DEVELOPMENT AND UPSCALING OF INTEGRAL SUSTAINABLE ENERGY INNOVATIONS IN HOUSING – THE ROLE OF PRACTICE AND UNDERLYING DRIVERS

Combining theoretical perspectives for a new research agenda

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Abstract: The goal of this paper is to elaborate a theoretical framework and research design for further research related to the question 'What practices and underlying drivers explain adoption of integral sustainable energy innovations in the Dutch housing sector?'. Although there are many efforts to speed up development and diffusion of sustainable innovations in the Dutch built environment, innovative capacity of the construction sector in particular has been rather low. There have been a number of experiments showing integral sustainable innovation in practice, but application on a large scale has been disappointing. Some traditional applications seem to be 'locked in', whereas other innovative ones are ' locked out', for example in the field of energy. Furthermore, it looks like there is a 'deadlock' on innovations in the sector as both the demand and supply side of the market are not able or willing to make sufficient investments. Additionally, government innovation support programs do not provide the 'right' incentives to trigger momentum (Faber and Hoppe, 2013). In this paper we survey multiple interdisciplinary theoretical perspectives - such as transition management (Loorbach, 2007), the 'multilevel perspective' (Geels, 2002), and strategic niche management (Kemp et al., 1998) - that can be of use when studying development and diffusion of sustainable innovations in the built environment. In this paper we conceptualise the concepts of sustainable innovation and what we call 'sustainable innovation practice'. The paper ends with a theoretical framework which allows for analysis of the development and diffusion of integral sustainable energy innovations in housing by assessing demonstration projects.

Keywords: sustainable development, innovation system, transitions, housing, integral energy innovations.

1. Introduction

There have been many efforts to speed up development and diffusion of sustainable innovations in the Dutch built environment. For example a great number of policy instruments have been used by the Dutch national government from the 1970s onward to stimulate house-owners (either owneroccupants or housing associations) to improve energy performance levels. After initial success between 1977-1987, objectives were however never met (Hoppe, 2009). Allthough there are many technological opportunities available, the Dutch built environment has difficulty to harvest this potential. There is a number of barriers to energy innovation in the housing sector. In general innovative capacity is low (Faber and Hoppe, 2013).

This paper further explores the paradox between economic and technological potential on the one hand and low adoption levels of energy efficiency improvements in the Dutch housing sector on the other. This paper explores whether specific innovation practices can be identified related to the adoption of integral sustainable energy innovations in the Dutch housing sector, and what the underlying drivers are for these energy innovation practices. Finally the paper explores ways to analyse how these drivers and practices develop and contribute to (or hinder) an energy transition in the Dutch housing sector. The main research question for this paper is the following.

What practices and underlying drivers explain adoption of integral sustainable energy innovations in the Dutch housing sector?

In this paper we survey multiple interdisciplinary theoretical perspectives - such as transition management (Loorbach, 2007), the 'multilevel perspective' (Geels, 2002), and strategic niche management (Kemp al., 1998). We make a selection of drivers for integral sustainable energy innovation in housing, which results in recommendations for a theoretical framework to analyse empirical cases (experiments and demonstration projects).

The paper is structured as follows. In section 2 we discuss energy innovation in the housing sector. In section 3 we discuss theoretical literature on transitions, transition management and strategic niche management. In section 4 we conceptualize sustainable innovation, sustainable innovation practice and underlying drivers, and we integrate these concepts into a theoretical framework. In section 5 a new research agenda and a preliminary research design is presented. In section 6 we draw the most important conclusions.

