Business responses to sustainable energy development in urban regions: a regional-level perspective on a global transition process

Daniel J.H.M. van den Buuse
University of Amsterdam – Amsterdam Business School

Submission for the Ivey/ARCS 6th Annual PhD Sustainability Academy
November 21-24, 2013 in London, Canada

Abstract

The transition towards a more sustainable energy future has widely been recognized as a key challenge for the twenty-first century, given the economic, political and environmental consequences related to fossil fuel dependence of economies on a global scale at present. Cities and metropolitan regions are increasingly identified as important in issues related to energy and climate change and emerging at the forefront of this debate, which is reflected in the emergence of high-profile international networks as well as in local-level initiatives addressing sustainability-related issues in cities and metropolitan regions (i.e. ‘sustainable cities’, ‘smart cities’, or ‘eco-cities’ initiatives). This study aims to focus on the role of business in such initiatives. It will review literature on transition processes in socio-technical systems to provide a societal-level perspective to the issue, and propose to adopt the perspective of the business model to research the role of business within this transition process from an organizational-level perspective.

Note on the progress of the research project

This study outlines the fourth empirical research project part of the PhD dissertation, which focuses on business responses to a sustainability-induced transition in energy markets, and is in a rather early stage of development at this point (started in September 2013). At present, the theoretical framework based on a review of literature on sustainability transitions (partly presented in this document) is being developed, of which the first draft is presented in this document (using quotations in multiple instances). Upon completion of the theoretical framework, data collection is planned to start in January 2014. In the dissertation as a whole, the first two papers of the dissertation focus on incumbent firms in the energy industries and their uptake of high-potential renewable energy technologies (RETs), in the context of evolving government policies and stakeholder pressures. Two co-authored papers on this research have been published in academic journals to date. This includes a paper on the commercialization and development of solar photovoltaic technology in the oil industry (in Energy Policy, 2012), and a paper on the regionalization strategies of Europe’s major electric utilities in their traditional and sustainable energy activities (in British Journal of Management, 2013). The second part of the PhD dissertation will focus on the development of business models for RETs beyond the main energy industries by looking at two specific contexts: RET-based electrification in emerging and developing countries, and RET-based sustainable development in cities and metropolitan regions. The first project has been completed, this piece presents the current stage of development for the second project.

Introduction: the importance of cities in the transition towards a more sustainable energy future

The transition towards a more sustainable energy future has widely been recognized as a key challenge for the twenty-first century, given the economic, political and environmental consequences related to fossil fuel dependence of economies on a global scale at present. Cities have a particularly important role in this process, given they are responsible for approximately 70% of Greenhouse Gas (GHG) emissions, both directly as generators of these emissions, as well as indirectly as end-users of fossil fuel based energies and other goods and services, of which the production generates emissions elsewhere (United Nations, 2011). In the context of the global process of urbanization, particularly in emerging and developing countries, as well as expected growth in the earth's population in the decades to come, sustainable development of cities and urban regions will become increasingly more important. The United Nations notes that cities are now 'widely acknowledged as strategic vehicles for addressing today's challenges of climate change', and specifically emphasizes the importance of regional-level responses to the global challenge of climate change, mentioning that "strategies developed at and for the urban level to tackle climate change, improve energy efficiency, and ensure green growth are essential for building local and global sustainability" (United Nations 2011, 11). While the attention to the concept of 'sustainable cities' in the international policy arena has been growing in recent years, the (potential) role of business in this process has been largely unexplored.

Growing momentum for the concept of sustainable cities is reflected by the recent launch of several high-profile initiatives centered on sustainable cities. At the 2012 Rio +20 United Nations Conference on Sustainable Development, the multi-stakeholder partnership 'Sustainable Cities' was launched, identifying the intersection of energy and metropolitan regions as key to a sustainable energy future, stating: 'urban areas are uniquely positioned to lead the greening of global economy through improvements in transport, energy, buildings, technology, water and waste systems, as well as producing a wide range of economic and social benefits. To achieve this, existing and new-build cities will have to adopt sustainable development strategies, including efficiency gains, innovative infrastructures and technological enhancements in order to meet the demands of this rapidly growing urban population' (Sustainable Cities 2012, 1). In a similar vein, the Organization for Economic Co-operation and Development (OECD) launched the OECD Green Cities Programme in 2011, aimed at sustainable urban development or 'green growth' in cities. In addition to these high-profile initiatives, the inherent importance of cities to climate change mitigation in the context of urbanization and sustainable development is identified in recent academic studies as well. Carvalho et al. 2013 state in this context: “Cities and metropolitan regions are increasingly important in issues related to energy and climate change on high-profile international networks as well as in local-level initiatives, thereby providing key places for experimentation, early adoption, market formation and social legitimization of new energy solutions” (Carvalho et al. 2013, 5). In researching cases on emerging ‘eco-cities’, Alusi et al. (2011, 2) identify that “the pathway taken by urban development over the next few decades will play a crucial role in the trajectory of worldwide greenhouse gas emissions and natural resource depletion. Cities consume 60% to 80% of the world’s energy production, and with the urban population of the developing world projected to reach more than 5 billion people by 2050. Ideas of how to combine urbanization and sustainability are of critical and immediate importance”.

The increasing importance of urban regions and cities in this respect implies that a regional-level scope on this global issue is important. Consequently, both private and public stakeholders within the urban regions and cities are at the forefront of this process and can have an encouraging or hindering role in this process. Especially the role of public actors, or more specifically local authorities and municipalities, have already received attention in various studies. Amongst other studies, Bulkeley & Betsill (2005, 45) emphasize the role of local authorities in terms of their response to initiatives to promote and implement sustainable energy solutions, stating that “local authorities are key actors in the urban arena in terms of coordinating action between different partners (…) Many have undertaken innovative measures and strategies to reduce their impact on climate change, which can act as demonstration projects or form the basis for new experimentation (…) Strategies to implement urban sustainability usually rest on the development of exemplar projects or ‘best practices’, from which lessons can be learned, and applied, within the urban arena or transferred between cities”. Such ‘pioneering’ cities, focused on stimulating and facilitating the implementation of sustainable energy solutions, can provide a favorable environment or ‘ecosystem’ for businesses seeking to develop and commercialize sustainable energy solutions. While insights in especially the role of public actors in the urban context have already been addressed in several studies, as exemplified above, gaining insight in the role of private actors, as well as the interaction of public actors with the private sector, has been rather limited to date. However, this focus on local authorities in the urban context has been identified as a key limitation of research in the field to date, given that non-state actors including companies, NGOs, and international foundations have been involved in responding to climate change at the urban level as well (Broto & Bulkeley, 2013; Bulkeley & Newell, 2010). As such, the role of business in the development, implementation, and commercialization of innovative technologies enabling such a shift towards sustainable development in urban regions is of pivotal importance to enable such a transition process, towards sustainable cities yet has received insufficient attention in academic research.

While this study aims to address the role of business in the transition towards sustainable cities, this transition process is embedded in the fundamental sustainability challenges faced by cities and societies on a global scale. Over the last decade, a field of research has emerged that specifically addresses these transitions towards sustainability, generally referred to as sustainability transitions literature (Markard & Truffer, 2008; Van den Bergh et al., 2011; Truffer & Coenen, 2012; Farla et al., 2012; Coenen et al., 2012). According to Coenen et al. (2012, 968), this field has made a considerable contribution towards "understanding the complex and multi-dimensional shifts considered necessary to adapt societies and economies to sustainable modes of production in areas", which includes energy. Farla et al. (2012, 991) describe the field of research of sustainability transitions as an "emerging field is characterized by a wide variety of topics, approaches and methodologies, but a general feature is that transitions towards sustainability are framed from a systems perspective. This is consistent with the general understanding of socio-technical transitions, which are conceptualized as major changes in technological, organizational and institutional terms for both production and consumption. Socio-technical transitions involve a broad range of actors and typically unfold over considerable time-spans. In the course of such a transition (radically) new products, services, business models and organizations emerge, partly complementing, partly substituting existing ones". The next section will discuss a literature review of key concepts in literature, and identify the importance of addressing the role of actors in transition processes, given a major research gap exists in this context at present.

