of the studies on the relationship between EP and FP have focused their analysis on a limited variety of industrial sectors such as pulp and paper (Jaggi and Freedman, 1992) or mining (Magness, 2006). Moreover, they take into account only specific indicators of environmental pollution (King and Lenox, 2001; Jung et al., 2001; Hughes et al., 2001; Hart and Ahuja, 1996) and do not distinguish between performance improvements attained by end-of-pipe solutions (addressing environmental pollution after it is produced) and those achieved through more proactive strategies (Ilinitch et al., 1998).

To a lesser extent, the lack of uniformity in the FP measures used has also been problematic. The most recurrent measures of FP found in the literature are return on assets (ROA), return on equity (ROE) and return on sales (ROS; e.g. Earnhart and Lízal, 2007). Along with these financial ratios, market-based measures such as market value, stock returns and Tobin's q have been employed (e.g., Dowell et al., 2000; Gilley et al., 2000; Khanna et al., 1998). Several scholars have pointed out that because financial ratios and market-based measures have a different focus they may lead to different results. For instance, financial ratios are effective indicators of a firm's ability to generate value from its assets in the short term, but they are not appropriate in measuring intangible and long-term benefits associated with a better EP (Orlitzky et al., 2003; Delmas and Nairn-Birch, 2010). As a result, market-based measures may give a more comprehensive picture of the long-term economic benefits associated with EP enhancements. Furthermore, financial ratios express a firm's efficiency in generating value by using its assets as well as the firm's internal capabilities and performance whereas market-based measures reflect the external perception of performance (Orlitzky et al., 2003).

2.2. The natural-resource-based view approach

The NRBV was developed to complement the pre-existing resource-based theory with the omitted environmental variable. One important insight of this approach is that resources help firms to develop capabilities that can, in turn, lead to competitive advantage. More specifically, Hart and Dowell (2011, p. 1466) argue that firms can gain competitive advantage by developing "capabilities that facilitate environmentally sustainable economic activity". In Hart's (1995) original work, three key strategic capabilities were described: pollution prevention, product stewardship, and sustainability. Each strategic capability can yield a different type of competitive advantage which can, in turn, have implications for performance (Aragón-Correa and Sharma, 2003). Pollution prevention focuses on waste minimization and can lead to increases in efficiency and cost reduction. Product stewardship, by extending pollution prevention to the full life cycle of a product, creates opportunities for firms to profit from differentiation. Sustainability, in comparison, leads to strategic alignment with emerging changes in the business environment (Aragón-Correa and Sharma, 2003).

In later research, Hart and Dowell (2011) have highlighted the role of clean technology in the sustainability category. They maintain that clean technology brings about disruptive change and requires strategies that go beyond the greening of the firm. Moreover, it involves ability in dealing with "areas of knowledge that are uncertain, constantly evolving, and dynamically complex" (Hart and Dowell, 2011, p. 1471). As a result, firms may not necessarily be able to achieve a competitive advantage in this domain.

Ultimately, Hart and Dowell (2011) have called for new research to test whether the NRBV's core proposition may also be applied in the context of high uncertainty and discontinuous change typically associated with the adoption of clean technologies. In this study, we answer this call by using the case of electric utilities to test if Hart's (1995) original argument is also valid in the domain of renewable energy.

2.2.1. Moving from if it pays to when it pays to be green

More recently, some authors have criticized the argument that firms with a proactive environmental strategy can have more advantages than firms with reactive strategies. For instance, Orsato (2009, p. 3) rightly observed: "If there are so many advantages for business, why is corporate proactive behavior not a widespread phenomenon? Why hasn't commerce yet led us to sustainable societies?" These scholars, therefore, suggest that research on the relationship between EP and FP may gain more consistency if the focus is shifted from the question "Does it pay to be green?" to the question of "When does it pay to be green?" Their view is supported by the argument that EP improvement may pay only under certain conditions, such as for firms that have certain attributes or that reduce pollution by certain means or in certain time frames (Dixon-Fowler et al., 2012; Orsato, 2009; Bernicchi and King, 2007; King and Lenox, 2001).

Recent empirical research has started to reveal some factors that can moderate the EP–FP link. For instance, Karagozoglu and Lindell (2000) found that supportive/less supportive regulation plays a fundamental role in determining whether the greening of a firm pays. Building on this, Stoeckl (2004) determined that firms benefit most from supportive regulations when they operate in highly competitive markets. Among internal factors that moderate the EP–FP link, Hart and Ahuja (1996) found that emission reduction initiatives had a higher impact on FP more for heavy polluters than for firms with an already lower level of emissions. In contrast, Aragón-Correra et al. (2008) demonstrate that a firm's size is another relevant factor in the EP–FP relationship.

After a review of the main literature, two main conclusions can be drawn. First, the discussion to date has mainly revolved around how the greening of the firm, sometimes seen in a proactive way and sometimes in a reactive one, can lead to better performance. However, very few authors have concentrated on what Hart (1997) calls a beyond-greening strategy, that is, those strategies that address sustainability. Second, consistent with Bernicchi and King (2007), we feel that future research would benefit if the focus were to shift towards identifying the contingencies that affect the EP–FP relationship.

3. Renewable energy and financial performance of electric utilities

In this study we look at a specific aspect of utilities' EP: the adoption of renewable energy technology in electric power production. We focus on the electric utility industry for two reasons: (a) the industry owns a large share of the generation and distribution infrastructure, (b) the electricity and heat generation sector is by far the sector with the highest amount of CO2 emissions. According to IEA (2015), the sector accounts for 42% of global emissions.

Over the last two decades, the power sector has been privatized in numerous developed and developing countries (Bacon and Besant-Jones, 2001) though it remains highly regulated. The growth of renewable energy production in the industry has been mainly driven by policy mechanisms such as feed-in tariffs and renewable quota obligation/portfolio standards. (For a more in-depth review of these mechanisms, see, e.g., Menanteau et al., 2003). The first type of mechanism is a form of subsidy that guarantees a certain price over a long period of time. The second is a regulatory intervention of the government forcing electric utilities to produce a portion of their electricity from renewable energy sources (Verbruggen and Lauber, 2012).

Although these policy mechanisms, especially feed-in tariffs, have contributed to a wider diffusion of renewable energy in the sector, it is unclear if deeper levels of renewable energy penetration also lead to better FP for electric utilities. Research in this field to date has focused on the more general link between EP and the performance of electric industry firms. For instance, Pätäri et al. (2014) looked at the relationship between corporate social responsibility and FP, finding that corporate social responsibility is correlated to only market-based measures. Filbeck and Gorman (2004) concentrated on the link between companies with a more proactive environmental strategy and FP and found a negative relationship. Sueyoshi and Goto (2009) investigated whether environmental investment and expenditure enhance the FP of electric utilities in the United States. They established that there is no influence of environmental investment on FP.

Furthermore, according to Sueyoshi and Goto (2009), renewable energy production implies higher costs for utilities. These costs are triggered by three key factors. First, new linkages to the grid need to be built because sites with good renewable energy sources are often far from consumption areas. Second, the grid needs to be reinforced to accommodate fluctuating amounts of electricity. Third, plants using renewable energy sources have much higher capital costs than do conventional power plants relying on fossil fuels. Such factors, in combination with how the price of electricity in many countries is essentially regulated to safeguard consumers, can lead to a situation in which investment in renewable energy may not immediately improve the FP of electric utilities.

4. Data and methods

4.1. Sample

To evaluate the relationship between the adoption of renewable energy and FP, we used an unbalanced panel of 66 electric utilities over the period 2005–2014. We acquired the data concerning firms' renewable energy production and FP from Thomson Reuters's DataStream (Thomson Reuters, 2016). We searched under the category “electricity” for utilities involved in electricity production and identified about 180 firms. Subsequently, we removed from the sample those firms that were only engaged in electricity distribution and kept firms that were also energy distributors but that mainly focused on generation. Other companies for whom we could not find financial data were also removed from the sample. The companies we eventually selected are from 26 different countries, with North America, the European Union and Eastern Asia as the three most important groups. Appendix A shows the number of firms from each country and region.

4.2. Variables

4.2.1. Dependent variables

In most previous studies financial ratios such as ROA, ROE and ROS have been used (Earnhart and Lízal, 2007). To a lesser extent market-based measures such as market capitalization, stock returns and Tobin's q have been employed (e.g., Pätäri et al., 2014, Dowell et al., 2000; Gilley et al., 2000; Khanna et al., 1998). Because some scholars (Orlitzky et al., 2003; Delmas and Nairn-Birch, 2010) have indicated that financial ratios may possibly not be able to capture the long-term FP of a firm, we used both accounting and market-based measures to increase the reliability of our analysis (Martin, 1993).

Thus, our dependent variables include ROE, ROA and Tobin's q. We measured ROE and ROA, respectively, as the ratio of net income to shareholder's equity and net income to total assets. In accordance with Lindenberg and Ross (1981), we calculated Tobin's q as the ratio of a firm's market value to the book value of its total assets. Tobin's q reflects reputational effects, investor trust and investor risk (Guenster et al., 2005). In an equilibrium situation its value is 1. A Tobin's q larger than 1 means that the market value of the firm is higher than the book value of its assets and, consequently, the company is overvalued. On the other hand, when the Tobin's q is smaller than 1, the market value of the firm is smaller than the book value of its assets. This condition suggests that the market may be undervaluing the company.

4.2.2. Independent and control variables

Our main independent variable was the volume of renewable energy produced yearly (RE.VOLUME) expressed in gigajoules. Because several authors (e.g., Telle, 2006; Earnhart and Lízal, 2007; and Hart and Ahuja, 1996) have suggested that there is often a time lag between the initiation of emission reduction initiatives and the manifestation of the possible financial benefits, we also used four time-lag values of our main independent variable. In doing so, we separately analyzed both the concurrent effects of the increase in renewable energy production on FP as well as the possible delayed effects captured by the lagged variables RE.VOLUME lag1, lag2, lag3, and lag4.

In addition to our main independent variable, we included several control variables in our model that were identified through the review of the literature. They are firm size (SIZE), risk (RISK), capital intensity (CAPINT), firm growth (GROWTH), carbon intensity (CARBINT), and yearly time trend for the years 2005–2014 (TIME). In addition, we also used some control variables for the context of a firm. They include the level of renewable energy penetration (RE.PENETRATION) of the firm's home country as well as two dummies for evaluating differences between developed economies (DE) and emerging markets (EM).

Firm size has often been considered to be a determinant of EP and FP. This is connected to the previously discussed effect of slack resources (Waddock and Graves, 1997) that may create a double loop between EP and FP. Several proxies for firm size have been proposed, including the natural logarithm of the number of employees (Nishitani and Kokubu, 2012), sales (Pätäri et al., 2014) and total assets (Gallego-Álvarez et al., 2014; Sueyoshi and Goto, 2009; Wang et al., 2014; Elsayed and Paton, 2005). Because all of the firms in our panel were listed, we used the natural logarithm of market capitalization as a proxy for size. We expected this variable to be positively correlated to the FP variables.

Firm risk is another control variable often cited in the context of EP–FP studies. Firms that have a high level of commitment to environmental protection may be rewarded by the market because their investors may perceive lower risks associated with that company (Sharfman and Fernando, 2008). Some studies have used a firm's Beta as a proxy for risk. In line with Waddock and Graves (1997) and McWilliams and Siegel (2000), in this study we used leverage, expressed as the ratio of the total debt to total assets, to measure risk. We also expected this variable to be positive. Capital intensity increase has been associated with reduction of direct costs and thus is another frequently used control variable (Berman et al., 1999). Consistent with Wang et al. (2014), we measured capital intensity as capital expenditures divided by sales and use the natural logarithm. Previous literature (Russo and Fouts, 1997) has shown that the relationship between EP and FP is strengthened when the company is in a fast-growing industry. To control for firm growth rate, we used a firm's annual change in sales, expressed as a percentage.

Because one of our purposes was to determine whether there were differences for firms with high CO_2 emissions in comparison to firms with low emissions, we tested if carbon intensity acted as a moderator. We derived this variable by dividing the amount (in tons of CO_2e) of greenhouse gas emissions by the value of total assets expressed in USD. Based on Hart and Ahuja (1996), we expected that this variable, in interaction with the volume of renewable energy produced, would be positive.

To account for the effects of the contexts in which the studied electric utilities operate, we controlled for the level of renewable energy penetration in the firm's home market. We used the level of renewable electricity penetration as a proxy for both the growth of the sector and the level of policy support because renewable energy expansion is mainly policy driven. Consequently, we assumed that countries with high levels of renewable energy penetration probably also have strong policy support mechanisms which drive the growth of the sector. Finally, we created dummy variables to control for possible differences between developed economies and emerging markets. Table 1 presents a synthesis of how we defined and measured our variables.

4.3. Regression model and estimation methods

The analytical method we selected to answer our research question was linear regression for panel data. We applied both fixed effects (FE) and random effects (RE) estimation methods with the support of the statistical software package STATA, version 14. In addition, we used the Granger causality test to verify if, along with a correlation, there was also a causality link between EP and FP.

FE and RE effect methods have strengths and limitations. Considering a general linear regression panel model.

$$Y_{it} = \beta_0 + \beta X_{it} + \gamma Z_i + \alpha_i + \varepsilon_{it} \qquad i = 1, 2, \ldots, N, \quad t = 1, 2, \ldots, T \tag{1}$$

where

- Y_{it} is s the dependent variable observed for individual i in time t,
- β_0 is the constant term,
- X is the independent variables whose values can vary across time,
- Z is the independent variables whose values do not change across time,
- β and γ are the coefficients for X s and Z s,
- α_i the error term that varies only across individuals but not across time (heterogeneity),
- ε_{it} is the error term which assumes different values for each individual at each point in time,

the types of assumptions that are made about α_i distinguish one model from the other. In other words, the distinction between the two models lies in whether the individual–specific time– invariant effects, $\alpha_{i,}$ are correlated with the regressors or not. In an FE model α_i is assumed to be correlated with X_{it}, but an RE model is uncorrelated. For FE models the two main estimators used are least squares dummy variable (LSDV) regression and the within effect estimation method whereas for the RE models they are GLS (generalized least squares) or FGLS (estimated generalized least squares). In this study we used the within-effect estimation method for the FE model and the GLS for the RE model.

One of the main characteristics of the FE model is that it eliminates all the unobserved time invariant factors such as sex, race and religion as well as those contextual factors that change slowly over time (Baltagi, 2008). Therefore, an important limitation is the fact that it cannot assess the effect of variables that have little within-group variation, because it considers only within-individual differences, discarding any information about differences between individuals. This characteristic limits the risk of bias due to omitted variables, but it comes at the cost of higher standards errors (Allison, 2009). On the other hand, the RE model can estimate the impact of time invariant factors and has lower standard errors than the FE model does, but it does not control for possible omitted variables.

Another important difference stemming from the two different assumptions described above is connected with the type of inferences that can be made. In an FE model it is implicitly assumed that all the individuals in the sample are one of a kind and are not a random sample from a population at large (Verbeek, 2008). This is useful only if we want to make, for instance, predictions for a particular country, region or type of industry. On the contrary, RE estimation models assume a normal distribution, so we can make inferences to a larger population (Verbeek, 2008). To decide which of the two estimation models is the most appropriate, the Hausman test can be applied. In this study we kept both FE and RE models in order to show the variation of our findings under the different assumptions underlying the two models.

In addition to the level of correlation, we also wanted to investigate possible causal links between our focal variables. We studied this issue using a Granger causality test, in which a variable X is said to Granger-cause variable Y if the lagged values of X help to explain Y even though the past values of Y have been taken into account. Thus, the changes in variable X should precede the changes in Y. In practice, Granger causality between X and Y can be tested with the following equations:

$$Y_{it} = \alpha_0 + \sum_{j=1}^{n} \alpha_j Y_{it-j} + \sum_{k=1}^{n} \beta_k X_{it-k} + \varepsilon_{1it} \tag{2}$$

$$X_{it} = \gamma_0 + \sum_{j=1}^{n} \gamma_j Y_{it-j} + \sum_{k=1}^{n} \delta_k X_{it-k} + \varepsilon_{2it} \tag{3}$$

where the error terms are assumed to be uncorrelated. X is said to Granger-cause Y if its coefficients are statistically significantly different from zero jointly and vice versa for Y. The alternatives are,

Table 1
Variables definition.

Variable name	Variable definition	Transformation applied	Unit of measure
ROE	Return on equity calculated as net income divided by shareholder's equity		
ROA	Return on assets calculated as net income divided by total assets		
Tobin's q	Tobin's q calculated as the market value of a firm as expressed by enterprise value divided by book value of total assets		
RE.VOLUME	Volume of renewable energy generated yearly	Natural logarithm	Gigajoules
TIME	Yearly time trend for the period 2005–2013		Years
SIZE	Size of the firm in terms of market capitalization	Natural logarithm	USD
RISK	Ratio of total debt to total assets		USD
CAP.INTEN	Ratio of capital expenditures to sales	Natural logarithm	USD
GROWTH	Increase in percentage in sales on a yearly basis		
RE.PENETRATION	Share of renewable power for a firm's home country calculated on a yearly basis		TWh
CARBINT	Ratio of total amount of greenhouse gas emissions to total assets		Tons CO2e/ USD

Table 2
Descriptive statistics.

	N	Mean	Std.	ROE	ROA	Tobin's q	RE.VOLUME	SIZE	RISK	CAPINT	GROWTH	RE.PENETRATION	CARBINT
ROE	646	9.658	14.331	1									
ROA	651	4.442	4.154	0.733	1								
Tobin's q	633	0.876	0.356	0.270	0.414	1							
RE.VOLUME	482	16.766	2.086	−0.019	−0.098	−0.142	1						
SIZE	641	16.161	0.999	0.218	0.138	0.013	0.302	1					
RISK	653	0.373	0.143	−0.237	−0.266	0.078	0.050	−0.239	1				
CAPINT	649	−1.926	0.767	−0.064	−0.015	0.152	−0.091	−0.015	0.019	1			
GROWTH	647	0.183	2.025	0.002	0.024	0.186	0.092	−0.015	−0.037	0.213	1		
RE.PENETRATION	609	2.772	0.757	0.060	0.034	0.025	0.009	−0.019	0.015	0.061	0.079	1	
CARBINT	591	1.444	1.721	−0.001	0.063	0.149	−0.235	−0.160	0.192	0.198	−0.004	−0.096	1

therefore, that either X Granger-causes Y, Y Granger-causes X, they both Granger-cause each other or there is no relationship.

We followed the method used in Pätäri et al. (2014) and assumed that the coefficients of the explanatory variables were the same for all cross-sectional units (in our case, companies) and that there was no causal variation among the cross-sections. Instead of finding optimal lag lengths by using, for example, Akaike or Bayesian information criteria, we simply tested several alternative lag structures and examined whether there were any changes in the results for different lag lengths.

5. Results

5.1. Descriptive analysis

Table 2 presents the descriptive statistics of the variables of interest. The second and third columns are the mean and standard deviation for each of the variables and the other columns show the correlation matrix. The average value of Tobin's q was 0.856. Therefore, according to the typical interpretation of this market-based indicator, the companies in the study were, on average, undervalued. The total debt to assets ratio was about 38%, the ratio of capital expenditure to sales was about 14.5%, and average annual sales growth for the companies was about 8%. The amount of renewable energy produced was a bit more than 19 million gigajoules per year.

In general, the unconditional pairwise correlations between the variables were rather small. As can be expected, the correlations between ROE, ROA and Tobin's q were some of the largest in the table. In addition, the amount of renewable energy generated was positively related (0.302) to firm size, suggesting that larger companies produced more renewable energy. The correlation between renewable energy and the carbon intensity (the ratio of produced carbon emissions to total assets) was negative but rather modest. Also, for the other pairs, the absolute value of correlation was below 0.3, thus the multicollinearity was not a problem in our estimations.

To complete our descriptive analysis and before proceeding with the regression models, we created three scatterplots to visually inspect the data (see Appendix B). As can be seen, all of the figures show a negative relationship between the volume of renewable energy and all of the performance measures.

Because we have a panel data sample, we also visualized how the average value of our dependent and key explanatory variables changed over time. Fig. 1 clearly shows that the firm performance measures and the volume of renewable energy moved in completely opposite directions during almost the entire sample period. Only after 2013 did all the variables seem to increase in tandem.

Note: The table presents the mean values and standard deviations for the variables and simple unconditional pairwise correlations between them. In total the unbalanced panel has 66 companies for the years 2005–2014.

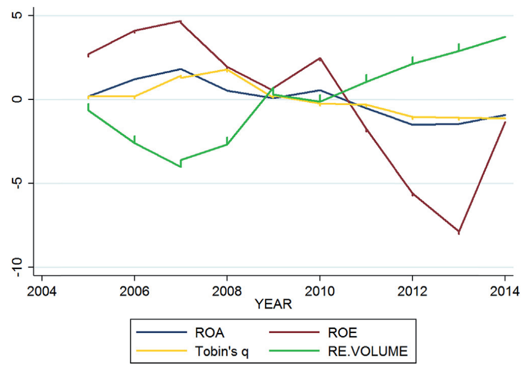

Fig. 1. Average change of renewable energy production ROE, ROA and Tobin's q over time. In order to plot all of the time series in the same figure, we first scaled RE.VOLUME and Tobin's q by multiplying their values by 10. We then calculated the cross-sectional yearly averages for the variables and demeaned those time series.

5.2. Results of regression analysis

For our estimation we required that all our variables were stationary. Thus, we started by testing the stationarity using the Fisher test and found that Tobin's q and SIZE were non-stationary.[1] However, when the trend term was included in the Fisher tests, both of these became stationary and thus for the final estimations both Tobin's q and SIZE were de-trended.

Subsequently, we analyzed the relationship between FP and renewable energy production. Table 3 reports the results from the panel data regressions. In order to add robustness, the results for both the FE models (odd columns) and the RE models (even columns) have been reported. In the first and second columns we used return on equity (ROE) as the dependent variable, in the third and fourth columns it was return on assets (ROA), and in the fifth and sixth columns it was Tobin's q. The columns for Tobin's q estimations present the long-term performance whereas the other measures (i.e., ROE and ROA) reflect short-term performance. Of the explanatory variables, our main interest lies in the volume of the generated renewable energy (RE.VOLUME).

As the table shows, the results were rather similar under both the FE and RE models. RE.VOLUME was consistently negative for all

[1] To save space these results are not reported here but are available from the authors.

Table 3
Renewable energy and firm performance.

