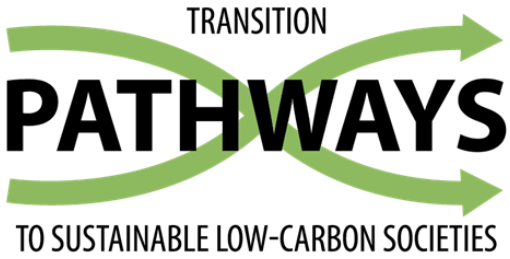

PATHWAYS project

Exploring transition pathways to sustainable, low carbon societies

Grant Agreement number 603942

Deliverable D2.1: Analysis of green niche-innovations and their momentum in the two pathways

Main report: Introduction and findings

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23 December, 2014

Preface

This report is the outcome of task 2.1 in Work Package 2 of the PATHWAYS project ('Exploring transition pathways to sustainable, low carbon societies'). The overall aim of Work Package 2 is to provide a socio-technical analysis of the *dynamics of transition pathways* in five empirical domains: electricity, heat/buildings, mobility, agro-food and land-use. This socio-technical analysis uses the Multi-Level Perspective (MLP) as its conceptual framework, which focuses on interactions between radical niche-innovations, incumbent regimes, and exogenous secular 'landscape' developments. The basic idea is that transitions come about through the alignment of processes at three levels: a) green niche-innovations build up internal momentum (e.g. through learning processes, price/performance improvements, and support from powerful groups), b) changes at the landscape level create pressure on the regime, c) destabilisation of the regime creates windows of opportunity for the diffusion of niche-innovations.

The analysis of future transition pathways in WP-2 is operationalised through five analytical tasks which subsequently address the following topics:
Task 2.1: Green niche-innovations and their momentum in the two pathways (deliverable due in Month 12).
Task 2.2: Stability and tensions of incumbent socio-technical regimes in five empirical domains (deliverable due in Month 18).
Task 2.3: Integrated analysis of D2.1 and D2.2 to asses feasibility of different transition pathways (deliverable due in Month 22).
Task 2.4: Comparison of transition pathways in both countries (deliverable due in Month 28).
Task 2.5: Forward-looking analysis of transition pathways (deliverable due in Month 32).

This main report provides the results of task 2.1, based on findings in 12 country sub-reports that underlie this main report. These 12 reports analyse the momentum of 6-8 green niche-innovations in five empirical domains:
Electricity: Germany and the UK
Heat/buildings: Sweden, Germany, and the UK:
Mobility: The UK and the Netherlands
Agro-food: The Netherlands, Portugal, Hungary
Land use and bio-diversity: Portugal and the Netherlands.

Throughout the research process, there have been various interactions between the WP-2 coordinators and the different research teams (e.g. bilateral conference calls and a workshop on 17-18 July to discuss progress reports). We also organised two internal reviews of the main report, and an internal review of each of the twelve country reports. Nevertheless, the various research teams are responsible for the findings and quality of the different country-reports. The findings from the different country reports (task 2.1) will form important inputs into later parts of the analysis (task 2.3, 2.4 and 2.5), which will be reported in future documents.

Contents

Executive summary

This report constitutes Deliverable 2.1 in the PATHWAYS project ('Exploring transition pathways to sustainable, low carbon societies'). Deliverable 2.1 makes an analysis of green niche-innovations in five empirical domains (electricity, heat, mobility, agro-food and land-use) in the following European countries.
1) Electricity: Germany and the UK
2) Heat: Sweden, Germany, the UK
3) Mobility: The UK and the Netherlands
4) Agro-food: The Netherlands, Portugal and Hungary
5) Land use and bio-diversity: Portugal and the Netherlands.

Each country report investigates six to eight green niche-innovations, aimed at assessing their momentum with regard to two ideal-type transition pathways A and B (Table 1) Pathway 0, which represents Business-as-Usual, in which actors do not seriously engage with sustainability transitions, or fail to do so in time (too little, too late).

	Pathway 0: Business as Usual	**Pathway A: Technical component substitution**	**Pathway B: Broader regime transformation**
Departure from existing system performance	Minor (no transition)	Substantial	Substantial
Lead actors	Incumbent actors (often established industry and policy actors)	Incumbent actors (often established industry and policy actors)	New entrants, including new firms, social movements, civil society actors.
Depth of change	Incremental change	Radical technical change (substitution), but leaving other system elements mostly intact	Radical transformative change in entire system (fundamentally new ways of doing, new system architectures, new technologies)
Scope of change	Dynamic stability across multiple dimensions	1-2 dimensions: technical component and/or market change, with socio-cultural and consumer practices unchanged	Multi-dimensional change (technical base, markets, organisational, policy, social, cultural, consumer preferences, user practices)

Table 1: Two ideal-type transition pathways and their defining elements

This main report describes the conceptual framework used in Work Package 2 ('Dynamics of transition pathways') of the project, based on a socio-technical approach to transitions, including the multi-level perspective (MLP). The MLP (described in section 1.1.) suggests that transitions come about through interacting developments at three analytical levels: a) radical niche-innovations, b) incumbent socio-technical regime, c) exogenous socio-technical landscape.

Deliverable 2.1 focuses on the level of niche-innovations. Section 1.2 summarises the literature on strategic niche management, and describes the analytical research protocol that is used in each of the country/domain reports. This protocol indicates that the dynamics of each green niche-innovation will be analysed on three dimensions:

1. Innovation and market trajectory (techno-economic).
2. Actors and social networks (socio-cognitive).
3. Governance and policy.

Section 1.3 discusses methodological aspects such as the process for selecting the most important niche-innovations in each domain, the sources used for data-collection, methodological procedures and structure for the country reports.

Chapter 2 provide the results of the analysis of green niche-innovations in these domains and countries. These results are based on the executive summaries and conclusions from the 12 country sub-reports that underlie this main report. These 12 country/domain reports first provide a brief description of the existing socio-technical system. Then they provide an argument for the 6 to 8 niche-innovations that have been selected for further analysis. The bulk of each country/domain report is the empirical analysis of the 6 to 8 niche-innovations, which is structured along the three analytical dimensions:
1. Innovation and market trajectory (techno-economic).
2. Actors and social networks (socio-cognitive).
3. Governance and policy

Each country/domain report ends with conclusions regarding momentum and pathway A/B. Specifically, this main report provides the findings with regard to two issues:

- Characterizing momentum: a) provide a *relative* ranking of the 6-8 niche-innovations in terms of momentum, b) provide an overall assessment of the momentum of each niche-innovation in terms the following categories (very small, small, moderate, large, very large), c) briefly describe the momentum on the three analytical categories (techno-economic, socio-cognitive, governance).
- Indicate whether the 6-8 niche-innovations are more oriented towards pathway A or B?

The main findings of task 2.1 are summarised in 12 sub-sections in chapter 2. The complete country-reports are available by the end of January 2015 on the website of the PATHWAYS-project (http://www.pathways-project.eu/).

1. Introduction

1.1. General introduction: Our view on transitions and transition pathways in WP-2

The PATHWAYS project investigates transition pathways to sustainable, low carbon societies from three methodological angles: 1) integrated assessment models (quantitative computer models), 2) socio-technical analysis (qualitative case studies of socio-technical systems), and 3) participative action research (local projects working on at the 'transitions in the making').

Socio-technical analysis in WP-2

WP-2 is concerned with socio-technical analysis of transition pathways. *Socio-technical analysis*, which is an approach in the domain of innovation studies, investigates interactions between technical and social dimensions (including economic, cultural and political dimensions). It is sociological in the sense of focusing on the various groups of social actors that interact in the reproduction and change of socio-technical systems.

Socio-technical transitions

Transitions in a socio-technical perspective are about substantial changes in energy, transport, and agro-food systems, which entail not only technical changes, but also changes in markets, user practices, policy, cultural discourses, infrastructure, and governing institutions. As a shorthand, these changes are labelled 'socio-technical' transitions. Socio-technical transitions can vary in their *scope* of change (how many system elements change) and the *degree* of change (are changes more incremental or radical). The various system elements are reproduced or changed by actors and social groups (e.g. firms, supply chains, researchers, consumers, policymakers, wider publics, social movements). Consequently, transitions come about through interactions between actors and social groups, whose actions together change system elements. These interactions may entail power struggles (e.g. with regard to changes in regulations), building of new networks and coalitions, developing visions about sustainable future, exploring these visions through concrete learning processes (e.g. building new technical capabilities, learning about consumer preferences and market demand), economic investments and jockeying for market share.

Multi-level perspective on socio-technical transitions

Before introducing our view on transition *pathways*, we briefly discuss the underlying socio-technical conceptualisation of transitions used in our project. This is provided by the Multi-Level Perspective (MLP). The MLP (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007) and distinguishes three analytical levels:

* The *sociotechnical regime* refers to the semi-coherent set of rules and institutions (such as shared meaning systems, heuristics, rules of thumb, routines, standardized ways of doing things, social norms, formal regulations) that shape the perceptions and actions of the incumbent actor groups who reproduce or change elements of socio-technical systems. So, a socio-technical system refers to the more tangible 'measurable' elements (e.g. technical artefacts, market shares, infrastructure, regulations, consumption patterns, public opinion), whereas regimes refer to intangible and underlying rules and institutions. Incumbent actors tend to be 'locked in' to existing regimes and systems (Unruh, 2000), because of sunk investments (in skills, factories, infrastructures), economies of scale, increasing returns to adoption (Arthur, 1988), favourable regulations, cognitive routines that make 'blind' (Nelson and Winter, 1982), social norms and behavioural patterns. Innovation in existing regimes and

systems is therefore mostly incremental, aimed at elaborating existing capabilities and protecting vested interests.

* Radical novelties that deviate on one or more dimensions from existing regimes are conceptualised as emerging in *niches*, i.e. particular domains of use, actor constellations and geographical areas with special characteristics. The novelty may be a new behavioural practice (e.g. car sharing), a new technology (e.g. battery-electric vehicles) or a new business model (e.g. energy service companies). Radical novelties emerge initially as unstable configurations with poor price/performance characteristics. Hence, niches act as 'incubation rooms' protecting novelties against mainstream market selection (Kemp *et al*., 1998; Hoogma *et al*., 2002). Niche-innovations are initially often developed by small networks of dedicated actors, often outsiders or fringe actors.

* The *sociotechnical landscape* forms an exogenous environment beyond the direct influence of niche and regime actors (macro-economics, deep cultural patterns, macro-political developments). Changes at the landscape level can take various forms (Van Driel and Schot, 2005): 1) factors that do not change (or that change very slowly), such as physical climate, 2) rapid external shocks, such as wars or oil price fluctuations, and 3) long-term changes in a certain direction (trend-like patterns), such as demographical changes or climate change.

These three levels in the MLP refer to heterogeneous configurations of increasing stability, which can be seen as a nested hierarchy with regimes being embedded within landscapes and niches existing inside or outside regimes (Figure 1). Niche actors work on radical innovations (e.g. technical improvement, opening up markets, finding customers, lobbying policymakers for support), which they hope will eventually be used in the regime or even replace it. This is not easy, however, because the existing regime is stabilized by many lock-in mechanisms. Nevertheless, niche-innovations are crucial, because they form the seeds for systemic change. The MLP helps explain why there may simultaneously be a flurry of change activities (at the niche level) and relative stability of existing regimes.

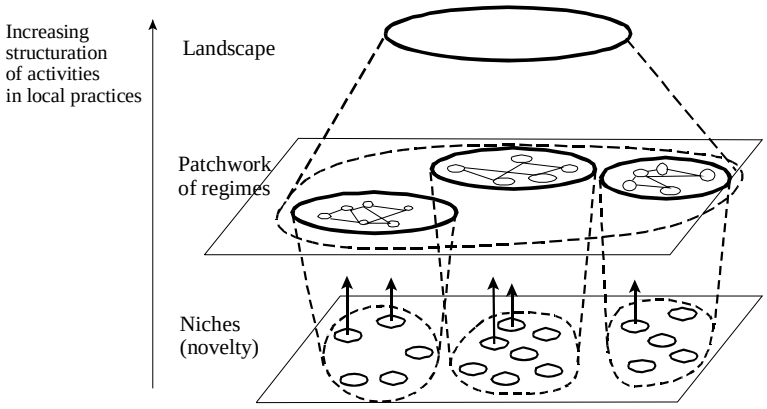

Figure 1: Static multi-level perspective as nested hierarchy (Geels, 2002: 1261)

The basic idea of the MLP is that transitions are non-linear processes that result from the interplay of multiple developments at the three analytical levels. Although each transition is unique, the general dynamic is that transitions come about through the interaction between processes at these three levels (Figure 2): a) niche-innovations build up internal momentum, b) changes at the landscape level create pressure on the regime, c) destabilisation of the regime creates windows of opportunity for niche-innovations.

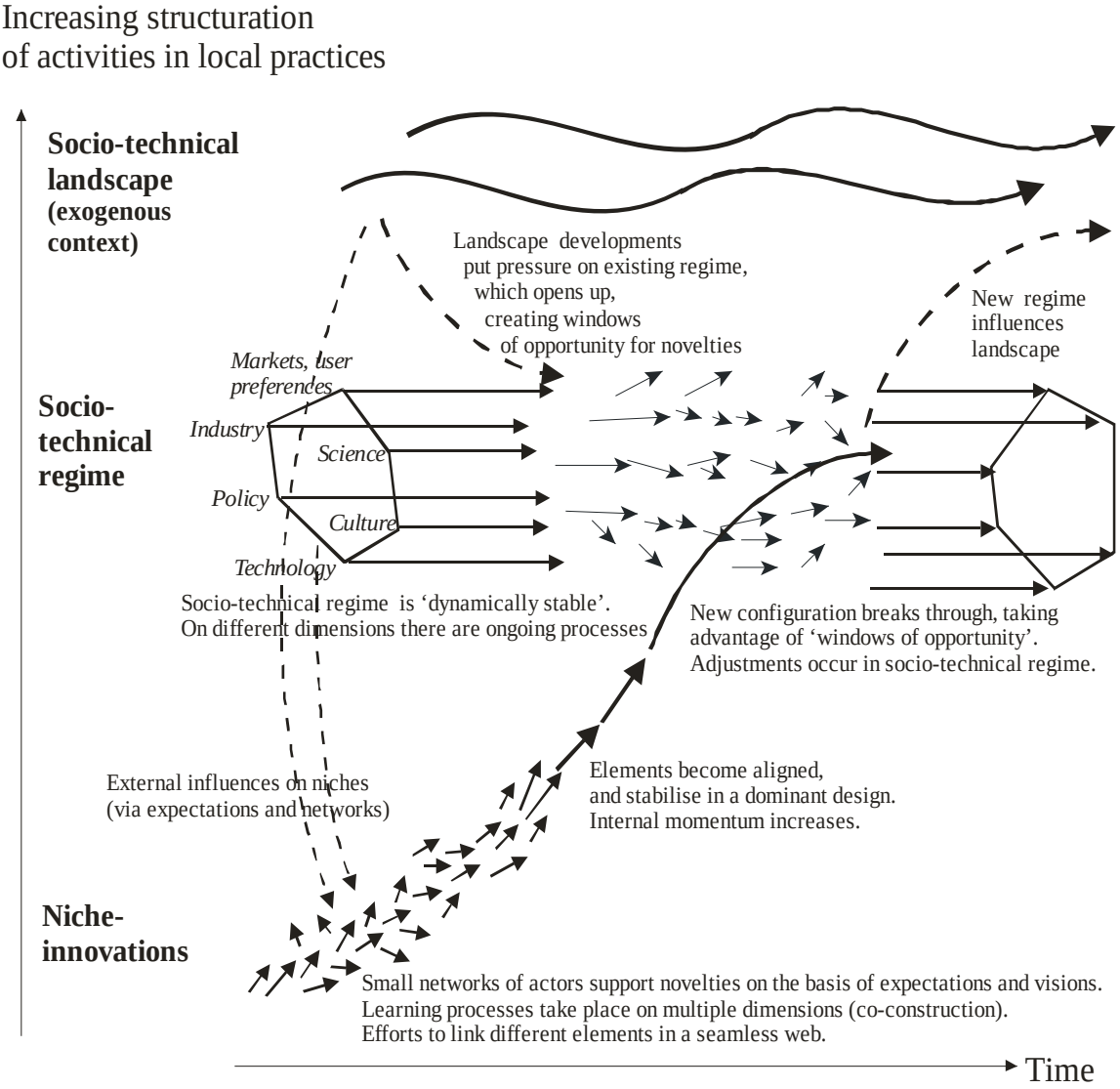

Figure 2: Multi-level perspective on transitions (adapted from Geels, 2002: 1263)

An important implication is that the MLP does away with simple causality in transitions. There is no single 'cause' or driver. Instead, there are processes on multiple dimensions and at different levels which link up and reinforce each other ('circular causality'). Another implication is that there is no guarantee that transitions will succeed: niche-innovations may fail to build up sufficient momentum or suffer setbacks (leading to hype-disappointment cycles); tensions in existing regimes may remain small so that 'windows of opportunity' for niche-innovations do not materialize.