Transitions in socio-technical systems: theory and concepts

The transition process towards a more sustainable energy future can be characterized as a transition process in a socio-technical system from a societal-level perspective, and entails the fundamental shift from one socio-technical systems to the next. Firms in the energy industry are embedded in this broader context, and inherently cannot be viewed in isolation from the broader societal-level context when considering business responses to a sustainability-induced transition in energy markets. Socio-technical transitions are characterized as complex, evolutionary, non-linear, long-term, transformative processes in which changes occur in multiple dimensions of a socio-technical system. Socio-technical systems include actor networks (firms, other organizations, collective actors, individuals), institutions (regulations, technical and societal norms, good practice standards), and material artifacts and knowledge (Geels, 2004; Geels, 2002; Markard, 2011; Markard et al. 2012). In relation to a more sustainable energy system, Jacobsson & Johnson (2000) argue that the emergence of renewable energy technologies (RETs) and the consequent alteration of the energy system require to be researched from systemic perspective with a focus on networks, institutions and firms' perceptions, competencies and strategies, and identify central issues which are key to understanding systemic change in the energy sector. First, the process of transition towards a new regime inherently means supplementing or replacing establish, incumbent technologies with novel, innovative technologies, which require a broader knowledge base beyond fossil-based energy technologies for their development and diffusion. Second, changes in the institutional context to align it with needs of renewable technologies is important, given the incumbent system is supported by an institutional framework established around incumbent technologies. Third, the emergence of new actors or groups of actors promoting the emergence of new technologies (labeled as 'prime actors') is crucial in the construction of a new system, given actors with incumbent positions in the established system can be expected to obstruct the process (Jacobsson & Johnson 2000, 633-637).

Over the last two decades, a body of literature has emerged on transitions in socio-technical systems. In defining transitions in socio-technical system, a comprehensive definition of a technological system is given by Carlsson & Stankiewicz (1991, 94), stating: 'technological system may be defined as a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion and utilization of technology. (…) They consist of dynamic knowledge and competence networks. In the presence of an entrepreneur and sufficient critical mass, such networks can be transformed into development blocks, i.e. synergistic clusters of firms and technologies within an industry or a group of industries'. Energy can be characterized as a socio-technical system, given it has linkages to user practices, application domains (markets), symbolic meaning of technology, infrastructure, industry structure, policy and techno-scientific knowledge (Geels 2002, 1257). These linkages, which inherently create interdependencies between components of a socio-technical system, are also emphasized by Rotmans et al. (2001), who define transitions as "a set of connected changes, which reinforce each other but take place in several different areas, such as technology, the economy, institutions, behavior, culture, ecology and belief systems. A transition can be seen as a spiral that reinforces itself: there is multiple causality and co-evolution caused by interdependent developments" (Rotmans et al. 2001, 16). In a similar vein, Geels (2002, 1257) defines technological transitions beyond merely technological aspects, stating technological transitions involve "major long-term changes in the way societal functions are fulfilled", whereby "technological transitions do not only involve changes in technology, but also changes in user practices, regulation, industrial networks, infrastructure, and symbolic meaning or culture".

When considering transitions in socio-technical system towards a normative, sustainable direction, literature on sustainability transitions specifically addresses the fundamental sustainability challenges faced by modern societies on a global scale. Markard et al. (2012, 956) define sustainability transitions in similar terms to socio-technical transitions: "transition involves far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural. Transitions involve a broad range of actors and typically unfold over considerable time spans (e.g., 50 years or more). In the course of such a transition, new products, services, business models, and organizations emerge, partly complementing and partly substituting existing ones. Technological and institutional structures change fundamentally, as well as the perception of consumers regarding what constitutes a particular service (or technology)". By nature, socio-technical transitions therefore consist of complex, co-evolving processes over prolonged periods of time, involving far-reaching shifts in a range of dimensions part of the socio-technical system. Kemp (1994) identifies the importance of the concept of technological regimes as highly relevant to achieving sustainable development towards a more sustainable economy in general, and a more sustainable energy future in particular, stating (Kemp 1994, 1038):

> "For its operation, the economic system depends on an energy system which is almost totally based on fossil fuels – coal, oil, and natural gas. (…) Together with these energy sources, we have conversion and end-use technologies in which energy is converted into useful energy forms and energy services. The energy sources and technologies even extend well beyond industry – into consumption patterns and people's way of life. Although alternative energy-supply technologies are available, the move towards an energy system based on renewables and other non-hydrocarbon energy technologies is hindered by small-scale production and the fact that so far they have benefited insufficiently from dynamic learning effects which are so important for energy technologies. Furthermore, the capital-intensive petrochemical firms vested in the fossil-based energy system have no interest in developing non-hydrocarbon energy technologies. They will only move into the business of alternative energy technologies

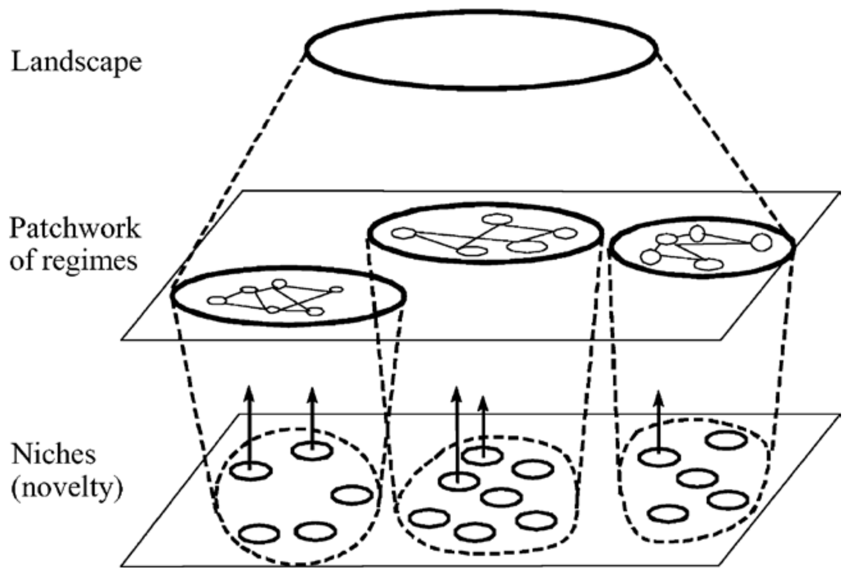
when fossil fuels are depleted or when the costs of extracting fossil fuels are becoming too high".

Energy is highly important field of study within sustainability transitions. Markard et al. (2012, 961) conduct a comprehensive literature review of literature on sustainability transitions, and identify sustainability challenges in the energy sector, including the broad range of renewable energy technologies including wind, solar and biomass, to be the most extensively covered sector in studies on sustainability transitions, accounting for 36% of all papers published. Conceptualizations of how transitions emerge in socio-technical systems, as well as the phases and pathways taken by such transformative change processes, have been well-established in the literature. In particular, the Multi-Level Perspective (MLP) and Strategic Niche Management (SNM) have been the basis for conceptualizing transition processes. The next section will outline the concepts in more detail.

