PATHWAYS project

Exploring transition pathways to sustainable, low carbon societies

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Deliverable D2.3: 'Integrated analysis of D2.1 and D2.2 to assess the feasibility of different transition pathways'

Main report: Introduction and findings from 11 country studies

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Preface

This report presents the findings from task 2.3 in WP-2 of the PATHWAYS project, which combines analyses from D 2.1 and D2.2 to assess the feasibility of different transition pathways in five empirical domains (electricity, heat/buildings, mobility, agro-food, land-use) for several European countries.

The PATHWAYS project aims to 'Explore transition pathways to sustainable, low carbon societies'. Work Package 2 aims to provide a socio-technical analysis of the *dynamics of transition pathways* in five empirical domains for several European countries. 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 2.3, based on findings in 11 country sub-reports that underlie this main report. These 11 reports make interpretive assessments of the feasibility (practicality, achievability) of sustainability transitions *in the present*, differentiated for pathway A and B, in five empirical domains and different countries:
Electricity: Germany and the UK
Heat/buildings: Sweden, Germany, and the UK:
Mobility: The UK and the Netherlands
Agro-food: The Netherlands, Hungary
Land use and bio-diversity: Portugal and the Netherlands.

This main report provides an introduction to task 2.3 (describing the conceptual framework and research template that all researchers shared) and offers the conclusions from the different country/domain studies (based on the executive summaries from these reports). For more information, the reader can consult the individual country/domain reports, which are available on the website of the PATHWAYS project (http://www.pathways-project.eu/).

Throughout the research process, there have been various interactions between the WP-2 coordinators and the different research teams. We also organised an internal review of each of the eleven country reports, including executive summaries. Despite these quality control measures, the various research teams are responsible for the findings and quality of the different country-reports, including summaries.

Contents

Executive summary and results

This report constitutes Deliverable 2.3 in the PATHWAYS project ('Exploring transition pathways to sustainable, low carbon societies'). Deliverable 2.3 combines the findings in D2.1 ('Analysis of green niche-innovations and their momentum in the two pathways') and D2.2 ('Analysis of stability and tensions in incumbent socio-technical regimes') to make an interpretive assessment of the feasibility of sustainability transitions *in the present* for five empirical domains, in the following European countries:
<u>1) Electricity</u>: Germany and the UK
<u>2) Heat</u>: Sweden, Germany, the UK
<u>3) Mobility</u>: The UK and the Netherlands
<u>4) Agro-food</u>: The Netherlands and Hungary
<u>5) Land use and bio-diversity</u>: Portugal and the Netherlands.

The core **research questions** are
1. Do your analyses of recent developments in green niche-innovations (D2.1) and regime (in)stability (D2.2) suggest that a transition is beginning to take place?
2. If so, does this transition look more like pathway A or pathway B (see Table 1)?

This main report has two parts.
The **first part** (chapter 1) provides a conceptual introduction and research protocol.
Section 1.1 describes the general socio-technical framework that guides WP-2 (section 1.1). This multi-level perspective (MLP) 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 2.2 focuses on the level of socio-technical regimes and landscape.
Section 1.2 conceptualises the temporal unfolding of transitions, distinguishing four phases:
- Phase 1: Predevelopment: R&D support, subsidized small market niches.
- Phase 2: Early market niches.
- Phase 3: Breakthrough, wider diffusion, self-sustaining momentum.
- Phase 4: Stabilization of new system.

The guiding question for D2.3 is whether or not transitions in different domains and countries has (or is about to) enter phase 3. Or are niche-innovations they still stuck in phase 1 or 2? Entering phase 3 requires two simultaneous developments, which we studied in D2.1 and D2.2.
- Have some niche-innovations gained high internal momentum? The analyses in D2.1 separated this momentum into three sub-dimensions: a) innovation and market trajectory (techno-economic), b) governance and policy, c) actors and social networks (socio-cognitive).
- Are existing regimes still strongly locked-in or are they beginning to 'open up' because of tensions and problems? D2.2 differentiated the overall regime lock-in in several dimensions (related to the main social groups): a) industry, b) consumers, c) policy-makers, d) public debate and opinion, e) pressure from social movements, NGOs, scientists.

Section 1.3 describes the research protocol that is used in each of country/domain report. This regime analysis protocol addresses the following analytical tasks:
- The internal momentum of each niche-innovation (very high, high, moderate, low, very low)? Give a brief qualitative description of the different dimensions of internal momentum (techno-economic, socio-cognitive, governance).

- Assessment of dominant system/regime trends in your domain/country (degree of lock-in and stability, degree of reorientation towards environmental problems).
- State which niche-innovations are about to break through (if any)? Does this suggest a transition is imminent or presently unfolding? If yes, does this transition follow pathway A or B?
- Based on the niche and regime analyses, what is the scale of the transition challenge (how far are developments removed from address the sustainability goals)?
- Are there indications that important actors (policymakers, wider public, big firms) are gearing up to address this challenge? For instance, are they developing concrete plans, visions, policies? Or is there generally too little sense of urgency in the public debate, limited political will, too little investment, perceptions that other problems are more important (e.g. sectoral jobs, economic recovery etc.)?

The **second part** of the report (chapter 2) provides the results of the integrative analysis of the current dynamics in different domains and countries. These results are based on the executive summaries from the 11 country reports that underlie this main report. These results, which aim to answer the questions above, are presented both in text and tables. The complete country-reports are available on the website of the PATHWAYS-project (http://www.pathways-project.eu/).

Results:
Table A below summarises the main findings from the 11 country reports with regard to the internal momentum of the various niche-innovations on a five-point scale (very high, high, medium, low, very low). It also attributes the niche-innovations to transition pathway A and B. Significant results from this comprehensive analysis are the following:
1) Most green niche-innovations have medium, low or very low momentum. This means that a transition does not appear to the imminent in most domains without further policy support.
2) Only a few niche-innovations are assessed as having high or very high momentum:

- Energy-efficiency light bulbs (both in UK and Germany), driven by a European ban in incandescent light bulbs
- German onshore wind, mainly enacted by new entrants (citizens, farmers, city authorities, NGOs) and civil society enthusiasm
- German solar-PV, mainly enacted by new entrants (citizens, farmers, city authorities, NGOs) and civil society enthusiasm
- UK offshore wind, stimulated by strong government support and private sector interest in attractive subsidies
- UK smart meters, with a 100% roll-out being mandated by the government by 2020.
- Dutch car sharing, with rapid increase in *urban* customers, positive cultural meanings and acceptance by policymakers as part of future mobility systems
- Dutch (plug-in) hybrid electric vehicles, with sales exceeding 5% of total car sales in 2012, high socio-cultural acceptance and moderate policy support

Most of these niche-innovations relate to new *technologies*, with only one option (Dutch car sharing) relating to a more prominent social innovation.
3) For three domains (electricity, heat/buildings and mobility), the niche-innovations seem more or less equally distributed over pathway A and B. For two domains (agro-food and land-use), most niche-innovations relate to pathway B. The suggested explanation for the latter is that regime actors in these domains mainly focus their attention on incremental improvements in the existing regime. Regime actors in these domains mostly perceive green niche-innovations as uninteresting or unviable, leaving them to smaller peripheral actors, who

develop more radical (pathway B) innovations, but have limited resources to achieve high momentum.
4) Some niche-innovations are differentially deployed and socially embedded in different countries, leading to Pathway A in one country and pathway B in another country. Onshore wind, for instance, is ranked as Pathway B in Germany (implemented by new entrants) and as pathway A in the UK (implemented by incumbent utilities). So, the character and meaning of niche-innovations may not be intrinsic, but related to actor strategies and perceptions.

	Pathway A	**Pathway B**
German electricity	CFL and LED lighting: High Offshore wind: Medium Smart meters: Low	Onshore wind: Very high Solar-PV: High Bio-energy: Low
UK electricity	CFL and LED lighting: Very high Offshore wind: High Bio-power: Medium Onshore wind: Medium	Smart meters: High Solar-PV: Low
Swedish heat/buildings	Heat pumps: Medium Waste heat recovery: Low/medium Small-scale biomass: Low Individual metering and billing: Very low	District heating: Low Low-energy housing: Very low
German heat/buildings	Heat pumps: Low Small-scale biomass: Medium Solar thermal: Low	Low-energy/passive house: Low/medium Smart metering: Low/medium
UK heat/buildings	Smart heating controls and meters: Medium Low energy retrofits: Very low	Solar thermal: Low Small biomass: Very low District heating: Very low Heat pumps: Very low
UK mobility	(Plug-in-)Hybrid Electric Vehicles: Medium Battery Electric Vehicles: Medium Inter-modal Ticketing (Smart Cards): Low Biofuels: Low Hydrogen Fuel Cell Vehicles: Low	Inter-modal Ticketing (Smart Cards): Low Car-sharing: Low Urban Cycling/Sharing Schemes: Very low Compact Cities: Very low
Dutch mobility	(plug-in) Hybrid electric vehicles: High Battery electric vehicles: Medium Biofuels: Medium Compact cities; Medium Hydrogen fuel cell vehicles: Very low	Car sharing: High
Dutch agro-food	Algae production for fish feed: Medium Hybrid meat: Low Cultured meat: Very low	Sustainable fishing, Marine Stewardship Council: Medium Dairy alternatives/ Soy drinks: Medium Flexitarians: Medium Local and regional food: Medium Organic food: Medium
Hungarian agro-food		Localized food chains: Low Community-Supported Agriculture: Low Organic agriculture: Low Vegetarianism/less meat: Low
Portuguese multi-functional land-use	Multi-functional landscapes for energy: Low	Biodiverse cities: Medium/low Land sharing: Medium/low Business and Biodiversity: Medium/low Biodiverse pastures: Medium/low Fire Resilient landscapes: Medium Land sharing Medium Rewilding: Low Multi-functional landscapes for energy: Low
Dutch multi-functional land-use		Agro-food business/biodiversity: Medium Agricultural nature conservation: Medium Resilient landscapes: Medium Local renewable energy: Medium Urban Farming: Low Agro-tourism: Medium

Table A: Summary of internal momentum and attribution to different pathways of niche-innovations in eleven different countries/domains

Table B below summarises the main findings from the 11 country reports on degrees of lock in (due to stabilizing forces) and degree of tensions/cracks (due to tensions and problems) in existing regimes in terms of a three point-scale (strong, moderate, weak). Significant results from this comprehensive regime analysis are the following:

1) Most empirical domains are not characterized by a single regime, but by multiple regimes. This observation is an interesting challenge for transitions theory, which mostly focuses on single regimes.