2. Energy innovation in the housing sector

2.1 The Dutch housing sector and barriers to energy innovation – empirical literature

A recent study by Faber and Hoppe (2013) provides insight in the dynamics in the Dutch housing sector and the barriers that prevent improvement of overall energy efficiency of the sector by applying a sectoral systems of innovation approach. The single most important barrier that was identified relates to the regulatory design: many regulations were considered to focus on laggards rather than front runners, providing little incentive for innovative action and regulative design was found to often complicate energy investments due to bureaucratic complexity or lack of integration (Faber and Hoppe, 2013, p. 635). Another important barrier is related to the demand: historically a focus on volume over specific quality demands developed. There is a focus on price tendering with little attention for energy issues. Consequently, there is a deadlock in the market: construction

companies complain about not finding demand and owners complain about the reluctance of construction companies to come up with more viable options (Faber and Hoppe, 2013, p. 634). The third important barrier concerns the role and functioning of primary and secondary agents. Primary agents in the housing sector are project developers and a range of building firms, including installers and other specialised construction workers. Housing associations, the heterogenous group of house owners and local governments are also considered important primary agents. Secondary agents include national government, banks, supporting information and extension agencies, research institutions, consultancies, architects and intermediaries. Due to the project based nature of co-operation the building sector as a whole was found to be fragmented. Sectoral fragmentation hampers development of shared visions and integrated approaches, locking in a culture of mutual distrust and a general conservative attitude. There are very few leaders in the field of energy innovation who could gear involved parties to more integrated ways of project management. The fourth barrier identified is the sectoral context, with its imperfect competitiveness conditions and unfavourable financial conditions considering innovation (Faber and Hoppe, 2013, p. 633-644). Barriers to energy innovation in the housing sector are addressed in several studies in scholarly literature (e.g., Pries and Dorée, 2005; Hal, van, 2000; Hoppe and Lulofs, 2011; Hoppe, 2009; Waals, van der, et al. 2003; Bueren, van, 2009; Mleczik, 2013).

2.2 Recent sectoral innovation programmes

As indicated in the previous section many barriers are sectoral barriers such as fragmentation, a culture of mutual distrust, a lack of transformative leadership and the competitiveness conditions (Faber and Hoppe, 2013). There is a need for sectoral policies and programs to stimulate innovation especially in the construction and housing sector.

An example of such a sectoral programme to stimulate innovation in the sector was the programme for system and proces innovation in the Dutch construction sector (in Dutch: PSIB) that was established in 2004 (the programme functioned until 2008). In their project plan (PSIB, 2004) they explain that limitations in space, mobility and environment challenge the construction sector and that meeting these challenges would put the sector in a position to contribute to socio-economic benefit for society. A number of factors are mentioned why the sector is not capable of creating economic growth. Firstly, the market mechanism is such that little attention is given to optimisation of the price-quality ratio and to requirements for continuity of private sector participants. Secondly, there is little understanding of the requirements of clients and the needs of society. The construction process is focused on internally optimising subprojects rather than on the total project life cycle. Thirdly, the industry is highly fragmented, with many parties involved in the different phases of a construction project and there is little coordination between research institutes and advisory bodies. Additionally the business integrity of the industry was recently called into disrepute as a result of the parliamentary investigation on tendering practices. This controversy has contributed to the poor image and created an atmosphere of distrust within the industry. The general feeling in the industry is that the key to overcoming these problems is innovation, driven by a culture change. Consequently, an agenda for system transition with eight intended transformations of the construction industry has been set (figure 1) (PSIB, 2004).

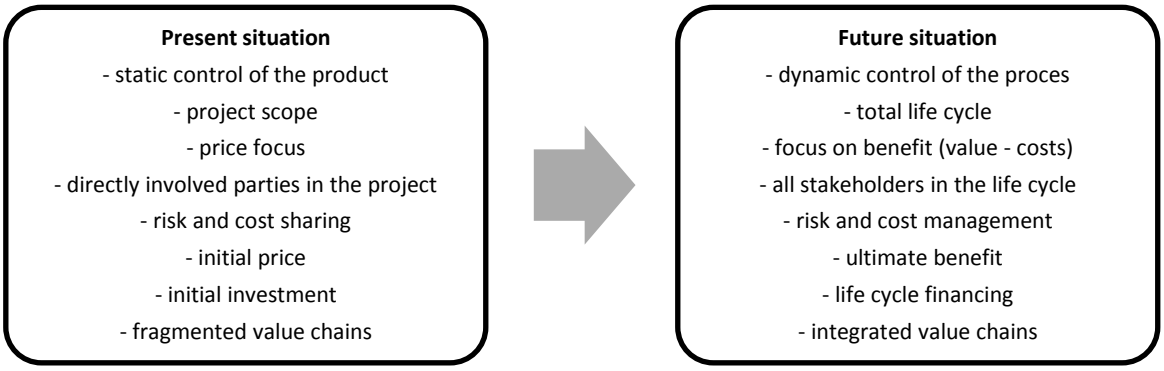

Figure 1: Agenda for system transition as set by the programme for process and system innovation in the construction industry (PSIB, 2004)

