Strategic collaboration in innovation ecosystems
- a case study of collective system building in the Dutch smart grid sector

Julia Planko

ISBN: 978-94-6295-828-9
Cover design: Visual Notes Amsterdam
Layout and printing: ProefschriftMaken

Strategic collaboration in innovation ecosystems
- a case study of collective system building in the Dutch smart grid sector

Strategische samenwerking in innovatie-ecosystemen
- de casus van de Nederlandse smart grid sector

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht op gezag van de rector magnificus, prof.dr. G.J. van der Zwaan, ingevolge het besluit van het college voor promoties in het openbaar te verdedigen op vrijdag 2 februari 2018 des middags te 2.30 uur

door

Julia Vera Planko

geboren te Essen, Duitsland

Promotoren: Prof.dr. J.M. Cramer
Prof.dr. M.P. Hekkert

Copromotor: Dr. M.M.H. Chappin

This thesis was accomplished with financial support from Hogeschool Utrecht.

Table of contents

CHAPTER 1

Introduction

1.1. Sustainability transitions and entrepreneurs

Climate change is proceeding fast, and our planet's resources are dwindling. Increasing environmental pressure and resource scarcity affect our economy and have negative societal impacts (Bleischwitz, Giljum, Kuhndt, & Schmidt-Bleek, 2009). To achieve resource efficiency and a low carbon society, societies need to change their current patterns of energy and resource use. In other words, what is needed is a societal transition towards more sustainable production and consumption (Andersen & Tukker, 2006; F. Berkhout, 2002; Grin, Rotmans, & Schot, 2010). Societal transitions have been defined as "radical, large-scale and integrated socio–technical changes" (Van den Bergh, Truffer, & Kallis, 2011, p.8). Since consumers are reluctant to abandon their comfortable lifestyles, such transitions will only be possible if 'alternative technologies' are available to assist in using resources in a more sustainable way (Hargadon, 2010). For this reason, it is important that sustainability innovations are introduced (Meelen & Farla, 2013); these are novel products and services that are environmentally and/or socially beneficial and that are focused on a sustainability goal (F. Bengtsson & Agerfalk, 2011; Schaltegger & Wagner, 2011). Sustainability innovations comprise eco-innovations, green innovations, clean technologies and green technologies.

Some of these sustainability innovations are radical in nature, as they are characterized by new markets and are disruptive to both manufacturers and consumers (J. Hall & Vredenburg, 2003; Markard & Truffer, 2006; Schaltegger & Wagner, 2011). Radical innovations often require special skills, infrastructure and institutional changes, including organizational changes, new regulations, and changes in values. In addition, short-term costs are often high as the new technologies have not yet obtained any learning effects and economies of scale (Kemp, 1994). These disadvantages also hold for radical sustainability innovations (Schaltegger & Wagner, 2011); however, radical sustainability innovations have even more obstacles to face.

First, to combat climate change, painful changes in consumer behaviour are necessary, and sustainability technologies compete with 'regular, painless' technological solutions (Hargadon, 2010). Second, the implementation of sustainability technologies is often decentralized and systemic in nature (Hargadon, 2010). Therefore, society-wide changes are necessary for the successful commercialization of innovative sustainability technologies (Geels, 2002, 2005; Kemp, Schot, & Hoogma, 1998). Third, many sustainability innovations have to compete with locked-in socio-technical systems such as the fossil fuel energy system. These locked-in systems are characterized by abundant financial resources as well as long learning trajectories which have led to low technology costs, economies of scale and an optimal alignment with institutional arrangements (Meelen & Farla, 2013; Unruh, 2000). Fourth, the benefit of the sustainability innovation is a collective good– a cleaner environment. The higher costs of sustainability innovations are borne by firms and/or users, whereas the benefits are reaped by society as a whole (Geels, 2011; Geels, Hekkert, & Jacobsson, 2008). As a result of this collective good aspect, the role of the government becomes more important, leading to uncertainty about future markets and regulations, thus making firms reluctant to commit to and invest in sustainability technologies (Geels et al., 2008; Jacobsson & Bergek, 2011a; Knight, Pfeiffer, & Scott, 2015).

The wide-spread adoption of radical sustainability technologies requires system-wide socio-institutional transformations (Caniëls & Romijn, 2008). Radical sustainability technologies cannot develop into a large market without fundamental economic and socio-cultural changes (Van Den Bergh et al., 2011). Systemic changes are necessary, including societal changes in markets, user practices, policy and governing institutions. Changes in economic frame conditions, such as taxes and the regulatory framework, are necessary; however, they are likely to lead to power struggles, as incumbent actors with vested interests will try to defy these changes (Geels, 2011).

Radical sustainability innovations can only emerge and break-through if they are supported by a community of actors that are capable of developing the innovation, bringing it to the market and creating legitimacy for the sustainability innovation. Such a supportive community has been labelled the innovation ecosystem or innovation system (Adner, 2006; Adner & Kapoor, 2010; Bergek, Hekkert, & Jacobsson, 2008; Hekkert & Negro, 2009a; Jacobsson & Bergek, 2011a; Suurs, Hekkert, & Smits, 2009a). An innovation ecosystem does not only consist of entrepreneurs or firms; many different actor groups can be part of an innovation ecosystem, including firms, research institutes, policymakers, governmental agencies, consumer groups, branch organizations, social movements and financial institutions (Farla, Markard, Raven, & Coenen, 2012). In fact, all actors involved horizontally and vertically along the value chain of the innovation are part of the innovation ecosystem. When radical sustainability innovations emerge, the innovation ecosystem is often underdeveloped, and tends to consist of very few actors. Over time, as the innovation further develops, the innovation ecosystem also grows and develops. From the theory on innovation ecosystems[1], we know that the size and functioning of the innovation ecosystem is crucial for determining the success of radical innovations (Van de Ven, 1993; Van de Ven, Sapienza, & Villanueva, 2008). Therefore, it is important that an innovation ecosystem is created if the development and dissemination of radical sustainability innovations are to be successful.

1.1.1. The role of entrepreneurs in sustainability transitions

The emerging field of 'transition studies' aims to "explain the co-dynamics of technologies, institutions, social and economic sub-systems and conditions in functional domains like energy, water, food, housing, etc." (van den Bergh et al., 2011, p. 8). The transition literature usually adopts the viewpoint of policymakers, who can assist in reducing obstacles to sustainability innovations by influencing the other system actors with incentives, regulations and education. However, the driving force behind sustainability transitions is often formed by entrepreneurs (J. Hall, Daneke, & Lenox, 2010; Vogel & Fischler-Strasak, 2014). An entrepreneur is someone who discovers, evaluates and exploits opportunities

[1] The term innovation system can be used interchangeably with the term innovation ecosystem (Oh et al., 2014).

to create future goods and services (Shane & Venkataraman, 2000). Entrepreneurs are not only actors who set up new start-ups, but can also be managers within companies, the so-called intrapreneurs (Cooper, 1985; Menzel, Aaltio, & Ulijn, 2007). The broader definition, i.e. including intrapreneurs, will be used in this thesis.

Entrepreneurs are essential to the innovation ecosystem because of their role of turning ideas into products and taking advantage of market opportunities (Hekkert et al., 2007). They invent and diffuse goods and/or services, which stimulate and facilitate more sustainable consumption and behaviour (J. Hall et al., 2010; Hockerts & Wüstenhagen, 2010). Without their ideas, innovations and entrepreneurial activities, systemic change would stagnate (Jacobsson & Bergek, 2011a).

To be successful, however, entrepreneurial activities aimed at sustainable development also need to focus on influencing market conditions, striving both for changes in regulations and for societal change (Schaltegger & Wagner, 2011). Therefore, in addition to developing and optimizing their technological innovation, entrepreneurs engage in 'proactive entrepreneurial action' by altering or creating institutions (such as norms, property rights and legislation) that support sustainable development (Pacheco, Dean, & Payne, 2010). However, little research has been conducted on how entrepreneurs create new markets and institutions that stimulate the transition towards a more sustainable society (J. Hall et al., 2010).

1.1.2. The need for a new management paradigm

To realize the society-wide changes required for systemic change, entrepreneurs need to collaborate – both with each other and with other system actors (Bergek, Jacobsson, & Sandén, 2008b; Musiolik, Markard, & Hekkert, 2012; Nill & Kemp, 2009; Schot & Geels, 2008). By joining forces within the system and by enhancing collaboration between actors, the obstacles described above can be overcome (Davenport, Leibold, & Voelpel, 2007). This calls for a new strategic management approach, since conventional strategic management literature suggests that the innovative firm isolates itself from competitors, to profit longer from first-mover advantages. Davenport et al. (2007) suggest that rather than competing with other firms, companies should cluster together in networks with other companies who develop similar technologies and compete with other networks of competing technologies.

In order to develop a sound management approach for entrepreneurs who want to develop and commercialize a radically new sustainability technology, a holistic view needs to be taken of the innovation ecosystem in which the entrepreneur operates. As mentioned above, in order to increase market success, entrepreneurs should not only focus on developing their own product, but also on building, together with other actors, the system around it, which provides them with necessary factors such as research grants, market development and favourable institutional arrangements (Van de Ven, 1993). Thus, entrepreneurs can shape the environment in which their sustainability innovation is to be developed and launched.

1.1.3. Gap in the transition literature

The transition literature gives valuable insights into the processes of sustainability transitions and the dynamics of actor groups shaping their environment in favour of their sustainability innovation. The technological innovation systems (TIS) literature, which is part of the transition literature, explores the dynamic processes that are necessary to build a technological innovation system. This is the socio-technical system consisting of actors, rules, resources and technologies that contributes to the development and dissemination of a specific technology. The TIS approach has been empirically proven to be a valid framework for analysing processes of technological change (Hekkert & Negro, 2009b). Although the TIS framework is typically used as a basis for policy recommendations (Jacobsson & Bergek, 2011b), it has the potential to connect the micro-level theory of firm behaviour with system dynamics and thus to generate "potentially important insights on the level of individual actors' strategies and behaviour, including networking behaviour and impact." (Coenen and Lopez, 2010, p.1156) Using such a systemic perspective can help system actors influence and support the necessary processes that propel the innovation to market success (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Farla et al., 2012; Hekkert & Negro, 2009b; Hekkert et al., 2007). The fact that entrepreneurs play a role in achieving systemic change is acknowledged in the transition literature; however, it is not yet fully understood how entrepreneurs can pro-actively influence the macro-environment in which they operate.

There is a need to develop practical tools and instruments for entrepreneurs who engage in building a favorable innovation ecosystem around their technology. "So far, recommendations have been provided on a strategic level rather than instrumental. An important improvement would be to develop a set of tools and instruments that would help practitioners active on an operational level to get involved in innovation system building." (Suurs, Hekkert, & Smits, 2009b, p.9652) This is in line with the findings of Davenport et al. (2007), who state that "[…] the new knowledge-networked innovation economy requires a totally different strategic management mindset, approach and toolbox" (Davenport et al., 2007, p.8). Hence, strategic management approaches and strategic management tools need to be developed to facilitate entrepreneurs in developing sustainability innovations and building the innovation ecosystem.

1.2. Aim of the thesis and research questions

The aim of this thesis is to develop a set of systemic strategy frameworks for system-building entrepreneurship. This is not only useful for a better theoretical understanding of collective action in emerging innovation ecosystems but also as guidance to entrepreneurs in building a supportive innovation ecosystem for their radical sustainability technologies. To this end, two literature strands will be combined. Sustainability transition research, which is generally aimed at the macro or meso level and used for policy making, will be linked with insights from strategic management literature, in which entrepreneurs traditionally focus on their own business and view the external environment as a given fact. Subsequently, empirical cases will be analyzed to explore the strategies and best practices of system-building entrepreneurs, to learn from their actions and to provide guidance. The empirical findings are linked to the two literature strands. First, the focus will be on the processes and important activities for system building, and following this the concept of collective system building will be developed. Then, it will be investigated how networks for collective system building can be managed effectively, and how system-building entrepreneurs coordinate their activities. Last, it is examined how to enable the collaboration of system-building entrepreneurs, who are sometimes competitors. Throughout the thesis, several gaps in the transition literature will be addressed, using insights from selected strategic management fields.

1.2.1. Strategic collective system-building

Much progress has been made in the field of technological innovation systems studies to provide meso-level frameworks for the analysis of system dynamics and system functions, which can be used by e.g. policymakers to understand and improve system performance. Yet, there is still a need to better understand the micro-level foundation of innovation systems (Markard & Truffer, 2008a). Markard and Truffer (2008) suggest closing this knowledge gap by linking the micro level to the macro level by systematically analyzing strategic decisions of innovative actors as well as the contribution to system performance by these actors. Musiolik and Markard (2011) draw a link from innovation system literature to strategic management literature by elaborating on the importance of strategic action and cooperation in technological innovation systems. As the conceptual starting point, they use the TIS framework, and they state that TIS key processes do not simply emerge but are deliberately generated by actors in the TIS (Musiolik & Markard, 2011). In a following step, Musiolik et al. (2012) studied the micro-level dynamics of innovation systems by analyzing the interplay between firm, network and system level processes. They looked into system-building processes that were initiated by actors in the TIS. System building is defined as "the deliberate creation or modification of broader institutional or organizational structures (system resources) in a technological innovation system carried out by innovating actors" (Musiolik et al., 2012, p. 4). This includes the creation and coordination of value chains as well as the more general infrastructure endowments supportive of the new technology. Innovating actors can identify deficits in technological innovation systems and eliminate these by building supportive system structures, such as education programs or technical norms (Musiolik et al., 2012).

Literature gaps that still remain in their approach are (1) the incorporation of strategic decision making at the firm level into the development process of a TIS, (2) greater insight into the obstacles to collective action, and (3) the analysis of how system builders direct and guide the development of a TIS (Musiolik et al., 2012, p. 15) To increase our understanding of the system-building processes and activities that entrepreneurs can strategically undertake, two steps were taken.

First, it was explored if the TIS framework can also be used by entrepreneurs who want to implement sustainability technologies in the market. Therefore, it was examined whether the TIS framework is in line with entrepreneurs' points of view, which led to the following first research question:

1

Research question 1: To what extent does the TIS framework match the entrepreneurs' perceptions regarding important system-building processes?

The second step was to determine what activities entrepreneurs undertake to build an innovation ecosystem, in order to provide a strategic management tool for system-building entrepreneurs. This led to the second research question:

Research question 2: What system-building activities can entrepreneurs undertake to create a favorable environment for their technological innovation, and how can these activities be combined into a practical strategy framework that can be used for strategic collective system building?

1.2.2. Management of collective system-building networks

Collective system-building networks are inter-organizational networks, composed of firms, government actors and research institutions, which collaborate to achieve a common goal that they could not have achieved individually. They do so in different constellations of actors, which are usually key actors in the innovation system. The aim of these system-building networks is to build a supportive innovation ecosystem around an innovative technology.

So far, little is known about how to manage these system-building networks effectively. Farla et al (2012) suggest addressing how actors collaborate and coordinate their actions when 'making transitions'. They state that further research is needed into the coordination between actors in the development and implementation of their strategies (Farla et al., 2012) .

To better understand how these goal-directed networks can efficiently be managed, insights from the strategic network literature were used. The literature on strategic networks in emerging business fields discusses the same phenomenon (system building) from a different perspective. Actors in emerging business networks are universities, research centers, research units of major corporations and small but innovative science and technology-driven firms (Möller, 2010), i.e. these actors are comparable to the actors in technological innovation systems. Actors linked in complex inter-organizational networks create and commercialize new business fields (Möller & Svahn, 2009), and such business fields consist of several overlapping networks (Möller & Svahn, 2003). These complex collaborative networks of actors are driven by the aim to produce state-of-the art products and services as well as highly efficient production and business processes, which together generate added value for customers (Möller, 2010). The same is true for collective system-building networks. Several overlapping system-building networks are engaged in building a new technological innovation system, which ultimately delivers added value to consumers. To better understand how these networks can be managed, the third research question was formulated as follows:

Research question 3: How are networks for collective system building managed so as to reach their collective system-building objectives?

1.2.3. Collaboration versus competition in collective system building

In collective system building, there is collaboration among the actors along the supply chain, including research institutions and government actors as well as among horizontal actors. Firms collaborate with their direct competitors, which involves not only benefits but also many risks. This triggered the question how firms cope with the dilemma of collaborating in system building with their competitors.

Several authors stated a gap in the transition literature with regard to this question. Coenen (2010) suggests further research into micro-level theories, so as to create an integrated framework to analyze barriers and drivers for innovative companies who operate with the two-fold rationale of competitiveness and sustainability. Moreover, Farla et al. (2012) state that it is "[…] promising to address the issue of collective action, both in terms of how actors collaborate and coordinate their actions in 'making transitions' as well as the role of competition and conflicts therein" (p.6). In addition, Musiolik et al. (2012) suggest shedding more light on the obstacles to collective action (such as free-riding).

To fill this gap in the transition literature, insights from the coopetition literature were used. Coopetition can be either narrowly defined as the dyadic relationship between two rival firms, or broadly defined as the relationship between multi-firm alliances who simultaneously cooperate and compete with each other (M. Bengtsson & Kock, 2014; Wilhelm, 2011). Adopting the broad definition of coopetition, scholars have analyzed coopetition in the context of dynamic inter-firm relationships in business networks, value nets, supply chains, clusters, and value-adding networks, which include suppliers, customers, competitors and complementors (Bouncken & Kraus, 2013; Fernandez, Le Roy, & Gnyawali, 2014; Pathak, Wu, & Johnston, 2014; Tidström, 2013; Walley, 2007). Especially in knowledge-intensive, dynamic and complex fields such as high-tech industries, and particularly for technological innovations which change existing technologies, it is important that actors along the value chain collaborate, even with their direct competitors (Bouncken & Kraus, 2013; Gnyawali & Park, 2009; Park, Srivastava, & Gnyawali, 2014; Ritala & Hurmelinna-Laukkanen, 2009; Ritala & Sainio, 2014).

Even though collective system building originates from the transition literature, some coopetition scholars describe similar aspects in firms setting up organized systems through network structures: such firms cooperate through strategic networks with other system actors to engage in collective activities with the aim of mutual gain (M. Bengtsson & Kock, 2000; Osarenkhoe, 2010; Zineldin, 2004). To achieve their aims, networks need to adopt a collective strategy and coordinate their activities (Osarenkhoe, 2010; Zineldin, 2004). They have a common vision and common goals, to which they align their different interests in order to create opportunities for competitive advantage as a cluster over other clusters (Park et al., 2014; Zineldin, 2004). Firms combine complementary resources in developing new technologies and develop and access network-based resources (Gnyawali & Park, 2009; Liu, 2013). Collaborating actors share knowledge and resources to achieve higher innovative performance and to shape the institutional environment in favor of their own technology (Ritala & Hurmelinna-Laukkanen, 2009). With combined forces, such actors can remove external obstacles and neutralize threats (Oh, Phillips, Park, & Lee, 2014). Firms collaborate to set standards and to create interoperable solutions, new business models and new markets; moreover, they educate consumers about the benefits, functions and usage of their innovations (Bouncken & Kraus, 2013; Ritala, 2012; Ritala & Sainio, 2014). To sum up, many of the aspects of system building as described in the transition literature are also mentioned in the coopetition literature. Therefore, we have used this literature stream to fill the aforementioned gap in the transition literature, and to answer the following question:

Research question 4: What strategies do actors in networks employ to minimize the risks and increase the benefits from collaboration for system-building?

1.3. Empirical case: The Dutch smart grid sector

As empirical case for this study, the Dutch smart grid sector was chosen, as it is an emerging innovation ecosystem of a radical sustainability technology. A smart grid is an electricity network combined with an ICT network, which is adapted to the introduction of renewable energy sources (Interreg IVB, 2011). Essentially, smart grids are not one technology, but a complex set of intertwined technologies. For example, a smart device, such as a smart washing machine, is automatically switched on by specially designed software when solar panels produce a great deal of electricity, thus preventing the grid from being supplied with too much energy. Although most of the technologies of which a smart grid system is composed are incremental in nature, the smart grid itself, as a combination of technological and service innovations, can be considered a radical innovation, as the introduction of this systemic innovation will disrupt existing business fields. Due to the complexity and interdependency of this new technology, actors know that they need to collaborate. This makes the smart grid sector a relevant case in the context of collective system building.

In the Netherlands, both small start-ups and incumbent energy companies that are trying to diversify their business are working hard to develop and implement smart grid technology. Actors are prone to collaborate and they form various networks with different constellations of actors. These networks have set up pilot projects, for example to test full-scale smart grid concepts in practice or to work on the standardization or the acceleration of smart grid development and implementation (Kema, 2012; Laan, 2012; NL Agency, 2012a, 2012b; SEC, 2012). Moreover, the Dutch government supports the development of this field and launches projects and programs aimed at accelerating the collaboration of companies that are active in the smart grid field. In addition, there are numerous other national and international networks, pilot projects and collaborative projects, with different constellations of public and private actors (Hertzog, 2013; Hübner & Prüggler, 2011). Furthermore, smart grid actors face many obstacles of radical sustainability innovations, such as high uncertainty about technological developments, inertia from the incumbent system, and the requirement of society-wide changes (Verbong, Beemsterboer, & Sengers, 2013). These factors make the Dutch smart grid field a suitable case for analyzing the processes of and strategies for collective system building.

For this research, two data collection rounds were conducted. In the first round, data were collected to answer the first two research questions. Key actors of the Dutch smart grid sector were interviewed, and the findings were validated with an additional survey. Based on the outcome of the first interview round, two further research questions were formulated, and a second round of data collection was conducted, in which the most important networks were identified and key actors of these networks were interviewed. With the exception of one actor, who was interviewed in both rounds, there was no overlap in the interviewees in the two interview rounds.

1.4. Outline of the thesis

Chapter 2 introduces the Technological Innovation Systems framework as the starting point for this research. The framework is explained, and its applicability from an entrepreneurs' point of view is tested. It is established that the framework matches the entrepreneur's perspective, although slight adjustments are suggested from the entrepreneurs' point of view. Chapter 3 then zooms in on the activities entrepreneurs undertake to build an innovation ecosystem. Subsequently, the TIS literature is linked to the strategic management literature on business ecosystems and innovation ecosystems. Based on this, the concept of collective system building is introduced and empirically tested, leading to the introduction of a strategy framework for collective system building. One of the outcomes of this research is that collective system building takes place in networks, and coordination is needed. Therefore, Chapter 4 focuses on the management of strategic system-building networks in emerging business fields. It investigates how system-building networks are managed effectively, and how the efforts of system-building actors can be coordinated. Chapter 5 then deals with the dilemma of competition versus collaboration in innovation ecosystem building. System-building entrepreneurs need to collaborate with actors along the value chain, including their direct competitors. With insights from the coopetition literature, the benefits, risks and enablers of such collaboration are identified, and mechanisms are suggested for minimizing the risks inherent to collaborating with competitors for system building. Chapter 6 concludes the thesis by reflecting on the overall merits of this study.

CHAPTER 2

Combining the technological innovation systems framework with the entrepreneurs' perspective on innovation

This chapter is based on: Planko, J., Cramer, J., Hekkert, M. P., & Chappin, M. M. H.. (2017). Combining the technological innovation systems framework with the entrepreneurs' perspective on innovation. Technology Analysis & Strategic Management, 29(6), 614-625.

Abstract

For their technological sustainability innovations to become successful, entrepreneurs can strategically shape the technological field in which they are involved. The technological innovation systems (TIS) literature has generated valuable insights into the processes which need to be stimulated for successful development and implementation of innovative sustainability technology. To explore the applicability of the TIS framework from the perspective of entrepreneurs, we conducted a case study in the Dutch smart grids sector. We found that the TIS framework generally matches the perspectives of entrepreneurs. For its use by entrepreneurs, we suggest a slight adaptation of this framework. The process 'Market formation' needs to be divided into processes that are driven by the government and processes that are driven by entrepreneurs. There should be greater emphasis on collaborative marketing, on changing user behaviour and preferences, and on the development of fair and feasible business models.

2.1. Introduction

Societies need to change their current patterns of energy and resource use if they want to make the transition towards more sustainable production and consumption pathways to mitigate climate change (Grin et al., 2010). Such a transformation can be accelerated by sustainability technologies (Hargadon, 2010), i.e. technologies which enable a more efficient use of resources, less stress on the environment and even cleaning of the environment (Weaver, Jansen, Grootveld, Spiegel, & Vergragt, 2000). Many ideas for innovative sustainability technologies have already been generated; however, these often fail to enter the market (Caniëls & Romijn, 2008). One major obstacle is that competing and established unsustainable technologies are usually supported by the normative and regulatory environment within which they have evolved (Geels et al., 2008). In other words, the success of any introduction of new technologies is not only determined by the technology itself, but also by the social system that develops and implements the new technology (Foxon & Pearson, 2008).

To overcome these barriers to technology adoption, Musiolik et al. (2012) suggest that innovative actors have to develop 'supportive structures' which legitimize and stabilize the emerging technology. The driving forces of those innovative actors are often entrepreneurs who try to implement sustainability technologies in society, and thus stimulate the transition towards sustainable development (J. Hall et al., 2010). Entrepreneurs do not need to wait for such a 'supportive system' to emerge, as they can actively accelerate its development. They can trigger social changes and optimize research collaborations and product development (Berkhout et al. 2006). In this way, they increase the chances that their innovation will be successfully implemented and will flourish (Van de Ven, 1993). Entrepreneurs can strategically shape the technological field in which they are involved (Garud, Hardy, & Maguire, 2007; Musiolik et al., 2012), and collectively construct a supportive technological system (Caniëls & Romijn, 2008; Musiolik et al., 2012). The literature on technological innovation systems (TIS) has generated valuable insights into the process of building a supportive technological system (Markard & Truffer, 2008b; Musiolik et al., 2012). Numerous scientists have tested the TIS framework from a system perspective (e.g. Hudson, Winskel, and Allen 2011), in order to give strategic advice to policymakers who wish to stimulate the implementation of new technologies (Meelen & Farla, 2013). However, so far the framework has not been empirically tested from the viewpoint of a single group of private actors, such as entrepreneurs. This micro-level perspective is missing in the TIS framework (Markard & Truffer, 2008b), even though it is well-known that entrepreneurs play a central role in innovation and commercialization processes. The aim of this article is to explore the applicability of the TIS framework from the perspective of entrepreneurs, and to answer the question to what extent the TIS framework matches the perceptions of entrepreneurs on important system-building processes and whether it encompasses all the processes that entrepreneurs claim to be relevant. If so, the TIS framework can be used by entrepreneurs for strategically constructing a supportive technological innovation system around their new technology, which can help to increase the chances of a successful implementation of their technology in society (Van de Ven, 1993). In order to empirically explore the applicability of the TIS framework from an entrepreneurial viewpoint, a case study was conducted in the Dutch smart grid field.

2.2. Theoretical background

In this section we explain how we define entrepreneurs, their link to sustainability transitions and the TIS framework we use.

2.2.1. Entrepreneurs as drivers of sustainable development

An entrepreneur is "someone who specializes in taking responsibility for and making judgemental decisions that affect the location, the form, and the use of goods, resources, or institutions" (Hébert and Link 1989, p.39). Entrepreneurs are not only actors who set up new start-ups, but can also be managers within companies (so-called intrapreneurs) (Menzel et al., 2007). It has been acknowledged that it is impossible to understand business landscapes without studying the behaviour of entrepreneurs (Baumol, 1990). Entrepreneurs are often the drivers of change processes in society (Shane & Venkataraman, 2000), and this also applies to the context of sustainable development. Not only are entrepreneurs involved in the transformation of industries towards sustainable development, but they can also be the drivers of sustainability transitions (J. Hall et al., 2010; Vogel & Fischler-Strasak, 2014). They invent and diffuse goods and/or services, which stimulate and enable more sustainable consumption and behaviour (J. Hall et al., 2010). More than only introducing and marketing these products, they also engage in 'proactive entrepreneurial action' by altering or creating institutions (such as norms, property rights and legislation) that support sustainable development (Pacheco et al., 2010). However, little research has been conducted on how entrepreneurs create new markets and institutions which stimulate the transition towards a more sustainable society (J. Hall et al., 2010). We use literature from transition studies to shed more light on these developments.

2.2.2. The technological innovation systems framework

The emerging field of 'transition studies' is concerned with transitions towards sustainability, i.e. fundamental technological, organizational and institutional changes in both production and consumption, which will lead to more sustainable development. Within the transition studies literature, these socio-technological changes are analysed from a systems perspective. Such changes are generally initiated by radically new products, services or business models. The following three approaches clarify how societal transitions take place: the multi-level perspective, the transition management approach and the innovation systems approach. In these approaches, there is some overlap in the processes they highlight for building a technological regime. However, the approaches differ in the analytical levels and the perspective they take. To study the build-up of an innovation system by entrepreneurial actors, the innovation systems approach is the most suitable one, as it is used for analysing and improving the conditions for the development of new technologies (Farla et al., 2012). Turning an invention into a marketable product or service involves a number of actors. The innovation systems approach considers the 'business ecosystem' of an innovating firm and analyses the flow of information and technology as well as the interactions and relationships between the actors involved, such as enterprises, research institutions and the government (Edquist, 2004). Over the years, different innovation systems approaches have emerged that were based on the different boundaries of the system: the national, regional, sectoral and technological innovation systems. As we investigate how entrepreneurs can implement a technological sustainability innovation, the technological innovation systems approach is the most suitable of these for our study.

The technological innovation systems (TIS) approach deals with the formative phase of building a system for new technologies. A technological innovation system consists of a network of actors involved in launching a new technology. It contains all the components that influence the innovation process for a newly emerging technology, rather than only the components that are exclusively dedicated to that particular technology. A TIS can be analysed in terms of its structural components and in terms of its functions. Structural components are actors, networks and institutions (Bergek, Jacobsson, Carlsson, et al., 2008). 'Functions of innovation systems' are the key processes that are important in building an innovation system. They are the dynamic processes between the structural components (actors, networks, institutions) of the system. Each key process contributes to building a favourable 'ecosystem' around the new sustainability technology. More importantly, the interaction between system functions accelerates the emergence and growth of an innovation system in virtuous circles, thus increasing the chance of market success (Musiolik and Markard 2011; Jacobsson and Bergek 2011).

The TIS framework is a suitable approach for exploring how entrepreneurs can stimulate sustainability transition, for three reasons: First, the TIS framework is concerned with emerging environmental technologies (Jacobsson & Bergek, 2011a). It has been developed by scientists and tested empirically with many case studies in the renewable energy sector (Bergek, Jacobsson, Carlsson, et al., 2008). Second, the analysis can be conducted during the formative phase (as opposed to ex-post), which is crucial in the context of emerging technologies (Hekkert et al., 2007). Finally, the approach has been empirically proven to be a valid framework to analyse processes of technological change (Hekkert & Negro, 2009b). Although the TIS framework is typically used as a basis for policy recommendations (Jacobsson & Bergek, 2011a), Coenen and Lopez state that it has the potential to connect the micro-level theory of firm behaviour with system dynamics and thus to generate "potentially important insights on the level of individual actors' strategies and behaviour, including networking behaviour and impact." (Coenen and Lopez, 2010, p.1156)

Based on these arguments we expect that the TIS framework can also be used by entrepreneurs who want to implement sustainability technologies in the market (and thus stimulate sustainability transitions). To test this assertion, we examine whether the TIS framework is in line with the viewpoints of entrepreneurs.

2.2.3. Key processes of the TIS framework

A number of key processes have been identified that are essential for the proper functioning of a TIS (Bergek, Jacobsson, Carlsson, et al., 2008). Several variations of the TIS framework have been developed by different authors, ranging from models that differentiate seven key processes to models that identify nine key processes. However, in essence these models have all been based on the same set of seven dynamic processes, which are described below.

Key process 1: **Entrepreneurial Experimentation.** Entrepreneurs are key in the TIS as they turn the potential of new ideas into business opportunities. These entrepreneurs can either be new start-ups or incumbent firms (Hekkert et al., 2007), including large, established firms diversifying into the new technology (Bergek et al. 2008). By testing new technologies, applications and markets, social learning processes are triggered and information can be gathered about the way in which the technology functions under different circumstances as well as about the reactions of consumers, government, competitors and suppliers (Hekkert & Negro, 2009b).

Key process 2: **Knowledge development.** Learning activities such as research and development and learning in a practical context are fundamental to any innovation process. Knowledge cannot only be gained about the new technology, but also about markets, networks and users (Bergek, Jacobsson, Carlsson, et al., 2008; Hekkert et al., 2007).

Key process 3: **Knowledge diffusion.** Conferences, workshops and alliances stimulate the exchange of knowledge. This is important not only for the exchange of R&D-specific knowledge, but also for the exchange of knowledge between government, companies and the market (Hekkert & Negro, 2009b).

Key process 4: **Guidance of the search.** This key process summarizes all the activities and events that convince actors to enter the TIS or to further invest in it. A positive expectation about the development of the technology is the main aspect here. This expectation may be based on changes in customer attitudes, input prices, regulations and policy (Bergek, Jacobsson, Carlsson, et al., 2008; Hekkert et al., 2007).

Key process 5: **Market formation.** Since new sustainability technologies generally have difficulty competing with incumbent technologies, the creation of temporarily protected niche markets is necessary for the technology to further develop and to gain market share. Such niches can be created with favourable tax regimes, guaranteed consumption quotas, environmental standards and by government procurement policies (Bergek, Jacobsson, Carlsson, et al., 2008; Hekkert & Negro, 2009b).

Key process 6: **Resource mobilization.** Sufficient resources are necessary for the emerging TIS to function properly. Financial and human resources need to be mobilized to enable the building of the innovation system; and complementary assets need to be developed, such as complementary products, services and network infrastructure (Bergek, Jacobsson, Carlsson, et al., 2008; Hekkert et al., 2007).

Key process 7: **Creation of legitimacy.** Sustainability innovations often struggle with overcoming innovation inertia caused by the incumbent regime which is reluctant to change.

Therefore, advocacy coalitions need to lobby for resources and favourable tax regimes and need to put the new technology on the political agenda (Hekkert et al., 2007).

2.3. Methodology

In order to explore the applicability of the TIS-framework for entrepreneurs, a single embedded case study was carried out (Eisenhardt, 1989; Yin, 2009) that considered the dynamic processes of system-building in the innovation system of the Dutch smart grid sector. The units of analysis were the key processes of the TIS framework.

2.3.1. Empirical setting

The Dutch smart grid case was chosen because it is an emerging technological system with a growing network of public and private actors. A smart grid is defined as an electricity network in combination with an ICT network, which is adapted to the introduction of renewable energy sources (Interreg IVB, 2011). A smart grid is a complex set of technologies, and we will use the term 'the smart grid technology' for the overall set of technologies. Important actors include businesses in engineering, grid operation, consultancy, ICT and energy production (NL Agency, 2012c).

The development of a smart energy innovation system in the Netherlands is well under way. The combination of an emerging sustainable technology and its systemic nature makes the Dutch smart grid an interesting and relevant case to study the applicability of the TIS framework for entrepreneurs.

2.3.2. Data collection

Data were collected between December 2012 and March 2013 by means of semi-structured interviews. During the interviews, a three-step approach was taken. First, the interviewees were asked an open question about successful commercialization of their innovative technology, to find out if they spontaneously mentioned any of the TIS key processes as a required process. In a second step, the TIS framework was briefly presented and explained to the entrepreneurs. They were asked to state whether these processes were or should be in place in the Dutch smart grid field, and to what extent they regarded these processes as important. This step was included to allow a systematic comparison of the answers for all key processes. Finally, entrepreneurs were asked if, from an entrepreneurial viewpoint, any process was missing.

In total fourteen interviews were conducted. For the selection, a list was compiled with 25 key actors of the Dutch smart grid sector based on information provided by one of the major experts in this field. The list was triangulated with the report 'Who is who guide – players in the Dutch smart-grid sector' (NL Agency, 2012c). All 25 people on this list were requested to participate. Ten immediately agreed to be interviewed. These ten people worked for several companies of the smart grids value chain – such as energy companies, IT companies, suppliers of input materials and consultancies – and represented the broad field of the smart grids sector. During the interviews, four additional actors were frequently mentioned as significant players in this field. These four were also on the list of the 25 key actors mentioned above, but they had not yet replied to our initial request. These four individuals were approached again and were interviewed. During the interview process, a saturation point became apparent: at a certain moment, the interviews no longer revealed any new insights.

All interview partners held senior positions such as senior director, executive partner, business developer, division manager smart grids or senior project development manager. This enabled them to reflect upon the TIS framework. The interview partners were all entrepreneurs in the emerging technological innovation system, according to the definition of entrepreneurs given by Bergek et al. (2008) and Hekkert et al. (2007). Of the fourteen interview partners, two were entrepreneurs in the narrow sense, and twelve were entrepreneurs in the broad definition of the term.

2.3.3. Data analysis

All interviews were transcribed and analysed using ATLAS.ti software. The analysis process entailed two steps. First, we coded the data, predominantly according to the TIS processes derived from the literature review. To avoid ending up with only very general codes for the key processes, we also acknowledged the different elements that are part of the key processes as described in the theoretical framework. If it appeared that a text fragment could not be linked back to one of the processes of the TIS framework, we used an open coding procedure. This enabled us to identify any missing processes. The second step was the comparison of these empirical findings with the TIS framework.

2.4. Findings

This section describes the results of the interviews per TIS key process. The abbreviations [P1] to [P14] after a quotation refer to the interview partner.

The analysis of the answers to the open question *'What is important to commercialize their innovative technology?'* made clear that some of the entrepreneurs interviewed knew of all the key processes to build a technological innovation system. Other interviewees mentioned only some of the TIS key processes spontaneously. However, each key process was mentioned by one or more interviewees. The results of the systematic discussion of the TIS key processes with the interviewees are described below.