Multi-level perspective (MLP)

The multi-level perspective (MLP) conceptualizes a pattern of long-term transitional change in socio-technical systems, and consists of three interrelated levels: the landscape (macro) level, regime (meso) level, and niches (micro) level, whereby the different levels can be characterized as analytical concepts to understand the dynamics of transition processes in socio-technical systems (Geels, 2002). The foundations of the MLP have been described and further refined in several publications (Rip 1994; Rip & Kemp 1998; Kemp et al. 1998; Rip, 2000; Kemp et al. 2001; Geels, 2002; Geels, 2004; Geels & Schot, 2007), making the MLP a well-established concept in studying socio-technical transitions.

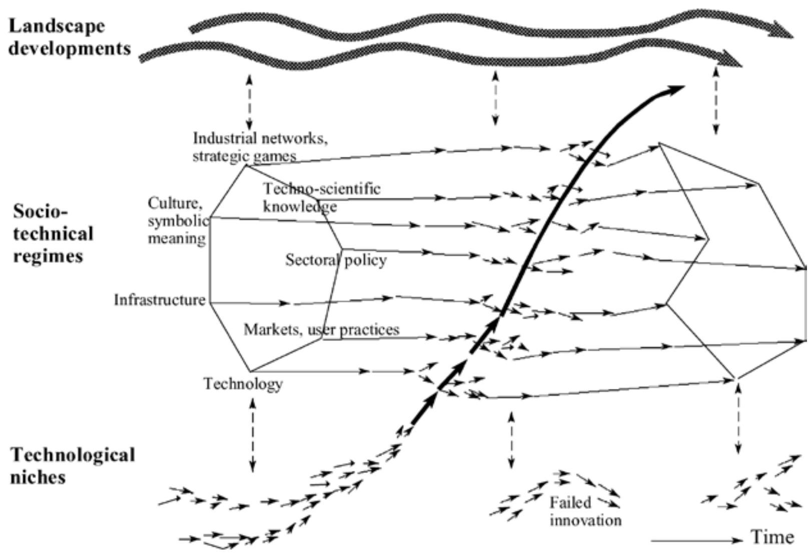
The landscape level is the external context in which socio-technical systems are embedded, and consists of heterogeneous factors long-term trends beyond the influence of actors at the regime and niche levels, which include economic, political, institutional, cultural, and environmental factors. The regime level consist of a patchwork of regimes, in which three interrelated elements constitute the technological regime: (1) a network of actors and social groups, which develops over time; (2) a set of formal and informal rules that guide the activities of actors who reproduce and maintain the elements of the socio-technical system, and (3) the technical elements and infrastructure consisting in the system (Geels, 2004). In a similar vein, Kemp et al. (2001, 272) define technological regimes as "a grammar or rule set comprised in the complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology or a mode of organization." The niche level in the MLP represents the level in which radical innovations can develop without being exposed to the selection mechanisms at the regime level, given the latter predominantly generates incremental innovations on regime technologies. Niches are often referred to as 'incubation rooms' or 'protected spaces' (Schot, 1998; Geels, 2002), in which radical innovations can develop shielded from the selection mechanism at the regime level. The three levels in the MLP are characterized as a nested hierarchy by Geels (2002), who explains the hierarchical relationship between each level in the MLP as follows: "The meso-level of socio-technical regimes accounts for stability of existing technological development and the occurrence of trajectories. The macro-level of landscape consists of slow changing external factors, providing gradients for the trajectories. The micro-level of niches accounts for the generation and development of radical innovations. The nested character of these levels, means that regimes are embedded within landscapes and niches within regimes. Novelties emerge in niches in the con- text of existing regimes and landscapes with its specific problems, rules and capabilities. Novelties are produced on the basis of knowledge and capabilities and geared to the problems of existing regimes" (Geels 2002, 1261).



The multi-level perspective (MLP) as a nested hierarchy, in which regimes are embedded in landscapes and niches within regimes (taken from Geels 2002, 1261):

Raven (2007, 2391) characterizes the process of transitions as conceptualized through the MLP in a comprehensive way, stating: "this model of transition emphasizes the multi-level and multi-actor dynamics of transitions (…) transitions occur as a result of complex interaction pattern between all levels and a range of actors. Established firms, new (innovative) firms, users, governments (local, national, supranational), scientists and NGO's have strategies, interests and motivation (often conflicting). The innovation patterns that develop out of their interactions often have an emergent rather than planned and structured character". Regimes are characterized by dynamic stability, and inherently experience incremental innovations on established technologies. Geels & Schot (2007, 406) explain the dynamics stability of regimes, by stating: "Stable regime still experience dynamics: firms compete in markets, invest in new product development, pioneer mutations, engage in takeovers, etc. But these processes take place within the stable rule-set and proceed in predictable directions (trajectories). Over time, accumulated incremental innovations in stable regime can boost performance". As such, actors with incumbent positions in the dominant regime will predominantly engage in incremental, competence-enhancing innovations on existing regime technologies.

Radical innovations are pioneered in niches (Geels, 2002), which are shielded from regime-level selection pressures. Emergence of tensions and problems at the regime level, potentially creates a window of opportunity for niche level technologies to be integrated in the configuration of the regime level. Geels (2002) identifies the general pattern by which radical innovations break out of the niche level towards the regime level as 'niche-cumulation', whereby the process is characterized by a gradual application of the radical innovation in subsequent application domains or market niches. Kemp (1994, 1043) mentions in this context that "the creation of a market niche for radically new technologies with a low environmental impact should be considered as a learning experiment, not just for the suppliers and potential users of these technologies but also for public authorities which want to achieve a smooth transition towards a more environmentally sustainable energy future". In later work, Kemp et al. (2001) identify four ways in ways niches are important for the takeoff of a new technological regime, and thereby important to the wider diffusion of a novel technology. These include (1) helping to demonstrate the viability of the new technology; (2) providing financial means for further expansion; (3) fostering support from customers, investors, suppliers, and other actors; and (4) setting into motion interactive learning processes, development of complementary inventions, and institutional adaption in management, organization, and the institutional framework in which firms operate (Kemp et al. 2001, 275).



A dynamic model of the MLP, depicting interactions between the levels of the MLP and the process of how transitions in socio-technical systems emerge (model taken from Geels 2002, 1263)

The concept of niche developments in relation to novel technologies emerging outside the dominant regime is very relevant when considering the emergence of RETs in the existing energy system. Collaborative approaches in which actors from public and private societal spheres are working together on a novel technology, shielded from the selection mechanisms of the market level, can be experimental in nature and centered around sustainability-enhancing technologies. Kemp et al. (2001, 275) elaborate on the importance of niches as a 'protected space, stating: "niche development often start in protected spaces, where regular market conditions do not prevail because of special protection in the form of research and development (R&D) programs (of companies and governments), subsidies or loosening institutional constraints. Such protected spaces can be called technological niches to distinguish them from market niches. They often take the form of experiments. Examples are experiments with electric vehicles in various European countries and cities, which would not be possible without the sponsorship and support of different actors. Technological niches often precede market niches. Both processes of niche development can occur simultaneously and reinforce each other." In relation to initiatives aimed at sustainable energy solutions for cities, the deliberate creation of niches in with sustainable energy solutions can be experimented with, the strategic management of such niches becomes highly important.

Strategic Niche Management (SNM)

Building on the MLP, another well-established concept in studying transition processes in socio-technical systems is Strategic Niche Management (SNM), which specifically focuses on the role of niches within the MLP, and their role in shifting from one technological regime to the next. Niches are crucial as an environment shielded from the socio-technical regime in which radical innovations can be developed. SNM, a concept introduced by Rip (1992) and further developed by Schot et al. (1996) and Kemp (1997), is centered around managing transition processes via niches dedicated to high-potential emerging technologies. Based on three strategies for technological regime change, Kemp et al. (2001, 280) describe the potential for SNM to enable innovative technologies to develop outside the dominant regime, and the steps involved in this process, as follows: “start by creating protected spaces, or niches, for promising new technologies. These spaces, in the form of technological niches, function as local breeding spaces for new technologies, in which they get a change to develop and grow. Once the technology is sufficiently developed, and broader use is achieved through learning processes and adaption in the selection environment, initial protection may be withdrawn in a controlled way”.