In 2008 PSIB published a transition agenda for the construction industry based on several debate sessions starting in a broad network of actors in 2006. In this transition agenda was explicitly stated that all sectors, including construction, need more sustainable economic models. Necessary development and change in this sector is letting go of and opening up the current structure (institutions), culture (mindset, attitude and behavior) and practices (procedures, rules and laws) (PSIB, 2008). The programme PSIB ended in 2008, but this does not mean that the transition had taken place.

2.3. Integrated energy concepts for sustainable innovation in the housing sector

In his recent thesis Mleknic (2013) explaines that the highest reductions in energy use can be achieved with integrated design concepts for housing. Since the 1970s many concepts were introduced (e.g. 'the autonomous house', 'the climate- responsive design', 'the passive house', 'the (net) zero-energy house', 'the zero-carbon house') and many innovations were developed to substantially reduce the energy used by buildings (e.g. thick thermal insulation, minimised thermal bridges, air-tightness solutions, insulated glazing systems and heat recovery for ventilation). Still the integrated design concepts have not reached a mainstream market . Barriers for adoption are found at both the supply side and the demand side of the market (Mleknic, 2013). These observations further strengthen the case for a sectoral approach and the need to look at practices and their underlying drivers in the housing sector.

3. Theoretical framework – transitions approach

In this section the concepts of transitions, sustainability transitions and technological transitions are explored (3.1). The frameworks transition management and strategic niche management for analysing and managing transitions are explored (3.2) and a specific application of strategic niche management on social innovation is looked at (3.3).

3.1 Transitions

The traditional top down policy implementation apparently does not provide the right incentives for radical sustainable innovations and sometimes even hinder sustainable development by supporting mainstream solutions and possibly contributing to the lock-in of traditional applications and practices. There is growing attention for the transitions perspective, in research, policy making and

practice (e.g. Kemp et al., 1998; Rotmans et al., 2001; Geels, 2002; Raven, 2005; Loorbach, 2007). There is a need for more fundamental change. In the built environment technical innovation has to be accompanied by changes in structure, culture and practice both on the supply side and the demand side of the market. This fundamental change directed at a sustainable built environment can, according to transition literature, be called a transition.

Transitions are major, non-linear changes in societal cultures, structures and practices (Grin et al., 2010) that arise from the coevolution between economy, society and ecology. Transitions can be viewed as a shift from one dynamic equilibrium (e.g. a fossil based centralised energy system) to another (say a renewable energy-based, decentralised system). They are the result of interacting developments at different levels of scale that, under specific conditions, might over time fundamentally alter dominant practices, paradigms and structures. Usually, transitions take a very long predevelopment phase in which there is a gradual build up of pressure on a dominant regime, which may be understood as the dominant structure, culture and practices in a societal system. This pressure stems from an internal dysfunction of the regime, increasing competition of alternatives, or a changing external context (for example a financial crisis). When these pressures start to reinforce each-other a relatively rapid systemic change might occur. In transitions research, transitions are thus visualised as processes of multi-level (Geels, 2002), multi-phase (Rotmans et al., 2001) changes.