Transition pathways

Having described our conceptualisation of the overall dynamics of socio-technical transitions, we can now discuss transition *pathways*. Based on a large number of historical case studies of transitions, Geels and Schot (2007) identified four transition pathways:

1) Transformation: In this pathway, incumbent actors respond to landscape pressures and regime tensions by adjusting the *direction* of existing development paths and innovation activities. Current practices are amended and improved (e.g. higher efficiencies, less waste) by adjusting R&D patterns, search heuristics, incentives, regulations and behavioural

patterns. The basic system architecture remains intact (including positions of incumbent actors), but environmental performance is improved (many small changes over time can lead to substantial changes).

2) Reconfiguration: Niche-innovations are adopted into the regime to solve local problems, and subsequently trigger adjustments and knock-on effects in the basic system architecture. So, transitions come about through new combinations between niche-innovations and existing systems. This transition pathway often entails alliances/collaborations between new entrants and incumbent actors.

3) Technological substitution: This transition pathway is driven by technical niche-innovations that substitute existing technologies. Geels (2005) distinguished different sub-patterns: a) technical component substitution, which (initially) leaves much of the wider system intact; the transition from propeller aircraft to turbojets is an example of a shift in engine technology, which enabled airplanes to fly faster, higher and longer distances (over time, however, this shift was accompanied by changed in runways, air-traffic control, aircraft size, and travel patterns), b) disruptive innovations and technological discontinuities overthrow existing technologies and associated systems; the shift from sailing ships to steamships, for instance, not only entailed substitution of technical artefacts, but also changed building materials (from wood to iron), shipbuilding practices, ports (which had to deepened and enlarged), shipping and trading patterns (because steamships were faster and more reliable, which allowed the introduction of liner services), a global fuel infrastructure (coal bunkers in ports), and new cargo-loading machines (to enable rapid turn-around).

4) De-alignment and re-alignment: In this transition pathway, large and rapid landscape pressures cause major internal regime problems leading to their disintegration (de-alignment of system elements); this erosion then creates space for the emergence of various niche-innovations; the co-existence of various niche-innovations creates uncertainty and may delay actors to make full-scale commitments for fear of betting on the wrong horse; eventually processes of re-alignment occur around one of the innovations, leading to a new regime.

To keep research in the PATHWAYS project doable, we have decided to adopt a simpler view on transition pathways, which distinguishes two ideal-types that differ on to three defining elements: 1) the kinds of actors involved (relative to the established regime), 2) the depth of change (degree of radicality relative to initial system), and 3) the scope of change (number of socio-technical dimensions involved). Based on these defining elements, we identify two fundamentally different pathways (A and B), which are two different routes for realising major improvements in sustainability performance (Table 1).

Pathway A is close to technical substitution pathway in the Geels and Schot (2007) typology, while pathway B combines elements of ‘reconfiguration’ (changes in system architecture) and ‘de-alignment and re-alignment’ (broader social and cultural changes enacted by radically new entrants). These two ideal-types are a working hypothesis for WP-2, which can be rejected or amended. For instance, if research in some empirical domains (e.g. agro-food or land-use) finds that none of the green niche-innovations has great momentum, then it may be useful to include transformation or reconfiguration transition pathways in our thinking about future sustainability improvements. We may also want to place more emphasis on social innovation (either in Pathway B or in a new pathway), e.g. regarding car sharing, more cycling, eating less meat.

	Pathway 0: Business as Usual	Pathway A: Technical component substitution	Pathway B: Broader regime transformation
Departure from existing system performance	Minor (no transition)	Substantial	Substantial
Lead actors	Incumbent actors (often established industry and policy actors)	Incumbent actors (often established industry and policy actors)	New entrants, including new firms, social movements, civil society actors.
Depth of change	Incremental change	Radical technical change (substitution), but leaving other system elements mostly intact	Radical transformative change in entire system (fundamentally new ways of doing, new system architectures, new technologies)
Scope of change	Dynamic stability across multiple dimensions	1-2 dimensions: technical component and/or market change, with socio-cultural and consumer practices unchanged	Multi-dimensional change (technical base, markets, organisational, policy, social, cultural, consumer preferences, user practices)

Table 2: Two ideal-type transition pathways and their defining elements

Table 1 also includes a baseline Pathway 0, which represents Business-as-Usual, in which actor do not seriously engage with sustainability transitions, or fail to do so in time (too little, too late). The contrast with Pathway 0 is also useful to highlight that both pathway A and B are radical (although in different ways) and require substantial efforts and policies.

Structure of work in WP-2

Informed by the above conceptual backgrounds, WP-2 consists of five tasks with different deliverables:

Task 2.1: Green niche-innovations and their momentum in the two pathways. The deliverable, due in Month 12, makes an analysis of various green niche-innovations in five empirical domains (electricity, heat/buildings, mobility, agro-food, land-use) in various countries. The analysis aims to assess which green niche-innovations have the greatest momentum, and how this maps on to the two ideal-type transition pathways.

Task 2.2: Stability and tensions of incumbent socio-technical regimes in five empirical domains (deliverable due in Month 18). This task aims to assess how stable/unstable existing regimes are (also in relation to landscape pressures), and what the strategies and beliefs of powerful incumbent actors are.

Task 2.3: Integrated analysis of D2.1 and D2.2 to assess feasibility of different transition pathways (deliverable due in Month 22). This task will assess what the chances are of the two ideal-type transition pathways. It will also reflect on the usefulness of the two ideal-types, and possible consider other transition pathways from the Geels/Schot typology (e.g. if none of the green niche-innovations has sufficient momentum to break through more widely, or if existing regimes are still very stable and locked in).

Task 2.4: Comparison of transition pathways in both countries (deliverable due in Month 28). This task will compare studies of different countries in the same domain (e.g. UK and German transitions in the electricity domain), and draw more specific lessons about actor strategies, governance styles and policy instruments.

Task 2.5: Forward-looking analysis of transition pathways (deliverable due in Month 32). This task will speculate about how different interactions in the MLP can lead to different future transition pathways.

Structure of introductory chapter and report

This report presents the findings from task 2.1 in WP-2, which aims to make socio-technical analyses of green niche-innovations in five empirical domains (electricity, heat/buildings, mobility, agro-food, land-use) and several European countries.

This introductory chapter introduces the conceptual framework that has been used as analytical research protocol for the different domain and country studies (section 2.1), briefly discusses data-sources and methodological procedures (section 1.3), articulates the rationale for the country selection in the five empirical domains (section 1.4), and specifies the structure for the country studies (section 1.5). Chapter 2 then present the core findings from the 12 country studies which have been done by different research teams in the PATHWAYS project (section 2.1 to 2.12). The complete country-reports are available on the website of the PATHWAYS-project (http://www.pathways-project.eu/).

1.2. Conceptual framework, research protocol and research goals

Difficulties faced by radical niche-innovations

The analysis of green niche-innovations draws on insights from the literature on niches and Strategic Niche Management (Kemp *et al*., 1998; Hoogma *et al*., 2002; Geels and Raven, 2006; Schot and Geels, 2008). The SNM-literature focuses not so much on the initial *invention* of radically new ideas (e.g. from scientific research), but on the introduction of these ideas (and their concrete embodiment) into markets and society. Early introduction is usually called 'innovation', whereas later introduction is called 'diffusion' (Figure 3).

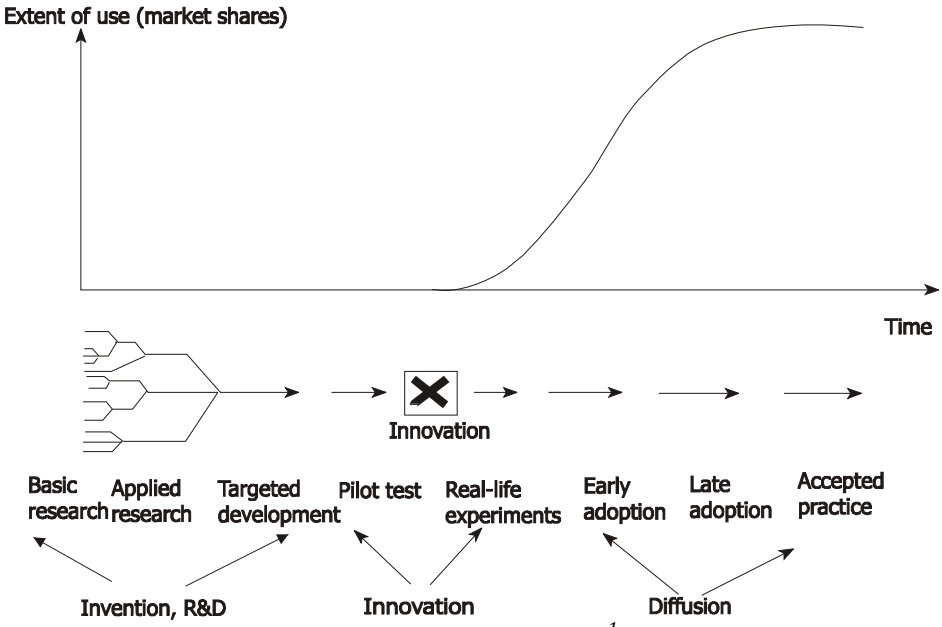

Figure 3: Phases in technological development[1]

[1] This kind of representation runs the risks of being associated with the linear model of innovation, which has been extensively criticised (e.g. for ignoring various feedbacks between phases). It is also

Radical innovations (technical products or otherwise) need to be embedded in (at least) three different environments (Deuten *et al*., 1997) (Figure 4):
* Markets (and user practices) and industries (including supply chains).
* Regulatory and policy environment (e.g. formal rules and standards).
* Wider society (cultural discourses, norms, social acceptance)

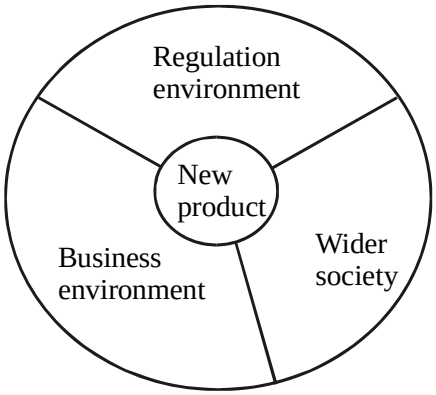

Figure 4: Relevant environments for new products (Deuten et al., 1997: 134)

While the first environment refers to economic viability, the second and third environment refer to political support and socio-cultural acceptance/legitimacy.

Radically new ideas and innovations often face the so-called 'valley of death', which refers to the gap between research and market introduction (Auerswald and Branscomb, 2003). Many new ideas fail to cross this chasm or take a very long time to do so. Some reasons for this are:
1) Radical innovations may (initially) have poor price/performance characteristics, which lowers their economic viability.
2) There may be no immediate market demand, because functionalities are not clearly articulated or because users are unaware of the innovation or perceive it as strange and at odds with mainstream user practices. Markets, user preferences and user competences may thus need to be co-constructed with new technologies (Coombs et al., 2001; Oudshoorn and Pinch, 2003).
3) Third, a broader socio-technical context may need to be constructed in which new technologies can function, e.g. new infrastructures, complementary technologies, symbolic meaning, industry structures, subsidies and support programmes.

The SNM perspective offers a way of understanding how the valley of death can be crossed.

Strategic Niche Management (SNM) perspective

The SNM perspective suggests that experiments, pilot and demonstration projects in real-life contexts often play important roles in crossing the valley of death (Verheul and Vergragt, 1995; Brown et al., 2003; Engwall, 2003). These projects are sheltered from immediate market selection through subsidies and dedicated support networks. The SNM-literature conceptualizes these 'protected spaces' as niches where actors can experiment with the alignment between technical variations and (adjustments in) various selection environments. These projects allow niche actors to learn about innovations in real-life circumstances. Niche-

technology-focused, and may be harder to apply to social innovations. Nevertheless, Figure 3 is useful as a heuristic to distinguish different phases linked to some core processes.

innovations thus have a 'local' dimension (of use and experimentation in concrete projects) and a 'global' dimension, which refers to the community of niche actors who share certain rules such as problem agendas, search heuristics, expectations and understandings (Figure 5).[2]

Sequences of local projects may gradually add up to an emerging field (niche) at the global level (Figure 5). Niche development may start with one or a few projects, carried by local networks of actors, who are interested in innovations for idiosyncratic or local reasons. The cognitive rules (such as expectations) that guide these projects are initially diffuse, broad and unstable. Local projects form test beds for these diffuse ideas and spaces for the elaboration of new ideas. Subsequent comparison and aggregation of lessons in local projects may gradually result in more articulated, specific and stable cognitive rules at the global niche level, giving rise to a stable trajectory.

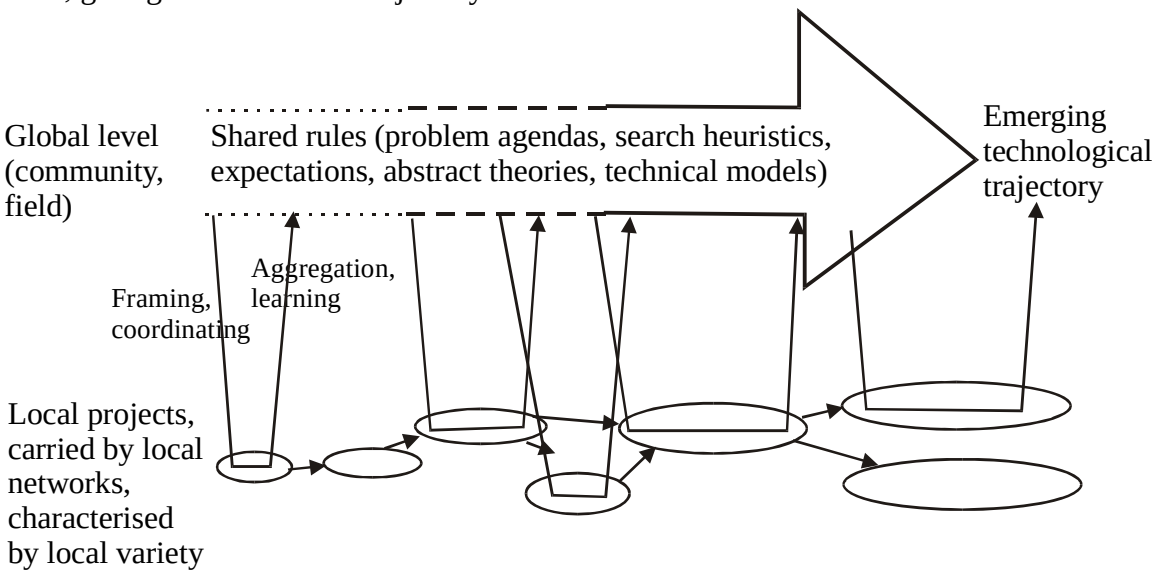

Figure 5. Niche-innovation trajectory carried by local projects (Geels and Raven, 2006: 379)

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

The initial SNM-literature (Kemp *et al*., 1998; Hoogma *et al*., 2002), which paid special emphasis to socio-cognitive processes, distinguished three core processes in the development of niche-innovations:

- The articulation of expectations and visions. Expectations are considered crucial for niche development because they provide direction to learning processes, attract attention, and legitimate (continuing) protection and nurturing.
- The building of social networks. This process is important to create a constituency behind the new technology, facilitate interactions between relevant stakeholders, and provide the necessary resources (money, people, expertise).