Key process 1: Entrepreneurial experimentation

All interviewees stated that 'Key process 1: entrepreneurial experimentation' is a crucial process and is evidently present. Another element mentioned as essential for the success of the smart grid technology was the development of commercial products, user-friendly products or services that have added value for the consumer. Here, several interviewees used the analogy of the launching of the iPad to illustrate that the product itself should be so tempting that it is pulled into the market. Sustainable technologies should not be purchased by users for ideological reasons or because of subsidy schemes, but because they are just better than their unsustainable substitutes: *"If we really want to change things in this world, we need to make things that people need and want, which basically means these things need to be economically viable. So we need to make sustainable new concepts that are better in every way, so that the product is not only sustainable, more flexible, and cheaper; it simply needs to be better."[P1]*

Key process 2: Knowledge development

Interviewees also stated they perceived 'Key process 2: knowledge development' as a crucial process in building an innovation system. Moreover, they highlighted the importance of knowledge of user behaviour and user preferences: entrepreneurs need to gather more of such knowledge, so that they can improve the implementation in the technological development process. A better understanding of societal changes is necessary to comprehend which changes are acceptable to users, and how these changes can be initiated. Some respondents stated that too much research focuses on the technical aspects and that more research is needed to understand the social and societal aspects of the transition process.

Key process 3: Knowledge diffusion

The interviewees mentioned that it is not enough to only generate knowledge. They also perceived knowledge diffusion as a prominent and very important process: *"We want to have an impact on society or on the economy. We have the knowledge, but we won't have any impact if we don't share it with other people."[P4]* This sharing occurs by means of demonstration projects, workshops, conferences and publications. Knowledge diffusion is often carried out by actor networks: *"Yes, the [network name] does quite a lot of that. We try to be present at most relevant conferences, and regularly organize workshops both formally and informally." [P6]*

Key processes 1-3: interrelatedness

Moreover, it became apparent that from the viewpoint of entrepreneurs, Key processes 1-3 are highly interrelated and interdependent when building a system as complex as a new decentralized energy system. Especially in open innovation processes, knowledge development, knowledge sharing and testing are interwoven, and therefore the interviewees usually do not make clear distinctions between these processes: *"Most people try to combine this with demonstration-type projects, so they combine entrepreneurial activities with their knowledge-development activities." [P6] "If we combine certain things, this may create future possibilities. So, together with other companies, let's test whether this will fit in the new system, or will suddenly even open up new possibilities." [P5]*

Key process 4: Guidance of the search

In order to stimulate more financial investments in the development of the new technology and its infrastructure, the entrepreneurs interviewed deemed it necessary that the sector has a common vision: *"It is necessary to know in which direction the market is moving" [P6].* Clear government guidelines will stimulate investment. Similarly, economic incentives may motivate companies and financial investors: *"Governments do not really provide any perspective of where we´re going and in which areas we should invest. […] It´s difficult for companies to really invest." [P1] "A clear economic need or a government guideline is very important for that step." [P5]*

Key process 5: Market formation

Entrepreneurs agreed that market formation was important. The data showed that from an entrepreneurial point of view, it is important to distinguish between processes that are driven by government actors and processes that are driven by entrepreneurs.

Key process 5a: Market formation by the government

The first process is driven by the government. The government already supports the development of smart grids in a limited way: it provides subsidies and some limited tax incentives. However, the interviewees stated that the government should accelerate the development of the innovation system by changing regulations, rather than by providing subsidies, favourable tax regimes or procurement policies: *"You need the government as a partner for regulations but not for tax regimes, subsidies, loans or such like. The market should do that. But the government could help with regulation." [P7]*

Current regulations, however, do not stimulate but actually block the implementation of new technologies: *"At the moment it is the other way around. They may not do it on purpose, but the public authorities still block the way in which the market can develop." [P14] "It is not about technology, but rather about the regulatory framework. That is the most important constraint." [P13]* The entrepreneurs stated that the government should allow pricing mechanisms (e.g. real time pricing) and new business models which enable the adoption of the technology, and which would allow companies to reap financial benefits from applying smart grid technology, and which would stimulate changes in user behavior. Several interviewees mentioned the generation of fair and feasible business models as important for system building. The market should be designed in such a way that economic incentives are provided to the people who have to make the investments: *"So the first thing that is necessary is that there is at least some economic value. And secondly, that the economic value goes to the people who make the decisions and who make the investment. And it is especially the second thing that is so terribly difficult." [P5]* Cooperation is necessary between private actors (who have the necessary knowledge) and public actors (who have regulative power) to design and facilitate feasible business models, so that the market forces can come into play.

Key process 5b: Market formation by entrepreneurs

The second process is mainly driven by entrepreneurs. All interviewees agreed that developing the market, raising user awareness and creating demand were essential processes in the commercialization of the technology. Still, most interviewees were not yet active in this process, and some only to a limited extent. User awareness was mainly generated through pilot projects, involving a limited number of users. So far, no large-scale marketing efforts such as nationwide campaigns to raise awareness for the new energy system have been conducted or planned: *"We need to incentivize the customers because if they don't want to participate in this new energy system, it is not going to happen." [P11]*

To this point, user awareness and knowledge of smart grid technology have been too low to generate a demand-pull. End users need to be motivated to change their behaviour: *"The biggest problem is not so much technical, but rather how to get the customers and the end users willing and active in this new energy system." [P11]* Interviewees suggested that demand-pull needed to be created, but acknowledged that so far the sector did not know how to achieve this: *"So it is not about forcing, it is about seducing these customers. But as a sector we have no idea how to do this." [P11]*

To raise user awareness and change user preferences, some interviewees found a collaborative marketing approach with other key actors in the innovation system most effective, as many resources are required to create user awareness and demand at such a large scale: *"This should be done in close interaction with key players in the market." [P14]*

Moreover, some interviewees criticized companies for focusing too much on optimizing the technology, while neglecting the societal part. They advised end users and their preferences to be further integrated into the development process of the technology: *"It is not just about technology. […] The product has to improve people's lives."[P7]* Products and services should be developed keeping in mind the often unaware and inexperienced end user, who has to be willing and able to use them.

Key process 6: Resource mobilization

Entrepreneurs were involved in different forms of resource mobilization. Whereas the mobilization of resources was considered important for system building, some entrepreneurs remarked that resources are necessary for all TIS key processes, and therefore questioned whether Key process 6 was a separate key process.

Key process 7: Creation of legitimacy

Lobbying to create legitimacy and acceptance of the new technology is a common process in the innovation system. Most actors had undertaken lobbying activities both individually as a company and collectively through networks and branch organizations, which resulted in subsidies for the new technology. Lobbying is seen as an essential process for convincing government to change legislation and to invest in or to provide subsidies for the new technology. These activities ultimately help stimulate investment in the new technology by suppliers as well as consumers: *"It helps the market move in the right direction." [P13]*

Missing key processes

After having discussed the TIS key processes with our interviewees, we asked them whether they thought that an important process was missing. Several entrepreneurs stressed that it is not only important to develop and exchange knowledge, but also to orchestrate these activities, as a great deal of overlap was observed: *"People are reinventing the wheel" [P9].* It was suggested that better coordination of the activities related to knowledge building, testing and diffusing would accelerate the optimization and implementation of the technology.

2.5. Discussion and Conclusions

The aim of this research was to explore to what extent the TIS framework is also applicable from an entrepreneurial perspective. The findings show that entrepreneurs intuitively carry out the dynamic system-building processes described by the TIS framework. The TIS framework widely matches the perspectives of entrepreneurs.

The findings further show that entrepreneurs find Key processes 1-3 very important and that these are prevalent in the system, but that from an entrepreneurial point of view they were actually perceived as one key process. This underlines the importance of collective actions, combined resource use and knowledge exchange. From an entrepreneurial point of view it is moreover important to highlight that, for the technology to be successful, commercial products need to be developed. This underlines the need for entrepreneurs not only to optimize the technology, but also to develop economically viable products which are attractive for end users. Furthermore, entrepreneurs stressed the importance of obtaining knowledge about user behaviour and integrating this knowledge into the product development process. Although developing the knowledge of users is mentioned in the TIS theory (Hekkert et al., 2007; Jacobsson & Bergek, 2011a), the integration in the development process has not been described explicitly. In previous empirical studies this topic received less attention due to the characteristics of the technology in focus (Negro, Hekkert, & Smits, 2008).

The findings for 'Key process 4: guidance of the search' are in line with the TIS framework. To a large extent this also applies to 'Key process 5: market formation'. The interviewees acknowledge the importance of the government, which can support market formation by implementing favourable tax regimes, minimal consumption quotas and environmental standards, or by generating demand, e.g. by government procurement policies (Bergek, Jacobsson, Carlsson, et al., 2008; Jacobsson & Bergek, 2011a). In a common effort by private and public actors, fair and feasible business models need to be generated, so that market forces can come into play. The government needs to create a regulatory framework for the new technology, which enables and supports these new business models. From an entrepreneurial point of view, this is perceived as more important for technology implementation than the creation of niche markets and the introduction of tax incentives. This finding is in line with the literature on sustainable entrepreneurship and business models (Bocken, Short, Rana, & Evans, 2014; Boons, Montalvo, Quist, & Wagner, 2013).

In addition, market formation processes can also be carried out by entrepreneurs. Entrepreneurs can raise user awareness and stimulate changes in user behaviour, in order to develop a market for their innovative technology. So far, market creation by entrepreneurs has received little attention in the TIS literature (Bergek, Jacobsson, & Sandén, 2008a). Possibly because in the energy technologies studied before, consumer preferences play a smaller role than in the case of smart grids technology.

Entrepreneurs can join forces and try to stimulate changes in user behaviour and preferences. Most potential users and the general public often need to go through a lengthy process of persuasion before they embrace a new technology that requires a change in behaviour. Entrepreneurs should consider end user behaviour and contemplate changing user preferences in the early phases of product development. These findings are supported by the transition studies literature. To change a technological regime gradual processes are necessary that fundamentally change both society and societal sub-systems (Kemp & Loorbach, 2003). New institutions need to be established and existing ones changed (Voß, Smith, & Grin, 2009). Ultimately, the rules and norms in society determine collective action, such as embracing a new technology (Van de Ven, 1993). Institutional change, such as a change in regulations and user preferences, is an important factor to be considered by system-building entrepreneurs. Changes in user behaviour and preferences require changes in values, attitudes and beliefs that are deeply rooted in society (Kemp & Loorbach, 2003). Furthermore, collaborative marketing efforts are considered more effective than individual efforts. These findings are supported by Van de Ven (1993), whose theory describes collaborative market creation as an essential element for a supportive entrepreneurial infrastructure of a new technology.

While 'Key process 6: resource mobilization' is prevalent in the system, it can be debated whether from an entrepreneurial point of view this should be regarded as a separate key process: entrepreneurs know that they have to mobilize resources for all their activities. However, as a whole the sector can also mobilize resources for system-level activities (Musiolik & Markard, 2010). The findings for 'Key process 7: creation of legitimacy' were also in line with the TIS framework.

Additionally, the analysis revealed that several entrepreneurs were missing one important element that had not yet been explicitly mentioned in the TIS framework: coordination. They stated that coordination at the system level contributes to more efficient resource use and to fewer redundant activities. In the general innovation management literature, collaboration in the value chain has been mentioned as a success factor in launching innovations (Cormican & O'Sullivan, 2004), and the emergence and coordination of specialized goods and service providers is also considered of importance for a well-functioning innovation system (Bergek, Jacobsson, Carlsson, et al., 2008). Recently, Musiolik and Markard stated that the coordination of actors and activities in the value chain is a key process which enhances the overall functioning of the innovation system, which 'has not been mapped yet' (Musiolik & Markard, 2011). However, it may be argued that coordination is not a key process, but that it simply accelerates all other key processes. Moreover, 'Key process 4: guidance of the search' also gives some direction to actors in the system. Yet, several entrepreneurs mentioned coordination as missing, and thus it seems to be an important element in the process of building a technological system from the viewpoint of entrepreneurs. It should be explored further.

To conclude, the TIS framework gives entrepreneurs valuable insight into the processes that are important for the successful development and implementation of their innovative sustainability technology. Based on our findings we suggest a small adaptation of the TIS framework to enhance its applicability by entrepreneurs. We deem it necessary to separate 'Key process 5: Market formation' into processes driven by government actors and processes driven by entrepreneurs. The latter category has as yet been underrepresented – or not explicitly stated – in the TIS literature, which mainly focuses on advice for policymakers and on different types of empirical cases. From an entrepreneurial point of view, there should be greater emphasis on collaborative marketing, on changing user behaviour and preferences, and on the development of fair and feasible business models.

The findings of this research contribute to the field of innovation systems literature by providing a stronger entrepreneurial foundation. So far the innovation system literature has been aimed at scholars and policymakers (Meelen & Farla, 2013). Entrepreneurs are at the centre of cyclical innovation and ultimately stimulate societal changes by collaborating with governmental actors and scientists, and by creating markets (A. J. Berkhout et al., 2006). The TIS framework matches the perspectives of entrepreneurs, and this makes the TIS literature and the broader innovation systems literature interesting to entrepreneurship scholars. The insights from this study can contribute to closing the gap in the entrepreneurship literature on how the processes that drive sustainability transitions unfold when entrepreneurs try to seize business opportunities in new markets (J. Hall et al., 2010).

Our study has some limitations. First, it was based on only one case, namely the smart grids field in the Netherlands, which limits its generalizability. The complexity and interdependency of the smart grid technology increases the need for coordination. Therefore, the applicability of the TIS framework by entrepreneurs should also be tested for a less complex technology.

Second, it may be argued that the results are influenced by use of the broad definition of entrepreneurs, i.e. including intrapreneurs. Despite differences in the organizations of the two distinct types of entrepreneurs (small start-ups vs. larger and incumbent firms), both types of entrepreneurs share the common objective to seize new business opportunities (Bergek, Jacobsson, Carlsson, et al., 2008). Therefore, it is unlikely that the two types have a different perception of the importance of the key processes and, furthermore, no indication for this was given during the interviews.

Finally, we only considered the key processes separately, and we disregarded the dynamics between them. Given the systemic nature of building a technological innovation system, and the cyclicality and importance of feedback loops described in the entrepreneurship literature (e.g. Berkhout 2006) and in the TIS literature (e.g. Bergek et al. 2008), it would be interesting to examine how the emerging processes influence each other. Our exploratory study took place at one moment in time, and it was not possible to observe the development of and dynamics between the key processes over time. The dynamics between emerging key processes from an entrepreneurial point of view constitute an interesting field for future research.

CHAPTER 3

Strategic collective system building to commercialize sustainability innovations

This chapter is based on: Planko, J., Cramer, J. M., Chappin, M. M. H., & Hekkert, M. P. (2016). Strategic collective system building to commercialize sustainability innovations. Journal of Cleaner Production, 112, 2328-2341.

Abstract
The implementation of innovative sustainability technologies often requires far-reaching changes of the macro environment in which the innovating firms operate. Strategic management literature demonstrates that the chances of a successful diffusion and adoption of an innovative technology in society are increased if the firms wanting to commercialize this technology collaborate in networks or industry clusters to build a favourable environment for their technology. However, the strategic management literature does not offer advice on how to strategically create this supportive external environment. We fill this gap with complementary insights from the technological innovation systems literature. We introduce the concept of strategic collective system building; this concept describes processes and activities that networks of actors can strategically engage in to collectively build a favourable environment for their innovative sustainability technology. Furthermore, we develop a strategy framework for collective system building. To underpin our theoretical analysis empirically, we have conducted a case study in the Dutch smart grid field. The resulting strategy framework consists of four key areas: technology development and optimization, market creation, socio-cultural changes and coordination. Each of these key strategic areas is composed of a set of system-building activities.

3.1. Introduction

Society-wide replacement of polluting technologies with alternative sustainability technologies enables consumers to maintain satisfying lifestyles without destroying the planet's ecological capacity for future generations. Therefore, sustainability technologies play an important role in sustainable development (Hargadon, 2010; Jansen, 2003; Nill & Kemp, 2009). Sustainability technologies are technologies which enable more efficient use of resources, less stress on the environment and even cleaning of the environment (Foxon & Pearson, 2008; Weaver et al., 2000). Many new technologies to solve or mitigate sustainability challenges have already been invented. However, their market implementation often fails – even if their performance is superior to incumbent technologies (Caniëls & Romijn, 2008). Actors who come up with radically new sustainability technologies find it difficult to further develop their solution and to launch it on the market, because competing established technologies are widely supported by the socio-technological regime within which they have evolved (Geels, 2002; Kemp et al., 1998). Moreover, the adoption of a new sustainability technology sometimes requires inconvenient changes in consumption patterns, without offering additional functionalities to the consumer (Hargadon, 2010; Jansen, 2003). To overcome these obstacles and to enable a wide diffusion of sustainability technologies, significant socio-cultural, economic and legislative changes are required (Kemp & Loorbach, 2003). The active engagement of a wide range of public and private actors is necessary to achieve these changes (Farla et al., 2012; Van Den Bergh et al., 2011). Among these actors, the driving forces of the transition process are often entrepreneurs and entrepreneurial managers[2] who develop and diffuse sustainability innovations (J. Hall et al., 2010; Teece, 2010). To increase the chances of success of their technological innovation, they can – in collective efforts – try to achieve changes in the macro environment that support the implementation and user acceptance of their technology (Van de Ven, 1993).

Strategic management literature describes the need of innovative actors to collaborate strategically in order to shape their environment. Several authors suggest that firms collaborate in networks or industry clusters in order to compete with alternative technologies. Besides investing in their own development, they need to invest in the development of the business ecosystem in which they operate (Astley, 1984; Iansiti & Levien, 2004; Moore, 1996; Pitelis, 2012; Van de Ven, 1993). If they work together, they can create a favourable environment in which their firm can prosper. However, the strategic management literature does not provide insights into how to strategically build up such a supportive external environment. We attempt to fill this gap with complementary insights from the technological innovation systems literature.

The technological innovation systems (TIS) literature is part of the broader field of transition literature. Whereas the strategic management literature adopts the perspective of the firm,

[2] The narrow definition of the term entrepreneur describes new entrants who have a vision on new business opportunities in new markets (start-ups); the broader definition includes 'entrepreneurial managers', which are employees of incumbent companies who diversify their business strategy to take advantage of new developments (Hekkert et al., 2007).

the transition literature analyses socio-technological change from the system perspective. The transition literature has generated various conceptual frameworks to analyse and stimulate the dynamics of socio-technological transition processes[3], one of which is the technological innovation systems framework (Geels et al., 2008; Hekkert & Negro, 2009b; Hekkert et al., 2007; Jacobsson & Bergek, 2006, 2011b; Markard & Truffer, 2008b; Suurs, Hekkert, & Smits, 2009a). This framework has generated valuable insights into the processes and activities that innovative actors need to undergo and undertake in order to create a favourable environment in which their technology can flourish. This activity has been coined 'system building' (Musiolik et al., 2012). However, the insights from the system-building literature originate mainly from the system perspective and so far specific insights from the firm perspective have been missing. By complementing the TIS literature with insights from the strategic management literature, we have shifted the focus to the firm perspective. We will introduce the term 'collective system building' to describe processes and activities that firms can conduct in networks to collectively create a favourable environment for their innovative sustainability technology.

The objective of this chapter is to combine insights from the strategic management literature and the technological innovation systems literature in order to provide a strategy framework for entrepreneurs and entrepreneurial managers to collectively build up a favourable environment for their sustainability technology. Networks of entrepreneurs and entrepreneurial managers who engage in strategic collective system building can use this practical framework to generate system-building strategies. The combination of these two literature strands will result in a strategy framework that considers both the system level and the firm level. Since we have analysed activities at the firm level that influence the system level, our framework for strategic collective system building contributes to both fields of literature. The strategic management literature so far does not provide insights into how to strategically build up a supportive external environment. Our framework will do so. The TIS literature so far focuses on the system-level, whereas we will add the firm perspective.

To design a practical strategy framework for system-building entrepreneurs and entrepreneurial managers, we focused on two research questions. First, which system-building activities can entrepreneurs and entrepreneurial managers engage in to create a favourable environment for their technological innovation? Second, how can these activities be assembled into a practical strategy framework that can be used for strategic collective system building? To answer these research questions, we reviewed the literature on technological innovation systems with regard to system building and complemented it with insights from the strategic management literature. Moreover, we conducted a case study in the Dutch smart grid field to empirically underpin the theoretical analysis.

[3] Socio-technological transitions are major changes in technological, organizational and institutional terms in both the production and consumption side, triggered by the innovation of a radically new technology. The implementation of the new technology in society entails the introduction of new services, business models and organizations (Farla et al., 2012).

3.2. Theoretical background on collective system building

In this part we review the literature on system building. The concept 'system building' originated in the TIS literature. We start by giving an overview of system building as described in the TIS literature. Then we describe similar (but differently termed) concepts, originating in the strategic management literature, of collective actions that firms undertake to create a favourable environment. We conclude this part by combining these literature strands, by introducing the concept of collective system building and by providing an overview of collective system-building activities that we have identified in the literature.

3.2.1. System building described in the technological innovation systems literature

The term 'system building' originates from the TIS literature. System building is defined as "the deliberate creation or modification of broader institutional or organizational structures in a technological innovation system carried out by innovative actors. It includes the creation or reconfiguration of value chains as well as the creation of a supportive environment for an emerging technology in a more general way." (Musiolik et al., 2012, p. 1035) System building can be driven by a single, powerful actor (Hughes, 1987), but more often it is carried out as a collective effort by a network of actors[4] (Garud et al., 2007; Garud & Kumaraswamy, 1993, 1995). In the course of this chapter we will focus on collective efforts of system building by networks of actors, which we call 'collective system building'.

The TIS literature has generated valuable insights into the processes of system building (Markard & Truffer, 2008b; Musiolik et al., 2012). A technological innovation system contains all the components that influence the innovation process of a newly emerging technology. The TIS field is concerned with the key processes in an emerging technological innovation system (Bergek, Hekkert, & Jacobsson, 2008). 'Functions' are dynamic key processes that take place in the emerging innovation system, triggered by activities by system actors (Bergek, Hekkert, et al., 2008; Hekkert et al., 2007). An overview of these functions is given in Table 3.1. Each key process contributes to building a favourable business ecosystem around the new sustainability technology. Moreover, the interactions between system processes accelerate the emergence and growth of an innovation system in virtuous circles and thus increase the chances of market success (Bergek, Jacobsson, Carlsson, et al., 2008; Hekkert & Negro, 2009b; Jacobsson & Bergek, 2011b; Musiolik & Markard, 2011).

Several versions of the TIS framework can be found in the TIS literature. Depending on the author, the TIS framework has 7-9 functions. The core processes described are displayed in the following table.

[4] Such networks of actors consist of innovative actors, which are mainly entrepreneurs and entrepreneurial managers, but can also comprise policymakers or employees of public research institutes.

TIS framework key process	Description of activities
F1: Entrepreneurial experimentation	Testing new technologies, applications and markets, social learning processes
F2: Knowledge development	Learning activities such as research and development and learning in a practical context
F3: Knowledge diffusion	Stimulating knowledge exchange through conferences, workshops and alliances between companies but also between government, companies and the market
F4: Guidance of the search	All the activities and events that convince actors to enter the TIS or to further invest in it
F5: Market formation	Creation of temporarily protected niche markets through favourable tax regimes, minimal consumption quotas, environmental standards or creation of demand, e.g. through government procurement policies
F6: Resource mobilization	Financial and human resources need to be mobilized to enable the building-up of the innovation system (monetary or in-kind)
F7: Creation of legitimacy	Counteract resistance to change; lobbying to create legitimacy of the new technology, to put the technology on the political agenda, and for favourable tax regimes

Table 3.1: Key processes for building up a technological innovation system
Based on Bergek et al., 2008b; Hekkert and Negro, 2009; Hekkert et al., 2007; Jacobsson and Bergek, 2011; Suurs and Hekkert, 2009; Suurs et al., 2009b.

Recently, Musiolik and Markard stated that the coordination of actors and activities along the value chain is a key process that enhances the overall functioning of the innovation system, but which 'has not been mapped yet' (Musiolik & Markard, 2011). For a well-functioning innovation system, the emergence and coordination of specialized goods and service providers is important (Bergek, Jacobsson, Carlsson, et al., 2008; Foxon, Makuch, Mata, & Pearson, 2004). The creation of standards such as technical guidelines and standard components is important for coordination (Musiolik et al., 2012; Van de Ven, 1993). For strategic collective system building, the coordination of activities is of major importance. Moreover, socio-cultural changes need to be triggered for the new technology to become widely accepted. Users need to be willing to change their behaviour patterns so that they can adopt the new technology (Geels, 2004). Changes in the education system are necessary to change values and norms in society and to provide sufficiently skilled workforce (Kemp & Soete, 1992). Therefore, we have incorporated 'coordination along the value chain' and 'triggering socio-cultural changes' into the development of a strategy framework for system building.

The TIS framework provides a comprehensive overview of system level processes. It has been developed and tested for use by policymakers who intend to support the development and diffusion of an emerging sustainability technology by stimulating key processes at the system level. However, the TIS framework can also be used by networks of entrepreneurs who want to collectively create a supportive environment around their new technological sustainability innovation. Since the TIS key processes take place at the system level, but firms operate on the micro level, the TIS processes have to be broken down into strategic activities which can be carried out by firms. To introduce the firm perspective, we have complemented the TIS literature with insights from the strategic management literature.

3.2.2. System building described in the strategic management literature

The terms 'system building' and 'collective system building' have not yet been mentioned in the strategic management literature. Most strategic management literature focuses on firm-centred activities. However, several literature strands within the strategic management literature describe collective efforts by actors to influence the environment in which they develop an innovation.

Van de Ven's theory of an 'entrepreneurial infrastructure' defines how entrepreneurs who want to implement an innovative technology need to build an entrepreneurial infrastructure together with other businesses in their industry sector (Van de Ven, 1993). Entrepreneurs have to develop their own innovation and design their individual business strategy, but at the same time they need to collaborate strategically with actors along the supply chain, including direct competitors, to build a supportive infrastructure which will stimulate the fast diffusion of their technology. Elements of this entrepreneurial infrastructure are market consumption, institutional arrangements, resource endowments and proprietary activities[5] (Van de Ven, 1993). Collaborating ("running in packs") with competitors will increase the likelihood that their technology will be successful (Van de Ven, 1993, 2005). Individual entrepreneurs need to understand that individually they do not have the resources, power or legitimacy to produce change. They need to become "nodes in value chain networks" and compete as a network with other networks (Van de Ven, 2005). Building a supportive system around their new technology and collectively striving for change towards a new technological regime are essential elements of collective system building.

In the strategic management literature, the term 'business ecosystem' is used to describe the economic and social landscape of which an individual business is part and in which it evolves together with other businesses (Iansiti & Levien, 2004; Moore, 1996). A business ecosystem is a business network that goes beyond the supply chain of the focal company. It consists of all the individuals with whom a business interacts, including suppliers, technology producers, customers, competitors, producers of complementary assets, sellers, financial actors, governmental actors, media and regulatory agencies. It is impossible to draw precise boundaries of a business ecosystem (Iansiti & Levien, 2004; Moore, 1996). The analogy with a biological ecosystem is used to highlight the interrelatedness and interdependency of businesses in a changing environment. The health of the ecosystem determines the success and survival of the individual firm (Iansiti & Levien, 2004). The key to a successful ecosystem

[5] These four terms constitute the pillars of Van de Ven's concept of entrepreneurial infrastructure. In brief: market consumption includes the changing of norms as well as market creation; institutional arrangements refer to laws, regulation and legitimation; resource endowments are science, technology, financing and competence training; proprietary activities include product development, business functions and resource channels (Van de Ven, 1993).

is a network of mutually beneficial relationships with other ecosystem actors. Organizations need to intelligently co-evolve with their overarching business and social environment. Especially with regard to innovation, a strong collaboration with customers and supplier partners is essential, as well as the good management of a wide network of co-evolving organizations (Moore, 1996). Iansiti and Levien (2004) predict that for technology-innovating firms, competition will occur between business ecosystems or business ecosystem domains, rather than between individual firms. Business strategies need to go beyond the firm's individual strategy, and need to consider the network environment in which the company operates (Iansiti & Levien, 2004).

Pitelis describes that some entrepreneurial managers collaborate in networks or clusters and engage in inter-firm collaboration to co-create markets of ecosystems, aimed at capturing value from resulting business opportunities. They collaborate when they perceive a potential for value capture that is higher than from stand-alone activities (Pitelis, 2012). The description of their co-creation of a supportive ecosystem matches the concept of collective system building.

Astley also assumes a systemic viewpoint. He uses a 'social ecology' approach and argues that businesses should not regard the environment in which they operate as an intractable externality to which they are exposed and to which they merely react. In contrast, they should realize that they are component parts of their environment, and through interaction with each other create resources and institutions that generate opportunities and threats for organizations. In order to pro-actively manage organization-environment relationships, Astley advises businesses to generate a strategy at the collective level (in addition to their individual business strategy). He defines collective strategy as "the joint formulation of policy and implementation of action by the members of inter-organizational collectivities" (Astley, 1984, p. 527). Collective strategies guide inter-firm networks to the collective mobilization of resources and actions oriented towards the achievement of a common goal (Astley, 1984; Astley & Fombrun, 1983). Astley describes two important elements of collective system building. First of all, companies do not merely react to changes in their environment, but they can actively shape it. Second, companies need to formulate strategies at the network level in order to shape their environment.

Following the same line of thought, Davenport et al. (2007) argue that today's fast-paced innovation economy requires a new strategic management mind-set, approach and toolbox. Companies need to abandon the idea of individual competition and instead understand that they need to compete in clusters against other clusters. They need to adopt a holistic view of the business ecosystem in which they operate and develop their knowledge and capabilities together with peer businesses. Instead of individual growth, they need to focus on holistic value creation through collaboration in business networks (Davenport et al., 2007). The holistic view of value creation as a business ecosystem is an important element of collective system building.

To summarize, the strategic management literature states that to develop and implement innovative technologies, entrepreneurs need to strategically cooperate in business ecosystems, in which they co-evolve and co-create value. Moreover, they need to change the environment in which they want to implement their innovation. The first two columns of Table 3.2 give an overview of the respective literature strands.

3

Literature strand & authors	Argument / concept	Relation to TIS literature	
		In line with TIS literature	**Missing in strategic management literature**
Entrepreneurial infrastructure (Van de Ven 1993, 2005)	Entrepreneurs need to collaborate strategically with other businesses of their industry to build a supportive infrastructure around their technology	- Building a supportive system around their technology - Competition as a network against other networks (competing technologies)	- The dynamic processes necessary to build the system - The inertia from the existing (competing) technological regime
Business ecosystem (Iansiti & Levien, 2004; Moore, 1996; Pitelis, 2012)	An individual business is merely a part of the business ecosystem it operates in; the health of the business ecosystem determines the success of the individual firm	- Interrelatedness and interdependency of business in a fast-changing environment - Co-evolution of firms - Co-creation of markets - Competition between (technological) systems - Business strategies for the network level necessary	Strategies on how to establish a flourishing business ecosystem, and on how to proactively change the environment
Social ecology approach (Astley, 1994; Astley & Fombrun, 1993)	Firms are not merely exposed to their environments, but they are component parts of it; through interaction they can create resources and institutions	- Formulation of collective strategy (strategy as a network of firms) - Firms can actively change or shape the environment in which they operate	Strategies on how to influence the environment and on how to create resources and institutions
Cluster competition (Davenport et al. 2007)	Firms co-create value through collaboration in business networks; firms compete as clusters against other clusters (instead of individual competition)	- Collaboration in networks to create value - Competition in networks against other networks (of competing technologies)	View on the external environment which can be created by competing networks

Table 3.2: Arguments for system building in the strategic management literature

3.2.3. Strategic collective system building

The review above shows that both the technological innovation systems framework and the strategic management literature highlight the importance of collaboration and the need to build up a favourable environment around the new technology. However, concrete system-building activities are hardly mentioned in the strategic management literature. Column 3 of Table 3.2 shows the overlap of the respective strategic management literature strand with TIS literature, and column 4 summarizes how the TIS literature can complement it. Although the TIS literature does mention system-building activities, it is focused on the system perspective and system level changes, and the firm perspective is underrepresented. Combining both literature fields therefore generates valuable insights into strategic collective system building for entrepreneurs and entrepreneurial managers who want to achieve system level changes, by carrying out strategic activities at the firm level. In other words, the TIS literature and the strategic management literature complement each other. The strategic management literature takes on a firm perspective which considers the environment ('inside out thinking'), whereas the TIS literature takes on a system perspective in which it considers the firm ('outside in thinking'). Based on the literature discussed above, we introduce the term 'collective system building'. The term 'collective system building' emphasizes the collective nature of system building, as opposed to 'system building' which can also be driven by very powerful individual actors. Collective system building can be carried out intuitively or strategically. We define 'strategic collective system building' as the strategic activity of networks of entrepreneurs and entrepreneurial managers to build up a supportive environment and infrastructure for their innovative sustainability technology. The concept 'strategic collective system building' has been derived from literature. According to the literature reviewed above, firms do not have to wait for a supportive environment to emerge, in which their innovation will flourish. They can pro-actively create such an environment. Successful strategic collective system building is expected to lead to a wider adoption of the technology, larger markets and greater implementation in society. An overview is provided below of the different collective system-building activities that have been identified in the literature.

3.2.4. Strategic collective system-building activities

This section provides an overview of collective system-building activities: activities that actors can strategically engage in, so as to build a supportive environment in which they can commercialize their innovative technology. Based on these activities, we have developed a strategy framework for collective system building.

We use the system-building activities mentioned in the TIS literature as the starting point, and complement them with insights from the strategic management literature. Collective system building activities which are described in the TIS framework are: testing new technologies, applications and markets; knowledge development; knowledge exchange (Bergek, Jacobsson, Carlsson, et al., 2008); co-creation of products and service (Musiolik et al., 2012); creation of temporarily protected niche markets (Bergek, Hekkert, et al., 2008); creating a shared vision (Negro et al., 2008); and standardization (Bergek, Jacobsson, Carlsson, et al., 2008). The review of the TIS literature also revealed some other collective system building activities that are mentioned but not explicitly described in the TIS framework. They are described in the broader literature on sustainable technological change. These collective system building activities are: collaborating with government to adapt legislation (Kemp & Loorbach, 2003; Kemp & Soete, 1992), changing user behaviour (Geels, 2004), changing the education system (Kemp & Soete, 1992), and generating a skilled pool of labour (Wolfe & Gertler, 2004).

Moreover, we brought in the firm perspective by reviewing the strategic management literature. The strategic management literature describes elements of system building (as shown in Table 3.2), but it does not provide a list of activities for building up a supportive innovation system. Nevertheless, some activities that contribute to the creation of a supportive system around a new technology could be derived from this literature strand: collaborative marketing to raise user awareness (Hagedoorn & Schakenraad, 1994; Rothwell, 1991; Van de Ven, 2005; Van de Ven, Sapienza, & Villanueva, 2008), collaborative competition against other technology clusters (M. Bengtsson & Kock, 2000; Cooke, 2008; Davenport et al., 2007; Porter, 1998; Ritala & Sainio, 2014; Wolfe & Gertler, 2004), establishing collaboration-prone organizational cultures (Lam, 2004; Ritter & Gemünden, 2003b), defining a common goal (Harmaakorpi, 2006a; Lambooy, 2004a), and providing a platform for open innovation (Chesbrough & Appleyard, 2007; Laszlo, 2003a).

3.3. Method

In the previous part, we derived from the literature the concept of strategic collective system building. In addition, several activities that were potentially relevant for system building were identified in the literature reviewed. The next step was to develop a strategy framework for collective system building; in other words, we wanted to indicate the activities that system-building firms can strategically undertake to build a supportive technological innovation system in which their innovation can flourish and can be commercialized. In order to fully explore all the activities that are ongoing in the field and to find empirical evidence on collective system building and system-building activities, we conducted a single embedded case study in the field of the Dutch smart grid sector.

3.3.1. Selection of case study

The Dutch smart grid sector has been chosen because it is an emerging technological system. A smart grid is an electricity network combined with an ICT network, which is adapted to the introduction of renewable energy sources (Interreg IVB, 2011). Smart grids are essentially not one technology, but a complex set of intertwined technologies. For example, smart devices, such as a smart washing machine, can be automatically switched on when solar panels produce a lot of electricity, thanks to specially designed software; this can prevent the grid from being supplied with too much energy. Due to the complexity and interdependency of this new technology, actors know that they need to collaborate. This makes the smart grid sector a relevant case in the context of collective system building. In the Netherlands, small start-ups all along the value chain as well as incumbent energy companies that try to diversify their business are working hard to develop and implement smart grid technology. Actors are prone to collaborate and they form various networks with different constellations of actors. These networks have set up pilot projects, for example to test full-scale smart grid concepts in practice or to work on the standardization or the acceleration of smart grid development and implementation (Kema, 2012; Laan, 2012; NL Agency, 2012a, 2012b; SEC, 2012). Moreover, the Dutch government supports the development of this field and launches projects and programmes which aim to accelerate the collaboration of companies that are active in the smart grid field. In addition, there are numerous other national and international networks, pilot projects and collaborative projects, with different constellations of public and private actors (Hertzog, 2013; Hübner & Prüggler, 2011). These factors make the Dutch smart grid field a suitable case for analysing the processes of collective system building.

3.3.2. Data collection

To collect data, semi-structured in-depth interviews were carried out with 14 key actors in the field. First, a list of 25 key actors was compiled, based both on information provided by a key player in the Dutch smart grid field and on the report 'Who is who guide – players in the Dutch smart-grid sector', published by NL Agency, an executive agency of the Dutch government (NL Agency, 2012c). From this list of 25 potential interviewees, ten people were selected that broadly covered the field. They were either owners of start-ups or high-ranked managers from major companies along the smart grid value chain. Based on the information gained during these interviews, four additional interview partners were asked to participate. These four had been mentioned by the interviewees as important players in the field.

Of the fourteen key actors interviewed, twelve can be classified as entrepreneurs in the broad definition of the term, or intrapreneurs (managers in large companies who try to seize new business opportunities by diversifying), and two as entrepreneurs in the narrow sense (start-ups). The intrapreneurs were high-ranked managers instructed by their firms to develop business opportunities in the smart grid field. They held positions such as senior director, executive partner, business developer, smart grid division manager or senior project development manager.

The face-to-face interviews consisted of two parts. In the first part, the respondents were asked to reflect upon the general question of what is necessary to make the technology a success. They were also asked to discuss activities necessary for system building. In the second part, the respondents were shown the TIS key functions and the list of activities based on the literature review (see section 2.4). Subsequently, they were asked to reflect upon these activities in terms of their actual usage, the respondents' involvement in conducting these activities, and the relevance of the activities in the context of system building. The interviews took 80-140 minutes and were conducted between December 2012 and March 2013.

