Article

The Interplay Between Sustainable Entrepreneurs and Public Authorities: Evidence From Sustainable Energy Transitions

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Abstract

Sustainable entrepreneurs are considered to play a crucial role in fostering sustainable development. However, transitions in sociotechnical systems, such as a transition to low-carbon energy solutions, are unlikely to succeed without the coordination with regional political actions, particularly in sectors characterized by path dependency and lock-ins. Based on an empirical analysis of the interplay between firms and public authorities when opening new energy niche markets through Sustainable Energy Action Plans, this article explores the role of sustainable entrepreneurs. We investigate the different levels of engagement with public authorities in co-evolutionary processes toward sustainable development. From this empirical research, four types of co-evolutionist sustainable entrepreneur are derived—hero, visionary, bandwagoner, and explorer. These correspond to the different degrees of interaction with public authorities and system level of action, and extend the definition of the sustainable entrepreneur. The related academic and managerial implications contribute to the current debate on sustainable entrepreneurship.

Keywords

sustainable entrepreneurship, sustainable transition, low carbon economy

Introduction

Sustainable development means meeting the needs of present generations without jeopardizing the ability of futures generations to meet their own needs. It offers a vision of progress that integrates immediate and longer-term objectives, local and global actions, and regards social, economic, and environmental issues as inseparable and interdependent components of human progress (Brundtland & World Commission on Environment and Development, 1987).

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Sustainable entrepreneurs (SEs) are assumed to have a catalytic role in sustainable development (Parrish & Foxon, 2009). In most of the business environments, new sustainability pressures create several market failures, thus opening up new opportunities for new entrants (Cohen & Winn, 2007; Dean & McMullen, 2007; Hart & Milstein, 1999). Sustainable entrepreneurship can thus bring about a transition toward a more sustainable society through sustainable products and processes (Hall, Daneke, & Lenox, 2010). However, some studies argue that such radical shifts are unlikely to succeed without parallel political actions (Gibbs, 2009) and favorable systemic contexts, such as knowledge, infrastructures, availability of venture capital, labor markets, tax systems, and so on (Weber & Rohracher, 2012).

Sustainable development entails sustainable transitions, particularly in sectors characterized by path dependency and lock-ins such as energy, water, and transportation (Fuenfschilling & Truffer, 2014; Markard, Raven, & Truffer, 2012). There are several approaches that address the factors and the dynamics of sociotechnical system changes triggering sustainable development within the sustainable transition (ST) theoretical framework. For example, innovation system approaches focus on the adaptations of systemic contexts parallel to firms' ST activities (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007; Weber & Rohracher, 2012). On the other hand, transition management concerns the transformation of the systemic context itself and the complex dynamics that drive this system's transformation toward an ST (Loorbach & Rotmans, 2010; Weber & Rohracher, 2012).

One of the major contributions of the innovation systems perspective, and of the ST perspective in general, is that the concept of market failures is replaced with a broader set of system failures (e.g., poorly working networks, institutional failures, infrastructure failures; Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Markard et al., 2012). The underlying idea of this theoretical framework is that the systems are composed of actors, institutions, material artifacts, and knowledge, whose interaction provides specific societal services. ST thus implies a shift in sociotechnical systems toward more sustainable modes of production and consumption through the involvement of a broad range of actors in the technological, material, organizational, institutional, political, economic, and sociocultural transformation (Markard et al., 2012).

One important aspect is the guidance and governance in ST (Smith, Stirling, & Berkhout, 2005), and a particularly important challenge is to engage the actors and stimulate societal pressure so that the innovative regime actors and the newly emerging market niches converge into new societal regimes (Loorbach & Rotmans, 2010). This enables policies to influence new sustainable ventures and to stimulate sustainable corporate cultures from the outset (Gibbs, 2009).

Despite recent studies increasingly focusing on the role of different actors in the governance of STs (Bos & Brown, 2012; Shove & Walker, 2010), to the best of our knowledge only little attention has been paid to the nature and the different degrees of interaction between public authorities and SEs. Acknowledging the limitations of the idea of "hypermuscular entrepreneurs" shaping institutions (Fuenfschilling & Truffer, 2016), we thus aim at collecting evidence of the evolutionary paths that connect opportunities for STs related to new technologies, public governance, and entrepreneurial dynamics.

The energy sector and the transition to a low-carbon economy through renewable energy provide an appropriate setting to explore the co-evolution of SEs with public authorities. The energy sector encounters different pressures and changes triggered by energy market liberalization, environmental protection, and climate change problems (Kanellakis, Martinopoulos, & Zachariadis, 2013).

The liberalization of energy market, which started in the 1990s, has given a more critical role to energy companies. The energy companies that emerged from liberalization, despite being partially publically owned, are autonomous players in the competitive market, driven by their interests in survival and economic profitability, but also constrained by increasing environmental concerns. In this new economic context, energy companies have become a strategic partner for

local and national governments in ensuring energy security and transition to a low-carbon economy. This is because they invest money in energy infrastructures and technologies and guarantee continuous energy supply to industries and households (Proedrou, 2012). We thus focus on firms, both regime and niche actors, that have cooperated in defining and implementing the Sustainable Energy Action Plans (SEAPs) of local authorities within their adhesion to the Covenant of Mayors, thereby promoting ST.

Our study contributes both to the literature on sustainable entrepreneurship and ST. After a review of the literature on the relationship between ST and sustainable entrepreneurship, we analyze 13 European SEs playing a key role in the transition to a low carbon economy. We thus propose a typology of SEs and a model of ST that takes into account the interplay between SEs and public authorities. The discussion provides new insights into ST theory through the interpretation of the dynamics that characterize the institution-business interplay, between actors who share a common interest in sustainability. Some study implications and limitations conclude the article.

Literature Review

Sustainable Development and Sustainable Entrepreneurship

To date, the integration of sustainability and competitiveness has not systematically inspired business strategies to stop the degradation of natural and social capital related to climate change, biodiversity losses, resource depletion, and pollution. While some market failures explain the business contribution to environmental degradation, entrepreneurial literature generally recognizes opportunities in these failures (Patzelt & Shepherd, 2011). SEs are thus often highlighted out by scholars as the actors that trigger society's transition toward sustainable development (Cohen & Winn, 2007; Dean & McMullen, 2007; Pacheco, Dean, & Payne, 2010). In fact, sustainable entrepreneurship is defined by Hockerts and Wüstenhagen (2010) as "the discovery and exploitation of economic opportunities through the generation of market disequilibria that initiate the transformation of a sector toward an environmentally and socially more sustainable state." (p.482) For example, Parrish and Foxon (2009) show that SEs can be important *catalysts* for larger scale socioeconomic structural transformations and that this role can be complementary to that of *filling gaps* left by commercial industries and government bodies in provisioning critical social and environmental goods and services.

Scholars have tried to understand what exactly a SE is and in what circumstances it is possible to become one. Schaltegger and Wagner (2011) argue that SEs can be new firms as well as individual operating in established companies, or in the process of building up corporate ventures, spin-offs, and so on, thus representing an endogenous source of change within firms. In fact, SEs within leading companies can be core drivers of sustainable development, who shape markets and society through product and process innovation by influencing the company with their personal goals and preferences in such a way that these are reflected in the company's goals (Schaltegger & Wagner, 2011).

Hockerts and Wüstenhagen (2010) argue that, considering the temporal interaction of industry life cycles, appropriability regimes and the emergence and development of sustainability demands, the sustainable transformation of industries seems to be more frequently fostered in the early stages by new entrants. Conversely, incumbents tend to react to the activities of new entrants by engaging in corporate sustainable entrepreneurship. In other words, while more radical sustainability innovation tends to be driven by newer and smaller firms, well-established and large firms take sustainable innovation into mass markets (Schaltegger & Wagner, 2011).

York and Venkataraman (2010) suggest that in industries in which environmental innovations are likely to supplant existing products, entrepreneurial firms (defined by Katila, Chen, & Piezunka, 2012, as those that start from weak market and resource positions) will be more likely

than incumbents to introduce these innovations. However, in view of the emergence and legitimization of sustainable development within business and policy circles that have changed the rules of the game, Hall et al. (2010) question the generalization of this distinction between new entrants and incumbents in the transformation of our economies into more sustainable systems. Pinkse and Groot (2013) suggest that SEs are politically active but also use collective action; thus, the presence of incumbents in industrial associations could thwart their political influence.

Consequently, the need for further research stems from the fact that the potential for societal transformation through sustainable entrepreneurship alone, defined by Hall et al. (2010) as the Panacea Hypothesis, remains more prescriptive than descriptive and maybe too optimistic.