[2] So, the terms 'local' and 'global' have sociological rather than geographical meaning here. The interest of WP-2 is at the 'global' level (i.e. the innovation trajectory as such), whereas research in WP-3 is more at the 'local' level (studying particular city-level projects).

- Learning processes at multiple dimensions:
  a) technical aspects and design specifications
  b) market and user preferences
  c) cultural and symbolic meaning
  d) infrastructure and maintenance networks
  e) industry, production networks, supply chains, distribution networks
  f) regulations and government policy
  g) societal and environmental effects

Research protocol for niche-analysis in task 2.1

While SNM-ideas are useful for task 2.1 in the PATHWAYS project, they also have a limitation because of the focus on the *early emergence* of radical innovations and the associated socio-cognitive processes. Task 2.1, however, is interested in the *momentum* of green niche-innovations, and particularly the potential for an upswing in the early diffusion curve (i.e. between real-life experiments and early adoption in Figure 3). 'Momentum', which in physics is defined as the product of mass and velocity of an object, can be applied to socio-technical niche-innovations by looking at increases in market shares, investments, price/performance improvements, size of social networks, commitment and strategies of actors, shared positive visions, policy support. So, while building on SNM-ideas, we will also broaden our perspective to explicitly include techno-economic dimensions and governance/policy dimensions to better capture development of innovations as well as later stages of diffusion of transitions.

Concretely, the analyses of green niche-innovations in the various country/sector studies will therefore analyse the following three dimensions of 'momentum' of green niche-innovations:

1. Innovation and market trajectory (techno-economic).

This part of the analysis may address issues such as:
- Growth in market shares or another growth indicator (e.g. number of innovative land-use projects, land surface with multi-functional land-use, size of investments).
- Technical development trajectory (e.g. increasing size of wind turbines) and/or price/performance developments (e.g. levelised costs of electricity from wind turbines)

2. Actors and social networks (socio-cognitive).

This part of the analysis may address issues such as:
- Changes in the size and composition of the social networks/constituency supporting the niche-innovation: are more actors joining? Are different kinds of actors joining? Is the niche-innovation mainly supported by 'small' actors (e.g. entrepreneurs, activists) or are big industrial players or high-level policymakers also becoming involved (which may substantially increase momentum).
- Are there actors opposing the innovation leading to controversies and social acceptance problems?
- Have visions and expectations regarding the niche-innovation stabilised and converged, leading to greater strategic actor commitment? Or are there multiple competing views?
- Have learning processes on various socio-technical dimensions led to a stable configuration? Or are there still substantial uncertainties (e.g. about price/performance, market demand, business models, infrastructure provision)?

3. Governance and policy.

This part of the analysis may address issues such as:

- Have policymakers strategically committed to the niche-innovation, giving it a prominent place in their policy plans? Or is the interest still largely peripheral?
- Are policymakers actively supporting the niche-innovation with concrete deployment-oriented policies (e.g. supportive regulations, financial subsidies, infrastructure programs)? Or is policy support relatively weak (e.g. focused at R&D or committees)?
- With regard to multi-level governance, is there alignment between local, national and European policymakers and policy instruments?

Research goals:

Each country study has analysed 6-8 promising green niche-innovations in their particular domain (electricity, heat/buildings, mobility, agro-food, land-use). Using the research protocol, described above, each study has addressed the two following goals:

- Characterize momentum: a) provide a *relative* ranking of the 6-8 niche-innovations in terms of momentum, b) provide an overall assessment of the momentum of each niche-innovation in terms the following categories (very small, small, moderate, large, very large), c) assess the momentum on the three analytical categories (techno-economic, socio-cognitive, governance).
- Indicate for each of the 6-8 niche-innovations if they are more oriented towards pathway A or B?

1.3. Methodology: Case-selection, data-sources, procedures

Selection of the 6-8 niche-innovations

The country analyses of different empirical domains have been done by sector experts. Methodologically, these experts have first presented a long-list of possible green niche-innovations in their domain. Subsequently, they have selected about 6-8 green niche-innovations that were analysed in more detail, using the research protocol. This selection was guided by the following criteria:

1) We have chosen innovations with substantial impact in the sustainability scenarios studied in PATHWAYS. These can include both innovations that are already having impact (in terms of market share or investment) or emerging innovations that may have impact in the future (e.g. smart meters where there are many visions, promises, plans, ambitions). Inventions, which are still in the R&D phase, are hard to study, however. The project therefore focuses on innovations, where there is some real-world experience in the last 5-10 years.
2) We have selected innovations that deviate to a significant degree from the current socio-technical regime. We did not include incremental innovations which will be studied in task 2.2.
3) We have chosen both technical and social (behavioural) innovations
4) We have selected some innovations that are supported by incumbent actors and other innovations that are supported by new entrants.

Data-collection

The research was empirically challenging, because it addresses multiple niche-innovations and multiple dimensions (techno-economic, socio-cognitive, political). Data-collection partly drew on the tacit knowledge of the sector experts (which have been included in the PATHWAYS project because of their long-standing expertise). It further used secondary sources (books, articles, reports), complemented with semi-structured interviews and primary sources (White Papers, policy documents, newspapers, company annual reports, industry

journals). Quantitative data have also been used (especially for the techno-economic analysis), although this was easier for technical innovations (related to Pathway A) than for social and institutional innovations (related to Pathway B).

Data-analysis in the socio-technical case studies did not work like a 'truth machine' (where one enters the date into the protocol, turns the handle and gets the answers). Rather, heterogeneous data were integrated to construct an interpretive analysis.

Procedures

The interactions in the PATHWAYS project have been organised to support the researchers during their research.

- At the kick-off meeting the outline of the research protocol was discussed and subsequently written up by the WP-leader
- In the first few months, the WP-leader organised bilateral conference calls with researchers in the five empirical domains to discuss both the research protocol and the selection of 6-8 niche-innovations (both the long list and short list)
- At the second project meeting in in July 2014, we spend 2 days (17-18 July) discussing 12 draft-reports of green niche-innovations in different domains and countries. Detailed comments and suggestions for improvement were given on each report. We also revisited the research protocol, which led to simplified version, which was reported in section 1.2 above. Final instructions for the deliverable for task 2.1 were send to the researchers in month 10.
- These instructions included a guide for the content of each country report, which included: an executive summary, an *introduction* (section 1) providing a brief sketch of the socio-technical system, a motivation of the *case selections* (section 2) of green niche innovations, the *main analysis* (section 3) of the niche-innovations, and a conclusion (section 4) with overall assessment of momentum in each niche-innovation.
- All reports were delivered to the work package leader by 28 November 2014. To ensure sufficient quality, we then organised two internal reviews of the main report, and an internal review of each of the twelve country reports.

Chapter 2 below reports the core findings of the different country reports, drawing closely on their executive summaries and conclusions from each country report.

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2. Research findings from different country sub-reports

2.1. Green niche-innovations in the German electricity system

Germany has been one of the frontrunners in climate and renewable policy since the mid-1980s. In the context of its energy transition (the *Energiewende*) it aims at reducing its greenhouse gas emissions by at least 80-95% by 2050 (compared to 1990 levels) and to achieve a share of renewable energies in gross electricity consumption of at least 80% by 2050. A large number of instruments are in place to contribute to this envisioned decarbonisation of Germany's energy system through the development of renewable energy sources, power grids and energy efficiency. One important aspect in this regard is that there is a wide societal support for the energy transition towards renewables.

The share of gross electricity generation from renewable energies has increased from 3.6% in 1990 to 22.8% in 2012. This rising trend in renewable electricity generation was initially driven by wind and biomass, with PV expanding rapidly since 2009. However, despite these strong growth trends in renewables and a corresponding reduction in the CO_2 emissions from electricity generation between 2007 and 2009, this decarbonisation trend has been reverted since 2010 with once again rising CO_2 emissions. Electricity consumption has risen by 15% from 1990 to 2011, but it has started to stabilize from 2007/08 onwards, leveling off at around 530 TWh in 2013.

The analysed niches in the German electricity system are onshore wind, solar PV, offshore wind and bioenergy (i.e. four supply side niches) and CFL and LED lighting, smart meters, power to gas and vehicle to grid (i.e. four demand side niches). Most of the supply side niches in the German electricity system follow pathway B, i.e. can be associated with broader regime transformation, and not just technical component substitution as foreseen for pathway A. One reason for this assessment for onshore wind, solar PV and bioenergy is that lead actors tend to be new entrants, including citizens, farmers and municipalities. By now, large incumbents are attempting to enter these niches, but their role has remained limited so far, except for the case of offshore wind for which they – alongside with new entrants – play a key role. Offshore wind as large-scale technology also differs in the depth and scope of change: while it can be described as radical technical change, other system elements are not as radically impacted as is the case for onshore wind and solar PV. These small-scale intermittent supply side technologies with their increasing market shares necessitate a reconfiguration of the German energy system and energy markets. Finally, given that particularly solar PV but also onshore wind and bioenergy has turned consumers into prosumers these pathway B niches are associated with multi-dimensional changes, including socio-cultural and consumer practises.

The situation differs for the demand side niches studied for the German electricity system as these can be assigned to pathway A as radical change by and large remains limited to radical technological change. For example, CFL and LED lighting focus on technological substitution without broader behavioural changes. Similarly, the niche of smart meters could be thought of as being associated with pathway A as the partial implementation strategy pursued by the German government may limit broader regime changes – however, there is the potential that the niche could be leading to broader and deeper changes, including changes in consumption patterns, so that an assessment may require some more detailed analysis of the underlying vision and potential consequences of the German roll-out strategy. Finally, power-to-gas and vehicle-to-grid as very young niches represents two radical

technical solutions to wider system changes in the electricity system resulting from an increased need for electricity storage. For these niches, incumbent actors tend to play a key role. Also, broader system changes appear limited, although the vehicle-to-grid niche holds the potential for change that goes deeper and beyond the technical dimension.

All examined niches exhibit different degrees of momentum, spanning from very low to very high, which is summarized in **Error! Reference source not found.**2 and further elaborated in the remainder of this section.

Niche-innovation and ranking	**Momentum**	**Main drivers of momentum**	**Pathway**
1. Onshore wind	Very high	- Large techno-economic potential at lowest cost - Currently still relatively high socio-cognitive acceptance - Continuing deployment support, but attempt to limit rate of deployment and integrate into market	B
2. CFL and LED lighting	High	- technological and economic advantages (including total cost of ownership) - technology has yet to overcome reluctance in social acceptance on the user side - political support largely originating from the EU (ban of incandescent lamps in 2009)	A
3. Solar PV	High	- high cost burdens for final customers due to EEG surcharge, but costs are expected to continue to decrease - social acceptance for rooftop PV is still high - up to 2013 very high momentum, but now reduced due to a deterioration of the policy mix (attempts to limit diffusion rate, large cutbacks in the level of support granted through feed-in tariffs)	B
4. Offshore wind	Medium	- continuing high costs and delays in grid connection - industry actors remain firmly committed to this technology which by now is also attractive to large utilities - long-term targets recently reduced, but instrument mix remains favorable with extensions of high levels of support	A
5. Bioenergy	Low	- high costs and little cost reduction potential, but technological advantage of being a non-fluctuating energy source - wider sustainability concerns and competing uses of biomass for the decarbonization of other sectors - policy commitment for further expansion limited (very low rate of diffusion foreseen)	B
6. Smart meters	Low	- high implementation costs with cost-benefit ratios rarely being positive for individual households - socio-cognitive acceptance rather low due to the issue of data protection - policy makers are yet hesitant to show significant commitment to an accelerated deployment	A (with potential for B)
7. Power-to-gas	Very low	- economic viability of projects difficult, investors hesitant - policy mix not tailored to support this niche	A
8. Vehicle-to-grid	Very low	- Costs for batteries are high – although decreasing – and revenue opportunities remain limited due to limited price spreads on electricity markets - policy mix so far focuses on providing R&D funding	A (with potential for B)

Table 2: Assessment of Momentum and transition pathway of analysed niches

The highest momentum is found for onshore wind, mainly for techno-economic reasons as it constitutes the largest potential to achieve Germany's energy transition goals at the lowest

costs. Also socio-cognitive acceptance is still relatively high for this by now almost established energy technology, but may come under more pressure with further deployment due to NIMBY and landscape concerns. Although the rate of expansion is attempted to be contained within a desirable range (breathing cap) by the EEG2014, the policy mix is still supportive and continues to provide a largely unchanged feed-in tariff level for a guaranteed period of time – but with prospects for more market integration.

A high momentum is also found for efficient lighting technologies, mainly for the technological and economic advantages (including total cost of ownership) and the political support largely originating from the EU, with the most prominent instrument being the ban of incandescent lamps in 2009. However, despite these drivers the technology has yet to overcome reluctance in social acceptance on the user side.

Solar PV is a special case as momentum was very high until beginning of 2013, but was dampened significantly due to a deterioration of the policy mix, both in terms of the introduction of a breathing lid and large cutbacks in the level of support granted through feed-in tariffs. The reasons behind these policy mix adjustments are mainly the overshot of added capacities relative to deployment targets, resulting in high cost burdens for final customers. However, social acceptance for rooftop PV is still high and costs are expected to continue to decrease, so that further capacity additions are envisaged to achieve roughly the same level as onshore wind. Still, given that the momentum used to be higher in the past we have rated it as high and not anymore very high.

The momentum of offshore wind is assessed as moderate in light of the long-term targets, which were recently reduced. Given the more favorable conditions in the North Sea the momentum there is higher than in the Baltic Sea. With the amendment of the EEG there is once again a favorable policy mix in place, but the continuing high costs and delays in grid connection reduce the momentum of this niche. Yet, industry actors remain firmly committed to this technology which is also attractive to large utilities, so that the momentum could increase in the future.

Bioenergy has by now a rather low momentum, mainly for its high costs and little cost reduction potential. However, compared to wind and PV it exhibits the technological advantage of being a non-fluctuating energy source. Still, policy commitment for a further expansion of this niche is limited, also for wider sustainability concerns and competing uses of biomass for the decarbonization of other sectors.

The momentum of smart meters, being a relatively new technology on the demand side, is also assessed rather low, mainly due to high implementation costs. Cost-benefit ratios are rarely positive for individual households. In addition, socio-cognitive acceptance is rather low mainly due to the issue of data protection. As a consequence, policy makers are yet hesitant to show significant commitment to an accelerated deployment of smart meters.

Power-to-gas is also a demand-side technology of rather low momentum. As economic viability of projects (which are yet to be realized) is difficult, investors are hesitant, especially as the policy mix is not tailored to support this niche. For example, a policy support mechanism for energy storage is missing, thereby hindering deployment.

Vehicle to grid is found to exhibit the lowest momentum which is not surprising giving that the technology is not yet available on the market. Costs for batteries are high – although

decreasing – and revenue opportunities remain limited due to limited price spreads on electricity markets. Apart from these techno-economic barriers the policy mix so far focuses on providing research funding.

2.2. Green niche-innovations in the UK electricity system

Table 3 summarises the conclusions of the niche-analysis of UK electricity, with regard to relative ranking, contributions to momentum, and pathway A/B assessment. Ranking the six niches from highest to lowest momentum, it considers momentum in terms of three interdependent dimensions: techno-economic, socio-cognitive and governance; it also presents our interpretation of whether the niche fits better with Pathway A or B. This leads us to the following overall assessment and a ranking of niche momentum, based on judgments about how the strength of momentum combines across the three dimensions.