Understanding the barriers hindering the introduction of a new technology with favorable, more sustainable characteristics in comparison to existing regime technologies is crucial, in particular in relation to SNM. Barriers in this respect can be economic, technical, institutional, or social, as mentioned by Kemp (1994, 1043): “Barriers may be economic (when the new technology is unable to compete with conventional technologies given the prevailing cost structure), they may be technical (lack of complementary technologies, infrastructure facilities, appropriate skills or problems of integration in the existing technical infrastructure), and they may be social and institutional (related to laws, attitudes, perceptions , habits). To deal successfully with these barriers, and integrated and coordinated policy is required, which involves not only the implementation of taxes and subsidies that change the marginal costs of using particular technologies or setting the emission reduction standards but also the formulation of long-term goals and the creation of an actor network to sustain a new technological trajectory”.

The aims for SNM are fourfold according to Kemp et al. (2001, 1998), and include aims with respect to the institutional framework, feasibility assessment, stimulate technology development, and network formation: (1) Articulate necessary changes in technology and in the institutional framework that are necessary for the economic success (diffusion) of the new technology; (2) Learn more about the technological and economical feasibility and environmental gains of different technology options, thereby learning about the social desirability of the technologies; (3) Stimulate further development of selected technologies to achieve cost efficiencies in mass production, promote the development of complementary technologies and skulls, and stimulate changes in social organization that are important to wider diffusion of the new technology; and (4) build a constituency behind the product including firms, public authorities and researchers, whose coordinated actions are needed for a substantial shift in interconnected technologies and practices (Kemp et al. 2001, 289). While niches cannot be fully controlled, the role of governments in the formation process of technological niches to act as protected spaces for a novel technology can have an important though the establishment of "a set of successive experiments with a number of technologies" consisting of several elements (Kemp et al. 1998, 186). First, the selection of a novel technology (step 1) that is labeled as appropriate for support through SNM has to take place, whereby several preconditions for new technologies including social, technological-scientific, economic, and managerial-institutional preconditions have to be taken into account. Second, an appropriate experiment setting has to be selected (step 2) and set-up (step 3) for the application of the new technology. Niche policies developed in the set-up phase of the experiment have to be decided upon based on the use and diffusion of the new technology, and the nature of the barriers involved. These can include economic barriers (new technology is not at a cost-competitive level with conventional technologies), technical barriers (lack of complementary technologies, infrastructure or skills), or social and institutional barriers (existing laws, practices, perceptions, norms and habits), and can include policy elements like formulating long-term goals, the creation of an actor network, coordination of actions and strategies, and implementation or taxes, subsidies and standards (Kemp et al. 1998, 188). After the establishment of the experiment, the last two steps include the upscaling of the experiment (step 4) one it has been well-established in the technological niche, and the finally the breaking down of the protection (step 5) when it is considered as being no longer necessary or desirable (Kemp et al. 1998, 188).

Transitions towards sustainability (in which a transition process from one regime to the next evolves towards a sustainability-induced, normative direction) are distinct from historical transitions in socio-technical systems (in which the evolutionary pathway from one regime to the next has no specific normative direction). Lachman (2013, 270) compares historical transitions to sustainability transitions based on earlier work by Geels (2010) and Raven (2006), and identifies three main distinctions. First, the perceived urgency of sustainability-related issues is lower in comparison to environmental issues for which the impact is instantly visible. Taking climate change as an example, the long-term effects for societies on a global scale are far more damaging and dramatic than the short-term effects, given the fact it will take decades for the full effects of climate change to materialize. Hence, the pressure for a regime shift by developments at the landscape level for an issue such as climate change carries less urgency than issues, which have a more evident and visible short-term impact. Second, a sustainability-oriented transition is unlikely to follow a trajectory towards a single 'silver bullet' solution, but will presumably include the generation of multiple solutions over the course of the transition process Third, the direction in which the transition is leading is characterized by a normative goal which shapes the strategies and actions of actors involved in the transition process, as opposed to a purely evolutionary process in which no particular direction or trajectory is determined. As such, the next section is dedicated to the phases and pathways in transition processes.

Transition phases and pathways

The conceptualization of transition processes in socio-technical transitions in the MLP and SNM have been key in understanding how the transition from one regime to the next unfolds over decades, and what the dynamics are between the landscape, regime and niche level. Particularly the dynamic model of the MLP (Geels, 2002) points out the interaction between the different levels, and shows how radical innovations can emerge from niche to regime level. Particularly when instability at the regime levels occurs, a 'window of opportunity' can arise for novel technologies, as Geels (2004, 914) explains: "as long as socio-technical regimes are stable and aligned, radical novelties have few chances and remain stuck in particular niches. If tensions and mis-matches occur, however, in the activities of social groups and in ST-regimes, this creates 'windows of opportunity' for the breakthrough of radical novelties". Hence, regimes characterized by dynamic stability will still experience incremental innovations and changing dynamics within the regime, thereby evolving within the regime trajectory. Regime change, in which a socio-technical regime transitions from one regime to the next, arises as a result of external pressure put on the regime, or internal conflicts arising within the regime (Rotmans et al., 2001). Several studies have explored the phases and pathways in transitions, thereby furthering understanding of how transition processes shaped.

Considering transformation processes in socio-technical systems, Geels (2005) defines two routes for system innovation. In the first, technological substitution, innovations develop in niches shielded from the regime, and breakthrough from niche level to mainstream markets occur after gaining internal momentum combined with pressures from the landscape level pushing towards a regime shift. Hence, the dynamic stability of the regime developing incrementally within the set trajectory starts shifting, inherently causing adoptions and transformative change to elements of the regime, before eventually stabilizing and evolving into a newly established socio-technical regime (Geels 2005, 686). Where the technological substitution route can be characterized as a ‘technology-push’ route following pressure from the landscape, the wider transformation route emerges in response to persistent problems in the regime or changes in the landscape. When simultaneous changes occur in regime dimensions, actors will embark on experimentation with alternative technological options beyond the regime technologies for a prolonged time period. Over the course of this period, characterized by experimentation and strategic maneuvering by actors, technological options become narrower and possible evolve into a dominant technology, which will then be the center of the newly emerging technological regime (Geels 2005, 687).

Building on the work of Geels (2005), Raven (2007) elaborates on the two general strategies to transitions in socio-technical systems, niche accumulation and hybridization. In niche accumulation, a radical innovation is developed, improved and stabilized in several niche markets, before breaking out of the niche level and introducing the innovative technology to mainstream markets. The niche technology can be characterized as a radical innovation in comparison to regime technologies, and thereby differs in comparison to the regime in terms of markets, technologies, involved actors and institutional arrangement. This is in line with Geels (2005), who characterizes the process of niche accumulation by a gradual process in which a radical innovation is developed in a technological or specialized market niche, and subsequently introduced to multiple application domains or market niches. Small innovative firms are generally the driving actor in the niche accumulation strategy, whereby the main rationale is learning about technology and markets, as technological design can be optimized and fitted for use in different markets so that the technology becomes more robust. The introduction of the innovation in niche markets improves the technology-market fit, increases momentum, and can lead to the emergence of a new regime, which is better able to compete with mainstream technologies and markets (Raven, 2007). In the hybridisation, transitions start close to the existing regime and aims to entice mainstream regime actors to bend the existing trajectory towards an alternative, more desirable trajectory. Contrary to niche accumulation, incumbent firms are normally the driving actor in the commercializing process, whereby the main rationale is integrating the innovation into the existing regime infrastructures an add-on to existing technologies. As such, innovations in hybridization have a symbiotic relationship to the regime level, where innovation in niche accumulation has a competitive niche-regime relationship (Raven 2007, 2392). Within the hybridisation strategy, Raven (2007) describes the diffusion of an innovation as a ‘fit-stretch pattern’, which can occur from three sub-strategies: first, through market differentiation, in which firms explore markets without changing the technical design of the innovation; second, through stretching technological design, for example focused at enhancing price-performance ratios of the innovation; and third, through a process of co-evolution, where changes in technology and market build upon each other gradually (Raven 2007, 2397). Given niche accumulation and hybridization provide two extremes to a spectrum, transitions in socio-technical systems will presumably emerge as a mixture between both strategies in the evolution of the transition process over time.