VARIABLES	(FE) ROE	(RE) ROE	(FE) ROA	(RE) ROA	(FE) Tobin's q	(RE) Tobin's q
RE.VOLUME	**−0.844*** (0.491)	−0.301 (0.331)	**−0.174*** (0.0996)	**−0.166*** (0.0860)	**−0.0161****** (0.00527)	**−0.0125**** (0.00578)
SIZE	**13.15***** (3.700)	**12.69***** (3.054)	**2.186***** (0.586)	**2.498***** (0.465)	**0.252***** (0.0459)	**0.264***** (0.0478)
RISK	**−45.56**** (19.20)	**−26.58***** (8.220)	**−10.58***** (3.613)	**−8.582***** (2.151)	**0.397**** (0.152)	**0.147*** (0.0881)
CAPINT	−1.625 (1.619)	−0.664 (1.357)	−0.241 (0.355)	−0.193 (0.367)	0.0181 (0.0209)	−0.0117 (0.0293)
GROWTH	1.376 (2.219)	2.105 (2.657)	0.621 (0.696)	0.707 (0.759)	0.0122 (0.0213)	0.00303 (0.0265)
RE.PENETRATION	**1.612*** (0.929)	**2.065**** (0.908)	−0.00204 (0.123)	0.0507 (0.120)	**−0.0215***** (0.00790)	**−0.0217***** (0.00792)
TIME	**−0.922***** (0.268)	**−0.998***** (0.245)	**−0.268***** (0.0552)	**−0.255***** (0.0488)	**−0.0161***** (0.00288)	**−0.0156***** (0.00289)
CONSTANT	**1886***** (539.5)	**2022***** (493.3)	**549.5***** (110.3)	**522.3***** (98.14)	**32.65***** (5.744)	**31.60***** (5.801)
Observations	441	441	442	442	441	441
Number of firms	66	66	66	66	66	66
R-squared						
within	0.1548	0.1496	0.2851	0.2826	0.4638	0.4488
between	0.1521	0.1773	0.1250	0.1437	0.0459	0.2754
overall	0.1510	0.1672	0.1936	0.2072	0.1785	0.3062

Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels.

the indicators, though the level of significance varied. The control variables SIZE, RISK, RE.PENETRATION and TIME were statistically significant in most of the models and their behavior was essentially in line with what we expected. SIZE had a positive coefficient, implying that larger companies also have higher ROE, ROA and Tobin's q. However, although the total debt to assets ratio (RISK) was negatively related to ROE and ROA, more debt to assets correlated positively with Tobin's q. This may indicate that risk-taking in the short term has negative repercussions on performance, but in the long run it may pay off. The renewable energy penetration variable had the highest variation between the models. For ROE it was positive and significant, for Tobin's q it was negative and significant, and for ROA it was not significant. What is notable is the negative and highly significant time trend, which shows that during the period 2005–2014 electric utilities experienced negative economic outcomes.

After we derived the basic regression analysis in Table 3, we ran the same models for developing and emerging markets separately (see Appendix C). We still saw that in developed economies the relationship between renewable energy production and the performance measure was negative and significant. The same also applies to the emerging markets, which suffered, however, from a limited number observations (only 86 firm-year observations).

The results illustrated in Table 3 show the concurrent effect of renewable energy production on performance. To add dynamism to our basic models, we introduced the first four lags (i.e., the observations from the previous four years) of RE.VOLUME to explain the performance measures. As Table 4 shows, although there is now more variation in the results, the negative relation between renewable energy and firm performance could still be noticed because all the significant RE.VOLUME variables with a lag of 2 or higher had a negative coefficient. For ROA the negative coefficients of lagged variables were clearly visible but there were fewer of them for ROE and Tobin's q.

By including the lagged values, some of the control variables lost their significance. RE.PENETRATION was significant in one model only and the time trend also lost its significance for all but Tobin's q models. CAPINT became significant for ROA and Tobin's q fixed effects and, for some reason, sales growth had a negative effect on Tobin's q. However, firm size and debt to assets ratio remained negative and significant for all of the models.

As for the possible moderation effect of carbon intensity, Table 5

Table 4
Lagged renewable energy values and firm performance.

VARIABLES	(FE) ROE	(RE) ROE	(FE) ROA	(RE) ROA	(FE) Tobin's q	(RE) Tobin's q
RE.VOLUME lag1	−1.307 (3.280)	0.950 (1.097)	0.273 (0.449)	**0.429*** (0.232)	0.00843 (0.0143)	0.0129 (0.0218)
RE.VOLUME lag2	**−1.625*** (0.934)	−0.133 (0.408)	**−0.374***** (0.131)	**−0.255***** (0.0672)	**−0.0162*** (0.00839)	−0.0131 (0.00908)
RE.VOLUME lag3	−1.300 (0.805)	0.421 (0.745)	**−0.338**** (0.149)	**−0.216**** (0.0910)	−0.0121 (0.00845)	−0.00375 (0.00835)
RE.VOLUME lag4	−2.539 (1.653)	**−1.032*** (0.543)	**−0.362***** (0.128)	**−0.277**** (0.108)	**−0.00926*** (0.00477)	0.00842 (0.00703)
SIZE	**21.70*** (12.35)	**19.83***** (5.411)	**2.416*** (1.310)	**3.368***** (1.017)	**0.444***** (0.0708)	**0.297***** (0.0550)
RISK	**−88.34***** (30.23)	**−37.53***** (10.84)	**−12.45**** (5.585)	**−7.925***** (1.969)	**1.231***** (0.282)	**0.116*** (0.0654)
CAPINT	−11.33 (8.043)	−0.194 (2.513)	**−1.500**** (0.653)	−0.665 (0.708)	**−0.101***** (0.0352)	−0.00775 (0.0139)
GROWTH	5.125 (5.897)	6.268 (5.953)	0.156 (1.314)	0.277 (1.207)	**−0.0835***** (0.0293)	**−0.0915**** (0.0402)
RE.PENETRATION	5.321 (4.790)	**4.447*** (2.637)	0.263 (0.267)	0.392 (0.246)	−0.000283 (0.00758)	−0.00854 (0.0105)
TIME	−0.310 (1.324)	−0.745 (0.539)	−0.143 (0.158)	−0.0915 (0.0998)	**−0.0173***** (0.00648)	**−0.0195***** (0.00661)
CONSTANT	740.7 (2605)	1502 (1088)	306.0 (310.7)	193.4 (199.8)	**34.65***** (12.86)	**39.17***** (13.29)
Observations	197	197	197	197	197	197
Number of firms	59	59	59	59	59	59
R-squared						
within	0.1211	0.0873	0.1773	0.1507	0.6594	0.5107
between	0.1508	0.2718	0.1693	0.2506	0.0477	0.2656
overall	0.0737	0.1659	0.1654	0.2314	0.0730	0.3427

Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels.

Table 5
Interaction between the volume of renewable energy and carbon intensity and effect on ROA.

VARIABLES	(FE) ROA	(RE) ROA
RE.VOLUME	**−0.362**** (0.158)	**−0.323***** (0.117)
SIZE	**2.146***** (0.582)	**2.469***** (0.446)
RISK	**−10.76***** (3.706)	**−9.523***** (2.318)
CAPINT	−0.222 (0.350)	−0.219 (0.340)
GROWTH	0.758 (0.788)	0.872 (0.883)
RE.PENETRATION	0.0233 (0.137)	0.0929 (0.130)
CARBINT	**−2.406*** (1.428)	**−2.216**** (0.985)
RE.VOLUME x CARBINT	**0.168*** (0.0959)	**0.157**** (0.0669)
TIME	**−0.256***** (0.0631)	**−0.242***** (0.0505)
CONSTANT	**528.7***** (126.2)	**498.5***** (101.7)
Observations	412	412
Number of firms	64	64
R−squared		
within	0.2811	0.2792
between	0.1546	0.1756
overall	0.2192	0.2307

Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels.

reports the results when we introduced this variable and its interaction with RE.VOLUME. We present the results for ROA only because the interaction term was not significant for Tobin's q, and for ROE it was significant only under the FE model.

As Table 5 shows, RE.VOLUME and most of the control variables still behaved similarly to the previous models. CARBINT was negative and statistically significant whereas its interaction with RE.VOLUME was statistically significant but positive. In order to understand the moderation effect of CARBINT, we calculated the slope of our dependent variable on the independent variable when the moderator assumes a high value (high carbon intensity) and when it assumes a low value (low carbon intensity). We did this by centering CARBINT one standard deviation above and one standard deviation below the mean. Fig. 2 shows the regression lines when holding the moderator variable constant at its high and low values. We can see that when firms have high carbon intensity (i.e., the moderator is kept at its highest value), the correlation between ROA and RE.VOLUME becomes positive whereas in the opposite case it is negative.

To complete the analysis of the correlations, we examined the economic significance of our variables. Because the variables have not been standardized to any specific interval, comparing their

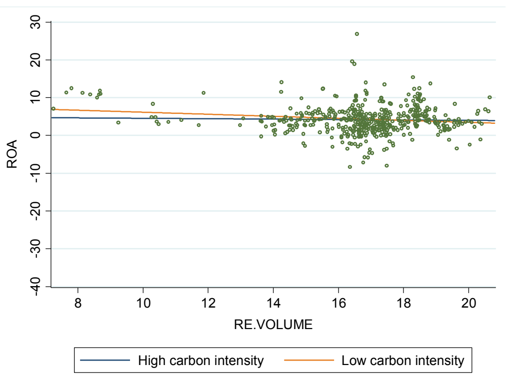

Fig. 2. Moderating effect of carbon intensity.

coefficients does not provide any indication of which ones are the most important for firm performance. In Table 6 we provide measures for the economic significance of our results.

Economic significance was calculated as the product of estimated coefficient (from Table 3) and one standard deviation of each variable (from Table 2, except for SIZE where the economic significance was calculated using standard deviation of the de-trended logarithm of total asset value, 0.274). As can be seen, SIZE had by far the largest effect on the performance measures and RISK the second highest. The volume of renewable energy was the third largest (in absolute terms) and all the rest of the variables were smaller than in most estimations. The three most economically significant variables were also those that were consistently statistically significant in almost all the models of Table 3.

All in all, although the significances between our estimations vary, all of our models found a negative correlation between the amount of renewable energy produced and firm performance measures. Firm size was clearly the most important determinant of firm performance, but the renewable energy volume had a notable effect on it as well.

5.3. Robustness check

Although in our basic model we have already partially controlled for countries support to renewable energy with RE.PENETRATION variable, we wanted to verify the robustness of our results by including a dummy variable for each country-year where a country has used subsidies or regulations to boost its renewable energy capacity. For this, we created three dummy variables: FIT_IEA, FIT_REN21, QUOTA/RPS_REN21. The first two dummies assume a value of 1 for the years when there was a feed-in tariff scheme in a firm's home country and 0 if there was not. The only difference between the two is the origin of the data. In the first case, data were from the Global Renewable Energy Policies and Measures Database (IEA/IRENA, 2016) and in the second from the annual reports on the renewable energy market, industry and policy trends published by REN21 (REN21, 2016). The third dummy, in contrast, assumes a value of 1 for the years when there was a quota obligation or renewable portfolio standards (RPS) in the home market of the electric utility and 0 if there was not. For the last dummy we have data only from REN21 reports. When a policy mechanism was not available at the national level, like in the case of feed-in tariff in the US and Canada, we formed the variables at the regional level, checking if the company's headquarters were located in the region/state in question.

Subsequently, we estimated the same models as in Table 3 but, for reasons of space, only the result for the variables of interests (i.e., RE.VOLUME and the dummy variables) is included in Table 7.[2] As can be seen, the results for RE.VOLUME remained consistent. Thus, the presence of a feed-in tariff scheme or a quota obligation/RPS did not have an effect on our original estimations, because the relationship between the amount of renewable energy and the performance measures remains negative.

One surprising finding was the fact that almost all the coefficients of the dummies were negative. However, in the case of quota obligation/RPS under the FE model, for ROE and ROA they were positive and significant, but for Tobin's q they were, again, negative. When interpreting the coefficients of the dummies, we need to be careful because, even though they are mainly negative, several are not significant. All in all, the main finding from the robustness check was that our original results did not change when

[2] Coefficients for the rest of the control variables remain rather similar between each estimated model and are available from the authors.

Table 6
Economic significance.

VARIABLES	ROE (FE)	ROE (RE)	ROA (FE)	ROA (RE)	Tobin's q (FE)	Tobin's q (RE)
RE.VOLUME	−0.090	−0.018	−0.019	−0.032	−0.002	−0.001
SIZE	0.603	0.685	0.100	3.478	0.012	0.072
RISK	−0.303	−0.057	−0.070	−0.177	0.003	0.001
CAPINT	−0.055	−0.007	−0.008	−0.022	0.001	0.000
GROWTH	0.018	0.009	0.008	0.028	0.000	0.000
RE.PENETRATION	0.058	0.002	0.000	0.074	−0.001	−0.001

Table 7
Renewable energy, feed-in tariff, quota obligation/RPS and firm performance.

VARIABLES	(FE) ROE	(RE) ROE	(FE) ROA	(RE) ROA	(FE) Tobin's q	(RE) Tobin's q
RE.VOLUME	**−0.925*** (0.489)	−0.268 (0.341)	**−0.191*** (0.101)	**−0.165*** (0.086)	**−0.016***** (0.005)	**−0.012**** (0.006)
FIT_IEA	**−4.300*** (2.289)	−1.786 (1.621)	**−0.872*** (0.516)	**−0.796*** (0.444)	−0.015 (0.036)	−0.011 (0.030)
RE.VOLUME	**−0.911*** (0.484)	−0.263 (0.348)	**−0.185*** (0.098)	**−0.162*** (0.086)	**−0.017***** (0.005)	**−0.012**** (0.006)
FIT_REN21	−2.117 (1.634)	−0.807 (1.675)	−0.351 (0.431)	−0.338 (0.399)	−0.038 (0.031)	−0.023 (0.024)
RE.VOLUME	**−0.861*** (0.495)	−0.297 (0.334)	**−0.179*** (0.101)	**−0.171**** (0.086)	**−0.016***** (0.005)	**−0.012**** (0.006)
QUOTA/RPS_REN21	**2.062*** (1.177)	−0.322 (1.786)	**0.587**** (0.282)	0.399 (0.352)	**−0.028**** (0.012)	**−0.044**** (0.020)

Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels.

Table 8
Granger causality test between renewable energy production and performance measures.

	Lag 2	Lag 3	Lag 4	Lag 5
RE.VOLUME ⇏ ROA	1.943	1.222	0.924	0.652
	0.145	0.302	0.451	0.660
RE.VOLUME ⇏ ROE	0.406	0.206	0.266	0.317
	0.666	0.892	0.900	0.902
RE.VOLUME ⇒ Tobin's q	**2.861***	**2.693****	0.143	1.160
	0.059	0.047	0.966	0.332
ROA ⇏ RE.VOLUME	0.571	1.214	0.480	0.615
	0.565	0.305	0.751	0.688
ROE ⇏ RE.VOLUME	1.255	1.592	0.574	0.390
	0.287	0.192	0.682	0.855
Tobin's q ⇒RE.VOLUME	1.979	**3.074****	1.515	1.062
	0.140	0.028	0.199	0.384
Observations	329	263	201	146

Note: Table 8 shows the results of the Granger causality test for different lag lengths. The null hypothesis is that the variable on the left does not Granger-cause the variable on the right. The table shows F statistics and its corresponding p value below. ** and * refer to statistically significant results at the 5% and 10% levels.

we explicitly controlled for the role of feed-in tariff and quota obligation/RPS[3] schemes.

5.4. Granger causality test

Even though Table 3 already provided evidence that higher amounts of renewable energy production may lead to negative firm performance, we tested the causation more formally and also in both directions. Due to data limitations, however, we only tested for lengths of 2, 3, 4 and 5. The results (the F-test statistics of a joint null hypothesis that all coefficients of X are zero as well as the corresponding p values) can be found in Table 8.

For ROA and ROE the null hypothesis was not rejected for any of the cases, meaning that there was no Granger causality with the renewable energy production in either direction. However, we found that for lags of 2 and 3 there was a statistically significant relationship from renewable energy to Tobin's q and for a lag length of 3, the direction also goes the other way. When the regressions were carried out using equations (2) and (3), we found that all the lagged coefficients of RE.VOLUME were negative, thus providing even more evidence for the negative relationship between Tobin's q and renewable energy production.

6. Discussion and conclusions

The aim of this study was to verify if the NRBV of a firm can also be applied in the case of clean technology. To find some empirical evidence we used the example of electric utilities switching to renewable power production. In general, our results support a negative relationship between an increase in renewable energy production and both short-term and long-term FP. This is partially congruent with Sueyoshi and Goto (2009), who pointed out that the higher capital costs of renewable energy affect the FP of electric utilities in the short term. In contrast to Sueyoshi and Goto (2009), however, we also found that an increase in renewable energy production Granger-causes a reduction of firms' long-term FP. In addition, our findings indicate that the relationship between an increase in renewable power production and profitability is contingent on the level of carbon intensity of the firm. Therefore, firms that have a high level of CO2 emissions may benefit more from the deployment of renewable electricity than firms with low CO2 emissions. Based on these results, we are inclined to think that the NRBV may not entirely apply to the case of utilities increasing renewable energy production.

The presence of the moderating effect of carbon intensity answers our second research question positively and is in line with previous research (Hart and Ahuja, 1996). Moreover, it echoes Aragón-Correa and Sharma (2003), who proposed a contingent-resource-based view of proactive corporate environmental strategy. Because carbon intensity plays a role in moderating the relationship between the increase of renewable energy and a firm's performance, there may be, for firms that have already deployed renewable energy to some extent, an equilibrium point beyond which any increase in its capacity may be economically detrimental. After all, if the deployment of renewable energy always boosted a firm's FP, why is it that of the top 100 greenest utilities in the world, only five had a share of renewable energy higher than 20% at the end of the period under examination (Energy Intelligence, 2014; note that the figures do not include hydropower)?

The idea that electric utilities may need to balance profits from

[3] To further study the regional and country related differences, we also estimated the random effects models by including regional and country dummies. The results, which are available from the authors, remained the same.

conventional assets with investment in renewables can be easily understood in light of the organizational ambidexterity perspective (March, 1991). According to this view, firms need to ensure that they have an optimal mix of exploration and exploitation activities to ensure success in the short and long term. In our case, exploitation activities are utilities' existing fossil fuel investments, and exploration activities are the deployment of renewable energy. We propose that the concept of ambidexterity (Gupta et al., 2006; Raisch et al., 2009) may be used to refine the NRBV understanding of the link between the processes of environmental change for sustainability within the firm and its performance.

When this concept is applied here, we arrive at one broad implication of our findings: due to the need of incumbent firms to balance their exploitative and explorative activities, they may promote only a gradual development of renewable energy. Thus, in general terms, to accelerate the shift to clean energy production the participation of new actors who do not have sunk investments in fossil fuel assets needs to be promoted (see also Ruggiero et al., 2015).

A further interesting finding of our study is the fact that also the correlation between the share of renewable power of a firm's home country and firm's long-term performance was negative. This result could be explained by the fact that the expansion of renewable energy contributes to the devaluation of firms' fossil fuel assets. When renewable capacity increases, the overall quantity of electricity available on the market increases. A higher availability of electricity leads to lower wholesale prices and, consequently, lower margins for conventional power plants (The Economist, 2013). The concern in the investor community regarding the impact of renewable energy expansion on electricity prices is well illustrated in the following quote from a report by Moody's (2012):

Large increases in renewables have had a profound negative impact on power prices and the competitiveness of thermal generation companies in Europe. What were once considered stable companies have seen their business models severely disrupted, and we expect steadily rising levels of renewable energy output to further affect European utilities' creditworthiness.

Evidence of a reduction in the value of electric utilities' assets, which in accounting is called impairment (Accounting Dictionary, 2016), can be found also in a recent report by Ernst and Young (2013). The report showed that between 2010 and 2013 large utilities wrote a total of €62.7 billion in impairments off their balance sheets.

With regard to the role of subsidies and regulation, the results of the robustness check showed that the sign of the correlation between renewable energy increase and profitability does not change when controlling for the presence of a feed-in tariff or a quota obligation scheme. However, companies operating in countries with a non-feed-in tariff regime as well as companies operating in countries with a quota obligation/RPS system have higher short-term performance compared to the rest. Although this result requires further validation because it was found only under a FE estimation model, it can be explained by the different nature of the two policy mechanisms. The feed-in tariff system supports new and small-scale producers, leaving the burden of integrating renewable energy to incumbent power companies (Verbruggen and Lauber, 2012). Obligation quota/RPS schemes, instead, boost incumbent power companies' profits, leaving only a minor part of the economic benefits of renewable energy to new producers (Bergek and Jacobsson, 2010; Stenzel and Frenzel, 2008; Verbruggen and Lauber, 2012).

An important remark needs to be made here about the negative time trend variable we found. It suggests that the growth of renewable energy capacity driven by falling technology costs and subsidies is not the only factor that has contributed to the reduction of firms' profitability. Other important factors may also include, for example, cheap natural gas, a stagnant demand for electricity, overcapacity, nuclear phase-outs in some countries and the financial crisis. At play, therefore, are unfavorable market conditions in combination with the growth of renewable energy.

Before concluding, we feel it is important to highlight some of the limitations of this study. First, because we used unbalanced data, some companies might have had a larger effect on the results than others. This became clear when we compared developed and emerging countries, where the former had about four times more observations. Thus, our sample set was heavily tilted towards developed countries and their more mature electricity markets. Second, we were able to introduce only four lagged values of our key explanatory variable, but investments in the energy sector may take a long time to pay themselves back. Last, we measured firm performance only in terms of short- and long-term FP. Future research may instead apply other parameters to measure performance, such as avoided negative externalities.

We conclude this article with two final thoughts. Although our study showed that the deployment of renewable energy may not necessarily have positive economic implications (at the least) for electric utilities operating in mature markets (i.e., those markets affected by overcapacity, declining demand and so on), this should not restrain them from seriously answering the global call for increasing the share of renewable energy. The problem, in fact, may not be the adoption of more renewable energy per se but the challenging task of balancing it with conventional generation while gradually phasing out fossil fuels. Second, our findings are bound to the assumption that utilities will continue deploying renewable energy with a traditional centralized model. However, in the near future customer-side models (Richter, 2012) will play a central role. We believe much of the future of the industry depends on its ability to rethink its business model and develop new core competences that leverage the versatility of renewable energy technology.