Geels (2002) specifically adressed technological transitions. He defines a technological transition as a major technological transformation in the way a societal function is fulfilled. Technological transitions do not only involve changes in technology, but also changes in user practices, regulation, industrial networks, infrastructure and symbolic meaning or culture. A technological transition does not occur easily. Radically new technologies have a hard time to break through, because regulations, infrastructure, user practices and maintenance networks are aligned to the existing technology. In other words: new technologies often face a mismatch with the established socio-institutional framework. To understand the complex dynamics of socio-technical change the multilevel perspective is developed. The three levels are niches, regimes and landscape. The regimes account for the relative stability of the socio-technical configurations that are in place. By regime the semicoherent set of rules carried (embedded in practices, minds, knowledge base, products, processes, structures, etc.) by different social groups (engineers, users, policy makers, suppliers, capital banks, etc.) are meant. The term landscape refers to wider technology-external factors – an external context for interactions of actors. Regimes usually generate incremental innovations, radical innovations are generated in niches (relatively protected 'incubation rooms'). The level of niches accounts for the generation and development of radical innovations. The further success of a new technology is not only governed by processes within the niche but also by developments at the level of the existing regime and landscape.

In short, transitions are characterised by the following elements:
- Transitions concern not merely technological development but transformation of socio-technological systems, including technical artefacts but also practices, structures and culture.
- A transition process is multi-level and multi-phase. It is a non-lineair process.
- Transitions concern radical, transformative change, there is some form of mismatch or resistance between the niche and the regime and the niche developments are not yet mature.

3.2 Transition Management and Strategic Niche Management

Based on the concept of transition both Transition Management (e.g. Loorbach and Rotmans 2006; Loorbach 2007) and Strategic Niche Management (e.g. Kemp et al., 1998; Raven, 2005) are analytical tools that have been developed to analyse and influence the development of desired transitions. Transition Management and Strategic Niche Management provides us with analytical tools, but also tools for action and policy making.

Transition Management is aimed at influencing long term developments (transitions) towards a sustainable future (Loorbach and Rotmans 2006). Most of policies and institutions are directed at short term and mid term solutions. In order to create a sustainable future long term goal seeking strategies need to be developed, in which sustainability, social equality, democracy, quality of life and reflexivity all need to become drivers for societal innovation instead of only economic growth, efficiency increase and continuing specialisation and fragmentation. Transition Management is long-term governance for sustainable development based on a complex adaptive systems approach (Loorbach and Rotmans 2006). The basic ingredient of Transition Management is to experiment and explore in a structured but flexible way, learning by-doing and doing-by-learning, and through that process develop sustainably (Loorbach, 2007). Within the S-curve a cascade of system innovations at level of sub-systems, product and process innovations take place. The 'transition' is a collective term referring to a wide range of interconnected innovations at different levels (Loorbach 2007). Through a combination and integration of innovations embedded in a broader and longer-term strategy, transition management tries to 'deepen, broaden and scale-up' (Loorbach 2007) ongoing innovations into system-innovations and ultimately transitions.

Also Kemp et al. (1998) argue that technical change may be oriented towards social goals by policy makers. Strategic niche management is said to be a way to manage transition into another technological regime by creating temporary protected spaces for more sustainable technologies. This strategy builds on the on-going dynamics of socio-technical change and exerts pressures to modulate the dynamics into desirable directions. Essential to strategic niche management is stimulating learning about problems, needs and possibilities of a technology, building actor networks, alignment of different interests to a goal, altering the expectations of different actors and fostering institutional adaptations. Niches are characterised by the following three core processes: articulation of expectations and visions which provide guidance to the innovation activities, building of social networks so that the resource base of niche innovations is expanded and, taking place of learning and articulation processes on various places Geels (2002). It is the ambition of the niche to produce momentum for the innovation, in the sense that various learning processes become aligned so that a stable configuration emerges that challenges dominant 'regimes' (Kemp et al., 1998; Schot & Geels, 2008), which are the dominant socio-technical rule-sets that are associated with a technology. Niches have a 'cosmopolitan' aspiration (Raven, 2005). Experiments are principally not stand-alone activities, as they serve to facilitate broader socio-technical transitions. Therefore aim of niche experiments is also to generate delocalised knowledge about socio-technical alternatives.