2) For most regimes the stabilising lock-in forces are 'strong' or 'moderate', which means that incumbent actors are still committed to them and are not reorienting themselves towards a major transition.

3) There are only few domains where existing regimes are weakly locked-in:

- German electricity generation which was assessed to have destabilised because of major tensions (due to nuclear phase-out, increase in renewable electricity technologies, ambitious greenhouse gas reduction targets in the Energiewende, financial and business model problems)
- UK cycling (despite small increases in recent years, UK cycling remains marginal and is mostly seen as an 'abnormal' activity)
- Dutch fishing (the regime is assessed as becoming less locked-in, because over-fishing problems and policies such as fish quota are leading to shrinking numbers of Dutch fishermen)

4) In most regimes, the cracks, tensions and endogenous problems are assessed to be 'moderate' or 'weak', which suggests that incumbent actors think that they can continue with business as usual or with incremental change.

5) There are a few regimes where tensions/cracks are assessed as 'strong', which in most cases (except German electricity) is due to economic problems:

- German electricity generation (major tensions because of nuclear phase-out, increase in renewable electricity technologies, greenhouse gas reduction targets in the Energiewende, financial and business model problems)
- Hungarian pork regime (tensions are mainly economic, related to price squeezes, competition and struggles for economic survival by Hungarian pig farmers)
- Portuguese agriculture regime (tensions mainly arise from economic problems, decreasing farmer income's and decreasing interest in farming from young people)
- Dutch nature regime: the old regime of nature protection (excluding humans from nature areas) is under pressure from new ideas and policies with more permeable boundaries between nature and society.

The combined conclusions from both tables **suggest that a transition is not imminent in most domains**, with the momentum of most-innovations assessed as medium, low or very low and most existing regimes assessed as relatively stable.

- German electricity generation is a clear exception, where a transition does appear to be underway towards renewable energy (with the Energiewende aiming for 80% renewable electricity in 2050).
- A low-carbon transition is also beginning to unfold in UK electricity generation. This is a more mixed transition than Germany, however, which the government envisages to include renewable electricity technologies (up to 30% by 2020, but no commitment afterwards) as well as expanded nuclear power and CCS (which would enable continued use of gas and coal).
- Although the Swedish heat generation regime is assessed as locked-in and niche-innovations having moderate momentum, it is worth pointing out that a low-carbon

transition has already largely occurred there, with 65-70% of heat coming from renewables.

For most other domains, however, the findings suggest that a sustainability transition will be slow in the absence of stronger policies, reorientation of firm strategies and greater public commitment.

	Lock-in, stabilizing forces	**Cracks, tensions, problems**
German electricity generation regime	Weak	Strong
German electricity networks regime	Moderate/strong	Moderate
German electricity consumption regime	Moderate	High
UK electricity generation regime	Strong	Weak/moderate
UK electricity networks regime	Strong	Weak
UK electricity consumption regime	Strong	Weak/moderate
Swedish district heating regime	Strong	Moderate
Swedish heat pump regime	Moderate/strong	Weak
German gas heating regime	Strong	Weak/moderate
German oil heating regime	Moderate/strong	Moderate
German district heating regime	Moderate	Moderate
German residential building stock	Strong	Moderate
UK heating regime	Moderate	Moderate
UK building regime	Strong	Weak/moderate
UK auto-mobility regime	Strong	Weak/moderate
UK railway regime	Moderate	Moderate
UK bus regime	Moderate	Weak
UK cycling regime	Weak/moderate	Weak
Dutch auto-mobility regime	Strong	Moderate
Dutch public transport regime	Strong	Weak
Dutch cycling regime	Strong	Weak
Dutch meat regime	Strong	Moderate
Dutch fish regime	Moderate	Moderate
Dutch dairy regime	Strong	Moderate
Dutch vegetable farming regime	Strong	Moderate
Dutch retail regime	Strong	Moderate
Hungarian pork regime	Moderate	Moderate
Hungarian beef regime	Strong	Moderate
Hungarian retail regime	Strong	Moderate
Land-use by Portuguese agriculture regime	Moderate/strong	Strong
Land-use by Portuguese forestry regime	Strong	Weak/moderate
Land-use by Portuguese nature regime	Strong	Moderate
Land-use by Portuguese urban regime	Strong	Weak
Land-use by Dutch agricultural regime	Strong	Weak/moderate
Land-use by Dutch nature regime	Moderate	Strong
Land-use by Dutch water regime	Strong	Weak
Land-use by Dutch urban regime	Strong	Moderate

Table B: Summary of stability and tensions in existing regimes in eleven different countries/domains

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 '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 *socio-technical 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 *socio-technical 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.

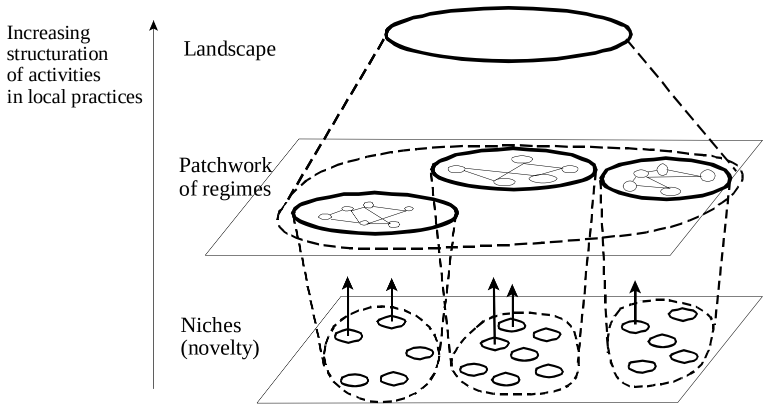

Figure 1: Static multi-level perspective as nested hierarchy (Geels, 2002: 1261)

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 the diffusion of niche-innovations.

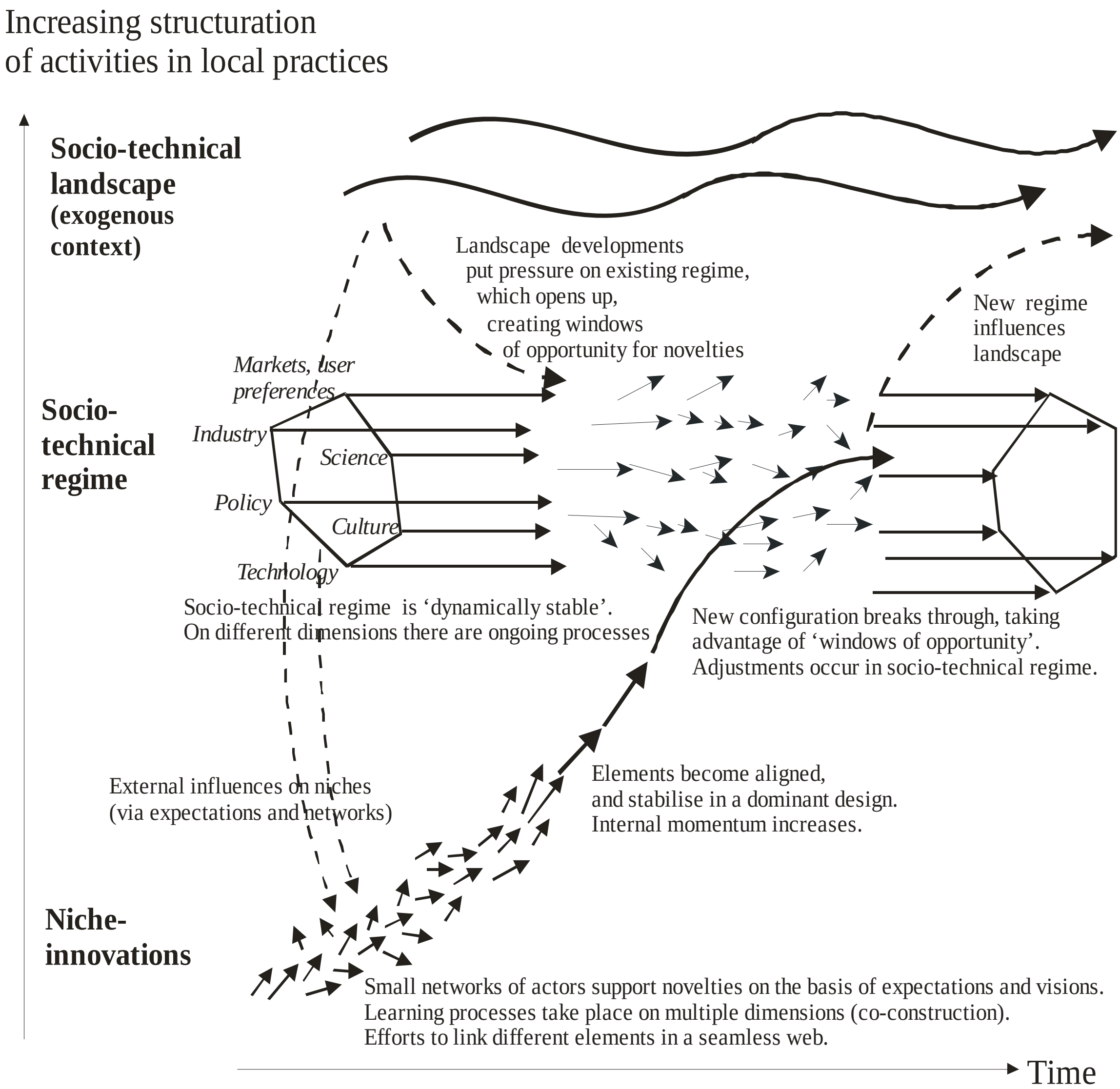

Figure 2: Multi-level perspective on transitions (adapted from Geels, 2002: 1263)

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 (Van de Poel, 2003). 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 (Geels, 2006a; Berkers and Geels, 2011). 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 changes 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.

Table 1: Ideal-type transition pathways and their defining elements

	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)

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 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.

Table 1 also includes a baseline 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). 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 A and B (Table 1).