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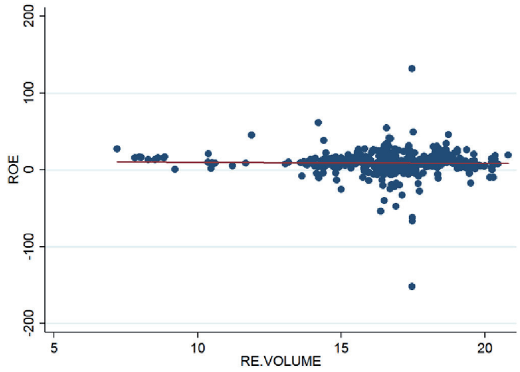
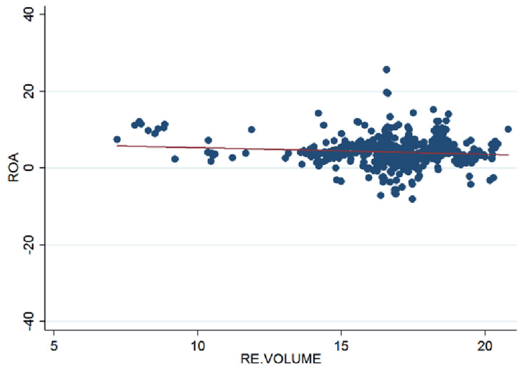
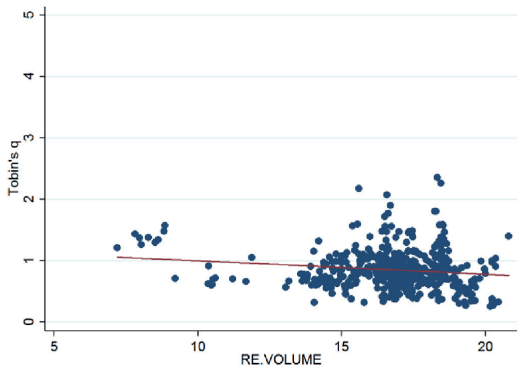
Appendix A. Number of firms per world regions/countries.

EU	**19**	**EA**	**20**
Austria	1	China	3
Czech Republic	1	India	2
Finland	1	Japan	11
France	2	Malaysia	1
Germany	2	New Zealand	1
Greece	1	Philippines	1
Italy	3	South Korea	1
Poland	1		
Portugal	1	**SA**	**7**
Russia	1	Bolivia	1
Spain	2	Brazil	4
Switzerland	1	Chile	1
UK	2	Colombia	1
NA	**20**		
Canada	3		
US	17	**Total**	**66**

Appendix B. Scatter plots with a fitted line for ROE, ROA and Tobin's q with respect to RE.VOLUME.







Appendix C

Panel 1. Random effects model for firms from developed and emerging markets

VARIABLES	(DE) ROE	(EM) ROE	(DE) ROA	(EM) ROA	(DE) Tobin's q	(EM) Tobin's q
RE.VOLUME	−0.283 (0.328)	−1.505 (1.219)	**−0.211**** (0.103)	**−0.766*** (0.458)	0.00515 (0.00333)	**−0.0535*** (0.0279)
SIZE	**12.69***** (3.403)	**8.867**** (4.346)	**2.166***** (0.402)	**3.345**** (1.595)	**0.213***** (0.0413)	**0.297***** (0.113)
RISK	**−37.79***** (8.604)	**22.14** (14.97)	**−10.67***** (1.844)	4.615 (5.783)	−0.0241 (0.0311)	−0.0440 (0.173)
CAPINT	1.405 (1.327)	**−2.439*** (1.451)	0.485 (0.309)	**−1.096**** (0.490)	**0.0227*** (0.0120)	−0.0182 (0.0380)
GROWTH	3.791 (3.081)	0.709 (2.435)	0.919 (0.583)	0.323 (1.029)	**0.0841***** (0.0299)	−0.0435 (0.0311)
RE.PENETRATION	**2.921***** (1.130)	0.347 (1.029)	0.0907 (0.138)	−0.0463 (0.279)	**−0.0147*** (0.00845)	**−0.0389***** (0.0113)
TIME	**−1.060***** (0.274)	**−1.187**** (0.534)	**−0.273***** (0.0485)	**−0.403*** (0.229)	**−0.0189***** (0.00307)	−0.00868 (0.00877)
CONSTANT	**2153***** (550.2)	**2413**** (1073)	**559.8***** (97.49)	**827.1*** (462.1)	**37.92***** (6.167)	18.43 (17.50)
Observations	355	86	356	86	356	85
Number of firms	50	16	50	16	50	16
R−squared						
within	0.1562	0.2308	0.3161	0.2457	0.4482	0.5051
between	0.3656	0.4052	0.3408	0.3513	0.3669	0.6545
overall	0.2133	0.3324	0.3347	0.3143	0.4322	0.4984

Panel 2. Fixed effects model for firms from developed and emerging markets

VARIABLES	(DE) ROE	(EM) ROE	(DE) ROA	(EM) ROA	(DE) Tobin's q	(EM) Tobin's q
RE.VOLUME	**−0.928*** 0.515)	**−3.720*** (2.048)	**−0.195*** (0.104)	−0.651 (0.902)	**−0.0150***** (0.00557)	−0.0454 (0.0335)
SIZE	**13.76***** (4.367)	8.819 (5.584)	**1.994***** (0.526)	2.880 (2.142)	**0.240***** (0.0498)	**0.259**** (0.0957)
RISK	**−61.15***** (21.45)	16.52 (16.37)	**−13.75***** (3.966)	−0.0174 (5.669)	**0.432**** (0.173)	0.106 (0.221)
CAPINT	0.204 (2.334)	−1.909 (1.485)	0.425 (0.349)	**−1.187**** (0.538)	0.0254 (0.0315)	0.0167 (0.0170)
GROWTH	3.239 (2.630)	0.723 (2.356)	**0.959*** (0.571)	0.230 (0.968)	**0.0885***** (0.0300)	−0.0318 (0.0269)
RE.PENETRATION	1.976 (1.185)	0.373 (0.979)	0.0111 (0.138)	−0.0298 (0.302)	−0.0133 (0.00898)	**−0.0419***** (0.0105)
TIME	**−0.896***** (0.322)	−0.989 (0.666)	**−0.267***** (0.0521)	−0.427 (0.280)	**−0.0174***** (0.00298)	−0.00586 (0.00822)
CONSTANT	**1842***** (650.4)	2058 (1326)	**548.6***** (104.5)	875.2 (556.2)	**35.08***** (5.970)	12.66 (16.23)
Observations	355	86	356	86	356	85
Number of firms	50	16	50	16	50	16
R-squared						
within	0.1395	0.2500	0.2938	0.2662	0.4381	0.3907
between	0.3967	0.3670	0.3809	0.3276	0.3308	0.7105
overall	0.2187	0.3136	0.3460	0.3111	0.4193	0.5634

Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels.

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II

TRANSITION TO DISTRIBUTED ENERGY GENERATION IN FINLAND: PROSPECTS AND BARRIERS

by

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Transition to distributed energy generation in Finland: Prospects and barriers

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HIGHLIGHTS

- We examine the possibilities and challenges of the transition to DE in Finland.
- Technological niches are emerging both in the heat and electricity sector.
- Business model innovation is evident only in the electricity sector.
- Removing barriers and developing new business models will accelerate the transition.

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ABSTRACT

Small-scale distributed energy generation is expected to play an important role in helping Finland increase its energy self-sufficiency. However, the overall strategy to date for promoting distributed energy remains unclear. It is not yet well understood which factors promote the growth of the distributed energy sector and what barriers need to be removed. In this article we present the results of a questionnaire directed at a panel of 26 experts from the distributed energy value chain and 15 semi-structured interviews with industry and non-industry representatives. We investigated, from a sociotechnical transition perspective, the possibilities and challenges of the transition to distributed energy in Finland through 2025. The results show that a shift to a prosperous future for distributed energy is possible if permit procedures, ease of grid connection, and taxation laws are improved in the electricity sector and new business concepts are introduced in the heat sector. In contrast to other European countries, the transition in Finland is expected to take place through a market-based approach favoring investment-focused measures. We conclude that incentive-based schemes alone, whatever they may be, will be insufficient to create significant growth in Finland without institutional change, removal of barriers, and the engagement of key actors.

1. Introduction

In the context of the current energy transition, distributed energy (DE) is believed to hold many advantages not only for increased renewable energy (RE) capacity but also for increased energy efficiency as a result of lower transport or transfer losses, increases in energy self-sufficiency and better security of supply (Alanne and Saari, 2006; VTT, 2015). In addition, DE offers local businesses and communities new opportunities for socioeconomic development (Li et al., 2013; Phimister and Roberts, 2012).

There are several definitions of DE, but a common one refers to a system where energy production and consumption are in close proximity (Allan et al., 2015). In such a system, prosumers (i.e. consumers with generation capacities) who produce heat or electricity for their own needs can also send their surplus electrical power into the electric grid or share excess heat via the district heating network (Alanne and Saari, 2006; Nystedt et al., 2006). DE systems usually utilize RE sources and rely on small-scale energy-generating technologies such as photovoltaics, micro-wind turbines, small CHP installations, ground source heat pumps, biofuel boilers or micro-hydro (Gaia, 2014).

EU member states have adopted differing approaches to increase their share of DE. For example, Germany has a comprehensive plan, the *Energiewende* ("energy transition"), to move away from fossil fuels and nuclear power. Under the Energiewende, a variety of policy initiatives, most importantly feed-in tariffs, have been

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implemented (Pegels and Lütkenhorst, 2014) to stimulate the shift from centralized energy production to DE (Praetorius et al., 2010). Sweden is using a quota system based on a green certificate trading scheme in combination with strong general incentives, such as a carbon dioxide tax to make fossil fuels less competitive in the household and service sector (Svebio, 2015). As a result of these policies, in both Germany and Sweden, new actors such as local communities, farmers and householders are enabled to play a key role in the spread of DE and development of new concepts of energy governance (Moss et al., 2014).

In Finland in recent years there has been increasing interest in small-scale DE generation technologies, including heat pumps (Heiskanen et al., 2011; SULPU, 2014a) and solar photovoltaics (Haukkala, 2015), but there are still great challenges to be overcome in order to achieve a large market penetration of DE (VTT, 2015). According to the vision of the Finnish government, expressed in the report *National Energy and Climate Strategy* (TEM, 2013), small-scale distributed electricity in the 2020s “may play a significant role in reducing the consumption of purchased electricity” and contribute to meeting the national “self-sufficiency target” (2013, pp. 11, 39). However, it is unclear how this goal will be reached in light of the fact that in Finland at the moment there is only an estimated 4–6 MW of photovoltaic capacity and 36 small biogas CHP power plants connected to the grid (Auvinen, 2015). The possibilities of distributed heat production have also been discussed in Finland for a decade (Sipilä et al., 2005), but centralized district heating relying on fossil fuels remains the most important method of heat provision (Finnish Energy Industries, 2013).

Prior research has discussed the overall potential of RE technology (Lund, 2007; Peura and Hyttinen, 2011) and energy efficiency services in Finland (Matschoss et al., 2015). Some studies have discussed, in general terms, the factors hindering the deployment of DE in the Nordic countries (Järvelä et al., 2011; Palm and Tengvard, 2011) and energy diversification in Finland (Aslani et al., 2013). Few authors have discussed the deployment of specific RE sources, highlighting issues such as the success factors for the market growth of heat pump technology (Heiskanen et al., 2011), the institutional aspects affecting wind power development (Spodniak and Viljainen, 2012; Varho, 2006) and the barriers to green electricity purchase in Finland (Hast et al., 2014). However, to date it remains unclear (a) why the overall Finnish DE capacity remains low despite the government's endorsement, (b) which factors promote the growth of the sector and (c) what barriers should be removed. Additionally, scant attention has been devoted to analyzing the development of the DE sector from a systemic perspective.

In this article, we address these identified research gaps by investigating, from a socio-technical transition perspective, the possibilities and challenges for the development of the Finnish DE sector in the next decade. We assume a socio-technical transition perspective because it provides a broad understanding of the factors at play in the transformation of an energy system, including regulation, infrastructure, industrial networks and consumer demand (Geels, 2002). By *possibilities* we mean the potential growth outcomes that could be achieved in Finland and by *challenges* we refer to the difficulties that need to be overcome to allow the transition to take place. Thus, our research question can be formulated as follows: What are the possibilities and challenges of the transition to DE in Finland through 2025? The scope of our analysis is limited to small-scale DE generation. Specifically, we use the Finnish Government's definition of small-scale electricity generation, which includes production up to 2000 kVA (Motiva, 2014), and assume a limit of 1000 kW for small-scale heat production.

To answer our research question, we used a questionnaire directed at a panel of 26 experts in the DE value chain and 15 qualitative semi-structured interviews with energy industry and non-industry actors. Our findings show that the transition to DE in Finland can have a prosperous future but market barriers need to be removed and new business models are required. This study contributes to the growing body of research in energy transition by examining the situation in a country that is trying to achieve a transformation of its energy system with less government intervention than in other European countries.

The article includes a description of the Finnish energy sector in Section 2, the theoretical framework in Section 3, material and methods in Section 4 and the results in Section 5. Results are discussed in Section 6 and we conclude with some policy recommendations in Section 7.

2. The Finnish energy sector

2.1. Electricity

Finland possesses many energy-intensive industries, such as paper and pulp, metal, and chemical industries, which, when combined with the northern location of the country, contribute to high per capita energy use. There are about 120 companies operating in the electricity sector but three companies own nearly half of the total installed capacity (Kivimaa and Mickwitz, 2011). Stand-alone electricity production is mainly used in summer cottages and as an emergency backup.

Finnish electricity production relies on several energy sources. The average shares of energy sources and net imports in Finnish total electricity consumption for 2010–2012 are given in Fig. 1. The shares of each source vary considerably from year to year, depending on temperatures and on the availability of hydropower in the Nordic countries. Renewable power accounts for about one third of total electricity consumed in Finland and is mostly based on forest biomass and hydropower (Statistics Finland, 2014). Nuclear power has the largest share (26%) of total electricity consumption and new capacity is being built by a consortium of Finnish power and industrial companies (Olkiluoto 3). In addition, the partially state-owned power company Fortum and several municipality-owned energy companies are planning to purchase another reactor (Hanhikivi 1).

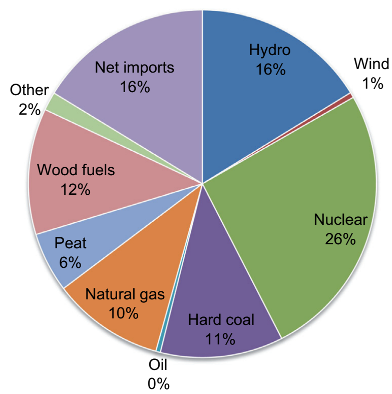

Fig. 1. The average shares of energy sources and net imports in Finnish electricity consumption 2010–2012.

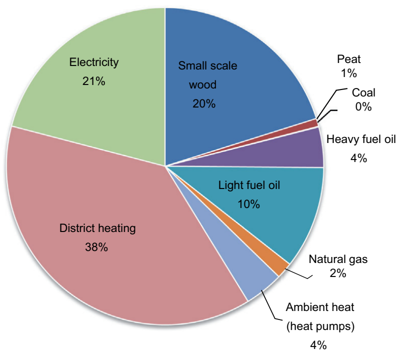

Fig. 2. Average shares of heating of buildings in Finland in 2010–2012. Note that district heating and electricity production use coal, natural gas, peat, wood and other sources.

2.2. Heat

Heating is a key energy need in Finland, accounting for about one fourth of all energy consumption (Statistics Finland, 2014). In 2010–2012, space heating took, on average, some 330,000 TJ a year, although the yearly variation is great due to annual differences in the weather (Statistics Finland, 2014). Co-generation of heat and power is common in both industry and municipalities, and use of district heating is widespread (see Fig. 2). Small-scale use of wood in heating is also widespread, particularly in the countryside (accounting for about 26% of heating of residential buildings in 2012), and many single houses use light fuel oil. Otherwise, much of the residential heating is either centralized district heating (33%) or relies on electricity (24%; Statistics Finland, 2014). Heat pumps using ambient heat are becoming popular, with over 60,000 units being installed yearly. As a main source of heating for a house, ground heat applications have gained in importance, with about 100,000 installations around the country (SULPU, 2014b).

2.3. Policy mechanisms supporting RE in Finland

The current policy support for producers of renewable electricity is twofold, including investment subsidies in the form of a state grant and a long-term premium tariff system (TEM, 2013). The state grants were allocated €145 million in 2013, and the tariff system €125 million, with an increase of up to €200 million in 2015 (TEM, 2013). The state grant allocated to RE production investment can account for up to 30% of a project's overall cost, but can increase up to 40% if the project involves the use of new technology (Finlex, 2012). State grants can be awarded only to companies, municipalities and other legal entities such as federations, associations or foundations. In the premium tariff system, the producer is paid a tariff that is equal to the difference between the target price and the spot market price over a three-month average. In order to be eligible, the minimum capacity of the generators must be at least 500 kVA for wind and 100 kVA for biogas and biomass, and fulfill detailed terms defined in legislation (Finlex, 2010). Even if the capacity-level requirements of the feed-in tariff are, in theory, within the limits of small-scale DE production, other conditions such as producing electricity only for commercial purposes and fulfilling specific long-term economic parameters implies that the feed-in tariff scheme currently supports only large energy producers (TEM, 2014). Additional economic incentives come as a tax deduction that applies to labor costs originating from renovation or extension work carried out in private households. Furthermore, the state of Finland provides funding for research, development and innovation projects in the field of sustainable energy generation (€180 million in 2013).

For heat production in Finland, there are three support mechanisms: the same state grant mechanism that is available for electricity producers, a price-based incentive for CHP plants called "heat bonus", and a special subsidy for farmers who invest in heat plants utilizing RE sources (RES-Legal, 2014). Only CHP plants utilizing biogas or biomass, achieving an efficiency of more than 75% and having a minimum capacity of 1000 kVA, are eligible for the heat bonus. The heat bonus is fixed at €50/MWh for plants utilizing biogas and €20/MWh for plants utilizing wood. The subsidy for farmers can be given in the form of a state investment aid, soft loans, or with the state acting as a guarantor for a loan. The exact amount of subsidy can vary (RES-Legal, 2014).

3. Theoretical background

3.1. Socio-technical transition perspective

To analyze the growth of Finnish DE, we assumed a socio-technical transition viewpoint. The term *socio-technical transition* is increasingly being used to denote a major transformation in technological solutions as well as with regard to wider societal change, including regulation, user practices, infrastructure, industrial networks and culture (Geels and Schot, 2007; Geels, 2002). Geels (2002, 2005, 2010, 2011) adopts a multilevel perspective (MLP) to look at socio-technical transformation, proposing three analytical levels: landscape (macro), socio-technical regime (meso) and niche (micro). Innovation originates at the niche level and when a socio-technical regime is destabilized under the pressure of changes at the landscape level, new windows of opportunity open for innovation. The landscape level relates to material and immaterial elements that sustain society, including political ideologies, demography, the macro-economy, and the natural environment (Rip and Kemp, 1998). This is the exogenous context that, according to Geels (2011), changes slowly. In the case of the transition to DE generation in Finland, the landscape is shaped by Finnish, Nordic and EU developments as well as by the societal conditions found on the regional level.

The niche level refers to those spaces that feature experimentation with new practices and technologies. These spaces are protected ones, such as demonstration projects or market niches. In certain market niches, the customers are willing to pay more for the new technology because it delivers some distinctive benefit that cannot be provided by the established technologies (Levinthal, 1998; Malerba et al., 2007; Schot and Geels, 2008). Nygrén et al., 2015 describe how the early adopters of DE in Finland have various motives for their investments, such as interest in technology, available raw material for energy consumption, environmental concern, and cost savings.

Between the landscape and the niche level is the socio-technical regime level. According to Geels (2011), it represents the "semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems" (p. 27). Smith (2007) adds that socio-technical regimes are "the product of long histories of interaction between technologies, users, knowledge and institutions" (p. 447). These regimes come to be shaped over a long period of time by different forces, including technology, industry, science, culture and policy (Geels, 2011). Unruh (2000) observed that an important characteristic of regimes is that they tend to become locked-in through a path-dependency process. Due to such lock-in mechanisms, it becomes difficult to change the development trajectory of regimes even when – as in the case of climate change – there is growing evidence of the risks for society

(Unruh, 2000). The Finnish energy regime is characterized by a strong orientation to technological expertize and the influential role of a political elite in energy decision-making. This elite consists of market actors and interest organizations whose main objective over the years has been to secure cheap energy for energy-intensive industries by giving priority to large centralized solutions (Huttunen, 2014).

3.2. Transition management

Within the socio-technical transition literature, a strand of studies has focused on the ways in which transitions may be steered by means of long-term policy intervention. Transition management theory draws on the multi-level perspective. While the latter aims at developing an analytical framework to understand the dynamics of socio-technological change, the former is a management strategy that seeks to guide gradual processes of transformation towards sustainability (Rotmans et al., 2001).

Kemp et al. (2007) identify three spheres of governance activities that are important for steering socio-technical transitions: strategic, tactical and operational. Strategic activities include the process of developing visions and long-term goals. Tactical activities focus on translating the vision into the regime through agenda building, negotiation and networking, and barrier removal. Operational activities include experiments, projects, innovations and implementation conducted at the niche level. As Rotmans et al. (2001) suggest, according to transition management theory, national governments can facilitate energy transition by "inspiring a collective learning process and encouraging other actors to think along and participate" (p. 25).

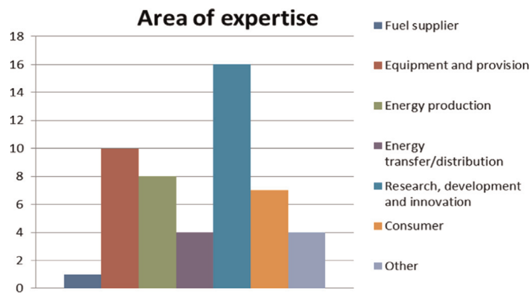

Fig. 3. The role in the RE value chain the panelists were most familiar with, based on their own estimations. Each panelist was allowed to name several parts of the value chain.