An important difference between Transition Manegement and Strategic Niche Management is that the entry point of Transition Management is a shared vision on desired direction and the entry point of Strategic Niche Management is an emergent technology development in a niche. Important elements of both Transition Management and Strategic Niche Management are learning, building

actor networks, shaping expectations, allignment of visions and experimenting. Both Transition Management and Strategic Niche Management provide an analytical framework to study change in dominant structure, culture and practice as part of a socio-technological niche development (for example zero-energy housing).

3.3 Conflicting and shared values framework to analyse niche-regime interaction

The changes in culture, structure and practice are essential for the system change in the construction sector. Witkamp et al. (2011) have applied the Strategic Niche Management framework on social innovation, i.e. the rise of 'social entrepreneurship' in the Netherlands. They added the analysis of shared and conflicting values between the niche and the regime to the Strategic Niche Management approach and that proved to be a viable way to gain understanding of their (in)compatibility, and to a better anticipation of potential future conflicts rather than considering levels of stability. The use of conflicting and shared values allowed for a detailed picture of interaction promises and problems, and therefore a basis on which to build suggestions that could stimulate growth (Witkamp et al., 2011). This conflicting and shared values approach can be of specific use when focussing on the change in energy innovation practice and the underlying drivers.

Values always refer to underlying motivations or beliefs that do not change overnight, and that fuel more practical rules or behaviour. In focusing on the values that separate the social entrepreneurship niche from the regime(s), this research searches for fundamental differences between these domains. These differences will not be absolved within a short time frame and must be acknowledged if the interaction between the niche and regimes is to be understood and improved. When pitching niche against regime, one can identify values that are either conflicting or shared. Conflicting values will be indicated by the barriers that the niche actors encounter. Shared values, on the other hand, can be extracted from stories of cooperation and mutual interest between actors from both domains (Witkamp et al., 2011).

4 Developing a theoretical framework linking the concepts sustainable innovation, sustainable innovation practice and underlying drivers

4.1 Sustainable innovation

An important starting point for the current debate on sustainable development was the publication of the Brundtland report in 1987. In that report the World Commission on Environment and Development (Commission Brundtland), defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). This immediately points to the complexity of the issue. There are many stakeholders to be considered, not only from the present, but also from future generations. As the direction of (environmental and social) sustainability impacts of innovations are highly uncertain sustainable innovation is concerned with additional risks (Hansen et al.,2012).

Sustainable innovation means the integration of different, sometimes conflicting needs. Sustainable solutions are not found in only one technological solution but is more often found in a combination of products and services, or a product-service system. Transition literature shows that shifts towards more sustainable ways to fullfill our needs are radical changes in socio-technical systems, including change in cultures, structures and practices (Grin et al., 2010).

Hansen et al. (2012) uses the target dimension (economic, environmental and (or) social benefits) and the life cycle dimension to illustrate the concept of sustainability oriented innovation.

Hence the definition of sustainable innovation is 'introduction of new products, processes, product-service-systems with balanced social, ecological and economical benefits, considering the life cycle and considering the needs of present and future stakeholders'.

4.2 Sustainable innovation practice by organisations or individuals

Sustainability issues can be perceived as unstructured problems, wicked problems, messy problems or persistent problems (e.g. Loorbach, 2007, Cuppen, 2010). This as opposed to simple problems. Technology is often put forward as an answer to 'simple' problems. This is not sufficient in the case of sustainability issues. This is one of the explanations why application of sustainable solutions in the housing sector has been relatively scarce. Instead of designing or stimulating a specific technological solution policy making and development processes should be designed to embrace complexity and focus on learning by constructive conflict (Cuppen, 2010).

Hansen et al. (2012) claim that sustainable oriented innovation is more complex and incorporates even higher risks than conventional innovation processes. This is related to so called directional risks as the direction of sustainability impacts of innovations are highly uncertain, particularly in the the long term. He argues that it is crucial to embed the holistic concepts of sustainability oriented innovation (i.e. the target dimension covering social, environmental and economic factors and the life cycle dimension covering phases from resource extraction to end-of-life; and innovation types beyond product and process innovation) in processes. Hansen et al. describe four elements to be important in sustainability oriented innovation processes: (1) the importance of the phase of problem definition (narrowing down the innovation focus too early on products and technologies or never even questioning such focus can hinder the development of product-service systems, which in turn have a much larger sustainability potential), (2) the possible added value of sustainability checkpoints in the innovation process ,(3) involvement of actors outside the organisation in the innovation process and (4) the development of a sustainability-oriented innovation culture.