Task 2.4: Comparison of transition pathways in between 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 2.3 in WP-2, which combines the findings in D2.1 ('Analysis of green niche-innovations and their momentum in the two pathways') and D2.2 ('Analysis of stability and tensions in incumbent socio-technical regimes') to make an interpretive assessment of the feasibility of sustainability transitions *in the present* in five empirical domains (electricity, heat/buildings, mobility, agro-food, land-use) for several European countries.

The remainder of this introductory chapter conceptualises the temporal dynamics of transitions, focusing on the breakthrough phase (phase 3). Section 1.3 describes the analytical research protocol for the different domain and country studies. Chapter 2 then present the core findings from the 11 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 on the temporal unfolding of transitions

The aim of this section is to briefly provide the main outlines of the conceptualisation of the temporal unfolding of transitions.

General phases in transitions

In all of our domains there are niche-innovations (which have been identified and analyzed in D2.1). But that in itself is not enough to bring about a transition. So, we need to better understand several phases in the unfolding of transitions, focusing on the dynamics for further up-scaling and breakthrough (which is ultimately necessary for a transition to happen).

We can distinguish four general phases in transitions, which are represented with vertical dotted lines in Figure 3.

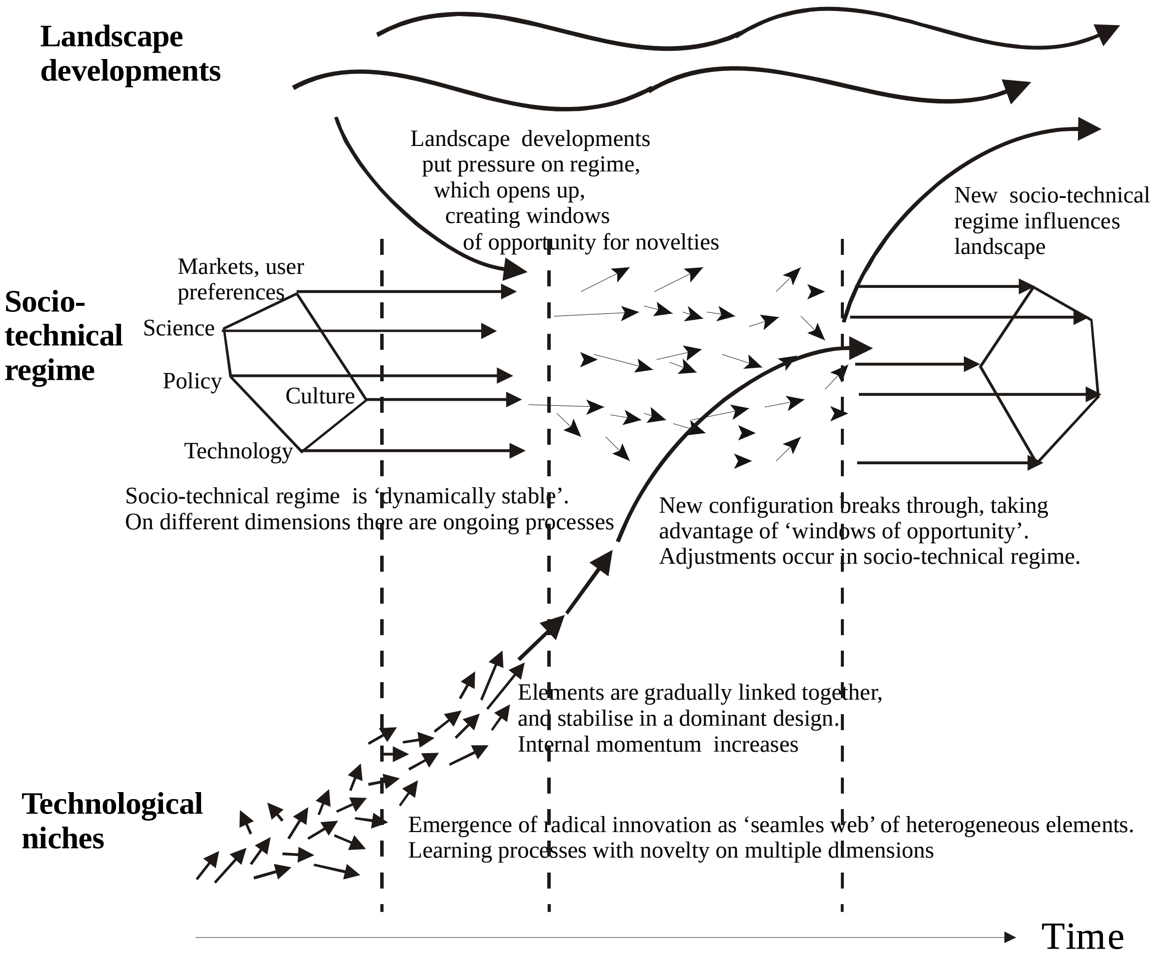

Figure 3: Four phases in multi-level perspective (Geels, 2006: 1006)

1) Predevelopment: R&D support, subsidized small market niches.
In the first phase, novelties emerge in niches in the context of existing regime and landscape developments. There is not yet a dominant design, and various options and designs may be competing with each other. Actors improvise, engage in experiments to work out the best design and try to align heterogeneous elements in co-construction processes. Actors support the niche, hoping that novelties will eventually be used in the regime or even replace it. This is not easy, because the existing regime is entrenched in many ways (e.g. institutionally, organizationally, economically, culturally). Radical novelties often have a mis-match with the existing regime and do not easily break through.
2) Early market niches.
In the second phase the novelty is used in small market niches, which may (still) benefit from some subsidies and policy support. Early market niches provide resources for real-world learning and specialization. Gradually a dedicated community (of engineers, producers, social movements, new entrants) emerges, directing their activities to further improvement of the niche-innovation. As this community articulates new standards, practices, rules and institutions, the niche-innovation develops a trajectory of its own. As users interact with the innovation and incorporate them into their user practices, they build up experience with it, and gradually explore new functionalities.
3) Breakthrough, wider diffusion, self-sustaining momentum.
The third phase is characterized by a breakthrough of the new technology, wide diffusion and competition with the established regime. There are two complementary drivers. On the one hand, there are *internal drivers* in the niche, e.g. price/performance improvements, increasing returns to adoption, virtuous cycles of niche-internal processes, and actors with vested interests that push for expansion of the technology.

On the other hand, breakthrough of technologies from the niche-level depends on *external circumstances* at the regime and landscape level that create 'windows of opportunity'. There may be ongoing processes or tensions in the regime to which the new technology can link up. Windows of opportunity can arise because of problems that cannot be met with the available technology, e.g. technical bottlenecks, reverse salients (Hughes, 1987), diminishing returns of existing technology (Freeman and Perez, 1988). There may also be changes in markets and user preferences, possibly influenced by wider cultural changes. Or changes may occur in policy agendas, resulting in stricter regulations that create problems for the existing technology. Competition and strategic games between firms may also create opportunities for new technologies. Relative outsiders, or firms that have lost market share, may invest in radically new technologies to leapfrog and outmaneuver incumbent firms. On top of that, there may be changes at the landscape level that put pressure on the regime and change the selection environment. The key point of the multi-level perspective is that transitions come about when niche-internal processes link up with ongoing processes and tensions at the regime and landscape level. This means that existing regimes are not only barriers to be overcome; ongoing regime processes may also provide opportunities.
4) Stabilization of new system.
As the innovation enters mainstream markets, it enters a competitive relationship with the established regime. In the fourth phase, the new system stabilizes and begins to replace the old regime. This is accompanied by wider changes in the socio-technical regime to remove mis-matches that the innovation had with wider socio-economic dimensions. The new regime may eventually influence wider landscape developments.

Specific dynamics for breakthrough in phase 3

These phases are useful for D2.3 because you can ask if your analyses show that the niche-innovations (which we studied in D2.1) are beginning to enter phase 3, which is when a transition really begins to occur. Or are they still stuck in phase 1 or 2?

Entering phase 3 requires two simultaneous developments, which we studied in D2.1 and D2.2.

- Have some niche-innovations gained high internal momentum? The analyses in D2.1 separated this momentum into three sub-dimensions: a) innovation and market trajectory (techno-economic), b) governance and policy, c) actors and social networks (socio-cognitive).
- Are existing regimes still strongly locked-in or are they beginning to 'open up' because of tensions and problems? D2.2 differentiated the overall regime lock-in in several dimensions (related to the main social groups): a) industry, b) consumers, c) policy-makers, d) public debate and opinion, e) pressure from social movements, NGOs, scientists.

The importance of the second development is that problems in the existing regime may lead to actor reorientations and developments that can enhance the momentum of niche-innovations. These, in turn, may help address three specific challenges for the upscaling of niche-innovations:

1) Finance and business interest:

Firstly, greater amounts of financial investment are needed to facilitate on-the-ground deployment of green options. This money can come from governments (e.g. direct investment programs, investment or adoption subsidies, capital grants, cheap loans, feed-in-tariffs, green investment bank), equity markets, or balance sheet payments from incumbent firms which diversify into the niche-innovation. Commercial actors and firms are often important to address the challenge of mobilizing large sums of money, as Giddens (2009: 123) notes: "The role of businesses, small and large, is going to be absolutely crucial in responding to climate change, not least because they will have to supply a good deal of the funding and also pioneer new technologies". The availability of these types of finance is shaped by economic conditions, financial regulations, investor confidence, investment strategies from big firms, and government incentives (including the provision of stability and security)

2) Changes in policy and institutional frameworks.