3.3.3. Data analysis

All interviews were transcribed and analysed using Atlas.ti software. This analysis consisted of two main steps. The first step resulted in a set of system-building activities, and in the second step these activities were clustered. First, we coded the data according to the activities derived from the literature review. However, if it appeared to be impossible to refer back to the literature reviewed, we used wider strategic management literature to base the new codes on. The outcome was a set of 22 system-building activities, which entrepreneurs of the Dutch smart grid field perceive as important for strategic collective system building.

The next step was to analyse the relationships between these activities and entrepreneurs' motivations to engage in these activities, i.e. their ultimate system-building goal when engaging in these activities. This enabled us to cluster the activities into over-arching categories, based on the system-building goal they contribute to. To refine our clusters, we compared the resulting system-building objectives with the literature on system building. In an iterative process, we compared the findings from the interviews with the existing literature on system building. This analysis revealed four main clusters to which system-building activities can be assigned. For example, entrepreneurs mentioned that they engage in knowledge development, diffusion and testing activities in order to optimize their technology. When these findings were compared with the literature, it was concluded that one important objective of system building is the development and optimization of technology. This is how the first cluster Technology development and optimization emerged. Applying this approach, we identified four clusters: Technology development and optimization, Market creation, Socio-cultural changes and Coordination.

3.3.4. Validation of results

After finishing our analysis, we validated our results in several steps. First, we constructed an online survey in which we asked whether the respondents agreed with our analysis on the system-building activities that were revealed as being necessary and important. Respondents could answer on a 5-point Likert-scale, from 'very unimportant for system building' to 'very important for system building'. In addition, they could choose 'not necessary for system building' and give comments on each cluster of activities, in case they thought an activity was missing or if they disagreed with a specific category. We also checked that they agreed with the over-arching system-building goals.

We used the survey to collect data from two different groups. The first group consisted of eight of our interview partners. With this step we wanted to make sure that we had correctly perceived and displayed the opinions of the interviewees in the developed framework. The second group comprised of different managers of the Dutch smart grids sector, who had not been interviewed by us previously. During a practitioners conference on smart grids, fourteen managers were approached to participate in the research. They were asked to fill in the same questionnaire as the group described above. This helped us to also validate the results for the smart grids sector. In the end, half of them, seven entrepreneurs, filled in the survey.

The second step of the validation was a 1.5-hour meeting in a workshop setting, attended by approximately twenty entrepreneurs from different fields. The aim of the workshop was to discuss the framework and its applicability to other industries.

3.4. Findings

First, we examine whether the concept of strategic collective system building, which we introduced based on our literature review, actually occurs in practice. Subsequently, it is determined whether practitioners engage in the system-building activities derived from the literature and which additional system-building activities were mentioned. Moreover, we consider how the system-building activities can be reframed so that practitioners can use them more easily for strategy making in the future.

3.4.1. Strategic collective system building in practice

Our data revealed that entrepreneurs and entrepreneurial managers of the Dutch smart grid system were aware that they need to collaborate to implement their technology in the market. They realized that such implementation requires a transition towards an efficient decentralized renewable energy system, which can only be achieved in collective efforts. As one interviewee stated, "A single company cannot change the system; companies have to do it jointly." [P6] Close collaboration along the value chain is necessary to build a new technological system: "We have to work together with other companies, mainly with clients, with user groups - everyone. Together, together, together. It is the core of our mission, which is building the system." [P10] Interviewees were aware that they need to work together with all kinds of actors along the whole value chain: customers, competitors, suppliers, universities and the government. As one interviewee said, "We ideally want to collaborate with all of them, all kind of actors. Normally as a company your main actor is a customer, somebody who buys your equipment, but we also want to have our contacts with the government; we also want to have our contacts with the universities." [P14] Furthermore, the interview partners were aware that they were part of a technological system, and that collaboration was required to co-develop products and services which are compatible and will enable the system to function efficiently: "There is not a company in the world that can develop all the components, the system architecture, […], so you have to bring all these companies together or at least a great number of companies; we are not enough yet. In that way, you can design the system and while you are doing that, these companies are developing services and products and solutions that fit in that system." [P2]

Entrepreneurs and entrepreneurial managers reasoned that the advantage of collaborating with competitors is that standards can be set which help the new technology to be spread and compatible systems to emerge[6]. Moreover, the interviewees were aware that cooperation on optimizing the technology or its inputs will lead to a greater adoption of the technology. They know that if they want to reap business opportunities in this new system, they need to cooperate. However, they admitted that it is not easy to collaborate at such a large scale and with so many different actors.

We found that entrepreneurs and entrepreneurial managers do engage in system-building activities. They are aware that they have to solve problems and overcome barriers at the system level. However, they do not strategically plan system level changes. Instead, they formulate their strategies at the firm level, and collaborate in networks to achieve their companies' objectives. As a result, they intuitively engage in system-building activities which tackle problems at the system level. However, most interviewees stated that a more strategic approach to collective system building would lead to faster diffusion and adoption of their new technology. To summarize, entrepreneurs and entrepreneurial managers are aware that they have to build a system, and they consider system-level changes; yet, in most cases, their strategic focus is on the firm level.

3.4.2. System-building activities mentioned by entrepreneurs and entrepreneurial managers

This section focuses on the system-building activities that were discussed during the interviews and the underlying goals entrepreneurs aimed to achieve by carrying out these activities. Our research revealed 22 system-building activities. Table 3.3 gives an overview of these activities. The seven functions of the technological innovation systems framework needed to be broken down into system-building activities that entrepreneurs can strategically engage in. Entrepreneurs agreed that these activities are important for system building (column 3). They further agreed that the system-building activities derived from the strategic management literature are important for system building (column 4). A few system-building activities were considered important by interviewees, but this could not be underpinned by the TIS literature or the strategic management literature reviewed in section 2 (column 5).

[6] Some interviewees stated that collaboration within a nascent industry is not a new phenomenon. Examples were given of optical discs and mobile telephony: "DVDs would never have been a success if there had been only one company. It was the fact that many companies were involved and that it was really the industry that put it there that caused it to become one of the best solutions in the world. The same is true for mobile telephony: if there had not been a GSM standard, they couldn't have sold mobile phones." [P5]

Cluster	System-building activity	Stated by entrepreneurs and in line with TIS literature	Stated by entrepreneurs and in line with strategic management literature	Stated by entrepreneurs; not mentioned in the literature reviewed in section 2
Technology development & optimization	Testing new technologies, applications and markets	X [a]	o [b]	
	Knowledge development	X	o	
	Knowledge exchange	X	o	
	Co-creation of products and services	X	o	
	Development of commercially viable products			X
	Feedback loops with user groups			X
Market creation	Creation of temporarily protected niche market	X		
	Collaboration with government to adapt legislation	X		
	Collaborative marketing to raise user awareness		X	
	Collaborative competition against other technology clusters		X	
	Generate new business models			X
Socio-cultural changes	Changing user behaviour	X		
	Changing the education system	X		
	Generating a pool of skilled labour	X		
	Establishing collaboration-prone organizational cultures		X	
	Creating new facilitating organizations			X
Coordination	Standardization	X		
	Creating a shared vision	X	o	
	Defining a common goal		X	
	Providing a platform for open innovation		X	
	System orchestration			X
	Thinking in system-building roles instead of company objectives			X
	Creating transparency of all activities going on in the field			X

Table 3.3: System-building activities and the literature fields they can be related to:
[a] "X" indicates that these activities mentioned by entrepreneurs are described in the respective literature field
[b] "o" indicates that these activities are not only derived from the TIS framework and validated empirically, but are also mentioned in the strategic management literature

The purpose of a strategy framework is to help managers and other decision makers to structure and organize information on which they can base their strategic decisions (Knott, 2006; Mintzberg, Lampel, & Ahlstrand, 1998). In order to draw up a practical strategy framework that can be used by entrepreneurs and entrepreneurial managers for strategy making, we needed to cluster the system-building activities. By clustering the activities into categories, a structure for organizing information is introduced to the framework. The category Technology development and optimization summarizes all the activities that lead to the development and optimization of the new technology, including supplementary products and services. These activities are usually seen as core activities by actors who want to launch an innovative technology. The second category is Market creation. Many authors, especially management scholars, highlight the importance of market creation by push and pull factors. If users are not aware of or interested in the existence of an innovative technology, this technology will not succeed in the market, however optimized it may be (Foxon & Pearson, 2008; B. H. Hall & Khan, 2003; Hargadon, 2010). The third category is Stimulation of socio-cultural changes. Socio-cultural changes such as changes in the mind-sets of customers, producers and policymakers are often a necessary requirement for a new sustainability technology to be embraced by society. Furthermore, changes in the education system need to take place. These three categories also represent the goals of system building. In addition, a range of activities were mentioned which entrepreneurs carry out in order to coordinate system-building activities and thus accelerate the process of system building. We clustered these activities into the category Coordination. This category is not a system-building goal in itself, but it facilitates and accelerates system building and is therefore another key area for strategic system building. It comprises all the activities and processes that contribute to a better coordination of system-building activities. This category is visualized on a different level in Figure 3.1 (at the centre of the triangle), as it is not a goal of system building, but a facilitator and accelerator of the system-building goals represented by the other three categories.

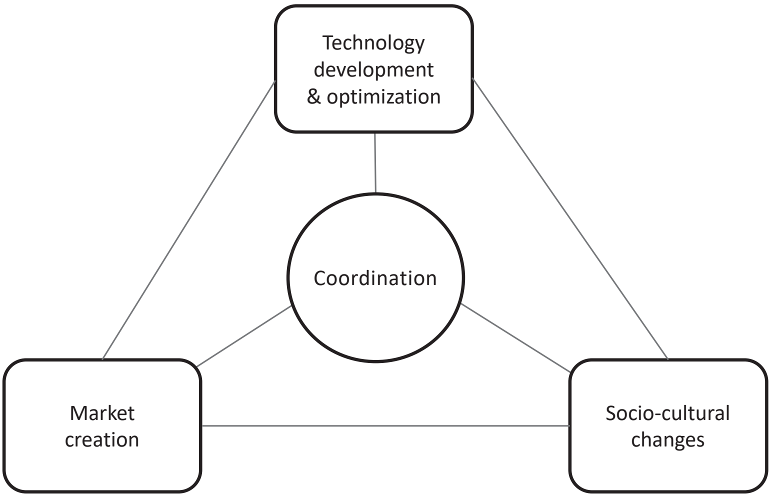

Figure 3.1: Strategy framework for collective system building by entrepreneurs

3.5. Discussion of the strategy framework

This part discusses the strategy framework and the individual system-building activities it is composed of. We start by describing and discussing a cluster as visualized in Figure 3.1, and then we elaborate on each of the system-building activities that make up the cluster. In each section, we first discuss the system-building activities derived from the TIS literature and confirmed by our empirical data, followed by the system-building activities that can be underpinned by the strategic management literature as summarized in section 3.2.4. Subsequently, we describe additional system-building activities that emerged from our case study data, but that could be linked neither to the TIS literature, nor to the strategic management literature reviewed in the theory section above.

3.5.1. Technology development and optimization

A well-functioning and viable technology is the key component of a new innovation system. If the technology is faulty, all other system-building activities may be in vain. Especially in the view of system-building entrepreneurs, who often happen to be engineers, the development and optimization of the new technology can be expected to be the primary goal. Below we briefly describe activities that contribute to the development and optimization of the innovative technology.

The three system-building activities (1) *testing new technologies, applications and markets*, (2) *knowledge development* and (3) *knowledge exchange* were derived from the TIS framework (Bergek, Jacobsson, & Sandén, 2008a; Hekkert et al., 2007; Jacobsson & Bergek, 2011b). Entrepreneurs found these activities or processes vitally important. However, they remarked that from their perspective, the three activities often overlapped and were perceived as one activity. For example, a shared pilot project simultaneously contributes to testing, knowledge development and knowledge exchange. With regard to strategy design, this finding highlights the importance of clustering the system-building activities according to system-building goals. *Co-creation of products and services* was mentioned in the TIS framework as well as in the strategic management literature, specifically the business ecosystem literature. Collective development efforts stimulate complementarity of products and services as well as cost-effectiveness; thus, the system as a whole is strengthened (Hekkert et al., 2007; Iansiti & Levien, 2004; Moore, 2005; Pitelis, 2012; Ritala & Hurmelinna-Laukkanen, 2009). *Development of commercially viable products* emphasizes that while optimizing the functionality of the new technology, developers need to keep in mind the added value for the customer as well as the user-friendliness of their products and services. *Feedback loops with user groups* can be established as part of pilot projects or through communication platforms. In order to optimize technology, especially with regard to user-friendliness and user acceptance, the cooperation with user groups can provide valuable information. This information needs to be captured and processed and used for further development of the technology. These last two activities are derived from the case study data. Of course, the development of products is also part of the TIS literature

(F1: entrepreneurial experimentation), to which the last two activities might be added. However, the specific distinction that the products should also be commercially viable (and not just an optimally functioning technology, which may be too expensive or difficult to use) is not explicit in the TIS framework. In addition, the creation of feedback loops with user groups is not specifically described in the TIS framework, because the TIS literature focuses on the system level (from a policymaker's perspective) and our research focuses on the entrepreneur's perspective. Taking on the firm perspective generates this more specific distinction of system-building activities.

3.5.2. Market creation

One of the main conditions for a new technology to be widely adopted is that there is a market for it (B. H. Hall & Khan, 2003; Rothwell, 1991; Van de Ven, 1993, 2005). Push and pull factors have to be considered for market creation (Foxon & Pearson, 2008), producers have to be supported and interest needs to be raised among potential customers. Especially for radically new technologies, an effort has to be made to raise user awareness and demand (Hargadon, 2010; Markard & Truffer, 2008a). Moreover, regulation needs to be adapted to enable and support the new technological system, and to allow market forces to come into play (Foxon et al., 2004; Foxon & Pearson, 2008; B. H. Hall & Khan, 2003; Loorbach & Rotmans, 2006).

Several authors argue that the *creation of temporary niche markets* is an important measure for a new technological innovation to further develop into a technological regime (Geels, 2002, 2005; Markard & Truffer, 2008b). Regarding smart grids, however, several interviewees stated that more than the creation of niche markets, changes in the regulatory framework support the commercialization of the new technology. They indicated that temporary niche markets can keep in place the existing structures of the macro-environment which favour and reinforce the incumbent technological regime. However, these interviewees conceded that temporarily protected niche markets have proven successful for other innovative technologies. These findings show that not all system-building activities may be applicable for all technologies.

All entrepreneurs interviewed acknowledged the importance of *collaboration with other system actors to raise user awareness and demand* for the new technology. Potential customers have to be aware that there is a new technology and that it offers benefits. Consumers have a selective perception and only pick up specific messages about products if they have a basic knowledge about the product and its general functionalities (Kotler, Armstrong, Wong, & Saunders, 2008). Therefore, when marketing radical innovations, first a general awareness and understanding of the technology has to be generated. This first marketing phase can be conducted collaboratively by innovation system actors. This enables them to combine their resources and achieve higher leverage effects (Hagedoorn & Schakenraad, 1994; Rothwell, 1991; Van de Ven, 1993, 2005; Van de Ven, Polley, Garud, & Venkataraman, 2008). Once potential customers are aware of the new technology, individual companies can start communicating specific facts about and benefits of their own particular product or service.

Entrepreneurs were aware that if they want to achieve large-scale transitions, they need to collaborate in order to overcome the existing technological regime. Strategic management literature suggests that the actors of the new technological regime have to understand that they need to compete as a cluster (network of actors) with other clusters of alternative technologies (Cooke, 2008; Davenport et al., 2007; Porter, 1998; Wolfe & Gertler, 2004). If firms understand that they do not have to compete with peers that develop a similar technology, but rather *compete collectively against alternative technologies*, they can create a larger market for their product or service than if they competed individually (value creation). This larger market can then be divided up (value appropriation) by the collaborating companies (M. Bengtsson & Kock, 2000; Porter & Kramer, 2011; Ritala & Hurmelinna-Laukkanen, 2009; Ritala & Sainio, 2014).

Most interview partners pointed out that the current legislation is one of the main obstacles to the introduction of the new technology. The national government plays a major role in creating a market for the new technology. It can adapt l*egislation in order to support the implementation* of the new technology (Fischer, 2008; Georg, 1994; Kemp & Loorbach, 2003; Kemp & Soete, 1992; O'Connor, 1997). Entrepreneurs who want to commercialize a sustainability technology should inform the government of the new technology so that the government can design a supportive regulative framework (Suurs et al., 2009a). Networks of entrepreneurs can lobby to convince governmental actors to put the support of the new technology on the political agenda (Hekkert et al., 2007).

The *generation of new business models* is necessary to allow the market forces to come into play and support the implementation of the new technology. Entrepreneurs stated that to make their technology commercially viable, the market should be designed in such a way that economic incentives are provided to those who have to make investments, change their user behaviour or switch over to the new technology. In order to design such stimulating business models which incentivize investments in the new technology and the change of user behaviour, the government would have to conduct regulative changes. The cooperation of private actors (who have the necessary knowledge) and public actors (who have regulative power) is necessary to draw up and enable feasible business models. For example, government regulations concerning the energy system were designed many years ago for the incumbent central fossil fuel-based energy system. These regulations do not permit specific pricing mechanisms (e.g. real time pricing) that would allow companies to reap financial benefits from applying smart grid technology or stimulate users to change their behaviour.

3.5.3. Socio-cultural changes

For technological sustainability innovations to be widely adopted, they need to be embedded in society. System-building entrepreneurs have to strive for changes in the mind-sets of consumers and producers; these entrepreneurs need to change values and norms in favour of the new technology. Individually, they do not have the means and the power to achieve socio-cultural changes7; however, they can trigger these changes in collective efforts and in collaboration with the government. Considering the lengthy time horizons of socio-cultural changes, it is advisable to start working on these changes very early in the system-building process. The entrepreneurs interviewed acknowledged that socio-cultural changes are exceedingly important if the technology is to be adopted, but that this area is still often neglected. Some interview partners mentioned that neglecting the necessary socio-cultural changes in the product development phase is one of the main obstacles to a successful implementation of a technology. These findings can be related to the strategic management literature as well as the TIS literature. Hall and Khan state that even the most optimally functioning new technology may commercially fail if it cannot be embedded in society (B. H. Hall & Khan, 2003). The successful implementation of a radically new sustainability technology requires deep societal changes in different areas (Hollingsworth, 2000; Kemp and Loorbach, 2003; Loorbach and Rotmans, 2006; Van den Bergh et al., 2011).

The following activities can be carried out by entrepreneurs to trigger necessary socio-cultural changes. As underpinned by the strategic management literature, intra-firm changes need to take place. Companies may need to *change the way they organize their business activities* and introduce a company culture which is predisposed to collaboration (Garud & Kumaraswamy, 1995; Katkalo, Pitelis, & Teece, 2010; Lam, 2004; Ritter & Gemünden, 2003b). The norms and values of users need to be changed if they are to accept uncomfortable *changes in user behaviour* (Andersen & Tukker, 2006; Geels, 2004; Leiserowitz, Kates, & Parris, 2006; Schwarz, 2010; Young, Hwang, Mcdonald, & Oates, 2010). Moreover, the *educational system* needs to be adapted to achieve changes in people's attitudes and to *generate a skilled workforce* (Freeman, 1995; Jansen, 2003; Kemp & Soete, 1992; Laszlo, 2003b). Furthermore, entrepreneurs mentioned the need to create *new types of organizations* that can play a facilitating role in the emerging industry and support the long-term collaboration between firms in the industry.

[7] When we refer to socio-cultural changes we mean changes in factors such as routines, shared values, norms and trust (cp. Doloreux & Parto, 2004) ingrained in a society, i.e. in the mind-sets of people who live in this society. These changes differ from the changes described in section 5.2, 'Market creation'. Market creation also comprises change, but at the level of laws and regulations or marketing activities. Of course, the right socio-cultural changes will have a huge impact on user behaviour and user demand, as well as on the willingness of governmental actors to change regulations. As mentioned earlier and visualized in Figure 3.1, the four categories of this framework are highly intertwined and interrelated. Achieving the goals in one category accelerates the achievement of goals in the other categories.

3.5.4. Coordination

The coordination of all system-building efforts accelerates system-building processes. Many actors are involved in system building, each with their own agenda and their own strategic plan. These actors make resources available for system building. The system as a whole benefits most if the resources are combined and efforts are aligned. Without coordination, individual efforts may prove futile. Whereas the system-building categories described above represent system-building goals, the activities clustered in this category function as accelerators and help to speed up system-building processes, to achieve system-building goals and to do so more quickly.

Musiolik and Markard argued that coordination along the value chain is a key process for the development of an innovation system (Musiolik & Markard, 2011). Our data showed that this also holds true for the smart grid system and that the entrepreneurs interviewed perceived such coordination as vitally important. However, the analysis of the data indicated that activities aimed at system-building coordination go beyond value chain coordination and that more innovation system actors are involved.

The *creation of a shared vision* towards which the development of the system should move, and the *definition of a common goal* are both important for the coordination of system-building activities (Harmaakorpi, 2006b; Lambooy, 2004b; Quintana-García & Benavides-Velasco, 2004; Schoonhoven, Eisenhardt, & Lyman, 2012; Suurs et al., 2009b). The creation of a common goal is more than merely trying to find a compromise of individual company goals. Ideally, system-building entrepreneurs should align their company goals towards the achievement of this common goal.

Entrepreneurs also stated that *standardization* is important to enable the co-development of products and services. Standardization is necessary to build a compatible, reliable new system, in which customers and end-users can easily switch between suppliers or brands. Standardization allows companies along the value chain to simultaneously develop their products and services. While the system is evolving, companies can develop their products and services which will then fit into the new system. Without standardization, too many one-point solutions emerge and the new technology cannot be cost-effective (and hence cannot survive in competition with alternative technologies). An integrated approach is necessary in which actors of the innovation system agree on shared standards. The importance of standardization is stated in the TIS literature (Bergek, Jacobsson, Carlsson, & Lindmark, 2005; Musiolik et al., 2012) as well as in strategic management literature (Pitelis, 2012; Ritala & Hurmelinna-Laukkanen, 2009; Yami & Nemeh, 2014).

To coordinate and accelerate knowledge development and product optimization, the interviewees advised *setting up open innovation platforms*. These platforms also speed up the co-development of complementary products (Chesbrough & Appleyard, 2007; Laszlo, 2003b). The activity *system orchestration* refers to the managing and aligning of individual system-building efforts. Regime change is possible only if many actors collaborate and combine their resources. If they do not align their activities, their individual efforts may prove futile and they may not be able to gain enough leverage to compete with the incumbent technological regime. To manage and connect all individual efforts, a high degree of coordination is necessary. However, this coordination should not be too rigid; if too many rules are set in the formation phase of the new system, the creativity and innovation potential of the system may be hampered.

If a high degree of coordination and system orchestration has been achieved, as well as trust between networking actors, it has been suggested that entrepreneurial managers should *think in system-building roles* rather than in company objectives. To increase the effects of collective system building, entrepreneurs would need to detach themselves from the primary aim of selling their company's product or service, and instead consider which role they can play in building the new system. In other words, it is the system that is seen as the entity in which a role is to be performed, rather than the individual organization. A balance needs to be found between achieving the company objectives and common system objectives.

A much stated problem for system building regarding smart grids was the huge overlap in research and knowledge diffusion activities such as pilot projects and conferences. This overlap results in redundant activities and therefore inefficient resource use. The *creation of transparency of all activities going on in the field* helps to reduce such overlap and to avoid the depletion of resources.

3.5.5. Validation of results

After having analysed and discussed the above findings, we validated them in two additional steps (described in detail in section 3.4). The online survey among our interviewees and among a second group of different entrepreneurs from the smart grid sector revealed that both groups of respondents regard almost all different activities within the category Technology development and optimization as 'important' or 'very important' (between 4 and 5 on a 5-point scale). In addition, it became clear that – only for the interview partners – the co-creation of products and services and the feedback loops with user groups were slightly less important (3.9 and 3.6 on a 5-point scale) than the other activities in this cluster.

With respect to the category Market creation, both groups of respondents rated the activities *creation of a temporarily protected niche market* and *collaborative competition against other technology clusters* as the least important activities in this cluster. These activities, however, still score on average at least a 3 (on a 5-point scale), with the exception of the *creation of a temporarily protected niche market*, which was given an average of 2.3 by the interview partners. One respondent explained that "a protected niche market has the inherent risk of free riding". Someone else stated that temporarily protected niche markets can only be a boundary condition; they cannot make a technology succeed, if the technology does not provide its users with added value. With respect to the category Socio-cultural changes, all activities were indicated as relevant and the average scores for importance were between neutral and important, with an average of 3.3. Only one respondent thought that *creating new facilitating organizations* was not relevant for system building.

The activities were also clearly considered important for the category Coordination. The analysis revealed that our interviewees rated the importance of the activities for this category between 3.8 and 4.4. For the second group the average scores for the activities ranged between 3.4 and 4.3. In general, these activities are seen as relatively important.

Regarding the overarching categories, we asked the respondents to consider the importance of each category. The results indicate that they found all categories important, although some categories were ranked slightly higher in importance than others. Both groups overall ranked Market creation highest, followed by Technology development and optimization, Coordination and Socio-cultural changes. In sum, the outcome of our survey confirmed that the system-building activities described above are necessary and important for collective system building.

The workshop with entrepreneurs from different fields also revealed that the entrepreneurs valued the strategy framework. It also became clear that the framework was applicable for other industries. For example, one participant from the health care sector explained that this framework would also be suitable for her sector. However, she suggested that it might be clearer for her sector to relabel Technology development as Product development, because innovations in the health care sector are not necessarily technological innovations. A participant from the creative industry stated that this also held for his industry. The outcome of the meeting was that participants agreed that the strategy framework would be suitable for their particular industries.

3.6. Conclusions and implications

The objective of this chapter was to combine insights from the strategic management literature and the TIS literature in order to provide a strategy framework for entrepreneurs and entrepreneurial managers to collectively build a favourable environment for their sustainability technology. By creating a supportive innovation system or business ecosystem for their new technology, they increase the chances of successful commercialization. A wide diffusion of sustainability technologies, which replace unsustainable technologies, accelerates the transition towards sustainable development. First, we introduced the concept of collective system building and illustrated it with the empirical case of the Dutch smart grid field. Our empirical study shows that the theoretical concept we developed based on literature review actually occurs in the smart grid field. Collective system building takes place, although generally this does not occur in a strategic manner. However, the interviewees confirmed that a more strategic approach to collective system building ('strategic collective system building') would accelerate the diffusion of their new technology. Based on the concept of strategic collective system building we have developed a strategy framework for entrepreneurs and entrepreneurial managers to collectively create a favourable environment for their sustainability technology. We term it 'strategy framework for collective system building'. The strategy framework consists of four key areas for strategy making: technology development and optimization, market creation, socio-cultural changes and coordination (see Figure 3.1). Each of these key strategic areas is composed of a set of system-building activities. The first three categories are system-building goals which entrepreneurs collectively strive for. The category 'coordination' comprises all the activities that manage and align system-building efforts, lead to combining forces and resources and thus accelerate the system-building processes. An overview of these categories and system-building activities is presented below in Figure 3.2.

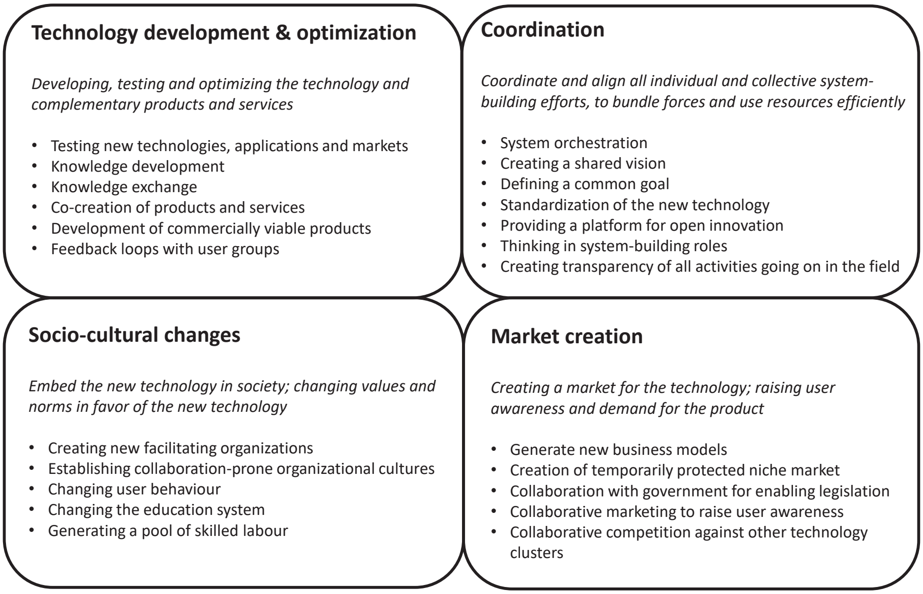

Figure 3.2.: Overview of the strategy framework for system building and its system-building activities

The system-building activities identified in the study were derived from or referred to the TIS literature and the strategic management literature. This underlines the importance of combining these fields of literature. Focusing on only one of these fields would have resulted in an incomplete strategy framework, whereas the combination of these fields of literature results in a comprehensive overview of system-building activities. The system perspective of the TIS literature complements the firm perspective of the strategic management literature, and the combination of both fields acknowledges the interplay of between both levels. An overview has been generated of system-building activities that networks of firms can carry out to achieve system level changes. The strategic management literature so far only described the importance of a supportive external environment, but did not yet provide insights into how to strategically build up such environment. The use of the TIS literature enabled us to make it clearer which processes entrepreneurs need to trigger to influence changes at the system-level, which lead to a more favourable environment in which to implement their innovative technology. Moreover, we contribute to the TIS literature, which has been focused on the system-level and the perspective of policymakers, by introducing to it the firm perspective. Beyond the literature discussed in the theory section, we recognized that additional valuable insights can be gained from the open innovation literature, as some system-building activities from the category Coordination are supported by that field of literature.

Our research was based on a single case study, which might be a limitation. However, the framework used was firmly based on extensive literature research and if possible we related our findings to the literature to increase its generalizability. Moreover, we obtained rich empirical data since we spoke to the most important actors in the field and to leading representatives of different actors along the value chain who are driving system building around the smart grid technology in the Netherlands. It is not yet clear how applicable the new strategy framework is for different emerging technologies; after all, not all the system-building activities mentioned in the framework may be equally relevant for different technologies or in different domains. Even though the validation step of our research showed that the strategy framework might be suitable for other industries, it also showed that the focus in some industries may indeed be slightly different. The specific characteristics of a technology or a domain could result in different weighting of the importance of the activities and of activity clusters. In the case of the smart grid technology, for instance, the respondents rated the activities related to coordination as very important. As explained earlier, smart grid technology does not comprise one technology, but a complex set of intertwined technologies. Due to the complexity and interdependency of this new technology, actors know that they need to collaborate and this may explain the importance attributed to coordination. In other cases, for example if there is a great deal of resistance among consumers or if the technology is questionable, other activities from the category Socio-cultural changes may be considered more important. The strategy framework that we developed cannot be considered a one-size-fits-all solution yet. Therefore, a possible next step is the validation of the framework in different technological fields.

With regard to the practical implications of our research, we have reframed system building from a strategic management perspective, and thus provided a framework that entrepreneurs and entrepreneurial managers can use for system building. The framework depicts an overview of activities that firms can undertake in order to build a system. Networks of entrepreneurs can use this framework as a tool to collect and structure information, based on which they can generate strategies for system building. We have facilitated the structuring of information by clustering system-building activities according to the underlying system-building goals that these activities contribute to. This framework can also be used by networks of entrepreneurs to facilitate their understanding, not only of the various system-building goals but also of the activities they can carry out to achieve these goals. It might help them to identify activities that firms already focus on enough, as well as activities that have not yet been given sufficient attention and resources. They can use the framework to set goals, divide tasks and distribute roles. Depending on the type of technology, its broader context and the development phase of the emerging field, not all activities may be equally important. This prioritization as well as the task division between network partners has to be undertaken by the practitioners. Moreover, the presentation of system-building activities according to system-building goals facilitates the setting of strategic objectives for practitioners, which helps them to measure and evaluate the outcome of their strategic activities.

CHAPTER 4

Managing strategic system-building networks in emerging business fields: A case study of the Dutch smart grid sector

This chapter is based on: Planko, J., Chappin, M. M. H., Cramer, J. M., & Hekkert, M. P. Managing strategic system-building networks in emerging business fields: A case study of the Dutch smart grid sector. Industrial Marketing Management, 67, 37-51.

Abstract

Companies that wish to launch innovative sustainability technologies can collaborate in strategic networks of actors from industry, government and research institutes to pro-actively build a business ecosystem around their new technology. This is called collective system building. In this paper, we examine how to effectively manage networks for collective system building. Based on a review of the literature, we identify the key factors of effective network management and we propose a conceptual framework for network management at the network level. Subsequently, we conduct a multiple-case study in the Dutch smart grid sector to examine how these key factors are implemented by system-building networks. We find differences with the existing network management literature regarding network composition, network management structure, governance modes, decision-making processes, project management, the free-rider problem and trust-building mechanisms. Our study contributes to a better understanding of effective management of system-building networks, which in turn can lead to greater success in establishing new business fields. We contribute to the literature on strategic business networks, specifically on emerging business networks building new business fields.

4.1. Introduction

Corporate collaboration in inter-organizational networks has become a predominant form of business management (Gulati, 1998; Hagedoorn & Schakenraad, 1994; Möller & Svahn, 2003, 2009; Nalebuff & Brandenburger, 1996). A critical success factor for businesses will be the ability to build and develop strategic networks (Partanen & Möller, 2012), especially in fast-changing technology-intensive sectors, in which the products and services offered are not only complex in themselves, but also include a large variety of complementary products and services (Partanen & Möller, 2012). Due to high velocity markets, the high level of technological complexity and the diversity of resources and capabilities required to develop the necessary infrastructure, it is almost impossible for a single firm to create new technology (Möller & Svahn, 2009). Such radical innovation often requires building a new business field (Möller, 2010; Möller & Svahn, 2009). The creation and commercialization of new business fields is carried out by linked actors in complex inter-organizational networks (Möller & Svahn, 2009), whose aim is to create state-of-the-art products and services and high efficiency production and business processes, which generate added value for customers (Möller, 2010). In other words, a supportive ecosystem is necessary for radical innovation.

The creation of a supportive ecosystem around a new innovation is one of the crucial success factors for commercializing radical innovations (Aarikka-Stenroos & Lehtimäki, 2014). In fact, the main external barrier to radical innovation is an undeveloped network and ecosystem around the innovation (Sandberg & Aarikka-Stenroos, 2014). Therefore, to increase market success, firms intentionally build network relations and develop new business fields in innovation networks (Aarikka-Stenroos, Sandberg, & Lehtimäki, 2014). The development of such an ecosystem is largely beyond a single firm's influence and needs to take place in networks (Sandberg & Aarikka-Stenroos, 2014).

Building a supportive business ecosystem is relevant for any firm aiming to develop and commercialize radical innovation, but especially for radical sustainability innovations. Sustainability transitions cause actors to operate in great uncertainty and require transformative change (Knight et al., 2015). Society-wide changes are necessary for the successful commercialization of innovative sustainability technologies (Geels, 2002, 2005; Kemp et al., 1998). To realize such changes, firms need to collaborate with other actors (Musiolik et al., 2012), as together they can pro-actively change their environment and build a favorable ecosystem in which their innovative technology can flourish. In transition literature, this process is called 'collective system building'. Collective system building is defined as the "processes and activities that firms can conduct in networks to collectively create a favorable environment for their innovative sustainability technology" (Planko, Cramer, Chappin & Hekkert, 2016, p. 2329). It aims at developing and optimizing technology, triggering socio-cultural changes, and creating a market for the new technology, including changes in governmental regulations and user behavior.

System-building networks can be classified as strategic networks, i.e. networks created intentionally by three or more organizations with the aim of achieving a common goal, and with deliberately created structures and negotiated roles and responsibilities (Järvensivu & Möller, 2009; Möller & Rajala, 2007). These strategic networks need to be managed intensively in order to be effective (Heidenreich, Landsperger, & Spieth, 2016; Landsperger, Spieth, & Heidenreich, 2012; Milward & Provan, 2006; Provan, Fish, & Sydow, 2007; Rampersad, Quester, & Troshani, 2010; Rusanen, 2013; Turrini, Cristofoli, Frosini, & Nasi, 2010). Moreover, different types of strategic networks need to be managed differently (Järvensivu & Möller, 2009; Möller & Rajala, 2007; Möller & Svahn, 2003): networks in established industries or aiming at incremental change need different management and coordination mechanisms than networks operating in emerging business fields, so-called 'emerging business nets' (Möller & Rajala, 2007). System-building networks are emerging business nets, as they operate in great uncertainty in emerging business fields, trigger radical system-wide changes, and combine old and new actors. The majority of network management research has focused on networks in more established business fields (Choi & Hong, 2002; Håkansson & Persson, 2004; Möller & Svahn, 2009; Wilhelm, 2011), and the management of networks in emerging business nets is under-researched (Möller & Svahn, 2009). The few studies on network management in emerging business fields focus on the firm's perspective, examining how managers can reap the most benefits for their firm from their network collaboration (Ford & Håkansson, 2013; Freytag & Ritter, 2005; Gulati, 1998; Håkansson & Ford, 2002; Möller & Halinen, 1999; Partanen & Möller, 2012; Ritter & Gemünden, 2003a, 2003b, 2004; Ritter, Wilkinson, & Johnston, 2004; Thorgren, Wincent, & Örtqvist, 2009). However, rather than management within networks to reap firm-level benefits, this chapter focuses on the management of networks to reap system-level benefits.

In sum, network management at the network level in emerging business fields is under-explored (Aarikka-Stenroos et al., 2014), and more empirical research is required to generalize exploratory findings (Heidenreich et al., 2016; Rampersad et al., 2010). Therefore, it is important to investigate the key drivers of effective network management at the network level (Rampersad et al., 2010). The aim of our chapter is to gain a better understanding of how system-building networks are managed to build a new business ecosystem. Our research question is "how are networks for collective system building managed to reach their collective system-building objectives?" From the literature, we have identified the key factors of network management to achieve common objectives, and we empirically examined whether these key factors were relevant for system-building networks and how they are manifested in these networks.