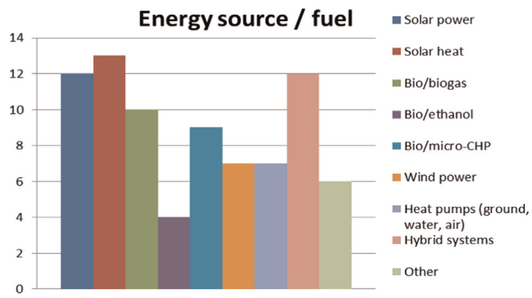

Fig. 4. The energy source/fuel the panelists were most familiar with, based on their own estimations. Each panelist was allowed to name several energy sources/fuels.

4. Materials and methods

4.1. Overall research design

In our research design, we used two tools to collect data: a questionnaire with scale-based evaluation questions directed at an expert panel in the DE value chain, and qualitative semi-structured interviews of energy industry and non-industry actors. The combination of these two sets of data offered data triangulation that, in the view of Denzin and Lincoln (1994), can be seen as an attempt "to secure an in-depth understanding of the phenomenon in question" (p. 2).

4.2. Expert panel

A panel of 26 experts was selected to represent the value chain of renewable DE production in Finland. Some panelists could be considered to be stakeholders rather than experts in an academic sense (see also Varho and Huutoniemi (2014)). They represented different areas of expertize (Fig. 3) and a variety of energy sources within the RE value chain (Fig. 4). Solar power and heat as well as hybrid systems are slightly more represented in the panel than other individual technologies. However, if all the bio-based technologies are considered together, bioenergy is also strongly represented in the panel. The panelists' workplaces varied from large organizations (over 250 employees) to small-sized ones (fewer than 50 employees).

Of the respondents, 17 answered in face-to-face interviews and 9 answered online. The themes for the questionnaire were created by the research team in the prestudy phase based on the results of a workshop with DE experts. They included technological solutions, market development, business concepts, and energy policy and support for RE. After testing the questionnaire, a few questions were eliminated to avoid redundancy.

The data from the expert panel was collected in 2013 between August and October. Renewable DE production was approached through 50 change factors and trends found in the sector. These were grouped under the four themes described above. The panelists expressed a preferred and a probable future view (Amara, 1981) for the year 2025 as well as an importance valuation for each element (i.e. change factor or trend). Preferred and probable futures were expressed on a five-step scale of $-2\ldots+2$, where -2 referred to a substantial decrease from the present level, 0 referred to no changes to the present level and $+2$ referred to a substantial increase from the present level. Importance was estimated on a scale of 1–5.

4.3. Futures table construction

The results of the expert panel are shown in Table 1. Five elements that received the highest average importance evaluation have been included from each theme. However, the final two dimensions in Table 1 represent the dimensions rated respectively as the sixth and seventh most important ones within the energy policy theme. They are included in the table due to their relevance in the qualitative interviews.

The mean of preferred future views (with standard deviation) was calculated, along with the mean of views considered probable by the panelists. The means of preferred view represent a future image named *Prosperity*. The means of probable views represent a future image called *Steady growth*. We included a third future image, called *Stagnation*, to represent a dystopian future by considering how best to describe a view that in essence would be the opposite of the Prosperity image. The first two future images therefore represent views to be found within the Finnish DE value chain whereas the third one is a counterpoint to the future images

Table 1
Future views on distributed renewable energy development until 2025.

Dimension	Change factors and trends in the distributed RE sector	Prosperity Mean [SD][a]	Steady growth Mean [SD][a]	Stagnation by research team
Technological solutions	The use of grid connected small-scale production solutions (e.g. in households, farms and small enterprises)	+1.81 [0.49]	+1.24 [0.72]	Little use
	Number of hybrid energy systems (e.g. in households, farms and small enterprises) in small-scale production of heat and/or power	+1.48 [0.67]	+1.26 [0.81]	Remains low
	Purchase and use of small-scale electricity production systems parallel to main purchase channels of electricity	+1.64 [0.57]	+0.96 [0.68]	Little use
	Purchase and use of small-scale heating systems parallel to the main heating system	+1.15 [1.12]	+1.15 [0.73]	Little use
	Number of PV panels in small-scale production of electricity (e.g. in households, farms and small enterprises)	+1.50 [0.71]	+1.12 [0.73]	Remains low
Market development	Number of mid-sized equipment or component manufacturers in the market	+1.42 [0.50]	+0.96 [0.46]	No new manufacturers
	Public acceptance of distributed small-scale renewable energy production	+1.58 [0.65]	+1.13 [0.80]	Growing opposition to DG
	The ease of finding buyers for small amounts of electricity produced by small-scale producers	+1.35 [0.75]	+0.69 [0.79]	Few buyers or very low prices
	The share of fuel and production in the total consumer price of electricity	+0.88 [0.95]	+0.74 [0.69]	Heavy taxation on electricity
	Constructors' demand for smart property-specific equipment (equipment that optimizes the consumer's energy bill based on price signals)	+1.17 [0.76]	+0.67 [0.64]	Remains low
Business concepts	Number of business networks that offer turn-key concepts for small-scale production	+1.36 [0.64]	+0.83 [0.56]	Networks or cooperation minimal
	Independent web services that offer alternatives for an energy system solution to one's home	+1.27 [0.92]	+0.85 [0.67]	Conflicting or fragmentary information
	Personal consultation services for choosing an energy system for one's home	+1.23 [0.76]	+0.77 [0.59]	Consultation services not developed
	Number of "production-site rent" packages, where a company installs and operates a renewable energy system on a site it rents (e.g. roof or land)	+1.38 [0.75]	+0.76 [0.60]	New concepts minimal
	Financing options offered by energy companies for distributed energy system investments (e.g. to households, farms and small enterprises)	+1.17 [0.64]	+0.54 [0.72]	No such financing available
Energy policy and support to RE	The clarity and ease of the permit process for implementation of small-scale energy production (including the length of the process)	+1.65 [0.78]	+0.68 [0.78]	Processes slow and vary across municipalities
	Research and development funding for renewable energy (such as demonstration projects)	+1.58 [0.62]	+0.84 [0.62]	R&D funding cut
Top 6 and 7 dimensions in policy	National level renewable energy funding programs (e.g. German-style kfW bank low-interest loan programs)	+1.32 [0.66]	+0.54 [0.66]	Do not emerge
	The ease of getting a grid connection for small-scale electricity producers	+1.68 [0.78]	+0.79 [0.78]	Obstacles remain
	Small-scale producer's surplus electricity net metering and charging based on a contract between an energy company and the producer	+1.56 [0.83]	+0.79 [0.83]	Net metering does not emerge
	Long-term support for renewable energy (e.g. feed-in-tariff)	+0.92 [1.04]	+0.40 [0.91]	Does not emerge
	One-time investment subsidies for distributed small-scale renewable energy production in e.g. households, farms and small enterprises	+0.96 [1.11]	+0.45 [0.86]	Subsidies removed/reduced

[a] The respondents in the expert panel gave their preferred and probable future view of each driving force using a five-step Likert scale (−2 refers to a substantial decrease from the present level, 0 refers to no changes to the present level and +2 refers to a substantial increase from the present level).

Table 2
Name, description and number of experts interviewed in each organization.

Name of organization	Description	Number of interviewees
Energiateollisuus	The association of Finnish energy industries	2
Fortum	Energy sales company	1
Helsingin Energia (HELEN)	DSO company owned by the City of Helsinki	1
Hinku (Carbon Neutral Municipalities)	Grassroots movement that aims at promoting CO_2 emission cuts at the town level	1
Jyväskylän Energia	DSO company owned by the City of Jyväskylä	1
Lähienergialiitto	The association of small-scale energy producers	1
Aalto University	University	1
Oulun Sähkönmyynti	Energy sales company owned by the City of Oulu	2
Volter	Manufacturer of wood gasification technology for micro CHP plants	1
Sulpu	Finnish heat pump association	1
Company X (permission to display the name of this company was not given)	Manufacturer of bio-fuel heating systems	1
SITRA	The Finnish Innovation Fund	1
Työ- ja elinkeinoministeriö	Ministry of Employment and the Economy (TEM)	1
Vantaan Energia	DSO company co-owned by the Cities of Vantaa and Helsinki	2

that show growth. The future images are meant to be plausible (not necessarily probable) futures, and these may vary according to the progress of DE in Finland during the next decade.

4.4. Semi-structured interviews

The second data set was collected through 15 semi-structured interviews with another 17 experts (Table 2). Their professional profiles included senior managers working in energy companies (9), advisers to the government (2), project leaders (1), representatives of energy associations (4) and researchers in the field of energy economics (1). They were selected on the basis of their experience and their knowledge of the Finnish DE sector. The interview guide consisted of the same four main themes used in the expert panel questionnaire. The interviews lasted between 60 and 90 min and were conducted between April 2014 and March 2015. They were conducted in English, audio-recorded and transcribed verbatim by a professional transcriber. The quotes shown in Section 5 are direct quotes from the transcripts.

4.5. Analysis of interviews

To analyze the interviews, we utilized thematic analysis (Braun and Clarke, 2006). The themes of the interview guide served as a broad framework in which an inductive approach (Thomas, 2006) was used to allow important categories to emerge from the raw data. The written transcripts of the interviews were imported to ATLAS.ti 7 and coded. Subsequently, all codes were pieced together to see how they could potentially form a category. The initial categories obtained were then reviewed and refined according to the principle of “internal homogeneity” and “external heterogeneity” (Patton, 2002, p. 465) and classified under drivers, barriers, and business concepts.

5. Results

5.1. Results from the expert panel

Future images were created based on the average values given to dimensions that the panelists rated to be most important within each theme. It should be noted that there is a great deal of variation within views, as the standard deviation (SD) in Table 1 shows. The three future images are therefore only approximations of views, and should mainly be seen as illustrations of alternative future paths.

5.1.1. Prosperity

In the Prosperity future image, the growth of grid-connected systems and DE systems that provide supportive rather than exclusive power or heat production is significant. It is clear that even in this most optimistic future vision, small-scale DE production is not expected to entirely replace previous energy products. PV has a central role, but in the heat sector so do heat pumps. Information services for DE increase, new manufacturing companies appear and grow, and business networks develop. Public acceptance is high and many citizens offer their land or rooftops as energy production sites. New services emerge, such as consultation about household energy production equipment. Small producers can easily find funding for their equipment, permits for installing them, and buyers for their surplus of electricity or heat. To enable this development, policy mechanisms were considered the most important factor. In contrast, direct monetary support, such as feed-in tariffs and investment subsidies, were considered less important, though they were envisioned to grow significantly in the Prosperity vision. The views regarding such support varied a great deal.

5.1.2. Steady growth

Even if the future does not follow the path set in the first future image, the DE sector can continue to demonstrate some growth, as expressed in the Steady growth future image. The main difference between the Prosperity and Steady growth future images is in the speed of the process. The most significant differences are found in energy policy and governance. In Steady growth, research and development funding, low-interest funding, feed-in-tariffs and investment subsidies are limited, either in terms of the sums available or in terms of what kind of applications are eligible. The development of permits, grid connections, net metering and funding all lag far behind in this future image. The consequences of these limitations are numerous: new business concepts spread more slowly, the number of manufacturers grows slowly, and reliable information is not as easy to find. Distributed electricity production, in particular, increases more slowly in Steady growth than in Prosperity. The difference is not as notable in regard to heat, which probably reflects the existing growth of the heat pump market.

5.1.3. Stagnation

The Stagnation future image is a pessimistic image, with only mainly negative changes from the present day. In this image, Finland continues with a highly centralized energy system and there is no political willingness to introduce a stronger support system for small-scale RE. Therefore the use of DE technologies progresses slowly in both heat and power production. New businesses are not created and existing ones grow slowly. Business networks, cooperation and joint turnkey services fail to develop, funding for research and development is cut, and the entire DE sector starts to wither. Consumers are faced with fragmented, perhaps even conflicting information about DE alternatives, as well as confusing and slow bureaucratic processes regarding installation, energy sales, and taxation. Investments are rarely profitable, as financial policy incentives are even reduced. The public view turns more negative towards small-scale installations.

5.2. Results from semi-structured interviews

5.2.1. Drivers of small-scale distributed heat production

Heat pumps, biomass gasification in small CHP plants and wood-pellet boilers were considered the most important technologies for the growth of the distributed heat generation sector in Finland. However, out of these three, only heat pump technologies have reached significant market expansion (currently about 5 TWh/ per year).

Environmental awareness, high heat demand in buildings, energy savings and lack of access to the heat network in certain areas were the main drivers for small-scale distributed heat generation. Most of the interviewees felt that two main state incentives have contributed to the growth of the sector. They are the 20% investment support given to householders until 2012 to replace oil/electric-heating systems with heat pumps, biomass or a district-heating and the tax deduction on labor costs for home renovations and repairs. The latter measure was considered a successful incentive because it has been steadily available for a decade.

In addition, some interviewees also believed that one of the most effective ways to promote the growth of the sector is the taxation of fossil fuels, which they state has been more stringent in Sweden than in Finland.

> Supporting nuclear and all other fossil fuels doesn't really build a bright future, so we should put more tax on the other methods of [heat] production and we would not really need any big support for the renewables. And that is what they have done in Sweden.

5.2.2. Barriers of small-scale distributed heat generation

The barriers to the market growth of small-scale heat generation were slightly different according to the type of technology. In the case of wood-pellet heating technology, they were connected to increased operation costs, and issues in the reliability and quality of wood pellet supply. In the case of ground source heat pumps, they were to be found in connection with construction codes and drilling regulations. Ground source heat pumps had lower operating costs than wood-pellet boilers.

In the case of micro-CHP plants, it was found that the growth of this technology is being influenced by developments in the electricity market and therefore hindered by the same factors that affect small-scale electricity production. (See Section 5.2.4 for a more detailed description of these barriers).

The interviews also revealed that the trade of excess heat has not yet developed due to technical, cultural and economic barriers that currently prevent small heat producers who are connected to the district heating system to sell their heat surpluses to the network.

> It would be ideal to sell extra heat production to the network but in practice it has not worked so well. [Energy] companies have been wondering if it would be convenient to buy cheap energy from customers who have heat pumps, like in the case of PV, but practically, when you are speaking about heat, it is a much more complicated system. Also we don't have that sort of culture in which somebody is buying heat for the district heating network.

5.2.3. Drivers of small-scale distributed electricity generation

As for distributed electricity generation, small-scale wind and solar PV were the most mentioned technologies. However, interest in micro-turbines appeared to be decreasing, while the interest in solar PV was showing signs of growth. The interviews also revealed that different technological solutions for small-scale distributed electricity production, such as smart grids and energy storage, are being tested and demonstrated in several parts of the country.

The market for small-scale distributed electricity in Finland seemed to be mainly driven by a few energy companies and small-sized energy technology suppliers. Willingness to pay more for green electricity was an important element that emerged in many interviews as a driver for market development.

The main policy initiative that was identified as a beneficial driver was the TEKES-funded program aimed at research and development for smart grids (CLEEN, 2014). The program brought together research centers, energy companies, the ICT industry as well as the energy technology industry.

When discussing future policy instruments that could promote small-scale renewable power generation, two main views emerged about the possible introduction of a feed-in tariff scheme. According to the industry representatives and the main energy providers, the state should have no role in shaping the sector and should allow free-market development in which no actors are favored over others:

> Politicians must have the courage to let the market function. It is not a market if someone gets some kind of support and is free from responsibility that others are carrying.

A feed-in tariff scheme was considered by the representatives of the energy industry as an inefficient way to promote small-scale distributed energy due to the high administration costs, unfair benefit distribution, and possible energy policy inconsistency. They often referred to the negative experiences of other countries. On the other hand, the interviewees from energy technology companies and the association of the small-scale energy producers did not consider the introduction of a feed-in tariff possible politically. They preferred other policy mechanisms they considered to be more feasible in the Finnish context.

When asked what a suitable policy instrument for Finland would be, the majority of the interviewees indicated investment support or tax rebates. Another group of interviewees, however, seemed to believe that there is no need for any policy support mechanism because the cost of RE technology will continue to decrease.

5.2.4. Barriers to small-scale distributed electricity generation

Half of the interviewees were concerned about the possible impact of distributed power on the electrical grid. Other respondents, who were not from energy companies, believed that this type of concern is just a way to resist the diffusion of distributed electricity generation. The divergence of views is illustrated in the following quotes; the first is from an industry member while the second is from a non-industry member:

> All the rest of the world is checking out now how Germany copes with the grid problems that they are facing. For example, they have huge problems with the electrical feed at the moment. And I guess that in the near future you will see really big electrical power losses in the grid in Germany in really big areas, which are directly related to this issue that they have

such a huge amount of photovoltaic in the grid.

Of course, they are afraid that they will meet some technical problems like what we can see in Germany if the distributed production grows so much. We are so far from that that it's not a problem. But that's kind of good explanation to say why not go to that direction.

Other technological barriers to the integration of distributed power into the electric grid included the lack of standard procedures for grid connection and issues with metering.

In the market development of the sector, most of the interviewees believed the main barrier to be the low price of electricity. Furthermore, the interviews suggested that the energy companies have interests in not facilitating the market entry of small electricity producers. In particular, the interviewees who worked for municipally owned energy companies were concerned about the profitability of the existing investment in (large-scale) conventional energy generation. However, while some representatives of the energy companies worried about the consequences of widespread diffusion of distributed electricity for their business, others argued that it would be better if their companies would be part of this change rather than trying to resist it.

Barriers related to the electricity market were also found. Although services that allow prosumers to sell surplus electricity to a utility have significantly increased in recent times, the buy-back rates are low. The Finnish buy-back rate system is currently based on a net purchase and sale scheme in which the prosumers pay the retail price for the electricity they use while the energy company purchases their excess generation at its avoided cost, which can be about one third of the retail price.

The two main administrative barriers preventing development of the distributed electricity market were identified as taxation and the variability and complexity of building permit procedures. In Finland, the municipalities have broad autonomy in permit regulation. As a result, every municipality applies its own set of rules for building permits for large as well as small RE installations. Municipalities also apply different construction permit fees.

In Finland currently, taxation of small-scale electricity production is based on the installed capacity, not on the actual production. For generation systems up to 50 kVA, the electricity tax is not paid. However, if a generation system of a size between 50 and 2000 kVA occasionally feeds any surplus electricity into the grid, electricity tax has to be paid for all the electricity generated for personal consumption.

Table 3 presents a summary of the drivers and barriers for the deployment of DE in Finland that were identified in the semi-structured interviews.

5.2.5. Business concepts for DE

Besides the factors driving the development of the DE sector described above, some emerging business concepts were also identified as factors contributing to the growth of DE in Finland. The emergence of new business concepts was observed, however, only in the electricity sector, while in the heat sector little change was found in business model development. In this sector some unsuccessful examples of heat pump leasing were found, but the dominant model remained the traditional customer up-front investment. The emerging business concepts identified for small-scale distributed electricity production consists of the following models: turn-key, facilitator, utility-side solar PV, and joint purchase.

5.2.5.1. Turn-key (energy optimization) model. This model has been introduced with some variations by a few large energy companies. The utility provides its customers with a turn-key solution that includes the generation equipment and the possibility to sell the electricity surplus to the utility as well as planning, installation and grid connection. The customer benefits from energy efficiency and cost savings, and no longer has to worry about energy provision needs because the energy company takes care of the entire process. For the utility, this model allows the possibility to generate revenues from long-term energy services that aim at optimizing customer consumption. Remaining barriers include the relatively high costs of generation equipment and installation, the long payback time, and the low profitability of small domestic projects. The currently low buy-back rates prevent this scheme from being profitable to households.

5.2.5.2. The facilitator model. This model was introduced by Oulun Sähkönmyynti Oy, the City of Oulu's municipal company. It is the only model currently existing in Finland in which a user can sell its electricity surplus directly to another user (Oulunenergia, 2015). As one of its products, the company markets *Farmivirta* ("farm power"). It has supply contracts with small RE producers who produce electricity from different RE sources including woodchips, small-scale hydropower, biogas, and solar. These small producers generate electricity mainly for themselves but sell their surpluses (minimum 50 MWh/a) through the utility's customer network. Different from a conventional net purchase and sale scheme, in this model it is the small-scale producer who fixes the price while the utility only facilitates the electricity sales for a small fee. The model offers a solution to the current low buy-back rates. In addition, it can have positive impacts on the economy of rural areas where, for example, farmers and village or housing cooperatives can be incentivized to engage in small-scale energy production. The interviewees suggested that this model is being

Table 3
Drivers and barriers for the deployment of DE in Finland.

Heat		Electricity	
Drivers	Barriers	Drivers	Barriers
Environmental awareness	Increased operation costs	Market opportunities for companies	Concerns for grid stability
High heat demand in buildings	Reliability and quality of supply of wood pellets	Willingness to pay more for green electricity	Lack of standardized procedures for grid interconnection
Energy savings	Construction codes	R&D on smart grids	Issues in metering
Lack of access to the heat network in rural areas	Drilling regulation		Low price of electricity
			Concerns for the profitability of municipal power plants
20% investment support for heat pumps	Lack of trade schemes for excess heat		Low buy-back rates
Fossil fuel taxation			Taxation
			Variability and complexity of building permit procedures

driven by an emergent concept of local production that has originated in the organic food movement and its diffusion depends on the customers' willingness to pay more for green and/or local electricity. The electricity is marketed nationwide and the current producers of *Farmivirta* are located in different parts of the country.

5.2.5.3. Utility-side solar PV. This model has been introduced recently by Helen Ltd., which is owned by the City of Helsinki. It is the first real model aiming to commercialize solar PV in Finland on a large scale. The utility is currently using a 340 kWp installation (HELEN, 2015) to provide access to solar PV to those customers who do not have, for example, a suitable rooftop or who do not want to get involved directly with energy generation but have a willingness to pay more for green energy. The company benefits from the new revenue streams that emerge from this new market segment. The customers can satisfy their needs to act on behalf of the environment. The main barrier to utility-side solar PV models is that they are less competitive than household solutions, because the latter are not affected by the electricity tax when deployed for self-consumption.

5.2.5.4. The joint purchase model. The fourth model is an emerging grassroots movement more than a real business concept. It aims to drive the demand for small-scale energy generation equipment. In Finland there are at least two examples of large joint purchases made recently. The first is the Lappeenranta purchase group (Aurinkosähköä, 2015) that was launched by ordinary citizens and the second is the purchase group that was established within the Carbon Neutral Municipalities network (in Finnish is called HINKU; SYKE, 2014). As part of the latter initiative, the largest collective purchase of PV panels in Finland was made in 2014. The purchase consisted of 30 solar electric systems of 2–7 kW for a total value of €240,000. The panels were installed on the rooftops of municipal buildings and of private citizens who had joined the purchase group in four member-municipalities of the HINKU network. Purchasing RE technology represents a complex task for ordinary citizens. Joint purchases are easier and they generate considerable discounts on the equipment costs. In the case of the HINKU network, their first collective purchase resulted in a discount of almost 40%.