The second challenge in the take-off phase concerns changes in policy and institutional frameworks. On policy dimensions, the odds are often stacked against niche-innovations, because formal institutions have been adjusted to the needs of incumbent actors (Walker, 2000). Niche-innovations often face a 'mis-match' with existing institutions (Freeman and Perez, 1988). So, further breakthrough and wider diffusion depends on changes in policy and institutional frameworks. This is especially the case for transitions towards sustainability, which refer to collective goods (with associated free rider problems). Because private actors have no immediate incentive to address sustainability problems, public authorities have to change economic frame conditions and formal institutions (regulations, subsidies, incentives, taxes). That is why many green growth reports not only call for more investment, but also for stronger policies. UNEP (2011, p. 2), for instance, claims that: "there is a need for better public policies, including pricing and regulatory measures, to change the perverse market incentives that drive this capital mis-allocation. (…) To make the transition to a green economy, specific enabling conditions will be required. (…) At a national level, examples of such enabling conditions are: changes in fiscal policy; reform and reduction of environmentally harmful subsidies; employing new market-based instruments; targeting public investments to 'green' key sectors; greening public procurement; and improving environmental rules and regulations as well as their enforcement." Also the OECD (2011, p. 8) argues for changes in fiscal and regulatory settings (such as tax and competition policy), innovation policy, environmental policies, which "include a mix of price-based instruments (for instance environmentally-related taxes) and non-market instruments such as regulations, technology support policies and voluntary approaches". Similarly, Meadowcroft (2011: 71) argues that: "State intervention and governance reform are essential. To put this another way: markets may drive the uptake of the iPhone (…), but they will not produce a carbon emission-free energy system (…). Changes to *law* - modifying the regulatory frameworks within which economic actors conduct their affairs (for example, by introducing a carbon tax of a GHG emissions cap and trade system) - and *a significant expenditure of social revenue* (for example, to accelerate development and deployment of new technologies and to ease societal adjustment to new patterns of production and consumption) are essential to encourage sustainability transitions."

3) Changes in public discourse and support.

The third challenge in the take-off phase entails securing wider public support and cultural legitimacy (Geels and Verhees, 2011). This is instrumentally important because "whatever can be done through the State will depend upon generating widespread political support from citizens" (Giddens, 2009: 91). Urgent demands from public opinion can offer politicians incentives to jockey for green agendas (Burnstein, 2003). Major policy shifts are therefore often accompanied by shifts in public opinion and cultural discourse, which, in turn, are shaped by social movements, media, industry associations, and special-interest groups (Hilgartner and Bosk, 1988). The literature on issue-attention cycles offers interesting ideas in this respect. The basic proposition is that social problems ('issues') have dynamics of their own and go through several phases. Concerns about social problems tend to emerge in civil

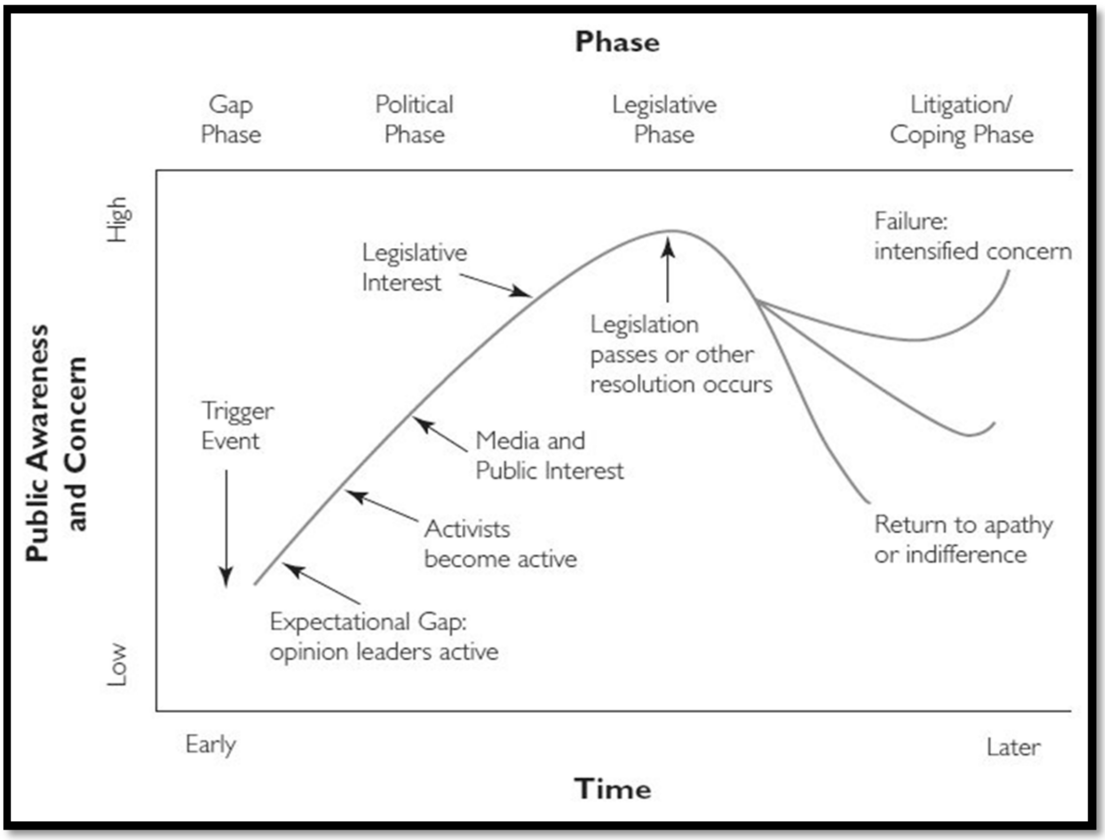

Figure 4: Temporal dynamics of issue lifecycles (Rivoli and Waddock, 2011: 91)

society, then affect public opinion, subsequently spill over to political debates, and possibly lead to policies (Figure 3). The introduction of substantive legislation often coincides with a peak in public concern (Y-axis in Figure 4).

Issue-attention cycles do not necessarily progress linearly through all phase. Public attention and concern may also decline *before* substantive legislation is introduced. Downs (1972) warned that such declines may happen when publics realize that the costs of solving the problem are very high. This realization may cause three reactions: "Some people just get discouraged. Others feel positively threatened by thinking about the problem; so they suppress such thoughts. Still others become bored by the issue" (p. 40). He also notes that attention to issues may decline because of competition with other prominent issues (see also Hilgartner and Bosk, 1988, who developed a conceptual model in which social problems compete for attention in public arenas). These considerations may be relevant for contemporary sustainability transitions, where the financial-economic crisis is potentially an issue that competes with sustainability concerns.

So, these three broader (regime-level) changes can accelerate the momentum of niche-innovations, which can propel their breakthrough and diffusion in phase 3. It is not a coincidence that these three broader changes can respectively reinforce the three dimensions of internal niche-momentum: a) techno-economic, b) governance and policy, c) socio-cognitive.

However, the text above also suggests that these broader developments (in finance, policy, public opinion) can reverse and weaken. For instance, the public may lose interest in the focal issue (because it seems too difficult to address or because other issues are perceived to be more pressing), political will may weaken (for instance because of elections, changing governments or lobbying from vested interests), and financial investment may diminish (if policies change or markets don't materialize).

1.3. Research protocol and report structure for task D2.3

The task for D2.3 is to combine analyses from D2.1 and D2.3, and investigate if there are niche-innovations in your domain/country that, firstly, have high or very high internal momentum and, secondly, if these niche-innovations can take advantage of the windows of opportunity provided by the regime problems.

Additionally, the task is to assess if, and to what degree, existing regimes are beginning to reorient themselves to address the focal environmental problems.

It is suggested that country/domain reports divide their reports into the following chapters.

Executive summary

Summarise the main findings of your report (both in brief text and in tables) with respect to:

- Breakthrough feasibility of the various niche-innovations
- Assessment of regime trends (degree of lock-in and stability, degree of reorientation towards environmental problems).
- Is a transition is imminent or presently unfolding? If so, does this transition follow pathway A or B? If not, make a statement about the scale of the transition challenge (e.g. discrepancy between contemporary developments and future goals).

Table 2: Breakthrough analysis of niche-innovations in the X domain in country Y

Niche-innovation	**Internal momentum**	**Strong or weak alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
XX				
YY				
ZZ				
Etc.				

Table 3: Assessment of regime trends in the X domain in country Y (with indicative 'scores')

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Regime A	weak	Strong	Limited (BAU)	e.g. too little sense of urgency
Regime B	Moderate	moderate	Moderate (some incremental change)	e.g. no political will
Regime C	strong	weak	Strong (substantial incremental change) ('radical incrementalism')	e.g. too little investment

1) Introduction

Set out goals, questions, structure of report.

2) Assessment of breakthrough feasibility of the various niche-innovations

Discuss <u>for each niche-innovation</u> (section 2.1 on niche X, section 2.2 on niche Y, etc).

1. What is the internal momentum of the niche-innovation (very high, high, moderate, low, very low)? Give a brief qualitative description of the different dimensions of internal momentum (techno-economic, socio-cognitive, governance).
2. How does the niche-innovation align with wider regime and landscape developments? Are there positive alignments (e.g. windows of opportunity related to regime problems) that result in: a) more finance, investment, b) positive, widespread public debates, c) broader policy adjustments, and political will, to help the niche-innovation diffuse? Or are there mainly mis-matches because existing regimes are still fairly stable?
3. Do the answers to question 1 and 2 suggest that the niche-innovation is about to break through more widely (i.e. enter phase 3)? If not, what is holding back the niche-innovation? Is it the lack of internal momentum (if so, which dimension)? Or the stability of the existing regime (and 'barriers' or mis-matches with the niche-innovation)

Please summarise the findings in a table like below.

Table 4: Breakthrough analysis of niche-innovations in the X domain in country Y

Niche-innovation	**Internal momentum**	**Strong or weak alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
XX				
YY				
ZZ				
Etc.				

3) Assessment of regime reorientation

Make an assessment of dominant system/regime trends in your domain/country (based on D2.2):

a) Are these trends continuing as Business as Usual, with limited regime change to address environmental problems?

b) Or are existing regime actors implementing incremental changes to address environmental problems?

Please summarise the findings in a table like below (adding your findings from report D2.2 to fill in the first two columns)

Table 5: Assessment of regime trends in the X domain in country Y (with indicative 'scores')

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Regime A	Weak	Strong	Limited (BAU)	e.g. too little sense of urgency
Regime B	Moderate	moderate	Moderate (some incremental change)	e.g. no political will
Regime C	strong		Strong (substantial incremental change) ('radical incrementalism')	e.g. too little investment

4) Conclusions and wider discussion

- State which niche-innovations are about to break through (if any)?
- Does this suggest a transition is imminent or presently unfolding? If yes, does this transition follow pathway A or B?
- Based on the niche and regime analyses, what is the scale of the transition challenge (how far are developments removed from address the sustainability goals)?
- Are there indications that important actors (policymakers, wider public, big firms) are gearing up to address this challenge? For instance, are they developing concrete plans, visions, policies? Or is there generally too little sense of urgency in the public debate,

limited political will, too little investment, perceptions that other problems are more important (e.g. sectoral jobs, economic recovery etc.)?