This chapter contributes to the emerging theory of network management (Järvensivu & Möller, 2009; Möller, 2010; Möller & Halinen, 1999; Möller & Rajala, 2007; Möller & Svahn, 2003, 2009, Ritter & Gemünden, 2003a, 2003b, 2004; Ritter et al., 2004). Instead of focusing on the firm, we study network management and the outcomes at the network level, in the context of building a new business field or business ecosystem for sustainability technologies. We provide additional insights into key factors of network management in emerging business fields.

4.2. Setting the scene: Sustainability transitions, the smart grid sector and system-building networks

To investigate how collaborative inter-organizational networks are managed to build new business fields, we chose the empirical case of the Dutch smart grid sector, a field in which actors develop interdependent and compatible products and services under great uncertainty, and collaborate to establish a new business field.

The Dutch smart grid sector is an emerging technological system. A smart grid is an electricity network combined with an ICT network, adapted to renewable energy sources. Its 'smartness' allows balancing the supply and demand of energy on the grid, thus making the electricity grid more sustainable, efficient and robust (Planko et al., 2016; Verbong, Beemsterboer, & Sengers, 2013). For example, smart washing machines enable users to do their laundry at the very moment when there is a surplus of energy on the grid, caused by other users' solar panels producing excess energy because of sunny conditions. Essentially, smart grids are not one technology, but a complex set of intertwined technologies.

Transition to a new technological regime is a long and difficult process. In order to implement their products and to achieve a sustainability transition, innovative actors build coalitions not only to develop new technologies, but also to create markets, build infrastructures and achieve changes in user practices, regulations, policy and cultural meaning (Geels, 2010). Regarding smart grids, actors also face many obstacles. There is still great uncertainty about the future evolution of the smart grid sector, and about how smart grids will evolve (Verbong et al., 2013), leading to a reluctance to invest (Tricoire, 2015). Moreover, some incumbents oppose the energy transition (Van Der Schoor & Scholtens, 2015). Users' daily lives are influenced by the new technology: its adoption requires drastic changes in both user behavior and society (Van Der Schoor & Scholtens, 2015; Verbong et al., 2013). To overcome these challenges and to build a new ecosystem, smart-grid actors closely collaborate in system-building networks.

In the Netherlands, firms along the energy value chain, research institutes, government actors and user groups are working hard to develop and implement smart grid technology. These actors form various networks with different constellations and different aims, for example testing full-scale smart grid concepts in practice, or standardizing or accelerating smart grid development and implementation (Planko et al., 2016). With these activities, such system-building networks aim to build a new business field with the smart grid technology at its core.

The phenomenon of system-building networks has been observed particularly in relation to sustainability transitions (Musiolik & Markard, 2010). Insights from sustainability transitions are very useful for understanding the emergence of new business fields and for bringing innovations to the market (Knight et al., 2015; Möller, 2010).

4.3. Key factors of effective network management: Proposal of a conceptual framework

Network management is defined as the tools and strategies used to manage a deliberately established inter-organizational collaboration in order to achieve its common goal (Klijn, Steijn, & Eldenbos, 2010; Milward & Provan, 2003b). It differs from organizational management, as networks have no organizational hierarchy and managers cannot apply the command-and-control mechanisms that are widely used within organizations. Instead, networks need to be managed in collaborative, non-hierarchical ways (Agranoff, 2006; Agranoff & McGuire, 2001; Dooley & O'Sullivan, 2007; McGuire, 2002; Milward & Provan, 2003b, 2006; O'Toole, 1997). The management of inter-organizational networks has been studied in many different, often overlapping fields and from different perspectives (Möller & Rajala, 2007), including industrial and business networks, strategic networks, innovation networks, and whole networks (Agranoff, 2006; Dhanaraj & Parkhe, 2006; Gulati, Nohria, & Zaheer, 2000; Järvensivu & Möller, 2009; Jones, Hesterly, & Borgatti, 1997; Klijn et al., 2010; Milward & Provan, 2003a; Milward, Provan, Fish, Isett, & Huang, 2009; Möller & Rajala, 2007; Möller & Svahn, 2003; Ritter et al., 2004). These studies have been conducted in very different empirical contexts but can be used to develop theory on network management of inter-organizational networks (Järvensivu & Möller, 2009).

For system-building networks, the literature on goal-directed networks is most relevant, particularly the literature on strategic networks. Within this literature stream, the literature on emerging business nets – and especially on innovation networks – is most pertinent. Emerging business nets are future-oriented networks composed of actors aimed at developing new technologies, products and business models, or even creating new business fields. These actors strive for radical, discontinuous and system-wide change; they operate under great uncertainty and their value-generation potential may only be fully realized in the future (Möller & Rajala, 2007; Möller & Svahn, 2003, 2006). The literature on emerging business nets does not yet include an overview of key factors of effective network management to achieve system benefits. Some research has been conducted in established industries on how to manage or orchestrate whole networks at the network level (Milward & Provan, 2003a; Provan et al., 2007; Turrini et al., 2010). However, these insights have not yet been tested for networks in emerging business fields.

In the following sections, we define network effectiveness and subsequently give an overview of the key factors of effective network management.

4.3.1. Network effectiveness and its key factors

According to Rampersad et al. (2010), the most important outcome of network management is network effectiveness, which is defined as attaining positive network-level outcomes that could not normally be achieved by individual organizational participants acting independently (Provan & Kenis, 2008; Raab, Mannak, & Cambre, 2013; Russell, Meredith, Childs, Stein, & Prine, 2014). Other authors define network effectiveness as (1) the actual or perceived ability to reach predetermined network goals (Turrini et al., 2010; Weiss, Anderson, & Lasker, 2002), (2) the perceived outcomes of network management strategies (Klijn et al., 2010), (3) the degree to which network collaborations are successful (Rampersad et al., 2010), or (4) the net's capability to invent and produce solutions that provide markets with more value than existing offerings (Möller & Svahn, 2003). Based on these definitions, we define network effectiveness as the perceived attainment of positive network-level outcomes with regard to reaching predetermined network goals.

To manage a network effectively, a number of key factors should be in place. Such key factors are elements that enhance network effectiveness (Rampersad et al., 2010; Thorgren et al., 2009). They are usually intertwined and influence each other (Klijn et al., 2010; McGuire, 2002), and together they enable the network to reach its goals, i.e. they contribute to network effectiveness. We identified key factors from the literature that contribute to effective network management at the network level and that are relevant for the management of networks in emerging business fields. We found that some factors are characteristics of the network whereas others are processes that enhance these characteristics. For example, some authors classify ´trust´ as a characteristic while others regard ´trust building´ as a managerial process. In order to make networks effective, managers have to create favorable conditions in which network actors can achieve positive network outcomes (Rusanen, 2013). We therefore decided to categorize the identified factors by network characteristics, as 'favorable conditions that need to be established'. Network goals can best be reached if these characteristics (e.g. trust) are in place. This, of course, needs to be organized and managed (e.g. trust building). We imply that managers strive to achieve these network characteristics by carrying out the relevant processes.

It was difficult to use an existing classification to merge the identified key factors because each author had chosen slightly different categories. Since we use key factors from different literature streams, some of the factors we identified would not fit into the existing categories. As Ritter et al. stated, "the problem with today's body of relationship and network literature is that it is fragmented and different pieces do not seem to fit together" (Ritter & Gemünden, 2003, p. 692). Therefore, we generated our own classification, which included sufficient categories to classify all the key factors but not too many categories, as this would make categorization less useful.

We have clustered the key factors of network management into the following four categories: network composition, governance structure, managerial processes and relational factors. *Network composition* involves the structural factors regarding the composition of the network. *Governance structure* comprises the structural characteristics that influence network governance. The cluster *managerial processes* contains the process factors, i.e. the core network management functions. The category *relational factors* comprises the personal and interpersonal factors (or 'soft factors') that influence network effectiveness. The categories and their key factors are explained below. A conceptual framework of all key factors is shown in Figure 4.1.

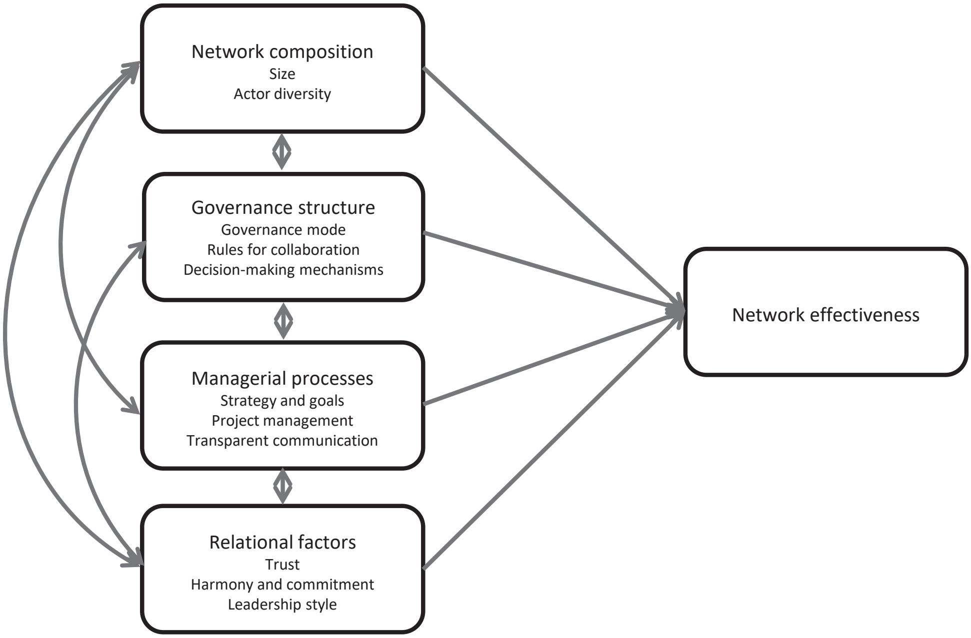

Figure 4.1: Proposed network management framework: key factors of network management (creation of the author, key factors based on literature review, clustering by author)

The key factors of network management described below can be – and often are – interrelated. Network management input, managerial behavior and their outcomes influence each other (Freytag & Ritter, 2005; Håkansson & Ford, 2002; Klijn et al., 2010; McGuire, 2002; McGuire & Agranoff, 2011; Turrini et al., 2010). For example, a high level of trust increases harmony and reduces formalization (Milward & Provan, 2003a; Rampersad et al., 2010), and aligned network goals may increase commitment (McGuire, 2002; O'Toole, 1997; Provan & Kenis, 2008). We are aware of this interrelatedness and take this into consideration when necessary. In Figure 4.1 the interrelatedness of key factors is visualized by arrows connecting the key factors. Of course, other factors also influence the realized network effectiveness, such as uncertainty, the complexity of goals and tasks involved, and the knowledge level of available network members. Since our interest is in network management, we focus on key factors related to network management.

4.3.2. Network composition

The two main factors of network composition are size and actor diversity (Russell et al., 2014; Turrini et al., 2010). An effective network should be large enough to carry weight but not too large to manage or to have a common goal. Depending on the network goal, there may need to be more actor diversity, i.e. more diversity in resources and abilities (Ojasalo, 2008; Thorgren et al., 2009; Turrini et al., 2010). To a large extent, the composition of the network is decided at the start. When networks are already in place, their composition may still be influenced by the inclusion and removal of members (Järvensivu & Möller, 2009; Möller & Rajala, 2007; Partanen & Möller, 2012; Ritter & Gemünden, 2003b; Rusanen, 2013; Spieth, Clauss, & Landsperger, 2011) and by keeping members committed (McGuire, 2002).

4.3.3. Governance structure

Governance structure includes the network's governance mode, rules and decision-making processes. These structures are often determined at the network design phase but then adjusted at different network stages (Raab et al., 2013; Russell et al., 2014).

Governance mode

Strategic management of the network involves the establishment of a formal organization containing all the net members involved (Möller & Rajala, 2007). The appropriate governance mode for networks depends on several factors, including size, goals, task and trust (Provan & Kenis, 2008). For small networks, the self-governing form may be appropriate, where network members collectively make both strategic and operational decisions about how the network operates, without formal governance (Provan et al., 2007). However, if the network grows, this mechanism may become inadequate (Milward & Provan, 2006).

Most network management authors reason that networks should be coordinated by a single entity. For example, Rampersad et al. state that "[a] single coordinating body is necessary to ensure continuity and the achievement of network objectives" (Rampersad et al., 2010). This coordinating entity may be an appointed network manager, an elected board, a hub firm or a network administrative organization (Agranoff, 2006; Dhanaraj & Parkhe, 2006; Ojasalo, 2008; Spieth et al., 2011; Turrini et al., 2010). For innovation networks, the existence of a network manager is often presented as the best option (Heidenreich et al., 2016; Landsperger et al., 2012; Spieth et al., 2011). The network manager directs network processes, acts as an indispensable central node, arranges, moderates and mediates meetings, resolves disputes, sets goals, creates an atmosphere of harmony and trust, and provides incentives to cooperation (Agranoff & McGuire, 2001; Landsperger et al., 2012; Milward & Provan, 2003a; Turrini et al., 2010). Moreover, the network manager has decision-making powers and represents the network to the outside world (Landsperger et al., 2012; McGuire, 2002). Network managers greatly influence network effectiveness: they mobilize network resources and much vital information passes through them. In particular networks with high actor diversity that operate in complex environments – such as system-building networks – benefit from a network manager (Heidenreich et al., 2016).

Rules, agreements and decision-making mechanisms

For networks to function effectively, clear cooperation agreements and formalized rules for collaboration need to be established and implemented (Agranoff, 2006; Agranoff & McGuire, 2001; Partanen & Möller, 2012; Spieth et al., 2011; Turrini et al., 2010). Rules and agreements may be formal or informal. The higher the level of trust in a network, the lower the need for formalized rules and contracts (Ojasalo, 2008). Formalization increases precision and fairness, but too much formalization leads to inflexibility and rigidity (Choi & Hong, 2002).

Furthermore, decision-making processes should be shared and equitable (Agranoff & McGuire, 2001; Spieth et al., 2011). As network members are partners rather than superiors and subordinates, they reach agreement by consensus rather than by imposing decisions (Möller & Rajala, 2007). Voting rules are often part of the by-laws, but voting usually only takes place after agreement has been reached or as a last resort (Agranoff, 2006; McGuire & Agranoff, 2011).

4.3.4. Managerial processes

Coordination of tasks and activities at the network level is necessary for network effectiveness; activities need to be orchestrated (Dhanaraj & Parkhe, 2006; Möller & Svahn, 2003; Paquin & Howard-Grenville, 2013). While influencing the network structure and composition, network managers also need to direct network processes, create optimal conditions for collaboration, and contribute to maximal performance (Chesbrough & Appleyard, 2007; Järvensivu & Möller, 2009). Adequate management mechanisms ensure that network outcomes are achieved (Ojasalo, 2008; Rampersad et al., 2010; Ritter et al., 2004; Rusanen, 2013; Spieth et al., 2011). The more integrated and coordinated the network is, the more effective it will be (Milward & Provan, 2003b).

Strategy and goals

To manage networks effectively, an overall strategy needs to be developed at the network level (Klijn et al., 2010; Ojasalo, 2008; Ritter & Gemünden, 2004; Rusanen, 2013). This strategy development includes the development of a vision and a clear mission, the setting of goals and common objectives, as well as a clear definition of deliverables (Agranoff, 2006; Agranoff & McGuire, 2001; Möller & Svahn, 2003; Rampersad et al., 2010; Turrini et al., 2010). This helps the effective allocation of resources towards network goals (Spieth et al., 2011). Agenda setting, developing a systemic view of the business field, and envisioning the development pathway of the new business field mobilizes actors, reduces uncertainty and provides direction for action (Möller, 2010; Möller & Rajala, 2007; Möller & Svahn, 2006). Network participants are more likely to be involved and committed to the network if there is general consensus on broad network-level goals (Provan & Kenis, 2008). Over time, network objectives need to be adapted according to changes in the external environment (Turrini et al., 2010).

Project management

The strategies described above also need to be implemented (Ojasalo, 2008; Ritter et al., 2004; Rusanen, 2013). To achieve the network goals, the network has to be managed as a project (Dhanaraj & Parkhe, 2006; Möller & Rajala, 2007). For example, administrative systems and processes need to be in place and network members need to be motivated (Page, 2003; Turrini et al., 2010), and regular meetings need to be organized with written agendas provided in advance (Heidenreich et al., 2016; Spieth et al., 2011; Turrini et al., 2010). In fact, the regularity of network gatherings is one of the main stabilizing factors (Spieth et al., 2011). Part of managing the network is to distribute tasks among the network members, to determine who is responsible for what, and to establish how to respond to free-riders (Milward & Provan, 2006; Möller & Svahn, 2003, 2006; Partanen & Möller, 2012; Ritter et al., 2004; Rusanen, 2013). This is especially challenging in networks, due to the lack of a chain of command (Milward & Provan, 2006). The performance of the network and its members as well as network progress should be measured and evaluated, in order to ensure the effective use of resources (Raab et al., 2013; Ritter et al., 2004; Rusanen, 2013; Spieth et al., 2011; Turrini et al., 2010).

Transparent communication

Another key factor of network management is clear and transparent communication (McGuire, 2002; Spieth et al., 2011). This includes the provision of all necessary information to all participants, enhancing information exchange between participants, and regular and transparent documentation of the network´s progress (Heidenreich et al., 2016; Rampersad et al., 2010; Ritter et al., 2004; Rusanen, 2013; Spieth et al., 2011). Transparent communication facilitates information flows and information capture, thus making networks more effective. Transparency can be increased with electronic tools, such as online interaction platforms (e.g. exchange forums and web-based team rooms), web-based information systems, and formal communication channels such as email and teleconferencing (Agranoff, 2006; Dhanaraj & Parkhe, 2006; Heidenreich et al., 2016; Rampersad et al., 2010; Spieth et al., 2011; Turrini et al., 2010).

4.3.5. Relational factors

The last cluster of key factors summarizes so-called 'soft factors', which are based on culture and norms as well as the behavior of network actors. These factors influence the atmosphere in the network and thus its outcome (Dhanaraj & Parkhe, 2006; Heidenreich et al., 2016).

Trust

Trust is defined as "confidence in an exchange partner´s reliability and integrity" (Rampersad et al., 2010). It is considered the main mechanism behind the dynamism of networks, making networks more efficient and effective (Heidenreich et al., 2016; Ozman, 2009; Spieth et al., 2011). The more trust there is in a network, the greater the ability to accomplish network goals (Milward & Provan, 2006). It is important that network managers develop trust and understanding between network members (Milward & Provan, 2006; Raab et al., 2013; Ritter et al., 2004). Trust can be built by having frequent high quality face-to-face interactions, by exhibiting frankness, by keeping promises, and through clear, pre-determined sanctions for trust violation (Dhanaraj & Parkhe, 2006; Milward et al., 2009; Ozman, 2009; Rampersad et al., 2010). Moreover, trust is seen as a complement to or substitute for governance mechanisms. The higher the level of trust, the less control and the fewer written agreements needed, thus reducing governance costs (Dhanaraj & Parkhe, 2006; Ojasalo, 2008; Provan et al., 2007; Rampersad et al., 2010) and increasing network effectiveness.

Harmony and commitment

Another key factor in network management that refers to the relationship between participants is harmony**.** A higher level of harmony increases network effectiveness**.** Harmony is described as an understanding of give and take, and a preparedness to acknowledge each other´s viewpoints (Heidenreich et al., 2016; Spieth et al., 2011). This level can be increased by developing mutual interests among network members, by involving actors in the planning and coordination of activities, and by addressing and managing conflicts (Provan & Kenis, 2008; Rampersad et al., 2010; Rusanen, 2013).

Furthermore, the level of commitment from members must be sufficiently high to attain network-level goals. Network members must allocate resources and staff to the network. In the absence of a hierarchy, they must voluntarily devote their time and skills to network tasks (Dhanaraj & Parkhe, 2006; Milward & Provan, 2006; Turrini et al., 2010). Moreover, the loss of members would decrease the dynamic stability of the network and would lead to a loss of knowledge, skills and resources. Therefore, an important task of network management is building and maintaining the commitment of all network members, especially critical ones (Järvensivu & Möller, 2009; Milward & Provan, 2006).

Leadership style

Whereas governance mode and coordination mechanisms are significant factors in network management, even more important than the organizational structure is the management quality (Klijn et al., 2010; Milward & Provan, 2006). In contrast to managers in organizations, network managers cannot exert top-down authority or command action. Nevertheless, they are responsible for the network output (McGuire, 2002; Turrini et al., 2010). Therefore, a specific type of leadership is necessary for network management, in which the principle of 'soft guidance' is required as a replacement for command-and-control. The network manager should adopt a synchronizing, enabling role, direct participative decision-making processes, and act as an impartial manager. He should inspire and motivate others to form a common vision and to freely engage in network tasks (Agranoff & McGuire, 2001; Landsperger et al., 2012; Milward & Provan, 2003a; Russell et al., 2014). The ideal network manager should possess high levels of authority as well as functional and task competence; moreover, he needs methodological competences similar to those of a project manager (Landsperger et al., 2012).

Table 4.1 summarizes how the key factors of network management described above should be implemented at the network level in order to increase network effectiveness. We use it as a conceptual framework for our empirical study of the system-building networks in the smart grid sector.

Key factors of network management	**How key factors should be implemented to increase network effectiveness**
Network composition	
Size	Depends on network's aim: large enough to have influence but small enough to be manageable.
Actor diversity	Depends on network's aim: higher diversity means more resources and capabilities but also more conflict potential.
Governance structure	
Governance mode	Different modes possible. Important to have a single coordinating body (organization or leader) in charge.
Rules for collaboration	Clear cooperation rules necessary. Formalization increases fairness but too much formalization leads to inflexibility.
Decision-making mechanism	Important to have consensus decisions (participative and equitable decision-making).
Network leadership structure	Assigned network manager contributes to better coordination and information flows within network.
Managerial processes	
Strategy and goals	Clear vision and common goals necessary to reach network objectives. Goal-alignment leads to higher effectiveness.
Project management	Good project management (regular meetings, written agendas, administrative systems) necessary to keep members motivated and to achieve network goals. Measuring and evaluation ensures effective use of resources.
Task distribution	Determine who is responsible for what; clear deliverables.
Transparent communication	Clear and transparent information exchange between all members increases information flow and information capture.
Relational factors	
Trust	Higher trust level increases ability to accomplish network goals.
Harmony and commitment	High level of commitment and harmony necessary for members to contribute time and resources to network.
Leadership style	Network effectiveness depends heavily on good network leader. Participatory leadership style necessary. Leader should adopt synchronizing, enabling and impartial role. Ideal network manager should possess functional and task competence as well as project management competences.

Table 4.1: How key factors should be implemented to have a positive influence on network effectiveness

4.4. Method

We adopted a case study approach, as was suggested by Choi & Hong for conducting research in an emerging business field (Choi & Hong, 2002). This was a multiple-case study

(Yin, 2009) in the Dutch smart grid sector to help understand how system-building networks are managed effectively.

The first step was the identification of networks operating in the Dutch smart grid sector. In a pre-study we identified the national networks that established the Dutch smart grid field. We did so by asking key actors, e.g. spokespersons at national smart grid conferences and smart grid experts from industries and research institutes. The outcome was a list of six networks that work towards different aspects of collective system building (e.g. lobbying for suitable regulation, working towards standardization, and developing and optimizing technology). Each of the networks is described in more detail in Section 6.1. Together, these networks form the Dutch smart grid sector. Möller & Svahn (2003) state that a business field consists of several overlapping strategic networks, and the Dutch smart grid field comprises these six overlapping strategic networks. The actors of our researched networks are often also members of one or more other networks, which makes the Dutch smart grid field a suitable industry for analyzing the key factors of the network management of system-building networks. Table 4.2 gives a brief overview of these networks.

Network	**System-building objective**	**Number of participants**
A – Testing & Development	Testing technologies + knowledge development + feedback loops with user groups	3
B – Standardization Framework	Standardization, to accelerate the development of commercially viable offerings	3
C – Device Standardization	Standardization, to enable household devices to easily connect with energy management services.	3
D – Industry Association	Infrastructure development + lobbying for legislation supporting the new technology	3
E – Product & Service Development	Development of commercially viable products + business model generation	4
F – Knowledge Exchange	Sector-wide knowledge exchange + collaboration with government (to create enabling environment)	4

Table 4.2: Overview of the researched networks and their system-building objectives

The next step was data collection on the different networks. We interviewed 3-4 key actors from each network: the network managers and chairmen, as well as members of the board of directors. We stopped interviewing more actors when we found our data was saturated for the network. Table 4.3 gives an overview of our interview partners, their network, and their role in this network. In the results section, we refer to the interviewees by their numbers in squared brackets, e.g. [1] indicates that the quotation is from interviewee 1, who is the network manager of network C. As can be seen from the table, some of our interview partners were members of two or more networks and were thus able to provide insight into these networks.

Interviewee number	Network	Role in network	Case letter
1	C	Network manager	1C
2	F	Network manager	2F
3	E	Network manager / chairman	3E
4	E	Member	4E
5	E	Network manager / project manager	5E
6	E	Member	6E
7	D	Network manager	7D
8	F	Member (project leader of a pilot project)	8FA
8	A	Member	8FA
9	A	Network manager / project manager	9A
10	B	Network manager	10B
11	B	Member	11BA
11	A	Member (former network manager)	11BA
12	C	Member (program line leader)	12CD
12	D	Member	12CD
13	C	Member (program line leader)	13CF
13	F	Member	13CF
14	B	Network manager / chairman	14B
15	D	Member	15D
16	F	Member	16F

Table 4.3: Roles and network membership of interviewees

The interviews were semi-structured and were conducted face-to-face. Each interview took 60-100 minutes. Our interview guide was based on the key factors identified from the literature. In addition, we checked how the interviewees perceived the influence of these key factors on network management outcomes and whether they mentioned additional key factors. We based our method on Van der Valk et al. (2011), who asked interviewees about the way in which the network is managed, to derive implications for management, and on Rampersad et al. (2010), whose "level of theory and analysis is the net while measurement is carried out by surveying multiple key informants within each network organization while retaining focus on net issues" (p. 795). In the interviews we also asked about network effectiveness. In line with previous research, we measured network effectiveness by asking network members about the perceived success in reaching network goals (Klijn et al., 2010; McGuire, 2002; McGuire & Agranoff, 2011; Provan et al., 2007; Provan & Milward, 2001; Turrini et al., 2010). As a final step in the data collection, we triangulated our interview data by studying network websites and strategy documents found on these websites or provided to us by interview partners.

All interviews were transcribed and analyzed using Atlas.ti software. We coded the data according to the key factors of network management derived from the literature review. If no pre-defined code was suitable, new codes were added. We first conducted an in-depth analysis of each network, identifying how the different key factors were implemented and in what way the key factors contributed to the effectiveness of that specific network. Then we conducted a cross-case analysis, to look for patterns across networks. Subsequently, we compared findings per key factor of network management. This helped us we gain insight into the influence on network effectiveness for each of the key factors. As discussed in Section 3, we were aware that the key factors of network management may be interrelated. Therefore, we also considered the interrelatedness of key factors when it was indicated in the interviews how they influenced each other. Finally, these results enabled us to compare our empirical observations with the conceptual framework.

4.5. Findings

First, we briefly introduce the six system-building networks in the Dutch smart grid sector. Then we compare our findings per key factor with the conceptual framework that we established based on our literature review. In addition, we depict how the key factors are implemented at the network level in networks building a new business field: the Dutch smart grid field.

4.5.1. Brief case descriptions

We briefly describe the six networks below, with regard to their objectives and perceived success.

Network A: 'Testing & Development'

'Testing & Development' was initiated by firms wanting to develop advanced smart grid technologies and services to secure an affordable and reliable energy supply and to enable end-users to control their own renewable energy management in an uncomplicated way. The network was founded with the aim of large-scale demonstration through several pilot projects and to test and develop smart grid technology. Network members collaborate with actors all along the value chain, including end-users. Twelve firms cooperate in five large-scale pilot projects to develop, test and optimize smart grid technology, using open innovation. 'Testing & Development' is perceived as relatively successful. Pilot projects were conducted well and generated much valuable knowledge. Not all the initial ambitions were met, but actors realize that their ambitions had been too high at the beginning, and unrealistic in hindsight.

Network B: 'Standardization Framework'

'Standardization Framework' is a spin-off of 'Testing & Development'. A few companies of 'Testing & Development' realized that they wanted to accelerate standardization, but that this was less important to other members. To achieve their goal of standardization sooner, they decided to form an additional network, 'Standardization Framework'. To accelerate the development of commercially viable offerings based on its new standard, the network develops specifications and guidelines that enable companies to develop complementary smart energy products, services and solutions. 'Standardization Framework' is a partnership of seven firms: energy suppliers, network operators, electrical equipment manufacturers, consultancies, and IT companies. The members perceive the network as successful. A draft version of the standard has been produced. There is much interest in the framework from companies, also internationally.

Network C: 'Device Standardization'

'Device Standardization' was initiated by private firms together with a research institute in order to develop a standard.[8] This new open standard enables the connection of household devices with energy management services. The standard can be built into devices and energy management services of different manufacturers, and it enables the devices to work together as a team – for instance to decide whether to use, store or sell locally produced energy, or to determine which device should be switched on first. On a smartphone or tablet, users can set their energy preferences, by turning devices on and off, or up and down whenever they want. This results in significant cost savings for consumers. Members of this network include seven firms and a research institute. The network is perceived as relatively successful by its participants and has received international recognition for its expertise and the standard that was developed. However, the actual implementation of their standard is taking longer than was hoped – the network still needs to grow, both nationally and internationally.

Network D: 'Industry Association'

'Industry Association' is a network with only grid operators as members, but with close connections to other stakeholders. It was set up many years ago and aims at representing the interests of its members and at conducting lobbying activities. Moreover, it is leading the 'Action plan sustainable energy provision 2030'. The network has a chairperson who represents the network externally and who manages the network's administrative organization. This organization has 16 staff members and is financed by its member firms via membership fees. The members perceive 'Industry Association' as successful. It is well-organized and seen as a good platform for exchanging knowledge and experiences. As it is recognized and known by influential actors such as ministries, it is also successful at lobbying.

[8] Both 'Standardization Framework' and 'Device Standardization' work on standardization but on different parts of standardization within the smart grid system. They complement each other. The networks have signed an 'agreement of understanding', indicating that they accept and respect each other's standardization efforts.

Network E: ‘Product & Service Development’

‘Product & Service Development’ was initiated by public actors. The Dutch government wants to enhance the strength of the Dutch smart grid sector, so as to excel worldwide. Therefore, it initiated this collaboration of government, companies, universities and research institutes. The network aims at developing and launching innovative products and services in the smart grid field. Moreover, it wants to orchestrate and support the development of the smart grid ecosystem. The network is perceived as very successful, and actors are content with the way the network is organized and with its intermediary outcomes. Not only has the network created much awareness, but it has also established a procedure for different parts of the smart grid ecosystem.

Network F: ‘Knowledge Exchange’

‘Knowledge Exchange’ is a public-driven network. Its objective is to accelerate the introduction of smart grids by stimulating collaboration of relevant actors on both national and regional levels, by diffusing knowledge, and by creating positive conditions for the implementation of the technology. A governmental agency manages this network on behalf of the Dutch Ministry. ‘Knowledge Exchange’ differs considerably from the networks described above. While it conforms to the definition of strategic networks, it is actually a program initiated by the government, with the aim of increasing knowledge transfer and demonstrating that smart grids are a suitable technology to foster the energy transition. The network has more than 100 member firms and research institutions, which participate in one of the 12 pilot projects. Each pilot project has a representative who reports back to the network manager. The pilot projects are only connected to each other through the network manager, who functions as the central node. The network is seen as relatively successful, in terms of connecting a wide range of actors in the field, stimulating knowledge exchange and demonstrating the usefulness of smart grids.

All networks were perceived successful or relatively successful in reaching their intermediary objectives. Appendix 1 shows an overview of the key factors of network management per network.

4.5.2. Empirical evidence on key factors of network management at the network level

Table 4.4 shows a brief overview of the key factors, how they should be implemented to increase network effectiveness based on literature, and the observations we made regarding the effects on the perceived effectiveness of these key factors in the networks we studied.

Key factors of network management	How key factors should be implemented to increase network effectiveness	Observed effects on perceived network performance (detailed description in text below)
Network composition		
Size	Depends on network's aim: large enough to have influence but small enough to be manageable.	Smaller size increases effectiveness; larger size may be necessary to link all players in sector for information flow/transparency, but this diminishes the exchange of vital information.
Actor diversity	Depends on network's aim: higher diversity means more resources and capabilities but also more conflict potential.	Depends on network's aim. Diversity necessary for most aims. Diversity does not necessarily increase conflict potential. Higher actor diversity may also mean that there is less direct competition which facilitates exchange of vital information.
Governance structure		
Governance mode	Different modes possible; important to have a single coordinating body (organization or leader) in charge.	Preferred mode: board of directors and then working groups who report back. Single coordination body necessary; consisting of network members; top-down approach not considered as effective (but may be necessary for sector-wide network which increases transparency).
Rules for collaboration	Clear cooperation rules necessary. Formalization increases fairness but too much formalization leads to inflexibility.	Clear rules necessary. Trust is better than much formalization. Very clear boundaries set for information sharing as enabler for collaboration.
Decision making mechanism	Important to have consensus decisions (joint and equitable decision-making).	Discussion till consensus (A-E) considered most effective. Top-down decision-making not appreciated by network members.
Network leadership structure	Assigned network manager contributes to better coordination and information flows within network.	Mostly two network leaders, rather than one. One content specialist and one project manager.
Managerial processes		
Strategy and goals	Clear vision and common goals necessary to reach network objectives. Goal alignment leads to higher effectiveness.	Jointly created vision and goals help to motivate members and give direction; if not jointly created, goals entail less motivation. Goal-alignment (firms-to-network) leads to higher effectiveness. Frequent goal-adjustment necessary in quickly changing environment. Goal-adjustment and goal-alignment influence network composition.
Project management	Good project management (regular meetings, written agendas, administrative systems) necessary to keep members motivated and to achieve net goals. Measuring and evaluation ensures effective use of resources.	Good project management vital to keep members motivated, as financial benefits lie in future and membership is voluntary Measuring and evaluation perceived important but proves difficult in uncertain, fast-changing environment.

[continued on next page]

Key factors of network management	How key factors should be implemented to increase network effectiveness	Observed effects on perceived network performance (detailed description in text below)
Task distribution	Determine who is responsible for what. Require clear deliverables.	Participatory distribution (ask who volunteers for a task or who would be most suitable).
Transparent communication	Clear and transparent information exchange between all members increases information flow and information capture.	Perceived as very important; electronic tools used such as website, platform, emails; provision of all information to all members.
Relational factors		
Trust	Higher trust level increases ability to accomplish network goals.	Trust seen as major factor for network effectiveness, especially because members have to share vital information. High level of trust decreases governance costs and facilitates collaboration and knowledge exchange. Selecting individuals when composing network increases trust level.
Harmony and commitment	High level of commitment and harmony necessary for members to contribute time and resources to network.	Goal-alignment increases harmony and commitment. High trust (hand-picked members) increases harmony. Network management style increases harmony and commitment.
Leadership style	Network effectiveness depends heavily on good network leader. Participatory leadership style necessary. Leader should adopt synchronizing, enabling and impartial role. Ideal network manager should possess functional and task competence as well as project management competences.	Leadership quality has high impact on network effectiveness. Participatory leadership style increases motivation. Neutral leader decreases fear of opportunistic behavior. Content-specialist necessary to chair meetings and represent network externally. Person with project management skills necessary to ensure good process management and high member motivation Two or three leaders necessary, often an external person (non-network member) is hired to fulfill one of these roles.

Table 4.4: Conceptual framework of key factors of network management and observed effects on perceived network effectiveness

Below we elaborate on each of the key factors and on how the managerial practices used influence the perceived network effectiveness. We illustrate our observations with selected examples from the networks we studied.

The single-case analysis (Appendix 1) indicates that there are many similarities between the networks. To avoid repeating results that are similar in all networks, we instead describe the key factors for all groups and highlight the differences between certain networks or describe specific conditions in which different types of managerial practices were used.

Network composition

The networks studied differ in size and actor diversity. Depending on the goal of the network, it is more desirable to have a smaller or larger network. For example, for the network 'Knowledge Exchange', the goal is industry-wide knowledge exchange. Therefore, a large network composed of diverse actors is desirable. 'Device Standardization', which aims to develop a standard for smart grid applications, deliberately started small so that the goal, a common standard, could be reached. 'Industry Association' is an example of a network with homogeneous actors, as it is an industry association. By contrast, 'Testing & Development' consists of members all along the energy supply chain, which is necessary to develop and optimize innovative products for end-users. The multiple-case study showed that the most suitable composition of the network in terms of size and diversity depends on the network's system-building goal.

The network composition needs to be adjusted over time, as a result of goal adjustment or goal alignment. For example, 'Device Standardization' had been founded by three organizations. The small size was beneficial in the initial phase of the network, because the goal of the network was to produce a standard, and according to the interviewees it is easier to develop a standard with fewer organizations. One of the organizations is a research institute that made sure that the developed standard would be beneficial to many companies, not only for those directly involved. For the next step, the rollout of the standard, more member firms are necessary.

With regard to stability, there was a remarkable finding in 'Testing & Development'. This network started with great ambition, resulting in a situation that *"ambitions were higher than activity within the network" [10]*. Some members were more ambitious than others, which led to conflicts and temporary stagnation. Asking companies to invest a substantial membership fee into the network solved this problem: only the companies that were really interested and ambitious invested, and the less interested firms decided to leave. This led to a decrease both in the size of the network and in the number of pilot projects. However, it strengthened the network and enabled it to achieve its goals.

Cluster governance structure: Network governance structure and leadership

Networks A-E have a similar governance structure. They have a board of directors that takes the most important decisions and which consists of 4-12 members, depending on the network. Moreover, they have workgroups, pilot projects or program lines which report back to the board of directors. Strategic decisions are taken during meetings of the board of directors. Furthermore, there are usually two network leaders who steer and orchestrate network activities. The networks 'Testing & Development', 'Standardization Framework', 'Device Standardization' and 'Product & Service Development' have two network leaders: a chairman, who is a technical expert and responsible for the content and who acts as spokesperson of the network, and a project manager, who directs the network processes. This role separation can be illustrated by the network 'Standardization Framework'.