As socio-technical regimes are dynamically stable in nature, and experience strong interdependencies between actors, networks and institutions embedded in the regime, will path-breaking, radical innovations experience barriers in breaking into mainstream markets. Building on earlier work on selection mechanisms on regime-level (Kemp, 1994; Rip & Kemp, 1998; Geels 2002, Smith, 2007) discussed earlier, Smith & Raven (2012) elaborate on several issues in relation to introducing path-breaking innovations to mainstream markets arising from regime-level selection pressures, thereby emphasizing the importance of creating protective space for path-breaking innovation in response to protection in the selection environment. In relation to different regime dimensions, these include: (1) industrial protection through industry structure (organizational networks, user-producer networks, industry platforms, etc.), which favors innovations which fit and complement existing industry structures and its dominant design, over path-breaking innovations which are incompatible with elements part of the industry structure; (2) technological protection through technologies and infrastructures (technical standards, infrastructural requirements, etc.), which limits the opportunity for path-breaking innovations to economically and technically performing in an optimal way, given prevailing technological standards and existing infrastructures do not fit its requirements; (3) market protection through markets and user relations (market institutions, user practices/preferences, etc.), which means market structures and institutions as well as user routines are embedded in the dominant regime, and thereby potentially incompatible with requirements for path-breaking innovations, making their introduction to mainstream markets challenging; (4) political protection through public policies (regulatory frameworks, policy targets, industry relations, etc.), given path-breaking innovations possibly require different policies and regulations than incumbent technologies, and prevailing regulations and tax structures potentially favor regime technologies; (5) sociocognitive protection through the existing knowledge base (scientific research programs, prevailing paradigms, etc.), given incremental knowledge development is pursued within the existing knowledge base over paradigmatic shifts, leading potentially to insufficient knowledge development and resource allocation to path-breaking innovations; and (6) cultural protection through cultural significance and associations with the regime (cultural value of innovation, symbolic meaning of technologies, etc.), meaning legitimacy and symbolic representations of a prevailing regime can be widespread, thereby possibly being a disadvantage to path-breaking technologies (Smith & Raven 2012, 1026-1028).

The role of actor-related patterns in the emergence of innovations from niche to regime level is of particular interest in the context of this study, given it focuses on the role of business (as key actors in regimes and niches) in a sustainability-induced transition in energy markets. Geels (2005) mentions in this context that "increasing support and involvement of actors is important to get the bandwagon going and stimulate diffusion and breakthrough", and identifies a number of firm-related patterns relevant in this respect, particularly related to incumbent firms. In response to radical innovations, firms can both accelerate as well as hinder the diffusion process. Regarding acceleration of the process, 'innovation races' and 'strategic games' between firms can accelerate the diffusion process, as well firms diversifying into new markets and technologies resulting from saturation and decreasing sales in existing markets. In the opposite direction, hindering firm-related patterns to diffusion processes can emerge when incumbent firms focus their efforts on incremental improvements to existing technologies when threatened by the emergence of new technologies from niches, thereby potentially delaying diffusion into mainstream markets. Also, when a new technology has become dominant in mainstream markets, firms can still hold on to old technologies in particular niche markets, or potentially evade other niche markets beyond the mainstream markets. When incumbent firms hold on to regime technologies and fail to recognize high-potential new technologies, thereby aiming to improve old technologies and shielding mainstream markets from new entrants, an effect referred to as 'missing the wave' emerges, potentially leading to the decline of the incumbent firm in the transition process (Geels 2005, 693).

While the emergence from innovations from niche to regime level is highly important in understanding the dynamics of the MLP, interactions between the levels and the pathways taken by transitions in socio-technical systems can take several paths. Rotmans et al. (2001, 17) identify four transition phases: a predevelopment phase characterized by a dynamic equilibrium, whereby the regime is stable and visible changes do not yet materialize; a take-off phase which marks the start of a change process in the system and the system is starting to shift; a breakthrough phase, marked by structural changes to the system through accumulation of changes in economic, institutional, ecological and socio-cultural context, which is then followed by an acceleration phase, in which learning processes take place collectively, diffusion of the novel technology takes place; and a stabilization phase, whereby a new dynamic equilibrium is established. The pathway towards this new dynamic equilibrium can take different shapes. Geels & Schot (2007) identify four transition pathways, based on the nature and timing of the interactions between the levels in the MLP. In the first one, the transformation pathway, moderate landscape pressure occurs at a point in time when niche innovations have insufficiently been developed, leading regime actors to modify the direction of development paths and innovation activities. The transformation path is characterized by reorientations of regime actors, utilizing their adaptive capacity to reorient development trajectories, whereby several technical variations emerge over the course of the transition, partly adapted to the changing dynamics in the selection environment. As such, a process of cumulative adjustments and reorientations characterize the transition process in the regime, in which regime actors generally survive, and potentially import external knowledge for niche innovations that have a symbiotic, non-disruptive character to the regime (Geels & Schot, 2007). In the second path, the de-alignment and re-alignment path, the pressure from the landscape is large, sudden and divergent, thereby creating problems within the regime and leading to erosion and de-alignment. When niche innovations do not provide a clear substitute and are insufficiently developed, a window of opportunity arises for multiple niche innovations to emerge from the niche level, and exist simultaneously for a period of time. The time period in which multiple niche innovation co-exist is characterized by uncertainty about the emerging trajectory, experimentation with multiple technologies, and competition between innovations over resources. When a dominant niche innovation emerges and gains momentum, re-alignment and re-institutionalization of a new socio-technical regime takes place centered around the dominant niche innovation (Geels & Schot, 2007).

The third path, labeled technological substitution, occurs in a situation when strong landscape-level pressures combined with sufficiently developed niche-level innovations enable breakthrough for innovations from niche-level to regime-level, thereby replacing the existing regime. A stable regime, in which actors engage in incremental innovations, is a barrier for niche innovations to emerge out of their niche. The opportunity created by strong, disruptive pressure from the landscape (thereby destabilizing the regime) creates the opening for sufficiently developed niche innovations to enter mainstream markets beyond the niche level, provided that they have had the possibility to stabilize and gain internal momentum at the niche level (Geels & Schot, 2007). The last transition path identified, the reconfiguration pathway, innovations developed in niches characterized by a symbiotic relationship with the regime are adopted by regime actors to solve local problems initially, but over time triggers substantial changes in the basic architecture of the regime. Specifically for distributed socio-technical systems in which multiple technologies are interconnected and transitions are triggered by a sequence of multiple component-innovations instead of one specific breakthrough technology, the reconfiguration path is highly relevant (Geels & Schot, 2007). In addition to these four transition paths, Geels & Schot (2007) mention that in a situation of disruptive landscape-level change, a sequence of the identified transition paths is likely, in which transformation leads to reconfiguration, and then possibly evolves towards either substitution or re-alignment and de-alignment.