6. Discussion

6.1. Understanding the multi-level implications of the transition to DE

Our findings show that at the landscape level, the Finnish political culture favors technological development and R&D policies. Moreover, the energy industry and the various ministries involved in energy development support a market-based approach, which is believed to bring about economic growth mainly by market forces. The institutional reluctance for direct energy policy interventions is one of the key aspects of the landscape and distinguishes the case of DE in Finland from other European countries. Sweden, for example, has many similarities to Finland, such as its climate and industrial structure, but there the approach has been completely different. Favoring the introduction of a green electricity quota system, Sweden has promoted a more widespread use of biomass and heat pumps in the residential sector through the heaviest taxation on fossil fuels in Europe (Nordic Council of Ministers 2014; Svebio, 2015).

At the level of the socio-technological regime, the results show several lock-ins preventing the advancement of DE. First, the energy industry network strongly resists the change to DE, although in the electricity sector it is also interested in the new business opportunities made possible by energy services. Opposition to distributed electricity is a result of energy companies having sunk costs in conventional power plants. Moreover, because municipal companies are often the network operators in Finland, they consequently see an expansion of distributed electricity as a threat to grid stability and their ability to recover the fixed costs of the electric distribution network. Second, the markets for small-scale RE electricity do not yet operate properly. The price for RE power sold to the grid by prosumers can be about one third of the normal retail price of electricity.

At the niche level, the forces fostering the transition seem to be primarily the new business opportunities available for energy technology providers and, as noted by Levinthal (1998) and Malerba et al. (2007), the willingness of consumers to pay more for sustainable energy. Businesses as well as prosumers have recognized the potential of DE technologies and are testing new business concepts. Some important niches have emerged for heat pumps, wood gasification in micro-CHP plants and wood-pellet boilers while others are being formed, for example, in solar PV technology. Heat pump technology is expected to bring about a transformation in the heat sector as estimations predict that by 2030, it will reach a capacity of 15 TWh/year (SULPU, 2014a). However, the heat sector appears to remain closed due to the fact that no business models for small-scale heat producers who want to sell their heat surpluses have been developed yet. This is in contrast to Sweden, for example, where the district heating network has recently been opened to local residents who have small amounts of excess heat (SITRA, 2012). On the other hand, in the electricity sector there is currently no predominant technological niche, but much more experimentation with new business concepts can be found.

To speed up the transition to DE, more actors need to be mobilized as well as innovative business concepts introduced. In this respect, research should investigate, among other possibilities, the role of a cooperative model in promoting the growth of DE. In Finland, surprisingly enough, energy cooperatives are not seen to have a significant future. This outlook may reflect the centralized nature of the sector as it is currently structured. Cooperatives do exist, however, in the Finnish food industry as well as in other sectors such as retail, insurance and banking. In 2013, there were some 4500 cooperatives, of which 90% were small enterprises (Pellervo, 2014). Therefore, such concepts are not foreign to Finland and their emergence in the energy sector may be anticipated.

6.2. Steering the transition

The results of this study demonstrate that in Finland, even in the most positive future view, small-scale DE generation will most likely exist in parallel with conventional energy supply channels for the mid-term future. In terms of growth, some of it will take place almost automatically due to the declining costs of generation equipment and the increasing interest in DE.

To understand the overall governance process of the DE transition (Rotmans et al., 2001) in Finland, it is useful to turn to transition management theory. In this framework, the state plays an important role, although knowledge institutes, prosumers and industries are important actors as well. Our findings indicate that though actions have been taken to steer the transition to DE in the strategic and operative sphere of governance, within the tactical sphere much work remains to be done. More specifically, the vision needs to be translated into the agenda of the key transition actors at the regime level.

According to Heiskanen et al. (2009), Finnish experiences with transition management experiments have displayed two main aspects: First, the state can determine the future of a sector only with the support of those actors who have a strong influence on technology and innovation policies. Second, to establish a collaborative problem-solving framework together that includes the relevant actors, a sense of urgency about the need for a transition is needed. Our results show that in Finland there has been interest in collaborative R&D projects – such as those solving the technical problems associated with the connection of distributed electricity to the grid – but they do not indicate that within the institutions themselves there is a sense of urgency regarding DE.

Another important aspect of tactical activities is the removal of barriers at the regime level (Loorbach, 2010). This study revealed that there are several barriers that need to be removed to ease the transition to DE in Finland. There are positive signs that the state is taking steps to ease grid connections and harmonize local permit procedures, as is demonstrated by the final report of the working group on small-scale RE generation (TEM, 2014).

7. Conclusion and policy implications

The aim of this study was to investigate experts' views about the possibilities and challenges for the transition to DE generation in Finland through 2025. We used a multi-level perspective and transition management concepts to understand the process and to derive some policy implications. Our findings indicate that in the heat sector, heat pump technology is expected to play a key role in making the sector more decentralized. However, achieving a transition to DE requires the introduction of business models, especially for small heat producers who have excess heat. In the electricity sector, a predominant technological niche has yet to emerge, but experimentation with new business models involving prosumers who have excess electricity are developing. This trend may indicate that the sector will undergo a gradual process of transformation to DE in the next decade. Additionally, our findings show that experts believe that Finland will rely mainly on a market-based approach to foster the growth of its DE sector.

However, if the goal of future policies in Finland will be to ease the transition to DE, then several actions need to be taken. First, the Finnish policy for small-scale DE should include two important sets of measures: removal of entry barriers and introduction/improvement of incentive mechanisms for small-scale DE. The first measure needs to resolve metering issues, ease permit procedures and simplify grid connection in the electricity sector. Furthermore, taxation legislation should be revised in two ways: small electricity producers should be taxed on the annual power generated rather than on the installed capacity and any electricity produced for personal consumption should be tax-free.

Second, although investment grants already exist, an investment support package should be offered for householders as well. Such a package could include one or more of the following incentives: tax rebates for the purchase of generation equipment, a production tax incentive at a set rate per unit of produced RE, soft loans granted by the state and issued by a private backer.

Though an important step, investment support measures may not be enough by themselves to promote market development. Consequently, although a feed-in tariff similar to the one adopted in Germany is not currently considered to be possible in Finland, another price-support measure, such as a real net-metering scheme, could be evaluated for distributed electricity.

In the heat sector, a shift to distributed heat production should be promoted through measures that help small-enterprises and local residents to supply excess heat to the district heating network. Such measures could aim, for example, at reducing the transaction costs for those parties willing to participate in a voluntary, market-based scheme.

However, despite the importance of these incentive mechanisms, they would be, in themselves, insufficient to stimulate significant growth in the DE sector in Finland. Triggering a more profound process of transformation demands a systemic approach in which institutional change, removal of barriers, and the engagement of key actors are promoted.

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III

REALIZING THE SOCIAL ACCEPTANCE OF COMMUNITY RENEWABLE ENERGY: A PROCESS-OUTCOME ANALYSIS OF STAKEHOLDER INFLUENCE

by

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Realizing the social acceptance of community renewable energy: A process-outcome analysis of stakeholder influence

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A B S T R A C T

This study shows how stakeholders influence the development of community renewable energy (CRE) schemes and how they are influenced by their outcome. It relies on information collected during 41 structured interviews with local people involved in CRE initiatives in seven regions of Europe. The interviews were thematically analyzed to identify different types of stakeholder influence. The findings show that stakeholder influence on CRE schemes take place at three distinct levels: macro, intercommunity and intracommunity. In addition, key stakeholders can support or hinder the development of a project according to whether or not they perceive that the output of the project may benefit or harm them. The study contributes to the research on local renewable energy (RE) development by showing how stakeholders take on multiple roles and how their roles may change from process to outcome. Furthermore, the study reveals the importance of two stakeholder groups: intermediary organizations and local champions. These were groups whose positive influence was crucial in the implementation phase and for whom ad hoc policy could be established.

1. Introduction

In light of the threat posed by climate change, many are advocating a rapid transition to a sustainable energy system relying completely on clean energy. To achieve this transformation, however, a number of questions need to be addressed. Some of them include whom to involve, how to distribute the costs and benefits in a fair way and on what scale energy provision systems should be designed.

The experience of the last two decades of renewable energy (RE) deployment has demonstrated that large-scale projects led by commercial companies have sometimes been criticized for the way the benefits are distributed and for the lack of fairness in procedural development [1]. These factors have often resulted in opposition by local groups of stakeholders, especially in the case of wind power generation [2]. As a result, a community-based approach to RE generation has recently gained in importance. This approach is generally characterized by small- to medium-scale projects carried out by groups of citizens. According to Walker and Devine-Wright [3], a community approach includes some form of public involvement in the decision-making process and some type of benefit for the local people. In addition, it can also encompass a form of collective control through ownership models such as a social enterprise or co-ownership with a commercial company (Walker [4]).

Most of the studies in the field of community renewable energy (CRE) development have focused on determining whether or not community involvement leads to less opposition to RE deployment [5–9]. Other research has tried to understand if small-scale RE initiatives can contribute to a significant increase in RE capacity [10] or promote capacity building (Walker and Devine-Wright [3]). Yet another stream of research has investigated how local stakeholders perceive the community benefits presented by wind power developers [11–13] and how in turn they contribute to the economic development of rural areas [14–17].

Despite this growing body of research, the literature still contains little knowledge about the role and the influence of the stakeholders involved in the establishment of CRE schemes. Finding this information is relevant because the success of a project depends to a great extent on the identification of key stakeholders and the management of the relationships with them [18]. Earlier attempts have already been made to address this gap. For example, Walker and Devine-Wright [3] identified two dimensions on which the influence of relevant stakeholders in CRE development could be studied: process and outcome. Nevertheless, more

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research is needed to identify and understand the interplay of the actors involved in community projects.

In this study, we carry out a stakeholder analysis to identify the people, groups or organizations that may influence, or be influenced by, CRE schemes. More specifically, we answer the question of how stakeholders influence the development of CRE projects (the process dimension) and how they are influenced by their outcome. To accomplish our research task we apply descriptive stakeholder theory (see [19]) and arrive at a stakeholder classification that explains the roles and the factors that make stakeholders assume certain roles in CRE development. We use stakeholder theory for two main reasons. First, in many cases it has proved useful in recognizing and managing relevant stakeholders because it explains "who and what really counts" to an organization ([20], p. 853). Second, in the context of CRE projects, a stakeholder approach to systematically study the roles of key actors has not yet been adopted.

2. CRE and stakeholder influence

2.1. CRE: concept definition

Although there is growing scientific interest in CRE development, to date no clear definition has been presented of what the term community should include. In general, a community renewable energy project can be described as "an installation of one or more renewable energy technologies in or close to a rural community, with input from members of that community" ([16], p. 4217). In the literature this approach is often called community energy [21] or community renewable energy (Walker and Devine-Wright [3]). In this paper we use the term community renewable energy (CRE), by which we mean RE projects that are highly open and participatory and that aim to deliver their benefits to a local community, as suggested by Walker and Devine-Wright [3]. Consequently, those initiatives started by municipalities or local businesses that were not participatory or that did not aim expressly at benefiting local people are not considered here.

2.2. Stakeholder influence

Since the publication of Freeman's [22] *Strategic Management: A Stakeholder Approach*, the focus of stakeholder theory has been on the interaction and interdependence between a company and its stakeholders [19,23,24]. In the light of stakeholder theory a firm can only exist through the interaction, transactions and exchanges carried out with its stakeholders [24]. We adopt a general definition of stakeholders as "any group or individual who can affect or is affected by the achievement of the organization's objectives" ([22], p. 46).

Within stakeholder theory, one stream of research has focused on studying stakeholder influence from two perspectives: how stakeholders influence companies [25] and which strategies companies apply to influence stakeholders [26]. In this study, because we are applying Freeman's original stakeholder definition we take a look at both how stakeholders influence CRE and how they are influenced by it.

Concerning stakeholder influence strategies [25], tied stakeholder influence to resource dependency theory. He suggests that the resource relationship determines which of the four types of strategies (direct withholding, direct usage, indirect withholding, or indirect usage) will be used by stakeholders. Others have followed this approach from different perspectives and examined, for example, stakeholder influence on financial performance [27,28], stakeholder influence on decision making [29] and how stakeholders may influence companies indirectly through networks [30]. The study of [20] implied that the salience of stakeholders depends on the possession of one to three stakeholder attributes: power, legitimacy and urgency. These attributes define the stakeholder's salience to managers, and thus its influence possibilities.

The question of how stakeholders are influenced by companies has received less attention. Instead, the research has examined the situations in which the stakeholders feel that their stakeholder group interests or stakeholder group identities are jeopardized and how this experience may lead to mobilization of stakeholders [31]. In addition, studies have looked at cases of how stakeholders may experience the negative (environmental) impact of corporate actions [26,32]. Furthermore, studies have shown how stakeholder power and influence may have a pivotal impact on a project's success or failure [18,33]. Berardi, for example, pointed out that the most significant barrier to the adoption of new energy-saving technology is the low influence-capacity of highly motivated stakeholders on the decision.

Freeman [22] and Mitchell et al. [20] proposed another interesting aspect connected to stakeholder influence: stakeholder dynamics. Freeman suggested that stakeholder influence is not static but changes over time according to how stakeholders' stakes change. Mitchell et al. [20] added that stakeholder positions can change from one class to another when their salience increases or decreases.

According to Walker and Devine-Wright [3], the understanding of CRE revolves around questions of both process and outcome. In this study we adopt a stakeholder framework based on this understanding and look at stakeholder influence with regard to both the process and outcome dimensions of CRE schemes. The process dimension refers to the actors that are involved during the implementation of the project, and the outcome dimension refers to the actors that are influenced by the results of the project. In Walker and Devine-Wright's study, these two dimensions are encapsulated in questions of "who is involved and has influence" in the development of a project and "who it is that benefits in economic and social terms" (p. 488). With respect to the latter question, we look at project outcomes in terms of who could possibly benefit from CRE schemes as well as in terms of who could possibly be negatively impacted by them.

2.3. Stakeholder influence on CRE

Prior studies in the wider context of environmental management have revealed the strong stakeholder influence on any environmental project in traditional business [26,34–36]. However, in CRE deployment a comprehensive approach to stakeholder analysis has not yet been taken. Though not studied systematically before, some research on CRE has already revealed three types of stakeholder influence.

The first type of influence has been shown by some studies that focused on how CRE projects may be triggered by stakeholder influence, especially by government policies, energy-market factors and local community cultures. When Bomberg and McEwen [37, p. 436] looked at government policies, they observed that the phenomenon is simultaneously supported and hindered by "structural resources", a term which refers to the broad political context for community energy mobilization. This is supported by Walker et al.'s [38] more positive view, which suggests that especially social enterprise models in CRE projects have been purposely favoured by government policies in the UK to foster the development of the RE market without controverting EU rules on state-aid.

Energy-market factors that trigger CRE projects have been discussed by Buchan [39] and Okkonen and Suhonen [40]. Okkonen and Suhonen reported that Finnish energy co-operatives were established in the early 1990s when the heating services traditionally provided by the municipalities were privatized. According to Buchan [39], the generous feed-in tariff and affordable membership costs of co-operatives have been two other important elements favouring the RE co-operatives in Germany.

The influence of local community cultures has been addressed by Buchan [39], Rogers et al. [41], Bomberg and McEwen [37] and Seyfang and Smith [42]. Buchan, Rogers et al., and Bomberg and McEwen suggested that the main drivers for CRE projects are based on the existing community cultures, identities of collective civic action and common views of sustainable development. However, Seyfang and Smith maintained that CRE projects are more a response to unmet social needs and ideology.

The second type of influence has been illustrated by those authors that investigated how CRE projects may benefit stakeholders, especially local communities, and how these projects have larger societal impact in terms of environmental or social sustainability. Concerning the benefits for local communities, Walker and Devine-Wright [3] concluded that there are different degrees of participation and locally shared benefits in CRE projects, but real community projects are those that have a positive outcome for the local community and that involve high levels of citizen participation. Li et al. [14] and Phimister and Roberts [15] suggested that CRE schemes bring primarily economic benefits because community-led initiatives increase rural household incomes and welfare by creating economic development. Rogers et al. [16] and Tracey et al. [17] provide more detailed descriptions of benefits. Rogers et al. found that residents in rural areas supported community energy projects because they expected that a local energy project could enhance community cohesion, promote sustainable use of natural resources and bring about socioeconomic changes. Tracey et al. noted that community enterprises can bring community renewal and local capacity building. Environmental sustainability benefits of CRE schemes may be obtained because CRE projects can significantly increase the overall RE capacity [10], they promote pro-environmental behaviour [41] or they contribute to the expansion of the RE technology market [38]. Social sustainability benefits, on the other hand, may be related to the generation of stable income and social regeneration [10,38] or the tackling of fuel poverty in rural areas [43].

The last type of influence has emerged in the research on how stakeholder influence may hinder the development of CRE, especially the political context and community acceptance of CRE schemes [5–7,9,37]. Bomberg and McEwen [37] suggested that community mobilization for RE is hindered by the political framework. With regard to community acceptance, authors seem to have confirmed that a community ownership approach can mitigate local opposition [5–7,9]. Painuly [44] suggested that the RE technology industry, consumers, NGOs, experts, policymakers and professional associations are, in general, influential stakeholders with whom there should be interaction in order to overcome the barriers to RE deployment.

Although the literature highlighted above has brought out some influences of the stakeholders involved in local RE projects, to date there is still a gap in knowledge about who such actors are, what their interplay is, what role they play and why they assume these roles in the development of energy provision projects controlled by local communities. Filling this gap is relevant because it helps us to better comprehend how sustainable energy provision systems may be established.

3. Data and methods

3.1. Data collection

The data for this study were collected as part of the SECRE project, an international initiative aiming at building a functional and collaborative scheme to preserve the vitality of peripheries by using self-sustainable energy solutions (http://www.secre.eu/). The data acquired in the SECRE project consisted of 53 cases of CRE projects from Scotland, Finland, Northern Ireland, Ireland, Norway, Sweden and Germany. Different types of RE technology were taken into account, including hybrid technology.[1] All the cases were selected according to a maximum variation sampling method [45] to gain deep insights from different types of CRE projects. For each case, a detailed, structured interview was carried out by one of eight SECRE project staff members. The interview consisted of a total of 12 sections that included information on the origin of the idea, engagement with stakeholders, resource and technology evaluation, funding, the implementation phase, community impressions upon completion of the project, running and monitoring the project, profitability, and community acceptance of the scheme. The set of questions was prepared by an international workgroup based on their previous experience. The same international workgroup also carried out a preliminary pilot test of the interview guide and the training of the interviewers. In most of the cases the interviews were recorded, but in a few cases permission for recording was not given and thus field notes were taken by the interviewer. After the notes and recordings had been processed, the transcripts were approved by the interviewees to ensure data reliability. All the interviews lasted between 60 and 90 min and were conducted from September 2012 to May 2013. A total of 56 interviewees participated in the study. They were project leaders (10), project founders (8), chairs of the trust (9), project developers (4), steering group members (3), volunteers (9), municipal officers (5), representatives of national authorities dealing with RE matters (3) and members of organizations providing support for CRE schemes (5). All the interviewees were selected on the basis of their level of experience and relevance to the governance of the projects.

The maximum variation sampling method employed generated a wealth of various types of CRE initiatives. To refine the sample, only cases that matched the categorization in Walker and Devine-Wright [3] were selected. Consequently, those cases of CRE projects that were not open and participatory and that did not deliver benefits to the local community were excluded. As a result, out of all the studied cases (53 total), 41 were chosen to be the focus of this study. Table 1 summarizes the countries of origin of the selected cases and Table 2 summarizes the type of RE technology and organizational model used.

Table 1
Studied CRE schemes and their countries/region of origin.

Country/region	Number of cases
Scotland	24
Germany	6
Finland	5
N. Ireland	2
Sweden	2
Ireland	1
Norway	1
Total	41

3.2. Data analysis

The written transcripts of the interviews and field notes related to the 41 CRE cases were analyzed by thematic analysis, which in the view of Braun and Clarke [46, p. 79] is a "method for

[1] Hybrid technology refers to a combination of different energy conversion technologies relying on more than one renewable energy source or a mix of renewable energy sources and fossil fuels.

Table 2
Types of RE and organization.

Type of technology	Number of cases	Type of organization	Number of cases
Wind power	19	Customer-owned company	1
		Partnership with a developer	4
		Social enterprise	13
		Cooperative	2
Biomass	11	Cooperative	8
		Social enterprise	3
Hybrid technology	6	Cooperative	1
		Social enterprise	5
Hydropower	3	Social enterprise	3
Solar power	1	Cooperative	1
Tidal power	1	Social enterprise	1
Total	41	Total	41

identifying, analysing, and reporting patterns (themes) within data." The themes emerging across the data were identified with a general inductive approach [47]. This approach allowed important themes to emerge from the raw data. The analysis focused on only the explicit meaning of the text. After close reading of the written transcripts of the interviews and field notes, coding started. Segments of text that appeared to be meaningful to the research question were coded in each single case by the one the authors. Subsequently, all the codes from the 41 cases were pieced together to see how they could potentially form an overarching theme. After this first phase of analysis, 544 thematic codes were generated. To increase the reliability of the coding procedure in the second stage of the analysis, another author checked that the coded text would fit the preliminary themes formed. The initial themes obtained were then reviewed and refined according to the principle of "internal homogeneity" and "external heterogeneity" ([48], p. 465). As a result, new themes or subthemes were added while others were modified or deleted. The final step was to check that the name given to each of the themes reflected their essential characteristic [46]. Once we had the themes created based on the data, we integrated them with our stakeholder theoretical approach. In each theme we analyzed which stakeholders were mentioned and how they influenced or were influenced by a CRE project. By analysing similarities and differences among themes, we constructed our final categories. Examples of coding categories and the corresponding stakeholders associated with each category are shown in Appendix A.

4. Results

The results of this study indicate that stakeholders influence or are influenced by CRE initiatives on three distinct levels: macro, intercommunity and intracommunity. Within the macro level, influential stakeholders were the government, energy suppliers, the network operator and commercial developers. At the intercommunity level, the relevant stakeholders were nearby communities and intermediary organizations. Finally, at the intracommunity level, the local community at large, people living near an installation, local project champions and businesses were identified as key stakeholders.