‘Standardization Framework’ has two leaders: a chairperson, who is an employee of one of the member firms, and a network manager from an external organization. The network deliberately employed an external network manager, someone with expertise and connections in the energy field who was not an employee of one of the member firms, to ensure and signal that this person was a neutral party, and not there to push his company’s objectives. This neutrality was considered especially important as the objective of the network is to develop an industry-wide standard. The network manager directs the processes in the network and acts as a project manager with a participatory leadership style and expertise in developing group dynamics. The board is chaired by the network chairperson, who is in charge of the network’s content. The chairperson is a technical expert and an employee of one of the member firms.

Financing mechanism

The financing mechanism of the networks seemed to be an important part of the governance structure. It influenced network composition (as described above), decision-making power as well as member commitment.

In ‘Testing & Development’, there was some dissatisfaction about members putting more effort and resources into the network than others. This problem was solved by introducing a membership fee. Members had to invest a substantial sum of money into the pilot project. For some members this was a breaking point, and they left the network, causing the network to shrink to twelve members. However, the smaller size was perceived as positive; it contributed to the success of the network, as *“only the motivated ones stayed” [8],* and these remaining members worked hard on the project.

Networks ‘Testing & Development’, ‘Standardization Framework’ and ‘Industry Association’ asked membership fees, and ‘Device Standardization’ expected financial contributions. By contrast, to participate in pilot projects of the network ‘Knowledge Exchange’, networks of firms were required to apply with a project plan; based on this, they received a first subsidy payment. Further payments were received when milestones described in the project proposal were achieved. This is the only network in which members receive money, instead of having to contribute money. The subsidy mechanism has been mentioned as one of the reasons why the network is not as successful as it could be.

Rules and decision-making mechanisms

Interview partners stated that they perceived the exact form of the chosen governance mechanism as less important for network effectiveness than having clear rules and decision-making mechanisms in place. Clear rules for collaboration are necessary to enable decision-making and knowledge sharing and to facilitate the collaboration processes. Within each system-building network, it is very clearly defined to which degree knowledge sharing is allowed within and outside the network. These clear boundaries actually enable the sharing of information.

In general, decisions were made at the highest possible level, and as few members as possible were involved in the decision-making process, to avoid these processes becoming too slow and too unclear.

To reach decisions, a general model can be observed. The chairperson or project leader provides the board members with relevant information prior to the meeting, so that they can make an informed decision. Managers prefer to receive tailored information, to better understand how the decision will benefit both their individual firm and the system in general. During board meetings, members discuss the decision to be taken, and in the end this always leads to consensus.

Cluster managerial processes: Strategy, goals, goal adjustment and goal alignment

To give direction to the activities of system-building networks, it was perceived important that a shared vision and mission was created jointly with all network members. To move towards this vision effectively, goals need to be set. In the fast-changing environment of the emerging smart grid sector, these goals need to be frequently adjusted to the changing environment. In networks A-E, members jointly determined vision and goals. There are two reasons why this was necessary. First, the key actors' input was required because of the high uncertainty on how the sector would evolve. Second, this ensured that company goals, which could be quite diverse within a network, would be aligned to the network's goals: either because members would make sure that the network goal was in line with their company's strategy, or because they would later try to align their long-term company strategy with the newly established network goal so that the company could reap future benefits from the new market.

An interesting mechanism for goal alignment was observed in 'Testing & Development'. When this network started, it had 36 members and five pilot projects were set up. Goals and objectives were formulated and adjusted several times after the network was set up, which was necessary because at first nobody knew where the smart grid sector was heading or how the technology would evolve. Moreover, it turned out to be difficult to collaborate efficiently together with so many parties because member firms had different goals. Some goals turned out to be so different from the network goals that the members discontinued the collaboration and left the network. This was perceived as positive, because only the motivated firms stayed and as their goals were aligned, they all worked hard towards the network goals. Another goal-alignment mechanism was that some companies within the network realized that together they strived for a different goal than the defined network goal, leading to a spin-off of a sub-group of members. They formed the network 'Standardization Framework', while they remained members of 'Testing & Development'; in the new network this smaller subgroup could work on their common goal with equally high levels of motivation.

Project management

Interviewees experienced project management as very important for the effective network management of system-building networks. System-building networks reap the benefits of their collaboration at a point much later in the future; in the present it is often still unclear what these benefits will be exactly. Therefore, meetings and interactions need to be well-organized to keep members motivated. Especially since network membership is voluntary (as opposed to participation in intra-organizational project groups), poor project management will lead to a decrease in commitment and motivation as well as an absence of members. After a meeting without a clear agenda, it is likely that only few members will attend the next one. *"If they know a meeting will be well-chaired and useful, people don't feel like they are wasting their time." [11]* Some interviewees stated that the quality of its project management can make or break a network.

Task distribution, incentivizing members and dealing with free riders

In networks we studied, tasks are distributed on a voluntary basis, according to members' skills and expertise. Participants are intrinsically motivated, members *"like the challenge of solving a problem, of developing something that hasn't been there" [3].* Since command-and-control mechanisms cannot be used, the network manager should *"arrange that things get done" [8].* This is achieved by personally addressing members and requesting they bring in their specific expertise. *"Usually the most capable person for the task volunteers to do it." [10]*

Network E experienced a single case of free-riding behavior: a member did not perform but received all the available information. Subsequently, the network manager had a private talk with the person concerned, who stepped down as a consequence.

Transparent communication

Interviewees described clear and transparent communication as an important key factor for network management. In a newly emerging sector, information is sparse and hard to attain, which makes it very valuable. All networks make use of electronic tools such as websites, email and teleconferencing. Moreover, they organize roadshows and networking events to increase information flows and connections among actors in the field. Several network managers mentioned that web-platforms for open innovation would enhance the information flow within the network and the sector, but so far such web-platforms have not yet been implemented.

Cluster relational factors: Trust

Networks A-E experienced high levels of trust, harmony and commitment. Trust was seen as a major factor for network effectiveness, particularly because actors in these networks have to share vital information about their business and their ideas in order to establish a compatible ecosystem. Most often trust is used as a governance mechanism taking the place of written agreements on IP rights. Drawing up written agreements for everything is seen as too costly and as hampering knowledge exchange. Since firms in the sector work in different constellations on different projects, it was often agreed that *“what was developed or shared in the pilot project, stays in the pilot project” [13],* meaning that members agreed not to share knowledge with other close partners. This clear definition of boundaries is based on trust. In some networks a level of trust was present from the start, when most of the firms had common collaboration experiences in previous projects. A remarkable trust-building mechanism was observed in network ‘Product & Service Development’, in which trust was established by handpicking members. All ‘active’ network members (the board of directors) were hand-selected. The network manager selected some members he knew personally, and these suggested further members. From the first meeting on, the atmosphere was excellent and participants were highly motivated. There were high levels of harmony and trust in the network, and its members perceived it as very successful because of the high initial level of trust and harmony, which remained at a high level thanks to network leadership skills (see below).

4

Commitment, motivation and harmony

High levels of commitment and motivation could be reached in the networks if members realized they were contributing to a state-of-the-art solution to a problem, if they were given freedom to bring in ideas and expertise and if there was a high level of trust which enabled them to share these ideas and knowledge without having to fear opportunistic behavior from other members. A participatory leadership style and good project management helped to keep motivation and commitment high. Moreover, network members were intrinsically motivated because they wanted to contribute to the transition process. *“Their drive and motivation is very high. It comes out of themselves, when they are together they all want to go faster.” [10]*

Leadership style

A network leader, someone who orchestrates the network, was seen as an important enabler of network success. *“If you don’t have somebody who stands up and says ‘if you do this and you do that, then we achieve our goals much faster’, people just keep walking around and don’t get anywhere at the end of the day.” [11]* Interviewees preferred a participatory leadership style. *“You don’t want to have a dominant leader, but rather a strong and committed one.” [6] “A top-down approach would absolutely not work. That’s impossible.” [7]*

The network leader should be strict when it comes to time-management during meetings and make sure that a discussion ends in a decision, to increase the effectiveness of meetings. However, when it comes to task distribution and goal development, network members should always be asked for their opinions and be included in the process. *“As a network leader you have to ask them questions. They themselves need to be in charge.” [10]*

"I don't have any top-down authority on them. Of course I talk with them about what we are trying to achieve together, but then they have to take their own responsibility and make that happen." [7]

The importance of the leadership style can be illustrated by the example of network 'Product & Service Development', the most successful network in terms of reaching its goals. The high motivation of the members of this network was attributed to the capabilities of the network manager, in addition to the high trust level. The manager of 'Product & Service Development' has a very participatory leadership style. He directs the participants to reach decisions, but they are the ones taking the decisions. He does this so subtly that some of the interviewees even stated, *"We do not have a leader. We do it all by ourselves." [4]* This perceived freedom and power seems to be very motivating. All members work hard to achieve the self-defined network goals, and everyone is glad to bring in their own expertise.

4.6. Discussion and conclusions

First, we discuss key novel findings as compared to the literature. Then we highlight the theoretical implications as well as the managerial implications of our study. Finally, we point out the limitations of this study and ideas for future research.

4.6.1. Discussion of findings and theoretical implications

In this study, we introduce a special type of emerging business network into the network management literature: collective system-building networks. Collective system-building networks fall within the definition of emerging business networks as (1) they achieve common innovation goals, such as the joint development of products, services or processes, (2) they create so-called dominant technological designs to accelerate market construction by influencing public opinion, and (3) they generate commercially viable business applications out of the evolving technology (Möller & Rajala, 2007). However, system-building networks have even more far-reaching goals, as they pro-actively aim to establish new business fields, and this has implications for the type of management they require (Järvensivu & Möller, 2009; Möller & Rajala, 2007). The existing network management literature turned out to be useful to study system-building networks. We first developed a framework for effective network management by identifying clusters of key factors of network management at the network level. The key factors were also applied in system-building networks. However, we observed some notable differences in the implementation of these key factors.

First, optimal network composition depends on the individual network's objective. This objective may change frequently in the fast-changing environment of the emerging smart grid sector, and the resulting changing network composition may be beneficial to the network. A decrease in network size can strengthen the network and enable it to achieve its goals. This is in contrast to the findings of most network management scholars, who see network stability as a major aim of the network (Freytag & Ritter, 2005; Håkansson & Ford, 2002; Landsperger et al., 2012; Milward & Provan, 2006; Rusanen, 2013). In fact, some system-building networks use a decrease in members as a goal-alignment strategy to reach goal consensus, by some firms leaving the network or by starting a new network with only those members who share a specific objective that differs from the original network´s objective. This may result from the situation that system-building networks emerge before the technology or the business field they are trying to develop exists. During the development of the technology and business field, the goals of the network are adjusted to the new developments. As a result, some companies may leave the network because they realize that their company goals are no longer aligned with the network goals. In conventional innovation networks, both the goal and the actor constellation are clearer from the beginning, and a reduction of network members would mainly lead to a loss of knowledge and skills. By contrast, for system-building networks a reduction in members may mean that the remaining members can more easily find goal consensus, thus making the networks more effective. In addition, we found that the networks working towards standardization preferred to start in a small constellation of actors, including 'neutral' research institutes, to enable the generation of a standard; for its implementation they increased the size of the network substantially, and they were especially interested in firm actors. This shows the importance of adjusting the size and actor types of the network to its most recent objective at a given moment in time.

Second, in contrast to what is stated in the literature, there is generally not one network manager who directs the network, but often two or sometimes more individuals who carry out this function. In the literature, the network manager is usually described as one person (Heidenreich et al., 2016; Landsperger et al., 2012). However, we found not one case in which there was only one person carrying out all the network manager's tasks as described in the literature. This is probably due to the highly technological nature of the emerging smart grid sector and the high uncertainty in which decisions are made. Technological content decisions require a different expertise and skill-set than traditional project management. Having both a project manager who is capable of effectively directing the project as well as a chairman who is an expert on the technological content and who can effectively lead discussions contributes to a better use of resources and leads to higher network effectiveness. Moreover, depending on the system-building goal, the neutrality of the leader is important, which means that an external person (non-network member) should be appointed to this position.

Third, regarding governance modes, our findings also deviated from the literature. Instead of being directed by an elected board or a network manager (Agranoff, 2006; Järvensivu & Möller, 2009; Rampersad et al., 2010; Spieth et al., 2011; Turrini et al., 2010), Networks A-E had a board of directors, who were not elected but appointed or hand-selected. Moreover, they had two individuals acting as network manager. Furthermore, some networks had a supervisory board, or a steering group which consisted of the CEOs of the member firms. It seems that for networks with complex tasks, such as system building, slightly different governance modes are required than described in the literature.

Fourth, with regard to decision-making processes, decisions were made jointly and equitably by way of discussion, which is in line with the network management literature (Agranoff & McGuire, 2001; McGuire & Agranoff, 2011; Spieth et al., 2011). Although there are often voting systems, these are mainly used as a last resort. What we found for system-building networks – and what has not been emphasized in the network management literature – is that decision-making processes take place in the smallest possible constellation, i.e. by the board of directors rather than by all network members together. Network objectives may be broad, company objectives may differ, and it is a fast-changing sector; therefore it seems to be more effective to take decisions with a smaller group of people. The clear governance mechanisms in place in system-building networks provide a hierarchy which facilitates decision making at the highest level. Furthermore, prior to a decision, all necessary and relevant information will be provided to the decision makers, probably because in an emerging industry such as the smart grid sector, little information is available yet, and most situations are new. Therefore, unlike in established sectors, board members cannot base their decisions on previous experience in similar cases.

Fifth, although only few network management scholars mention the importance of project management (Cristofoli, Markovic, & Meneguzzo, 2012; Turrini et al., 2010), it is seen as an essential key factor of collective system-building networks. The quality of project management can make or break a system-building network. Moreover, in network management literature, measurement and evaluation of performance are important for network effectiveness (Raab 2013; Ritter 2014; Rusanen 2013; Spieth 2011; Turrini 2010). However, while considered important, it is very difficult to implement in system-building networks. In the emerging smart grid sector, it is difficult to set the right performance indicators, due to a lack of experience with the new technology, the fast-changing environment, and the high uncertainty as to how the sector will develop.

Sixth, another contrast with the network management literature is found in the way the free-rider problem is addressed. Free-riders are often mentioned as problematic in the literature (Huggins, 2000; Wijen & Ansari, 2007) as they decrease network effectiveness. However, the free-rider problem was not experienced in the system-building networks studied. It was prevented by social pressure, i.e. explicitly discussing member contributions during meetings, or solved in personal talks, which led to the non-contributor voluntarily stepping down. In another case, the introduction of a substantial membership fee triggered non-contributors or less motivated firms to leave the network.

Seventh, in the network literature the level of trust is achieved either through previous collaborations or the outcome of-trust building processes (Järvensivu & Möller, 2009; Milward & Provan, 2006; Möller & Halinen, 1999; Möller & Svahn, 2009; Ojasalo, 2008; Ozman, 2009; Raab et al., 2013; Rampersad et al., 2010; Ritter & Gemünden, 2003b; Ritter et al., 2004). We found that a high level of trust can also be achieved by handpicking the individuals who are part of the network's core management team, rather than only selecting member companies. This also positively influences harmony and commitment.

Our findings have several theoretical implications. With our focus on system-building networks for sustainability transitions, we contribute to the literature on network management in general, and particularly to the literature on network management in emerging business fields. We respond to the need for more empirical research on emerging business nets (Aarikka-Stenroos et al., 2014; Möller & Svahn, 2009) by providing empirical insights into the effective management of these system-building networks. Moreover, we focused on network-level outcomes by studying network effectiveness. This has so far received limited attention in the network management literature (Rampersad et al., 2010), since most studies focus on firm-level outcomes. However, the network focus is important, given the fact that these system-building networks and emergent business nets generally aim to achieve collective goals. The special setting we studied also allowed us to add the empirical context of sustainability transitions to the emerging business networks literature. System-building networks operate in a fast-changing environment, under high uncertainty, and aim at implementing complex technological innovations. Being actors in sustainability transitions, they face additional challenges which have implications for the management of such networks (Aarikka-Stenroos & Lehtimäki, 2014; Aarikka-Stenroos et al., 2014; Sandberg & Aarikka-Stenroos, 2014). The conditions highlighted make the insights gained from sustainability transitions very interesting for the commercialization of radical technologies in general (Knight et al., 2015).

In this chapter, we show that these specific types of networks in this specific setting need to be managed differently with regard to some of the key factors of network management in order to increase the effectiveness of the network. Compared to the existing literature, the management of our collective system-building networks differed with regard to network composition, network management structure, governance modes, decision-making processes, project management, the free-rider problem and trust-building mechanisms. All in all, we obtained a better understanding of how system-building networks can be managed effectively to be more successful in establishing new business fields.

4.6.2. Managerial implications

Our findings also have implications for managers in emerging business fields who want to direct and coordinate network processes. We introduced a framework that displays the key factors of network management that managers can use. Our findings related to the framework have three major implications for managers. First, the role of the network manager should be executed by two individuals: a skilled project manager, as good project management is essential for system-building networks, and an expert on the specific technology. Second, relational factors play a major role in network management. A high level of trust, effective network leadership, and clear boundaries are necessary to create a positive atmosphere in the network. In turn, this positive atmosphere increases the performance of the network. High trust levels may be achieved by carefully selecting network members: not only the companies but also the individuals who will be part of the team. Knowledge flows within the network are enhanced by clear decision-making mechanisms and clear boundaries for information sharing. Moreover, a participatory leadership style increases members' motivation and commitment. Third, counter-intuitively, the introduction of a substantial membership fee can increase members' motivation, and a decrease in network size can have a positive impact on network effectiveness.

4.6.3. Limitations and suggestions for future research

A limitation to our study is that the results are based on networks in one sector only, the Dutch smart grid sector. However, this chapter has been a first, exploratory step; moreover, we covered all national networks in this sector. We did not interview all members within each network, which could be seen as a further limitation. In the selection of the interview partners, we made sure to select network members in leading roles and with different perspectives (e.g. the project manager or a network member). Their answers did not differ very much, and the number of interview partners was sufficient to saturate our data per network.

To generalize our findings to other industries, we suggest further research on system-building networks in different emerging sectors. Other emerging fields are also likely to operate under high uncertainty. Yet, if the technologies developed are less intertwined than smart grid technology, this might have a different influence on the implementation of key factors of network management. We expect the differences found regarding the implementation of the key factors network composition, governance modes, decision-making processes, project management, the free-rider problem and trust-building mechanisms, to be also applicable to other collective system-building networks, due to the complexity of system-building tasks and the high uncertainty in which actors operate in an emerging business field. For the key factor network management leadership, our finding that two network managers are necessary may not hold if the novel technology is less complex, in which case one single leader may be sufficient, as the existing network management literature suggests. However, these assumptions need to be tested in further research.

Another limitation is that we investigated the system-building networks at a specific moment. Our data represents a snapshot in time. This has resulted in a first overview of the importance and implementation of key factors of network management. Future research could assess the dynamics between key factors of network management in different stages of network development. Furthermore, future research could focus on the design stage of collaborative system-building networks, to gain a greater understanding of the formation of these networks. Moreover, for future research it would be interesting to investigate which management activities are most important in different phases of industry emergence. The networks we studied are now at the stage which Möller & Svahn (2009) call mid-emergence, or in a late moment of the early emergence stage. We see ample opportunities for other studies to investigate emerging fields in other stages of industry emergence.

CHAPTER 5

The dilemma of competition versus collaboration in innovation ecosystems

Abstract
Companies who want to successfully implement complex innovative technologies need to collaborate with other actors of the innovation ecosystem, including their competitors, so that they can develop standards, interoperable products, pool knowledge and resources and bundle forces to compete against other technologies. Collaboration with competitors brings benefits, but also many risks. We investigated how firms deal with the dilemma of competition versus collaboration when establishing an innovation ecosystem to implement a new technology in society. We identified benefits, risks and enablers of collaboration with competitors from the coopetition literature, and provided a systematic overview. Then we conducted research in the Dutch smart grids sector. We explored the strategies utilized by firms engaged in collective system building, how they minimize inherent risks and increase the benefits of collaborating with competitors. We found that system-building actors in the Dutch smart grid field use the enablers described in the coopetition literature. However, we found five additional enablers: *neutral entity in charge of coordination, creation of a common playing field, investment into the collaboration, clear collaboration structures and careful composition of partners in pilot projects.* Moreover, coopeting firms not only minimize inherent risks, but from the start of their collaboration, they use a ‘coping strategy’ to prevent these risks upfront.

5.1. Introduction

Industries are in flux and new ways of inter-organizational collaboration are necessary. In today's technologized information society, consumers often require market offerings that combine several products and services, as opposed to stand-alone products. Many technological innovations cannot succeed in isolation, instead an interoperable set of complementary innovations is needed to attract customers (Adner, 2006). Due to the co-creation of innovative products and services, organizations are highly interdependent. The success of an innovating firm often depends on the efforts of other actors in the innovation ecosystem (Adner & Kapoor, 2010). This innovation ecosystem - or innovation system - comprises complex business communities which develop technologies and bring innovations to the market (Autio & Llewellyn, 2014; Jackson, 2011; Moore, 1993; Oh et al., 2014). It consists of interdependent organizations creating specific products or technologies; and involves many actors such as suppliers, competitors, customers, universities, investors and policy actors (Jackson, 2011). Firms need to strategize within and around their innovation ecosystem (Iansiti & Levien, 2004). In cooperative networks they combine resources to co-create products and to shape their ecosystem (Adner & Kapoor, 2010; Autio & Llewellyn, 2014; Moore, 1993).

This co-creation of products and collaborative shaping of the innovation ecosystem is especially important for sustainability technologies, which aim to solve or mitigate societal problems, such as climate change, environmental pollution and overuse of finite resources (Geels, 2002; Hargadon, 2010; Kemp, Schot, & Hoogma, 1998). New socio-technological systems need to be built, where many technologies interact, e.g. low energy houses, carbon neutral cities, or sustainable transportation systems. (Jacobsson & Bergek, 2011b; Jansen, 2003; Kemp & Soete, 1992). The transition literature provides valuable insights into how such socio-technological systems emerge (Farla, Markard, Raven, & Coenen, 2012; Markard & Truffer, 2008c; Nill & Kemp, 2009; Schot & Geels, 2008). In the transition literature, the process of networks strategically creating and shaping their innovation ecosystem is called 'collective system building' (Musiolik & Markard, 2011; Planko et al., 2016). Companies who want to successfully implement complex innovative technologies need to strategically collaborate to build-up a favorable innovation ecosystem around their new technology (Musiolik & Markard, 2011). Key strategic areas in this so-called collective system-building are the development and optimization of the new technology, the stimulation of socio-cultural changes, as well as the creation of a market for the technological innovation. Moreover, to accelerate system-building processes, the different firm's system-building activities have to be coordinated (Planko et al., 2016). When engaging in collective system-building, firms face a profound dilemma: they have to collaborate closely with firms that are their competitors. Firms have to share crucial information with their competitors, and pool resources, in order to develop a technological system with compatible products and services, and to create a market for their products. This, however, entails many risks, such as knowledge leakage, dependencies, or loss of first-mover advantage. We want to understand how firms deal with the dilemma of competition versus collaboration when building-up an innovation ecosystem for an emerging technology. The transition literature has shown the importance of collaboration with competitors, but has not addressed this dilemma yet. To fill this gap in the transition literature, we will use insights from the coopetition literature.

The aim of this chapter is to explore how actors engaged in collective system building minimize the inherent risks and increase the benefits of collaborating with competitors. Our research question is: What strategies do actors use to minimize risks and increase benefits from collaboration for system-building?

To study competition with competitors in the context of complex high-technology industries, in which actors collaborate to build-up a prosperous innovation ecosystem around their new technology, we chose the empirical case of the Dutch smart grid field. Smart grids are not one technology, but many highly intertwined technologies. The development and implementation of smart grids requires intensive collaboration between actors along the supply chain. For the technology to be successful, they need to develop a variety of compatible and interoperable products and services. Actors in this sector know that they need to collaborate closely with all system actors, including their direct competitors, if the new technology is to be successful (Planko, Cramer, Chappin, & Hekkert, 2016). It can be compared to Silicon Valley twenty years ago: highly-driven entrepreneurs and intrapreneurs who collaborate very closely - while remaining competitors - to advance a new technology (Saxenian, 1991, 2000). Observing entrepreneurs in the ongoing process of system building at a time that the new sector emerges generates interesting insights into a new way of organizing business activities.

We contribute to the coopetition literature a systematic overview of enablers for collective system building - for networks of coopeting firms which aim to build innovation ecosystems to implement new technologies. Moreover, we close a gap in the transition literature by introducing strategies that system-building actors use to cope with the dilemma of competition versus collaboration in socio-technological transitions.

5.2. Coopetition at the multi-firm alliance level

The coopetition literature addresses the issue of the simultaneous cooperation and competition between different independent organizations - termed ‘coopetition’ (M. Bengtsson & Kock, 2014; Bouncken & Kraus, 2013; Walley, 2007; Wilhelm, 2011; Zineldin, 2004). Rival firms cooperate in some areas while competing in others (Luo, 2007). Competition often takes place close to the customer, in areas like value-added business practices, price, service and quality; while cooperation takes place in activities more distant from customers, such as R&D, standard setting, developing a new market and removing external obstacles and threats (M. Bengtsson & Kock, 2000; Gnyawali & Park, 2009; Liu, 2013; Osarenkhoe, 2010; Park et al., 2014; Ritala & Sainio, 2014). Firms collaborate to increase the size of the business pie, and then compete to divide it up (Chin, Chan, & Lam, 2008; Nalebuff & Brandenburger, 1996; Ritala, 2012).

Coopetition can be narrowly defined as a dyadic relationship between two rival firms or broadly defined as a relationship between multi-firm alliances who simultaneously cooperate and compete with each other, regardless of whether their relationship is horizontal or vertical (M. Bengtsson & Kock, 2014; Wilhelm, 2011). Taking on the broad definition, scholars have analyzed coopetition in the context of dynamic inter-firm relationships in business networks, value nets, supply chains, clusters and value-adding networks, which include suppliers, customers, competitors and complementors (Bouncken & Kraus, 2013; Fernandez et al., 2014; Pathak et al., 2014; Tidström, 2013; Walley, 2007).

5.2.1. Coopetition and innovation ecosystems

5

Coopetition at the multi-firm alliance level is especially important for knowledge-intensive, dynamic and complex fields, particular for high-technology industries due to their networked nature (Gnyawali & Park, 2009; Park et al., 2014; Ritala & Hurmelinna-Laukkanen, 2009; Ritala & Sainio, 2014). Especially for break-through technological innovations that change existing technologies or make them obsolete, and when technological uncertainty and market uncertainty are very high (Bouncken & Kraus, 2013; Ritala, 2012). Coopetition is a good strategy when new markets need to be created and consumers need to be educated about the benefits and functions of the new product, and when standards need to be set to develop complex interoperable solutions (Bouncken & Kraus, 2013; Gnyawali & Park, 2009; Ritala, 2012; Ritala & Sainio, 2014). These characteristics are also the case for the specific context of 'innovation ecosystem building' that we study.

5.2.2. Dilemma of collaboration with competitors

Coopetition is potentially beneficial, but also includes major risks for a firm (Ritala, 2012; Ritala & Hurmelinna-Laukkanen, 2009). This confronts firms with the dilemma of sharing resources and information with their competitors - and exposing themselves to the inherent risks - to build a stronger innovation ecosystem, or to collaborate less to reduce risks, but at the same time lose some of the benefits of collaboration. To reduce the risks arising from collaboration and to increase potential benefits, it is important to manage coopetition processes both at the firm-level and the network-level (Dahl, 2013; Osarenkhoe, 2010; Park et al., 2014). So far, little research has been done on how competitors manage coopetition processes at the network level to reduce risks from collaboration and increase its potential benefits (M. Bengtsson & Kock, 2014; Dahl, 2013; Fernandez et al., 2014). While some authors mention risks, benefits and enablers of coopetition at firm and network level, a systematic overview is missing. In the following chapter we will provide such an overview. It serves as theoretical framework for our empirical research.

5.3. Benefits, risks and enablers of coopetition

In this section we will describe the benefits and risks of coopetition we identified from the coopetition literature. In the coopetition literature, several benefits and risks of collaboration with competitors are mentioned. These benefits can occur at the firm-level or at the inter-organizational level. We have clustered and summarized these benefits and risks. Consequentially, we will describe the enablers for coopetition, which we identified from the coopetition literature.

5.3.1. Benefits and risks of coopetition

Benefits of coopetition can occur at the firm level or at the inter-organizational level, i.e. the network level or industry level. Of course, benefits at the inter-organizational level are automatically also benefits for individual firms in that network or industry. Table 5.1 provides an overview of the benefits of coopetition, categorized by the level at which the benefit occurs.

Level	Benefits
Firm level	**Risk and costs sharing:** firms can spread the risks and costs involved in various activities such as product development and standardization; this increases the incentive to take risks and be proactive in product development. They can share costs for R&D, for developing new products and of entering new markets
	Uncertainty reduction: coopetition reduces the costs, risks and uncertainties of new product development
	Access to resources and knowledge: firms gain access to additional know-how, skills, competence, market knowledge, reputation and other resources. A company can thereby use its limited resources in the most efficient way; which potentially improves the firm's innovation
Inter-organizational level	**Knowledge-sharing and resource pooling:** through knowledge sharing and pooling of resources and competencies networks of firms can increase their competitiveness and gain competitive advantage. They transfer capabilities and knowledge and enhance their skills. They can gain production efficiency benefits, through complementary resources, integrative technologies and reduced duplication. Through resource pooling they reduce time-to-market; achieve economies of scale; and can develop network-based resources, such as a skilled labor force.
	Interoperability of products: together firms can develop a technological standard and create common norms at industry-level. Adopting a common standard can help firms to promote their technologies, gain critical mass, and develop interoperable products and services. The development of an interoperable system of interconnected products and services is a prerequisite for market creation. It increases the speed of diffusion and the profits that can be captured from the markets.
	Market development: together, coopeting firms can create bigger markets sooner, through positive network externalities. A critical mass can be achieved sooner. As a cluster, they can educate potential users about the functionality and use of the new technology. Together, they can create a larger pie (market) and then compete for a piece of that pie (market share). The interoperability and compatibility of products and services increases customer value. Consumers benefit from multi-feature products at reasonable prices, higher compatibility, higher product quality and an increased product range. More attractive products mean consumers are easier to attract, and the market will grow more quickly.
	Shaping the institutional environment: through coopetition a network of firms can shape the institutional environment in favor of its own technological design. When there are more companies pushing in the same direction they consequently have more influence in an established or emerging industry. This results in higher innovative performance.
	Increased competitive dynamics: coopetition increases competitive dynamics and innovation because of group-to-group competition against other clusters. Together they can gain greater power and achieve synergistic outcomes that one firm could not achieve alone; as a cluster they can possibly outmatch stronger rivals.

Table 5.1: Benefits of coopetition identified from the coopetition literature

Based on: (M. Bengtsson & Kock, 2000, 2014; Bouncken & Kraus, 2013; Gnyawali & Park, 2009; Hung & Chang, 2012; Liu, 2013; Loebecke, Van Fenema, & Powell, 1999; Luo, 2007; Osarenkhoe, 2010; Ritala, 2012; Ritala & Hurmelinna-Laukkanen, 2009; Ritala & Sainio, 2014; Tidström, 2013; Walley, 2007; Zineldin, 2004).

Coopetition also bears risks at the firm-level and at the inter-organizational level. Table 5.2 gives an overview of these risks at each level.

Level	Risks
Firm level	**Opportunistic behavior by partners:** Firms who collaborate with competitors are exposed to the risks of knowledge loss to partners, and partners simply copying ideas, product innovations, or core competences. Furthermore, bigger partners can exploit a weaker partner's interest or take over the cooperation. The risk of opportunistic behavior by partners is especially high when cooperative agreements are loosely governed and structured.
	Knowledge leakage: coopeting firms risk unintended leakage of confidential knowledge to partners. Moreover, they risk sharing core knowledge and not gaining sufficient knowledge in return. This may lead companies to restrict knowledge sharing.
	Intra-firm goal conflict: tension may arise between the goals of firms and goals of the network. Coordinating and controlling the cooperation commitments demands a considerable amount of time and effort, which may lead to neglect of an organization's core business. Managers might feel role conflicts as an employee of the firm and as a network member.
	Loss of control: firms who coopete give up control over resources, they lose freedom of decision making, and their dependency on the network limits flexibility. Firms may lose competitive innovation and become dependent on other firms. They can lose autonomy and power. In particular, smaller firms can become depended on bigger ones.
	Power imbalance: asymmetrical power bases can lead to a loss of competitive advantage, dependencies and knowledge loss, usually for the smaller firm. Power and dependence can be a source of conflict.
	Insufficient returns: Firms need to invest time and money into the collaboration which may not yield the required return. Or one of the parties might not get enough of a return.
Inter-organizational level	**Reduced innovativeness:** firms that collaborate with competitors are less innovative; "group thinking" may hamper their creativity and innovation efforts.
	Coordination difficulties: Difficulty to coordinate the coopeting networks may lead to failure of the collaborative initiative.

Table 5.2: Risks of coopetition identified from the coopetition literature

Based on (Bouncken & Kraus, 2013; Gnyawali & Park, 2009; Liu, 2013; Loebecke et al., 1999; Luo, 2007; Osarenkhoe, 2010; Park et al., 2014; Ritala & Hurmelinna-Laukkanen, 2009; Ritala & Sainio, 2014; Tidström, 2013; Walley, 2007; Zineldin, 2004)

Regarding risks, most of the risks identified from the coopetition literature are borne by individual firms. They are the ones who will lose investments, resources or ideas, in case a risk materializes. There are only two risks at the inter-organizational level. That the whole collaborative initiative will fail, which of course will lead to losses to the firms who have invested into the collaboration. And that innovativeness can be reduced, as group-thinking can hamper the generation of diversified ideas. However, this argument is countered by the argument that cluster collaboration increases innovativeness due to cluster-against-cluster competition and synergistic outcomes (Gnyawali & Park, 2011; Pitelis, 2012). In sum, most risks are on the firm level, and most benefits are on the inter-organizational level. That is why these actors use strategies to make sure that they reap the benefits in this collaboration, so-called enablers of coopetition.

5.3.2. Enablers of coopetition

Firms who coopete in networks can create conditions that enable both competitive and collaborative relationships to coexist (Osarenkhoe, 2010). These conditions help to overcome difficulties and reap the advantages of collaboration, they are enablers of collaboration with competitors (Chin et al., 2008; Karhu, Tang, & Hämäläinen, 2014; Ojasalo, 2008). 'Enablers' either facilitate benefits or mitigate risks, and thereby enable the collaboration between competitors to take place. We identified the following enablers of collaboration from the coopetition literature.

Trust development: Trust enhances cooperative behavior, stimulates knowledge exchange, reduces potential for tensions and generally affects work group functioning positively. Trust cannot be forced, it needs to be developed. Moreover, the coopetition literature mentions a dis-enabler related to trust: 'general distrust'. General distrust, e.g. concerns about capturing rents or loss through knowledge leakage, impedes cooperation and value creation (M. Bengtsson & Kock, 2000; Bouncken & Kraus, 2013; Chin et al., 2008; Dahl, 2013; Fernandez et al., 2014; Liu, 2013; Osarenkhoe, 2010; Park et al., 2014; Ritala & Hurmelinna-Laukkanen, 2009; Tidström, 2013; Walley, 2007; Zineldin, 2004).

Mutual commitment: Commitment is related to the perception that each party bears responsibility for the goals and activities that contribute to the outcome and is interested in maintaining a valued relationship. Mutual commitment can be increased by sharing financial risks or by giving the collaborative relationship a formal status (M. Bengtsson & Kock, 2000; Chin et al., 2008; Fernandez et al., 2014; Osarenkhoe, 2010; Park et al., 2014; Ritala & Sainio, 2014; Zineldin, 2004).

Common vision and goals: A clear, strong vision and common goals are needed in a coopeting network to link up different organizations and their interests; these are based on mutual objectives and complementary needs. Voluntary and mutual agreements aimed at achieving common goals and strategic objectives together can be based on trust or stipulated in formal agreements, such as informal contracts (M. Bengtsson & Kock, 2000; Chin et al., 2008; Osarenkhoe, 2010; Zineldin, 2004).

Goal alignment: Networks should pursue collective strategies for value generation. The different firms' interests need to be aligned toward a common network objective. Common ground should be developed and diverging interests mitigated. This protects and improves the competitive position of the network and increases the chances of collaborative success (Bouncken & Kraus, 2013; Gnyawali & Park, 2009; Liu, 2013; Osarenkhoe, 2010). Moreover, the coopetition literature mentions 'insufficient goal alignment' as a dis-enabler: conflicting goals and objectives among partner firms and difficulty to align operations at the alliance level with the firm's long-term goals may lead to a failure of the collaborative initiative, especially when it is managed poorly (Liu, 2013; Osarenkhoe, 2010; Walley, 2007; Zineldin, 2004).

Rules for knowledge exchange: Effective knowledge sharing is an important objective; it can induce synergies. Determining when, with whom and under what conditions knowledge is shared and finding a balance between what to share and what to keep secret enhances knowledge exchange (Chin et al., 2008; Loebecke et al., 1999; Osarenkhoe, 2010; Tidström, 2013; Zineldin, 2004).

Inter-organizational coordination: Inter-organizational coordination mechanisms are indispensible for coopetition, especially to enable knowledge exchange and the provision of shared information. The following network coordination features were described as enabling in the coopetiton literature: clearly defined responsibilities of each partner; a positive atmosphere; an effective communication system to enable good communication processes; as well as a mutually accepted conflict resolution process (Chin et al., 2008; Osarenkhoe, 2010; Park et al., 2014; Zineldin, 2004).

Equal power distribution: The distribution of control and power between the partners is of importance for the performance of an alliance. Mutuality or equity in risk and contribution is important for the success of the alliance (M. Bengtsson & Kock, 2000).