Some studies suggest that sustainable entrepreneurship should be addressed in a wider context so as to encompass the changes in socioecological systems (Gibbs, 2009; Parrish & Foxon, 2009). In fact, current questions refer more to "how" than "if" SEs need to integrate a systemic perspective on sustainable development in their business strategies, particularly when tackling climate change through the implementation of a low-emissions energy supply and energy efficiency. In fact, tackling climate change is considered as a wicked problem since fundamental differences in goals, interests, and strategy often prevent cooperation, consensus, or shared solutions among the societal actors (e.g., Rotmans, Kemp, & van Asselt, 2001). Building on Gibbs (2009), who suggests that such radical shifts are unlikely to succeed without parallel political actions, the role of public policy and its interplay with sustainable entrepreneurship—which is the objective of our exploratory study—thus emerges as an important but underexplored field of investigation (Hall et al., 2010).

Sustainable Transition and Sustainable Entrepreneurship

Our exploration builds also on recent publications on ST that highlighted some challenges behind sustainable entrepreneurship. There is a widespread consensus in the academic and policy arena that persistent, long-term social and environmental problems, such as climate change, resource scarcity, and environmental degradation require fundamental transitions in sociotechnical systems (Markard et al., 2012; Parrish & Foxon, 2009). ST is particularly complex in sectors such as energy and transportation, both of which are characterized by path dependency and lock-ins (Unruh, 2000). This is because established technologies are highly intertwined with user practices and life styles, complementary technologies, business models, value chains, organizational structures, regulations, and institutional structures (Fuenfschilling & Truffer, 2014; Markard et al., 2012).

Several approaches have been developed to analyze and conceptualize ST based on insights from evolutionary economics, science, and technology studies and sociology. These encompass transition management (e.g., Loorbach, 2010; Rotmans et al., 2001), strategic niche management (e.g., Kemp, Schot, & Hoogma, 1998; Smith & Raven, 2012), the multilevel perspective on sociotechnical transitions (Geels, 2011; Smith, Voß, & Grin, 2010), and technological innovation systems (Bergek et al., 2008; Hekkert, Suurs, et al., 2007; Jacobsson & Johnson, 2000).

A key issue in ST is

> the challenge of orienting long-term change in large socio-technical systems. "Transitions" are understood as processes of structural change in major societal subsystems. They involve a shift in the dominant "rules of the game," a transformation of established technologies and societal practices, movement from one dynamic equilibrium to another—typically stretching over several generations (25-50 years).(Meadowcroft, 2009, p. 324)

A transition is thus conceived as a co-evolutionary process in which institutional, technological, behavioral, ecological, economic, and other processes are interlaced (Loorbach, van Bakel, Whiteman, & Rotmans, 2010).

A transition unfolds through system innovations developed on three structural levels, which alter the relationships between the actors involved in the system (Loorbach et al., 2010; Smith et al., 2010): a macro-level of environmental and societal trends and developments; a meso-level at which a regime of dominant structures, culture, and practices create a particular system function and incremental innovation; and a micro-level of niches, where radical innovations and alternatives to the regime are developed. A characteristic of a ST is guidance that together with governance is often fundamental to determine the success of the transition (Smith et al., 2005). In fact, when the direction of the transition is informed by long-term goals, a broad range of actors are expected to work together (Rotmans et al., 2001) and political actors are expected to play a major role (Markard et al., 2012).

These actors are expected to combine innovative bottom-up developments by coordinating different levels of governance, fostering new types of interaction, cycles of learning, and action for radical innovations and sustainability benefits (Kemp, Loorbach, & Rotmans, 2007).

Thus, four kinds of activities have a systemic relevance in societal transitions (Loorbach & Wijsman, 2013):

- *Strategic*: Activities aimed at developing a vision, long-term goal, and norm setting in terms of a societal system. The aim of these activities is to understand the structure of a complex societal problem and to create alternative futures often through opinion making, visioning, and politics.
- *Tactical*: Activities developed at the level of subsystems and aimed at changing the dominant structures (e.g., institutions, regulation, physical infrastructures, financial infrastructures), often through negotiation, collaboration, lobbying, networking, and so on.
- *Operational*: These activities include experiments and short-term actions that are carried out in the context of innovative projects and programs.
- *Reflexive*: Activities that relate to monitoring and assessing ongoing and societal changes. These activities are necessary to prevent lock-ins and to identify new ideas and options.

Transition theory emphasizes the involvement of key stakeholders in the activities listed above (Meadowcroft, 2009). The potential value of ST in studying sustainable entrepreneurship is that it stresses not just individual actions, but also networks (Whiteman et al., 2011) "helping us to move away from the notion of the lone entrepreneurial hero" (Gibbs, 2009, p. 69).

The pillars of the ST approach are the idea of co-evolution between organizations and their environment (Kemp, 1994; Porter, 2006), along with the potential of innovation to benefit sustainable development (Loorbach et al., 2010; Whiteman et al., 2011). Co-evolution means that key actors have a significant causal impact on each other's ability to persist (Parrish & Foxon, 2009). In terms of business, for example, it means that firms have a symbiotic, causal relationship with society and ecosystems (Korhonen & Seager, 2008; Porter, 2006).

However, this perspective on business activities and changing societal systems, as well as the related opportunities and challenges in addressing sustainability issues, has scarcely been considered in research (Korhonen & Seager, 2008;Rotmans, Kemp, & Asselt, 2001). In addition, the role of different actors in ST is still underexplored (Garud & Karnøe, 2003; Musiolik & Markard, 2011), as is the interplay across institutional and organizational actors to achieve a common goal (Parrish & Foxon, 2009; Whiteman et al., 2011). In fact, empirical studies on ST have focused more on the meso-level (Fuenfschilling & Truffer, 2014; Markard et al., 2012), such as innovation systems and sociotechnical regimes (e.g., Hekkert, Harmsen, & de Jong, 2007; Jacobsson & Lauber, 2006) or on the niche level (e.g., Loorbach et al., 2010; Loorbach & Wijsman, 2013). Only a few empirical studies have focused on the interaction between the two levels (Verbong & Geels, 2007). Despite this, there is evidence that, for example, policies could have a role in influencing new sustainable ventures aimed at developing sustainable corporate cultures from the

outset (Gibbs, 2009). In addition, achieving a better understanding of the co-evolving dynamics has emerged as being particularly important in helping firms increase their competitiveness and sustainability. Given this background, we have tried to shed light on the unexplored aspects of sustainable entrepreneurship in terms of STs and the interplay between SEs and public authorities. Our research thus aims to investigate the pathways of co-evolution of public authorities and SEs in managing the transition to sustainable development. Accordingly, we ask: *How do SEs interplay with public authorities when sharing a common interest in ST? What kinds of actions are involved? What are the entrepreneurial implications?*

Given the emergence of the Covenant of Mayors as a meaningful source of data for research on the systemic interactions between institutions and entrepreneurial influencers, we aim to increase knowledge of how SEs can have a role in the transition toward a low carbon economy and under what conditions.

Method

In order to investigate the role of SEs that explicitly interplay with public authorities to foster ST, we carried out an empirical study on energy measures within SEAPs. SEAPs are energy-planning documents drawn up by local public authorities that voluntarily adhere to the Covenant of Mayors (CoM), which is an initiative launched by the European Commission after the adoption, in 2008, of the EU Climate and Energy Package. The aim of CoM is to endorse and support local authorities, which are recognized as crucial players in mitigating the effects of climate change, in the implementation of sustainable energy policies. In return, signatory mayors voluntarily commit to meet and exceed the European Union 20% CO_2 reduction target by 2020.

The CoM has been portrayed by European authorities as an exceptional model of multilevel governance[1] as it is a unique bottom-up movement[2] mobilizing local and regional actors around the fulfillment of EU objectives related to climate change mitigation.

As explained in the SEAP guidelines, defining a Sustainable Energy Action Plan entails: (1) the definition of a long-term vision, (2) the establishment of a CoM team, (3) the compilation of a Baseline Emission Inventory (BEI), and (4) the development of an action plan in close collaboration with local stakeholders and citizens (European Commission, 2010). The vision for a sustainable energy future is the guiding principle of the local authority's SEAP. A comparison between the vision and the current situation is used to identify what action and development is needed to reach the desired objectives. SEAP uses the results of the BEI to identify the best fields of action and opportunities for achieving the CO_2 reduction target. It then defines concrete reduction measures, which translate the long-term strategy into action. Since the SEAP covers actions concerning the public and private sectors that fall within the jurisdiction of the local authority, the main target sectors are buildings, equipment/facilities, and urban transport. However, the SEAP may also include actions related to local electricity production (development of photovoltaic, wind power, combined heat and power, improvement of local power generation) and local heating/cooling generation. The stakeholders' involvement is considered as fundamental to the success of the CoM.