Niche innovation and ranking	**Momentum**	**Assessment of momentum through techno-economic, socio-cognitive and governance dimensions**	**PATHWAY**
1. Energy saving lighting	**Very High**	*Techno-economic momentum* is very high with rapid diffusion of halogen and CFLs, and with incandescent bulbs almost completely replaced; LEDs are a new, potentially revolutionary lighting technology with high energy efficiency and steep learning curves. *Socio-cognitive momentum* is generally high because all international industry actors work on energy-efficient lighting, with European companies focusing on LEDs (since Chinese firms dominant the CFL market); retailers, utilities, NGOs and policymakers also work to stimulate adoption of energy-efficient lighting. One problem are lingering consumer perceptions of lower quality of CFLs. Another problem is uncertainty about the precise temporality of a shift towards LEDs, and whether or not this shift will be hindered by a lock-in into CFLs and halogens. *Governance momentum* is high because of the ban on ILBs, which provided a very clear signal to market players about the direction of travel (i.e. more energy efficient lighting). Policymakers are also committed to energy-efficient lighting, because it represents one of the few successes of demand reduction.	**Pathway A**, although future adoption of LEDs might involve Pathway B characteristics
2. Smart meters	**High (but could drop significantly if problems arise in early implementation phase)**	*Techno-economic momentum* is is still relatively low in terms of actual diffusion (only 1% of the expected 53 million smart meters was implemented by 2014), but the growth rate is very high, starting from almost zero in 2012. Diffusion is expected to ramp up very quickly in the coming years, which would boost techno-economic momentum. There has also been considerable technology and system development in recent years, which contributes to momentum. *Socio-cognitive momentum* is high, is high, with the creation by government of substantial social networks (mainly from the production domcin) and the articulation of positive visions about the benefits of smart meters, which largelt crowd out some marginal dissenting voices. *Governance momentum* is high, because the government has strongly committed to a very ambitious roll-out programme (without waiting for outcomes of the 2007-2010 trial).	**Pathway B**, according to official visions, but would be pathway A if behaviour change does not happen
3. Offshore	**High**	*Techno-economic momentum* has been growing from a low	**Pathway A**

wind		base to the UK taking a world leading position, despite high costs cf. other RETs. Significant learning occurred during the 2000s, but technical obstacles remain, especially with envisaged expansion into deeper, more hostile marine environments. *Socio-cognitive momentum* is high, with the formation of a powerful network of actors from industry, government and NGOs, with aligned interests, which created high socio-political legitimacy and enthusiastic visions for future expansion. More recently, there have been some signs of erosion in legitimacy and support because of concerns over high costs, which have created uncertainty and affected investment decisions. *Governance momentum* has been very high due to strong interest across many government departments, but has been wavering in the most recent period because of cost concerns.	
4. Biopower	**Moderate**	*Techno-economic momentum* for most sub-niches is medium but decreasing, with slow or limited anticipated future growth (e.g. landfill gas, energy-from-waste). The momentum for biomass conversion of coal plants is high, however, with very rapid growth in recent years. The technical combination of bio-power and CCS is an enticing long-term prospect, but not yet leading to much concrete development. *Socio-cognitive momentum* is medium and perhaps decreasing, with prominent future visions now anticipating a boom-and-bust pattern with attention shifting away from dedicated biomass to coal conversion for the transitional period to 2020. Controversies about the sustainability of certain forms of biomass could undermine socio-political legitimacy. *Governance momentum* has shifted unevenly across the sub-niches of bio-power, currently favouring coal conversion in the prior to 2020, with withdrawal of support thereafter.	**Pathway A**
5. Onshore	**Moderate (and decreasing)**	*Techno-economic momentum* is now decreasing after an early period of high diffusion (c.f. other RETs) associated with its close-to-market status and learning curves that generated price / performance improvements. *Socio-cognitive momentum* is weakening because early implementation problems (poor stakeholder engagement) and a narrow support base (mainly of policymakers, utilities and project developers) have generated an increasingly negative public discourse. Some planned deployment is becoming vulnerable to local opposition. *Governance momentum* has been positive, but is weakening as a result of increasingly negative public discourse and visions, especially for the period beyond 2020, with the UK government considering a moratorium after this date	**Pathway A**, but with some, as yet unrealized, potential for Pathway B
6. Solar-PV	**Low**	*Techno-economic momentum* was relatively slow until 2010, when diffusion increased rapidly and beyond (government) expectations. Techno-economic increased substantially in recent years, because of decreasing PV module costs and rapidly increasing deployment. Further diffusion will require ongoing cost reduction which may be more difficult for Balance-of-System costs and wider system (grid) costs. *Socio-cognitive momentum* has been high, supported by strongly aligned actor-network of technology suppliers,	**Pathway B**

		installers, famers, consumers, NGOs and public science. There has been a largely positive public discourse and high social legitimacy, especially amongst advocates for decentralised (including 'prosumer') energy generation. *Governance and policy momentum* was low until the introduction of the Feed-in-Tarriff in 2010, but increased after the inclusion of solar-PV in government renewable energy plans from 2012 and dedicated solar-PV strategy documents in 2013 and 2014. Reductions in feed-in tariffs have recently created some uncertainty about future deployment and government commitment.	

Table 3: Ranking of UK electricity niches in terms of momentum and pathways

The assessment of overall momentum for each niche and its association with Transition Pathway A or B is based on the following arguments:

- Lighting has very high momentum because incandescent bulbs have been phased out through legislation, facilitating the widespread diffusion of energy saving light-bulbs, with the prospects of further significant gains through even more energy-efficient LEDS over the coming decades (although LED diffusion is lower in the UK than other European countries. Energy saving lighting is following PATHWAY A, principally because it is driven by incumbent actors and technology substitution is the main focus; some visions for future LED diffusion are suggestive of a wider revolution in domestic lighting which might precipitate significant shifts in interior design and therefore suggest the possibility for some PATHWAY B characteristics.
- Smart meters have high momentum, despite comparatively low current diffusion rates. This is because anticipated diffusion rates are extremely high based on strong socio-cognitive momentum and policy commitments for rapid deployment by 2020. This high momentum could drop significantly if implementation problems arise in the early phase (which are predicted by some critics). Visions for the deployment of smart meters follow PATHWAY B because they place significant attention on the prospects for behavioral change and demand management. If these promises are not realized, it will shift to PATHWAY A, deployed by incumbents, with benefits largely accruing to incumbents.
- Offshore wind has high momentum, because it is growing quickly, and is supported by a powerful network of actors, a generally supportive governance orientation and faces minimal organized opposition. Offshore wind is clearly following PATHWAY A because it is a substituting electricity generation technology, deployed by incumbent actors.
- Biopower has moderate momentum because it is a mature technology (so, there are limited opportunities for technology improvements), where deployment in most sub-niches is plateauing. The exception is coal-conversion-to-biomass which is growing significantly, but as part of a boom-and-bust strategy in which the role of biopower will decrease beyond 2020. Biopower follows PATHWAY A quite closely, although there may be further reconfigurations across domains with any rapid increases in land required for energy crops.
- Onshore wind has moderate and decreasing momentum because despite its relatively high level of existing deployment, it faces increasing problems with socio-political legitimacy and the prospects for a moratorium on new installations beyond 2020. On shore wind is most appropriately characterized as a PATHWAY A niche in the UK, because it is largely deployed and managed by incumbents; community level onshore wind (which would suggest some PATHWAY B characteristics) has minimal momentum.

- Solar-PV has low momentum because the niche is vulnerable to rapid fluctuations across the three dimensions. While diffusion has grown significantly (and unexpectedly) over the last few years on the basis of strong socio-political legitimacy and the feed-in-tariff, it remains the highest cost RET and policy support is exhibiting stop-start-stop characteristics. Solar-PV is most appropriately characterized as PATHWAY B in the UK because recent deployment and future visions have focused on decentralized power generation incorporating farmers for solar-farms and growing numbers of active and engaged 'prosumers' in the domestic roof-top sector.

2.3. Green niche-innovations in the Swedish heat system

The development of the Swedish heat domain from 1950s until today can be described as a success story. From a system fully dominated by coal and oil, the heat domain is today dominated by renewable energy. The main energy carriers in the Swedish heat domain are district heating, biomass and electricity. Electricity is in turn dominated by low carbon primary energy in the form of hydro and nuclear power. The total amount of renewable energy in the heat domain is between 60-70% (depending on yearly average temperature), which is highest in the European Union.

The policy landscape for heating in Sweden is currently steered by the EU Energy Efficiency Directive (2012/27/EU), and the Swedish draft ratification bill on the implementation of the EU Energy Efficiency Directive. But the focus on renewable energy and sustainable development in the heat sector goes further back in time. First to the oil-crises in the 70s which prompted a move away from dependence on foreign oil, and two daces later to the introduction of the Swedish CO_2 tax in 1991 as a feasible policy measure to mitigate climate change. In terms of important actors, the main two public actors today include the Swedish Energy Agency (SEA) and the National Board of Housing, Building and Planning (Boverket). The agencies have helped shape the heat regime with numerous reports, policy documents, investment programs, information campaigns and major investments in research and development of several niches as discussed below.

Sweden has made a transition from a heavily fossil fuel dependent heat system to a close-to fully renewable system. This has been an incremental change encouraged by early innovators, strong public support, the two oil crises and an ambitious climate and energy policy. Indirect factors have also played an important role. For example, the multi-dwelling housing ownership system in Sweden is communal both for social housing properties and private properties, where owners have a share in a whole building rather than owning a separate apartment. This has facilitated large-systems over individual and diverse ones and has in several ways facilitated the energy transition.

Today, the Swedish heat domain is characterised by three general factors. First, the heat regime is showing signs of *saturation.* All energy inputs and their associated niche – innovations indicate declining growth and among the main actors there is little belief in substantial growth of any particular technology. Second, the Swedish heat domain is *interconnected.* Several niches are linked in and dependent on each other. Third, niches are characterised by their *complementarity*.

Generally, the Swedish heat domain is characterised by its focus on hard technological innovations. Softer type of niche innovations, which aim for deeper changes in institutions and transformations in societal involvement appear to lag compared to the other niches. Table 4 summarises the conclusions of the analysis in terms of relative momentum, and pathway A or B. Most of the transition in the heat domain had **high momentum the past** decades in terms of heat generation. The heat domain is presently to a large extent renewable and the general feeling among actors is that the 'problem' is solved. There is little room for further development of existing energy sources and the momentum is low.

Niche innovation	Relative ranking	Momentum	Drivers of momentum	Transition pathway
Heat pumps	1	Moderate	Mainly driven by techno-economic factors. The most cost competitive option when DH is not available and often used combined with other heating technologies. Few socio-cognitive changes needed, and not thus not a driver. Policy (e.g., R&D support) has been important historically.	A (Long development in different phases. Radical technology but no wider societal changes needed for transformation)
District Heating	2	Moderate	Mainly driven by policy and governance and socio-cognitive e.g., culture of large scale system solutions developed by state and municipalities. Today techno-economic factor more important; DH is the most cost-competitive option in Sweden.	B (Broad regime transformation completed and new regime with stable market share today)
Waste heat recovery	3	Moderate	Techno-economic factors dominates, but policy/governance a driver to some degree.	A (Slow but steady development within DH domain)
Small Scale biomass	4	Low	Complex. Socio-cognitive driver is historically key in terms small biomass being a technology in single house dwellings, but recently the cognitive aspects is more of a barrier (user (un)friendly technology). Key driver over time probably techno-economic factors.	A (Stable market share, gradual replacement of traditional biofuel in small scale applications)
Low energy housing	5	Low	Socio-cognitive dominates. Techno-economic is not perceived as driver, and governance/policy is lagging.	B (Far reaching institutional change needed, high resistance from incumbent actors)
Individual metering and billing	6	Very low	Socio-cognitive dominates. Techno-economic is even a barrier as some researchers suggest solution is even increasing demand. Governance/policy is not driving either, rather resisting this development.	A and B (Substitution rather than regime transformation, but do require deep behavioural and institutional change)

Table 4. Niche innovations in Swedish heat sorted by relative momentum.

A heat source that is insufficiently explored in the Swedish heat domain is solar power. A common view is that Sweden does not receive enough sunlight. But, the amount of sunlight received by the solar energy over Stockholm on an annual basis in fact equals to that in central Germany. In 2012, the department of environmental management in the city of Stockholm released a report arguing that investments on solar heat and solar power in the city

were competitive with existing sources (Miljöförvaltningen 2012). Notwithstanding, we could not find sufficient data to include solar heating as an important niche of its own. For the building sector on the other hand, there are clear opportunities for energy efficiency. Low energy buildings, behavioural change, as well as further use of waste heat, are niches where there is large potential. However, the momentum is low in the buildings part of the domain and there is a need for more institutional support.

The heat domain in Sweden is to a large extent fuelled by renewable energy sources and several of the niches discussed in this report are now part of the wider regime. Initially, however, both heat pumps and district heating belonged to Pathway B and caused a broad regime transformation, going from fossil fuel dominated heat sector to a renewable one. Today, and in the recent past, development of these energy sources, belong to Pathway A as technologies are rather improved than substituted. Also small-scale bio fuel belongs to Pathway A, as the niche-innovation only substitute fuel and makes minor changes to an already existing set of technologies on small scale use of wood fuels in the single-dwelling housing sector.

Regarding the 'softer' types of niches, dependant on changed behaviour, new market solutions and application of technologies, such as individual metering and billing, and low energy housing, these belong to Pathway B. These innovations aim for deeper changes in institutions and transformations in societal involvement. In the Swedish case study, the developments of these appear to lag compared to the other niches.

2.4. Green niche-innovations in the German heat system

The findings show that the German heat domain has an overall stable actor configuration, but competition between the different systems and their respective actors (e.g. biomass, gas and heat-pumps) cater for a dispersed regime. Incumbent firms of existing technologies, many of them SMEs, are at least as important as new entrants and start-ups. Very important influences stem from the Federal Government and associated organizations like the Kreditanstalt für Wiederaufbau (KfW), Germany's federal state bank for funding issues and subsidies. Other important decision makers are the homeowners. Units tend to be heated separately and the decision for the applied heating system thus lies with the individual proprietor. This underlines the decentralism and diversity of the incumbent regime, in which gas heating dominates. However, gas is by far not the only technology, and it also relies on a variety of appliances, e.g. gas networks vs. singular solutions, centralized/decentralized heating in builidng units, including/not-including warm water provision etc. The activities of the homeowners are also strongly affected by their relations to tenants (representing 72% of German households) and the possibility of handing over investment costs. Large associations representing owners and tenants, respectively, represent their partly contradicting interests, lobbying for certain changes or activities in legislation and funding of potentially green technologies.

With regard to the heating domain and its technologies a strong relation to the electricity domain became apparent which leads to a very interesting link to German efforts for renewable energies (known as the 'Energiewende'). Some heat-related technologies, e.g. heat pumps and district heating require powering by renewables in order to have a CO_2-saving effect or positive environmental impact, while they may even be harmful when relying on conventional energy sources. Other technologies, most notably solar thermal installations,

compete with renewable energies (in this case photovoltaics) and are thus hampered in their development. Overall, for the reasons mentioned, the German heat domain presents an unclear picture. Right now, it cannot be projected which appliances will eventually lead to a regime change, if a regime change will happen at all. Most niches analysed have been identified to belong to the Pathway A type with considerable technological advancement and potential but little required changes in overall configuration.

A transition of the German heat domain has not happened yet. The assessment of niche technologies in this study has shown that their respective situation varies considerably. Not all technologies (or sub-types of these) can actually be regarded as "green" or environmentally friendly per se. Solar thermal, biomass heating and whole house refurbishments are real "green" niche technologies. The assessment of heat pumps gives an ambiguous picture: only with fully renewable operated electricity, can they be regarded as "renewable heat source". The energy saving effect of smart metering for individual households (heating and electricity) seems very limited due to isolated appliances with often non-user friendly technology. However, if combined the technology may be a necessary precondition for implementing future smart grids as it is the able to steer e.g. household appliances with regard to electricity availability in the grid. Smart metering may gain momentum through this factor.