These enablers have been mentioned in the coopetition literature as ways to reduce conflicts, mitigate tensions or as mechanisms which enable collaboration with competitors. In our empirical study, we investigate which strategies system-building actors use to enable collaboration with competitors when building innovation ecosystems around technological innovations. After analyzing which strategies the system-building actors use, we will compare these to the enablers identified from the coopetition literature which were described above.

5.4. Method section

To answer our research question, we conducted a single embedded case study (Yin, 2009) in the Dutch smart grids sector. The Dutch smart grids sector was chosen because it is an emerging industry in which actors collaborate closely with other actors all along the supply chain, including their direct competitors, to build up a favorable ecosystem for the smart grids technology to thrive in (Planko et al., 2016). Firms collaborate closely in networks of actors, including competitors. To build-up an innovation system and enable the development of compatible products they need to share ideas and knowledge with their competitors. These firms need to collaborate with each other, but also with universities to gain knowledge, with governmental actors to create a supportive regulatory framework and with user groups. Products have to be designed with users in mind, and in collaboration with user groups. This can help to prevent socio-cultural barriers, which may otherwise arise. Actors in the system know that they need each other in order to build the new innovation ecosystem. Companies would not be able to do this individually. They need to bundle forces to create interoperable products and markets for these products. Yet, they also compete for market share when the market is developed. This makes it a very interesting case to study coopetition.

In a pre-study we identified the key actors of the Dutch smart girds sector, as well as the most important networks in which companies collaborate to build the ecosystem. We identified a list of six national networks which are working on building-up the Dutch smart grids sector, and a list of key actors which were part of one or several of these system-building networks. Together, the actors in these networks build-up the Dutch smart grid ecosystem. These multi-firm alliances include competitors and other actors along the value chain. They comply with the broad definition of coopetition (M. Bengtsson & Kock, 2014; Wilhelm, 2011).

In total, we conducted 17 interviews with key actors operating within these system-building networks. Our interviewees held important roles in these networks, such as chairman, project manager, or member of the board of directors. We stopped interviewing more key actors when we found our data was saturated. Out of these 17 interviewees, 15 were company actors and two were governmental actors with important positions in the system-building networks. The 15 company actors had high positions in their organizations, such as CEO, chief innovation manager or director smart energy. The two governmental actors - interviewee numbers *[2]* and *[5]* - were also very important system-building actors. They worked closely with system-building entrepreneurs, and observed their collaboration obstacles, patterns and mechanisms. When we interviewed the two governmental actors, we asked questions specifically from the viewpoint of companies, e.g. which mechanisms enable companies to collaborate or mitigate risks. I.e. in all interviews we focused on the strategies for coopetition in the context of system-building from the viewpoint of companies.

The interviews were semi-structured and were conducted face-to-face. Each interview took 60-100 minutes. One part of the interviews addressed how the actors organized their collaboration for system-building. A specific part of each interview then focused on the collaboration with competitors for system-building. We asked them what risks and benefits they see in collaboration for system-building; and how they reduce these risks or increase these benefits; and how they facilitate this inter-organizational collaboration. We did not ask closed questions in which we mentioned specific enablers identified in the coopetition literature. Instead, we asked open questions, so not to influence interviewees, to avoid socially desirable answers.

For reliability, this study employed a semi-structured interview protocol to ensure that interviews were consistent. Interviews were recorded, transcribed and analyzed with Atlas.ti software. Data was coded according to risks and benefits as well as enabling mechanisms of coopetition.

To examine how system-building actors deal with the dilemma of collaboration with competitors in system-building, we used a two-step analysis. First, we analyzed our empirical case. We analyzed which benefits and risks they see in collaboration and how they facilitate the benefits and mitigate the risks. We identified enabling mechanisms as described by our interviewees. We then clustered the described mechanisms into enablers. Second, we compared our findings to the benefits, risks and enablers we had identified in the coopetition literature.

5.5. Findings: empirical evidence from the Dutch smart grids sector

In this section we will display the findings of our case study on the Dutch smart grids sector. First we will describe the manifold benefits smart grid actors experienced. Second, most interviewees stated that they did not perceive risks from collaboration with competitors. However, this was because they used strategies to prevent these risks upfront. In the third section we will describe the strategies the coopeting smart grid actors had put in place to prevent risks and increase benefits from collaboration.

5.5.1. Benefits of collaboration are abundant

Smart grid actors collaborate in different networks with different system-building objectives. In these networks, they bundle their forces. Smart grid actors experienced multiple benefits of coopetition at both the firm level and the inter-organizational level. These are described in the table below. For each benefit the key points mentioned by the interviewees are summarized, and the number of interviewees who referred to this benefit is indicated.

Level	Benefits	Empirical evidence from the Dutch smart grid sector	mentioned by interviewees #
Firm level	Risk and cost sharing	They share costs and risks. For example, costs of conducting full-scale pilot projects are very high; they are shared by participating firms. Firms further share costs for R&D, lobbying for new regulations, market development, and raising user awareness.	5,14
	Uncertainty reduction	The term 'uncertainty reduction' itself was not mentioned by interviewees. However, most of them mentioned that a shared vision on sector development gives them direction and helps them to make strategic decisions (see enabler 'common vision'). The common vision reduces uncertainty about the future. Furthermore, due to a shared framework in which to develop interoperable products, financial risks of investing into technological innovations are reduced.	term not mentioned as such, but topic addressed implicitly
	Access to resources and knowledge	Firms gain access to resources and knowledge to improve their innovation.	10

[continued on next page]

Level	Benefits	Empirical evidence from the Dutch smart grid sector	mentioned by interviewees #
Inter-organizational level	Knowledge-sharing and resource pooling	In different networks, they share knowledge and pool resources. There is a high degree of knowledge exchange. A larger pool of knowledge and resources helps them to develop and optimize their technology. Together, they generate network-based resources, for example infrastructures, in which they can test their interoperable products and services, university programs to educate future smart grid engineers, trainings for maintenance personal, or marketing materials to raise user awareness.	1,2,4,6,8,10, 14,15
	Interoperability of products	Most interviewed smart grid actors emphasized that only through collaboration was it possible to develop a wide variety of high-quality interoperable products and services.	1,2,3,4,5,6,8, 11,12,13,15,17
Inter-organizational level	Market development	Most actors mentioned that only through collaboration can they gain sufficient visibility and awareness of their new technology. As its functionality is by most potential users perceived as similar to the ones delivered by the fossil-fuel energy system, and moreover major changes in user behavior need to be achieved for technology adoption, a lot of resources are necessary to develop the market. One firm alone does not have the resources to trigger the required societal changes, such as changes in user behavior and reducing privacy concerns. Therefore, they bundle their forces to develop the market.	1,4,6,7,8,9,10, 12,14,16,17
	Shaping the institutional environment	Many interviewees stated that together they strive to *"create a rich environment to implement their technology" [3]*, to *"build up the ecosystem" [4]* and to achieve necessary societal changes. Collaborating in a formal network increases their bargaining power, e.g. when trying to influence policy makers to achieve enabling legislation or changes in the education system.	2,3,4,6,7,8,12, 14
	Increased competitive dynamics	Because smart grid actors have to compete with the incumbent fossil fuel sector, which is very strong and powerful, they need to be especially innovative. They understand that collaboration with competitors is essential for the success of their innovation.	6,10,11,13,14, 16,17

Table 5.3: Benefits of coopetition in the Dutch smart grid sectors

5.5.2. Risks of collaboration are minimized or even prevented

Initially, when asked about the risks of collaboration with competitors for system-building, several interviewees stated that at this stage they do not see risks. They rather saw a risk in not collaborating, which may lead to a loss of competitiveness. *"There is no risk in collaborating, only in not collaborating. If we are not actively involved in these collaboration platforms, we risk that we don't stay ahead of the developments in the Netherlands."[14] - "The risk is not collaboration, but that you do not collaborate enough. You need to work strongly together, otherwise it won't work at all." [16]*

However, when this was investigated further, it was discovered that they conduct a lot of activities to prevent risks from coopetition. Because they strategically minimize risks from the very beginning of their collaboration, or even prevent them upfront, they perceive the risks of collaboration with competitors as low. Below, Table 5.4 summarizes the main risks and how the actors aimed to prevent or minimize these. The enablers mentioned in column C are further described in Table 5.5, which also indicates which interviewees mentioned each enabler. Therefore, Table 5.4 does not include a column 'mentioned by interviewees #'.

Level	Risks	Empirical evidence from the Dutch smart grid sector
Firm level	Opportunistic behavior by partners	prevented - by using enablers 'trust development', 'investment into the collaboration' and 'neutral entity in charge of coordination'
	Knowledge leakage	prevented - by using enablers 'clear boundaries to information sharing' and 'clear boundaries to joint technology development'
	Intra-firm goal conflict	reduced - by using enabler 'common vision and goal alignment'
	Loss of control	prevented - by using enablers 'trust development', 'mutual commitment' and 'fair collaboration'
	Power imbalance	not experienced - due to enabler 'fair collaboration'
	Insufficient returns	not experienced - due to enablers 'fair collaboration' and 'common vision and goal alignment'
Inter-organizational level	Reduced innovativeness	prevented - by using enablers 'creation of a common playing field' and 'clear boundaries to information sharing'
	Coordination difficulties	minimized - by using enabler 'inter-organizational coordination'

Table 5.4: Risks of coopetition in the Dutch smart grid sectors

5.5.3. Enablers of coopetition

Actors in the Dutch smart grid sector use a variety of enablers to mitigate risks, or even prevent them. Some enablers are implemented upfront to avoid risks from coopetition, others are implemented during the process of building-up the innovation ecosystem. Enablers are also used to increase the benefits of collaboration. In this section, we describe the enablers the smart grid actors applied to cope with risks of coopetition, and to increase its benefits.

Enablers mentioned in coopetition literature	Enablers derived from empirical case	in line with theory/ new / different	mentioned by interviewee #
Trust development	Trust development	in line with theory	1,2,3,6,7,8,10,11,12, 13,15,16,17
Mutual commitment	Investment into the collaboration	new	8,12,16
Common vision and goals	Common vision and goals	in line with theory	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17
Goal alignment	Goal alignment	in line with theory	1,3,7,6,9,10,11,12,13
Rules for knowledge exchange	Clear boundaries to information sharing	in line with theory	2,9,10,14,17
	Clear boundaries to joint technology development	in line with theory	1,4,5,8,11,12,15,17
Inter-organizational coordination	Neutral entity in charge of coordination	new	2,3,6,7,8,9,10,13
	Clear collaboration structures	new	3,4,6,7,8,9,11,15
	Effective communication	in line with theory	2,6,7,11,13,15
Equal power distribution	Fair collaboration between big and small firms	different	1,12,16,17
not mentioned yet	Creation of 'common playing field'	new	5,6,10,11,12,14,17
not mentioned yet	Careful composition of partners in pilot projects	new	8,9,11,16

Table 5.5: Comparison of empirical findings to enablers identified in coopetition literature

Trust development: Almost all interviewees (13/17) stressed the importance of trust for collective system building. Sufficient trust enables collaboration between competitors, and enables them to develop system resources based on jointly created knowledge. In the smart grids field *"there's a high level of trust, people understand they need each other, there's no hiding back information." [11] Trust is created because "everybody knows that we need to collaborate, if we want to achieve our goals."[16]* Smart grid actors agreed that trust was developed through positive collaboration over time. However, some of the actors already knew each other, or at least the companies they collaborated with, from previous collaborations in different projects that their firms had conducted together in the past. Sometimes individual network representatives (not only their firms) were specifically chosen based on past experiences. This generated high levels of trust and decreased the risk of opportunistic behavior. The high trust level enabled them to share the knowledge and pool resources, to develop interoperable products and services and to collectively develop the market.

Moreover, trust was seen as an essential enabler for ecosystem building, as it is necessary for actors to share valuable information about their innovation and their firm's strategy, in order to be able to generate a shared vision for the sector, which is the prerequisite for coordinated collaborative system-building. *"And you need to be willing to share it with each other. Because most of the time you find out that you´re trying to move to the same end-point, which is not completely defined, but you can have a good vision about where you* *want to go. But your starting point is completely different. And that´s just a matter of... in the beginning it really is about trust, so do you trust each other to share a vision where you want to go, and what your development path is. You need to be open to show your strategy partly, and things that you do, but if you trust each other - well, then you can do it." [17]*

Investment into the collaboration: A few interviewees (3/17) mentioned that companies are more actively involved if they invest money and in-kind contributions into the network. *"Because we want to have them really actively involved, we ask: 'Okay, what is your main interest? And what would you invest in?' [...] And if people say: 'Well, we want to go to a certain route, want to create a road map', then they also should say, 'this is our strategic role in this, we're going to invest money into the development.' So they will be more committed." [13] - "Commitment from companies is important, they should be willing to invest." [3]* The willingness to invest into a system-building activity was also used as an indicator of what mattered most to companies and as input for strategically planning the collaboration. *"We wanted to discuss with our partners: 'What is your core interest? What do you really want to get out of this? Where would you put your money?' Then we can figure out how we can coordinate this and make it a collaborative effort."[13]* Investment into the collaboration was used as a specific mechanism to reduce opportunistic behaviour. For example, one network had at one occasion many members, of which a few seemed to extract knowledge rather than contribute. To reduce this opportunistic behavior, a substantial membership fee was introduced. This made the less motivated companies leave the network. But the motivated ones stayed, which lead to better goal alignment and higher commitment within the network; and decreased the risk for opportunistic behavior.

5

Common vision and goals: All interviewees mentioned that a common vision is necessary for this type of collaboration. Half of the interviewees even elaborated intensively on the importance of a common vision and jointly set goals to give direction to the collaboration and the building of the ecosystem. *"A collaborative system requires a common goal." [13]* The development of a common vision is crucial to enable benefits for collaboration to develop innovative technologies and establish a supportive business ecosystem. *"A common vision is necessary to form standards and to enable large scale implementation." [6]* The common vision gives direction to the development of the sector. Having a common vision allows firms to *"develop in the same direction" [13]* and to develop industry standards, which enable them to generate interoperable products and network resources. Based on this vision networks develop their network objectives.

"To make sure the [system-building] processes are ongoing, you have to make sure that you have the right vision and the same goals." [2] Common objectives were set for each network, together with all network members. This joint goal creation ensured that company goals could be aligned to network goals. Common objectives were regularly reviewed and if necessary adjusted to the further-developed innovation ecosystem. The common vision gives direction to the development of the sector. It is the basis for shaping the institutional

environment in favor of the smart grids technology, for developing interoperable products and for market development. It also helps to reduce uncertainty. Firms can align their goals and development efforts to this vision, which reduces the risk of investments. Common vision and goals are periodically adjusted, to changes of the environment and progress in technological development. *"During the initial period we created the starting vision and we invited others to join. But it needs to be adjusted. Once in a while we have a discussion, and make these adjustments. Often only small details about the tactics." [12]*

Goal alignment: The majority of interviewees (10/17) mentioned the necessity to align goals and to prevent goal-conflicts. The fact that smart grid actors develop their vision together facilitates that they will be able to align their company goals to it. *"It's about vision. It's about how you see this vision as part of your strategy." [12]* To enable goal alignment, the different interests and different company goals need to be acknowledged. *"Actors should try to understand each other's interests and take these into account." [3]* A lot of discussions about these different interests and goals helped the actors to find common ground and to align their goals with their respective system-building networks. *"In principle we have sessions with the board members of the partners every three months, to really make sure that they align on the goals and vision that we have." [11]*

Another mechanism to reduce goal-conflict was that some companies left the network, or started an additional smaller network, as they shared the same objective. Goal alignment helped to reduce inter-firm goal conflict and role-conflicts. Interviewees stated that they experienced role-conflicts as member of the network and as a member of the firm, when firm goals differed from inter-organizational goals, especially since most companies are not used to change and transition. The network member often functions as a change agent within his company. One network solved this problem by only having CEOs of companies as members - who could more easily adjust their company goals to the network goals.

Clear boundaries to information sharing: About one third of the interviewees (5/17) stated that an essential enabler for knowledge exchange is that there are very clear boundaries to information sharing. Knowledge exchange is necessary to develop the business ecosystem. Actors in the field know that to generate a common vision, to standardize technology and to co-create compatible products and services it is essential to exchange detailed information on their innovative ideas. *"Of course then there's a bit of tension between overlapping businesses where you have to share knowledge and interests of your own company with your competitor. But at the end of the day, all the partners understand that we cannot aggregate business if we don't collaborate." [17]*

However, this comprises the risk of knowledge leakage. In order to minimize this risk, the firms agree on very clear boundaries for information sharing. *"From the beginning on they should have clear boundaries in terms of exchanging information." [10] - "Make explicit what you should share with each other and what you shouldn't share." [17]* For example, three of the networks include pilot projects in smaller constellations of members. Within the pilot projects, network members share crucial information *("commercially valuable information"[9])*. But they ensure that this information is not shared outside the pilot project. They make agreements such as *"what is discussed in the project stays in project"[11].* This is important, since all of them also collaborate with other firms on other projects. If they would share this knowledge with other partners outside the project, the knowledge would quickly spread throughout the whole industry. This would make firms reluctant to share information at all. Knowing that the information stays within the agreed-on boundaries, reduces the perceived risk of knowledge leakage.

Moreover, when starting their collaboration, network members also clearly determine in which domain they collaborate and in which they don't. *"Okay, this is how far we collaborate, and after this point we are all on our own." [10]* This mechanism allows sufficient knowledge exchange within the network, the bundling of forces and the development of interoperable products, while at the same time reducing the risks of knowledge leakage and reduced competitiveness.

5

Careful composition of partners in pilot projects: About one fourth of the interviewees (4/17) mentioned another mechanism, which enables knowledge exchange on the system-level while minimizing the risk of knowledge leakage to competitors. In a network that developed knowledge and conducted different pilot projects, for each pilot project a constellation of actors that were not direct competitors was chosen. While there were direct competitors in the network as a whole, two direct competitors did not work in the same pilot project. This enabled the firms within each pilot project to share knowledge relatively openly. *"In this network there were some direct competitors from other energy suppliers and we arranged it in a way within the network that in every pilot project, we had only one supplier. So that there is some collaboration on the higher, conceptual level where you exchange your insights and ideas; but within one pilot we could be open on the innovations even when there is commercial interest."[8]*

However, at the end of the pilot projects, outcomes of the pilot studies were shared among all members. They published their findings in a report which was made available to all system actors, but they left out the crucial details. This enabled coopeting firms in a network to exchange knowledge, learn from each other and develop a vision, while at the same time not having to expose one's core knowledge to direct competitors.

Clear boundaries to joint technology development: While all interviewees agreed that strong collaboration is necessary for technology development and optimization, half of them (8/17) pointed out that the development of commercially viable products can and should be conducted individually. When it comes to final product development they prefer to do this individually, or only with complementary technology producers, but not with competitors. *"In my experience, with development of commercial products there was a line.*

On most system-building aspects you can collaborate, but when it comes to commercial product development it is different."[8] This is possible when there is an open infrastructure with an industry-wide standard. *"Commercially viable products can be developed on the open infrastructure by individual parties." [1]*

Neutral entity in charge of coordination: *"There is only one way to realize this transition and that is by coordinating our efforts with all different actor groups along the value chain." [7] - "But there is one thing necessary at the moment and that is strong coordination." [10]* Without a strong coordinator who steers discussions, it will take much more time to reach decisions and achieve results. *"You need a kind of coordinator or communicator if you develop something new. [...] The transition only works if we put new technologies in sync." [3]*

Not only was coordination necessary, but this coordination should be conducted by a 'neutral entity'. *"He should not be part of the discussion, he should have an objective view on things." [10]* Half of the interviewees (8/17) mentioned that having a neutral entity in charge of coordinating the inter-organizational collaboration reduced the perceived risk of opportunistic behavior by partners. This is because a neutral organization or 'neutral person' would have no interest in pushing their own agenda or deciding on network objectives which would mainly serve their company's objective. *"I think that is because we are not a commercial party, it is accepted that we take that role [of a coordinator]. We can steer discussions and encourage decisions, without being questioned by other network members." [13] - "I was chosen [as network coordinator] because I am independent. I will not take sides and I try to balance the interests of the parties."[1]* Or sometimes an employee of one of the network member companies was chosen, but it was clear to all network members that he was 'neutral enough' to think and act on the system-level, beyond the interests of his own company. The neutral entity can help to facilitate system actors to create joint objectives, it can reduce coordination difficulties, and it stimulates knowledge and resource sharing, and the bundling of forces.

Clear collaboration structures: Half of the interviewees (8/17) mentioned that clear collaboration structures enabled the collaboration. Clear governance structures and coordination mechanisms were essential for the network's functioning, as they enabled decision-making and efficient coordination of activities. This enabler is not about what knowledge and resources are exchanged, but *how* they are exchanged. One interviewee pointed out that more important than the specific type of governance mechanisms chosen, was *that* collaboration structures were introduced to the network, and that these structures were clear to all network participants. *"I think a good set of rules is important to make it work in a smooth way. Because if you don't have a clear set of rules, decisions will not be taken." [15]* Introducing to the network clear structures that facilitate the coordination of their collaboration decreases coordination costs and loss of control.

Effective communication: Almost half of the interviewees (7/17) stated that it was important to have effective personal and electronic communication channels in place. These ensure that all participants receive important information prior to meetings to enable them to take informed decisions. At the same time these effective channels ensure that network members are not overloaded with too much unnecessary information. An effective electronic communication platform can also increase transparency in the network. *"Transparency is also very important. [...It is created] through the website." [12]*

Especially for bigger networks effective communication is necessary to attract new members and to keep existing members motivated. *"Well, if you don't do anything about communication, if you don't have a good website, I guess it [the collaboration] will stop. You really need to keep on putting effort into it - by newsletters, by road shows, the website." [2]*

5

Moreover, good communication to external stakeholders is necessary for lobbying and societal changes, i.e. to shape the institutional environment. Effective communication facilitates knowledge exchange and decreases coordination difficulties.

Fair collaboration between big and small firms: To build up a new ecosystem successfully**,** big and small companies need to collaborate. The big ones have power and resources, the small ones are often the generators of innovative ideas but do not have sufficient power and resources to implement them. About one fourth of the interviewees (4/17) explained that in the smart grids sector, actors were aware that small companies are necessary for system-building processes, but that they cannot invest equal amounts of resources as their bigger collaborators. Bigger companies invest more into the network collaboration, in terms of money and in-kind contributions. This unequal contribution of resources is compensated by unequal power distribution. In return for making higher investments, the big companies get more decision-making power. *"In the general assembly, if you are a platinum member, you get five votes [instead of one vote as a regular member]." [12]* All partners consider this situation to be an acceptable solution. *"It is difficult to put a monetary value on it, but our co-operation with the big companies was really, really valuable, we gained a lot from it." [16]*

Actors find it important to have fair distribution of power and control, but they do not require it to be equal. *"For the smaller ones it´s less interesting to have also votes in how to organize things and to have governance rights, so they mainly contribute at content level. It´s about being fair how you organize projects. [...] A lot of small firms are not directly part of the main consortium, they cannot invest like that, but you take them along your development paths, and you make sure that the costs and benefits are shared in a fair way." [17] - "If we address actors as equal partners, we are more open, more creative to find solutions which weren't existing." [8]*

Creation of 'common playing field': Almost half of the interviewees (7/17) elaborated on the need to find the right balance between collaboration to bundle forces and align developments and competition to increase innovative solutions. If technology development activities are not aligned and knowledge is not shared, it means that sometimes *"the wheel is reinvented" [14]* and that resources are used inefficiently. On the other hand, the downside of highly aligning technology development would mean a loss of innovativeness, as many potential solutions would be neglected from the start. The smart girds actors did not experience that their collaboration slowed down innovation. However, they also stated that it was important to not focus on one solution too early and to keep developing innovative solutions independently, to use resources for trial and error testing and to generate a variety of ideas. *"It is good to have competition, because it will generate many alternative technology solutions, so the best solution can be delivered to end users and society. [...] On the other hand, if many initiatives are working on the same thing, than it is not efficient and a lot of money is wasted. But transition is not a straight line." [8].* Also, if all companies needed to decide on technological developments together, it would be a very lengthy decision-making process. *"If you agree on everything you are going to do that takes far too much time." [12]* Smart grids actors stated that better than deciding at a central institution in which direction to develop or *"dictating what to develop" [7]* was to *"create a space"[7]* in which companies and organizations can develop their ideas, innovations and products. *"It is not possible to come up with a 'grand scheme of collaboration to realize the energy transition', because players don't understand all aspects this transition entails. We cannot already define the course from the start. We [facilitating organization] are trying to create space; space for everybody who wishes to make a contribution to the sustainable energy transition. In practice, we shouldn't prescribe. We should let that be the initiative of companies, municipalities, civilians etc. We must enable them to work together." [8] - "To create this space we must collaborate on a high level, but that is not to prescribe the future, but to create space for people to create the future."[8]* To create this space, a common vision and industry-wide standards are necessary, and the institutional environment needs to be shaped, e.g. to achieve enabling regulations. A *"common playing field" [5]* was created which can lead to an increased product variety of compatible products, increased turnovers and a bigger market.

5.6. Discussion

We start by comparing our findings regarding benefits and risks to the extant coopetition literature, then we will focus on the enablers for collaboration at the network-level.

5.6.1. Benefits and risks

The benefits of coopetition as described in literature were also found in system-building in the Dutch smart grid sector. Interviewees elaborated more intensively on benefits at the inter-organizational level, and only a few interviewees mentioned benefits at the firm-level. That is unsurprising, as the focus during the interviews was on collaboration in networks. Comparing the benefits mentioned in literature to the empirical evidence, it can be concluded that the benefits mentioned in theory are also evident for system-building networks, i.e. at

the network-level. Our case study showed that system-building actors understand that it is necessary to collaborate with their competitors in order to build healthy ecosystem around their new technology. The more they collaborate, the more they can bundle their forces and develop the technology and its ecosystem faster.
The risks of coopetition mentioned in the literature also resided for system-building networks at the network-level in our empirical case. However, they are prevented or minimized by system-building actors, from the start of the collaboration. Our analysis revealed that for each of the risks mentioned in the literature, they had a strategy in place, to prevent or minimize that specific risk.

5

5.6.2. Enablers and coping strategy

Our analysis revealed that system-building actors had put a number of enablers in place, which helped them to cope with the dilemma of competition versus collaboration in system-building. We call this 'coping strategy', as they strategically used combinations of enablers to cope with the dilemma of collaboration versus competition. They deliberately implemented certain enablers or combinations of enablers upfront, to cope with the risks of coopetition. For example, to prevent opportunistic behavior by partners, they implemented the enablers *trust development, investment into the collaboration and neutral entity in charge of the collaboration.* To prevent the risk of knowledge leakage, from the start of their collaboration, they implemented *clear boundaries to information sharing* as well as *clear boundaries to joint technology development*. Over time, actors reviewed their coping strategy, and adjusted it to the further developed eco-system. Column C in Table 5.4 shows which enablers they combined in order to prevent a specific coopetition risk, i.e. of which combinations of enablers their *coping strategy* consisted.

In the findings section we already elaborated on which benefits the enablers increased and which risks they decreased. In the following section, we will discuss the differences between our findings on enablers and the extant coopetition literature.

5.6.2.1. Enablers in line with coopetition literature

Most enablers for coopetition in networks for system-building are in line with existing coopetition literature: Trust development, common vision and goals, goal alignment, rules for knowledge exchange and inter-organizational coordination. What had not been described yet was that these enablers are often intertwined. For example, we found that *trust* is the basis for the enablers *common vision and goals* as well as *rules for knowledge exchange. Common vision and goals* is the pre-requirement for *goal alignment*. A systematic overview of enablers for coopetition at the inter-organizational level had been missing; therefore the interrelations between enablers had not yet been discussed.

5.6.2.2. Enablers not yet specifically mentioned in the coopetition literature

We found three enablers that have not been specifically mentioned in the coopetition literature, and that could be linked to an already mentioned enabler.

While it was stated in the coopetition literature that *inter-organizational coordination* was important, the need for *clear collaboration structures* and a *neutral entity in charge of collaboration* were not explicitly stated. First, a plausible explanation that *clear collaboration structures* had not been mentioned as an enabler, is that the empirical cases so far used, such as dyadic relationship and supplier networks, have less actors involved or a focal company in charge, so collaboration structures are predefined from the start, without having to deliberately set them up. Second, a *neutral entity in charge of coordination* is necessary for system-building networks, but not mentioned in existing literature. A plausible explanation is that in established industries collaboration has a clearly defined purpose from the start of the collaboration, like the delivery of an existing product or service, or an incremental product innovation. The collaborative goals are a result of the company's goals. In system-building, often the opposite is the case: first the vision for the sector is designed, and then company goals have to be adjusted to these system-goals. Therefore, it is important to have a neutral leader, who can be trusted not to have a hidden agenda or push the sector's development in a direction that mainly serves his own firm.

While it is stated in the literature that 'sharing financial risks' increases *mutual commitment,* the enabler *investment into the collaboration* had not specifically been mentioned. A plausible explanation that investment into the collaboration has not yet been explicitly mentioned is that in most inter-organizational collaborations empirically studied so far the number of collaborating firms is already clear in advance and there is a plainly defined purpose. I.e. there is no 'fluid' network-forming and goal-defining phase in which information is already generated and exchanged. And in supplier network collaborations, new firms only join the network if a transaction will be made (e.g. intermediary products delivered), which inherently requires an investment on their part, and a 'membership fee' is not necessary.

5.6.2.3. Enablers entirely new to coopetition literature

Two more enablers for coopetition at the network level have been identified from our empirical case, which hadn't been mentioned in the coopetition literature yet and could not be related back to existing enablers. First, *careful composition of partners in pilot projects* has not been mentioned in the coopetition literature; a plausible explanation is that the level of observation in most empirical studies was at the firm-level, and not at the network-level. From a firm-level perspective the question is if the firm should participate in the collaboration or not, and what the inherent risks would be. In contrast, from a network-level perspective the question is how to enable a sector-wide knowledge exchange between competitors, without them being afraid of losing commercially valuable information to competitors. Second, the *creation of a common playing field* enables the coopeting actors to find the right balance between bundling their forces and generating manifold innovative technological solutions. This enabler has not been mentioned yet in the coopetition literature, a plausible explanation for this is that compared to the empirical cases so far studied where collaborating units usually have a fixed goal, system-building is an uncertain adventure. At the start of the collaboration goals are not yet defined, and it is not yet determined which firms and other actors will become collaboration partners.

5.6.2.4. Enabler different from the coopetition literature

We also found an enabler that differed from the coopetition literature: *Fair collaboration between big and small firms*. In the coopetition literature the enabler *equal power distribution* describes that equity in risk and contribution is important for the success of the collaboration. However, in our empirical case we found that actors understood that they needed big and small companies in their collaboration for system-building, and that small companies were not able to contribute as many resources - financially and in-kind - as big ones. Unequal distribution of power and financial contribution were accepted. Instead, what they aspired for was a fair distribution of benefits and costs among partners. A plausible explanation for this difference is the empirical focus of the study which suggested this enabler were alliances with equally sized actors, e.g. for R&D or complementary services, who are similar in size and have equal resources. They can make equal contributions and expect equal power distribution. In system-building networks that is not always the case.

5.7. Conclusion

Little research had been done on how to reduce risks and increase benefits of inter-organizational coopetition from a network-level perspective. In our study, we first provide a systematic overview of risks, benefits and enablers of collaboration with competitors, as described in the coopetition literature. Then we conducted an empirical study of the Dutch smart grid sector to investigate how system-building actors deal with the dilemma of collaboration with competitors. We found that system-building actors use the enablers for coopetition described in the coopetition literature. In addition, they use the following five enablers: *neutral entity in charge of coordination, creation of a common playing field, shared investments into the collaboration, clear collaboration structures and careful composition of partners in pilot projects.*

More importantly, we found that system-building actors do not merely implement enablers to increase the benefits and reduce the risks of coopetition. They apply a ‘coping strategy’, which is a deliberate combination of enablers implemented from the start of the collaboration and periodically adjusted to developments of the innovation ecosystem. Another remarkable finding is that they prevent risks upfront - instead of merely minimizing them. They strategically set up their collaboration in such a way that they minimize or even prevent risks and increase the benefits of coopetition.

To conclude, in collective system building, actors design collaboration with competitors up-front in a way that facilitates collaboration and alleviates its inherent risks. They strategically use combinations of enablers to cope with the dilemma of collaboration versus competition.

We contribute to the coopetition literature the empirical setting of system-building - actors all along the supply chain collaborating to establish an innovation ecosystem around a technological innovation. The findings are interesting for management scholars in general, as industries are changing and new ways of working are required, which are based on inter-organizational collaboration. Many sectors are in flux, moreover traditional sectors will not stay the same and become more interwoven. Ecosystem-building is therefore an interesting case to study the mechanisms of networked collaboration with competitors and other actors along the supply chain. The coopetition literature so far has mostly focused on empirical cases of networks of firms, multi-firm alliances or even more narrowly dyadic relationships between firms. The network-level had been understudied. We add to the coopetition literature insights on how coopeting networks of firms organize their coopetition at the inter-organizational level, and how they reduce its risks and increase its benefits. We furthermore introduced the term 'coping strategy' to the literature. A coping strategy is the deliberate implementation of combinations of enablers upfront of a collaboration with competitors, in order to minimize or prevent inherent risks of coopetition. Moreover, we filled a gap in the transition literature, by providing insights into how system-building firms strategically deal with the dilemma of competition versus collaboration. The chapter also makes a practical contribution. Practitioners who want to build-up a favorable ecosystem around their innovative technology can benefit from the insights this chapter generates. They can use the described enablers to strategically minimize or even prevent coopetition risks, and reap more benefits from it.

A limitation of this chapter is that we studied only one case, the case of the Dutch smart grids system. We tried to offset this by interviewing the most important key actors of the sector, covering the whole innovation ecosystem, and conducting in-depth interviews. For future research, our findings could be tested in more emerging industries, to increase generalizability. Moreover, we found some indications that different enablers and risks occur in different phases of industry emergence; but not enough to make claims about it. This would be interesting to investigate in further research.

CHAPTER 6

Conclusions and reflections

6.1. Answering the research questions

The aim of this thesis was to develop a set of systemic strategy frameworks for system-building entrepreneurship, to be used as theoretical frameworks to understand collective action in emerging innovation systems and as practical tools for entrepreneurs that provide guidance on how to build a supportive innovation ecosystem for their radical sustainability technologies.

In today's fast-paced high-technology societies, most innovations cannot succeed in isolation but need a healthy innovation ecosystem in which they can flourish. This especially applies to sustainability innovations, since these innovations face additional challenges. Innovating entrepreneurs do not have to wait until this innovation ecosystem emerges, but they can pro-actively build and shape it. The process of innovative actors establishing an innovation ecosystem around a technological innovation is coined 'collective system building', as system actors collaborate to build the innovation ecosystem. System-building takes place in strategic networks. These strategic networks are composed of system actors, such as company actors, governmental actors, research institutions and interest groups. In different constellations of actors, they build up an innovation ecosystem. Strategic collaboration and coordination of system-building processes can accelerate the emergence of an innovation ecosystem and thereby increase the chances of success of an innovative sustainability technology.

To generate strategy frameworks for collective system-building, the phenomenon of collective system building was studied from both a theoretical and an empirical perspective. Insights from the transition literature were combined with insights from the strategic management literature, and it was empirically studied whether this combination of insights has added value for practice. It was studied which practices and strategies system-building entrepreneurs use, what went well, how they tackle problems and how they optimize their collaboration. The outcome is a set of strategy frameworks which provide entrepreneurs with insight into how to operate when developing and implementing radical sustainability technologies.

In the following sections, the research questions of this thesis will be answered.

6.1.1. Strategy framework for collective system building

This thesis is rooted in transition studies literature. The TIS framework was used as the starting point for developing the 'collective system building' concept, and its related strategy frameworks. The TIS framework was chosen as starting point, as it gives valuable insights into the key processes of building an innovation ecosystem. Because the TIS framework had been originally developed for its use by policymakers, the first step was to test the extent to which the TIS framework is suitable to be used by entrepreneurs for system-building. The first research question was: *To what extent does the TIS framework match the entrepreneurs' perceptions regarding important system-building processes?*

It was found that the TIS framework widely matches the viewpoint of entrepreneurs. However, for its use by entrepreneurs, a few slight adjustments are suggested.

From the viewpoint of entrepreneurs, the key processes 'Entrepreneurial experimentation', 'Knowledge development' and 'Knowledge diffusion' are interrelated. Within these key processes, the development of commercial products needs more emphasis, as well as research on user behavior and acceptance. Moreover, the key process 'Market formation' needs to be divided into processes that are driven by the government and processes that are driven by entrepreneurs. Regarding this key process, there should be greater emphasis on collaborative marketing, on changing user behaviour and preferences, and on the development of fair and feasible business models. The findings further indicated that some entrepreneurs found that an additional key process around the coordination of system-building processes would be useful, as this would accelerate the emergence of a healthy innovation ecosystem, and resources would be used more efficiently.

6

Having shown that the TIS framework can be used in a slightly revised manner by system-building entrepreneurs, the next step was to create a strategy framework for networks of entrepreneurs who want to collectively create a supportive environment for their new technological sustainability innovation. The second research question was: *What system-building activities can entrepreneurs undertake to create a favorable environment for their technological innovation, and how can these activities be combined into a practical strategy framework that can be used for strategic collective system building?*

Both the transition literature and the strategic management literature acknowledge the importance of collaboration and the need to establish a favorable environment around the new technology. The strategic management literature takes on a firm perspective in which it considers the environment, whereas the transition literature takes on a system perspective in which it considers the firm. Based on these literature streams, the concept of strategic collective system-building was developed and then empirically tested.

The term 'collective system building' emphasizes the collective nature of system building, as opposed to 'system building' which can also be driven by very powerful individual actors. Collective system building can be carried out intuitively or strategically. 'Strategic collective system building' is defined as the strategic activity of networks of entrepreneurs to build-up a supportive environment and infrastructure for their innovative sustainability technology. Firms do not have to wait for a supportive environment to emerge, in which their innovation will flourish. They can pro-actively create such an environment. Successful strategic collective system building leads to a wider adoption of the technology, larger markets and wider implementation in society.

Based on the concept of strategic collective system building, a strategy framework was developed for entrepreneurs to collectively create a favorable environment for their sustainability technology. It was termed 'strategy framework for collective system building'. The strategy framework consists of four key areas for strategy making: technology development and optimization, market creation, socio-cultural changes and coordination (see Figure 6.1).