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2. Research findings from different country sub-reports

The sections below report the findings from the executive summaries of the 11 country-domain reports that underlie this main report for deliverable 2.2. The full reports are available on the website of the PATHWAYS-project (http://www.pathways-project.eu/).

2.1. Integrated analysis of the feasibility of transition pathways in the German electricity system

We combine niche and regime analyses conducted for the German electricity regime to assess the feasibility of transition pathways. For this, we consider the niches of solar PV, on- and offshore wind, bioenergy, CFL/LED lighting and smart meters, while the regime analysis is broken down into the electricity generation regime, the electricity consumption regime and the electricity network regime. Based on the developments in these niches and regimes in the past 10-15 years we make an interpretive assessment of the feasibility of the German energy transition of the electricity system *in the present*. That is, in this report we are focusing on the current status of the 'Energiewende', while a forward-looking analysis of future developments is reserved for a later PATHWAYS deliverable.

Breakthrough feasibility of the various niche-innovations
As a first step in this assessment we take a closer look at niche dynamics and their momentum. In particular, we assess the internal drivers in the niche and external circumstances at the regime and landscape levels to determine in which transition phase the development of the niche can be categorized. Our results are summarized in Table 6. The following main results emerge from this analysis:

- All generation niches are well or very well aligned with the landscape pressures arising from climate change and the anti-nuclear movement and benefit from Germany's strong manufacturing base. The same is true for CFL/LED lighting, but in addition energy security concerns are a further driver for this niche given its potential to achieve electricity demand reductions. Misalignments arise from environmental concerns which relate to wider sustainability impacts, such as on species or habitats (e.g. wind) and conflicting land-uses (most pronounced for bioenergy).
- In order to assess the alignment of a niche with the regime it is usually necessary not only to look at the most evident regime (e.g. generation regime for onshore wind) but to also asses the alignment with the interconnected network regime (e.g. delays in grid access in network regime for offshore wind, slowing down its momentum).
- Our analysis suggests that three of the six studied niche innovations have entered phase three, meaning that they have started diffusing more widely with largely self-maintaining momentum: onshore wind, solar PV and LED lighting.
- The majority of analysed niches anchored in the generation regime follow pathway B as actors tend to be new entrants and changes are evident in multiple dimensions (solar PV, onshore wind, bioenergy). In contrast, the analysed niches anchored in the network or consumption regime follow a pathway A type of transition pattern.

Table 6: Breakthrough analysis of niche-innovations in the electricity domain in Germany

Niche	Internal Momentum	Regime and landscape alignment	Breakthrough potential	Pathway
Solar PV	High (down from very high)	Very good (due to climate change, anti-nuclear movement, manufacturing base, and proportional voting system, and resulting cracks in generation regime; alignment with generation regime > network regime > consumption regime)	Entered phase 3, but with setback in 2013 (investments by new entrants, attractive FIT, unexpectedly strong LCOE reductions, target overachievement, EEG levy increase, compe-tition and consoli-dation, policy mix adjustments)	Pathway B (but some recent attempts to explore large-scale free field PV through the introduction of tender, interest of incumbents suggests some potential for pathway A characteristics)
Onshore wind	Very high (up from high)	Good (due to climate change, anti-nuclear movement, manufacturing base, and proportional voting system, but some conflict with environmental concerns; alignment with generation regime > network regime > consumption regime)	Entered phase 3 (investment by new entrants, attractive FIT, LCOE reductions, leader in the race for cheapest renewable energy technology, main challenge may be continued high level of public acceptance)	Pathway B (but cost-reduction tendency and interest by incumbents may lead to increasing number of large-scale parks, which for the future suggests some pathway A characteristics)
Offshore wind	Medium (fairly unchanged)	Fair - good (very good due to climate change, anti-nuclear movement, manufacturing base, mainstreaming in marine regime, but weak due to delays in grid access within network regime, mismatch between supply in North and demand in South and initial reluctance by (and against) incumbents)	Phase 2 (higher economic costs and technological risks than onshore wind, grid access delays, 2030 target reduction, may only enter phase 3 if cracks in onshore wind may call for alternatives)	Pathway A (but initial niche development was mainly driven by small project developers, onshore wind manufacturers, policy makers and regional utilities, while incumbents were late in joining this niche)

Table 6: Breakthrough analysis of niche-innovations in the electricity domain in Germany (continued)

Niche	Internal Momentum	Regime and landscape alignment	Breakthrough potential	Pathway
Bio-energy	Low (down from medium)	Good (due to climate change concerns, anti-nuclear movement, manufacturing base and possibly being a good complement to fluctuating renewables; but wider sustainability concerns and conflicting land uses)	Phase 2 (investment by new entrants, advantage of flexible generation, but high costs and limited reduction potential, competing uses, sustainability concerns, limits to further expansion)	Pathway B (mainly due to involvement of new entrants, including farmers and municipalities, and often small-scale character of plants, does not require radical change across all regime dimensions but can functions as complement to fluctuating renewables)
CFL/LED lighting	Very high (LED) Medium (CFL) (up for LED))	Very good (due to alignment with climate change and energy security concerns as well as pressures to reduce energy demand)	On the verge to phase 3 (LED) (high techno-economic progress, favoured by EU ban on competing incandescent bulbs)	Pathway A (technological substitution, so far without broader behavioural changes)
Smart meters	Low (with potential to increase to medium or even high)	Good (due to offering solution to challenges arising from intermittency of renewable power generation within smart grids by increasing flexibility)	Phase 2, with potential for breakthrough (positive CBA only for larger consumers, data protection concerns, but now 80% roll-out target until 2020)	A (if full potential of smart meters within a smart grid were harnessed, this could shift to pathway B, although small consumers likely not to be equipped with smart meters due to negative CBA rations and data protection concerns)

Regime orientation towards environmental problems

The electricity *generation regime* is undergoing radical changes, implying that the main future sub-regimes will be wind and PV with some flexible back-up (natural gas, biomass), but there is an ongoing dispute about the final regime dimensions. Resistance from regime actors is focused on reducing losses, buying time and identifying new business models to ensure survival in the new regime. In addition, there are major tensions and cracks in the electricity generation regime. The climate change problem and anti-nuclear movement have led to significant institutional changes, e.g. ambitious targets for GHG reduction, RES expansion and nuclear phase-out and specific policy instruments. The resulting structural changes in infrastructure (renewable energy makes up 50% of generation capacity, with a negligible share owned by large incumbents) with their reduction of electricity market prices and thus decreased profitability of existing conventional plants are forcing large incumbents to rethink their beliefs, strategies and organisational structures.

Table 7: Assessment of regime trends in the electricity domain in Germany

	Lock-in, stabilizing forces	Cracks, tensions, problems in regime	Orientation towards environmental problems	Main socio-technical regime problems
Generation Regime	Lock-in has weakened significantly, regime in flux, as transition is unfolding, resistance from incumbents focused on reducing losses and ensuring survival in the new regime	Strong, given major tensions due to pressure by growing share of fluctuating renewables (wind, PV) challenging business model and beliefs of incumbents due to merit order effect and firm political commitment to 'Energiewende' with nuclear phase out	Strong orientation towards expansion of renewables (at least 80% by 2050), phase-out of nuclear (by 2022) and ambitious GHG reduction target (-80 to 95% in 2050 for Germany's total GHG emissions)	Difficulty of phasing out coal leading to rising CO2 emissions, concern about deployment costs, market and system integration, potential public acceptance issues
Consumption Regime	Moderate / strong given future trend towards greater electrification (ICT, e-mobility, heat pumps), lack of supporting interest groups (lobbies) and rebound effects	Moderate given broad consensus on the benefits of energy efficiency, but only since 2014 seriously established as second pillar of 'Energiewende'.	Moderate (some incremental change leading to increased energy efficiency, but counter-effects partly overcompensating efficiency gains)	Lack of political will for progressive energy efficiency standards, little consideration of sufficiency options to reduce electricity consumption
Network Regime	Moderate as fairly stable regime, locked-in by rather conservative, slow-to-change regulation and public acceptance concerns	High, given strong tensions because of unfolding transition of generation regime and high political will to address delay in supportive changes in network regime to make 'Energiewende' a succses	Must-be enabler of 'Energiewende' by integrating rising share of fluctuating, decentralized renewables into electricity system (so far gradual change, but tendency for wider reorientation towards smart grids)	Low public acceptance of grid expansion, motivational and financial barriers to flexibilization of consumption regime, regulatory rigidity, conflicting interests of Federal States

In contrast, the electricity *consumption regime* remains partly strongly locked-in. The trend towards greater electrification in some fields (ICT, electric mobility, heat pumps) and some rebound effects (e.g. in lighting) may counteract the efforts to reduce electricity consumption. Also, there are some important actors for whom energy efficiency is not a top priority (esp. electricity utilities, retailers and wholesale trade); this may undermine the efforts to increase efficiency and reduce electricity demand. Yet, there is a relatively broad consensus of all affectted groups on the benefits of energy efficiency and the political target of reducing electricity consumption. In addition, energy efficiency has seen increased political attention since 2014.

The *network regime* is fairly stable with moderate lock-in. It is particularly the long-lived asset structure and regulation which stabilize the existing regime. Regulation changes, such as targeted investment incentives to spur certain developments, can theoretically be realized more easily, but seem to be slow and are not likely to result in radical changes but only gradual adaptations of the regulatory framework. However, pressures are very high. Renewable integration and increase in decentralized generation require adaptations to the network management and structure. This has already led to some changes being made to the regulatory framework allowing and encouraging network operators to make such adaptations. The changes also improve the incentives for network expansion, increase acceptance and streamline administrative processes. Also, there is a strong consensus that network expansion is needed at the transmission level as well as the expansion and greater intelligence of distribution networks. Further changes are targeted with adaptations in the regulatory framework and network access conditions and could trigger the reconfiguration of the network regime.

Transition unfolding in electricity generation regime with knock-on effect on network regime
Based on developments so far, we find that the transition challenge is smallest for the electricity generation regime and largest for the consumption regime, with the electricity network regime placed in the middle. However, all three regimes face substantial and unique socio-technical challenges, as summarized in the last column of Table 7. These problems are often connected to a lack of political will, resistance by vested interests, concerns regarding public acceptance and barriers to more radical changes.