The interplay between several actors, who are capable of meeting sustainability challenges, is particularly important as cities plan and prepare for climate mitigation and adaptation (Whiteman et al., 2011). Such interplay emerges in the design of the energy plan, where citizens and other stakeholders are thus involved and offered the opportunity to take part in the key stages in the SEAP development such as building the vision, defining the objectives and targets, and setting the priorities—with various degrees of involvement ranging from "informing" to "empowering" (European Commission, 2010).

The CoM is an important source of data for analyzing ST and sustainable entrepreneurship. It encompasses the three structural levels of the ST: the macro-level, which corresponds to societal

trends and developments (e.g., European climate policies, the Kyoto Protocol); the meso-level, which corresponds to a regime of dominant structures, cultures, and practices (e.g., local authorities, local regime actors); and the micro-level, which corresponds to the niches, innovations, and alternatives to the regime (e.g., environmental NGOs, SEs operating at niche level). On the other hand, the CoM requires signatories to formalize all kinds of actions: strategic (e.g., developing a long-term vision regarding local climate policies and GHGs reduction goals), tactical (e.g., identifying the objectives in energy subsystems, stakeholder engagement), reflexive (assessment of the renewable energy potential, monitoring), and operational (e.g., implementing projects and programs).

In order to guarantee a sharp delineation of actors, we focused on the transition from fossil fuel heating systems to shallow geothermal systems. We chose shallow geothermal systems since they are renewable, clean, domestic, and reliable (Rizzi, Frey, & Iraldo, 2011). Unlike many other renewable sources, shallow geothermal energy is not influenced by variable inputs and can be exploited almost everywhere. It is also flexible in that it can be exploited in small scale/household applications as well as in big scale installations and presents a dynamic business environment, for example, it is not yet dominated by large multinational technology providers. It thus represents an economic opportunity for both small/new ventures and big/incumbent firms. Thus, an investigation of the SEAPs in cities adhering to CoM all over Europe contributes to understanding what role a SE can play in fostering the technological shift.

The unit of analysis was the companies explicitly mentioned in SEAPs with reference to the development of SEAP strategies and/or the implementation of actions related to shallow geothermal energy systems. The explicit mention of these firms in SEAPs was assumed as a sign of the strong collaboration with the signatories of the CoM in the definition of policies for the development of shallow geothermal energy systems. The mention thus helps in identifying sample influencers of the policy-making process in the case of ST.

Because of the exploratory nature of this research, we collected qualitative data for interpretation purposes (Edmondson & Mcmanus, 2007). Data were retrieved by accessing two separate sources for each organization: SEAPs and public documents (i.e., supplementary data).

At the time of the study (January 2014), 3,628 SEAPs were available. Only 47 had a strategy and measures for the development of shallow geothermal energy for thermal purposes (Table 1), which reveals the early stage in the diffusion of these systems. Eleven SEAPs were selected because they explicitly mention companies involved in the development of SEAP strategies and/or the implementation of actions related to shallow geothermal energy systems for heating and cooling.

Supplementary data were collected from annual reports, newsletters, and blogs discussing, for example, the company's history, corporate strategy in the renewable energy sector, organizational structure, pilot projects for shallow geothermal energy, as well as other local initiatives. These data were analyzed in order to understand first whether the companies identified fell within the category of SEs; the type of organizations and the relationship with the public authorities; and to verify and complement the information gathered from SEAPs.

The criteria used to check if a company had a sustainable entrepreneurial behavior were the discovery, evaluation, or exploitation of shallow geothermal energy and/or renewable energy as economic opportunity as well as the contribution to the transformation of energy sector toward an environmentally and socially more sustainable state.

The study analyzed 13 companies located in Denmark, France, Germany, Italy, Switzerland, and the United Kingdom (Table 2). The supplementary data also helped in interpreting information from SEAPs by exploring the dynamics behind the firms' involvement in the SEAP, including the relationship with public authorities and firms' level of commitment to the transition to low carbon economy.

The mode of research was to search for patterns that linked the variables under investigation (Strauss & Corbin, 1998; Yin, 2009). The data were coded by three researchers using the same

Table 1. List of SEAPs With Strategy and/or Actions in the Field of Thermal Uses of Shallow Geothermal Energy.

Municipality or group of municipalities	Country	Region
Banja Luka	Bosnia Herzegovina	Banja Luka
Gradiska	Bosnia Herzegovina	Banja Luka
Bonn	Germany	KreisfreieStadt
Eggenfelden	Germany	Niederbayern
Frankfurt	Germany	Germany
Hamburg	Germany	Hamburg
Hannover	Germany	Hannover
Koeln	Germany	Nordrhein-Westfalen
Vaterstetten	Germany	Oberbayern
Willich	Germany	Düsseldorf
Worms	Germany	Rheinhessen-Pfalz
Copenhagen	Denmark	Hovedstaden
Alella	Spain	Cataluña
Caldesd'Estrac	Spain	Cataluña
Igualada	Spain	Cataluña
Irun	Spain	País Vasco
Paterna	Spain	ComunidadValenciana
Piera	Spain	Cataluña
Pujalt	Spain	Cataluña
SantQuirze del Valles	Spain	Cataluña
Santa Coloma de Gramanet	Spain	Cataluña
Taradell	Spain	Cataluña
Paris	France	Île de France
Poissy	France	Île de France
Nisyros	Greece	ΝότιοΑιγαίο (NotioAigaio)
Abbiategrasso	Italy	Lombardia
Canegrate	Italy	Lombardia
Castel Mella	Italy	Lombardia
CesanoBoscone	Italy	Lombardia
ComunitàPioniera del Marghine	Italy	Sardegna
ComunitàPioniera del SECS	Italy	Sardegna
Forlì	Italy	Emilia Romagna
Maranello	Italy	Emilia Romagna
Mirandola	Italy	Emilia Romagna
Poncarale	Italy	Lombardia
Rescaldina	Italy	Lombardia
Romano di Lombardia	Italy	Lombardia
San Possidonio	Italy	Emilia Romagna
Sassuolo	Italy	Emilia Romagna
Settala	Italy	Emilia Romagna
Vanzaghello	Italy	Lombardia
Vignate	Italy	Lombardia
Nadlac	Romania	Sud-Vest Oltenia
Ginevra	Switzerland	Lake Geneva region
Karşıyaka	Turkey	İzmir
Bath and North East Somerset	United Kingdom	Dorset and Somerset
Cornwall Council	United Kingdom	Cornwall and Isles of Scilly

Table 2. Summary of Information About the Firms Mentioned in the SEAPs Within Strategies and/or Actions in the Field of Thermal Uses of Shallow Geothermal Energy and Their Sustainable Entrepreneurial Stance.

Firm/SEAP/year	Type of organization	Economic opportunity identified in shallow geothermal energy and/or renewable energy	Contribution to the transformation of energy sector toward an environmentally and socially more sustainable state
Hovedstaden/ Geotermiske Samarbejde (HGS); Cophenhagen (Denmark)/2009	Partnership established by 4 firms: DONG Energy, HOFOR, CTR, and VEKS	"Geothermal energy and large heat pumps are crucial elements for the next thermal energy supply, and HOFOR, the biggest district heating company of the country, has assumed the role of contributing to the development of these technologies." Lars Therkildsen (HOFOR's CEO) [HOFOR press release, 03.01.2014] The president of CTR, Morten Kabell, said: "Since Copenhagen will become the first carbon neutral city in the world by 2025, we have to change radically district heating systems. I am happy that there is a wide support for the energy transition at urban level. Our plan is realistic: we will work for a sustainable biomass in the short-term, but we will invest more in the other renewable energies in the long-term." [HOFOR press release, 10.10.2014]	"Based on operation since autumn 2005, the experience has been positive. The demonstration project like this has a wider perspective for Copenhagen—It can be the starting point for a secure, environmentally friendly and inexhaustible heat source, all to the benefit of the district heating customers." [VEKS's website—2014]
Compagnie Parisienne de ChauffageUrbain (CPCU)/Paris (France)/2012	Local Public Utility for district heating	"[. . .] [Géométropole company] was established by CPCU, Climespace and CDC with a share respectively of 44%, 22% et 34% in order to ad address the following objectives: • Realization of technical, financial, legal, and commercial operations for the operation of thermal power station (heating&cooling) and two borehole heat exchangers connected to plant in 19th district in Paris ("Ouvrages") • Sale of heating and cooling products by Ouvragesto CPCU and Climespace so that they can provide heating and cooling to all Paris area and all agents in the city of Paris." [CPCU Annual Report—2014]	"CPCU associates the development of a virtuous energy mix within an effective network with the long-term objective of producing more than 50% of energy from local renewable energy sources and energy recovery, i.e., biomass, geothermal energy, heat recovery)." "CPCU aims to use local renewable energy sources or energy recovery in order to reduce the consumption of fossil fuels and improve the quality of air by reducing greenhouse gas emissions." [CPCU's company profile—2014] "CPCU's network provides a coherent thermal solution with environmental policy of the Municipality of Paris thanks to the use of renewable energy sources and energy recovery in the energy mix, and the reduction of CO2 emissions." [CPCU's company profile—2014]