In addition to the transition paths and breakthrough patterns discussed, work by Smith et al. (2005) elaborates on the governance of socio-technical transitions in different transitions contexts, whereby governance of regimes "can be understood as altering the given context of selection pressures and adaptive capacity, thereby modifying transformation processes, in terms of their pace and orientation" (Smith et al. 2005, 1502). In this vein, transition processes in socio-technical regimes are characterized as a function of two processes, including shifting selection pressures at the landscape level, be it economic, political or environmental, exerting pressure on the regime, and the coordination of resources inside and outside the regime in adapting to such pressures. Their typology in their 'coordination of actors/locus of resources' framework is based two dimensions: the articulation of selection pressures, which makes a distinction between the degree to which transition processes which are envisaged, coordinated and governed using steering mechanisms, versus transition processes which emerge from historic development and decision-making processes by actors within the regime; and the adaptive capacity in regime transformation, which takes into account the degree to which resources and capabilities to respond to these changing selection pressures are available inside or outside the regime (Smith et al., 2005). Internal adaption to pressure for regime change can take two forms: 'endogenous renewal' and 're-orientation of trajectories'. In the first context, endogenous renewal (internal adaption with a coordinated response), transformative change will have an incremental nature and will arise from alignment of smaller changes based on resources, capabilities and expectations originating within the regime, with a high degree of coordination. In the second context, re-orientation of trajectories (internal adaption without a coordinated response), the trajectory of regime change is highly unpredictable and emerges from a series of uncoordinated responses to pressure for regime change, without alterations to the actors, institutions and networks internal to the regime. External adaption to regime change can take two forms as well: 'emergent transformation' and 'purposive transitions'. In the first, emergent transformation (external adaption without a coordinated response), resources and capabilities outside the incumbent regime (i.e. technological innovations in niches) are central in responding to regime change, which has a autonomous character and is thereby not coordinated towards a particular direction. The second context, purposive transitions (external adaption with a coordinated response), is closest to transition management discussed earlier, and builds on external resources and capabilities beyond the incumbent regime to coordinate a transition towards an intended, pre-determined trajectory (Smith et al., 2005). Particularly in relation to researching transitions towards sustainability, whereby governing transition processes towards a normative direction (i.e. a more sustainable energy system) is highly relevant.

In managing a transition process towards a new regime such as a more sustainable energy system, Kemp et al. (2001) mention the importance lies in promoting a shift towards a more sustainable technological regime, rather than promoting a single novel technology. Kemp et al. (1998, 2001) define three strategies for regime shifts towards a more sustainable, desirable system. First, changing economic incentive structures to reward positive externalities and tax negative externalities, and have market forces and decisions made by individual actors on a decentralized level shape a transition process. Second, planning for the creation and building of a new technological system based on alternative and more sustainable set of technologies, comparable to the planning for large infrastructural systems. Third, building on the ongoing dynamics of the transition process within the socio-technical regime, thereby exerting pressures to modulate the change process into desirable directions.

Towards an organizational-level actor-centered analysis in sustainability transitions

While the theoretical foundation on transition processes in socio-technical systems has been well-established in literature in several conceptual approaches over the last two decades, major opportunities for further research in sustainability transitions have recently been identified in several special issues, particularly the ones in Research Policy (2012) and Technological Forecasting and Technological Change (2012). Considering the latter, a major research focus gap is identified in relation to the actors, strategies and resources involved in sustainability transitions. Although transition processes in socio-technical systems are inherently evolutionary and complex, involving a broad range of actors as well as economic, institutional, technological and social dynamics, the importance of individual actors cannot be overlooked. Individual actors ranging from companies and (local) governments to individuals can be a catalyst to a transition process (Rotmans et al., 2001). Farla et al. (2012, 992) point out that in the theoretical concepts and empirical studies in the field to date have predominantly focused on "sketching the bigger picture" on socio-technical transitions and innovation processes at the macro or systems level, while studies with a more "actor-oriented and agency-sensitive" focus has been rather modest to date. Within this context, Farla et al. (2012) explicitly emphasize the importance of focusing on the how strategies, resources and capabilities of actors influence and trigger a transformation in the system, as well as how system level change is translated back into the observed strategies of actors in transition processes. In this vein, the special issue poses two interrelated research questions as a basis for an actor-oriented analysis in sustainability transitions, which include (1) "what strategies do actors adopt to shape sustainability transitions and what resources do they mobilize and deploy in the realization of these strategies?" and (2) "what kind of different actors play a role in these transformation processes and how can and do they align their strategies (and resources) to achieve common goals?" (Farla et al. 2012, 992). The focus on actors in transition processes in socio-technical regimes was also emphasized by Geels (2005), mentioning that the MLP "needs to be filled in with a more detailed actor-related pattern", and that in relation to transition processes, "actor-related patterns are important building blocks to understand accelerations and slowing down in diffusion and breakthrough" (Geels 2005, 692).

The special issue provide some insights into actors in sustainability transitions, based on the seven papers included in the special issue (Penna & Geels, 2012; Schuitmaker, 2012; Musiolik et al., 2012; Quitzao et al., 2012; Bakker et al., 2012; Budde et al., 2012, Konrad et al., 2012). These papers are rather diverse in terms of the sustainability challenge addressed, the actors focused on, and strategies and resources deployed. Farla et al. (2012) provide some conclusions for actors as well as strategies and resources aggregated from the seven studies in the special issue. In relation to firms, studies in the special issue have found firms to be engaging in a number of different roles: firms were actively engaged in innovation trajectories in three studies, and helped building a supporting environment or innovation system in one study. Farla et al. (2012) conclude based on these firm roles, that firms purposely aim to create positive externalities and invite other actors to become part of an emerging field to create momentum against established technologies and competitive innovations, thereby indicating firm strategies “far-reaching and long-term oriented”, and thereby relevant for sustainability transitions. In terms of strategies, different foci observed across cases with a major variety in targets and strategies, while a common characteristic was amongst seven studies that all interact with the broader environment and actors part of the system. Regarding policymakers and public authorities, central and traditional role in financing pre-competitive phase of innovative, more sustainable technologies found in three of the seven studies, as well as new role in the pro-active creating of a niche through institutional arrangements which enabled experimentation with mode sustainable identified in one study.

As the discussion on the MLP and SNM so far has shown, the importance of niches in relation to sustainability-induced transitions is essential, given their potential to serve as a protective space in which path-breaking innovations can be developed shielded from mainstream regime-level selection pressures. When adopting an actor-oriented analysis in this perspective, Smith & Raven (2012) mention that in actor-oriented perspectives on niche developments, local-level experimentation is an important focus. Specifically, the relation between ‘local’ networks of socio-technical experimentation in specific project locations and ‘global’ networks responsible for converting that experience into more generic, mobile processes and norms.

In a similar way to that of the sustainability transitions literature, Johnson & Suskewicz (2009) propose to focus on the creation of a whole new system as opposed to the ‘conventional approach’ of developing individual technologies. On investments in clean-tech companies from 2005 onwards, the authors note that a key problem is that the majority of investments has been in companies that adopt conventional business models with the aim of fitting clean energy technologies into the existing energy system, while instead a ‘systemic shift based on a transformation framework system centered around four interdependent and mutually reinforcing components’ is needed (Johnson and Suskewicz 2009, 5). They identify the emergence of enabling technology, the development of an innovative business model, a carefully defined market-adoption strategy, and the availability of favorable government policy as critical components Using two case studies on two well-known high-profile initiatives, Better Place and Masdar City, the authors provide a narrative on how these initiatives adopt a systemic approach, which includes a novel technology being introduced via a business model new to the industry, collaboration between private and public stakeholders, and the influence of favorable policy on a national and local level (Johnson and Suskewicz 2009, 6-7). One of the key findings for the Masdar City initiative includes that a sheltered end market is created, which allows clean energy technologies and business models to mature with minimal barriers to implementation and adoption, thereby creating the potential for making these technologies 'viable options for building projects in developing and emerging markets and retrofits in the developed world' (Johnson and Suskewicz 2009, 8). While Masdar City is a pioneer project for establishing a fully carbon-neutral city, that has obvious replication restrains for financial reasons (the project was founded with 15 billion of government funds), it shows a system approach to the issue, and the potential for creating a sheltered environment at the local-level to allow business models and sustainable innovations to be tested and developed.