Fig. 1 shows the interconnections of all the stakeholders identified at the three distinct levels of influence. The dashed line illustrates that the levels of influence do not have exact limits but instead exhibit fluid boundaries. All the stakeholders found had a strong influence in the development process of CRE, assuming sometimes a supportive role, a hindering role or both roles at the same time. In terms of project outcome these actors sometimes received a benefit and at other times they were harmed. Only in three cases were they simultaneously a beneficiary and a harmed stakeholder. In the following section we explain the role of each stakeholder and the main factors that made them assume a certain role or multiple roles at the same time in the developmental phase of a project (process) as well as after a project was completed (outcome).

4.1. Macro level

4.1.1. Government

In all the countries investigated, national and local governments had implemented energy policies aiming to increase RE capacity. The governments were, however, both supportive stakeholders when making funding available and at the same time also hindering stakeholders when they were not able to ensure easy access to funding and a steady policy framework.

> "Yes, opportunity that exists for the moment, i.e. grant funding. . ." (ID 21) "The government themselves are a negative influence. This is due to the frequent changes in legislation. This then puts back plans or plans have to be changed completely. Thus, delaying projects for long periods of time." (ID 26)

In the cases of CRE projects from Scotland, it was found that in certain instances up to 90% of grant funding was available. Grant mechanisms and other forms of government support were found to a less diffuse extent in the other countries as well. However, in the case of the Scottish government, policy seemed to play a prominent role in promoting CRE. Feed-in tariff mechanisms were considered by about one quarter of the respondents as one of the external factors supporting community projects. However, the uncertainty around the government policies concerning public support for RE stalled some projects for long periods, because the banks would not give any loan until the outcome of the new feed-in tariff system was clear.

> "The change to feed-in tariff rules has stalled the whole industry for 18 months." (ID 26)

The majority of the CRE schemes reviewed depended on government grants or bank loans. On the other hand, in one quarter of the cases community funds were also used to finance part of a project. This was noticed in the case of energy co-operatives in particular.

> "Half of the money €93,500 came from capital from the cooperative. . . we were first turned down but when we put half the amount in the pot and reminded the bank that the people in the cooperative who wanted to borrow money already were customers of this bank. . ." (ID 39)

Community funds were rarely able to cover the entire costs of the investment but these funds often provided at least the start-up capital. The ability of a community to provide part of the start-up capital was considered in the majority of the cases as one of the most important factors influencing the decision of financial institutions to fund a community project.

4.1.2. Energy suppliers

The energy suppliers were companies responsible for the generation and, in some cases, the distribution and sale of electricity and heat. These stakeholders were indirectly supportive stakeholders of CRE initiatives due to the fact that in several countries they had increased the energy prices. Such increases had repercussions on the running costs of communal spaces, public halls and private households, a situation that led numerous communities to search for more affordable energy solutions.

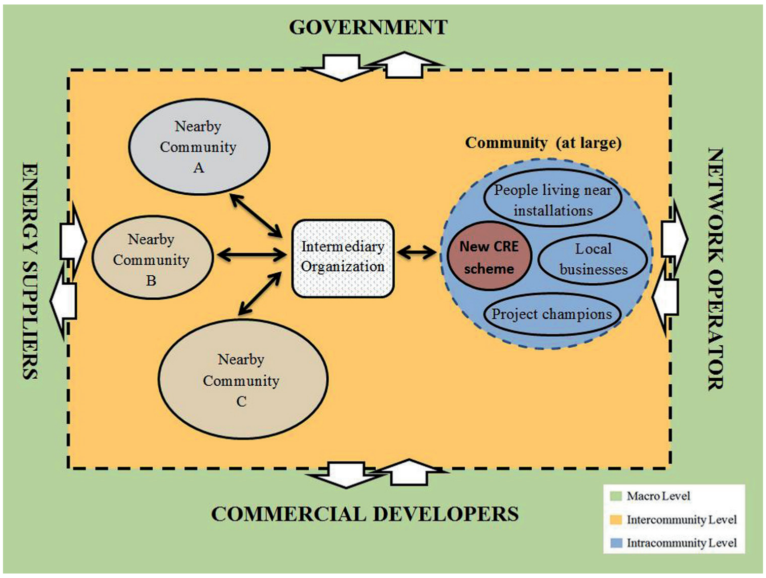

Fig. 1. Stakeholders having an influence on CRE projects at the macro, intercommunity and intracommunity levels.

> "The increasing price of oil and bills. Couldn't afford to keep going on paying these bills" (ID 43).

In Finland, for example, it was found that the energy price had increased at a rate of 10% per year. Steep energy prices seemed to be affecting particularly those rural remote communities which did not have access to the grid and that depended on diesel generators for power provision. In these instances, local residents embarked on a CRE project to save money by providing cheaper heat or power and to tackle fuel poverty. Fuel poverty was found to be an issue especially in rural remote areas where certain households did not have a connection to the network and could not afford to keep their homes warm at a reasonable price.

> "The residents wanted affordable heat; we have fuel poverty within the development." (ID 57)

In terms of project outcome, it appeared that in Germany some energy suppliers were harmed by CRE projects because their market share was reduced due to the high number of community-led projects that had started.

4.1.3. Network operator

The network operator was a company responsible for the distribution of electricity or heat to a network. This actor was identified as a supportive as well as a hindering stakeholder in the process dimension of CRE and as both a beneficiary and a harmed stakeholder with respect to the project outcome. In very remote areas where certain communities were not connected to the national grid due to the lack of energy infrastructures, local residents were forced to initiate CRE projects to improve their living conditions.

> "It was an obvious move. No grid connection is available to the mainland; we are off-grid, for the project we had to prove this... The project wasn't about being green it was about having power 24/7." (ID 34)

However, similar initiatives were started in less remote communities as well, such as in the cases of community heat networks built by co-operatives in Finland and Germany. With regard to network operators, the data also showed that in many instances long delays in obtaining the connection to the grid hindered the completion of a project. Such delays were often associated with technical issues.

> "The only issues the Trust had were the initial grid issues which held the project up." (ID 21)

In a few instances it also emerged that between community developers and a local network operator there were tensions when the latter hindered the connection to the network by increasing the network connection fee.

> "Local electricity Grid Company tried to overprice the grid connection and thus prevented our activities." (ID 17)

With regard to project outcome, grid operators were beneficiary actors due to the network connection fees paid by project developers and also harmed stakeholders due to the impact of discontinuous RE sources on grid stability. When the grid was in danger of breaching safety limits due to overproduction or underconsumption of electricity, grid operators used generation curtailment. As a consequence, RE producers that had a non-firm grid connection had their output either trimmed or were switched off entirely. Generation curtailment harmed several wind power developers, causing loss of income for the projects because during the curtailment periods the generators could not claim the feed-in tariff.

4.1.4. Commercial developers

Commercial developers were companies specialized in building and operating large RE power plants. In the development of the CRE schemes these companies assumed a supportive role when they were interested in cooperating with local communities and a hindering role when they were competing for both government funding and good RE sites.

> "The site was also wanted by a developer who wished to develop it as a commercial idea." (ID 32)

To overcome conflicts in project development, some developers had established partnerships with local communities, which could buy shares in a project or own part of it. According to most of the respondents, these joint ventures were fruitful because local communities were not required to put together a funding package and they could thereby avoid bearing the economic risk of the project. Moreover, because experienced commercial companies provided all the technical know-how required, local communities did not need to acquire technical knowledge to carry out complex projects.

> "I think the joint venture model is really interesting because of the removal of risk to the community. Because there was no requirement for the trust to become technically proficient and the level of administrative competence to progress a project like this from start to finish. Comparing it to other communities there are costs but it's better than 100% ownership, wouldn't have managed. . ." (ID 41)

With regard to project outcome, commercial developers were found to be a beneficiary stakeholder because of the income generated by co-owned projects with local communities and because of the enhanced reputation they gain when interested in developing a site together with local actors.

4.2. Intercommunity level

4.2.1. Nearby communities

In most of the cases nearby communities that had previously implemented a CRE scheme or that were completing one were identified as supportive and beneficiary stakeholders due to exchange of knowledge and experience. These exchanges of know-how triggered the implementation of new initiatives in neighbouring communities. Successful projects seemed to serve as a means to provide reassurance that CRE schemes were viable and could be replicated.

> ". . .there was an element that it had been done with communities that we looked at, so it was proven, it was repeatable." (ID 57)

The exchanges of know-how took place in regional networks where cooperation and the historical background of a community also played a crucial role. For instance, in Sweden it was found that village cooperation was a movement that had started already in the 1980s. Many clusters of villages already existed that worked together and shared their experiences in many joint initiatives, including RE generation. From the point of view of project outcome, most of the communities involved in this exchange of knowledge and experience benefited.

4.2.2. Intermediary organizations

Intermediary organizations were identified as supportive stakeholders through advice and guidance. They played a crucial role in providing support to inexperienced community groups that were carrying out RE projects.

> "Community Energy Scotland has been very good for financial, legal and moral support." (ID 21)

The support provided in the developmental phase of a project included not only technical and legal advice but also guidance on funding sources and applications, provision of feasibility plans and collection of best practices from other communities. In a few cases these organizations also operated as an agent between a commercial developer and local community groups.

> "Community Energy Scotland had the idea of bringing [Company X] over to Orkney for three days to demonstrate turbines that were already in Orkney, to showcase contractors already here and introduce community and private developers that would form a potential market for them. . ." (ID 58)

In Scotland intermediary organizations were sometimes other social enterprises, such as in the case of Community Energy Scotland (www.communityenergyscotland.org.uk). In other countries intermediary organizations were found more in connection with the public sector, such as in the case of the Sustainable Energy Authority of Ireland (http://www.seai.ie/Home/). In other instances the local municipalities also played a role as intermediaries, as they did in the case of the establishment of some energy co-operatives in Finland. However, only in Scotland was it noted that the local intermediary organizations aimed expressly at capacity building and knowledge transfer.

4.3. Intracommunity Level

4.3.1. Local community at large

The local community at large was identified as a supportive stakeholder due to three main factors: availability of material resources, community ownership as well as a general positive attitude to CRE development. The material resources given to the project consisted of RE sources and access to land. The presence of RE sources was found both as a by-product of another activity, such as excess heat from agricultural biomass power plants, or as naturally occurring resources, such as the presence of a nearby river for hydropower generation. With regard to land access it was found that projects were favoured when there was an agreement between the estate owners and the development group or when the issues concerning land lease or purchase were sorted out in the early phase of a project.

> "The land lords were in full support of the community trust and thus we did not need to buy out the land." (ID 21)

In the largest number of cases, community ownership was associated with community support. This association was often demonstrated by the fact that planning permits were issued without any objection or because in certain communities there had been a poll by which citizens were asked to vote whether they supported the project or not and often the results were in favour.

> "There were no planning issues. The local council granted planning. The community was always in agreement with the Trust and the renewable project. This is because it is a community owned RE project and it is for community benefit. This would not be the case if it were a commercial developer." (ID 26)

Several respondents seemed to believe that local ownership of RE generation was a way to control the energy future of their community. This aspect was particularly evident in those remote communities that did not have access to a network.

> "It is an investment in the future of the village as it makes it more independent from external energy suppliers and provides the possibility to shape our own future with ecologic energy." (ID 74)

In the majority of the projects reviewed it was found that the community at large had a positive attitude towards CRE schemes. This positivity appeared to be associated with expected positive benefits, reduction of energy costs, alleviation of fuel poverty and the possibility to determine one's own energy future. In a very few cases the community at large was also found to be a hindering stakeholder. This was mainly due to the scepticism of some community members who had doubts about the viability of the projects and concerns about their possible impact. These views gradually changed after a project was completed.

> "Once the plant was operational, the first views were negative, but they started to change quite rapidly once they noticed that there aren't any harmful side-effects such as noise, pollution, etc." (ID 69) ". . .the doubters were quieted." (ID 53)

With regard to project output, local communities were identified as beneficiary stakeholders through economic development, an enhanced sense of self-sufficiency, community identity, sustainability and start-up capital. Economic development was supported by the income generated by the projects that, in the majority of the cases, were found to be profitable. In more than half of the cases the flow of income generated was mainly used to pay back the loans while part of it was reinvested in the community. In certain instances the profits were purposely reinvested in developing more RE initiatives, energy conservation projects or environmental protection programmes for the collective. In other circumstances community enterprises aimed at establishing their own funding schemes by which social initiatives or businesses could be promoted.

> "It is printed in the articles of association: we are not distributing profits and all profits are used towards new wind energy investments. Thus we had worked so far towards the purpose of developing new wind turbine areas. . ." (ID 17)

Economic development was associated not only with the direct earnings emerging from the sale of RE to the network and the feed-in tariff mechanism, but also with the generation of new jobs from the schemes either directly or indirectly. The economic development theme emerged in almost all the cases, and the themes of self-sufficiency and identity were particularly recurrent in rural remote areas.

> "The need to try to redress the dwindling population of the island and awareness that we can't rely on grant funding. Having an identity and something to be proud of." (ID 32)

In almost one-tenth of the cases it was found that CRE projects also harmed some communities due to ill-feelings emerging among local residents, contrasting interests or lack of trust in the people who were promoting a community RE project.

4.3.2. Local businesses and people living near installations

Although in the majority of the cases local communities played a supportive role in the development of CRE schemes, in a small number of cases it was found that within a community there was also some opposition. Typically two groups of stakeholders had an interest in opposing a project. The first group included local businesses. According to this group of stakeholders, community enterprises running RE generation projects harmed them because these new enterprises were seen as competitors. Consequently this group of stakeholders opposed the projects during the developmental phase.

> ". . .opposition from the local business community, saw them, as competition." (ID 61)

Nevertheless, in many other cases local businesses also supported CRE development because it created new business opportunities for, among others, local contractors, small maintenance companies or farmers providing wood. In this case, local businesses were beneficiary stakeholders due to the income generated by new business opportunities.

> "A local grid company looks after the wind turbine park. This gives about a 50% job position in this company." (ID 31)

The second group of stakeholders who played a hindering role through their opposition consisted of local people living near an installation. The actors raised many arguments against project development, especially in the case of wind power, as they were directly harmed by the impact of an RE installation from noise and by the affected value of the landscape.

> "Some resistance around wind turbine and the aesthetics of the site, nervousness around noise issues from immediate neighbours. . ." (ID 56)

4.3.3. Local project champions

Local project champions were members of a local community who had a prominent role in starting, endorsing or carrying out a project. They emerged as a separate group of stakeholders from the community at large, because not all the community members were actually involved in a project. Local champions were supportive through primarily their individual values, skills and competencies.

While the local community at large possessed relevant material resources, project promoters sometimes owned relevant non-material resources. These non-material resources included a stock of skills, competencies and personality traits that, in certain cases, promoted CRE deployment.

> "He had technical skills as an engineer and found the location very promising for a wind turbine park. He did all the preparation work for the Norwegian authorities." (ID 31).

On the other hand, CRE development was hindered when project champions lacked essential skills and competences. This was found in the majority of the cases because the people involved in community projects were mostly inexperienced. Project champions often lacked technical competences not only in RE technology but also in finance, funding issues, project management, law, marketing and business management.

> "Firstly, there was a lack of expertise. The Community Trust is made up of local community members. They did not realise how complicated setting up a renewable project would be, they go into this thinking that renewables are an easy way to earn a sustainable source of income for the community. They are not renewable experts and have to learn as they go along." (ID 32)

Project champions' values were an important factor supporting local RE initiatives. The first set of values identified was volunteering for the initiative as a project promoter. Often the founding members or the initiators were the real driver behind the initiatives. Recurrent attributes such as being active, determined, and hands-on were associated with these subjects who often worked as volunteers. Volunteers were involved in many tasks, including planning, implementation and management.

> ". . .the villagers are hands-on guys with many handymen among them. Therefore, almost the entire work, except for the heating system, could be done through voluntary work." (ID 72)

The second set of values identified was the willingness to act for the environment. In several cases people got involved in RE generation because they felt the need to do something for the natural environment and reduce their CO_2 emissions. For instance, some communities were relying on unsustainable energy sources such as diesel fuels or peat. In some instances the implementation of an

Table 3
Summary of the findings of the study.

	Stakeholder	Process		Outcome	
		Supportive	Hindering	Beneficiary	Harmed
Macro	Government	Available funding Feed-in tariff	Difficulties in accessing funding Unsteady policy framework	Increased RE capacity	
	Energy supplier	High energy price			Lost market share
	Network operator	Lack of energy infrastructures (indirect)	Delayed connection to the network	Network connection fee	Affected grid stability
	Commercial developers	Interest to cooperate	Interest to compete	Income from partnerships Enhanced reputation	
Intercommunity	Nearby communities Intermediary organizations	Shared knowledge and experience Advice and guidance		Shared knowledge and experience	
Intracommunity	Local community (at large)	Availability of material resources Community ownership General positive attitude	Scepticism Lack of trust	Economic development Self-sufficiency Identity Sustainability Start-up capital	Shattered community cohesion Generation curtailments
	Local businesses	New business opportunities	Opposition	Income from new business opportunities	Competition
	People living near installations		Opposition		Impact on health due to noise Affected value of the landscape
	Local champions	Skills and competences Individual values	Lack of skills and competences	Learning Income from co-ops	

RE scheme fitted the general goal of a local community to promote sustainable development.

"They felt they were unsustainable as they were. . ." (ID 61)

The last group of values identified as an internal driver for the local champions was associated with the desire to demonstrate the viability of RE projects for the benefit of the community or to experiment with RE technology. This was the case for a community group in Sweden that started one of the first wind power co-operatives in the country:

"Five persons stated that there was no wind power plant in Sweden and we decided to become pioneers and build one to produce our own electricity. . ." (ID 66)

In terms of project outcome, local champions were beneficiary stakeholders because in many instances they learned a lot after a project was completed. Often the missing skills were learned through experience in the field. In addition, in the cases of project champions who were members of co-operatives that returned surpluses, they were also beneficiary stakeholders due to the income they earned.

Table 3 summarizes the findings of the study. The table describes the roles assumed by the stakeholders identified and the factors triggering such roles with respect to the process and outcome dimensions of CRE projects. Furthermore, all the stakeholders are also classified according to their level of influence, that is, macro, intercommunity and intracommunity.

5. Discussion

The results of this study showed that during the implementation phase (the process dimension) stakeholders can influence a project by playing a supporting and/or hindering role and have, thus, the potential to be beneficiary or harmed stakeholders. However, once a CRE scheme is established, these stakeholders may experience the benefit or be harmed (the outcome dimension) and may accordingly change their position as a supportive or hindering stakeholder. For instance, at the intracommunity level the local community at large may have concerns about the viability and the real benefits of CRE schemes, but when a project is completed and the positive outcomes are experienced their views can change. Similarly, a network operator may (indirectly) contribute to the establishment of CRE schemes and have a benefit in terms of income from network connection fees, but its role may change when it sees a threat to grid stability. These findings can be seen in the light of what [20,22] call stakeholder dynamics. Moreover, compared with what [18] pointed out – stakeholders can influence project outcomes – we find that stakeholders can influence project outcomes but that outcomes can also influence stakeholders.

Another important point that emerged from the results was that at the macro level, the government can be a hindering stakeholder when creating barriers to funding access or when not able to ensure a steady policy framework. However, it can also be a supportive stakeholder and have benefits in terms of increased capacity in the outcome phase. This finding demonstrates that stakeholders sometimes assume multiple or even conflicting roles and it is in line with the suggestion by Bomberg and McEwen [37] that structural resources (the political framework) have a dual function in promoting and also hindering CRE initiatives. Thus, even though the role of some stakeholders can be fairly predicted (e.g., people living near installations directly harmed by a project outcome express opposition in the developmental phase) in other cases stakeholders influence on a CRE project is less predictable. This is the case of network operators or local businesses that may see CRE development as a threat and also as an opportunity.

Another important contribution of this study is the creation of a framework to analyze stakeholders' influence on CRE projects. Fig. 1 shows the interconnection between the stakeholders and their levels of influence. Within this framework the study highlighted some important country differences in regards to stakeholder influence across the seven regions considered. To illustrate, while there was a wider trend in which energy prices increased the desire of local communities to reduce their energy costs, in Germany and Scotland stakeholder influence on CRE schemes at the macro level was more determined by ideological or political views. Our findings are consistent with Buchan [39] and Seyfang and Smith [42]. Moreover, in Germany the political and ideological influence behind the high number of citizen-led initiatives brought about a new scenario in which the energy companies were starting to lose market shares. This important element shows that grassroots innovation for RE generation and provision may lead to changes in the traditional business model of electric utilities in the near future. On the other hand, because under a widespread community-based scenario energy suppliers may have only a negative outcome, it is also possible to expect that these stakeholders may cause lock-ins in the process of replicating CRE generation on a larger scale.

In contrast to Germany, in remote areas of Scotland, Norway, Sweden and Finland stakeholder influence on CRE schemes was triggered more by issues connected to energy needs. In these regions CRE development may expand rapidly if network operators do not invest in new energy infrastructure to reach off-grid customers and the cost of RE technology continues to decline. On the other hand, however, more attention should be given to the strengthening and reinforcement of the grid as the more new renewable power is fed into the grid, the more network operators may be harmed by grid instability and, in turn, the more CRE developers may be penalized. In this regard, some possible solutions to reduce the consequences of variable output of intermittent resources and to reduce the risk that network operators apply in generation curtailment are the inclusion of energy storage devices into the electricity supply system and the promotion of flexibility in electricity consumption.

The final important contribution of this study is that it revealed the important role of local champions and intermediary organizations across the seven regions studied. Local champions have a prominent influence on CRE projects, and their role has been discussed previously in other fields of study, such as environmental management [49–51], but it has not yet been illustrated in CRE initiatives. These actors are driven by their values and give their time for the development of a project. However, despite their ability to make things happen, in most of the cases they are inexperienced or lack the proper skills to carry out RE projects.

As for intermediary organizations, their role in the RE context has been discussed in only two previous studies, by Kivimaa [52] and Hargreaves et al. [53], in which these organizations were described in the context of public–private sector interaction and grassroots innovation. We found that while intermediary organizations have an essential function in terms of knowledge transfer and capacity building, they emerge in response to different kinds of institutional backgrounds and needs. Our data, unfortunately, did not allow us to find specific information on the potential differences between these types of organizations which in certain cases appear as being more linked to government and in others to be more "neutral" (Kivimaa, 2012, p. 1338).