(continued)

Table 2. (continued)

Firm/SEAP/year	Type of organization	Economic opportunity identified in shallow geothermal energy and/or renewable energy	Contribution to the transformation of energy sector toward an environmentally and socially more sustainable state
Stadtwerke Bonn GMBH (SWB)/Bonn (Germany)/2008	Local Public Multi-utility	"SWB aims to guarantee sustainable and cost-effective energy and water supply." [SWB's company profile—2014]	Peter Weckenbrock, SWB's CEO, declared that SWB has become the energy transition in Bonn before the disaster of Fukushima a Bonn. [SWB press release, 30.06.2012]
		"We provide special tariff for heat pumps (ground source heat pumps or not). It is possible to choose discounted tariffs, if customers have energy efficient heating systems." [SWB's company profile—2014]	"Stadtwerke Bonn is involved in a dynamic urban society and assumes the responsibility for the environmental protection and climate change. These aspects belong to our corporate culture. Long-term benefits for Bonn's citizens and next generations are central in the entrepreneurial activity." [SWB's company profile—2014]
Mainova/Frankfurt (Germany)/2009	Local Public Multi-utility with specific business unity for energy services	Mainova contributes to the fight against climate change with several offers. In particular, Mainova has promoted the "Klima Partner Programm" [Mainova' s company profile—2014]	"Electricity, natural gas, heat and water—the Mainova is well aware of the importance of these four pillars for our region. With long-standing experience as a utilities provider as well as the future-oriented thinking of a modern provider of energy services, we are excellently prepared for the challenges of the years to come. The transition toward alternative energies represents an excellent opportunity and motivation to consistently focus on topics such as sustainability and renewable energies. In other words: we will continue to ensure that energy remains secure, clean and affordable for both private and corporate customers in the Rhine-Main region, one of the most demanding locations in Germany." [Mainova' s company profile—2014]
		"Dr. Constantin H. Alsheimer, Mainova's CEO: "Mainova and Frankfurter Sparkasse form an alliance in order strengthen to the development of renewable energy sources. These two companies well-established at regional level. They unify their forces to foster investments in renewable energy sources and increase the acceptance for renewable energy. Mainova AG wants that aware citizens contribute to energy transition. [. . .] We provide with Öko-Festzins Sparen the chance to invest in a green future in our region." [Mainova and Frankfurter Sparkasse press release, 15.06.2012]	Dr. Constantin H. Alsheimer, Mainova's CEO: "We have tackled worldwide climate change through local efforts with the "Klima Partner Programm." We always consider the interests of our consumers. The "Klima Partner Programm" has promoted actions in the amount of 3.325 tonnes of annual CO_2 saved since 2003." [Mainova press release, 20.03.2014]

(continued)

Table 2. (continued)

Firm/SEAP/year	Type of organization	Economic opportunity identified in shallow geothermal energy and/or renewable energy	Contribution to the transformation of energy sector toward an environmentally and socially more sustainable state
Hamburg Energy/ Hamburg (Germany)/2009	Local public utility established in order to work in the local energy sector by fostering renewable sources	"HAMBURG ENERGIE is an energy utility that feels the responsibility toward the city of Hamburg and its region. Our products will be eco-friendly and will be offered taking into account citizens' needs in Hamburg. These products can require higher prices," said Michael Beckereit, Hamburg Energie's CEO. [Hamburg Energie press release, 18.05.2009] The company is committed to the environmental protection by adapting its sales strategy. The company provides climate friendly electricity (nuclear and carbon free)." [Hamburg Energie' s company profile—2014]	"Anja Hajduk, town councilor for the Environment for the Municipality of Hamburg, stated: "HAMBURG ENERGIE can guarantee the conditions for the supply of environmentally friendly energy in Hamburg. [. . .] Therefore, Hamburg strengthens its contribution to the worldwide struggle against climate change and improves its quality of life, economic conditions and the level of technological innovation." [Hamburg Energie press release. 18.05.2009]
Stadtwerke Willich GmbH/Willich (Germany)/2010	Local Public Multi-utility	"Stadtwerke Willich has suitable economic resources and competences for tackling the competition and current energy transition." [Stadtwerke Willich's company profile—2014]	"While many people consider the opportunities related to the renewable sources, we are ahead: we practice the environmental protection by realizing the actual environmental protection in our activities." [Stadtwerke Willich's company profile—2014] "Stadtwerke Willich GmbH, Volksbank and the real estate company of Willich are working in order to guarantee the environmental protection at local local level and particularly at home." [BSW press release, 25.09.2013]
EWR/Worms (Germany)/2010	Local Public Multi-utility	"EWR will develop its grids for the energy revolution and will invest 100 million EUR in the next 10 years in pilot projects for the integration of renewable energy into existing grids." [EWR press release, 13.05.2014] "Today Liebenauer Feld GmbH, EWR and Pfalzwerke signed an agreement for the realization of installation in "Liebenauer Feld." This agreement aims to develop a district heating network that foster the use of geothermal energy or other innovative sustainable energy." [Pfalzwerke press release, 25.11.2003]	"[. . .] EWR's Board is the suitable subject for the promotion and development of wind energy, geothermal energy and biogas. The fulfilment of energy transition is incontrovertible, but the cooperation with citizens is crucial. All actors have to contribute to the common goal [of energy transition]." [EWR press release, 13.05.2014)

(continued)

Table 2. (continued)

Firm/SEAP/year	Type of organization	Economic opportunity identified in shallow geothermal energy and/or renewable energy	Contribution to the transformation of energy sector toward an environmentally and socially more sustainable state
HERA/Forlì (Italy)/2011	Local Public Multi-utility with specific business unity for energy services	"During 2014 [the company] will carry on the development of district heating systems with an increasing share of renewable energy sources or similar through projects in Forlì and the project "Polo Energie Rinnovabili" in Ferrara. The target for 2014 is the increase of served volume (+2%) through new business offers." [HERA Sustainability Report—2013]	Salvatore Molè (Dir. Technology and Development Hera): "We confirm the commitment of Hera for realization of the technological innovation and sustainable development. We will continue the path that has been already started. The laboratory, that will start operating after tomorrow inauguration, confirms the investments for renewable energies." [HERA press release, 27.09.2013]
AIMAG/Mirandola (Italy)/2010	Local Public Multi-utility	"Geological study for the identification of potential geothermal reservoirs in Mirandola underground"—carried out by Emilia Romagna Region in April 2008—highlights the existence of 3 hydrothermal systems. Hydrothermal system G1 will be exploited [. . .]. The exploitation of hydrothermal systems G1 requires the installation of heat pump." [Mirandola SEAP—2010]	AIMAG has developed several projects in the field of energy efficiency, CHP and renewable energies. In particular, AIMAG is involved in the innovation technology for renewable energies. [AIMAG's company profile—2014]
Services Industriels de Genève (SIG)/Genève (Switzerland)/2010	Local Public Multi-utility	"[. . .], deep and shallow geothermal energy is promising sector for the energy security in the Canton of Genéve." [SIG' s company profile—2014]	"SIG has promoted an energy policy for fostering the reduction of electricity consumption and the development of renewable energy sources since 2000. SIG is involved in the reduction of environmental impacts related to its activities, products and services in order to be a good practice at local and regional level. The Environment is the priority of SIG's strategy and its long term development." [SIG' s company profile—2014]
		"The development of geothermal energy is a priority for the regional energy policy. The geological characteristics in the area of Genève are very interesting. In order to exploit this resource, it is necessary to increase the knowledge about subsoil. This is the aim of program GEothermie 2020 that was presented today by State councilors Antonio Hodgers and Luc Barthassat, the President of Regional Assembly of Genéve Robert Borrel and SIG General Director Christian Brunier." [SIG-Canton of Genéve press release, 10.06.2014]	"[. . .] SIG is a key actor in this field. The firm fosters Genevan inhabitants in the reduction of energy consumption through the Programme éco21 and all energy services." [SIG Sustainability Report 2013]

(continued)

Table 2. (continued)