For every single niche, a multitude of actors is relevant. In all cases political influence was shown to be of utter importance. Due to a decentralized and heterogeneous market (and regime) for heat technologies and a wide range of different technologies in use – for example when compared to Sweden – the principal actors for each niche are the owners of property where a technology is to be implemented.

The slowly starting transition of the German heat domain does not follow a clear or unified pathway so far. While most niche technologies are incremental technologies supplied by incumbent actors and follow pathway A (small biomass, solar thermal and heat pumps), there are some niche technologies that involve a deeper transition and follow pathway B (low-energy housing, smart metering). District heating seems to be in between.

There is hence no common picture with respect to the momentum of niches in the heat domain. Rather, the single niche technologies vary largely with respect to the momentum that can be observed and expected in Germany:

- Biomass: ready technology with heavy research & innovation activities resulting in further efficiency gains and price decreases. Some large manufacturers with diverse green and fossil-fuel-based technologies reluctant to support a "100% green" strategy. Fairly good framework conditions and rising sales. Currently moderate momentum but with a good potential due to numerous niche innovators.
- Heat pumps: Increasing sales (probably due to effective collaboration and lobbying of stakeholders: manufacturers, electricity providers, craftsmen). Critical position of environmental NGOs (fossil fuel-based electricity input): medium-to-high momentum.
- Solar thermal: technological efficiency exhausted based on present technologies, prices stable at relatively high level (and not declining), competition with photovoltaics for roof area and other building efficiency technology for investment costs. Large potential but limited momentum.
- District heating: technology is ready, in place and used in large capacities in some places, but still a large potential in Germany. As German district heat comes mostly

from gas- or carbon-fuelled CHP, relative disadvantage to lignite electricity production as current low carbon certificate prices limit CHP momentum. Also not principally CO_2-reducing for the same reason – not a green niche per se. Investment-intensive and fossil-fuelled district heat is additionally seen ambiguous in the framework of the general German energy transition. If the framework conditions change, this technology may gain medium-high momentum.

- Low-energy housing/passive housing: technology is ready, incentive policies in place fostering BAT-diffusion instead of cheap, shallow refurbishment. Building codes mandate high efficiency standards for new buildings. In the new building sector, low-energy housing thus is becoming standard, but especially due to the split-incentive dilemma between the main actors owners and tenants, low-energy refurbishments are lagging behind their potential, and over the last years, refurbishment rates have not risen significantly. If the framework conditions do not change significantly, medium momentum.
- Smart metering: pilot phase in Germany. Metering for electricity and gas is legally linked. Still many market and implementation barriers. Possible uptake through price decreases and regulatory changes following the EED in the coming years. Low momentum with medium prospect.

Overall, the assessment of the momentum of niche technologies in the heat domain in Germany does not provide a very clear picture: there are many solutions available and ready. Some are gaining momentum, and for many the future depends on further landscape and regime-dependent framework conditions that may change the positions of the niche actors and their innovations. They all compete with a heating regime that is not entirely dominated by one single technology – although gas has a high market share – but in itself the regime is characterized by diverse and competing incumbent technologies and decentralization. An imminent regime change towards one specific mode is hence not to be expected. Table 5 summarises the conclusions of the niche-analysis of the German domain, with regard to relative ranking, contributions to momentum, and pathway A/B assessment.

Relative ranking of niches	**Momentum**	**Main drivers of momentum**	**Pathway**
1. **Heat pumps**	*Medium - high*	**<u>Techno-economic:</u>** - Heat pumps have a strong market potential: about 24% of new buildings are equipped with this heating technology. - Strong lobbying of large energy companies and regional distributors have strengthened the continuous sales. - Significant increases in terms of efficiency cannot be expected at this moment. **<u>Socio-cognitive</u>** - Environmental associations and consumer associations criticize the environmental protection effect based on the resources for electricity consumption of heat pumps. Heat pumps are no "green niche innovation" per se. - Investment costs have not decreased significantly over the last years **<u>Policy/governance:</u>** - The market incentive programme (Marktanreizprogramm), based on the German renewable energy law (EEG) offers attractive subsidies for the installation of heat pumps in buildings (exception: heat pumps providing process heat) to private persons, small and medium businesses, and municipalities.	**A**
2. **Small-scale**	*Moderate*	**<u>Techno-economic:</u>**	**A**

residential biomass heating systems		- Persisting barriers for faster technology adoption and heterogeneous interests among the actors. Small niche actors concentrate on exclusive biomass niche technologies and promote green beliefs with a clear positioning towards markets and policy, while larger more influential producers have biomass products among others. Their main business is with fossil-fuelled products – they do not intend to change the regime completely. Chances for further upscaling depend on the collaboration of the niche actors and whether they overcome conflicts of interest when producing both biomass and fossil-fuelled installations - New small biomass technologies have to be further optimised for large-scale production to activate economies of scale. **Socio-cognitive:** - Most relevant barriers for consumers are linked to higher initial investment costs and potentially higher maintenance efforts. - Rising public sensibility regarding environmental impacts of residential heating systems (possible trade-off between CO_2-reduction and air quality aspects). **Policy/governance:** - New small biomass technologies need also the support by appropriate policies and information campaigns. - Upscaling depends on governmental activities for changing the regulatory and incentive frameworks.	
3. **District heating**	*Momentum depends on landscape and energy price developments*	**Techno-economic:** - There is a strong link between CHP and DH in Germany. - The niche´s state is complicated by persevering fossil-fuel dominance. It depends on a direct link to the Energiewende to become a green niche perse. High uncertainties for investors and an often non-existent but cost-intensive infrastructure. - Due to high gas prices and low ETS certificate prices for coal, cleaner gas-fired CHP/DH is uneconomic. - DH energy prices are rising with input fuel prices. This is generally seen as one factor contributing to the stagnating market share of DH. **Socio-cognitive:** - Environmental NGOs are very critical on carbon-fuelled plants, which represent almost 90% of district heating plants. Another point they raise is to reverse privatisationsof the 1990s. Support from this side for a large-scale instalment is limited at best. **Policy/governance:** - If the framework conditions (carbon prices, grid regulations, others) change in favour of gas-fired CHP plants, the technology may gain further momentum in Germany. Higher prices of ETS certificates would e.g. increase the relative competitiveness of CHP plants and thus make CHP-connected district heating more attractive to operators. CHP/DH based on renewables would be desirable for a true transition, however a clear trend towards this is not visible at the moment.	**A/B**
4. **Low-energy/passive houses**	***Low (-medium)***	**Techno-economic:** - Germany has one of the highest instalment rates in absolute numbers. - Although technologies are on the market for decades now, and current technological development is very low in speed, it involves many dimensions (technical base,	**B**

		markets, organisational, political, social, cultural, and practices) and multiple technological elements (appliances, infrastructures, policies, etc.) - Installation and refurbishment rates are very low compared to opportunities in place. **Socio-cognitive:** - Niche actor configuration remains difficult: 1. Environmental NGOs support low-energy housing building 2. Owner and tenant associations fear rising costs – both sides are therefore highly critical with respect to building renovations. - Negative publicity (e.g. in the media) is hindering instead of accelerating investment. - The split incentive dilemma between tenants and owner slows refurbishment rates. **Policy/governance:** - Minimum standards aim at phasing out least efficient buildings while financial subsidies incentivise building owners to use best-available technologies. Information schemes and refurbishment activities in public buildings aim at raising awareness and generating private sector confidence. Public buildings are usually refurbished or constructed on low-energy/passive house standards to provide positive examples. - Although there are several instruments in place fostering low-energy housing, there is no reason to expect substantial growth in the momentum of low-energy or passive houses.	
5. **Behaviour change campaigns/Smart metering**	***Low (medium momentum outlook)***	**Techno-economic:** - Technically and legislatively metering for gas and electricity is in general directly linked. - Individual metering is standard since the interwar years. - The niche has not gained momentum beyond pilot programmes in Germany yet. - Studies show limited saving potential of smart-metering induced behavioural change due to high instalment costs. **Socio-cognitive:** - Cost and data security are identified as the most potent barriers to a larger rollout in Germany. If the consumers have the freedom of choice, acceptance problems would be reduced. **Policy/governance:** - Smart metering will probably gain momentum in the future due to ambitious policies that rely on substantial potential for energy efficiency gains. However, they will only be effective with regard to savings if complementary behaviour is promoted by these technologies. - Germany does not seem to take the role of an ambitious driver in favour of smart metering for gas. Germany is lagging behind with respect to smart metering for gas and there are few economic incentives for end-users on a market-based level.	**B**
6. **Solar thermal installations**	**Small**	**Techno-economic:** - Technical efficiency is almost exhausted (with some exceptions in specialised applications) and significant price decreases have not occurred and are not expected in the near future - Competition between solar thermal installations and photovoltaic (roof area) and other building efficiency	**A**

		measures in terms of investments and funding. **Socio-cognitive:** - As only one technical component is added to an existing system, institutions and socio-cultural practices remain stable and technological progress is incremental. No strong influence here. - Especially single dwelling house owners are investing in solar thermal technology in spite of relatively high costs. **Policy/governance:** - Technology manufacturers are lobbying for a more supportive policy framework. - Momentum of the further development of this niche into the mainstream system will largely depend on landscape conditions such as energy carrier prices and conditions influenced by the regime such as market incentive programmes or tax exemptions. - Legislative incentives/ obligations for new buildings to produce parts of their heating and cooling demand through the use of renewable energy. When using solar thermal, the share of renewable energy of the entire building energy consumption had to be at 15%.	

Table 5: Relative ranking, momentum and pathways in German heat niches

The arguments for the categorization into individual pathways are as follows.

- Biomass: This niche technology follows pathway A: Small-scale biomass heating technology can at least partly be regarded as compatible to the incumbent regime and some of the involved actors are large established heating appliance producers. For a basic transition no deeper behavioural change or significant sets of new actors will be necessary.
- Heat pumps: Heat pumps can be categorised as pathway A because installations of heat pumps represent only an additional installation of one technical component to an existing heating system while institutions and socio-cultural practices remain stable and technological progress is incremental.
- Solar thermal: This niche technology can be classified as pathway A because the technology only covers a part of the entire building energy demand (at least in the winter season and in existing buildings). It will likely remain a co-source of heat supply. As only one technical component is added to an existing system, institutions and socio-cultural practices remain stable and technological progress is incremental.
- District heating: Evaluation of the niche technology is ambiguous: The market entry of DH has been a decades-lasting process involving multidimensional change of the technology base, markets, organisation and policy with tendencies towards pathways B. Otherwise the process has not involved social, cultural or practice changes and main actors have always been incumbents. Although multiple new technologies had to be implemented simultaneously, they fitted well into the existing system. This rather points towards pathway A, and to a preservation of the existing system (Pathway 0).
- Low-energy housing/passive housing: The niche follows pathway B: Although technologies are on the market for decades now, and current technological development is very low in speed, it involves many dimensions (technical base, markets, organisational, political, social, cultural, and practices) and multiple technological elements (appliances, infrastructures, policies, etc.).
- Smart metering: The niche includes two aspects: The development/introduction of smart metering technology combined with behaviour change campaigns. The niche

follows pathway B: The niche is supposed to co-diffuse technology (smart metering) and behaviour change (energy conservation and demand-side-management/peak load reduction) which mutually enforce each other so as to enter consumer behaviour and attitude towards the utilization of heating and electricity use.

The analyses of the niches and actors have demonstrated high influence of legislation and public subsidization for the German heating domain. This has also illustrated that, while to some extent all new technologies and niches are subject to public support and regulation, the same goes for the incumbent technologies, indicating that the German government pursues no clear transition path. This is somewhat contrary to state influence in the "Energiewende", where the federal government has been – and still is – a (the) principal supporting actor (Lund 2009, Lipp 2007). It is also interesting to see how the heat domain is related to the "Energiewende". Actions and effects are sometimes complementary e.g. in biomass, smart metering and low-energy housing (most importantly smart housing) and even support each other. Specifically, some heating technologies have been found to only be CO_2-effective, when coupled with renewable energies. However, there are also competitive and conflicting relations e.g. for solar thermal. It can even be speculated that the attention given to the "Energiewende" both by legal authorities but also by the general public might hamper a transition in the heat domain which somewhat stands in the shadows of the electricity domain.

The mixture of incumbent and new actors within the German heating domain is also important to regard. Incumbents are active on many of the new markets within the domain, transcending their role as members of the existing regime and niche actors. There is thus no clear-cut picture of supporters and hinderers in this domain, and contradicting interests within certain groups and even companies exist. Therefore, a very differentiated picture needs to be drawn.

2.5. Green niche-innovations in the UK heat system

The United Kingdom presents an interesting context for change in the heating domain as it lags so far behind other Western European countries in terms of efficiency and innovation. However, having only recently 'discovered' the issue, the UK is setting a number of ambitious commitments in the frame of its first Heat Strategy and may well pick up on technological innovation developed elsewhere if it manages to develop the necessary skills and markets

Table 6 provides an assessment of the momentum of niche-innovations in UK heat, based on the consideration of innovation and market trajectory, supporting actors and networks, and policy and governance.

Niche and ranking	Momentum	Main drivers of momentum	Pathway
1. Smart heating controls and meters	Moderate	- market currently poorly developed - large market potential – virtually all homes connected in a large infrastructure rollout - innovation challenge resides in widespread rollout and effective management, rather than technological issues - supporting visions of smart grids. Potential downstream technological application and market development (accelerating feedback) - important policy plans and support for deployment. The national plans represent a massive infrastructure investment that should materialise to 2020. BUT delays. Hype/disappointment? Probably not, but lowered ambitions likely.	A but could enable B
2. Solar thermal	Low	- solar thermal (water) heating technology is a relatively mature proposition - UK market is quite small, but the largest compared to alternatives and steadily growing - well-developed markets in specific European countries, widespread availability of basic systems, promising innovation avenues, and standardisation - promising capability spillovers form PV installation - the domestic Renewable Heat Incentive may provide strong incentive for mainstream growth	B
3. Small biomass	Very low	- mature technology - poorly developed market (besides small market pocket off-grid housing) - few British manufacturers and suppliers involved - technological development abroad (e.g. Scandinavia)	B
4. District heating	Very low	- UK market for heat networks is currently poorly developed - early UK experiments (1960s-1980s) not followed through - technological and commercial success elsewhere (e.g. Sweden and Germany) - institutional, regulatory, infrastructural and market barriers in the UK - need for new business models and institutional forms rewarding long-term infrastructure commitments - current hopes for a new expansion phase (e.g. council housing and public utility) - some local momentum (local authorities driven) - recent Heat Strategy provide support BUT need to transform local authorities initiatives into strengthening of knowledge networks, skills and supply chains for greater momentum and legitimation	B with elements of A

5. Heat pumps	Very low	- heat pump technology is considered mature - not much skill and experience in the UK - current UK market for heat pumps is fairly small and niche (marginal off-grid pockets) - commercial distribution and promotion networks are poorly developed - lack of installation expertise on the ground. - high expectations about future deployment - within UK heating policy, heat pumps are seen as the main long-term option for domestic heating, especially from 2030 and onwards BUT deployment of heat pumps in the UK likely depend on the decarbonisation of the electricity system and efficiency improvements in the housing sector.	B
6. Low energy retrofits	Very low	- currently small market - large potential market, of old and poorly insulated building stock - retrofits rely on a number of proven techniques (insulation, glazing, ventilation) that have matured over the last decades, and have been deployed successfully elsewhere (e.g. Sweden, Finland, Germany, etc.) - publicly funded demonstrations are accumulating experimental knowledge on the ground BUT Important barriers to deployment include costs, building conservation requirements, a lack of skills and knowledge in the building industry, and poor material supply	A with elements of B

Table 6: Momentum analysis of 6 niche-innovations in the UK heat domain

While most niche-innovations have a dominant leaning towards one of the ideal Pathways A or A, some also have elements of both, as will be argued below.