As all three regimes are interconnected, the unfolding and carefully managed transition in the generation regime with the two break-through niches of onshore wind and solar PV (following pathway B) may have knock-on effects, particularly and most directly on the network regime that links generation and demand and therefore has an enabling function within the electricity system. The network regime is on the verge of moving to a reconfiguration pathway driven by changes in generation– albeit fairly slowly due to its conservatism. That is, given the great political commitment to the transition of the electricity generation regime towards renewable energies we argue that the network regime will eventually be tagged along, as the success of the 'Energiewende' project requires a reorientation of the network regime, as well. In contrast, so far the trickling through effect from the unfolding transition in the generation regime to the consumption regime is fairly limited. As a consequence the consumption regime has not moved beyond an incremental transformation pathway with gradual improvements in energy efficiency. However, most recent developments suggest an increase in political attention to energy efficiency as second pillar of the energy transition.

2.2. Integrated analysis of the feasibility of transition pathways in the UK electricity system

This report presents a combined analysis of findings from D2.1 and D2.2. It assesses the level of internal momentum for six niche-innovations in the UK electricity system and the extent to which these niche-innovations can take advantage of windows of opportunity provided by regime problems. It also assesses if, and to what degree, existing regimes are beginning to reorient themselves to address the focal environmental problems.

Internal niche momentum
Table 8 presents summary findings for the internal momentum of the six UK electricity niches, the extent to which the niches are aligned to existing regimes, future potential of the niche and whether the niche displays pathway A (mainly technology substitution) or B (deeper changes across several system dimensions) characteristics.
Three RETs (onshore wind, offshore wind and biopower) have been displaying moderate internal momentum and have strong alignment with broader regime characteristics because they conform to the large scale, centralized generation preferences of the incumbent industry and government. Solar-PV has low momentum (despite a recent burst of diffusion from a low base) and is poorly aligned to the regime because it involves new entrants and is largely associated with smaller scale, decentralized generation. Recent policy announcements (November 2015) about the removal or reduction of support for new RET initiatives suggest that the recent period of rapid RET diffusion will soon finish; there are significant

uncertainties about RET deployment beyond 2020, but in the absence of political support, the prospects do not look promising.

Table 8: Breakthrough analysis of niche-innovations in the electricity domain in the UK

Niche-innovation	**Internal momentum**	**Strong or weak alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
Onshore wind	Moderate	Strong: alignment with centralized, large-scale generation regime. Working with incumbents. Growing resistance from rural 'middle England'.	Further growth anticipated until 2020 (based on existing commitments). But, government support has been removed for new initiatives, so highly uncertain future.	A
Offshore wind	Moderate	Strong: alignment with centralized, large-scale generation regime. Working with incumbents.	Further growth anticipated, with Government visions to 2030. Cost concerns could create legitimacy problems.	A
Biopower	Moderate	Strong: alignment with regime has grown, especially with coal-to-biomass conversion, which fits with preferences for centralized, large-scale generation. Working with incumbents.	Boom-and bust over the next 5-10 years. Long-term prospects low, especially if CCS does not become viable.	A
Solar-PV	Low	Weak: deployed by new entrants and based on decentralized generation.	Despite a recent burst of diffusion, solar-PV remains marginal. Recent downgrading of feed-in-tariff is likely to significantly decrease diffusion	B
Energy saving lighting	Very High	Strong: technology substitution keeps regime largely intact, despite early difficulties with consumer uptake.	Following major EU regulation, CFLs (and halogens) have substituted ILBs. Prospects for LED substitution uncertain; negligible government support.	A
Smart meters	High	Strong: alignment with existing regime, with significant benefits expected for energy companies and considerable support expressed by Government. More radical consequences for changing consumer practices remain highly uncertain.	Mandated targets point to rapid and full diffusion by 2020. But, implementation problems and escalating costs could jeopardise this.	A (but some alternative visions hope for B character-istics)

For electricity consumption, the only significant niche innovation, energy saving lighting has had very high momentum, especially since the EU ban on incandescent light-bulbs in 2012. This ban stimulated a very rapid diffusion rate for energy saving light-bulbs, which had struggled to gain consumer acceptance beforehand. Although diffusion rates are still quite low for smart meters, this niche is considered to have high momentum because it has strong support from the UK government and powerful energy companies; a full roll-out is mandated for 2020, although this might be jeopardized if there are implementation problem or increasing concerns about high costs as some critics predict.

Regime re-orientation

Table 9 presents a summary assessment of developments in the generation, network and consumption regimes that make up the UK's electricity system, assessing the strength of stabilizing forces, cracks and tensions in the regimes, the extent of re-orientation to environmental and the main socio-technical problems in relation to a low carbon transition.

Table 9: Assessment of regime trends in the electricity domain in the UK

	Lock-in, stabilizing forces	Cracks, tensions, problems in regime	Orientation towards environmental problems	Main socio-technical regime problems
Generation Regime	Strong	Weak / Moderate	Limited / Moderate – plans to phase out coal, but new commitments to (shale) gas and nuclear (while removing support for RETs)	Political commitment to energy security and cost containment dominates climate protection.
Network Regime	Strong	Weak/ Moderate	Limited - some incremental change to accommodate RETs and upgrade grid to reduce 'leakage'	Incumbent resistance to more radical smart grid possibilities
Consumption Regime	Strong	Weak	Moderate – incremental innovations have yielded significant efficiency improvements across a range of domestic appliances.	Persistent cultural expectations drive demand for more domestic appliances (which are often more energy intensive).

Despite strong stabilizing forces, the generation regime has been experiencing some re-orientation. Coal powered generation has been under pressure and in November, 2015, the UK government announced that coal will be phased out over the next 10-15 years. However, this was accompanied by announcements of new commitments to nuclear and (possibly shale) gas powered generation. Political support for regime technologies is associated with strong commitments for lowering electricity costs and ensuring energy security; as such, support for RETs has been significantly reduced with the Conservative government arguing that 2020 renewables targets will be met on the basis of existing plans.

The network regime has experienced very limited re-orientation. Incumbent actors (especially, Ofgem and the distribution network operators) remain resistant to change and innovation efforts are focused on incremental improvements to the grid to reduce leakage and to incorporate RETs in new locations. There are visions for a future ICT enabled "smart grid", but little progress towards its realization.

The consumption regime has experienced moderate re-orientation through a focus on incremental innovation to increase the energy efficiency of domestic appliances. This has been stimulated by EU legislation (the Eco-design and Energy Labelling Directives), which stipulate minimum standards for the environmental performance of products that can be sold to consumers and comparable labels aimed at encouraging consumers to choose the most energy efficient products. International appliance firms, UK retailers and trade associations (especially AMDEA in the UK) largely support the efficiency agenda, which helps the sector to avoid criticism for high electricity bills and emissions. Efficiency improvements, however, have been partly offset by ratcheting demand for increasing numbers of household appliances, which in many cases are more energy intensive (e.g. larger fridges, plasma TVs).

Wider Reflections

- **Finance**: Financial estimates in various long-term (until 2023) scenarios suggest that the costs of the low-carbon transition range between £200 and £300 billion. While investments have increased markedly since 2010, the roll-out and system wide deployment of low-carbon options will require much greater expenditures in the next 15 years. The mobilization of this large amount of money is a major social and political challenge in the current climate of austerity and public cutbacks.

- **Politics and governance:** The unfolding of the UK electricity transition is very dependent on supportive government policies, which are underpinned by the commitments in the 2008 Climate Change Act. This radical policy was followed by a raft of specific implementation plans and policies. This dependence, however, makes the UK transition very vulnerable to the fickleness and fluidity of UK politics. Announcements in November 2015 bear out these concerns, with major reductions in support for RETs and new commitments for gas and nuclear. UK political governance is characterized by a technocratic, top-down, bulldozer style, in which a coalition of big firms and policymakers push through concocted plans rather than consulting with citizens and societal actors. This could cause legitimacy problems, potential leading to public resistance and protests, and therefore problems for a UK transition over the coming years.
- **Wider public:** There has been a decline in public attention for climate change in recent years, with attention shifting to concerns about jobs, competitiveness and energy prices since the financial-economic crisis. Civil society engagement in the energy domain is also conspicuously weak. At a broader level, some analysis suggests that the wider public has become more passive in relation to public debates more generally. If this broader problem is accurate, it may be quite a challenge to gain public support for the further unfolding of the UK electricity transition.

2.3. Integrated analysis of the feasibility of transition pathways in the Swedish heat system

Our Swedish heat energy domain case is one of few examples in the PATHWAYS project that shows radical system change over time where new niches have broken through and established themselves as new regimes. This development has been achieved with a combination of niche innovations and changes in old regimes. Importantly, the critical change of fuel in the District Heating (DH) regime was instrumental for the low carbon development of the system. This was a PATHWAY A change, resulting from concerted policy action that empowered new innovations, and spurred the de-alignment of existing technology solutions in the old oil-dominated regime. That is, change in the DH system has been rather narrow in a sub-set of system dimensions, most importantly switching fuels with minor adjustments in boiler technology, and some incorporations of innovations developed in niches. But clearly, change in the system has been aligned and symbiotic within the existing regime. Likewise, while Heat Pumps (HP) was originally a niche application, the reason behind its success has deep connections to other characteristics of our heat regime. It was aligned with the electricity regime (Air-to air HP), and, in the case of water radiator systems, aligned with that existing infrastructure in houses (ground source HP). Again, the incumbent regimes cannot be argued to have become substantially undermined and the dominating transition pathway pattern is one of symbiotic adoption of niche-innovations. But it is important to note that the net outcome has nonetheless been a rapid de-carbonization of the heat energy system. Despite the old regime’s reliance on fossil fuels, the past regime orientation was favourable to the transition. Reducing dependence on oil imports, securing supply, and early political commitments to tackle climate change was synergistic and oriented the regime toward solving the larger low carbon problem (Table 10). Finally, the success was inherently dependent on the high share of renewable energy in the power system and gradual phase-out of fossil fuels in the DH system.

In contrast to this, several of the niche innovations characterised as PATHWAY B type that require more significant system change along several dimensions meet heavy opposition unless they become aligned with existing regimes (Table 10). This clearly shows how inherently inert the Swedish heat domain system is, and that the way forward - based on the experiences of one of the few successful national cases in Europe - is that governance interventions need to consider system change, focusing on landscape pressures and regime dynamics, not only on niche innovations.