Firm/SEAP/year	Type of organization	Economic opportunity identified in shallow geothermal energy and/or renewable energy	Contribution to the transformation of energy sector toward an environmentally and socially more sustainable state
Community Energy Plus/Cornwall (UK)/2013	Privately owned company (Award as social enterprise)	Information and expert advice for helping householders and communities reduce their energy use and create a more sustainable future for all in Cornwall through renewable energy technologies energy efficiency measures. [Cornwall SEAP—2013]	Helping to reduce the carbon emissions that contribute to climate change. [Community Energy Plus's website—2014]
Cornwall and Isles of Scilly Local Entreprise Partnership/ Cornwall (UK)/2013	Not for profit company limited by guarantee	"The C&IoS LEP have also been developing three further LGF (Local Growth Fund) propositions. [. . .] In particular, The operationalization of the geothermal project(s) to deliver heat and power. This would be the first UK based geothermal deployment in the UK, and could provide a key component of the UK's energy mix moving forward." [Cornwall and Isles of Scilly Strategic Economic Plan]	The benefits associated to the employment of LGF for the development of the Geothermal energy: • Creation of a new renewable energy sector in the UK • Centre of excellence based around strong existing academic strengths and the expansion of research and the creation of high value jobs • Creation of a transferable model to other parts of the UK that could produce a significant amount of the UK's heat and power needs. [Cornwall and Isles of Scilly Strategic Economic Plan]
EGS Energy/ Cornwall (UK)/2013	Privately owned company	Guy Macpherson-Grant, Managing Director of EGS Energy, said: "Here in Cornwall, the UK's natural home for geothermal activity and where there is a world class geothermal resource, there is a great opportunity for EGS Energy to deploy the experience and skills of its leading team of experts. In establishing this pioneering plant, they will be building on their success in this field elsewhere in Europe, benefiting the local community along with the rest of the country." [EGS press release, 10.12.2010] "In collaboration with The Eden Project EGS Energy proposes to build the UK's first geothermal power plant generating both heat and electricity. [. . .], it should produce enough electricity to supply Eden and the equivalent of around five thousand households, as well as heating for the biomes and potentially some district heating (depending on economics and logistics)." [EGS's website—2014]	Matt Hastings, Eden's Energy Manager, said: "This is a great opportunity for anyone interested in our pioneering geothermal plans to come along, talk to the experts who are running the project and ask any questions they might have. Our geothermal project will add tremendous support to Cornwall's drive to be at the forefront of UK renewable energy and it's vital that the local community is involved throughout the process."[EGS press release, 16.06.2010]

software platform. Any discrepancies in coding were discussed until a full agreement was reached. During the analysis, when no significant differences were found, codes were recorded and reconciled (Poole, van de Ven, Dooley, & Holmes, 2000). Further search strategies were agreed in the case of gaps.

For the data analysis, a two-step approach was followed. In the first stage, we ran an exploratory coding procedure to find the main concepts regarding the firm's involvement in the shallow geothermal energy subsector emerging from the SEAPs and supplementary data (Strauss & Corbin, 1998). In the second stage, we aggregated the identified concepts (e.g., involvement in SEAP) into themes (e.g., type of activity in ST; Gioia, Corley, & Hamilton, 2013)—as shown in Table 3. The themes reproduced those identified by previous research on ST. We then assigned an overall governance interplay level and role in the system to each firm, ranging from bottom-up to top-down for the level, and from niche to regime for the role. On the basis of this classification, we developed a matrix combining the different levels of governance interplay and the level in the transition of each firm (Figure 1). This matrix helped understand the firms' involvement in the SEAP, the relationship with public authorities, and the firms' role in the transition to a low carbon economy. Where possible, the firms' different positions in the matrix were interpreted using the sustainable entrepreneurship theoretical framework.

Results

All the firms in our study are mentioned in SEAPs in the sections on strategy and/or actions with a clear commitment to develop geothermal systems for the transition to a low carbon economy. This commitment is evident in that policy makers mention them as crucial for local projects and initiatives, but also in that these firms and their top managers publicly declared a strong commitment to carrying out awareness campaigns and providing services or products in order to facilitate the transition toward sustainable energy systems.

For example, in the case of Hamburg Energie, Anja Hajduk—the town councilor for the environment for the municipality of Hamburg—stated:

> Hamburg Energie can guarantee the conditions for the supply of environmentally friendly energy in Hamburg. More customers will choose Hamburg Energie, more investments will be carried out in order to develop new systems for the production of sustainable energy in the area of Hamburg. This link with the local community is the first example in Germany. Therefore, Hamburg strengthens its contribution to the worldwide struggle against climate change and improves its quality of life, economic conditions and the level of technological innovation. (Hamburg Energie press release, 18.05.2009)

Similarly, Peter Weckenbrock, the CEO of SWB, declared: "SWB began the energy transition in Bonn before the disaster of Fukushima" (SWB press release, 30.06.2012), and EGS Energy in 2009 stated: "[. . .] Today we face three of the greatest challenges of our time, global recession, energy security and the threat of catastrophic climate change. The only solution to this triple crunch is a low-carbon recovery" (Letter signed by EGS Energy and published by *The Guardian*, 22.04.2009).

On the web, all these firms widely disseminate their commitment to geothermal energy and are involved in the definition and/or implementation of SEAPs. These companies had a crucial role in defining SEAPs and in the implementation of renewable energy policies, as is clear from the general and sector strategy sections of SEAPs, for example, "SWB and the City of Bonn support the development of renewable energy sources, and energy efficiency in the long-term" (Bonn SEAP—2008); "Mainova as major energy supplier of the city assumes a crucial role in the protection of the climate" (Frankfurt SEAP—2009); "The city council has established Hamburg Energie so as to it can influence the development of a supply of sustainable energy at city level" (Hamburg SEAP—2009).

Table 3. Data Analysis and Exemplary Quotes.

Firm	Involvement in SEAP	Type of governance for transition	Quote
Hovedstaden Geotermiske Samarbejde (HGS)	Pilot project (2005)	Operational	"Since 2005, the HGS companies have operated a demonstration plant at Magretheholm in conjunction with the Amager power station." [Danish Energy Agency press release, 15.06.2009]
			"Based on operation since autumn 2005, the experience has been positive. The demonstration project like this has a wider perspective for Copenhagen—it can be the starting point for a secure, environmentally friendly and inexhaustible heat source, all to the benefit of the district heating customers." [VEKS's website, 06.06.2006]
			"[. . .] The demonstration project like this has a wider perspective for Copenhagen-it can be the starting point for a secure, environmentally friendly and inexhaustible heat source, all to the benefit of the district heating customers." [Copenhagen SEAP—2009]
	Feasibility study (2008)	Reflexive	In 2008, the HGS companies made an assessment of geothermal reserves in the metropolitan region. The conclusion is that the region has geothermal reserves of about 60,000 PJ, which can cover 30-50 per cent of district heating requirements for several thousand years. Following this assessment, the City of Copenhagen has begun incorporating a geothermal plant into its Climate Plan, with the aim of making the City of Copenhagen CO_2 neutral in 2025. This plant will have a capacity five to six times higher than that of the Magretheholm plant, and can go into operation in 2015. [Danish Energy Agency's website, 15.06.2009]
Compagnie Parisienne de Chauffage Urbain (CPCU)	Pilot project (2012)	Operational	"[. . .] in particular the work carried out by the Paris Urban Heating Company (CPCU) whose network supplies some of the towns in the inner suburbs, and the geothermal energy project in the Clichy-Batignolles urban development zone, which could also benefit outlying districts." [Paris SEAP—2012]
			"CPCU, in cooperation with ANR (Agence Nationale de la Recherche) and BRGM (Bureau de Recherches Géologiques et Minières), is involved in the project Géostocal for the seasonal thermal energy storage. [. . .] This system can serve in the future eco-friendly neighborhood of Ivry Confluence and promote the use of renewable energy sources." [CPCU's company profile—2014]
	Feasibility study (2012)	Reflexive	"The City of Paris will study the possible energy choices for the new urban development zone as a matter of priority, favoring as much as possible the use of local renewable energies or connection to the local heating system (CPCU—Paris Urban Heating Company) and/or cooling system (Climespace) networks, whilst also improving air quality. As an example, studies will be carried out to identify the geothermal potential of the Bercy-Charenton urban development zone." SEAP: "[. . .] As an example, studies will be carried out to identify the geothermal potential of the Bercy-Charenton urban development zone." [Paris SEAP—2012]
	Information activities	Strategic	"CPCU is one of the founders of the Parisian Agency for Climate (Agence Parisienne du Climat [APC]) that was established in order to inform citizens of the contents of Climate Action Plan for the city of Paris." [CPCU's company profile—2014]

(continued)

Table 3. (continued)