Small biomass has many elements of a Pathway B development insofar as it is driven by new entrants (fuel supply and dedicated appliance manufacturers), is currently framed as a decentralised option, is relatively independent of the existing gas distribution infrastructure and related agencies, and requires a cultural-cognitive shift towards greater user involvement in heating practices. However, it also has elements of a Pathway A development insofar as it is compatible with a heating regime based on individual appliances with point-source heating.

District heating has many elements of a Pathway B development as it implies a shift in mentality towards collective energy provision, and requires substantial new infrastructure investments in heat networks, involving new actors (and skills) coalescing around new business models allowing commitment to investments with long lead times. However, it also has elements of a Pathway A development insofar as it is compatible with large-scale stationary heat production (albeit with local distribution) and the involvement of large energy suppliers.

Heat pumps are much more difficult to categorise. They have elements of a Pathway B development, as they rest on fundamentally different technical principles (heat transfer rather than combustion), are likely to involve dedicated actors and skills (installation, construction, etc.). However, in their present configuration, heat pumps are heavily reliant on large-scale centralised power supply and distribution network, and depend on decarbonisation in that domain.

Solar thermal heating has many elements of a Pathway B development insofar as it is currently an 'off-grid' or back-up energy proposition, disconnected from centralised energy systems or boiler-based heating, seeks to make the most of widely and freely available solar radiation, and rests on relatively new entrants and skills (that partly build on PV development).

Low energy retrofits have many elements of a Pathway A development insofar as they aim to improve the existing building infrastructure by implementing a number of known measures (replacing or upgrading conventional insulation materials, etc.) with an obvious role for the construction/refurbishment sector (albeit with the adoption of new skills and ways of doing). However, a number of elements point toward a Pathway B development, and particularly the relationship with major innovations occurring in the area of passive and zero-energy houses, which promise to fundamentally revisit the way we conceive of domestic heating, and how the construction sector operates (new actors, principles, and skills base).

Smart heating controls and meters have many elements of a Pathway A development insofar as they aim to tap into a latent energy saving potential, and are mainly driven by established energy utilities as a means to improve and balance their supply and distribution system through data-driven management at grid-level, etc. However, smart metering is inscribed in larger visions of smart energy systems for which it arguably may provide the infrastructure enabling all sorts of Pathway B type developments.

2.6. Green niche-innovations in the UK mobility system

Table 7 summarises the conclusions of the niche-analysis of UK mobility case, with regard to relative ranking, contributions to momentum, and pathway A/B assessment.

Niche and ranking	Main drivers of momentum	Transition pathway	Momentum
1) (Plug-in-)Hybrid Electric Vehicles:	Ongoing growth in the numbers licensed since the early 2000s and momentum in the UK. The automotive industry is the main actor. In the UK governance is a response rather than agenda-setting. The aim is to attract the production of new models to safeguard economic activity, to address carbon emissions reduction and to use tax and fiscal measures to stimulate uptake. HEVs can be used in similar ways to conventional ICE vehicles and therefore require little reconfiguration of infrastructure or user practices. For use in plug-in mode there is an emergent plug-in infrastructure in the UK and changes in user practices are needed. • Moderate momentum for market trajectory of HEVs • Moderate socio-cognitive momentum • Moderate governance and policy momentum	A	Moderate
2. Battery Electric Vehicles:	A new cycle of hype in the UK since 2005. Social, organisation and technological networks are being developed. Yet, BEVs remain a highly marginal part of UK mobility. In the production and use of BEVs there are many similarties with ICE. There are also numerous differences including an emerging, policy-driven plug-in infrastructure and new production and R&D facilities in the North-east of England. There is a key role for	A	Moderate

	incumbent actors. The main inhibitors to greater momentum are issues of vehicle range and cost. UK policy on BEVs aims to address decarbonisation and economic development. • Low momentum in terms of market trajectory • Moderate socio-cognitive momentum • Moderate governance and policy momentum		
3. Inter-modal Ticketing (Smart Cards):	Long-term growth in London and limited development elsewhere in the UK. The challenge of building an interoperable smartcard specification was underestimated. The policy narrative is of the 'inevitability' of smartcards but this has met the reality of the need for new business processes and commercial agreements. Smartcards aim to integrate sub-regimes of the public transport regime; this involves both existing interests and new interests in configuring new business processes and user patterns. • Momentum of market trajectory is high in London and low elsewhere • Socio-cognitive momentum is low to moderate • Governance and policy momentum is low to moderate	A/B	Low
4. Car-sharing/Clubs	'Haphazard' development from 2000, with rapid growth in membership from 2007 (geographically concentrated in London). Car clubs remain highly marginal. The sector has undergone and continues to undergo rapid change. Local authorities are key actors whose role is subject to experimentation. This requires significant reconfiguration in conceptions of users, business model, tracking, monitoring and payment infrastructure and a mix of new and incumbent actors. • Momentum of market trajectory is moderate in London and low elsewhere • On the socio-cognitive dimension there is low to moderate momentum • In governance and policy terms momentum is low	B	Low
5. Biofuels	Shift from optimism around 2003 that biofuels could provide a viable (if partial) substitute for UK liquid transport fuels to a flatlining of supply towards the end of the decade. Biofuels are currently more expensive than fossil fuels. It is difficult to characterise a UK-specific trajectory of biofuel technology development. The UK governance style at present appears unlikely to provide the required push to reach targets set at the European level. Can be viewed as substitute for liquid transport fuels. Though a wider framing sees the reconfiguration of land-use systems from production for food to production for fuel. • Market trajectory momentum is low to moderate • Socio-cognitive momentum is low • Governance and policy momentum is low	A	Low
6. Hydrogen Fuel Cell Vehicles	Were the subject of much hype from the late 1990s, that stalled around 2005 in the face of technical and cost difficulties and the 're-emergence' of BEVs. Since 2012 there have been the beginnings of a much more modest momentum in the UK. In order to be able to support hydrogen fuel cell vehicles, the existing road infrastructure and some manufacturing capacity can be used. A new hydrogen production, distribution, storage and fuelling infrastructure needs to be configured around the vehicle -	A/B	Low

	elements of which have been the subject of demonstrations in the UK. • Market trajectory momentum is low • Socio-cognitive momentum is low to moderate • Governance and policy momentum is low		
7. Urban Cycling/Sharing Schemes:	The UK's largest scheme commenced operation in 2010. There have been limited responses in the rest of the UK. Other interventions alongside bike-sharing may be important in reducing congestion, such as congestion charging. An effective public transport system and governance capacity may be a pre-requisite. Reconfiguration of many elements around the bicycle - requires a new conception of users, new business models, new actors, tracking, monitoring and payments technologies and the strategic development of infrastructure. • Market trajectory momentum is very low, except in London where it is moderate to high • Socio-cognitive momentum is low outside of London • Governance and policy momentum is very low	B	Very low
8. Compact Cities	The idea of a compact city has been promoted by national and sub-national policymakers and architects. There are many contemporary visions of new and 'retrofitted' cities which have limited realisation. By far the most well-developed is in London. In other cities in the UK this is much more piecemeal. This is not surprising given the weaker governance powers and capability relative to London and the less well-developed public transport systems. Involves a fundamental reconfiguration of a city through designing in public transport and designing out car use. • Market trajectory momentum is very low • Socio-cognitive momentum is very low • Governance and policy momentum is low to moderate	B	Very low

Table 7: Ranking of UK mobility niches in terms of momentum and pathways

Each of the eight niches involves some substitution and also some reconfiguration. Whether each of these eight niches are *more* oriented to pathway A or B can be summarised as follows:

1. Battery Electric Vehicles: In the production and use of BEVs there are many similarities with ICE. There are also numerous differences including an emerging, national policy-driven plug-in infrastructure and new production and R&D facilities in the North-east of England. The main inhibitors to greater momentum are issues of vehicle range and cost. Pathway A.
2. (Plug-in-)Hybrid Electric Vehicles: HEVs can be used in similar ways to conventional ICE vehicles and therefore require little reconfiguration of infrastructure or user practices. For use in plug-in mode there is an emergent plug-in infrastructure in the UK and some changes in user practices are required. Pathway A.
3. Hydrogen Fuel Cell Vehicles: In order to be able to support hydrogen fuel cell vehicles, the existing road infrastructure and some manufacturing capacity can be used. A new hydrogen production, distribution, storage and fuelling infrastructure needs to be configured around the vehicle - elements of which have been the subject of demonstrations in the UK. Pathway A/B.

4. Biofuels: Can be viewed as substitute for liquid transport fuels. Though a wider framing sees the reconfiguration of land-use systems from production for food to production for fuel. Pathway A.
5. Car-sharing/Clubs: This requires significant reconfiguration in conceptions of users, business model, tracking, monitoring and payment infrastructure and a mix of new and incumbent actors. Pathway B.
6. Urban Cycling/Sharing Schemes: Reconfiguration of many elements around the bicycle - requires a new conception of users, new business models, new actors, tracking, monitoring and payments technologies and the strategic development of infrastructure. Pathway B
7. Inter-modal Ticketing (Smart Cards): Smartcards aim to integrate sub-regimes of the public transport regime; this involves both existing interests and new interests in configuring new business processes and user patterns. Pathway A/B.
8. Compact Cities: Involves a fundamental reconfiguration of a city through designing in public transport and designing out car use. Pathway B.

2.7. Green niche-innovations in the Dutch mobility system

The Netherlands presents an interesting context for experimentation in the mobility domain, and is positioning itself at the cutting edge of many of the innovation presented in this report, providing a 'test-bed' for niche experiments and their development.

Table 8 summarises the conclusions of the niche-analysis of Dutch mobility, with regard to relative ranking, contributions to momentum, and pathway A/B assessment.

Niche	**Momentum**	**Main drivers of momentum**	**Pathway**
1. Hybrid electric vehicles (HEVs)	High (beyond niche)	- high momentum: mass commercialisation, important market share, stable design features. No longer niche? - Stepping stone within a broader governmental vision of 'electric mobility' - Gradual introduction of electric features within conventional cars paving the way for EVs - Next evolutionary step: plug-in hybrids - BUT unlikely that it will survive a mobility transition in the long-run because of technical compromise Techno-economic momentum: high (installed) Socio-cognitive momentum: high (accepted) Governance and policy momentum: stable	A
2. Carsharing	High	- positive signs of increasing momentum in recent years - urban markets developing fast. New services, new locations, etc. - Increasingly embeddedness in existing automobility networks (e.g. manufacturers, car hire services, municipalities) - Positive cultural and symbolic meanings (e.g. environmental, congestion) - Linked to high innovation rate (e.g. ICT, EVs, insurance, business model) - Policy visions as integral part of future mobility systems with a different role to play in a variety of pathways Techno-economic momentum: high Socio-cognitive momentum: high (actors and acceptance) Governance and policy momentum: high (support)	B with elements of A

3. Battery electric vehicles (BEVs)	Moderate	- multiple hype/disappointment cycles - Currently renewed momentum with indications that a significant threshold has been passed - market deployment of commercially viable vehicles - strong policy support for progress towards charging infrastructure rollout and national deployment targets - enthusiastic involvement of fleet operators - successful deployment of hybrids vehicles as a 'stepping stone' - increasing public exposure. - BUT achieving high density and interoperability of charging opportunities crucial for the stabilisation of development trajectory Techno-economic momentum: moderate (innovation but no dominant design) Socio-cognitive momentum: high (expectations and visions) Governance and policy momentum: moderate (support for rollout)	A with elements of B
4. Biofuels	Moderate	- Path creation initiated in the 1990s with hype/disappointments - Developments driven by EU policy since the early 2000s: market creation for biofuels *blending* - Flexifuel niche is small and stagnant (in Europe) - Technological diversity: 1G and 2G biofuels, in reaction to sustainability controversy o Progress on 1G commercialisation o Remaining doubts about commercial viability of 2G - Recent deployment of pilot & commercial plants indicates stabilisation - BUT concerns about traceability & scope for sustainably scaling up Techno-economic momentum: high (innovative sector) Socio-cognitive momentum: low (controversies) Governance and policy momentum: moderate (obligations)	A with elements of B
5. Compact cities	Moderate (past)	- past innovation. Substantial momentum and instalment (1960s-1990s), then abandoned in NL, in favour of network model - transportation and land-use regimes interaction - spatial planning innovation rather than technological focus - strongest driver was political will (national govt support) for change and policy implementation process (local planning regulations and practices) - agreements with developers (powerful private regime actor) - unexpected and often counterproductive results on sustainable mobility: no lasting improvement, but halting more negative development Techno-economic momentum: low Socio-cognitive momentum: moderate (consensus – at the time) Governance and policy momentum: high (strong political will –at the time)	A but could enable B
6. Hydrogen fuel cell vehicles	Very low	- Technologically at an experimentation (demonstration) stage - Precursor market experiments just emerging - High costs - considered as option for the medium and long term (2030 and beyond) - BUT doubts because of repeated hype cycles to date Techno-economic momentum: low (early days) Socio-cognitive momentum: low (not much exposure) Governance and policy momentum: low	A with elements of B

Table 8: Momentum analysis of niche-innovations in the Dutch mobility domain

Most niche-innovations have a dominant leaning towards one of the ideal Pathways, but also some elements of the other.

Battery electric vehicles have many elements of a Pathway A development insofar as they offer substantial improvement of propulsion technology within the frame of existing automobility (component substitution), and that most existing car manufacturers are now involved. However, they also have elements of a Pathway B development because they have been spearheaded by and generate space for new entrants, they require massive investments in charging infrastructure for which public authorities are most likely to be involved, they currently challenge drivers by requiring them to overcome or address their range anxieties, and are developing hand in hand with new forms of (service-oriented) mobility.

Hybrid electric vehicles have many elements of a Pathway A development insofar as they are an add-on technology that complements existing ICE engines with an electric drivetrain, and are developed by large incumbent car manufacturers without challenging prevailing notions about automobility or its underlying infrastructure. They however provide an interesting 'stepping stone' opportunity towards BEVs.

Hydrogen fuel cell vehicles have many elements of a Pathway A development insofar as they offer substantial improvement of propulsion technology within the frame of existing automobility (component substitution), and that many existing car manufacturers are currently developing prototypes. However, they also have elements of a Pathway B development because they require massive investments in charging infrastructure for which public authorities are most likely to be involved, they would challenge drivers by requiring them to overcome or address their range anxieties, and are linked to visions of a hydrogen economy which entails fundamental changes within the industrial (hydrogen production) fabric. Their time horizon appears further away than other niches considered here.

Biofuels have many elements of a Pathway A development insofar as their current NL application in blending with conventional fuels is not challenging the automobility regime (underlying processes, roles, and institutions), but only creating space for new actors and processes at the margin of the petrol fuel and distribution regime. However, they also present elements of a Pathway B development, in relation to land use, agro-food, and resource extraction regimes as they propose fundamental new ways of harvesting energy from land (and the oceans), with a potential new role for actors crossing traditional domain boundaries.

Car-sharing has many elements of a Pathway B development insofar as it is centred on new ways of considering (auto)mobility, operating a shift from material ownership to on-demand service, involves new entrants (fleet managers), encourages and builds on innovation across domains (e.g. ICT-intensive, compatibilities with BEVs, etc.), and is in greater alignment with visions of multi-modal transport. However, it also presents elements of a Pathway A development, insofar as it is based on automobility.

The compact city has many elements of a Pathway A development insofar as it is mainly based on the central agency and influence of (national and local) policy actors in reshaping urban development patterns in more desirable directions with objectives spanning multiple domains (housing, mobility, land use, etc.), but with limited involvement of dynamics on other dimensions (technological, cultural, etc.). Spatial planning at the city level nonetheless

offers interesting opportunities for the alignment of socio-technical change that may provide acceleration and directionality to Pathway B type changes.