Loorbach and Wijsman (2013) describe how businesses in sectors where major societal changes are expected or likely to occur are searching for ways to deal with such unpredictable changes. Businesses in sectors like construction and energy are challenged by fundamental sustainability issues. Various types of strategic behavior can be witnessed: from reactive and adaptive to proactive and transformative. Incremental adaptation seems to be a risky strategy from a transition perspective. Loorbach and Wijsman argue that in actively pursuing a transformative role, businesses can simultaneously help shift the market they operate in as well as transform their own business. By doing so the thought and practice of corporate social responsibility is evolving from trying to mitigate negative impacts towards systemic change and business transition. Loorbach and Wijsman applied the transition management model (Loorbach 2007) on business transitions in an explorative case study and found a number of elements to be important: (1) determine to which societal issue(s) or transition(s) the business can and aims to contribute, in other words making a strategic choice, (2) sustainability principles and a vision on market transformation become core business, interlinking it with an integrated perspective on the role of the business within their value chain, (3) to do so the business needs to create space to develop narrative and business case outside the day-to-day short term concerns, (4) developing strategies, identifying learning objectives, short term goals and

experiments, (5) developing coalitions and networks around crucial themes, (6) creating icons, pilots and experiments around specific business cases and new practices relating to the greater challenge, (7) developing flexible and cross business debate to reflect on and evaluate objectives, goals and actions and to see whether actual progress is made in the path to performing sustainably.

4.3 Underlying drivers

Both Hansen et al. (2012) and Loorbach and Wijsman (2013) touched the subject of organisational culture and leadership in their paper, without further exploring it. To what extent is leadership and dominant culture decisive in determining the space for transitions? What are the values a company and the R&D function is based on? How are managers trained and developed, incentivised, measured and rewarded? How is innovation success interpreted?

4.3.1 Organisational culture

The role of an organisation's culture (and its underlying values and ideology of management) in hindering or fostering the implementation of management innovations or technological innovations has been recognised in literature (e.g. Zammuto et al., 2000). Linnenluecke and Griffiths (2009) assess the concept of sustainability oriented organisational culture and whether organisations can become more sustainable through culture change. Various scholars have developed frameworks to provide conceptual foundation for the study of culture, amongst which the competing values framework (CVF) developed bij Quinn (1988) which Linnenluecke and Griffiths apply to look at the relation between cultural orientation and corporate sustainability. They find that there is a relation between organisational culture and how sustainability is implemented and the types of outcomes that can be achieved. Employees from different culture types place emphasis on different aspects in their pursuit to corporate sustainability. Sustainability related cultural change has a number of limitations and barriers e.g. organisational rigidity and the existence of organisational subcultures thoughout the organisation. There are some avenues and pathways for future research and practice: organisations have to abandon the dominant design and assumptions of the 'bureaucratic organisation'; the 'ideal' culture profile for sustainability needs to be low on internal process values, and high on open systems values.

4.3.2 Organisational capabilities

Another interesting perspective is to look at sustainability, firm or organisational behavior and value chains (networks / systems) from a complex adaptive systems perspective. Holling (2001) defines sustainability as the capacity to create, test and maintain adaptive capability. Development is the process of creating, testing, and maintaining opportunity. Sustainable development thus refers to fostering adaptive capabilities and creating opportunities. A complex adaptive system is a system that emerges over time into a coherent form, and adapts and organises itself without any singular entity deliberately managing or controlling it. The focus of complex adaptive system models and theories is on the interplay between a system and its environment and the co-evolution of both the system and the enviroment (Choi et al., 2001). A complex adaptive system is emerging, self-organising, dynamic and evolving. An organisation or value network or an entire sector can be seen as a complex adaptive system functioning in dynamic and complex environment. If we think of the value network as a complex adaptive system there are centain capabilities that are necessary in the system to be able to create value in a complex and dynamic environment.