Comparable to the systemic shift advocated by Johnson and Suskewicz (2009), Boons & Ludeke-Freund (2012) emphasize that the emergence of a new sustainable technology in itself is incapable of establishing a shift in the existing paradigm of production and consumption, while in combination with a new business model this would be possible. On the interaction between business models and sustainable innovations, the authors note that 'sustainable business models with a focus on technological innovation are market devices that overcome internal and external barriers of marketing clean technologies: of significance is the business model's ability to create a fit between technology characteristics and (new) commercialization approaches that both can succeed on given and new markets' (Boons & Ludeke-Freund 2012, 16). How the perspective of the business model can be applied in this study, is explored in the next section.

An organizational-level analysis of actors in transitions: a business model approach to exploring the role of business responses to sustainable cities

Business models have gained attention in management literature in the past few years by scholars from different research orientations, which has lead to multiple conceptualizations of the phenomenon and the adoption of inconsistent definitions of business models across different studies. Zott et al. (2011) performed a rather comprehensive review of academic publications on business models since 1995, analyzing 1177 papers in peer-reviewed academic journals, and conducting a review on 103 of the papers present in the initial sample. Their work identifies three 'silos' in which the concept of business models has developed in management literature to date, which include studies focused on (1) strategic issues related to value creation and firm performance, (2) innovation and technology management, (3) e-business and information technology usage (Zott et al. 2011, 2). Based on common themes found across these silo's in their literature review, the authors mention that business models can be seen as a 'firm-centric, yet boundary-spanning, activity system', which is distinct from other concepts found in the literature. Business models are identified as a new, distinct unit of analysis, positioned between the firm-level and the network-level (closeness to either construct depending on the definition of the researcher), and while concentrated at a specific organization, the business model can span beyond the boundaries of the focal organization (Zott et al. 2011, 24). Also, organizational activities, performed by either the firm studied or by its suppliers, partners or customers, are therefore captured in the conceptualization of the construct (Zott et al. 2011, 25), indicating that stakeholders in the network of a firm are an integrative part of a firm's business model. As such, the business model focuses on how value is created for customers, and the way a company is manages its partnerships, resources and activities for create that value, either owned or performed by the focal company itself, or acquired from partners to the focal company (Amit & Zott, 2010; Amit & Zott, 2011; Schaltegger et al., 2011).

A number of studies address the components considered to be part of the business model. Schaltegger et al. (2011, 16) identify four central business model pillars, which include: (1) value proposition (products and services offered by a firm, creating value for customers for which they are willing to pay); (2) customer relationships (relationship between firm and customer, which is created and maintained for long-term revenues); (3) business infrastructure (network of partners for value creation and customer relationships); and (4) financial aspects (structure of revenues and costs). The authors note that these pillar provide a generic overview the business model, while in the context of sustainability-oriented business model innovation the linkages and management between each of these pillars is essential. They furthermore emphasize that innovations aimed at sustainable development require the development of new business models, and the need to establish 'business cases for sustainability', stating that 'sustainability-oriented innovations are obviously predisposed to not fit with the dominant logic of an established business model […] accommodative and proactive sustainability strategies may help creating and adopting new business models which support the continuous and systematic creation of business cases for sustainability' (Schaltegger et al. 2011, 16). The latter implies a newly created business model could potentially create economic success while addressing an environmental or social issue, which could be contributing to sustainable urban development in the context of this study. In a similar vein, Amit & Zott (2010, 2) identify business models as a system of activities, and define the construct as ‘the bundle of specific activities that are conducted to satisfy the perceived needs of the market, including the specification of the parties that conduct these activities (i.e., the focal firm and/or its partners), and how these activities are linked with each other’. Several assumptions underlie their definition of business models, including the idea that the definition adopts a holistic perspective focused on capturing the essence of ‘how firms do business’, whereby value creation for all stakeholders participating in the business model is important, and in which core activities inherent to the business model can be conducted with support from partners of the focal firm (Amit & Zott 2010, 2-3).

Another approach to identifying components to the business model is introduced by Morris et al. (2005), who propose a framework based on a review of literature on business models. They define six questions identify the core business model components, whereby three levels of decision-making are introduced with increasing specificity, including the ‘foundation’, ‘proprietary’, and ‘rules’ levels. The foundation level describes the most important basic components of the business model, and is predominantly focused on the value proposition, the customer, internal processes and firm competencies, and the economic rationale of how the firm makes money through the business model (Morris et al. 2005, 729). Following the descriptive and generic foundation of the business model in this first phase, the proprietary phase is strategy specific and entails how the focal firm develops novel and innovative ways of creating value for customers, by connecting the components defined in phase one. Subsequently, the rules level determines a set of guiding principles and operating rules, which portray the focal firm’s strategic actions and reflect the components of the foundation and proprietary level. The use of a set of questions to identify the key components of a firm’s business model, and in which way the firm connects the different components to each other, is also applied specifically to business model innovation by Amit & Zott (2010). The authors propose to focus on three key characteristics of an activity system which can be leveraged individually as well as jointly, including the content (referring to the selection of activities to be performed), structure (depicting the linkages and sequencing of activities, and the exchange mechanisms between activities), and governance (identifying who will perform activities, which can be either the focal firm or other stakeholders within the network) of the activity system.

In relation to innovation literature, Zott et al. (2011, 18) identify two complementary views on business models, one in which “companies commercialize innovative ideas and technologies through their business models” (in which the business model is a vehicle to market innovations), and one in which "business models represent a new dimension of innovation, which spans from the traditional models of process, product, and organizational innovation, involving new forms of cooperation and collaboration" (in which the business model in itself is innovative in nature). When focusing on the role of business in enabling urban regions and cities to become more sustainable through innovative energy solutions, essentially both the innovative nature of the business model being developed in collaboration with other stakeholders, as well as the notion of the business model as vehicle through which innovations can be brought to the market, are highly relevant. In a similar vein, Boons & Ludeke-Freund (2012, 15) identify three combinations between business models and technological innovation when viewing the business model to be a vehicle or device to market an innovation, including employing a given technology through a new business model, the uptake of a new technology within the framework of an existing business model, and the triggering of developing a new business model by a new technology (which could work in the opposite direction as well). Perkmann and Spicer (2010) explore the relation between business models and capturing value from new technologies, and mention that 'value is not intrinsic in technologies but has to be realized via suitable and viable configurations of organizational structures and relationships with external actors', and continue to mention that 'no single best business model for exploiting any given technology can be applied' (Perkmann and Spicer 2010, 14). This indicates that context specificity and local conditions in dealing with a new technology, as well as interaction with stakeholders as an integrated part of the business model, are rather important. Given the introduction of sustainable energy solutions in an urban context calls for new business models to bring sustainable innovations to the market, including working in novel collaborative modes with stakeholders in the urban regions, the notion of business model innovation is key in this respect.