Firm	Involvement in SEAP	Type of governance for transition	Quote
Stadtwerke Bonn GMBH (SWB)	Strategic collaboration in the definition of SEAP	Strategic	Crucial role in the promotion of renewable energies and energy efficiency. "SWB and the City of Bonn support the development of renewable energy sources, and energy efficiency in the long-term." [Bonn SEAP—2008] Werner Hümmrich, President of SWB Energy and Water, said: "Our project is crucial for the challenging German energy transition." [www.general-anzeiger-bonn.de, press release, 30.06.2012]
Mainova	(a) Strategic collaboration in definition of SEAP	Strategic	"Mainova as major energy supplier of the city assumes a crucial role in the protection of climate." [Frankfurt SEAP—2009] "[. . .] we will continue to ensure that energy remains secure, clean and affordable for both private and corporate customers in the Rhine-Main region, one of the most demanding locations in Germany." [Mainova's company profile—2014]
Hamburg Energy	(b) Strategic collaboration in definition of SEAP	Strategic	"Crucial role of Hamburg Energie in the development of sustainable energy at urban level." [Hamburg SEAP—2009]
	Feasibility study	Reflexive	"HAMBURG ENERGIE has received the concession for the geothermal exploration and started to assess the underground." [Hamburg SEAP—2009]
Stadtwerke Willich GmbH	Pilot project	Operational	(c) "The use of geothermal energy through innovative technical solutions for heating and cooling." "Description: Implementation of pilot project for the development of geothermal energy with suitable communication activities." [Willich SEAP—2010]
	Feasibility study	Reflexive	"Feasibility study for the implementation of district heating system with the use of renewable energy sources." [Willich SEAP—2010]
EWR	Contribution to stakeholder engagement activities	Tactical	Information campaigns and expert advise for the promotion of geothermal applications. [Worms SEAP—2010]
HERA	Pilot project (2006)	Operational	Cooperation for the realization of district heating network in the city of Forlì. (It is not geothermal district heating, but adopts heat pumps using water form water purifier). The City Council of Forlì, with deliberation. 50 in 13 March 2006, approved "Operative agreement of framework agreement between the Municipality of Forlì and Hera S.p.A." in order to plan the actions for the development of district heating. The project for the development of district heating in the Municipality of Forlì is promoted by the deliberation of the Province (variante generale al PRG approvata con delibera della Giunta Provinciale n. 6819/28 del 28/01/2003). [Forlì Energy Plan—2008]

(continued)

Table 3. (continued)

Firm	Involvement in SEAP	Type of governance for transition	Quote
AIMAG	Pilot project	Operational	Implementation of pilot project for geothermal applications. [Mirandola SEAP—2010]
	Feasibility study (2008)	Reflexive	Geothermal power station: "Geological study for the identification of potential geothermal reservoirs in Mirandola underground"—carried out by Emilia Romagna Region in April 2008—highlights the existence of 3 hydrothermal systems. Hydrothermal system G1 will be exploited [. . .]. The exploitation of hydrothermal systems G1 requires the installation of heat pump [. . .]. "The study, requested by AIMAG, belongs to European project Thinking where AIMAG and AESS (Agenzia per l'energia e lo Sviluppo Sostenibile) in Modena are involved. This project aims to foster the development of energy sustainability at local level." [Mirandola SEAP—2010]
Services Industriels de Genève (SIG)	Pilot project	Operational	"Implementation of pilot project for geothermal applications." [Genève SEAP—2010]
	Feasibility study	Reflexive	"Preliminary study on the use of deep geothermal energy for the production of electricity and heating." [SIG's company profile—2014]
Community Energy Plus	Information activities	Strategic	Information and expert advice for helping householders and communities reduce their energy use and create a more sustainable future for all in Cornwall through renewable energy technologies energy efficiency measures. [Cornwall SEAP—2013]
Cornwall and Isles of Scilly Local Entreprise Partnership	Information activities	Tactical	"Stakeholder engagement activities: definition of actions for supporting and promoting geothermal opportunities." [Cornwall SEAP—2013]
			"As a powerful coalition between the private and public sectors, the LEP is uniquely positioned to influence those areas where policy and practice collide. We can foster mutual understanding and proactive working partnerships that can overcome the traditional polarisation of the public and private interest, and this is where we will focus our energies." [Cornwall and Isles of Scilly Local Entreprise Partnership Construction strategy, 2014-2020]
EGS Energy	Pilot Project	Operational	Building the UK's first geothermal power plant generating both heat and electricity. [Cornwall SEAP—2013]
			Matt Hastings, Eden's Energy Manager, said: "This is a great opportunity for anyone interested in our pioneering geothermal plans to come along, talk to the experts who are running the project and ask any questions they might have. Our geothermal project will add tremendous support to Cornwall's drive to be at the forefront of UK renewable energy and it's vital that the local community is involved throughout the process." [EGS press release, 17.12.2010]

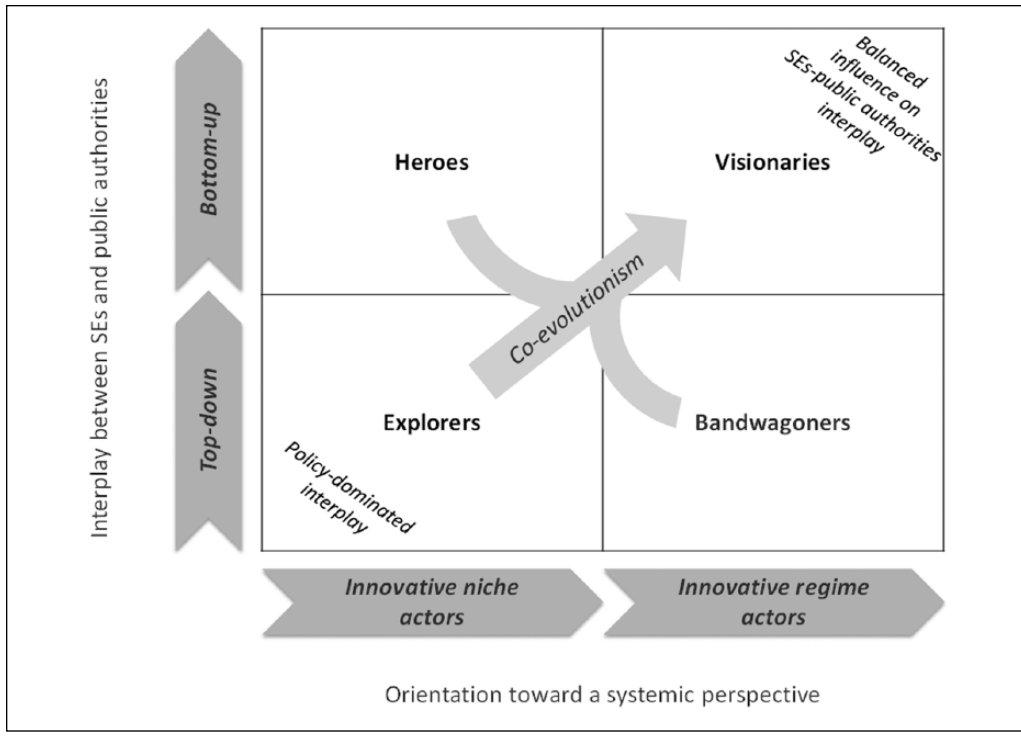

Figure 1. Classification of the SEs from a co-evolutionist perspective.

Besides the strategic level, the firms selected act also at the other levels outlined in the ST management framework (i.e., tactical, operational, and reflexive). At the tactical level, many municipalities rely on firms to plan and provide information activities aimed at stakeholders in order to support the development of geothermal systems for thermal uses, thus helping change the dominant structures at the subsystem level, that is, in our case physical and financial infrastructures. For example, EWR carries out "information campaigns and provides expert advice for the promotion of geothermal applications" (Worms SEAP—2010). Similarly, Cornwall and Isles of Scilly Local Enterprise Partnership were involved in "the definition of actions for supporting and promoting geothermal opportunities" (Cornwall SEAP—2013).

Regarding operational activities, these firms usually contribute to the creation of pilot projects considered as exemplary cases or planned as future activities in the SEAPs. The Paris SEAP (2012) reports:

> It will eventually be necessary to pool the energy distribution and production efforts of the Paris authorities in order to ensure the safety of the supply, reduce dependency on imports, manage and pool investment and production costs and curb energy prices for Paris consumers. [. . .] in particular the work carried out by the Paris Urban Heating Company (CPCU) whose network supplies some of the towns in the inner suburbs, and the geothermal energy project in the Clichy-Batignolles urban development zone, which could also benefit outlying districts.

Similarly, EGS Energy is mentioned in the Cornwall SEAP (2013) for building the United Kingdom's first geothermal heat and power plant in the area of the Eden Project in Cornwall. Matt Hastings, Eden's Energy Manager, said: "Our geothermal project will add tremendous support to Cornwall's drive to be at the forefront of UK renewable energy and it's vital that the local community is involved throughout the process" (EGS press release, 16.06.2010).