Table 10: Breakthrough analysis of niche-innovations in the Heat domain in Sweden

Niche-innovation	**Internal momentum**	**Strong or weak alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
Heat Pumps	Moderate	Well aligned, following "Transformation pathway" of symbiotic niche.-innovation and "De-alignment and Re-alignment"	Broken through, final phase four	Pathway A
District heating	Low	Perfectly aligned, is the regime, and developed in harmony with expanding society and need for energy	Phase four	Pathway B originally, but pathway A in terms of low carbon developments past 20-30 years
Waste heat recovery	Low	Perfectly aligned with the DH regime, again a transformation pathway of symbiotic niche-innovation	Phase two	Pathway A
Individual metering and billing	Very Low	Very limited alignment with regime and low niche protection.	Phase one, predevelopment	Primarily pathway A (Behavioural change, yes, but no fundamental change in several types of variables, no new technology needed)
Small-scale biomass	Low	Well aligned, technological substitution, but with few or none system changes	Phase two	Pathway A
Low energy housing	Very Low	Very high resistance from the regime	Phase one	Pathway B

Table 11: Assessment of regime trends in the Heat domain in Sweden

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Regime DH	Strong, natural monopoly	Moderate	Both High (GHG emissions reductions) and Weak (Waste incineration lock-in)	Overcapacity limits focus on Heat energy efficiency
Regime HP	Moderate (rather fluid between different types of HP solutions)	Low	High	None.

The current Swedish heat regime faces strong support from both policy and the civil society and is largely oriented toward solving environmental problems. Future goals of energy efficiency and material re-use rather than waste incineration are, however, new challenges where the current HP and DH dominated regimes are to some degree less well aligned to new environmental concerns and both regimes are part of the supply focused heat energy system in Sweden (Table 11).

2.4. Integrated analysis of the feasibility of transition pathways in the German heat system

In this report we assess the feasibility of different pathways towards a low-carbon heat domain in Germany as a contribution to a low-carbon society. In a first step, we assess the breakthrough probability of various niche innovations by appraising their internal momentum and analysing how they align with wider regime and landscape developments. We conclude that none of the niches analysed is about to break through in the short to mid term with the exception of a partial breakthrough of heat pumps in new buildings and low-energy standards for newly constructed buildings. An important aspect for discussion is that due to the low construction rate of new buildings, a transition depends largely on refurbishment of existing buildings. However, specific for the heat domain are very long investment cycles (about 20 years for heating systems, 30-40 years for buildings) and significant asset specificity of heating technologies. As summarized in Table 12, all niche innovations for heat supply have a low potential of break-through for existing buildings. For small-scale biomass heating systems the low potential especially relates to a currently missing joint position of manufacturers (incumbent firms with a diverse portfolio vs. specialised new market entrants), problematic asset specificity and high initial investment costs. The low break-through potential for solar thermal is mainly related to its inferior supply potential, i.e. the technology is not able to supply sufficient heat to completely substitute other heating appliances and can hence only be operated as an additional system. This further diminishes its already low cost efficiency. The third technology assessed, heat pumps, has a low momentum in existing building (medium for new constructions) and shows medium regime alignment, due to support from large electricity providers – providing a connection to the electricity domain. Even though all three niche technologies are promoted by policy through the market incentive programme (MAP) as renewable energy, the analysis reveals that this support is not sufficient to further spur their momentum.

The heat demand niche innovations show a similar picture. Smart metering and lower per-capita floor areas only have a low potential of break-through. The low per-capita floor area is a niche that is highly dependent on social changes (Pathway B), and even shows a negative trend. The diffusion of the other behavioural heat demand niche, smart metering, is hindered by high implementation costs and privacy concerns in spite of promotion by policy actors (connected to promotion of electricity smart metering). The only heat demand niche showing medium potential for a break-through is low-energy and passive housing. We judge the potential as medium due to its central importance to a potential heat system transition and the immense support the niche receives from parts of the regime. Policy makers, as important regime actors, take this niche as a role model for new building efficiency standards and promote the adoption of related technologies in the regime – also extending to the existing building stock. Therefore it seems, that whilst the government is trying to implement a top-down reorientation, the niche is not ready to break through. This, however, cannot entirely be blamed on the niche technology actors, but rather on a set of socio-cognitive and economic barriers, many of them related to other parts of the regime. Most relevant in this context are the significant up-front investments (monetary and transaction/information costs) that are still required for high-efficiency buildings (both new buildings and retrofits). As discussed in the analysis, associations of house owners and of tenants fear rising costs for their stakeholders and are thus critical to this niche (split incentive dilemma). Thus, the momentum of this niche is currently still low but might increase in the future if barriers are addressed appropriately.

Table 12: Summary table of the break-through analysis of niche-innovations in the heat domain in Germany.

Niche-innovation	Internal momentum	Strong or weak alignment with broader regime characteristics and developments	Likelihood of imminent breakthrough (and/or future potential)	Pathway A or B (or mixed)
Small-scale biomass heating systems	Medium to low	Low to medium	Low	A
Heat pumps	Low for existing buildings Medium for new buildings	Medium	Low for existing buildings Medium for new buildings (slow but steady)	A
Solar thermal	Low	Low to medium	Low	A
Low-energy and passive houses	Low, with medium outlook	High	Medium	A
Smart metering	Low, prospect medium	Medium	Low	A/B
Low per-capita floor areas	Low (negative)	Low	Low	B

In a second step, the analysis focuses on the existing regimes. The main question to be answered is whether trends in a regime's development continue as "business as usual" or whether incremental changes are implemented in order to reduce CO_2 emissions. The results of the analysis are presented in Table 1. While all sub-regimes show strong or moderate to strong lock-in and stabilizing forces, there are only moderate or weak to moderate cracks and tensions visible.

Within the heat supply regime, the landscape trend favouring a cut-back of carbon emissions in general is taken up in the technological development of gas and oil heating systems through the development of high-efficiency technologies (condensing boilers). The main technology applied is gas heating (49 % market share, BDEW 2013). For this technology, substantial efficiency gains have been achieved, leading to reductions in CO_2-emissions with high-efficiency gas condensing boilers dominating the market. However, the technology relies on fossil fuel and will, on its own, thus not lead to the transition needed. Combined with a significantly reduced heat demand (i.e. with a change of the building stock to ultra-low energy buildings), this development may nonetheless lead to a more sustainable heat domain. The third sub-system, district heating is only of minor importance for the overall regime analysis since it only has a stable market share of 12.8 % (BDEW 2013) and no signs of relevant increase in the near future. As compared to e.g. the Swedish case, in which DH is powered by renewable fuels, in Germany, the system mainly relies on fossil fuels and prospects for a future switch like in Sweden are not in sight. All in all, there is thus only limited prospect for a heat supply regime reorientation.

From an analytical perspective, the heat demand regime is highly interesting due to the strong oppositions it comprises. While on the one side policy (regime) actors try to push for a regime reorientation (aiming e.g. at a 2 % refurbishment rate), associations of house owners and tenants argue against it. The reason for this divide is the financial investment connected to refurbishments and the split incentive dilemma. The subsidies in place are currently not sufficient to solve this. In addition, a building refurbishment is a large project requiring substantial knowledge, effort and will by the investor, which does often not exist. The main barrier to a transition is thus a lack of investment. Due to the immense will of policymakers to change the regime, we still rate the overall regime to be in a mode of reorientation with incremental changes. However, this reorientation has only a medium potential for the overall transformation, since several barriers would need to be overcome to actually achieve a transition. Besides financially enabling conditions and solving the dispute over the distribution of costs and savings between investors and users, this also includes the consistent planning of single refurbishment actions for the complete building in order to capture full energy saving potential. This whole-house perspective does not only relate to heat demand measures but also includes heat supply technologies.

Table 13: Summary table of the assessment of regime trends in the heat domain in Germany.

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Gas heating system	Strong	Weak to moderate	Significantly increasing efficiency levels, compatible with biogas → Incremental changes	Reliance on fossil fuel
Oil heating system	Moderate to strong	Moderate	Increasing efficiency → Business as usual	Reliance on fossil fuel
District heating	Moderate	Moderate	Business as usual	Reliance on fossil fuel, limited availability of renewable fuels. No high market shares, thus not that relevant for regime change
Residential building stock	Strong	Moderate	Introduction of policy measures, Energetic refurbishment measures at higher level but low rates → Incremental changes	Resistance from tenants and house owners → insufficient private investment

2.5. Integrated analysis of the feasibility of transition pathways in the UK heat system

The purpose of this document is to make an interpretive assessment of the feasibility of sustainability transitions pathways within the UK heating domain *today*, with reference to ideal pathways A and B, as part of PATHWAYS D2.3, and in accordance with the protocol agreed by all project partners. This document builds on the analysis of niche innovations and of regime stability in UK heating, as presented in Deliverables D2.1 and D2.2 respectively. We first provide an overview of the main task at hand, with particular reference to the heating domain in the UK.

The bulk of the document is concerned with assessing the 'breakthrough feasibility' of specific niche-innovations. This is mainly done with attention to a multi-dimensional understanding and evaluation of niche momentum-in-context, and in relation to the identification of specific opportunities presenting themselves at regime level. Given these evaluations of niche progress, we seek explanation as to the main barriers, mismatches, or misalignment with sustainability transitions dynamics in the heating domain (see Table 14).