2.8. Green niche-innovations in the Dutch agro-food system

The agro-food sector has some characteristics that distinguish its transitions from transitions in other domains. First, the agro-food chain consists of many actors between production and consumption, each with their own problems and challenges. Second, the agro-food does not focus on one or a limited number of 'core' technologies what means there is no major technology breakthrough to be expected. Third, the production in agro-food systems is geographically dispersed and depends on the natural environment (space and resources) and its characteristics and conditions (soil characteristics, rivers, and weather conditions such as sun, rainfall, droughts, and storms).

Table 9 summarises the conclusions of the niche-analysis of the Dutch agro-food domain, with regard to relative ranking, contributions to momentum, and pathway A/B assessment.

Ranking of niche innovations	**Main drivers of momentum**	**Pathway**	**Overall momentum**
1) Sustainable fishing (Marine Stewardship Council)	Techno-economic: - Growing market share for MSC labelled fish - Difficulties with competition between large and small fisheries (certification is expensive)	B	Medium
	Socio-cognitive: - Much attention by large players - MSC is criticised - A lot of attention in public discourse: VisWijzer, Sustainable fish week, etc.		
	Governance and policy: - Governments adopt MSC regulation in their regulation - Focus is mainly on production not on consumption		
2) Dairy alternatives/ Soy drinks	Techno-economic: - Small market share, but increasing - Is becoming more widely available - Slightly more expensive alternative for dairy products	B	Medium
	Socio-cognitive: - Health aspects (lactose intolerance or perceived health benefits) are most important reason for consumers to shift to dairy alternatives; Environmental concerns are mentioned as well. - Change of habit is needed to change role of dairy in diets		
	Governance and policy: - No specific policy support - Government does play a role in responsible soy debates		
3) Vegetarianism, flexitarians	Techno-economic: - Economic reasons can be a reason for people to eat less/no meat - The market for meat-substitutes is stable, but number of people eating less meat (flexitarians) is growing	B	Medium
	Socio-cognitive: - Change in diet asks for change of habits, preferences and culture - LMIs (Less Meat Initiatives) have a role in increasing awareness on consequences of eating meat - Number of people eating less meat is increasing		

	Governance and policy: - Institutional environment is difficult to change, high stakes of parties involved - Dutch policy is not advising citizens on behaviour.		
4) Local and regional food	Techno-economic: - Number of initiatives and market share is increasing - Growing potential number of consumers - Local/regional food is not available for everyone as financial and social costs are involved	B	Medium
	Socio-cognitive: - Attention for authenticity of food is increasing - It is built on opposing the dominant system, and therefore it will not easy to move it to become mainstream - Availability year round and diversity of products are hindering factors		
	Governance and policy: - The government itself can only play a role by acting as launching customer.		
5) Organic food	Techno-economic: - The market share is small (2,4%) and relatively stable, even though organic products are sold for years - The number of organic farms is increasing	B	Medium
	Socio-cognitive: - It is remarkable that in a saturated food market organic food consumption was growing last 10-15 years - Reasoning for farmers to become organic is changing.		
	Governance and policy: - Government goals not reached - Governmental support was available		
6) Algae production for fish feed	Techno-economic: - Technically possible - Expensive production process	A	Medium
	Socio-cognitive: - In case it will become economically feasible the fish feed companies can play a major role in introducing it in the production chain.		
	Governance and policy: - Government is together with businesses investing money in research on algae production. However research is focusing on different applications of algae (e.g. energy production)		
7) Hybrid meat	Techno-economic: - Production costs are still high and R&D investments are decreasing - Marketing barriers still exist	A	Low
	Socio-cognitive: - Only a couple of actors on the market: partly new actors and partly established market parties - Health and environmental impacts can make hybrid meat interesting enough to become more widely available. - The name ‘hybrid meat’ is difficult to understand and often associated with ‘manipulation’		
	Governance and policy: - Policy is supporting research and developments with SBIR subsidies (Small Business Innovation Research).		
8) Cultured meat	Techno-economic: - Very expensive to produce cultured meat - Technical difficulties to produce it, especially on a large scale	A	Very low
	Socio-cognitive: - Potential a solution to land use issues, greenhouse gas emissions,		

	energy and water use associated with animal production - The opinion of consumers differs and cultured meat is both framed as 'solution to industrialised animal production' and 'modifying food' - There is a need for increased research on both technical issues and consumers opinions related to cultured meat		
	Governance and policy: - So far the government is subsidizing research - Government can play a role in knowledge development		

Table 9: Conclusions of Dutch agro-food niches

In general we can say that momentum for agro-food niche innovations is medium. However, these niche innovations are addressing various aspects of the agro-food system, varying from production to consumption. In general we can state that the role of the consumer and his diet, preferences etc. is important. All the niche innovations described are partly depending on the choices made by the consumer to buy or intend to buy a product or not. This part of the chain has mainly to do with consumer behaviour. On the other hand the market can determine the assortment of products and wider availability can lead to an increase in income and investments.

Another interesting point we can draw from this analysis is that there is an important role for businesses and the market. Government is mainly involved in regulations and is in some cases subsidizing the first developments (e.g. cultured meat and hybrid meat). Incumbent players have a huge role (e.g. supermarket deciding to sell hybrid meat or local/regional products), and it seems that regime actors have a prominent role in the upscaling of niche innovations as they have a lot of power. Crises, but also the feeling of urgency can lead to a breakthrough. For example food crises related to animal diseases or food scandals increase awareness and the need for a change of the system (regulations, organisations but also production methods). Health issues are increasingly a driver for change, mainly influencing behaviour of consumers (e.g. meat consumption, dairy consumption).

The niche innovations, MSC, Local food, Organic food, vegetarianism/flexitarianism and soy milk are mainly oriented towards pathway B. These innovations are mainly on transforming behaviour and are dependent on wider societal change. These innovations are mainly step-by-step moving in a certain direction and are less obvious creating a 'turn'/change towards lowering GHG emissions and land use.

Cultured meat, hybrid meat and algae are more technically oriented innovations and belong more to Pathway A. Once these innovations become more efficient, they could lead to a systems change leading to a change in impact on land use and GHG emissions. But we want to stress that the wider behavioural and cultural changes are necessary to make these innovations more prominent.

2.9. Green niche-innovations in the Portuguese agro-food system

Much of Portugal's agriculture is based on small farms, about half of the agricultural area is High Nature Value Farmland, and much of the agricultural area is under high risk of soil erosion or located in marginally productive soil, often with difficult topography and isolated from major transportation corridors or consumption centres. By contrast, industrial agriculture occupies smaller land shares and uses the latest technology available to thrive in a

very competitive international market. Therefore, sustainable solutions within the Portuguese context need both to address both fragmented land ownership as well as the extensive vs intensive divide as far as production modes is concerned. There is also the need to address lower carbon emissions within the agro food sector namely by shortening food miles. Another important issue within the agro food sector is to implement sustainable fishing practices.

Table 10 summarises the conclusions of the niche-analysis of the Portuguese agro-food domain, with regard to relative ranking, contributions to momentum, and pathway A/B assessment.

Niche-innovation and ranking	**Momentum**	**Main drivers of momentum**	**Pathway**
1) Organic farming	*Medium (to Low)*	**Techno-economic:** -Supply: Organic farming areas occupy more than 6% of the Portuguese UAA. The increasing organic land share large is a major driver of the momentum. Furthermore, new products are becoming organic. The organic wine production is still small but as there is market demand from external countries it is likely to steadily increase in the future. Demand - organic food in Portugal represents only 0.2 % of market shares being one of the lowest retail shares in Europe). However, this figure likely underestimates the real market transactions of organic food. Over the last few years, there has been increasing demand for organic food, boosting the number of specialised organic shops and organic farmers' markets. Sales have also been rising in mainstream supermarkets and health/organic food shops. Even in the current economic crisis situation in Portugal, the growth of organic retail sales is not increasing but is neither showing any signs of slowing down. **Socio-cognitive:** Both formal and informal organic food commitment. Learning and knowledge transfer is in place amongst formal organic farmers as well as several organic grass roots movements including charities, schools, etc. **Governance and policy:** - The organic farming is a niche that goes very well in the extensive and semi extensive land use systems of Portugal. Governance for this niche can transform what was once a handicap into an asset. - In the future, financial reasons constrain direct support; indirect support is available but its attractiveness to farmers is unknown	B
2) Shifts towards local food (PROVE)	Medium (to Low)	**Techno-economic:** Although market shares have been increasing it is still considered small approximately 2 % . In 2013 the PROVE initiative gave a mean monthly income of 600 euros to each one of the 130 farmers involved. **Socio-cognitive:** - Enlarging the community of faithful consumers mostly in urban and peri-urban areas. - Ability to network amongst 130 farmers and 5 000 consumers which have been successful engaging with wider society.	B

		Governance and policy: There is the need for longer term policy commitment, the network takes time to develop.	
3) Local breeds	Low	**Techno-economic:** Very active movement for certifying local breads, 33 autochthones animal breeds were registered in the last decade. Increasing market shares for certified local meat **Socio-cognitive:** The underlying motivations of the committed actors are both the appeal of maintaining the cultural values which are embodied in some of these local breeds as well as higher revenues. Consumers in Portugal are willing to pay the relatively higher prices of certified meat. The niche has been in development for some time yet new local breeds are still being registered but the number of new breeds being registered is decreasing. **Governance and policy:** Both the number of certified species as well as their market shares is important in the Portuguese context. Actors stated that in some cases the fact that meat is certified is a market barrier. The certification process is not only bureaucratic but expensive.	B
4) **Sustainable fishing**	Low	**Techno-economic**: Market shares of the whole fish sector are very important in Portugal but the market shares of sustainable fishing is unknown. Portugal has been committed in gauging the sustainability of the Portuguese fleet. **Socio-cognitive:** - Recreational fishing becoming important - There is active research on sustainable fishing **Governance and policy:** Need for more bottom up approaches. So far the government sets the policy goal and engages stakeholders on a formal top down approaches.	A/B
5) Eating less meat vegetarianism	Very low	**Techno-economic:** According to the estimates of the Portuguese vegetarian centre, in 2007, only 0.003 % of the Portuguese population was vegetarian. Since then the number of vegetarians is believed to be increasing but there are no recent estimates. Surprisingly though, despite the very low number of vegetarians in Portugal there is a high number of vegetarian restaurants and, more importantly, in all the "conventional" restaurants there is always, with barely no exceptions, a vegetarian dish option in the daily menu. It seems that although the demand is low there is a well-established offer that was even able to transform the mainstream menus! **Socio-cognitive:** - Very high committed community, structured network of actors but needs to overcome the cultural habits of the Portuguese meat diet. - Health issues and ideology are main underlying motivations of the vegetarian society. **Governance and policy:** No direct policy commitment but indirect measures such as increasing the negotiation power of big supermarket chains contributed to a decrease of vegetarian products.	B

6) Algae production for fish feed	Very low	**Techno-economic:** - Small number of spin off enterprises. - Algae production for feeding fish is a mediate topic. If feasible and economically viable it might change the aquaculture sector. Nevertheless further research and possibly new technologies have to become available. **Socio-cognitive:** Knowledge transfer from science to business seem to occur but more research is need to unveil the microalgae "universe" **Governance** Science based research and knowledge transfer policies in place but higher policy commitment is needed	B

Table 10: Conclusions of Portuguese agro-food niches

The momentum of most of these niche-innovations is medium to low. The niche considered with higher ranking was organic farming, followed by shifts towards local food, local breed, sustainable fishing and finally algae production. The majority of the niche-innovations are oriented towards Pathway B, with very dedicated actors, often outsiders or fringe actors. But their networking abilities and low socio/technical performance mean they face difficulty in reaching the mainstream. Only sustainable fishing involves a Pathway A. It also has elements of Pathway B, because the role of recreationalists in pushing the momentum might increase.

2.10. Analysis of green niche-innovations in the Hungarian agro-food system

From a socio-technical systems viewpoint the Hungarian agro-food sector could be depicted as a dual economy with a large-scale agro-industry and service providers on the one hand and dispersed small producers and organizations on the other. Hungary joined the EU ten years ago and recent studies have shown that for the most part the country's agri-food sector has been on the losing side of EU accession.

Sustainability goals have been introduced through the Hungarian Agri-Environmental Programme (HAEP) but Hungary still has the lowest rate of organic production in the EU. Remnants of informal and non-market mechanisms within the economy that evolved as a way of compensating for the supply side deficiencies of the planned economy helped maintain a strong local food culture and some aspects of sustainable agriculture in traditional agricultural family households.

A recent stocktaking of short food supply chain and local food system development differentiated between two types of supply chains. On the one hand the 'traditional' SFSCs that are farm-based, in rural locations, usually operated on-farm by family businesses and using traditional and artisanal production methods. On the other hand the 'neo-traditional' supply chains, more consisting of complex collaborative networks, often off-farm (delivery schemes in particular) or with strong social and ethical values (CSAs), urban (or peri-urban)-centred are more subject to a non-profit approach[3]. Recent simplification of food legislation on short food supply chains (SFSCs) and local food systems (LFSs) helped traditional food supply systems, such as farmers' markets, roadside and farm gate sales, you-pick farms, local

[3] Kneafsey, M., Eyden-Wood, T., Bos, E., Sutton, G., Santini, F., y Paloma, S. G. Trenchard, L. (2013). Short Food Supply Chains and Local Food Systems in the EU: a state of play of their socio-economic characteristics: Publications Office.

food festivals and food trails gain widespread attention, whereas other 'neo-traditional' supply schemes, typically initiated by urban non-farmers such as local food shops, purchasing groups, Community Supported Agriculture (CSAs) have also gained momentum.

Top-down policy processes under the New Agricultural and Rural Development Strategy 2020 open a window of opportunity for bottom-up initiatives. By creating an enabling environment, proportionately much higher allocation of (financial) resources for LFSs and SFSCs was made available.

The strongest actors of the agro-food sector are processors and traders; whereas retailers controls vertical food supply chains and small-scale producers have the least power to influence supply chains. Producers often need to make use of their own funds because of the high cost of loans and the relative immaturity of the farm credit and crop insurance system, particularly in the small producer segment of the sector. Lack of trust, capital shortage and hostile feelings towards co-operatives hinder the cooperation of the small participants of the agro-food sector. A very high level of consumers' total income is spent on food while relatively high proportion of the population is taking an active part in food self-provisioning. A recent study suggest that in a survey representative to the adult population of Hungary 36 percent of respondents stated that they have or use a garden, field or orchard, either by their house where they live or elsewhere[4].

The reality of organic farming in Hungary is that overall momentum of the movement is low, but in spite of this, the outlook is likely greater now than any point within the last decade. It is expected that gaining the full benefits EU support which is shifting to prioritizing ecological farming will give the organic sector in Hungary a much needed boost.

Vegetarian eating habits are constantly broadening especially among health conscious consumers and a new niche-market has been constructed within the counterproductive food policy framework promoting the expansion and modernisation of animal husbandry. Restaurants and food-delivery enterprises supplying vegetarian food have only a limited market share growth.

Alternative food production and distribution schemes in Hungary play an increasing role in restoring relationship between urban and rural areas. Struggles with financial autonomy, self-sustainability, and challenges of remaining only a sporadic example with no real momentum are on the current horizon.

The CSA sector is likely to expand through facilitating learning processes by educating members in adhering to healthier diets, and procuring food in a more environmentally friendly way, while also assisting the development of community relations, fostering the culture of sharing, gifting, bartering and donating. The main risk for farmers is to rely only on external financial resources to shape their markets.

Table 11 summarises the conclusions of the niche-analysis of the Hungarian agro-food domain, with regard to relative ranking, contributions to momentum.

Relative ranking of niche-momentum	**Main drivers of momentum**	**Pathway**	**Momentum**

[4] Balázs, Bálint (2014): Food Self-Provisioning in Hungary (unpublished manuscript).