Notes on the methodology and progress of the research project

Given the exploratory nature of this research project, this study will adopt a qualitative research approach by conducting multiple case studies, which will include archival data as well as semi-structured interviews. It will adopt a similar research design as earlier completed research papers part of the PhD project, and aims to contribute to both academic and professional settings. From an academic perspective, the limited insight into the actors and their strategies and resources they deploy within the sustainability transitions literature creates a major research gap in focusing on how actors and their strategies shape transition processes.

Also, gaining insight in the kind of actors involved in sustainability transitions, and the way in which they can align their strategies and resources to achieve common (sustainable development) goals, presents an important gap in existing literature. From a professional perspective, this study aims to contribute to gain insight in the role business (potentially) has in the transition towards sustainable cities. Recent high-profile policy initiatives, including the 'Sustainable Cities' initiative launched at the 2012 Rio +20 United Nations Conference on Sustainable Development and and the 'Green Cities Programme' launched by the Organization for Economic Co-operation and Development (OECD), outline the importance and characteristics of sustainable urban development, but do not specify the role of business in this process. Given the crucial role of business to develop, implement and commercialize innovative products and services to translate these solutions for sustainable cities from policy to practice, this study aims to contribute to this context as well. The research project is currently in the stage of developing a coherent theoretical research framework. Data collection has not started at present, but is planned to start at the end of 2013.

References

Alusi, A., Eccles, R., Edmondson, A. & Zuzul, T. (2011). Sustainable Cities: Oxymoron or the shape of the future?. *Harvard Business Review Working Paper,* 1-26.

Amit, R. & Zott, C. (2010). Business model innovation: creating value in times of change. *IESE Working Paper,* 1-15.

Boons, F. & Ludeke-Freund, F. (2012). Business models for sustainable innovation: state of the art and steps towards a research agenda. *Journal of Cleaner Production,* forthcoming

Bulkeley, H. & Betsill, M. (2005). Rethinking sustainable cities: multilevel governance and the 'urban' politics of climate change. *Environmental Politics,* 14(1): 42-63.

Bulkeley, H. & Betsill, M. (2006). Cities and the multilevel governance of global climate change. *Global Governance*, 12: 141-159.

Bulkeley, H. (2010). Cities and the governing of climate change. *Annual Review Environmental Resources,* 35: 229-253.

Bulkeley, H., Broto, C., Hodson, M., & Marvin, S. (2011). Cities and low carbon transitions. Routledge: London & New York.

Broto, V. & Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change,* 23: 92-102.

Carlsson, B. & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics,* 1: 93-118.
Carvolho, L., Gemini, M., Lazzerini, I., Van den Berg, L., Van der Borg, J., & Van Tuijl, E. (2013). Research Project. Energy transitions in cities. Lifestyle, experimentation and change – Background, review and frame of analysis. First case study: Stockholm. Enel Foundation, Rome: 1-63.
Coenen, L., Benneworth, P. & Truffer, B. (2012). Toward a spatial perspective on sustainability transitions. *Research Policy,* 41: 968-979.
Doganova, L. & Eyquem-Renault, M. (2009). What do business models do?: Innovation devices in technology entrepreneurship. *Research Policy, 38(10):* 1559-1570.
Farla, J., Markard, J., Raven, R. & Coenen, L. (2012). Sustainability transitions in the making: a closer look at actors, strategies and resources, *Technological Forecasting & Social Change,* 79: 991-998.
Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy,* 31: 1257–1274.
Geels, F. (2004). From sectoral systems of innovation to socio-technical systems – Insights about dynamics and change from sociology and institutional theory. *Research Policy,* 33: 897-920.
Geels, F. (2005). Processes and patterns in transitions and system innovations: refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change,* 72: 681-696.
Geels, F. & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy,* 36: 399-417.
Jacobsson, S., & Johnson, A. (2000). The diffusion of renewable energy tehnology: an analytical framework and key issues for research. *Energy Policy,* 28: 625-640.
Jacobsson, S., & Bergek, A. (2004). Transforming the energy sector: the evolution of technological systems in renewable energy technology. *Industrial and corporate change,* 13(5): 815-849.
Johnson, M. & Suskewicz, J. (2009). How to jump-start the clean-tech economy. *Harvard Business Review,* 1-10.
Kamal-Chaoui, L. and M. Plouin (2012), "Cities and Green Growth: Case study of the Paris/Ile-de-France region", OECD Regional Development Working Papers, 2012/02, OECD Publishing.

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

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. *Technology Analysis and Strategic Management,* 10: 175–196.

Kemp, R., Rip, A., & Schot, J. (2001). Constructing transition paths through the management of niches. In: Garud, R., Karnoe, P. (Eds.), *Path Dependence and Creation.* Lawrence Erlbaum, Mahwah, NJ: 269–299.

Lachman, D. (2013). A survey and review of approaches to study transitions. *Energy Policy,* 58: 269-276.

Markard, J. & Truffer, B. (2008). Technological innovation systems and the multi-level perspective: towards an integrated framework. *Research Policy,* 37: 596-615.

Markard, J., Raven, R. & Truffer, B. (2012). Sustainability transitions: an emerging field of research and its prospects. *Research Policy,* 41: 955-967.

Morris, M., Schindehutte, M. & Allen, J. (2005). The entrepreneur's business model: toward a unified perspective. *Journal of Business Research,* 58: 726-735.

OECD (2013A). Green Growth in Stockholm, Sweden. OECD Green Growth Studies, OECD Publishing. http://dx.doi.org/10.1787/9789264195158-en

OECD (2013B). Green Growth in Kitakyushu, Japan. OECD Green Growth Studies, OECD Publishing. http://dx.doi.org/10.1787/9789264195134-en

OECD (2013C). Cities and Green Growth: The Case of the Chicago Tri-State Metropolitan Area. OECD Regional Development Working Papers, OECD Publishing. http://dx.doi.org/10.1787/5k49dv6c5xmv-en

OECD (2013D). Green Growth in Cities. OECD Green Growth Studies, OECD Publishing.

Osterwalder, A. (2004). The business model ontology. A proposition in a design science approach. Universite de Lausanne, Lausanne .

Perkmann, M. & Spicer, A. (2010). What are business models? Developing a theory of performativity representations. *AIM Research Working Paper Series,* 1-19.

Raven, R. (2007). Niche accumulation and hybridization strategies in transition processes towards a sustainable energy system: an assessment of differences and pitfalls. *Energy Policy,* 35: 2390-2400.

Rotmans, J. Kemp, R., & Van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *Forsight,* 3(1): 15-31.

Schaltegger, S., Ludeke-Freund, F. & Hansen, E. (2011). Business cases for sustainability and the role of business model innovation. *Leuphana Universitat Luneberg Centre for Sustainability Management*, 1-32.

Schot, J., Hoogma, R., & Elzen, B. (1994). Strategies for shifting technological systems: the case of the automobile system. *Futures,* 26:1060–1076.

Smith, A., Stirling, A. & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy,* 34: 1491-1510.

Smith, A. & Raven, R. (2012). What is a protective space? Reconsidering niches in transitions to sustainability. *Research Policy,* 41: 1025-1036.

Sustainable Cities (2012). Sustainable Cities – Building cities for the future. Green Media Ltd.: London, 1-152.

Truffer, B. & Coenen, L. (2012). Environmental innovation and sustainability transitions in regional studies. *Regional Studies,* 46(1): 1-21.

United Nations (2011A). 'Global report on human settlements 2011 - Cities and Climate Change'. United Nations: New York & Geneva, 1-300.

United Nations (2011B). 'Climate Neutral Cities – How to make cities less energy and carbon intensive and more resilient to climate change'. United Nations: New York & Geneva, 1-85.

Zott, C., Amit, R. & Massa, L. (2011). The business model: recent developments and future research. *Journal of Management,* (volume not specified): 1-24.