Referring to the extension of the geothermal plant at Magretheholm included in the SEAP of Copenhagen (2009), VEKS (one of the companies that established the HGS), highlighted the importance of its demonstration plant for Copenhagen's carbon-free transition:

> Based on operation since autumn 2005, the experience has been positive. The demonstration project has a wider perspective for Copenhagen—It can be the starting point for a secure, environmentally friendly and inexhaustible heat source, all to the benefit of the district heating customers. (VEKS's website, 06.06.2006)

HGS also carried out a feasibility study:

> In 2008, the HGS companies made an assessment of geothermal reserves in the metropolitan region. [. . .] Following this assessment, the City of Copenhagen has begun incorporating a geothermal plant into its Climate Plan, with the aim of making the City of Copenhagen CO_2 neutral in 2025. This plant will have a capacity five to six times higher than that of the Magretheholm plant, and can go into operation in 2015. (Danish Energy Agency press release, 15.06.2009)

This latter activity can be considered as being reflexive.

From our data, municipalities often give firms the task of carrying out technical assessments on shallow geothermal energy projects or rely on the previous studies carried out by local firms (as in the case of the municipality of Copenhagen). Paris SEAP (2012) reports:

> The City of Paris will study the possible energy choices for the new urban development zone as a matter of priority, favoring as much as possible the use of local renewable energies or connection to the local heating system (CPCU—Paris Urban Heating Company) and/or cooling system (Climespace) networks, whilst also improving air quality. As an example, studies will be carried out to identify the geothermal potential of the Bercy-Charenton urban development zone.

The active role of CPCU in the assessment of shallow geothermal resource is also explained on the CPCU's website:

> In partnership with the ANR (Agence Nationale de la Recherche) and the BRGM (Bureau de Recherches Géologiques et Minières), CPCU takes an active part on the research project Géostocal, an assessment of the shallow geothermal energy, in particular in terms of stocking the heat in the earth during the summer for subsequent exploitation during the winter.

The interplay between firms and public authorities and the system levels have thus emerged in the ST activities. There is a broad and stable cooperation between firms and local/regional authorities in the creation of policies and projects for developing renewable sources, as documented by Community Energy Plus: "Since 1998 we have worked in partnership with a wide range of public, private and third sector organizations to support a variety of innovative projects relating to energy efficiency and renewable energy including community ownership models" (Community Energy Plus's website—2014).

Other examples of cooperation are represented by CPCU and SIG. CPCU stated: "The energy strategy of CPCU consists of: the choice of suitable energy sources and the research of their energy efficiency. [. . .] This strategy is defined in cooperation with the Municipality of Paris" (CPCU's company profile, 2014). SIG declared,

> The development of geothermal energy is the priority of the energy policy of the Canton of Genève. The geological conditions of the area of Genève are favourable. Since it is necessary to obtain more information about the subsoil, the Canton of Genève, in cooperation with SIG, launches the programme GEothermie 2020. (SIG—Canton of Genève press release, 10.06.2014)

The Willich SEAP (2010) also highlights the crucial role of firms in the implementation of the local energy policy: "The city of Willich with 52,000 inhabitants located in the district of Dusseldorf in Viersen, is supported by Stadtwerke Willich in the protection of the climate."

Stability seems functional to ST because it facilitates an effective exchange of resources and capabilities between firms and public authorities; however, it does not necessarily imply the top-down decision of a transition to a low carbon economy. Conversely, firms are often involved in setting energy strategies, including a long-term vision of the transition, beyond tactical and reflexive activities from both a bottom-up perspective as well.

Mainova reports: "The realization of Mainova Energy Talk, an annual meeting which involves practitioners, scholars and local stakeholders in the energy, building and environmental field" (www.franfrut.de press release, 19.11.2013). Similarly, HERA leverages on area managers "in order to facilitate the relationship with local authorities and strengthen the link with the territory [. . .]" (HERA's website, 2014). In such initiatives, the dialogue with local stakeholders aims to facilitate the implementation of a bottom-up approach to foster STs. Hamburg Energie established a Client Advisory Board which is also the advisory body of the company. "[. . .] The Client Advisory Board reserves 10 seats for institutions and associations. Representatives are the federation for environmental protection, tenants association, landlords association and trade association of Hamburg" (Hamburg Energie's company profile, 2014).

There is a clear parallelism with regime actors operating at the meso-level, which is also influenced by dominant structures, culture, and practices. Firms are also involved in very concrete and tangible activities, in particular in pilot projects, where they act as niche innovators operating at the micro-level.

Discussion

Our results suggest that both regime and niche actors are deeply embedded in the local business environment. Although this finding cannot be generalized because of the qualitative nature of the study, our study shows that the interplay between SEs and public authorities is crucial for innovative actors for working alongside public authorities toward STs. This interplay resides in formal or informal forms of long-term relationship with institutions and—in particular—with public authorities responsible for energy planning. The embeddedness in the local business environment facilitates transparency and, in turn, strategic complementarities.

Stable forms of collaboration between firms and public authorities range from sharing competencies and resources for policy making and developing a long-term vision, to the development of pilot projects. In other words, the interplay between SEs and public authorities covers all kinds of activities identified in the ST literature. Regardless of the form, this interplay—which is less frequently reported in the literature—emerges as a concrete and effective way to integrate a systemic perspective about the sustainable development in business strategies. The way both regime and niche actors are involved in SEAPs highlights the usefulness of combining bottom-up strategies, that is, those aimed at triggering the ST in the target market, with top-down strategies, that is, those aimed at implementing public policies. There is a clear presence of SEs in these firms, which influence both the company vision and the local authorities.

According to our findings, we propose a classification of SEs based on two dimensions: the degree of orientation toward a systemic perspective and the degree of interplay with the public authorities. Orientation identifies whether an actor operates at the meso-level, which is more common for innovative regime actors, or at the micro-level, which is more common for innovative niche actor. The interplay indicates whether firms are more inclined to trigger STs (bottom-up) or to be implementers of public policies aimed at reshaping the local context toward sustainable development (top-down).

Figure 1 represents our classification of SEs from a co-evolutionist perspective. In relation to innovative niche actors operating at the micro-level and with bottom-up strategies, SEs play the role of *heroes* (three firms in our study) as suggested by the literature on sustainable entrepreneurship (Gibbs, 2009). This box represents firms as in the case of HGS, Community Energy Plus and Cornwall, and Isles of Scilly Local Enterprise Partnership, which exploit ST activities to push the transition at the micro-level.

However, innovative niche actors can also be pulled by public authorities in participating in the transition to sustainable development. In this case, they can be defined as *explorers* (four firms in our study). In fact, these companies are often involved in pilot projects organized by public authorities, which are precursors of the transition to sustainable development. This is the case of EGS Energy, which is a local and privately owned company with a long experience in geothermal projects. EGS Energy, which aims to exploit geothermal energy on a commercial scale, both as a developer and as a consultant, has been involved in the Cornwall SEAP to build the UK's first geothermal power plant generating both heat and electricity.

When innovative regime actors push public authorities toward sustainable development, they can be referred to as *visionaries* (three firms in our study), as they impact the definition of the SEAP strategy and the implementation of actions planned. Mainova explicitly invests in a dialogue with local stakeholders, and especially with local authorities. For example, Mainova arranges an annual meeting called the "Mainova Energy Talk" in which practitioners, scholars, and local stakeholders discuss energy and environmental issues. This is part of a strategy to collect information and inputs from local stakeholders and practitioners while presenting and explaining its activities and projects that support the transition to a low carbon economy. Mainova also awards innovative projects in energy efficiency and the renewable energies sector. Finally, when regime actors are pulled by public authorities they can be considered as *bandwagoners* (four companies in our study) because they follow the policy direction toward sustainability. For example, AIMAG caught the opportunity to diversifying into new business areas by developing several projects in the field of energy efficiency, combined heat and power and renewable energies but it does not directly influence the transition to geothermal systems.

Since all the SEs identified in our analysis have a symbiotic, causal relationship with public authorities in changing societal systems, they can be considered as co-evolutionists. Figure 2 represents the multilevel model of the transition to a low carbon energy system within the CoM where the interaction between public authorities and the 4 categories of actors operating at different levels. Top-down and bottom-up governance efforts characterize the interplay between public-private actors and determine the co-evolution within ST.

Our classification of SEs launches a new reflection. In fact, with empirical evidence, our research confirms the suggestion of some scholars that sustainability-driven entrepreneurs can function as important *catalysts* to larger scale socioeconomic structural transformations and that this role can be complementary to that of *filling the gaps* left by commercial industries and government bodies in provisioning critical social and environmental goods and services (Parrish & Foxon, 2009). In addition, it shows that SEs can adopt different strategies to leverage on their interplay with public authorities. Both these views help in understanding the role of SEs far beyond that of the lone hero by fostering sustainable development and creating substantial market success with environmentally or socially beneficial products and services. In fact, SEs have different options for co-evolving with public authorities to develop a shared long-term vision and to implement STs through activities with a systemic relevance.