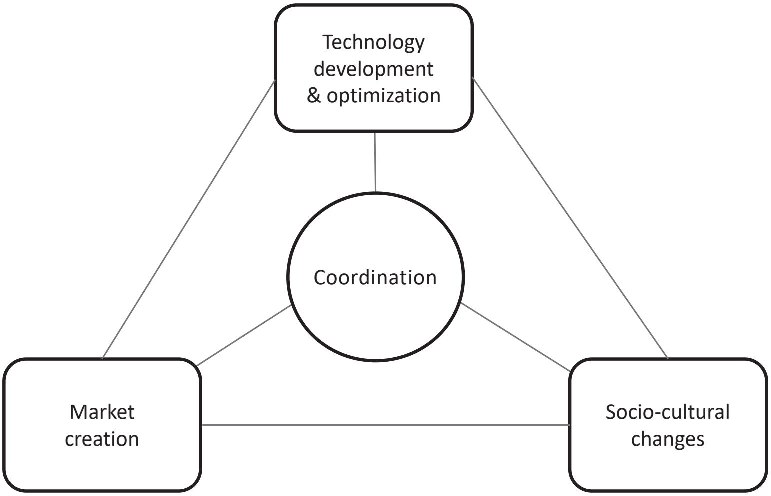

Figure 6.1: Strategy framework for collective system building by entrepreneurs

Each of these key strategic areas is composed of a set of system-building activities. The first three categories are system-building goals which entrepreneurs collectively strive for. The category 'coordination', on the other hand, comprises all the activities that manage and align system-building efforts, lead to combining forces and resources and thus accelerate the system-building processes. An overview of these categories and system-building activities is presented in Figure 6.2.

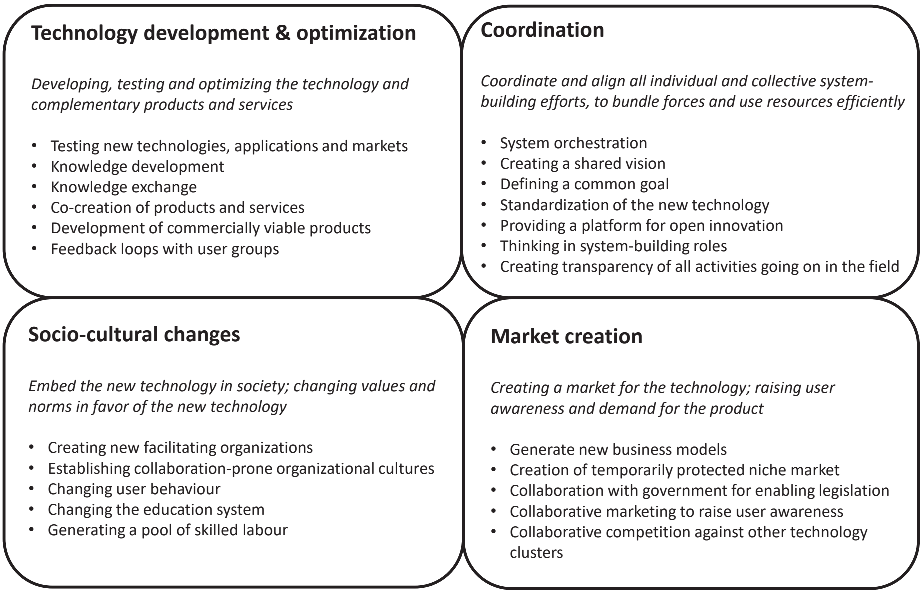

Figure 6.2: Overview of the strategy framework for system building and its system-building activities

The framework depicts an overview of activities that firms can undertake in order to build a system. Networks of entrepreneurs can use this framework as a tool to collect and structure information, from which they can effectively generate strategies for system building. The framework facilitates the structuring of information by clustering system-building activities according to the underlying system-building goals that these activities contribute to. This framework can also be used by networks of entrepreneurs to facilitate their understanding, not only of the various system-building goals but also of the activities they can carry out to achieve these goals. It might help them to identify activities that firms already focus sufficiently on, as well as activities that have not yet been given sufficient attention and resources. They can use the framework to set goals, divide tasks and distribute roles.

6.1.2. Coordination and management of strategic system-building networks

At the center of the strategy framework (Fig. 6.1) is the category ‘coordination’. Coordination of system-building accelerates the emergence and development of the innovation ecosystem and leads to a more efficient use of resources. Since collective system-building takes place in networks, the next step was to find out how these networks can be managed effectively, in order to reach their system-building goals. The third research question was: *How are networks for collective system building managed so as to reach their collective system-building objectives?*

Since the transition literature had little advice on how system-building actors ought to coordinate their activities, and because collective system-building takes place in networks, insights from the strategic network management literature were used. From this latter literature, key factors for effective network management were identified, and then empirically tested. The result is a framework of network management for system-building, which shows the key factors for network management, and summarizes how they should be implemented for the effective management of system-building networks (see Table 6.1).

Key factors of network management	How key factors should be implemented to increase network effectiveness for system-building networks
Network composition	
Size	Optimal size depends on network's aim: large enough to have influence but small enough to be manageable. Smaller size increases effectiveness; larger size may be necessary to link all players in sector for information flow/transparency, but this diminishes the exchange of vital information. Goal alignment more important than network stability.
Actor diversity	Depends on network's aim. Diversity necessary for most aims. Diversity does not necessarily increase conflict potential. Higher actor diversity may also mean that there is less direct competition which facilitates exchange of vital information.
Governance structure	
Governance mode	Different modes possible; preferred mode: board of directors and then working groups who report back. Single coordination body necessary; consisting of network members. Top-down approach not considered as effective (but may be necessary for sector-wide network which increases transparency).
Rules for collaboration	Clear cooperation rules necessary. Trust is better than much formalization. Very clear boundaries set for information sharing as enabler for collaboration.
Decision making mechanism	Important to have consensus decisions (joint and equitable decision-making). Discussion till consensus considered most effective. Top-down decision-making not appreciated by network members.
Network leadership structure	Assigned network managers contribute to better coordination and information flows within network. Mostly two network leaders, rather than one. One content specialist and one project manager.
Managerial processes	
Strategy and goals	Clear vision and common goals necessary to reach network objectives. Jointly created vision and goals help to motivate members and give direction; if not jointly created, goals entail less motivation. Goal-alignment (firms-to-network) leads to higher effectiveness. Frequent goal-adjustment necessary in quickly changing environment.
Project management	Good project management (regular meetings, written agendas, administrative systems) vital to keep members motivated and to achieve network goals; because financial benefits lie in future and membership is voluntary. Measuring and evaluation perceived important but proves difficult in uncertain, fast-changing environment.
Task distribution	Determine who is responsible for what. Require clear deliverables. Participatory distribution (ask who volunteers for a task or who would be most suitable).

[continued on next page]

Transparent communication	Clear and transparent information exchange between all members increases information flow and information capture. Provision of all information to all members considered very important.
Relational factors	
Trust	Trust is major factor for network effectiveness, especially because members have to share vital information. High level of trust decreases governance costs and facilitates collaboration and knowledge exchange. Selecting ('hand-picking') individuals when composing network increases trust level.
Harmony and commitment	High level of commitment and harmony necessary for members to contribute time and resources to network. Goal-alignment increases harmony and commitment. High trust (hand-picked members) increases harmony. Network management style increases harmony and commitment Free-rider problems prevented by social pressure and if occur solved by personal talks.
Leadership style	Network effectiveness depends heavily on good network leader. Participatory leadership style necessary. Neutral leader decreases fear of opportunistic behavior. Content-specialist necessary to chair meetings and represent network externally. Person with project management skills necessary to ensure good process management and high member motivation. Two or three leaders necessary, often an external person (non-network member) is hired to fulfill one of these roles.

Table 6.1: Framework of key factors for effective management of system-building networks

6.1.3. Enabling collaboration with competitors in innovation ecosystems

As system-building takes place in networks of actors all along the supply chain, especially for developing inter-operable products and services, it is necessary to strongly collaborate, also with direct competitors. Therefore, when engaging in collective system-building, firms face a profound dilemma: They have to share crucial information with their competitors, and pool resources, in order to develop a technological system with compatible products and services, and to create a market for their products. To build a stronger innovation ecosystem, they have to share resources and information with their competitors - and thereby have to expose themselves to the inherent risks.

The fourth research question was: *What strategies do actors in networks employ to minimize the risks and increase the benefits from collaboration for system-building?*

To give firms strategic advice on how to deal with this dilemma, the transition literature was complemented with insights from the coopetition literature, and empirical research has been carried out. The empirical findings revealed that system-building actors had put a number of enablers in place, which help them to reduce the aforementioned dilemma.

6

These enablers are mechanisms which reduce or prevent the risks of coopetition and increase its benefits. An overview of these enablers is shown in Figure 6.3.

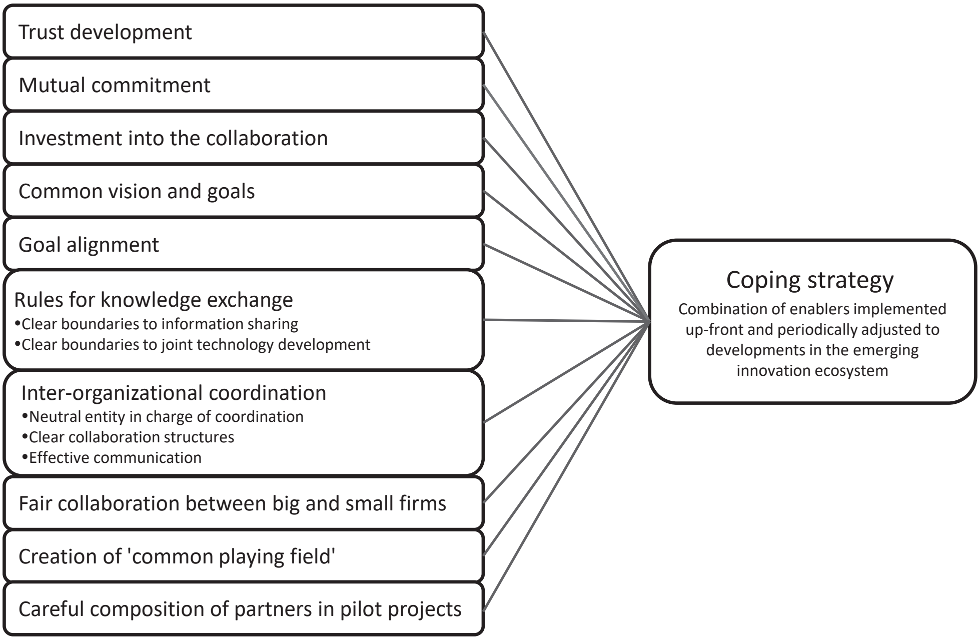

Figure 6.3: Overview of enablers used to reduce dilemma of collaboration versus competition

Another remarkable finding was that system-building entrepreneurs prevented risks upfront - instead of merely minimizing them. They apply a 'coping strategy'. A coping strategy is the deliberate combination of specific enablers, implemented from the very start of the collaboration and adjusted in the course of time in response to changing conditions of the emerging innovation ecosystem. They strategically set up their collaboration in such a way that they minimize or even prevent risks and increase benefits of coopetition.

6.2. Overall reflection

The combination of the transition literature with the strategic management literature was very valuable. Both literature streams describe the collaboration in innovation ecosystems, but from different perspectives. The transition literature takes a system-perspective, and provides an overview of the system-wide processes of the socio-technological transition that takes place when a radical sustainability innovation is successfully introduced into the market. It gives insights into the processes necessary to build up an innovation ecosystem. The strategic management literature, on the other hand, takes a micro-level perspective, and suggests strategies for firms on how to act in and influence an innovation ecosystem. It explains how firms can reap benefits from collaboration in networks, or how businesses should organize their collaboration at the firm-level. The combination of both fields of literature enabled the development of systemic strategy frameworks for networks of actors who pro-actively want to build up an innovation ecosystem around their technological innovation.

The main contribution of this thesis is the introduction of the concept of 'collective system building' and insights into how entrepreneurs collaborate in networks to collectively build up a supportive innovation ecosystem for their innovative sustainability technologies. Important insights have been gained into the collective action of entrepreneurs in sustainability transitions, and how they can shape innovation ecosystems. These innovation ecosystems also enable the implementation of not one technology, but combinations of technologies (such as in the case of smart grids), which together provide a solution to a societal problem. It is shown how actors in sustainability transitions can collaborate to provide solutions to societal problems, how they can pro-actively shape their innovation ecosystem and thereby enable systemic change and, ultimately, solve societal problems.

6

Theoretical contributions have been made to the strategic management literature, as well as to the transition literature. First, the contributions to the strategic management literature will be elaborated. In this literature, some authors had expressed the need for a new management paradigm, which focuses more on collaboration in networks, as opposed to individual competition. Although the extant strategic management literature already discusses the concept of business ecosystems or innovation ecosystems (Adner & Kapoor, 2011; Iansiti & Levien, 2004; Moore, 1993), the concept of strategic collective system building introduced in this thesis provides additional value. Scholars so far have focused on collaboration in established innovation ecosystems, and not on how to build a new system around an innovative technology. In addition, this literature stream has so far focused on management by *individual companies in* existing ecosystems, whereas this thesis contributes insights into how healthy innovation ecosystems can be strategically built through collective efforts by networks of firms. Additionally, the effective coordination of system-building networks was studied. Here, the contribution to the strategic management literature is the network-level perspective. Instead of management *in* networks, i.e. how firms can best act in networks, strategic advice on the management *of* networks was provided. Furthermore, it was studied how system-building actors organize their collaboration in networks, their bundling of forces and sharing of knowledge, and how to minimize the inherent risks of this collaboration. The contribution to strategic management literature is the network perspective on collaboration with competitors in emerging strategic networks, and how these networks can strategically minimize the risks inherent in their collaboration.

Theoretical contributions were also made to the transition literature. The main contribution is the focus on how entrepreneurs strategically build an innovation ecosystem. The strategy framework for collective system-building gives insights into strategic system-building and the activities system-builders can and should conduct in order to build-up an innovation ecosystem. This strategy framework gives insights into the collective action of private actors in sustainability transitions, and thereby fills a gap in the transition literature which so far had not explicitly incorporated this role of entrepreneurs. At the center of this strategy framework are ‘coordination’ processes. A further contribution to the transition literature is the collective agency of networks of entrepreneurs in sustainability transitions, how collective system-building is coordinated, how processes are organized and how actors cope with the risks inherent in the close collaboration with competitors, which is required for system-building. Moreover, tools and instruments for system-building entrepreneurs are provided.

The thesis also has several practical contributions. A set of strategy frameworks has been developed which entrepreneurs can use to pro-actively build up an innovation ecosystem around their innovative sustainability technology. These frameworks are described in the previous section. Based on the insights gained when working on this thesis, the following advice can be given to system-building entrepreneurs.

First and foremost, collaboration is vital. Instead of only focusing on developing and improving their own technology, entrepreneurs should, already at an early stage, identify other entrepreneurs who are working on similar technologies, as well as other system actors, such as customers, user groups and policymakers. With these system actors they should form networks, to start building up the innovation ecosystem.

Second, already when designing their technology, they should anticipate the necessary changes in user behavior, and other societal changes that need to be accomplished if large-scale adoption of their technology is to be achieved. These societal changes can only be realized in collaboration with other system actors.

Third, networks of system-builders can use the strategy framework for collective system-building (Figures 6.1. and 6.2), to create an overview of possible system-building activities. They can use the strategy frameworks for inspiration, to structure their information and ultimately to support decision-making. When using the strategy framework, they should adopt a systems-approach. They do not need to personally conduct all system-building activities listed in this framework. They should make sure to divide tasks within the emerging innovation ecosystem, to ensure an efficient and effective use of their scarce resources. Different actors or actor groups can take on different system-building tasks.

Fourth, to coordinate the system-building activities, which are conducted in different constellations of actors, an independent system coordinator is necessary. This system coordinator should orchestrate the system-building process, oversee the tasks to be done and help solve the problems that arise.

Fifth, a jointly created common vision and strategy is necessary to guide the development of the innovation ecosystem. Since the ecosystem is in development, this common vision and strategy needs to be reviewed regularly and if necessary adjusted.

Sixth, networks of system-builders can use the framework for effective network management (Table 6.1) to generate an overview of the ‘optimal’ key characteristics that should be in place to manage their network effectively. They can then compare their existing network characteristics with the optimal ones for system-building networks, consider where the gap is, and based on this decide which key factors should be adjusted or implemented first. If a new system-building network is to be set up, the key characteristics described in the framework can be used to create a blueprint for the network.

Seventh, to reduce the risks of collaborating with competitors, and to increase the benefits of this collaboration, system-building networks can implement sets of enablers, as shown in Figure 6.3. They probably cannot implement all enablers and mechanisms immediately, as this would cost too much time and money. They should jointly consider what the problems are that need solving, and then select mechanisms and enablers to solve them. With help of the framework, they can generate their own tailor-made coping strategy, to prevent the risks inherent in collaboration for system-building. This coping strategy needs to be periodically adjusted to adapt to changes in the emerging innovation ecosystem.

Many entrepreneurs already intuitively carry out system-building activities. Using the strategy frameworks described above can help them to turn their efforts into collaborative strategies. Strategic collaboration will help them to effectively bundle forces and to efficiently use their resources. This leads to a faster emergence of a stronger innovation ecosystem, which increases not only the success chances for their own technological innovation, but also accelerates the sustainability transition.

6.3. Limitations and future outlook

Since the aim of this thesis was to provide a strategy framework for system-building entrepreneurs, the focus was on the entrepreneurs' viewpoint. However, system-building networks do not only consist of entrepreneurs. They also comprise governmental actors as well as research institutions, financial institutions and user groups.[9] Most interviewees in this study were company actors, but also some government actors were interviewed for triangulation. All interviewees play active roles in the sustainability transition. Just as private actors, governmental actors are also involved in developing and shaping business models. They carry out important functions in system-building networks. The difference between private actors and governmental actors is, that the private actors have invested their own money, or their company's money, and need to earn a return on investment. This is of course different for governmental actors, who are also interested in the success of a project, but are not dependent on financial returns for their organization's survival. Their main motivation is to trigger societal changes, not to earn money. (In fact it is often the opposite – they often distribute money in the form of subsidies.) The focus of this thesis on system-building from an entrepreneurial viewpoint was deliberately chosen, as most of the transition literature is already focused on giving innovation policy advice to governmental actors.

As a consequence of this focus, the frameworks developed in this thesis, are to be used by system-building entrepreneurs. These entrepreneurs, however, also need to closely collaborate with other system-building actors. Governmental actors often play important

[9] Since system-building networks are composed of different constellations of actors, depending on their system-building goal, it can also be the case that some system-building networks only comprise private actors, such as a branch organization. However, these networks collaborate closely with policymakers.

roles in supporting the innovation system, and policymakers can strongly influence the development of a socio-technological regime. Research institutes, user groups and financial institutions also fulfill important functions in emerging innovation ecosystems. Entrepreneurs cannot achieve systemic change alone; different types of system-building actors are also necessary. System-building entrepreneurs need to be aware of the importance of these actors, and need to integrate them into their system-building strategies.

The field of transition studies is generally concerned with sustainability transitions. However, most of the historical transitions studied, were triggered by 'regular' innovations, not specifically sustainability innovations; the socio-technological transitions from one socio-technological system to another is studied. The insights gained in this thesis can be used by both sustainable and 'regular' technological innovations. The main difference between radical sustainability innovations and 'regular' radical innovations is that sustainability innovations often have to face more obstacles, as they are competing with an incumbent socio-technological system, which delivers the same functionality as the new sustainability technology. Because actors face these greater obstacles, it is crucial for them to sharpen their strategies and to join forces. Therefore, it is especially interesting to observe their system-building strategies. It can be assumed that the new insights gained into system-building can also be helpful for 'regular' innovations, as regular innovations also benefit from a healthy innovation ecosystem, as described in the strategic management literature. However, this assumption should be empirically tested, before claims can be made.

Another limitation of this thesis is that it focused only on one case, the Dutch smart grids sector. This focus was deliberately chosen because of the exploratory nature of this research, to be able to study a case in-depth. However, in order to generalize the findings of this thesis, more research is necessary, in different technological fields and in different cultural contexts. Moreover, while the focus here was on technological innovations in emerging industries, it would be very interesting to also study service innovations or systemic changes of established industries. This thesis can be seen as a starting point for many further interesting studies on strategic collective system building.

6

References

References

Aarikka-Stenroos, L., & Lehtimäki, T. (2014). Commercializing a radical innovation: Probing the way to the market. *Industrial Marketing Management*, *43*(8), 1372–1384. http://doi.org/10.1016/j.indmarman.2014.08.004

Aarikka-Stenroos, L., Sandberg, B., & Lehtimäki, T. (2014). Networks for the commercialization of innovations: A review of how divergent network actors contribute. *Industrial Marketing Management*, *43*(3), 365–381. http://doi.org/10.1016/j.indmarman.2013.12.005

Adner, R. (2006). Match Your Innovation Strategy to Your Innovation Ecosystem. *Harvard Business Review*, *84*(4), 98.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*, 306–333. http://doi.org/10.1002/smj

Adner, R., & Kapoor, R. (2011). Innovation Ecosystems and the Pace of Substitution : Re-examining Technology S-curves. *Strategic Management Journal*, *37*, 625–648.

Agranoff, R. (2006). Inside collaborative networks: Ten lessons for public managers. *Public Administration Review*, *66*(s.1), 56–65. http://doi.org/10.1111/j.1540-6210.2006.00666.x

Agranoff, R., & McGuire, M. (2001). Big Questions in Public Network Management Research. *Journal of Public Administration Research and Theory*, *11*(3), 295–326. http://doi.org/10.1093/oxfordjournals.jpart.a003504

Andersen, M. M., & Tukker, A. (2006). Perspectives on Radical Changes to Sustainable Consumption and Production. Copenhagen: Sustainable Consumption Research Exchange.

Astley, W. G. (1984). Toward an Appreciation of Collective Strategy. *The Academy of Management Review*, *9*(3), 526–535.

Astley, W. G., & Fombrun, C. J. (1983). Collective Strategy : Social Ecology of Organizational Environments. *The Academy of Management Review*, *8*(4), 576–587.

Autio, E., & Llewellyn, D. W. T. (2014). Innovation ecosystems: Implications for innovation management. In D. M. Dodgson, M, Philips, N., & Gann (Ed.), *The Oxford handbook of innovation management* (pp. 204–228). Oxford: Oxford University Press. http://doi.org/10.1093/oxfordhb/9780199694945.013.012

Baumol, W. J. (1990). Entrepreneurship: Productive , Unproductive, and Destructive. *Journal of Business Venturing*, *98*(5 (I)), 893–921. http://doi.org/10.1086/261712

Bengtsson, F., & Agerfalk, P. J. (2011). Information technology as a change actant in sustainability innovation: Insights from Uppsala. *Journal of Strategic Information Systems*, *20*(1), 96–112. http://doi.org/10.1016/j.jsis.2010.09.007

Bengtsson, M., & Kock, S. (2000). ”Coopetition” in Business Networks—to Cooperate and Compete Simultaneously. *Industrial Marketing Management*, *29*(5), 411–426. http://doi.org/10.1016/S0019-8501(99)00067-X

Bengtsson, M., & Kock, S. (2014). Coopetition-Quo vadis? Past accomplishments and future challenges. *Industrial Marketing Management*, *43*(2), 180–188. http://doi.org/10.1016/j.indmarman.2014.02.015

Bergek, A., Hekkert, M. P., & Jacobsson, S. (2008). Functions in innovation systems: A framework for analysing energy system dynamics and identyfying gloals for system-building activities by entrepreneurs. In C. Foxton, T.; Koehler, J.; Oughton (Ed.), *Innovations for a Low Carbon Economy: Economic, Institutional and Management Approaches*. Cheltenham: Edward Elgar Publishing.

Bergek, A., Jacobsson, S., Carlsson, B., & Lindmark, S. (2005). *Analyzing the dynamics and functionality of sectoral innovation system - a manual* (DRUID conferences No. 2005-05–09). Copenhagen.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, *37*(3), 407–429. http://doi.org/10.1016/j.respol.2007.12.003

Bergek, A., Jacobsson, S., & Sandén, B. (2008a). "Legitimation" and "development of positive externalities": Two key processes in the formation phase of technological innovation systems. *Technology Analysis & Strategic Management*, *20*(5), 575–592. http://doi.org/10.1080/09537320802292768

Bergek, A., Jacobsson, S., & Sandén, B. A. (2008b). "Legitimation" and "development of positive externalities": two key processes in the formation phase of technological innovation systems. *Technology Analysis & Strategic Management*, *20*(5), 575–592. http://doi.org/10.1080/09537320802292768

Berkhout, A. J., Hartmann, D., Duin, P. Van Der, & Ortt, R. (2006). Innovating the innovation process. *International Journal of Technology Management*, *34*(3/4), 390–404.

Berkhout, F. (2002). Technological regimes, path dependency and the environment. *Global Environmental Change*, *12*(1), 1–4.

Bleischwitz, R., Giljum, S., Kuhndt, M., & Schmidt-Bleek, F. (2009). *Eco-innovation – putting the EU on the path to a resource and energy efficient economy*. Brussels.

Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, *65*, 42–56. http://doi.org/10.1016/j.jclepro.2013.11.039

Boons, F., Montalvo, C., Quist, J., & Wagner, M. (2013). Sustainable innovation, business models and economic performance: an overview. *Journal of Cleaner Production*, *45*, 1–8. http://doi.org/10.1016/j.jclepro.2012.08.013

Bouncken, R. B., & Kraus, S. (2013). Innovation in knowledge-intensive industries: The double-edged sword of coopetition. *Journal of Business Research*, *66*(10), 2060–2070. http://doi.org/10.1016/j.jbusres.2013.02.032

Caniëls, M. C. J., & Romijn, H. A. (2008). Actor networks in Strategic Niche Management: Insights from social network theory. *Futures*, *40*(7), 613–629. http://doi.org/10.1016/j.futures.2007.12.005

Chesbrough, H. W., & Appleyard, M. M. (2007). Open Innovation and Strategy. *California Management Review*, *50*(1), 57–76.

Chin, K.-S., Chan, B. L., & Lam, P.-K. (2008). Identifying and prioritizing critical success factors for coopetition strategy. *Industrial Management and Data Systems*, *108*(4), 437–454. http://doi.org/10.1108/02635570810868326

Choi, T. Y., & Hong, Y. (2002). Unveiling the structure of supply networks: Case studies in Honda, Acura, and DaimlerChrysler. *Journal of Operations Management*, *20*(5), 469–493. http://doi.org/10.1016/S0272-6963(02)00025-6

Coenen, L., & Lopez, F. (2010). Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production*, *18*, 1149–1160.

Cooke, P. (2008). Regional Innovation Systems, Clean Technology & Jacobian Cluster-Platform Policies. *Regional Science Policy & Practice*, *1*(1), 23–45. http://doi.org/10.1111/j.1757-7802.2008.00002.x

Cooper, A. C. (1985). *Entrepreneurship*. John Wiley & Sons, Ltd.

Cormican, K., & O’Sullivan, D. (2004). Auditing best practice for effective product innovation management. *Technovation*, *24*(10), 819–829. http://doi.org/10.1016/S0166-4972(03)00013-0

Cristofoli, D., Markovic, J., & Meneguzzo, M. (2012). Governance, management and performance in public networks: How to be successful in shared-governance networks. *Journal of Management & Governance*, *18*(1), 77–93. http://doi.org/10.1007/s10997-012-9237-2

Dahl, J. (2013). Conceptualizing coopetition as a process: An outline of change in cooperative and competitive interactions. *Industrial Marketing Management*. http://doi.org/10.1016/j.indmarman.2013.12.002

Davenport, T. H., Leibold, M., & Voelpel, S. C. (2007). *Strategic Management in the Innovation Economy: Strategic Approaches and Tools for Dynamic Innovation Capabilities*. John Wiley & Sons.

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating Innovation Networks. *Academy of Management Review*, *31*(3), 659–669.

Doloreux, D., & Parto, S. (2004). *Regional innovation systems: a critical synthesis* (United Nations University Discussion Paper Series No. 2004–17). *United Nations University, Institute for New*. Maastricht.

Dooley, L., & O’Sullivan, D. (2007). Managing within distributed innovation networks. *International Journal of Innovation Management*, *11*(3), 397–416.

Edquist, C. (2004). Reflections on the systems of innovation approach. *Science and Public Policy*, *31*(6), 485–489.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, *14*(4), 532–550.

Farla, J., Markard, J., Raven, R., & Coenen, L. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change*, *79*(6), 991–998. http://doi.org/10.1016/j.techfore.2012.02.001

Fernandez, A. S., Le Roy, F., & Gnyawali, D. R. (2014). Sources and management of tension in co-opetition case evidence from telecommunications satellites manufacturing in Europe. *Industrial Marketing Management*, *43*(2), 222–235. http://doi.org/10.1016/j.indmarman.2013.11.004

Fischer, C. (2008). Emissions pricing, spillovers, and public investment in environmentally friendly technologies. *Energy Economics*, *30*(2), 487–502. http://doi.org/10.1016/j.eneco.2007.06.001

Ford, D., & Håkansson, H. (2013). Competition in business networks. *Industrial Marketing Management*, *42*(7), 1017–1024. http://doi.org/10.1016/j.indmarman.2013.07.015

Foxon, T., Makuch, Z., Mata, M., & Pearson, P. (2004). Innovation Systems and Policy-Making Processes for the Transition to Sustainability. In K. Jacob, M. Binder, & A. Wieczorek (Eds.), *Governance for Industrial Transformation. Proceedings of the 2003 Berlin Conference on the Human Dimensions of Global Environmental Change* (pp. 96–112). Berlin: Environmental Policy Research Centre.

Foxon, T., & Pearson, P. (2008). Overcoming barriers to innovation and diffusion of cleaner technologies: some features of a sustainable innovation policy regime. *Journal of Cleaner Production*, *16*(1), S148–S161. http://doi.org/10.1016/j.jclepro.2007.10.011

Freeman, C. (1995). The “National System of Innovation” in historical perspective. *Camb. J. Econ.*, *19*(1), 5–24.

Freytag, P. V., & Ritter, T. (2005). Dynamics of relationships and networks - Creation, maintenance and destruction as managerial challenges. *Industrial Marketing Management*, *34*(7 SPEC. ISS.), 644–647. http://doi.org/10.1016/j.indmarman.2005.06.002

Garud, R., Hardy, C., & Maguire, S. (2007). Institutional Entrepreneurship as Embedded Agency: An Introduction to the Special Issue. *Organization Studies*, *28*(7), 957–969. http://doi.org/10.1177/0170840607078958

Garud, R., & Kumaraswamy, A. (1993). Changing competitive dynamics in network industries: an exploration of sun microsystems’open systems strategy. *Strategic Management Journal*, *14*, 351–369.

Garud, R., & Kumaraswamy, A. (1995). Technological and Organizational Designs for Realizing Economies of Substitution. *Strategic Management Journal*, *16*(S1), 39–109.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*(8), 1257–1274. http://doi.org/10.1016/S0048-7333(02)00062-8

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, *33*(6), 897–920. http://doi.org/10.1016/j.respol.2004.01.015

Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Transitions towards Sustainability through System Innovation*, *72*(6), 681–696. http://doi.org/10.1016/j.techfore.2004.08.014

Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, *39*(4), 495–510. http://doi.org/10.1016/j.respol.2010.01.022

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. http://doi.org/10.1016/j.eist.2011.02.002

Geels, F. W., Hekkert, M. P., & Jacobsson, S. (2008). The dynamics of sustainable innovation journeys. *Technology Analysis & Strategic Management*, *20*(5), 521–536. http://doi.org/10.1080/09537320802292982

Georg, S. (1994). Regulating the environment: Changing from constraint to gentle coercion. *Business Strategy and the Environment*, *3*(2), 11–20. http://doi.org/10.1002/bse.3280030203

Gnyawali, D. R., & Park, B.-J. (Robert). (2011). Co-opetition between giants: Collaboration with competitors for technological innovation. *Research Policy*, *40*(5), 650–663. http://doi.org/10.1016/j.respol.2011.01.009

Gnyawali, D. R., & Park, B. (Robert). (2009). Co-opetition and Technological Innovation in Small and Medium-Sized Enterprises: A Multilevel Conceptual Model. *Journal of Small Business Management*, *47*(3), 308–330. http://doi.org/10.1111/j.1540-627X.2009.00273.x

Grin, J., Rotmans, J., & Schot, J. (2010). *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. New York: Routledge.

Gulati, R. (1998). Alliances and Networks. *Strategic Management Journal*, *19*(4), 293–317.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic Networks. *Strategic Management Journal*, *21*(3), 203–215.

Hagedoorn, J., & Schakenraad, J. (1994). The Effect of Strategic Technology Alliances on Company Performance. *Strategic Management Journal*, *15*(4), 291–309.

Håkansson, H., & Ford, D. (2002). How should companies interact in business networks? *Journal of Business Research*, *55*, 133–139. http://doi.org/10.1016/S0148-2963(00)00148-X

Håkansson, H., & Persson, G. (2004). Supply Chain Management: The Logic of Supply Chains and Networks. *The International Journal of Logistics Management*, *15*(1), 11–26.

Hall, B. H., & Khan, B. (2003). *Adoption of New Technology* (Other Recent Work No. E03-330). Berkeley, California.

Hall, J., Daneke, G., & Lenox, M. (2010). Sustainable development and entrepreneurship: Past contributions and future directions. *Journal of Business Venturing*, *25*(5), 439–448. http://doi.org/10.1016/j.jbusvent.2010.01.002

Hall, J., & Vredenburg, H. (2003). The challenges of innovating for sustainable development. *MIT Sloan Management Review*, *45*(1), 61–68.

Hargadon, A. (2010). Technology policy and global warming: Why new innovation models are needed. *Research Policy*, *39*(8), 1024–1026. http://doi.org/10.1016/j.respol.2010.05.009

Harmaakorpi, V. (2006a). Regional Development Platform Method (RDPM) as a Tool for Regional Innovation Policy 1, *14*(8).

Harmaakorpi, V. (2006b). Regional Development Platform Method (RDPM) as a tool for regional innovation policy 1. *European Planning Studies*, *14*(8), 1085–1104. http://doi.org/10.1080/09654310600852399

Hébert, R. F., & Link, A. N. (1989). In search of the meaning of entrepreneurship. *Small Business Economics*, *1*, 39–49. http://doi.org/10.1007/BF00389915

Heidenreich, S., Landsperger, J., & Spieth, P. (2016). Are Innovation Networks in Need of a Conductor? Examining the Contribution of Network Managers in Low and High Complexity Settings. *Long Range Planning*, *49*(1), 55–71. http://doi.org/10.1016/j.lrp.2014.03.003

Hekkert, M. P., & Negro, S. O. (2009a). Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Evolutionary Methodologies for Analyzing Environmental Innovations and the Implications for Environmental Policy*, *76*(4), 584–594. http://doi.org/10.1016/j.techfore.2008.04.013

Hekkert, M. P., & Negro, S. O. (2009b). Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change*, *76*(4), 584–594. http://doi.org/10.1016/j.techfore.2008.04.013

Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, *74*(4), 413–432. http://doi.org/10.1016/j.techfore.2006.03.002

Hertzog, C. (2013). Re-engineering Energy – A Dutch Perspective. Retrieved August 14, 2013, from http://www.smartgridlibrary.com/2013/07/15/re-engineering-energy-a-dutch-perspective/

Hockerts, K., & Wüstenhagen, R. (2010). Greening Goliaths versus emerging Davids - Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. *Journal of Business Venturing*, *25*, 481–492. http://doi.org/10.1016/j.jbusvent.2009.07.005

Hollingsworth, J. R. (2000). Doing institutional analysis: implications for the study of innovations. *Review of International Political Economy*, *7*(4), 595–644. http://doi.org/10.1080/096922900750034563

Hübner, M., & Prüggler, N. (2011). *Smart Grid Initiatives in Europe Country Snapshots and Country Fact Sheets*. Vienna.

Hudson, L., Winskel, M., & Allen, S. (2011). The hesitant emergence of low carbon technologies in the UK: the micro-CHP innovation system. *Technology Analysis & Strategic Management*, *23*(3), 297–312. http://doi.org/10.1080/09537325.2011.550396

Huggins, R. (2000). The success and failure of policy-implanted inter-firm network initiatives: motivations, processes and structure. *Entrepreneurship & Regional Development*, *12*(2), 111–135. http://doi.org/10.1080/089856200283036

Hughes, T. P. (1987). The evolution of large technical systems. In W. E. Bijker & T. P. Hughes (Eds.), *The social construction of technical systems*. Cambridge: MIT Press.

Hung, S.-W., & Chang, C.-C. (2012). A co-opetition perspective of technology alliance governance modes. *Technology Analysis & Strategic Management*, *24*(7), 679–696. http://doi.org/10.1080/09537325.2012.705120

Iansiti, M., & Levien, R. (2004). Strategy as Ecology. *Harvard Business Review*, *82*(3), 68–81.

Interreg IVB. (2011). *Smart Grids and Virtual Power Plants*. Lille.

Jackson, D. J. (2011). *What is an Innovation Ecosystem?* Arlington, VA.

Jacobsson, S., & Bergek, A. (2006). A Framework for Guiding Policy-makers Intervening in Emerging Innovation Systems in “Catching-Up” Countries. *European Journal of Development Research*, *18*(4), 687–707. http://doi.org/10.1080/09578810601094902

Jacobsson, S., & Bergek, A. (2011a). Innovation system analyses and sustainability transitions: Contributions and suggestions for research. *Environmental Innovation and Societal Transitions*, *1*(1), 41–57. http://doi.org/10.1016/j.eist.2011.04.006

Jacobsson, S., & Bergek, A. (2011b). Innovation system analyses and sustainability transitions: Contributions and suggestions for research. *Environmental Innovation and Societal Transitions*, *1*(1), 41–57. http://doi.org/10.1016/j.eist.2011.04.006

Jansen, L. (2003). The challenge of sustainable development. *Journal of Cleaner Production*, *11*(3), 231–245. http://doi.org/10.1016/S0959-6526(02)00073-2

Järvensivu, T., & Möller, K. (2009). Metatheory of network management: A contingency perspective. *Industrial Marketing Management*, *38*(6), 654–661. http://doi.org/http://dx.doi.org/10.1016/j.indmarman.2009.04.005

Jones, C., Hesterly, W. S., & Borgatti, S. P. (1997). A general theory of network governance: Exchange conditions and social mechanisms. *The Academy of Management Review*, *22*(4), 911–945.