In order for an organisation or a system to be able to create (public) value, it needs competent people committed to generating (development) results. The system needs the capabilities to create the (developmental) value that outside groups want. It needs the support structure to manage and sustain its capabilities. It needs to be able to find the resources and support in the wider context that allows the system to survive and grow. And it needs to be able to pull these aspects together with some sort of integration, synthesis and coherence. Morgan and Morgan (2008) describe five core capabilities as key, all of which, to a greater or lesser extent, can be found in all organisations or systems. These are the capabilities to commit and engage, to carry out functions or tasks, to relate and attract resources and support, to adapt and self-renew, and finally, to balance coherence and diversity (Morgan, 2008).

4.4 Theoretical framework

Based on integration of theoretical insights form the the literature addressed in the sections 4.1,.4.2 and 4.3 a theoretical framework (figure 2) is developed linking the concepts sustainable innovation (box on the right), sustainable innovation practice (box in the middle) and underlying drivers (box on the left). This framework adds to current literature that it explicitly brings together sustainable innovation with practice and underlying drivers in one model.

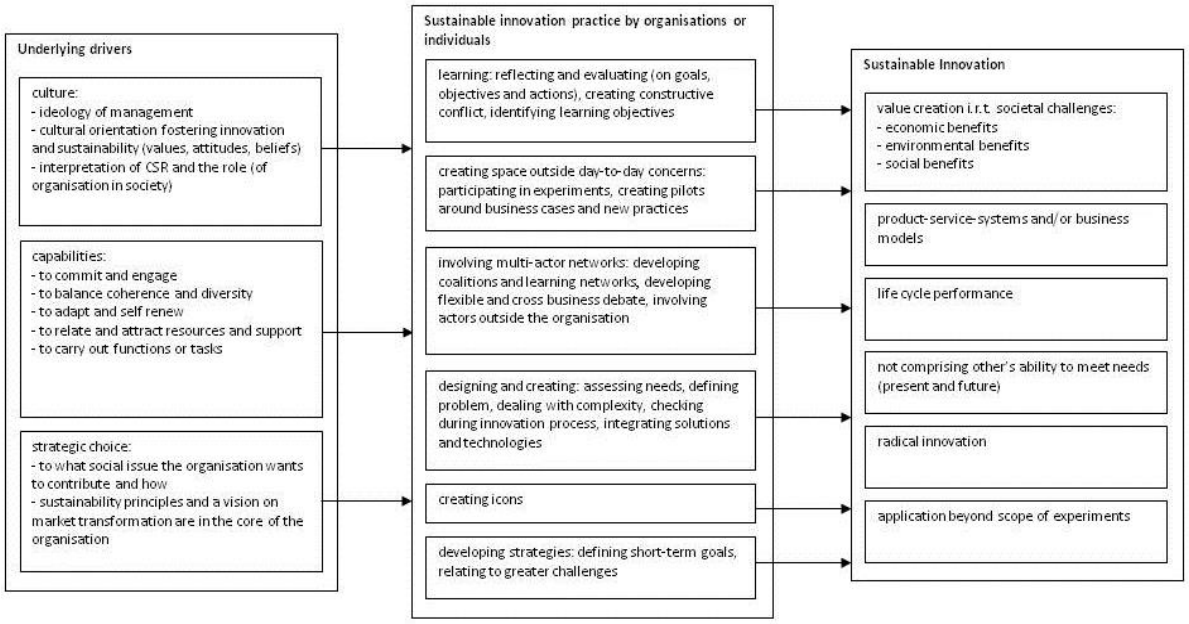

Figure 2: theoretical framework linking sustainable innovation, sustainable innovation practice and underlying drivers