Our findings concerning the link between ownership and community support confirm other previous research by McLaren Loring [5], Zoellner et al. [9], Warren and McFadyen [7], and Musall and Kuik [6]. In addition, they are in line with [14–16] with respect to the relationship between CRE schemes and socioeconomic development. In relation to community benefits, this study highlighted another important aspect that has not been discussed in studies on CRE generation: the role of local communities in providing start-up capital for RE projects. Although most of the initiatives studied depended on government grants and bank loans, in a good number of cases it was found that the projects were almost completely self-financed, especially in the case of co-operatives. This aspect is fundamental for RE deployment, which still relies heavily on state subsidies. Crowdfunding could offer one alternative to a post-subsidized RE economy in the near future.

This study also has a few limitations. These originate primarily from the method chosen for data collection and in the theoretical perspective. In truth, due to the high number of cases analyzed, part of the context in which the cases were originally imbedded was unavoidably lost. The stakeholder approach led us to develop a preliminary understanding of stakeholder influence in CRE generation. However, more qualitative research on the experiences of local champions focusing on their motivations for acting and their inhibitors would be required to better comprehend the role of this key actor group. Some case studies could better clarify how communities learn from each other. Finally, other research is also needed to understand what the most crucial phases of CRE projects are and what role stakeholders play at each stage of project development.

6. Conclusions and policy implications

This study showed how stakeholders may influence the development of CRE projects (process dimension) and how they are influenced by their outcome. Stakeholder influence on CRE schemes takes place at three distinct levels: macro, intercommunity and intracommunity. Stakeholders do not simply influence the development of CRE schemes by supporting or hindering them, but they can play both roles simultaneously. In addition, key stakeholders can support or hinder the development of a project according to whether or not they perceive that the output of the project may benefit or harm them. This characteristic was found at the intracommunity level in particular, where how a CRE scheme is perceived depends on the direct benefits that the community at large receives from the project. However, these views are not fixed and can change after a project has been completed. On the other hand, if stakeholders have only negative outcomes, they will have a hindering role in the development of CRE schemes. This was, for example, the case with people living near an installation. If stakeholders have both positive and negative outcomes, they may still hinder but their actions may have less impetus due to the benefits that are at stake. This was, for instance, the case of network operators.

A general stakeholder framework was also created to better understand the interplay of key actors. Based on this stakeholder framework we realize that the governments should ensure easier access to funding and a stable policy support to CRE projects. Conversely, at the macro and intracommunity level more ad hoc policies are needed to promote the successful integration of small-scale RE generation into the grid. Such policies should support, in particular, energy storage and demand-side management. At the intercommunity level, national and regional regulatory bodies should increase knowledge transfer through the establishment of intermediary organizations.

The study also showed the importance of local champions. These stakeholders have significant non-material resources that are able to unlock the potential material resources held by the community at large and stimulate local socioeconomic development. However, it was also revealed that while these actors are supported by their values, they may often lack technical skills and competencies. Thus, at the intracommunity level policy mechanisms should allow the transfer of essential technical skills to ambitious local champions. Finally, more countries could follow the example of the United Kingdom, which encourages social enterprises in CRE generation. As social enterprises reinvest their surpluses in the community and in RE development, they may become a means to tackle fuel poverty in rural areas and they may also contribute to the expansion of RE capacity.

Appendix A. Examples of coding categories and the corresponding stakeholders

Stakeholder	Theme	Subtheme	Sample quotes
Government	Available funding Difficulties in accessing funding Unsteady regulatory framework	Feed-in tariff	*"Availability of grants for such projects", "The change to feed-in tariff rules has stalled the whole industry for 18 months", "Funding planning process, initially recommended for refusal, a very hard and difficult time for the board personally"*
Energy supplier	High energy price	Fuel poverty Energy costs	*". . .increasing price of oil and bills. Couldn't afford to keep going on paying these bills", "The fact that the residents wanted affordable heat, we have fuel poverty within the development. . ."*
Local businesses	Opposition	Competition	*"Some opposition from local business community, saw them as competition"*
People living near installations	Opposition	Impact on health due to noise Affected value of the landscape	*"Some resistance around wind turbines and the aesthetics of the site, nervousness around noise issues from immediate neighbours"*

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.erss.2014.09.001.

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IV

UNDERSTANDING THE SCALING-UP OF COMMUNITY ENERGY NICHES THROUGH STRATEGIC NICHE MANAGEMENT THEORY: INSIGHTS FROM FINLAND

by

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Understanding the scaling-up of community energy niches through strategic niche management theory: Insights from Finland

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Renewable energy

A B S T R A C T

The growing phenomenon of civil society involvement in renewable energy generation has attracted researchers' interest. However, rather little is known of how a diverse and relatively small sector such as community energy could scale up and promote a change in energy production. We examine this issue through the lens of Strategic Niche Management (SNM) and conceptualize community energy as a socio-technical niche that holds the potential to promote a transition to renewable energy. Drawing on interview data with members of community energy projects and experts in Finland, we identify different types of community energy projects and the factors that may prevent them from scaling up. The study contributes a typology of community energy projects by showing which initiatives could be more inclined to be part of a strategy aiming at scaling up the sector. It also shows the tensions of SNM in the context of non-market-driven innovation, highlighting how exogenous factors such as cultural aspects, the specific context in which community energy develops and the characteristics of community groups are also relevant in the scaling-up process.

1. Introduction

With a share of 42% of global CO2 emissions, energy production is the human activity that contributes the most to climate change (IEA, 2016). To reduce the emissions in the energy sector, policy-makers have sought to promote renewable energy. However, despite the impressive growth of clean energy sources in recent years their share in global energy consumption remains just 19% (REN21, 2016). Considering that in the next three decades the energy demand is expected to be almost 69% higher than today (IEA, 2016), a rapid transition towards clean energy is needed.

The recent diffusion of renewable energy sources has been triggered by the improved performances and cost reduction of technologies such as solar photovoltaics (PV), heat pumps, small biomass cogeneration (CHP) plants and the use of alternative fuels in transportation (Dhinesh et al., 2017). Together with the rise of renewable energy in transportation and energy generation also smart energy management solutions that allow grid automation are diffusing (Amini et al., 2013). These technologies are not only promoting a change in the conventional way energy is provided but also enabling new actors to participate in energy production and saving. Among them are prosumers, groups of citizens and local communities. Although there is no strict definition, the involvement of these civil society members in energy generation and saving can be defined as community energy (Seyfang et al., 2013).

Within Europe, there are profound differences in the degree of citizens' participation in energy production and saving. Two frequently cited countries that have promoted a successful community energy approach are Germany and Denmark (Walker, 2008). Besides these well-known examples, however, community energy is growing in other countries as well, including the Netherlands (Boon and Dieperink, 2014), Scotland (Bomberg and McEwen, 2012), Spain (Kunze and Becker, 2015), Italy (Wirth, 2014), and England (Seyfang et al., 2013).

The emergent phenomenon of civil society involvement in renewable energy generation has attracted researchers' interest. The extant literature on this topic has dealt with the definition of community energy (Walker and Devine-Wright, 2008), organization form and embeddedness in social movements (Becker et al., 2017), drivers (Walker et al., 2007) and barriers (Bomberg and McEwen, 2012), role in increasing renewable energy acceptance (Ruggiero et al., 2014; Zoellner et al., 2008) and socio-economic benefits (Hain et al., 2005; Phimister and Roberts, 2012). More

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recently, some studies (Seyfang and Haxeltine, 2012) have begun exploring the role a community energy approach may play in accelerating the transition towards clean energy. However, this research remains unclear on how a very diverse and relatively small sector such as community energy could scale up and promote a change in the dominant way of energy production. This is an important question because incumbent energy producers oppose a deeper penetration of renewable energy (Geels, 2014; Ruggiero et al., 2015) due to its negative implications for the profitability of conventional power plants (Ruggiero and Lehkonen, 2017).

To investigate this issue in more depth, we look at the case of Finland, which has recently been showing signs of an emerging community energy approach (Maan Ystävät, 2016; Martiskainen, 2014). We carry out an analysis through the lens of strategic niche management (SNM; Kemp et al., 1998; Schot and Geels, 2008) to address the following research question: What types of projects are emerging in the Finnish community energy niche and what factors could be preventing them from scaling up?

The research analysis relies on 19 semi-structured interviews with two different groups of interviewees: (a) community energy project leaders ($n = 13$), and (b) representatives of various expert organizations and institutions ($n = 11$) that are involved in the community energy sector in Finland.

The paper has two important contributions. First, it provides new empirical data and a typology of community energy projects in the Finnish context, showing which initiatives could be more inclined to be part of a strategy aiming at scaling up. Second, it shows the tensions of SNM in the context of non-market-driven innovation, highlighting how exogenous factors such as cultural aspects, the specific context in which community energy develops and community groups' characteristics are also relevant in the scaling-up process.

The rest of this paper is organized as follows: in Section 2 we describe the theoretical frame underpinning this study and how SNM can be used to guide niche development within the context of community energy. Section 3 explains our research methodology, including details of data collection and analysis. In Section 4 we report the research findings, while Section 5 discusses their significance and Section 6 presents some conclusions.

2. Theoretical framework

2.1. Strategic niche management

Strategic niche management (SNM) emerged in the 1990s to address the problem of why sustainability-oriented innovations such as the electric car would not be able to bridge the gap between R&D and market introduction (Kemp et al., 1998). Building on insights from evolutionary economics, SNM scholars argued that sustainability-oriented innovations do not diffuse because firms, users, policymakers and scientists are bounded by rules. These rules determine the existing engineering practices, corporate governance structures, manufacturing processes and product characteristics (Geels, 2002). The overall set of rules guiding both engineers and social groups constitutes what Geels (2002) calls a "socio-technical regime". Socio-technological regimes provide stability to the activities of different social groups but become locked in and, thus, "path-breaking innovations" do not diffuse (Kemp et al., 1998; Smith and Raven, 2012). However, some scholars (Kemp et al., 1998; Geels, 2002) have observed, on the basis of historical case studies, that socio-technical regimes change and the transformation process takes place in small market niches. Consequently, SNM highlights the importance of artificially creating niches as initial test-beds for radical innovations (Schot and Geels, 2008). Because niches are protective spaces that allow for the experimentation of new social and technological configurations, they are referred to as socio-technical niches (Smith et al., 2016). In the literature there is no clear definition of a socio-technical niche, but it can be understood as a "constellation of culture, practices and structure that deviates from the regime [and] can meet quite specific societal needs, often in unorthodox ways" (Van den Bosch and Rotmans, 2008, p. 31). In this study we conceptualize community energy as a socio-technical niche that holds the potential to promote a transition to renewable energy.

Socio-technical niches are different from market niches (Smith and Raven, 2012). Market niches emerge when a new technology has more advantages than an established one for certain applications or a certain group of users (Schot and Geels, 2008). On the contrary, socio-technical niches are proto-markets in the sense that they precede market niche development (Kemp et al., 2001). Their aim is to temporally protect technological innovation from market pressures that may inhibit its development (Schot and Geels, 2008).

The literature on the development of socio-technical niches centres on the notion of niche nurturing (Kemp et al., 1998). Nurturing involves three important steps: shaping of expectations, learning, and networking (Schot and Geels, 2008). The shaping of expectations is a fundamental step in niche development because it provides direction for learning, attracts attention, and legitimates niche protection (Schot and Geels, 2008). Expectations can contribute to successful niche development when they are shared by many actors, are specific and their content is substantiated by current projects (Schot and Geels, 2008). Learning aims at finding solutions for overcoming barriers that prevent an innovation from functioning properly (Mourik and Raven, 2006). It should not just be limited to the accumulation of facts and data (i.e. first-order learning), but should also stimulate a change in cognitive framing and assumptions (second-order learning) (Schot and Geels, 2008). Networking contributes to create alignment inside a niche and coordinate the actors that can support local projects. It is considered to be most effective when networks are broad, include regime actors and there is substantial resource commitment by its members (Raven et al., 2016).

Another important process discussed in the literature is the scaling-up of niches. *Scaling-up* refers broadly to "moving sustainable practices from experimentation to mainstream" (Van den Bosch and Rotmans, 2008, p. 34). Some authors understand this as the process of niche building from local projects to a global niche (Geels and Raven, 2006; Geels and Deuten, 2006). A global niche emerges with the accumulation of local experiments over time and is taken as an indicator of an emerging community or a field (Geels and Raven, 2006). A global niche develops when local projects start to interact and share cognitive rules (Schot and Geels, 2008). The interaction between projects does not happen automatically but needs to be promoted by dedicated intermediary organizations (Geels and Deuten, 2006). The role of intermediary organizations is to foster networking and the aggregation of knowledge. They translate lessons from local experiments into more generic knowledge and use it to frame and coordinate local projects (Geels and Raven, 2006). This concept of scaling-up is also known as broadening (Van den Bosch and Rotmans, 2008) or accumulation (Naber et al., 2017) and refers essentially to the idea of repeating a sustainability experiment in new contexts and linking it to other domains.

According to other authors, scaling-up is the process by which sustainable practices developed in niches are translated (Smith, 2007) or embedded (Rotmans and Loorbach, 2006) into the regime. They label this second type of scaling-up as the societal embedding of experiments (Deuten et al., 1997; Kivisaari et al., 2004). In this study, we use the first conceptualization of scaling-up, referring to the process of niche building from local projects to a global niche illustrated by Geels and Deuten (2006) and Schot and Geels (2008).

A crucial aspect discussed in more recent literature and linked to the conceptualization of scaling-up is niche empowerment (Smith and Raven, 2012). This process involves activities that allow niche innovation to compete with an incumbent regime. Smith and Raven (2012) have identified two main strategies adopted by key niche actors for niche empowerment: (a) fit and conform, and (b) stretch and transform. The first aims to demonstrate that niche innovation can be perfectly integrated into the existing regime without bringing too much change to existing markets, institutions, infrastructures and base knowledge (Raven et al., 2016). The second, in contrast, tries to change the rules of the game by reforming institutions and setting new norms for sustainability (Smith and Raven, 2012). In both empowerment strategies, narratives are employed by niche advocates as political devices to promote their cause.

Among other things, the SNM approach has been criticized by some authors because of its predominant focus on technology, thus neglecting the more "social" aspect of innovation (Hielscher et al., 2013). For instance, Hegger et al. (2007) point out that because the real challenge in sustainability transitions is more in dealing with the complexity of the social reality rather than in technological improvement, the focus of niche experimentation should be on concepts and guiding principles. This ultimately would broaden the current innovation processes that Hegger et al. (2007, p. 743) see as being "so often dominated by engineers".

SNM has been utilized in the context of community energy studies only in a handful of papers, including Martiskainen (2017), Hargreaves et al. (2013), Seyfang et al. (2014) and Smith et al. (2016). These works have highlighted that even though community energy can be thought of as a form of both social and technological innovation, its key innovative element pertains especially to its social dimension, that is, to the motive to provide initiatives that also have social benefits in mind (Seyfang and Smith, 2007). This less market-driven rationale of community energy projects is in conflict with the core assumption of SNM that expects local projects to be scaled up in a linear way (Hargreaves et al., 2013). Therefore, we use SNM theory to further our understanding of its applicability to the community energy domain and identify the factors that prevent the sector from growing.

2.2. The notion of community energy

Community energy has different definitions depending on the context in which it operates. As a result, there is no unanimous consensus among researchers or practitioners on what the term should mean (for different definitions, see Middlemiss and Parrish, 2010; Parkhill et al., 2015). For example, in the UK context, community energy generally means sustainable energy projects which are initiated, led and developed by a range of civil society actors such as charities, cooperatives and neighbourhood networks (Middlemiss and Parrish, 2010). Such projects are very diverse and include a variety of technologies, group structures and motives for development (Seyfang et al., 2013; Walker and Devine-Wright, 2008). The notion of community (i.e. what it means to act together as a group and develop energy projects) is particularly highlighted in the UK context (Parkhill et al., 2015). In Germany, meanwhile, the term *Bürgerenergie* ('citizens' energy'), is commonly used to indicate community energy projects (Degenhart and Nestle, 2014). A project can be defined as *Bürgerenergie* in a narrow way or in a broad one (IEA-RETD, 2016). In a narrow way, it implies that citizens need to have the majority of the voting rights in an organization running a community project and to live in the region where the investment is made. In contrast, a project is understood to be *Bürgerenergie* in a broad way when the citizens have minority participation and do not all live in the region (what Walker, 2008 also refers to as community of interest). Thus, in Germany the definition of community energy often emphasizes more citizen ownership and control than inclusiveness.

2.3. Community energy in the Finnish context

In Finland two recent examples of community energy initiatives are joint acquisitions of solar panels by private citizens and small towns (Korjonen-Kuusipuro et al., 2017; Ruggiero et al., 2015) and a campaign started by the NGO Friends of the Earth to promote community participation in energy production (Maan Ystävät, 2016). These initiatives are often discussed under the term *lähienergia*, which translates as 'local energy' or 'nearby energy'. The concept of *lähienergia* was first developed by the Finnish Innovation Fund (SITRA), and is defined as "energy saved by a user or users collectively or renewable energy purchased from local production" (Syvänen and Mikkonen, 2011, p. 7). In the Finnish context, local energy can be understood to mean energy saving and renewable energy projects that use local resources and which also have links to community action. Furthermore, while community energy projects address both heat and electricity, in the Finnish context the focus of community energy has often been on heat (Martiskainen, 2014).

Community energy remains relatively small, but there is an increasing interest in small-scale distributed energy production and the possibilities for people to generate their own energy from renewable sources (Varho et al., 2016). The National Energy and Climate Strategy plans of the Finnish government in 2013 recognized that small-scale distributed electricity may play a significant role in reducing the consumption of electricity and increasing energy self-sufficiency (TEM, 2013), even though there is less focus on citizen-led solutions.

In terms of the number of community energy projects established in Finland, there is relatively little knowledge about the sector's current situation and how many community energy projects have actually been established. In 2014, however, the Ministry of Economic Affairs and Employment had a working group for advancing small-scale generation, and its aims included collecting data on small-scale generation and advancing knowledge of the sector's development.

With regard to policy support, Finland has adopted limited policies that would promote small-scale distributed energy production and citizen participation. Over the years, the main objective of policymakers has been to secure cheap energy for energy-intensive industries by giving priority to large centralized solutions (Huttunen, 2014). Currently, small-scale renewable power generation is supported only by investment grants (TEM, 2013). However, they can be awarded only to companies, municipalities and other legal entities such as federations, associations or foundations but not to private individuals (RES-Legal, 2014). For heat production, there is a price-based incentive for CHP plants called a "heat bonus", but it is available only to CHP plants utilizing biogas or biomass with a minimum capacity of 1000 kVA (RES-Legal, 2014).

3. Methodology

Fig. 1 shows the research process followed in this study. The theoretical framework derived from SNM theory was used to create the interview guide and analyse the data. The results obtained were then fed back into the theoretical framework to contribute to the extant theory on the scaling-up of socio-technical niches. Sections 3.1 and 3.2 illustrate the details of how the data was collected and

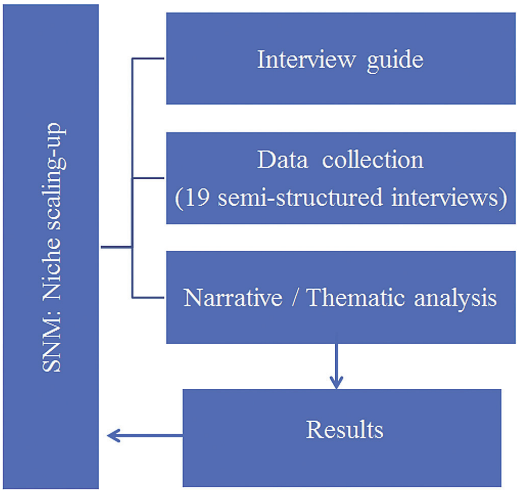

Fig. 1. Research process.

analysed.

3.1. Data collection

This study is based on primary data collected through 19 semi-structured interviews with two groups of interviewees. The first group consisted of people who were directly involved in community energy projects in Finland (i.e. community energy project leaders, $n = 13$). The chosen projects have different ownership models as well as various renewable energy sources (See Table 1). The interviews conducted with community energy project leaders focused on critical success factors for community energy projects and included five key themes as illustrated in the work of Seyfang et al. (2013). These were related to group vision and commitment, the resources needed in project development, relationship with the rest of the community, and the role of networks and policy.

The second group of interviewees consisted of representatives of various expert organizations and institutions that are involved in the community energy sector in Finland (n = 11). These were those actors that, as Van den Bosch and Rotmans (2008, p. 35) have stated, "can build an enabling environment for change". The expert interviews focused on key issues surrounding niche development, such as the state of the art of community energy in Finland, the potential for community energy development in Finland and how community energy projects could scale up.

All the interviews were conducted in Finnish and took place between March and June 2016. They were digitally recorded and subsequently transcribed verbatim. The interviewees were given the opportunity to remain anonymous. Therefore, we report in Tables 1 and 2 only some general information about the type of project or organization they belonged to.

Table 2
Description of expert organizations involved in the study and number of interviewees.

Intermediary organizations and niche actors	Number of interviewees
Lobbying organization	1
Expert company	1
Ministry	1
Regulatory agency	1
University	2
Ministry	1
Funding agency	1
Ministry	1
Member of Parliament	1
Solar energy expert	1

3.2. Data analysis

Narrative analysis was used to analyse the transcripts of the interviews with people who were involved in community energy projects in Finland. This method was chosen to create an understanding of how the projects were organized and how social relations were constructed (Eriksson and Kovalainen, 2008). The analysis was based on the belief that narratives are about human action and experience (Eriksson and Kovalainen, 2008). We used narratives to understand the development of the Finnish community energy projects, paying attention to the role of expectations, networking and learning illustrated in SNM theory (Schot and Geels, 2008). In our analysis, our first aim was to construct an abstract of each project based on the interviews. The abstract summarizes the events or incidents of the story (Labov and Waletzky, 1967). For that purpose we coded the section in which interviewees discussed the background and starting points of the projects, the challenges and support during development, and their current situation. On the basis of these, we were able to summarize the abstract of each project. We then integrated themes arising from our theoretical framework: shaping of expectations, learning, and networking (Schot and Geels, 2008). We coded the sections in which interviewees talked about these issues and analysed the meaning given to them in the narratives. We observed that some narratives shared certain aspects, and then started to form our typology of project stories. As a result of this process, three typologies of stories on the development of community energy projects were formed.

On the other hand, the transcripts of the interviews with the various expert organizations and institutions were analysed with a thematic analysis method (Braun and Clarke, 2006). This method was chosen to identify the main themes surrounding the issue of

Table 1
Details of community energy projects included in the study and number of interviewees.