Karhu, K., Tang, T., & Hämäläinen, M. (2014). Analyzing competitive and collaborative differences among mobile ecosystems using abstracted strategy networks. *Telematics and Informatics*, *31*(2), 319–333. http://doi.org/10.1016/j.tele.2013.09.003

Katkalo, V. S., Pitelis, C. N., & Teece, D. J. (2010). Introduction: On the nature and scope of dynamic capabilities. *Industrial and Corporate Change*, *19*(4), 1175–1186. http://doi.org/10.1093/icc/dtq026

Kema. (2012). PowerMatching City honored as a top sustainable solution at Rio + 20. Retrieved November 7, 2012, from www.kema.com/news/articles/2012

Kemp, R. (1994). Technology and the transition to environmental sustainability: The problem shifts of technological regime. *Futures*, *26*(10), 1023–1046.

Kemp, R., & Loorbach, D. (2003). Governance for Sustainability Through Transition Management. In *EAEPE 2003 Conference* (pp. 1–27). Maastricht.

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime Shifts to Sustainability Through Processes of Niche Formation: The Approach of Strategic Niche Mangement. *Technology Analysis & Strategic Management*, *10*(2), 175–198. http://doi.org/10.1080/09537329808524310

Kemp, R., & Soete, L. (1992). The greening of technological progress: An evolutionary perspective. *Futures*, *24*(5), 437–457.

Klijn, E.-H., Steijn, B., & Eldenbos, J. (2010). The impact of Network Management on Outcomes in Governance Networks. *Public Administration*, *88*(4), 1063–1082.

Knight, L., Pfeiffer, A., & Scott, J. (2015). Supply market uncertainty: Exploring consequences and responses within sustainability transitions. *Journal of Purchasing and Supply Management*, *21*(3), 167–177. http://doi.org/10.1016/j.pursup.2015.04.002

Knott, P. (2006). A typology of strategy tool applications. *Management Decision*, *44*(8), 1090–1105. http://doi.org/10.1108/00251740610690630

Kotler, P., Armstrong, G., Wong, V., & Saunders, J. (2008). *Principles of Marketing* (5th Europe). Prentice Hall.

Laan, M. van der. (2012). Powermatching City Hoogkerk. Retrieved November 7, 2012, from http://ict.eu/verticals/energy/customer-cases/powermatching-city-groningen-hoogkerk/

Lam, A. (2004). Organizational Innovation. In J. Fagerberg, D. Movery, & R. R. Nelson (Eds.), *Handbook of Innovation*. Oxford: Oxford University Press.

Lambooy, J. G. (2004a). The transmission of knowledge, emerging networks, and the role of universities: an evolutionary approach. *European Planning Studies*, *12*(5), 643–657. http://doi.org/10.1080/0965431042000219996

Lambooy, J. G. (2004b). The transmission of knowledge, emerging networks, and the role of universities: an evolutionary approach. *European Planning Studies*, *12*(5), 643–657. http://doi.org/10.1080/0965431042000219996

Landsperger, J., Spieth, P., & Heidenreich, S. (2012). How network managers contribute to innovation network performance. *International Journal of Innovation Management*, *16*(6). http://doi.org/10.1142/S1363919612400099

Laszlo, K. C. (2003a). The Evolution of Business: Learning, Innovation, and Sustainability in the twenty-first century. *World Futures*, *59*, 605–614. http://doi.org/10.1080/02604020390242114

Laszlo, K. C. (2003b). The Evolution of Business: Learning, Innovation, and Sustainability in the twenty-first century. *World Futures*, *59*(8), 605–614. http://doi.org/10.1080/02604020390242114

Leiserowitz, A. a., Kates, R. W., & Parris, T. M. (2006). Sustainability Values, Attitudes, and Behaviors: A Review of Multinational and Global Trends. *Annual Review of Environment and Resources*, *31*(1), 413–444. http://doi.org/10.1146/annurev.energy.31.102505.133552

Liu, R. (2013). Cooperation, competition and coopetition in innovation communities. *Prometheus*, *31*(2), 91–105. http://doi.org/10.1080/08109028.2013.818788

Loebecke, C., Van Fenema, P. C., & Powell, P. (1999). Co-opetition and knowledge transfer. *Database for Advances in Information Systems*, *30*(2), 14–25. http://doi.org/10.1145/383371.383373

Loorbach, D., & Rotmans, J. (2006). Managing Transitions for Sustainable Development. In X. Olsthoorn & A. J. Wieczorek (Eds.), *Understanding Industrial Transformation*. Dordrecht: Springer.

Luo, Y. (2007). A coopetition perspective of global competition. *Journal of World Business*, *42*(2), 129–144. http://doi.org/10.1016/j.jwb.2006.08.007

Markard, J., & Truffer, B. (2006). Innovation processes in large technical systems: Market liberalization as a driver for radical change? *Research Policy*, *35*(5), 609–625. http://doi.org/10.1016/j.respol.2006.02.008

Markard, J., & Truffer, B. (2008a). Actor-oriented analysis of innovation systems: exploring micro–meso level linkages in the case of stationary fuel cells. *Technology Analysis & Strategic Management*, *20*(4), 443–464. http://doi.org/10.1080/09537320802141429

Markard, J., & Truffer, B. (2008b). Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy*, *37*(4), 596–615. http://doi.org/10.1016/j.respol.2008.01.004

Markard, J., & Truffer, B. (2008c). Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy*, *37*(4), 596–615. http://doi.org/10.1016/j.respol.2008.01.004

McGuire, M. (2002). Managing Networks : Propositions on What Managers Do and Why They Do It. *Public Administration Review*, *62*(5), 599–609.

McGuire, M., & Agranoff, R. (2011). The Limitations of Public Management Networks. *Public Administration*, *89*(2), 265–284. http://doi.org/10.1111/j.1467-9299.2011.01917.x

Meelen, T., & Farla, J. (2013). Towards an integrated framework for analysing sustainable innovation policy. *Technology Analysis & Strategic Management*, *25*(8), 957–970. http://doi.org/10.1080/09537325.2013.823146

Menzel, H. C., Aaltio, I., & Ulijn, J. M. (2007). On the way to creativity: Engineers as intrapreneurs in organizations. *Technovation*, *27*(12), 732–743.

Milward, H. B., & Provan, K. G. (2003a). Managing networks effectively. In *National Public Management Research Conference, Georgetown University*. Washington, DC.

Milward, H. B., & Provan, K. G. (2003b). Managing the hollow state Collaboration and contracting. *Public Management Review*, *5*(1), 1–18. http://doi.org/10.1080/1461667022000028834

Milward, H. B., & Provan, K. G. (2006). *A Manager's Guide to Choosing and Using Collaborative Networks*. Washington, DC.

Milward, H. B., Provan, K. G., Fish, A., Isett, K. R., & Huang, K. (2009). Governance and Collaboration: An Evolutionary Study of Two Mental Health Networks. *Journal of Public Administration Research and Theory*, *20*(Supplement 1), i125–i141. http://doi.org/10.1093/jopart/mup038

Mintzberg, H., Lampel, J., & Ahlstrand, B. (1998). *Strategy Safari: A Guided Tour Through The Wilds of Strategic Management*. New York: The Free Press.

Möller, K. (2010). Sense-making and agenda construction in emerging business networks — How to direct radical innovation. *Industrial Marketing Management*, *39*(3), 361–371. http://doi.org/http://dx.doi.org/10.1016/j.indmarman.2009.03.014

Möller, K., & Halinen, A. (1999). Business Relationships and Networks: Managerial Challenge of Network Era. *Industrial Marketing Management*, *28*(5), 413–427. http://doi.org/http://dx.doi.org/10.1016/S0019-8501(99)00086-3

Möller, K., & Rajala, A. (2007). Rise of strategic nets - New modes of value creation. *Industrial Marketing Management*, *36*(7), 895–908. http://doi.org/10.1016/j.indmarman.2007.05.016

Möller, K., & Svahn, S. (2003). Managing strategic nets a capability perspective. *Marketing Theory*, *3*(2), 209–234. http://doi.org/10.1177/14705931030032002

Möller, K., & Svahn, S. (2006). Role of Knowledge in Value Creation in Business Nets. *Journal of Management Studies*, *43*(5), 985–1007.

Möller, K., & Svahn, S. (2009). How to influence the birth of new business fields - Network perspective. *Industrial Marketing Management*, *38*, 450–458. http://doi.org/10.1016/j.indmarman.2008.02.009

Moore, J. F. (1993). Predators and Prey: A New Ecology of Competition. *Harvard Business Review*, *71*(3), 75–86. http://doi.org/Article

Moore, J. F. (1996). *The death of competition: leadership and strategy in the age of business ecosystems*. New York: HarperBusiness.

Moore, J. F. (2005). Business ecosystems and the view from the firm. *Antitrust Bulletin*, *51*(31).

Musiolik, J., & Markard, J. (2010). *Innovation networks and resources in technological innovation systems : Insights from the field of stationary fuell cells in Germany* (Winter 2010 PhD Conference). Aalborg.

Musiolik, J., & Markard, J. (2011). Creating and shaping innovation systems: Formal networks in the innovation system for stationary fuel cells in Germany. *Energy Policy*, *39*, 1909–1922.

Musiolik, J., Markard, J., & Hekkert, M. P. (2012). Networks and network resources in technological innovation systems: Towards a conceptual framework for system building. *Technological Forecasting and Social Change*, *79*(6), 1032–1048. http://doi.org/10.1016/j.techfore.2012.01.003

Nalebuff, B., & Brandenburger, A. M. (1996). *Coopetition*. Philadelphia, PA: Harper Collins Business.

Negro, S. O., Hekkert, M. P., & Smits, R. E. H. M. (2008). Stimulating renewable energy technologies by innovation policy. *Science and Public Policy*, *35*(6), 403–416. http://doi.org/10.3152/030234208X323334

Nill, J., & Kemp, R. (2009). Evolutionary approaches for sustainable innovation policies: From niche to paradigm? *Research Policy*, *38*(4), 668–680. http://doi.org/10.1016/j.respol.2009.01.011

NL Agency. (2012a). *PowerMatching City II*. Utrecht.

NL Agency. (2012b). *Smart grids & smart metering*. Utrecht.

NL Agency. (2012c). *Who is who guide Players in the Dutch smart-grid sector*. Utrecht.

O'Connor, M. (1997). The internalisation of environmental costs: implementing the Polluter Pays principle in the European Union. *International Journal of Environment and Pollution*, *7*(4), 450–482.

O'Toole, L. J. J. (1997). Treating Networks Seriously: Practical and Researched-Based Agendas in Public Administration. *Public Administration Review*, *75*(1), 45–52.

Oh, D. S., Phillips, F., Park, S., & Lee, E. (2014). Innovation ecosystems: A critical examination. *Technovation*, *54*, 1–6. http://doi.org/10.1016/j.technovation.2016.02.004

Ojasalo, J. (2008). Management of innovation networks: a case study of different approaches. *European Journal of Innovation Management*, *11*(1), 51–86. http://doi.org/10.1108/14601060810845222

Osarenkhoe, A. (2010). A coopetition strategy – a study of inter-firm dynamics between competition and cooperation. *Business Strategy Series*, *11*(6), 343–362. http://doi.org/10.1108/17515631011093052

Ozman, M. (2009). Inter-firm networks and innovation: a survey of literature. *Economics of Innovation and New Technology*, *18*(1), 39–67. http://doi.org/10.1080/10438590701660095

Pacheco, D. F., Dean, T. J., & Payne, D. S. (2010). Escaping the green prison: Entrepreneurship and the creation of opportunities for sustainable development. *Journal of Business Venturing*, *25*, 464–480. http://doi.org/10.1016/j.jbusvent.2009.07.006

Page, S. (2003). Entrepreneurial Strategies for Managing Interagency Collaboration. *Journal of Public Administration Research and Theory*, *13*(3), 311–339. http://doi.org/10.1093/jopart/mug026

Paquin, R. L., & Howard-Grenville, J. (2013). *Blind Dates and Arranged Marriages: Longitudinal Processes of Network Orchestration*. *Organization Studies* (Vol. 34). http://doi.org/10.1177/0170840612470230

Park, B.-J. (Robert), Srivastava, M. K., & Gnyawali, D. R. (2014). Walking the tight rope of coopetition: Impact of competition and cooperation intensities and balance on firm innovation performance. *Industrial Marketing Management*, *43*(2), 210–221. http://doi.org/10.1016/j.indmarman.2013.11.003

Partanen, J., & Möller, K. (2012). How to build a strategic network: A practitioner-oriented process model for the ICT sector. *Industrial Marketing Management*, *41*(3), 481–494. http://doi.org/http://dx.doi.org/10.1016/j.indmarman.2011.05.002

Pathak, S. D., Wu, Z., & Johnston, D. (2014). Toward a structural view of co-opetition in supply networks. *Journal of Operations Management*, *32*(5), 254–267. http://doi.org/10.1016/j.jom.2014.04.001

Pitelis, C. (2012). Clusters, entrepreneurial ecosystem co-creation, and appropriability: a conceptual framework. *Industrial and Corporate Change*, *21*(6), 1359–1388. http://doi.org/10.1093/icc/dts008

Planko, J., Cramer, J. M., Chappin, M. M. H., & Hekkert, M. P. (2016). Strategic collective system building to commercialize sustainability innovations. *Journal of Cleaner Production*, *112*, 2328–2341. http://doi.org/10.1016/j.jclepro.2015.09.108

Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*, *76*(6), 77–90.

Porter, M. E., & Kramer, M. R. (2011). Creating Shared Value. *Harvard Business Review*, *89*(1/2), 62–77.

Provan, K. G., Fish, A., & Sydow, J. (2007). Interorganizational Networks at the Network Level: A Review of the Empirical Literature on Whole Networks. *Journal of Management*, *33*(3), 479–516. http://doi.org/10.1177/0149206307302554

Provan, K. G., & Kenis, P. (2008). Modes of Network Governance: Structure, Management, and Effectiveness. *Journal of Public Administration Research and Theory*, *18*(2), 229–252. http://doi.org/10.1093/jopart/mum015

Provan, K. G., & Milward, H. B. (2001). Do Networks Really Work? - A Framework for Evaluating Public-Sector Organizational Networks. *Public Administration Review*, *61*(4), 414–423. http://doi.org/10.5465/APBPP.1999.27628083

Quintana-García, C., & Benavides-Velasco, C. a. (2004). Cooperation, competition, and innovative capability: a panel data of European dedicated biotechnology firms. *Technovation*, *24*(12), 927–938. http://doi.org/10.1016/S0166-4972(03)00060-9

Raab, J., Mannak, R. S., & Cambre, B. (2013). Combining Structure, Governance, and Context: A Configurational Approach to Network Effectiveness. *Journal of Public Administration Research and Theory*, *25*(2), 479–511. http://doi.org/10.1093/jopart/mut039

Rampersad, G., Quester, P., & Troshani, I. (2010). Managing innovation networks: Exploratory evidence from ICT, biotechnology and nanotechnology networks. *Industrial Marketing Management*, *39*(5), 793–805. http://doi.org/10.1016/j.indmarman.2009.07.002

Ritala, P. (2012). Coopetition Strategy - When is it Successful? Empirical Evidence on Innovation and Market Performance. *British Journal of Management*, *23*, 307–324. http://doi.org/10.1111/j.1467-8551.2011.00741.x

Ritala, P., & Hurmelinna-Laukkanen, P. (2009). What's in it for me? Creating and appropriating value in innovation-related coopetition. *Technovation*, *29*(12), 819–828. http://doi.org/10.1016/j.technovation.2009.07.002

Ritala, P., & Sainio, L.-M. (2014). Coopetition for radical innovation: technology, market and business-model perspectives. *Technology Analysis & Strategic Management*, *26*(2), 115–169. http://doi.org/10.1080/09537325.2013.850476

Ritter, T., & Gemünden, H. G. (2003a). Interorganizational relationships and networks: An overview. *Journal of Business Research*, *56*(9), 691–697. http://doi.org/10.1016/S0148-2963(01)00254-5

Ritter, T., & Gemünden, H. G. (2003b). Network competence: Its impact on innovation success and its antecedents. *Journal of Business Research*, *56*(9), 745–755. http://doi.org/10.1016/S0148-2963(01)00259-4

Ritter, T., & Gemünden, H. G. (2004). The impact of a company's business strategy on its technological competence, network competence and innovation success. *Journal of Business Research*, *57*(5), 548–556. http://doi.org/10.1016/S0148-2963(02)00320-X

Ritter, T., Wilkinson, I. F., & Johnston, W. J. (2004). Managing in complex business networks. *Industrial Marketing Management*, *33*(3), 175–183. http://doi.org/10.1016/j.indmarman.2003.10.016

Rothwell, R. (1991). External networking and innovation in small and medium-sized manufacturing firms in Europe. *Technovation*, *11*(2), 93–112.

Rusanen, H. (2013). Managing constant change in innovation networks. In *Proceedings of the 22nd Nordic Academy of Mangement Conference*. Rykjavik.

Russell, J. L., Meredith, J., Childs, J., Stein, M. K., & Prine, D. W. (2014). Designing Inter-Organizational Networks to Implement Education Reform: An Analysis of State Race to the Top Applications. *Educational Evaluation and Policy Analysis*, *37*(1), 92–112. http://doi.org/10.3102/0162373714527341

Sandberg, B., & Aarikka-Stenroos, L. (2014). What makes it so difficult? A systematic review on barriers to radical innovation. *Industrial Marketing Management*, *43*(8), 1293–1305. http://doi.org/10.1016/j.indmarman.2014.08.003

Saxenian, A. (1991). The origins and dynamics of production networks in Silicon Valley. *Research Policy*, *20*, 423–437. http://doi.org/10.1016/0048-7333(91)90067-Z

Saxenian, A. (2000). The Origins and Dynamics of Production Networks in Silicon Valley. *Entrepreneurship: The Social Science View*, 308–331.

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: Categories and interactions. *Business Strategy and the Environment*, *20*(4), 222–237. http://doi.org/10.1002/bse.682

Schoonhoven, C. B., Eisenhardt, K. M., & Lyman, K. (2012). Speeding Products to Market : Waiting Time to First Product Introduction in New Firms Claudia Bird Schoonhoven, *35*(1), 177–207.

Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, *20*(5), 537–554. http://doi.org/10.1080/09537320802292651

Schwarz, M. (2010). *Social Innovation: Concepts, research fields and international trends*. Dortmund.

SEC. (2012). Smart Energy Collective. Retrieved August 14, 2013, from http://www.smartenergycollective.com/site/pagina.php?id=44

Shane, S., & Venkataraman, S. (2000). The Promise of Entrepreneurship as a Field of Research. *The Academy of Management Review*, *25*(1), 217–226. http://doi.org/10.2307/259271

Spieth, P., Clauss, T., & Landsperger, J. (2011). Managing Innovation Networks in the Engineering Industry : Moderating Effects of Spatial Proximity. In *DRUID*. Copenhagen.

Suurs, R. A. A. (2009). *Motors of Sustainable Innovation: Towards a theory on the dynamics of technological innovation systems*. Utrecht University.

Suurs, R. A. A., & Hekkert, M. P. (2009). Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands. *Technological Forecasting and Social Change*, *76*(8), 1003–1020. http://doi.org/10.1016/j.techfore.2009.03.002

Suurs, R. A. A., Hekkert, M. P., & Smits, R. (2009a). Understanding the build-up of a technological innovation stystem around hydrogen and fuel cell technologies. *International Journal of Hydrogen Energy*, *34*, 9639–9654.

Suurs, R. A. A., Hekkert, M. P., & Smits, R. E. H. M. (2009b). Understanding the build-up of a technological innovation system around hydrogen and fuel cell technologies. *International Journal of Hydrogen Energy*, *34*(24), 9639–9654. http://doi.org/10.1016/j.ijhydene.2009.09.092

Teece, D. J. (2010). Technological Innovation and the Theory of the Firm: The Role of Enterprise-Level Knowledge, Complementarities, and (Dynamic) Capabilities. In N. Rosenberg & B. H. Hall (Eds.), *Handbook of the Economics of Innovation* (1st ed., Vol. Volume 1, pp. 679–730). Elsevier B.V.

Thorgren, S., Wincent, J., & Örtqvist, D. (2009). Designing interorganizational networks for innovation: An empirical examination of network configuration, formation and governance. *Journal of Engineering and Technology Management*, *26*(3), 148–166. http://doi.org/10.1016/j.jengtecman.2009.06.006

Tidström, A. (2013). Managing tensions in coopetition. *Industrial Marketing Management*. http://doi.org/10.1016/j.indmarman.2013.12.001

Tricoire, A. (2015). Uncertainty, vision, and the vitality of the emerging smart grid. *Energy Research & Social Science*, *9*, 21–34. http://doi.org/10.1016/j.erss.2015.08.028

Turrini, A., Cristofoli, D., Frosini, F., & Nasi, G. (2010). Networking Literature About Determinants of Network Effectiveness. *Public Administration*, *88*(2), 528–550. http://doi.org/10.1111/j.1467-9299.2009.01791.x

Unruh, G. C. (2000). Understanding carbon lock-in. *Energy Policy*, *28*(12), 817–830. http://doi.org/10.1016/S0301-4215(00)00070-7

Van de Ven, A. H. (1993). The development of an infrastructure for entrepreneurship. *Journal of Business Venturing*, *8*(3), 212–230.

Van de Ven, A. H. (2005). Running in packs to develop knowledge intensive technologies. *MIS Quarterly*, *29*(2), 365–378.

Van de Ven, A. H., Polley, D. E., Garud, R., & Venkataraman, S. (2008). *The Innovation Journey*. New York: Oxford University Press.

Van de Ven, A. H., Sapienza, H. J., & Villanueva, J. (2008). Entrepreneurial pursuits of self- and collective interests. *Strategic Entrepreneurship Journal*, *370*(2007), 353–370. http://doi.org/10.1002/sej

Van Den Bergh, J. C. J. M., Truffer, B., & Kallis, G. (2011). Environmental innovation and societal transitions: Introduction and overview. *Environmental Innovation and Societal Transitions*, *1*(1), 1–23. http://doi.org/10.1016/j.eist.2011.04.010

Van Der Schoor, T., & Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews*, *43*, 666–675. http://doi.org/10.1016/j.rser.2014.10.089

Van der Valk, T., Chappin, M. M. H., & Gijsbers, G. W. (2011). Evaluating innovation networks in emerging technologies. *Technological Forecasting and Social Change*, *78*(1), 25–39. http://doi.org/10.1016/j.techfore.2010.07.001

Verbong, G. P. J., Beemsterboer, S., & Sengers, F. (2013). Smart grids or smart users? Involving users in developing a low carbon electricity economy. *Energy Policy*, *52*, 117–125. http://doi.org/10.1016/j.enpol.2012.05.003

Vogel, P., & Fischler-Strasak, U. (2014). Fostering Sustainalbe Innovation Within Organizations. In C. Weidinger, F. Fischler, & R. Schmidpeter (Eds.), *Sustainable Entrepreneurship* (pp. 191–205). Berlin, Heidelberg: Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-642-38753-1

Voß, J.-P., Smith, A., & Grin, J. (2009). Designing long-term policy: rethinking transition management. *Policy Sciences*, *42*(4), 275–302. http://doi.org/10.1007/s11077-009-9103-5

Walley, K. (2007). Coopetition : An Introduction to the Subject and an Agenda for Research. *International Studies of Management and Organization*, *37*(2), 11–31. http://doi.org/10.2753/IMO0020-8825370201

Weaver, P., Jansen, L., Grootveld, G. van, Spiegel, E. van, & Vergragt, P. (2000). *Sustainable Technology Development*. Sheffield: Greenleaf Publishing.

Weiss, E. S., Anderson, R. M., & Lasker, R. D. (2002). Making the most of collaboration: exploring the relationship between partnership synergy and partnership functioning. *Journal of Health Education and Behavior*, *29*(6), 683–698.

Wijen, F., & Ansari, S. (2007). Overcoming Inaction through Collective Institutional Entrepreneurship: Insights from Regime Theory. *Organization Studies*, *28*(7), 1079–1100. http://doi.org/10.1177/0170840607078115

Wilhelm, M. M. (2011). Managing coopetition through horizontal supply chain relations : Linking dyadic and network levels of analysis. *Journal of Operations Management*, *29*(7–8), 663–676. http://doi.org/10.1016/j.jom.2011.03.003

Wolfe, D. A., & Gertler, M. S. (2004). Clusters from the inside and out: local dynamics and global linkages. *Urban Studies*, *41*(5–6), 1071–1093. http://doi.org/10.1080/0042098 0410001675832

Yami, S., & Nemeh, A. (2014). Organizing coopetition for innovation: The case of wireless telecommunication sector in Europe. *Industrial Marketing Management*, *43*(2), 250–260. http://doi.org/10.1016/j.indmarman.2013.11.006

Yin, R. K. (2009). *Case Study Research. Design and Methods* (4th ed.). Thousand Oaks: Sage Publications.

Young, W., Hwang, K., Mcdonald, S., & Oates, C. J. (2010). Sustainable Consumption: Green Consumer Behaviour when Purchasing Products. *Sustainable Development*, *18*(1), 20–31. http://doi.org/10.1002/sd.394

Zineldin, M. (2004). Co-opetition: the organisation of the future. *Marketing Intelligence & Planning*, *22*(7), 780–790. http://doi.org/10.1108/02634500410568600

Appendix

Appendix 1

Empirical evidence on key factors of network management per network

Empirical evidence: networks in the Dutch smart grid sector (networks A-F)						
Network characteristics	**A**	**B**	**C**	**D**	**E**	**F**
network objective(s)	product development; market creation	standardization	standardization	influence regulatory framework; lobbying	knowledge exchange; system orchestration	knowledge exchange; technology optimization
public/private driven	private	private	private	private	public	public
age at time of interview	5 years	1 year	2 years	8 years	3 years	3 years
perceived success	relatively successful	successful	relatively successful	successful	successful	relatively successful
Key factors of networkmanagement						
Network composition						
Size - number of members (at time of interview)	12	7	6	10	12 [350 “passive members”]	105
Actor diversity	diverse	diverse	diverse	all horizontal	diverse	diverse
Governance structure						
Governance mode	BOD, 5 projects report back to BOD	BOD, all members have seat	BOD; general assembly	BOD; CEO meetings; workgroups	BOD; supervisory board; 4 program lines	network manager/ steering group; de-central
Rules for collaboration						
Primary decision-making mechanism	discussion until consensus	discussion until consensus	discussion until consensus	discussion until consensus	discussion until consensus	top down by steering group

[continued on next page]

Empirical evidence: networks in the Dutch smart grid sector (networks A-F)

Network characteristics	**A**	**B**	**C**	**D**	**E**	**F**
financing mechanism: - in-kind contribution	in-kind	in-kind	in-kind	in-kind	in-kind	in-kind
- monetary contribution	membership fee	financial contributions expected	membership fee	membership fee	none	pilot projects receive subsidy money
Network leadership structure						
official network manager	yes	yes	yes	yes	yes	yes
external network manager	no	yes	yes	yes	no	no
neutral leader	relatively neutral	neutral	neutral	relatively neutral	neutral	neutral
Number of leaders with different roles	2 leaders	3 leaders	2 leaders	2 leaders	2 leaders	one leader / de-central
Managerial processes						
Strategy and goals						
shared vision	yes	yes	yes	yes	yes	no
shared vision jointly created/prescribed	jointly created	jointly created	jointly created	jointly created	jointly created	vision imposed top-down by Ministry of Economic Affairs
common goal	yes	yes	yes	yes	yes	yes
common goal jointly defined or prescribed	jointly	jointly	jointly	jointly	jointly	prescribed
incentivizing members	motivated members (membership fee)	high intrinsic motivation	motivated members (membership fee)	motivated members		

[continued on next page]

Empirical evidence: networks in the Dutch smart grid sector (networks A-F)						
Network characteristics	**A**	**B**	**C**	**D**	**E**	**F**
(membership fee)	high intrinsic motivation	have to reach milestones before receiving (full) subsidy money				
Project management	very important	very important	very important; PM could be improved	very important	very important	during pilots: very important
organization of meetings	well-chaired and efficient	well-chaired and efficient	well-chaired and efficient	well-chaired and efficient	well-chaired and efficient	no network-level meetings
response to free-riders	private conversation; social pressure prevents	not experienced yet; social pressure prevents	not experienced yet	private conversation	private conversation	private conversation (during projects)
measuring and evaluation	yes, simple goal measuring	not yet	not yet	not yet	not yet	yes, milestone evaluations
task distribution	participatory	participatory	participatory	participatory	participatory	tender in writing
Transparent communication - (electronic) tools of network coordination	yes	yes	yes	yes	yes	yes
Relational factors						
previous collaboration experience	medium	high	medium	high	high	low
Trust	high	very high	high	high	very high	medium
harmony and commitment	high	very high	high	high	very high	medium
strong/supportive leadership style	+/-	++	+	+	++	-

Summary

The implementation of innovative sustainability technologies often requires far-reaching changes in the macro environment in which the innovating firms operate. The chances of successful diffusion and adoption of an innovative technology in society increase if the firms wanting to commercialize this technology collaborate in networks or industry clusters, thus building a favorable environment for their technology.

In networks, entrepreneurs can strategically collaborate with other technology producers, complementary businesses, customers and government actors. By combining their forces, they can accelerate building a supportive innovation ecosystem or business ecosystem in which their innovation can flourish. Together, they optimize the technology, develop standards and interoperable products, create markets, raise user awareness, develop feasible business models, strive for positive governmental regulations and trigger societal changes, which enable a large-scale adoption of the new technology. This process is called 'collective system building'.

In this thesis, the transition literature has been combined with insights from the strategic management literature, based on which the concept of strategic collective system building has been formed. To underpin the theoretical analysis empirically, a case study of the Dutch smart grid field has been conducted, and this has led to the development of a set of systemic strategy frameworks for system-building entrepreneurship. These frameworks do not only help gain a better theoretical understanding of collective action in emerging innovation ecosystems but can also be used as guidance to entrepreneurs in building a supportive innovation ecosystem for their radical sustainability technologies.

The term 'collective system building' describes the processes and activities that networks of actors can strategically engage in to collectively build a favorable environment for their innovative sustainability technology. First, a strategy framework for collective system building is presented, which focuses on the processes and important activities for system building. The strategy framework consists of four key areas: technology development and optimization, market creation, socio-cultural changes and coordination. Each of these key strategic areas contains a set of system-building activities. The framework can be used as a tool for strategy making by system-building networks.

Subsequently, it was investigated how such system-building networks can be managed effectively, and how system-building entrepreneurs coordinate their activities. A framework for network management at the network level has been proposed, with four categories: network composition, governance structure, managerial processes and relational factors. The framework shows what the key factors of effective network management are and how they can be implemented by system-building networks.

Last, the dilemma of collaboration versus competition in collective system-building was investigated. Companies that want to implement complex innovative technologies successfully need to collaborate with other actors, including their competitors, in the

innovation ecosystem. Collaboration with competitors not only brings benefits, but also many risks. A systematic overview is provided of the benefits, risks and enablers of collaboration, and the strategies utilized by firms engaged in collective system building are explored. It is shown how system-building firms minimize inherent risks and increase the benefits of collaborating with competitors by adopting a 'coping strategy'.

This research contributes to the transition literature, as well as to the strategic management literature. Moreover, its strategy frameworks can serve as practical tools for system-building entrepreneurs. Companies that want to launch innovative sustainability technologies can strategically collaborate in networks to pro-actively build an innovation ecosystem. This increases the companies' chances of market success, and ultimately contributes to sustainable development.

Samenvatting

De implementatie van innovatieve duurzaamheidstechnologieën vergt vaak verregaande veranderingen in de macro-omgeving waarin de innoverende bedrijven opereren. De kans op succesvolle verspreiding en invoering van een innovatieve technologie wordt vergroot als de bedrijven die deze technologie op de markt willen brengen, gaan samenwerken in netwerken of clusters, en op die manier een gunstige omgeving voor hun technologie creëren.

In netwerken kunnen ondernemers strategisch samenwerken met producenten van vergelijkbare technologieën, complementaire ondernemingen, klanten en de overheid. Door hun krachten te bundelen, kunnen zij versneld bouwen aan een ondersteunend innovatie-ecosysteem of business-ecosysteem, waarin hun innovatie kan floreren. Samen optimaliseren ze de technologie, ontwikkelen ze standaarden en interoperabele producten, creëren ze markten, vergroten ze het bewustzijn van de gebruikers, ontwikkelen ze haalbare bedrijfsmodellen, pleiten ze voor positieve regelgeving, en zorgen ze voor maatschappelijke veranderingen. Deze handelingen moeten leiden tot de grootschalige invoering van de nieuwe technologie. Dit proces wordt 'collectief systeembouwen' genoemd.

In dit proefschrift wordt transitieliteratuur gecombineerd met inzichten uit de strategisch management literatuur, en deze twee liggen ten grondslag aan het idee van strategisch collectief systeembouwen. De theoretische analyse wordt empirisch onderbouwd door een casestudie in het 'smart grid' veld in Nederland; deze casestudie heeft geleid tot het ontwikkelen van een aantal systemische strategiekaders voor het opbouwen van ondernemerschap. Deze kaders zijn niet alleen nuttig voor een beter theoretisch begrip van collectieve actie in opkomende innovatie-ecosystemen, maar ook kunnen ze fungeren als leidraad voor ondernemers bij het opbouwen van een ondersteunend innovatie-ecosysteem voor radicale duurzaamheidstechnologieën.

De term 'collectief systeembouwen' beschrijft de processen en activiteiten waaraan netwerken van actoren strategisch kunnen deelnemen om zo collectief te bouwen aan een gunstige omgeving voor hun innovatieve duurzaamheidstechnologie. Als eerste wordt een strategisch kader voor collectief systeembouwen gepresenteerd, dat zich richt op processen en activiteiten die hiervoor belangrijk zijn. Het strategisch kader bevat vier belangrijke gebieden: technologische ontwikkeling en optimalisering, het creëren van een markt, sociaal-culturele veranderingen, en coördinatie. Elk van deze belangrijke strategische gebieden bevat een aantal activiteiten met betrekking tot systeembouwen. Het strategisch kader kan door systeem-bouwende netwerken worden gebruikt als instrument voor het ontwikkelen van strategieën.

Vervolgens wordt in dit proefschrift onderzocht hoe dergelijke systeem-bouwende netwerken effectief kunnen worden beheerd en hoe systeem-bouwende ondernemers hun activiteiten coördineren. Er wordt een kader voorgesteld voor netwerkbeheer op netwerkniveau, met vier categorieën: samenstelling van het netwerk, bestuursstructuur,

managementprocessen en relationele factoren. Het kader maakt duidelijk wat de belangrijkste factoren van effectief netwerkbeheer zijn en hoe deze kunnen worden geïmplementeerd door systeem-bouwende netwerken.

Als laatste wordt het dilemma van samenwerking versus concurrentie onderzocht. Bedrijven die complexe innovatieve technologieën succesvol willen implementeren, moeten samenwerken met andere actoren in het innovatie-ecosysteem, inclusief hun concurrenten. Samenwerking met concurrenten brengt niet alleen voordelen, maar ook veel risico's met zich mee. Een systematisch overzicht wordt gegeven van de voordelen en de risico's van samenwerking, en van degenen die samenwerking mogelijk maken; ook worden de strategieën onderzocht waar bedrijven die zich bezighouden met collectief systeembouwen gebruik van maken. Er wordt aangetoond hoe het gebruik van een 'coping' strategie de inherente risico's minimaliseert en de voordelen van samenwerking met concurrenten vergroot.

Dit onderzoek draagt bij aan zowel de transitieliteratuur als de strategische management literatuur. Bovendien kunnen de strategische kaders dienen als praktische hulpmiddelen voor systeem-bouwende ondernemers. Bedrijven die innovatieve duurzaamheidstechnologieën op de markt willen brengen, kunnen strategisch samenwerken in netwerken om pro-actief een innovatie-ecosysteem te ontwikkelen ten behoeve van hun innovatie. Dit vergroot hun kansen op succes en draagt uiteindelijk bij aan duurzame ontwikkeling.

Curriculum Vitae

Julia Planko obtained a B.A. in International Business Management in Bochum and Rennes, with the specialization marketing and international trade. Followed by an M.A. in International Economics in Berlin with a focus on industrial economics and development economics. For her Master thesis entitled 'Structural policy tools for sustainable tourism development', Julia was awarded a DAAD scholarship to conduct field research in Madagascar. After finishing her studies, she worked as a lecturer at the Berlin School of Economics, and as intern at the Federal Ministry for Economic Cooperation and Development, in the department 'Principles, conception and political planning of development policy'. Currently, Julia works as a researcher and lecturer at the HU University of Applied Sciences Utrecht. She teaches in the International Business Management program and develops and coordinates courses in the field of sustainable business and corporate social responsibility. Moreover, she is part of the research group Cooperative Entrepreneurship. As part of this research function, Julia was a PhD candidate at the Copernicus Institute for Sustainable Development, Utrecht University. During her PhD trajectory, Julia received the EU-SPRI Circulation award, which enabled her to work as guest researcher at the research institute INGENIO (CSIC and UPV) in Valencia. Her PhD thesis is entitled 'Strategic collaboration in innovation ecosystems - a case study of collective system building in the Dutch smart grid sector'.

List of publications

Planko, J., Cramer, J., Hekkert, M. P., & Chappin, M. M. H.. (2017). Combining the technological innovation systems framework with the entrepreneurs' perspective on innovation. Technology Analysis & Strategic Management, 29(6), 614-625.

Planko, J., Cramer, J. M., Chappin, M. M. H., & Hekkert, M. P. (2016). Strategic collective system building to commercialize sustainability innovations. Journal of Cleaner Production, 112, 2328-2341.

Planko, J., Chappin, M. M., Cramer, J. M., & Hekkert, M. P. (2017). Managing strategic system-building networks in emerging business fields: A case study of the Dutch smart grid sector. Industrial Marketing Management, 67, 37-51.