5 A new research agenda and a preliminary research design

The development of sustainable innovation practice and underlying drivers as a part of the energy transition in the housing sector is a central issue in this research. We will therefore further develop and assess, and elaborate the theoretical framework linking sustainable innovation, sustainable innovation practice and underlying drivers (see Figure 2) on a number of case studies to validate its use and find out what elements in the model are most significant in determining sustainable

innovation. Based on the characteristics of sustainable innovation we will select a number of organisations that have realised energy innovations in the Dutch housing sector for analysis. The clusters of variables for this part of the research will be based on the items in figure 2. For underlying drivers (independent variables) these clusters will be organisational culture, capabilities and strategic choice (Linneluecke and Griffiths, 2009; Morgan, 2008). For the sustainable innovation practice (dependent variables) these clusters of variables will be learning, creating space for innovation, multi-actor networks, design and creation and developing strategies (Cuppen, 2010, Hansen et al., 2013; Loorbach and Wijsman, 2013; Loorbach, 2007). For sustainable innovation (dependent variable) a number of selection criteria (indicators) define sustainable energy innovation (WCED, 1987; Hansen et al., 2013; Grin et al., 2010).

The first research question in the new research agenda is equal to the research question in this paper, but will be validated by applying it in a number of case studies.

Proposed research question 1:
What practices and underlying drivers explain adoption of integral sustainable energy innovations in the Dutch housing sector?

Based on literature the conflicting and shared values framework appears to be a promising approach to look at the niche –regime interactions in the case of energy innovation in the Dutch housing sector, with specific attention for the change in practice and underlying drivers. It is possible to apply Strategic Niche Management methodology on a radical innovation that is not characterised by a technical artefact (e.g. a social innovation) (Witkamp et al., 2011).

The conflicting and shared values framework will be further developed and applied on a number of ambitious energy innovation projects (experiments and demonstration projects) in the housing sector. A double research approach is proposed: (1) analysing the development of the desired underlying drivers (culture, capability and mission) as part of the development of a socio-technical innovation, in this case energy efficiënt housing, and (2) analysing the development of the desired underlying drivers (culture, capability and mission) as an innovation in itself (a social innovation).

Analysis of a radical innovation using strategic niche management consists of the following steps: (a) identify what the niche is about and what regimes it opposes, (b) look at the internal niche processes: social network, shared expectations by actors and the learning mechanism, and (c) describe the niche-regime interaction (Raven, 2005).

The first approach concerns studying the development of integral sustainable energy innovations (for example zero-energy house or passive house) in the housing sector, including sustainable practices and underlying drivers as part of culture, structure and practice. In this case the niche is integral sustainable energy innovation. This niche develops against the backdrop of various regimes e.g. the energy sector and the housing sector.

The second approach concerns studying the development of sustainable practices and favourable underlying drivers as a niche in itself within the housing sector. The regimes that are important are different from the regimes in the first approach. From this perspective organisational regimes and sectoral regimes are expected to be important. In the case of organisational regimes a group of agents in the niche (e.g. employees that participate in experiments) are facing the regime of their

own organisation. At a sectoral level niche organisations face very different values and practices by other organisations in the sector.

Proposed research question 2:
What lessons can be learned from experiments and demonstration projects about the development of energy innovation practice and the underlying drivers?

6 Conclusions

The research question 'What practices and underlying drivers explain adoption of integral sustainable energy innovations in the Dutch housing sector?' has been answered by developing a theoretical framework consisting of the underlying drivers organisational culture, capabilities and strategic choice (Linneluecke and Griffiths, 2009; Morgan, 2008), sustainable innovation practice being learning, creating space for innovation, multi-actor networks, design and creation and developing strategies (Cuppen, 2010, Hansen et al., 2013; Loorbach and Wijsman, 2013; Loorbach, 2007).

Various studies point the importance of practices and underlying drivers like culture and capabilities. There still seems to be a need to gain more understanding of the proces of developing and upscaling integral sustainable energy innovations in the housing sector and the broader system changes that are necessary in the sector. Even though the research framework needs furter elaboration it appears to be a suitable approach to contribute to a better understanding for research, policy and practice of sustainable innovations, in particular those in the housing sector.

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