While previous studies on sustainable entrepreneurship have mainly provided evidences that (1) the sustainable transformation of industries seems to be fostered in the early stages by new entrants and (2) incumbents react to the activities of new entrants by engaging in corporate sustainable entrepreneurship activities (Hockerts & Wüstenhagen, 2010; Schaltegger & Wagner, 2011; York & Venkataraman, 2010), our study shows that SEs have more options for playing a

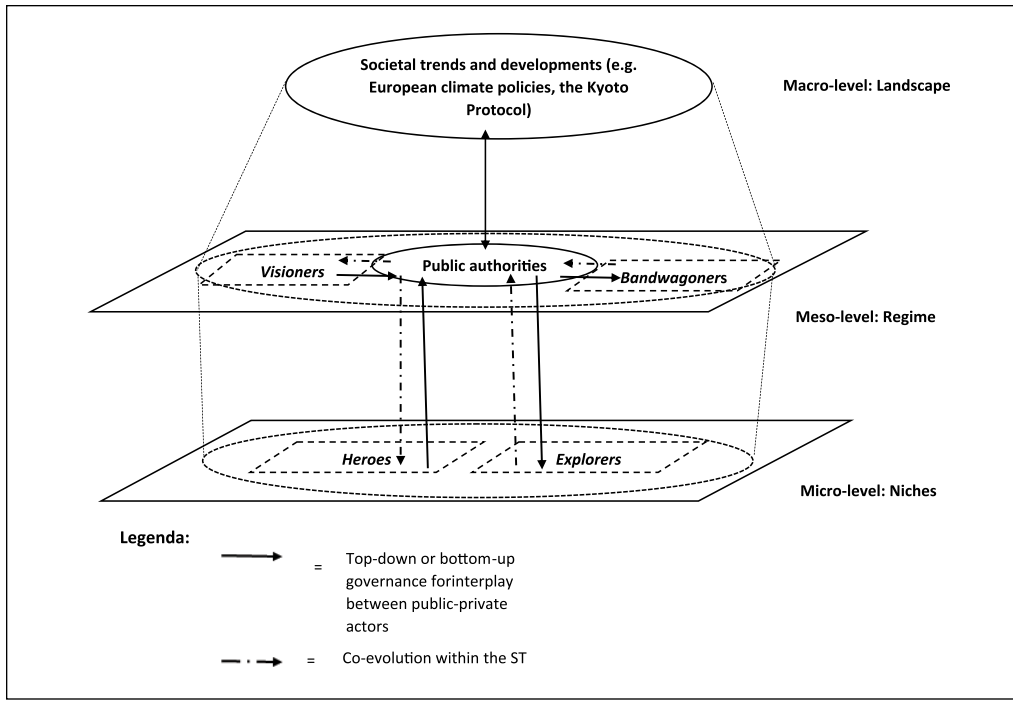

Figure 2. The multilevel model of the transition to a low carbon energy system within the Covenant of Mayors.

more systemic role in changing market conditions in a ST. In fact, from a governance perspective (top-down vs. bottom-up), it is worth distinguishing between an innovative regime and niche actors rather than incumbents versus new entrants.

By looking at SEs as actors that co-create new societal regimes and co-evolve with institutions and other regime actors, the governance of the ST (i.e., strategic, tactical, operational, and reflexive) is functional to the alternative postures of SEs. Corporate resources (e.g., human, technical, financial), shared values related to sustainable development and the awareness of the significant causal impact on the mutual ability to persist (Parrish & Foxon, 2009; Winn & Pogutz, 2013) justify the empowerment of SEs as valuable partners of public authorities in all ST activities toward a low carbon economy. We therefore propose sustainable entrepreneurship in a ST as the co-creation of new market, cultural, and societal regimes through the development of strategic, tactical, reflexive, and operational activities (including market activities). The aim of these activities carried out by economic actors (both innovative regime and niche actors) with institutional and other regime actors in a co-evolutionary process, is to overcome the unsustainable systems. This definition extends and integrates those of previous studies which mainly focus on the process of discovering, evaluating, and exploiting the economic opportunities provided by environmentally relevant market failures, thus limiting the relationship between SEs and the market (Cohen & Winn, 2007; Dean & McMullen, 2007; Hockerts & Wüstenhagen, 2010).

Conclusions

This study has explored how SEs can co-evolve with public institutions toward a ST. We focused on the ST toward a more sustainable energy system within the CoM. Our exploratory study provides a vertical investigation on SEAPs that supports a theoretical model where role of SEs in

STs goes far beyond that of the lone hero that tries to foster sustainable development by creating a substantial market success with environmentally or socially beneficial products and services. In fact, SEs can find different ways to co-evolve with public authorities, which in turn are increasingly called to develop and share a long-term vision, cultivate and leverage on the interplay with SEs at the local level, and then, support the local business environment to achieve global goals.

We found that SEs are thus able to co-create new societal regimes more because of their ability to actively take part in the governance of the transition management through strategic, tactical, operational, and reflexive actions than their ability to unilaterally introduce sustainable products and services. SEs can adopt different strategies in order to benefit from contributing to STs. In fact, from the perspective of the interplay between SEs and public authorities, it is worth distinguishing between top-down and bottom-up approaches rather than passive and active approaches, between innovative regime and niche actors rather than incumbents and new entrants. In other words, we support a model where either SEs trigger the transition to sustainable development (i.e., bottom-up approach), as mainly proposed by the previous studies or, unlike suggested in most of the literature, they are enablers and implementers of public policies aimed at reshaping the local context toward sustainable development (top-down approach).

We have provided empirical evidences of the importance for ST of harmonizing strategic, tactical, operational, and reflexive activities at different scale levels through the interplay across institutional and business levels. While previous research has focused on the role of actors in transition processes on a specific scale, that is, regional, business, sector, international (Markard et al., 2012), we have shown how public authorities and innovative regime actors at the meso-level and innovative niche firms at the micro-level can co-evolve and co-create pathways for the transition toward sustainable development.

This study provides important managerial implications for SEs. In fact, on the one hand, SEs that intend fostering sustainable development and creating substantial market success with environmentally or socially beneficial products and services could usefully search the endorsement of public authorities as a way to be involved in strategic, tactical, reflexive, and operational ST activities. This should enable them to share risks with institutions, such as public authorities and other local stakeholders, through participating in the co-creation of new societal regimes and co-evolving with institutions and other regime actors along the transition to a low carbon economy. Our study also shows that the forms of intervention to progress toward the ST are context-dependent and, thus, it is not possible to provide SEs with a one-fit-all prescriptive combination of activities. The presence of trained personnel or teams managing the dialogue and coordination with local institutions is thus a fundamental issue for developing SEs' strategies. Accordingly, SEs experiencing bottom-up and top-down approaches need to develop suitable capabilities without overlooking institutional contexts.

On the other hand, public authorities could usefully recognize the contribution of SEs to STs in terms of knowledge, resources, and values and, thus, influence and involve SEs and consider them as crucial partners within transition process. Public authorities are therefore recommended to design policies for the transition toward a low carbon economy by taking into account the local business environment and the characteristics of potential SEs in order to provide an effective contribution to the ST.

In this framework, we argue that trade associations, "complementary" firms, universities, and research centers are particularly important in shaping the local business environment, and thus, they could usefully be viewed as facilitators of the transition process.

These findings seem particularly relevant in sectors that require fundamental transitions in sociotechnical systems. Our qualitative approach limited to one specific industry and within the European Union does not allow generalization to other sectors, but provides interesting evidences on forms of SEs that are almost neglected in current literature. Our results suggest new directions for further investigation in other sectors and beyond the European countries.

Although we have presented the four types of SEs as being distinct, the typology is stylized and requires a carefully contextualization. In fact, for the classification of SEs we considered only the actions regarding the development of shallow geothermal energy within SEAPs, which were the subject of our analysis. Outcomes cannot be generalized to the firm's overall business strategy and might vary in time. It is therefore likely that the same firm could fall into a different quadrant considering a different action/subsector or timeframe, which is not the focus of our investigation.

Another limitation is related to the nature of published data and the related limitations in the identification of additional categories of firms along the governance of the public–private interplay dimension, which calls for a purposive selection of further case studies.

Finally, while we discussed new forms of SEs in the early phase of ST and their determinants, future studies could provide further insights into the evolution of SEs throughout the overall ST development.

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Notes

1. Retrieved from http://www.covenantofmayors.eu/about/covenant-of-mayors_en.html
2. Retrieved from http://www.covenantofmayors.eu/The-Covenant-of-Mayors-for-Climate.html

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