Project	Organizational form	Renewable energy technology	Number of interviewees
1	Development association	Biomass	3
2	Housing company	Solar energy	1
3	Local homeowners' association	Solar energy, heat pump	1
4	Joint ownership between a private company and a cooperative	Biomass, wind energy	1
5	Ecovillage	Biomass	1
6	Cooperative	Small hydropower	1
7	Purchase group	Solar PV	1
8	Cooperative	Wind energy	1
9	Housing company	Biomass	3

how to promote the growth of the Finnish community energy niche. The themes of the interview guide served as a broad framework in which an inductive approach (Thomas, 2006) was used to allow important categories to emerge from the raw data. The written transcripts of the interviews were imported to data analysis software and segments of text that appeared to be meaningful to the research question were coded. Subsequently, all codes were pieced together to see how they could potentially form a category. The initial categories obtained were then reviewed and refined according to the principle of “internal homogeneity and external heterogeneity” (Patton, 2002, p. 465) and classified under the three conceptual themes of shaping of expectations, learning, and networking (Schot and Geels, 2008).

4. Results

4.1. Narratives of community energy project development

Based on the narrative analysis of interviews with project actors, a typology of stories related to community energy project development was formed. We identified three types of community energy projects: cost reduction, technical expertise, and system change. Table 3 reports a short abstract of each of the three types of stories found and the characteristics of the process of networking, learning and articulation of expectations identified in each one of them.

4.1.1. Type 1: cost reduction projects

Type 1 projects were called *cost reduction projects*. These include Projects 1 and 3. The project abstracts describe them as local initiatives, limited to small areas such as a property, a block or a small village community. The main drivers of the projects were either a particular need or the perceived benefits of community energy. In Project 1, the village development association wanted to reutilize the village school that had been closed and for which they needed heating. In Project 3, the main reason was instead the concern of homeowners over rising electricity prices.

In the cost reduction projects, the expectations were cost related. In Project 1, they aimed at low-cost heating and electricity for the old school building that the villagers wanted to use. In Project 3, the main motivation was cost savings, since electricity prices had been rising and households were concerned about energy issues. Environmental reasons played only a minor role. In Project 1, “not causing pollution” was mentioned as a “by-product”. In Project 3, environmental reasons were not mentioned as often as increasing understanding of alternative energy sources. During the implementation process, the projects were supported by the local communities and also received publicity in TV news and radio.

Despite the expectations, Project 1 was not profitable at the time of the interview due to value added tax liability. The project participants had not understood before starting the project that this tax needed to be paid. As a result, the project members were planning to generate more income by renting a part of the old school building. In Project 3, the interviewees felt that their targets, especially cost savings, had been reached.

Networking and learning were also intertwined in these projects. Both had a couple of strong key actors as the driving force behind the initiatives, but their skills, expertise and finances were limited. Therefore, they searched for external support. In Project 1, they received help from forest owners and woodchip entrepreneurs in their village, a loan from a bank and financial support from the local Centre for Economic Development, Transport and the Environment (ELY Centre). In Project 3, the initiative was supported by the board of the housing association and they received EU funding from the local rural development association. In addition, they took a loan from a bank before EU funding was received. Technical expertise was provided by two teachers at the local technical college, the administration of the local housing fair, and a professor from a technical university. In both projects, this type of network-based learning was a prerequisite for implementing the project, without which the projects would not have been implemented. However, there was no indication of learning and networking between community energy projects nor was there evidence of interest in expanding the projects.

4.1.2. Type 2: technical expertise projects

Type 2 projects were called *technical expertise projects*. These include Projects 2, 5, 6 and 9. The project abstracts describe them as local initiatives, limited to small areas such as a property, a block or a small village community. All four projects were strongly based on existing know-how among key project members at these locations. The reasons for starting a project varied: an outdated heating system (Project 2), energy self-sufficiency (Project 6), an ecological lifestyle (Project 5), and energy and cost savings (Project 9). In all of the projects, environmental protection or energy self-sufficiency were, in addition to possible cost savings, important sources of motivation.

During the development of the projects, two of them (2, 5) received no external support for planning or implementation. The key project members were not able to identify funding possibilities. In Projects 2 and 9, community members' attitudes were mentioned as a strong supporting factor. In Project 5, the interviewees mentioned ecological lifestyle as the main driver for the renewable energy initiatives. Project 6 was based on an already existing floodgate without which they could have not started the project. Cooperation with the local energy company was mentioned as a supporting factor. On the other hand, technical challenges and the need for learning by doing were mentioned as hindrances, as was the lack of economic incentive in feeding surplus electricity into the grid due to the high distribution fee. In addition to these, Project 9 featured technical difficulties and opposition from local community members due to the noise caused by the pellet delivery truck.

The technical expertise projects seemed to have fulfilled expectations. In Project 2, the goal had been a 50% cost reduction, and it was achieved. In Project 5, the ecovillage members are happy with the results but were still wishing to increase the level of energy self-sufficiency. Project 6, seemed to be profitable and “it is paying itself back”. In Project 9, the new system worked well and led to cost savings. In all the technical expertise projects, expectations of cost savings were supported by either environmental reasons or aims for self-sufficiency.

In regards to learning and networking, all the technical expertise projects had active key members who also possessed know-how and practical experience in the field of renewable energy. For this reason, very little evidence of a need for learning in external networks was identified in the interviews. Internal learning in the projects was, however, reported. In Project 2, the key members had prior experience with solar power. In Project 5, the key members of the ecovillage possessed the required know-how, but they also cooperated with a local energy technology firm to find alternative solutions and devices. A local entrepreneur supplied woodchips for them. They also had cooperation with some other eco-communities through voluntary work. In Project 6, the houses involved in the hydropower plant were family members' and one of them had previous technical knowledge of hydropower generation. They received financial support from the local ELY Centre and from the Ministry of Economic Affairs and the Environment. They cooperated with the local energy company to sell excess energy to the local grid. They had no connections with other similar projects. In

Table 3
Typology of Finnish community energy projects.

Type	Project	Abstract	Networking and learning (interlinked throughout the data)	Expectations
Cost reduction projects	1,3	External support as a prerequisite. Aim for low cost, not so much environmental reasons. Local, limited locations. No aim to expand the project.	Closed networks, learning from chosen external support and/or suppliers. No indication of learning and networking between the projects. No experienced need for wider learning since no aims to expand	Lower costs
Technical expertise projects	2,5,6,9	The know-how of key actors as a starting point and motivational factor; environmental reasons equally important (or prioritized). Local, limited locations. No aim to expand the project.	Existing know-how, internal learning in the project. Cooperation with suppliers reported (learning from them). Minor indication of learning and networking between the projects.	Environmental and cost savings
System change projects	4,7,8	Aim to create a new way of producing energy to facilitate societal change. Less limited projects, not so strictly limited locations. Aim to expand.	Strongly based on key actors' existing know-how. Aim to spread information. Open networks, not strongly dependent on small geographical locations. Wider networks, some benchmarking with prior projects.	Interest in increasing renewables Wider new solutions and changes in society

Project 9, the key project members visited similar pellet facilities in the surrounding area and learned how the technology works. They also reported cooperation with the equipment supplier. In contrast to Type 1 projects, Type 2 projects based on technical expertise were less focused on learning in external networks. However, as was the case for Type 1 projects, participants in Type 2 projects expressed a lack of interest in expanding their initiatives.

4.1.3. Type 3: system change projects

Type 3 projects were called system change projects. This type includes Projects 4, 7 and 8. The project abstracts summarize these initiatives as system change projects strongly based on the interest of their members to diffuse certain new technologies or knowledge about renewable energy production. They possessed in-depth information on renewable energy due to their backgrounds. In Projects 7 and 8, the members were private persons, but in Project 8 it was a company. In this project, the need for electricity and heat was combined with a company's need for product development, specifically, to develop a method for electricity and heat production on a local small scale. The project was a result of cooperation between the company's R&D department, employees, business partners responsible for planning the grid, the local municipality and families who wanted to build a small, decentralized system. These actors wanted to focus on local and renewable energy sources. In Projects 7 and 8, the starting point was the concern over climate change and the willingness to increase the use of renewable energy sources. The outcome of Project 7 was a joint purchase of solar panels for 20 detached houses whereas in Project 8 the outcome was the establishment of a wind power cooperative.

Each project faced challenges during the implementation. Project 4 seemed to work technically, but the electricity market regulation hindered its expansion. Project 7 received local media attention, but convincing people to buy solar panels as part of a group was still seen as relatively challenging. Moreover, it was felt that the low solar production in the winter coupled with the high distribution fee paid when electricity is fed into the grid were factors discouraging the use of solar panels in Finland. In Project 8, the bureaucracy related to obtaining authorization to start raising capital on the equity market was seen to be particularly challenging.

At the time of the interview, Projects 4 and 8 were struggling due to financial reasons. Project 4 did not achieve profitability during its first five years. The technical issues were solved but the feed-in tariff scheme and the electricity market regulation hindered it. However, at the time of the interview, heat was used in the local grid and electricity was also being sold to the grid. Project 7 was successful and the amount of members was increasing. Their motives for participating varied from environmental and economic reasons to energy self-sufficiency and having a new hobby. The project was profitable for the members. They used about half of the energy produced and the rest they sold to the grid.

Concerning expectations, Project 4 was established to promote product development for the company, but the profitability aims were not achieved. Project 7 was based on the general interest in increasing solar energy in Finland, and due to its expansion as well as the notable media attention, the project supporters were satisfied with the results. Project 8 aimed at increasing wind power in Finland, but at the time of the interview the profitability goal of the cooperative had not been met.

With regard to networking and learning, the three change agent projects evidenced wider networking than Type 1 and Type 2 projects as well as promoted the participation of multiple actors. Project 4 was focused on learning, since the company wanted to build the project as an experiment. However, learning was reported to happen by trial and error instead of in networking. Project 7 was initiated by two key project members, but it received help from a range of actors. These included the local energy company, which also purchased some of the solar energy produced by the project. The key project members possessed practical experience and technical know-how before the project. The project had a clear aim to expand. They distributed information concerning solar power in their learning workshops and in lectures given by the two project members. Project 8 was based on technical know-how and the interest in wind power of one of its key members. This project networked with similar projects in Finland and Sweden as well as with educational organizations. Those contacts provided them with, for example, information on different ownership structures for wind power production, technical expertise and discussions on opportunities for increasing cooperation. In contrast with the other project types, system change projects were the only group of initiatives showing strong evidence of networking and learning between projects and a clear aim to expand the initiatives.

Fig. 2a, b and 2c illustrate the differences between the three types of projects described above. The black dots represent the community energy projects, the circle around them the niche and the arrows show the direction of learning and networking they have. In Fig. 2a, all the arrows go from the black dots towards outside the circle meaning that cost reduction projects are not interlinked and try to learn and network with actors outside the community energy niche. In Fig. 2b there are fewer arrows from the black dots towards outside because technical expertise projects are more focused on learning internally. The dashed arrow illustrates, however, the presence of some weak interlinks between the projects. In both Fig. 2a and b the circle around the black dots is dashed to illustrate that there is less evidence of niche building. Finally, in Fig. 2c all the arrows point to the black dots because there is evidence of networking and learning among projects within the niche.

The expert interviews showed that while the definition of community energy is usually understood to mean local energy (see 2.2), discussion remained around what forms such local energy could actually take in Finland. Community energy in the Finnish context also includes a range of project types. Examples mentioned by the interviewees ranged from, for instance, the extreme of a village owning and producing its own energy independently from the grid to joint purchases of renewable energy technology or owning shares in a renewable energy project. In the latter case, these were likely to be owned by a utility rather than a community. However, as one interviewee said, “we have to think what different formats this type of communal energy could have”, indicating that the concept of community energy is not set in stone and that there is room for visioning what community energy in the Finnish context means. This visioning also involved the use of good examples of pioneering projects, especially those that would be willing to share issues that did not work out and the challenges linked to such projects.

We would need those brave pioneer examples. Communities who would be ready to provide a face for this issue and also tell about good as well as painful issues, what didn't work and what worked well. People here are quite sceptical about issues that sound too good: it is either marketing or otherwise too good to be true. We ought to find those real user experiences and promote things that way.

The interviews did not show evidence of key actors agreeing on a joint vision of community energy in Finland. On the contrary, several issues remained to be addressed. Some interviewees also felt that there is a need in Finland to consider how the community energy sector could be promoted overall. The sector should not be supported just as “a goal in its own right” but instead the focus should be on increasing renewable energy, efficiency and flexibility in the energy system:

If we get more renewable energy, more efficient systems, and more flexibility within our energy system with it, then there is a good reason to promote it. We have to think about it this way, rather than just support a certain communal energy model for the sake of it.

The same interviewee also mentioned that it would be good to find a replicable model that would make it easier for people to switch to renewable energy. This would also be something that could be supported financially or by some other support means.

Finland's energy policy was seen as being unsupportive of community energy and as more oriented to centralized energy solutions or individual household solutions. Interviewees mentioned especially the Electricity Market Act as a potential barrier to community energy. The Act requires that those who sell electricity outside their own property must connect to the national grid and pay a transfer fee, which is half the price of electricity. This makes, in particular, cooperatively produced energy unprofitable.

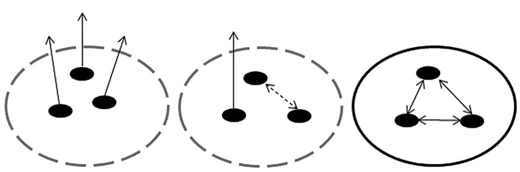

Fig. 2. Typology of community energy projects.

The recognition of small-scale energy production in government programmes and communities working together with energy companies were mentioned as potential solutions for supporting the diffusion of community energy. Furthermore, some of the experts believed that with greater interest in small-scale generation from the public and the EU ambition to introduce new near zero–energy buildings from 2020 onwards, concepts such as building integrated renewable energy will become more relevant in Finland as well.

In addition to policy support, the opportunities for community energy were considered likely to depend on a specific context, such as whether projects are situated in cities, small towns, villages or rural areas. The experts indicated that these locations will face different issues in terms of their resource, skills and knowledge bases as well as their financial and technological solutions.

Regarding what community energy could represent in the Finnish context, interviewees also mentioned cultural aspects. They pointed out that there is a rather strong culture in Finland of watching what your neighbours are doing – that is, whether they have done something before you have or whether you have achieved something first – which could influence community energy projects and shape expectations for the sector. For example, concepts such as joint ownership, which is often used as a model in community energy projects (see e.g. Kunze and Becker, 2015; Seyfang et al., 2013) was relatively rare in Finland – one interviewee mentioned the lack of joint ownership in farming equipment as an example:

> … for instance, in agriculture we have a very limited number of jointly owned combine harvesters. Every farm has its own and this is the case in many other issues. Joint ownership, for some reason, does not feature strongly in our culture. We should talk about it, about why it is not an option for us.

As one interviewee pointed out, however, there are cooperatives in other sectors, with two million in housing alone, regulated by the Limited Liability Housing Companies Act. These could provide great potential for community energy solutions as well because, in a way, the organizational structure is already in place.

In the views of the interviewees there was a need to discuss what ownership of community energy projects could be like, for example, would they be owned by the community itself or some other actor, like a municipality or an energy utility and how they could be financed. In a culture where people are keen to see what others are doing, expectations could be further shaped by obtaining commitment to projects early on through the engagement of communities during the design and planning stage of projects. Furthermore, the experts believed that identifying areas with strong pre-existing community cohesion might be essential to the success of community energy projects: “if you have a strong local community for some other reason, then it could also get involved in energy issues”.

4.1.4. Learning and networking

With regard to learning and networking, the interviews with the experts showed that while there were intermediary organizations active in the sector in Finland, this activity remained limited to a small, albeit increasing, number of organizations and to ad-hoc, rather than strategic, action. In addition, although some of these intermediaries had organized projects focused on small-scale generation and had self-generation as a starting point, they lacked a strong community aspect.

Some of the examples of intermediary activity mentioned in the interviews included the HINKUmap and the Green Doors energy walks organized within the Carbon Neutral Municipalities

(CANEMU, or *HINKU* in Finnish) project initiated by the Finnish Environment Institute. The first is a simple database of projects located in Finland, and it does not provide lessons from those projects. The second is an initiative that promotes visits to households with sustainable energy projects by groups of interested people. According to the interviewees, the latter activity provided an opportunity for people to share their experience and ask questions covering topics such as project costs, realized savings, the installation process, and potential for financial aid such as grants.

Motiva and the Finnish Clean Energy Association were two intermediary organizations mentioned in the interviews that seemed to somewhat share learning from projects, and provided information on solar power, in particular. However, they were seen as having a different focus, with the first more linked to advocacy work and policy lobbying, and the second to the provision of local energy advice.

In the view of the experts, expanding intermediary and advocacy work could benefit the sector. Nevertheless, questions remained over who would be best placed to share information and knowledge about community energy. For instance, one interviewee said that community energy project owners might not see it as their role, and hence there could be a need for the intermediary organizations to provide and share information nationwide. This would also include framing community energy and thus building stronger expectations for the niche:

The Finnish Clean Energy Association should organize a local energy day to get everyone together. This issue should be framed more strongly. Through international examples and Finnish examples.

A question was also raised over who should be responsible for the actual energy generation system in smaller scale projects, especially in cases where people were selling electricity back to the grid and needed to deal with actors such as network operators. In other words, community energy projects needed to consider a multitude of issues before development could begin, with the skills base and agreed responsibilities being key issues to consider. Some interviewees said that there might, for example, be a need for intermediary organizations who could arrange all of this and sell that service to community organizations, though it remained open as to who would set those up and whether they ought to be profit-making companies or public companies.

5. Discussion

The analysis of the narratives emerging from the interviews with specific community energy projects revealed that there are some networks fostering the sharing of experiences and learning between projects, but they are, in general, not yet broad or deep in the Finnish context (Schot and Geels, 2008). In many instances learning between projects is limited, though system change projects show the highest degree of networking, learning, and interest in expanding. System change projects, therefore, constitute what Seyfang and Smith (2007, p. 593) call a “strategic niche” – in other words, a niche that seeks larger scale transformation – and could be the starting point for an overall strategy aiming at scaling up the community energy sector.

Regarding the wider scaling-up process, results from the thematic analysis with experts indicate that there are factors preventing the niche from scaling up to the global niche phase. One of the main limitations is the lack of a shared vision of what community energy should mean in the Finnish context. This is shown in the differing aims for expansion among the three types of projects identified, the limited national policy support for community energy, and the continuing discussion among experts on who should support the sector. Previous studies have demonstrated that a shared vision is essential for successful niche development (Seyfang et al., 2014), especially in attracting external support such as funding, resources and policy support (Raven and Geels, 2010).

Another factor limiting projects from scaling up to the global niche phase is the failure of existing intermediary organizations to aggregate local experiences into more abstract knowledge (e.g. best practices, tool kits, business models) to frame or coordinate the projects on the ground (Geels and Deuten, 2006). Moreover, their actions do not seem to follow an overall strategy, as the SNM literature would prescribe (the “dedicated work” talked about in Geels and Deuten, 2006, p. 266). The lack of dedicated work by intermediaries is a crucial aspect that has been discussed in prior research on community energy development (see e.g. Hargreaves et al., 2013). To promote niche upscaling, intermediary organizations need to aggregate knowledge, create networks that assist new community energy projects and campaign for niche development (Hargreaves et al., 2013). The third point relates to what Smith and Raven (2012) call niche empowerment – creating powerful narratives as political devices to promote the community energy niche. In the case of Finland, where the local context for most of the current projects is essential, local/regional intermediaries carrying out knowledge aggregation and lobbying activities could be better placed to support the development of the community energy niche than national ones are.

The findings of this study have particular significance for SNM theory and the study of community energy as a form of grassroots innovation (Seyfang and Smith, 2007; Smith and Seyfang, 2013). The process of scaling up local projects to the niche level illustrated in SNM does not seem to be as straightforward in the community energy sector, and it might be contingent on the type of projects and exogenous factors. As for the type of projects, this study found that some community energy initiatives do not wish to be scaled up. This had already been suggested by Seyfang and Smith (2007).

With regard to exogenous factors, this study revealed that cultural aspects, the specific context in which community energy develops (e.g. a rural or urbanized area) as well as the characteristics of community groups such as community cohesion (Martiskainen, 2017; Seyfang et al., 2013) may be important antecedents of the processes that lead to the scaling-up of local projects (Schot and Geels, 2008). The consideration of exogenous elements such as the presence of favourable pre-existing conditions would imply that prior to applying SNM prescriptions, intermediary organizations could look for strong local communities that are already engaging in other communal activities and that could, therefore, be more fertile ground for community energy projects (Stewart and Hyysalo, 2008). Identifying such communities could result in the development of system change projects, in other words, those with the highest interest in expanding the niche, sharing learning and networking.

Although this study has identified initiatives that may contribute to expanding the community energy sector, future research should address the question of how to involve unwilling community energy actors in the scaling-up process and how to deal with conflicting expectations.

6. Conclusions

This paper aimed at better understanding the scaling-up of community energy niches as a strategy to accelerate the transition to clean energy production. It applied SNM theory to fulfil two goals. First, to understand what types of community energy projects exist in the Finnish community energy niche and, second, to identify the factors that may prevent them from scaling up, that is, moving from the level of local projects to a global niche. To address these two research tasks, we carried out a narrative analysis as well as a thematic analysis of interviews with community energy practitioners and experts.

Three types of community energy projects were identified: cost reduction, technical expertise, and system change projects (see Table 3). Of these, only system change projects showed a potential for scaling up. At the global niche level the most important factors limiting the scaling-up included the lack of a clear vision for the sector and of dedicated work by intermediary organizations coupled with an unfavourable policy and regulatory framework.

The study makes two important contributions. First, it provides a typology of community energy projects showing which initiatives could be more inclined to be part of a strategy aiming at scaling up the sector. Second, it shows the tensions of SNM in the context of non-market-driven innovation highlighting how exogenous factors such as cultural aspects, the specific context in which community energy develops and community groups' characteristics are also important in the scaling-up process.

In the context of Finland, there are encouraging signs of a possible future expansion of the community energy niche, especially in light of the fact that it may help the country in increasing its share of locally generated renewable energy (Varho et al., 2016; Ruggiero et al., 2015). However, moving more decisively in that direction would require more support for the various projects as well as more dedicated work by intermediary organizations to facilitate networking and learning activities.

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