1. Localized food chains, regional food production	Increasing role in restoring relations between urban and rural areas with considerable environmental benefits. Challenge of remaining isolated without real momentum. Struggles with self-sustainability.	B	Medium
2. Community Supported Agriculture	Increasing numbers of consumers and widening social network, but Recurring price anomaly weakens the economic momentum; Policy clearly supports the innovation.	B	Medium
3. Organic agriculture (including consumption / demand side)	Price/performance improvements main driver Policy forms a secondary driver (because price/performance improvements led to positive visions that lead to support policies) Networks of big firms and policymakers are increasing, but there are still doubts and contesting views in wider public	B	Low
4. Vegetarianism / lowering meat consumption	Broadening network and niche-market of the health conscious through restaurants and food-delivery enterprises. Counteracting food policy, no sign of direct support	B	Low

Table 11: Conclusions of Hungarian agro-food niches

All four cases belong to pathway B. Changes depend on wider societal change, especially from the most important players of the broader regime. Some of the new entrants in the sector (mainly small scale enterprises with considerable capacity to risk taking and handling uncertainties) take the lead in shaping socio-technological changes reflecting wider behavioural and cultural changes in the consumption patterns. None of these niche-innovations has great momentum, and could be interpreted only as very tight pathways providing transition of more and more initiatives taking baby steps towards sustainability.

2.11. Green niche-innovations in the Portuguese land-use system

Land use in Portugal has been under multiple socio-economic, environmental as well as political pressures. Multifunctional land use is seen as promising for halting biodiversity loss as well as for enhancing the biodiversity status in the context of Portugal. In order to instil innovative land management strategies suitable for addressing biodiversity issues more generally there is a need to explore the development of promising multifunctional niches.

Table 12 summarises the conclusions of the niche-analysis of the Portuguese land use/biodiversity domain, with regard to relative ranking, as contributions to creating momentum.

Niche-innovation and ranking	**Momentum**	**Main drivers of momentum**	**Pathway**
1) Biodiverse cities	*Medium (to low)*	**Techno-economic:** - The number of Urban Farming (UF) has been steadily increasing over the last decade. From a set of small number of cases in 2000- highly connected with ideological motivations- the	B

		movement rapidly generalized to 61 Urban Farming (UF) varied grass root movements. Major Portuguese cities such as Lisbon, Porto and Coimbra hold simultaneously different types of urban farming movements – some led by municipalities, while others are carried out by schools or charities. - Traditional Green Infrastructures (GI) have increasingly been managed more environmentally friendly, due to pressures by recreationalists such as birdwatchers - Urban planners play a key role by merging UF movements within the city "traditional" green infrastructures GI. **Socio-cognitive:** - Share of knowledge. Urban farmers usually involve their families so farming knowledge passes through generations: Social networks are increasing: urban farming involves farmers, research institutions, charities, schools. - Commitment by planners to link UF and GI is increasing in Portugal. City councils are feeling pressures to reduce the financial costs of GI management. As urban farmers manage the allotments at their own costs city councils save money in managing GI. **Governance and policy:** In the Portuguese green growth strategy for 2020 biodiversity in cities is taken seriously and there are very specific milestones to achieve it.	
2) **Land sharing,** Integrated Territorial Integration (ITI)	*Medium (to low)*	**Techno-economic:** ITI- Integrated Territorial Interventions – was one of the measures included into the Portuguese rural development program 2007-2013. For the first time, one national programme compensated farmers and communal lands organizations for their management of land for nature. There were approved 1919 projects this representing a budget of 61 196 million euros for enhancing the biodiversity status of the traditional farming systems included into protected areas/heritage sites. This is capital considered of utmost importance for enhancing biodiversity status in protected areas. **Socio-cognitive:** - The implementation of ITI gave the opportunity to fringe actors such as communal land organization to enhance its agro-silvo and cultural heritage as a whole. - Communal land managers take up the program while individual farmers did not see it as particularly rewarding. **Governance** ITI is by itself an innovative form of governance, sharing goals between agriculture and nature. There were visible problems in the implementation as the targeted actions were not achieved	B
3) Business and Biodiversity (BB)	*Medium (to low)*	**Techno-economic:** - Though the B and B programme, companies voluntarily undertake biodiversity compromises such as restoring habitats for wild animals, planting new forestareas, foreseeing to get better reputation and social acceptance. In Portugal, there were 64 official compromises between private enterprises and the Business and Biodiversity programme. - Restoration of habitats for different bird species was one of the most popular B and B actions. - As it comprises restoration of areas, money should be available for longer periods for their management and maintenance.	B

		Socio-cognitive: The voluntary nature of the programme aims at creating trust between actors and an increasing commitment from society but this engagement with the civil society was not achieved by the program. Learning as well as knowledge share can be enhanced by the BB program **Governance and policy:** - The government will support again the BB program with a very high commitment to it. - It is targeted to increase in 50% up to 2020 and in 75% up to 2030 the number of environmental compromises. This is in line with CDB-COP 2007. The problem is in our view that the type of actions to undertake are not specified. Enterprises can simply commit to support the program doing nothing to improve biodiversity status.	
4) Biodiverse pastures	*Medium (to low)*	**Techno-economic:** - Pastures occupy a larger share of the Portuguese land. Biodiverse pastures is a new way of managing grasslands in Portugal. Sown Biodiverse Permanent Pastures Rich in Legumes (SBPPRL). The Portuguese carbon fund has been supporting the geographical expansion of the SBPPRL by remunerating the farmers for the provision of an environmental service. 50 000 ha of SBPPRL were installed from 2009 to 2014. - In addition to the previous the carbon fund also demonstrated interest in remunerating the farmers willing to control shrub encroachment at pastures through the use of non-invasive techniques promoting carbon sequestration in the soil, 37 000 ha of shrubs were removed without mobilizing the soil. **Socio-cognitive:** Private enterprises and NGOs were crucial. The "business" model seems to work well. 1400 farmers were involved in this movement and the interaction and learning processes of such an high number of farmers both with forestry and agriculture NGOs as well private companies seem to work well **Governance and policy:** - A lot of policy support- and money from the Portuguese carbon Fund -was decisive for the success of the niche development until now. - As the niche developed only with public money and there is uncertainty of funds in the future, the useful development of the past might came be hampered in the future. - Until now the actors involved were not able to be independent from public funds-although future strategies include the involvement of consumers to see the extent to which they can pay higher for the meat produced in these pastures.	B
5) Fire Resilient landscapes	*Low*	**Techno-economic:** - Although the Mediterranean type vegetation presents unique adaptation characteristics to fire, forest fires are the most important threat to biodiversity of forests and wooded areas in Southern Europe. There is a very high commitment from the society as a whole for addressing the fire issues in the context of Portugal. - Despite innovative socio-economic arrangements are in place e.g. Targeted grazing and its networks it is still missing a comprehensive strategy to make the fire issue viable in techno	B

		economic terms. **Socio-cognitive:** High societal demand for the urge to act as far as reducing the impacts of fire is concerned, and maybe, the economic crisis in Portugal- likely fostering imagination-created innovative land management strategies. In fact, partnerships amongst private and public bodies are becoming more common- as willingness to cooperate is higher. Actors supporting this innovation emerged from the civil society from different backgrounds. Fire issues extend well beyond the places were forest is located – in situ- but also extend directionally and omni-directionally . The core actors that "officially" started developing/supporting the innovation were "formal" governmental institutions that called for the engagement of civil society and NGOs into the process. **Governance and policy:** Policy commitment is high as well high is the societal awareness. There was an even higher policy commitment some years ago	
6) Land sparing-rewilding	Low	**Techno-economic:** In densely populated areas such as Europe, ecological rewilding, can be seen as implementing by only reducing human control of landscapes through the passive management of ecological succession at the landscape scale. Ecological rewilding can be seen as an opportunity to steer the unintended land abandonment process already under way in inland Portugal. **Socio-cognitive:** There is small scale empirical research showing that the rewilding process is seen by local populations as negative. The main argument against it is that it implies the loss of landscape identity- e.g. the cultural meaning of humanized landscapes will be lost. The main argument in favour is that is able to offset the ongoing land abandoned process with possible economic gain to farmers… **Governance and policy:** There are European as well as national movements by NGOs exploring the rewilding concept and its implementation issues. There is no policy commitment to it yet	B
7) Multi-functional landscapes for energy	Low	**Techno-economic:** - The area of land managed for the production of renewable energy has been increasing. For example, some communal organizations see as more rentable to manage the land to produce energy-wind turbines rather than the traditional timber industry. - New business models are developing with very different energy sources such as biomass either from forestry or by agriculture by products. Some businesses use this energy production reduce their energy costs this way becoming more competitive e.g. the hot water from producing olive oil being used to heat the company building (e.g. Sovena) **Socio-cognitive:** The Portuguese are particularly committed to go renewable and are proud to be one of the countries with the renewables have been steadily increasing. There was a technical political debate over the argument that forestry biomass will solve the problem of forest fires hence being a win-win solution. It is nowadays an established concept. **Governance and policy:**	A/B

		There is still a strong governmental commitment, but not at the same level of the past.	

Table 12: Conclusions of Portuguese land-use niches

The results of this study show that the rate of momentum is low to medium for all the niches studied. The niche seen as having the higher momentum is biodiverse cities, follows the land sharing-ITI niche, the business and biodiversity BB, biodiverse pastures, fire resilient landscapes, land sparing-rewilding, and multi-functionality for renewable energy. The majority of the niche-innovations have very dedicated actors, often outsiders or fringe actors (Pathway B), but their networking abilities are insufficient to reach the mainstream. It is important however that some niches are already translating into some mainstream practices. Nevertheless, this study highlighted that the majority of the niches will struggle to embed into mainstream. Another important outcome of the study is that some of the niche innovations studied are linked to each other- mutually reinforcing each other as well as the multifunctional land use niches space. For example some actors leading the fire resilient landscape niche (enterprises participating in the target grazing) also committed to Business and Biodiversity programme. The networking amongst the different actors of the different land use niches might be useful for enhancing some of the multi-functional land use niche momentum.

2.12. Green niche-innovations in the Dutch land-use system

The competing claims on land lead to changes in the way land is used. Multifunctional land use combines different functions in a certain area, and aims that these functions are strengthening each other. Combining different functions of land will reduce the amount of space needed, but can also lead to for example new economic activities (in the case of multifunctional agriculture) or change environmental impacts. In multifunctional land use every type of land use is part of its own socio-technical regime, we have to deal with combinations of regimes. Important land uses in the Netherlands are agriculture, cities (built up areas), recreation (as sport fields and large parks for example), infrastructure, water (storage, transportation) and nature conservation.

Table 13 summarises the conclusions of the analysis of multi-functional land-use niches in the Netherlands, with regard to relative ranking, contributions to momentum.

Niche innovation	**Main drivers of momentum**	**Pathway**	**Overall momentum**
1) Agro-food business and biodiversity	Techno-economic: - Number of participants in projects is rising (e.g. in 2014 around 500 (4%) arable farmers was part of the Skylark foundation) - But dependent on the financial situation of the business	B	Medium
	Socio-cognitive: - Social network is increasing: new actors entering the market; big industrial players involved as well - Commitment is increasing: Biodiversity is becoming a more important part of companies' strategies as they are becoming more aware of their dependency on biodiversity and the risks and opportunities that are associated with biodiversity for their business. They are aware they need to deal with biodiversity - Learning is increasing: Community of Practice (CoP) to exchange ideas and knowledge		
	Governance and policy:		

	- Policy support is increasing: e.g. projects like The Economics of Ecosystems and Biodiversity (TEEB) are gaining attention and biodiversity is increasingly linked to economy.		
2) Agricultural nature conservation	Techno-economic: - The number of initiatives (and farmers participating) is still increasing - Is about a new way of generating income - As it is about maintaining areas, money should be available during a longer period (it is not about an investment once) - The amount of land used for agricultural nature conservation is increasing	B	Medium
	Socio-cognitive: - The network of urban farmers is growing as more farmers are participating - The idea is that the amount of land used for agricultural nature conservation will further increase until 2020.		
	Governance and policy: - It can be expected that only 25% of the farmers will apply agricultural nature conservation without subsidies, so farmers are still depending on policy support via subsidies. - Policy is changing: agricultural nature conservation will be organised in a collective way		
3) Water management and nature conservation	Techno-economic: - Different options are available to develop more room for the river (it is technically feasible)	B	Medium
	Socio-cognitive: - NGOs, Rijkswaterstaat and land owners were able to connect to each other and realize their own goals leading to collaborative actions. - Windows of opportunity for several policy domains came together (biodiversity goals, protection population against floods, creating nature)		
	Governance and policy: - A lot of policy support as a result of floods in the 1990s leading to a budget of 2.2 billion euros for Room for the River projects.		
4) Local renewable energy	Techno-economic: - Number of projects is increasing: wind farms, biomass production, use of biomass from nature areas - New models are developed to pay investments in local cooperatives	B	Medium
	Socio-cognitive: - Need for renewable energy as fossil fuels will become scarce in the future, lead to geopolitical instability and contribute to global warming. - Social network is increasing as new type of organisations are entering the market: e.g. local energy cooperatives - NIMBY (Not In My Back Yard) effects of wind farms/mills - Competition with existing incumbent parties		
	Governance and policy: - Regulations need to be adapted to new ways of organising energy production (e.g. taxes, etc.) - New ways to deal with spatial planning necessary		
5) Urban Farming	Techno-economic: - No business models available for the long term, and economic figures are not available - Number of initiatives is increasing	B	Low
	Socio-cognitive: - Social network is increasing as many initiatives are popping up - Visions: A lot of promises for sustainability, however also a lot of uncertainties regarding the effects on sustainability - Related to health effects as well		

	Governance and policy: - No active policy support - Spatial planning causes difficulties		
6) Tourism (combining agro and tourism and nature and tourism)	Techno-economic: - Nature is a 'social good' (belongs to everyone and no-one), what makes it hard to reward it - Relatively stable market share in relation to other secondary activities of farmers	B	Low
	Socio-cognitive: - The idea is that if people spend their spare time in nature, they will become aware of it and willing to help protecting the area - Tourism and nature conservation are separate worlds, hardly combined		
	Governance and policy: - New collaborations often difficult to fit in regulations		

Table 13: Conclusions of Dutch land-use niches

The overall momentum in the land use domain is medium. Many activities have started. A lot of these niche innovations are related to public goods. Therefore the government is a major source of money for nature conservation, making the developments dependent on policy support. In general the amount of public money available is decreasing, and this means people are looking for other ways of combining practices leading to different functions in one area to increase possibilities and make efficient use of resources.

A distinction can be made between maintaining and spatial planning/design innovations:

- Maintaining land is about measures to maintain certain characteristics of the area. Measures are necessary over and over again, so is money. One investment is not enough, but money is necessary on a regular basis. Examples of maintenance innovations are: agro-food business and biodiversity, local renewable energy, agricultural nature conservation and tourism.
- Spatial planning/design innovations ask for an investment in the beginning (e.g. water management and nature conservation) and only a limited amount of money in later stages. One investment can lead to a change in land use. The innovations urban farming and water management and nature conservation belong to this category. It is also possible that a change in spatial planning lead to a change in land use that is not necessarily multifunctional, but a shift from one way of land use to another.

Niche-innovations that combine functions and collaborate with other actors or participate on different movements simultaneously (e.g. protecting against floods and creating nature) tend to lead to more efficient land use and directly or indirectly influence biodiversity.

Niche-innovation in multifunctional land use seems to be examples of reconfiguration of the regime. Multifunctional land use combines functions and therefore is especially happening on the margins/edges of the existing systems. Rules and regulations do not always accept the combination what makes it for example difficult to implement new initiatives in existing spatial planning.

Breakthroughs are often caused by crises (e.g. floods of the 1990s, oil crises).

In the Dutch land use domain, all innovations are in Pathway B. Most innovations are about wider societal change and are about a broader societal involvement. New parties are entering the domain (e.g. local energy collective, collaborations between companies and farmers) but existing actors are also developing new tasks (e.g. farmers involved in tourism).