Table 14: Breakthrough potential analysis of 6 niche-innovations in the heat domain in the UK

Niche innovation	**Internal momentum**	**Alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
Small biomass	Very low and limited market pocket	Low alignment: - off supply grid not challenging for housing - no policy ambition	Low / unlikely	B
District heating	Very low Potential for **high momentum** in future	Low/Moderate: - technical and socio-cognitive misalignment - but included in future policy visions	Currently low but High if policy ambitions are implemented	B with elements of A
Heat pumps	Very low Potential for **high momentum** in future	Moderate: - no major technical or policy incompatibility (except need for interaction with electricity regime) - prominent inclusion in future heat vision	Currently low but potentially high if policy ambitions are implemented	B
Solar thermal	Low and limited market pocket	Moderate alignment: - off supply grid - additional quality limits conflict but reduces overall potential	Moderate but quantitatively limited: housing regime not showing signs of preparedness for large-scale adoption	B
Low energy retrofits	Very low but large potential market	Very low, due to misalignments with housing regime: - infrastructure lock-in (old building stock) - technical difficulties and lack of skills - rigid building regulations - lack of incentives	Currently very low. Long-term breakthrough *possible* if rules were fundamentally re-adjusted, but currently not visible in the short- to medium-term.	A with elements of B

Smart heating controls and meters	Moderate	High. Strong alignment (framed as win-win for supply and demand energy savings): - technically unchallenging - socio-cognitive alignment with supply - policy support	High. Only doubt is maintaining budget for planned rollout. Unclear that this would lead to significant environmental impact reductions.	A but could enable B

We then assess current and foreseeable regime dynamics, with specific attention to the kinds of regime reorientation activities and strategies that can be observed in both the heating and housing sub-domains (see Table 15). This leads us to further specifying the scale of the transition challenge ahead.

Table 15: Assessment of regime trends in the heat domain in the UK (with indicative 'scores')

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Heating	Moderate	Moderate	Moderate (incremental change towards efficiency improvements; promising new heat strategy)	Lack of skills and capabilities Scale of challenge not recognised
Housing	Strong	Weak/Moderate	Weak (piecemeal insulation; no consistent plan although efficiency gains expected under heat strategy)	Infrastructure inertia (building stock) Lack of skills, and incentives

The **heating regime** is fairly stable in particular due to strong infrastructural lock-in (gas grid / housing stock), the concentration of powerful actors on the (energy) supply side, the captivity and relative lack of awareness on the demand side (consumers), and a tendency for business as usual in the equipment installation and maintenance trade. However, this stability does not seem to be strongly related to active resistance strategies, which is hopeful for future change.

There are major tensions ahead for the heating regime, potentially developing towards a high degree of alignment (energy security and price stability, climate concerns, emergence of credible alternatives elsewhere). The current heating arrangement, relying on an increasing proportion of imported gas is thus seen as unsustainable in the long run. There are some signs of willingness to make strategic decisions and commitments on the policy side (although the credibility and durability of such discourse remains questionable). There are however substantial sources of uncertainty regarding current political ambitions to stimulate a transformation in this domain.

The **housing regime** in the UK is characterised by strong inertia, which is predominantly related to infrastructural elements such as the building stock, but is also translated in low consumer interest, and unpreparedness of the construction sector. The sources of inertia are mainly structural, rather than the fruit of active resistance strategies.

The scope for change in terms of cracks and tensions is currently relatively low, and unlikely to counterbalance the current stability. A number of early changes in social mobilisation, awareness-raising with respect to energy efficiency, and the development of the Heat Strategy are however signs that the current situation could be changing.

We conclude by evaluating the foreseeable fate of niche-innovations, their potential for contributing to transitions dynamics (and qualification thereof), and reflecting on transitions dynamics in heating in the UK.

The importance of implementing large-scale changes in the heating regime is progressively being recognised. The UK has recently shown ambitious commitments for a transition to low-carbon heat, including an anticipated full decarbonisation of residential heat by 2050. There are however a number of challenges and barriers for reaching its goals. A particularly inefficient and slow moving building stock and a generally poor track record with low carbon heat are two challenges to be named. Nevertheless, if these commitments are taken seriously and hence the necessary steps implemented sincerely (e.g. effective roll-out of efficiency measures, a virtual replacement of all gas boilers with heat pumps, and support for District Heating (DH)), vast opportunities can open up for the development of a sustainable heat industry. However, a history of ‘changing moods’ in UK energy policy and the failure to guarantee long-term stable conditions for low carbon solutions raises further doubts as to the feasibility of the current ambitious strategic objectives for heat.

In sum, there are currently signs of the beginnings of a reorientation of heating towards decarbonisation, and related ambitious plans. There is, however, a rather concerning lack of preparedness on tangible dimensions, as well as substantial novel uncertainties at governance and policy levels that point towards more of the same (in fact with less movement towards decarbonisation). So, the current heating (and housing) regime is pursuing a business-as-usual strategy, with no strong or long-term commitments to decarbonisation in practice, despite the identification of a number of opportunities with only moderate barriers in the future

2.6. Integrated analysis of the feasibility of transition pathways in the UK mobility system

This report presents an *interpretive* assessment of the feasibility (practicality, achievability) of sustainability transitions *in the present* in the mobility domain in the UK. It asks: Do analyses of recent developments in green mobility niche-innovations and regime (in)stability in the UK suggest that a transition is beginning to take place and, if so, does this look like substitution or reconfiguration? To address this question the report summarises a break through analysis of niche-innovations in the mobility domain in the UK (see Table 16).

Table 16: Breakthrough analysis of niche-innovations in the mobility domain in the UK

Niche-innovation	Internal momentum	Strong or weak alignment with broader regime characteristics and developments	Likelihood of imminent breakthrough (and/or future potential)	Pathway A or B (or mixed)
(Plug-in) Hybrid Electric Vehicles	Moderate	High potential alignment, but: - Needs plug-in infra - High battery costs - Hedging by dominant regime interests	Moderate to high	A

Battery Electric Vehicles	Moderate	Weak to moderate alignment: - 'Greening' of automobility - Needs plug-in infra - Higher costs than ICE comparators - Absent electricity regime actors - Policy promotion but governance experimentation	Weak to moderate	A (with some B)
Inter-Modal Ticketing	Low	Unclear which regime might align with - Promotes public transport v private car use - Low alignment with automobility regime - Breakthrough in London but weak alignment elsewhere	Weak to moderate	B
Car-Sharing Clubs	Low	Weak to moderate alignment - Aligns but also needs ICT systems - Ltd evidence of significant re-alignment of cultural understandings - Ltd new governance experimentation	Weak to moderate	B
Biofuels	Low	Weak alignment - Potential alignment between biofuels and automobility - Questions of process/source of biofuel generation - UK biofuel policy strongly shaped by shifting wider discourse, pressure from NGOs & Euro legislation	Weak	A (with some B)
Hydrogen Fuel Cell Vehicles	Low	- Fairly significant alignment - fundamental need for new fuel infra - Socio-cognitive alignment - though H2 safety issues - Large-scale infra requires coordinated policy & governance	Weak	B (and A)
Urban Cycling/Sharing	Very Low	Not intended to align with automobility regime but to provide an alternative to short car and public transport journeys	Moderate	B

Compact Cities	Very Low	Involves fundamental reconfiguration of a city through designing in public transport and designing out car use - This has been limited in the UK	Weak	B

The report also assesses regime trends in the land-based passenger transport system in the UK: Lock-in and stabilising forces; cracks, tensions and problems in the regime; and what this tells us about the orientation towards environmental problems of the regime and the main socio-technical problems the regime faces in this respect (see Table 17).

Table 17: Assessment of regime trends in the mobility domain in the UK

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
UK auto-mobility regime	Strong	Weak/moderate	Moderate (some incremental change)	* Dominance of regime actors - industry and policy * Sunk investments * Cultural dominance of automobility
UK railway regime	Moderate	Moderate	Limited change	* Deeply fragmented rail system * Network capacity limits * Costs to tax payers and customers
UK bus regime	Moderate	Weak	Slow, incremental change	* Fragmented system with no point of control * Disproprionate use by the poor, elderly and disadvantaged
UK cycling regime	Weak/moderate	Weak	Incremental but very limited contribution to overall emissions	* Unclear whether there is a cycling 'regime' in the UK * Cycling remains marginal. * Realisation of cycling infrastructure has been limited.

The report suggests that the eight green niche-innovations assessed are *not* about to break through more widely. It provides an assessment of dominant regime trends for land-based passenger mobility in the UK. There is either moderate incremental, slow incremental or limited change in these regimes individually.

Integrating niche and regime analyses, the report suggests that in the land-based passenger mobility domain in the UK, there is a slow and spatially selective reconfiguration rather than a transition beginning to unfold. Such change as it is happening in the UK mobility sector is coming not from privileging green niche innovations but through *multiple* processes that primarily involve dominant regime interests. These are: (a) incremental change within transport regimes, (b) some substitutional changes between niches and regimes, (c) limited change in relationships between transport regimes, and (d) some change to transport regimes from symbiosis with non-transport regimes. Change can be understood as a process that includes gradual, incremental and spatially uneven change producing slow reconfiguration.

The main reason for this is the ongoing dominance of a neoliberal discourse in relation to land-based mobility and a lack of political will amongst dominant regime actors for radical transformation. Many niches have limited internal momentum in the UK. Furthermore, the regime and sub-regimes of the land-based passenger mobility system in the UK are still, generally, locked-in rather than exhibiting significant cracks and tensions. As such, a transition to sustainable mobility is not imminent. Changes in the overall land-based passenger transport system prioritise efficiency and incremental change in existing regimes and systems rather than radical change within and between regimes. While the scale of the required change is significant, existing regime interests often act as a 'brake' on more radical reconfiguration.

2.7. Integrated analysis of the feasibility of transition pathways in the Dutch mobility system

The purpose of this document is to make an interpretive assessment of the feasibility of sustainability transitions pathways within the Dutch mobility domain *today*, with reference to ideal pathways A and B, as part of PATHWAYS D2.3, and in accordance with the protocol agreed by all project partners. This document builds on the analysis of niche innovations and of regime stability in Dutch mobility, as presented in Deliverables D2.1 and D2.2 respectively. We first provide an overview of the main task at hand, with particular reference to the mobility domain in the Netherlands.

Table 18: Breakthrough potential analysis of 6 niche-innovations in the mobility domain in the Netherlands

Niche innovation	**Internal momentum**	**Alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
Battery electric vehicles (BEVs)	**Moderate** Potential for **high momentum** in near future	Moderate alignment: - 'greening of car' - lack of infrastructure - political will	Moderate to high	A with elements of B
Hybrid electric vehicles (HEVs)	High (beyond niche)	High alignment (proven)	High but capped (upper limits to further expansion?)	A
Hydrogen fuel cell vehicles	Very low	Moderate alignment: - 'greening of car' - no of infrastructure - no exposure	Currently low Hopeful monstrosity?	A with elements of B
Biofuels	Moderate	Moderate/low alignment: - 'greening of petrol' - 'greening of car'? - legitimacy hurdles	Moderate/low	A with elements of B
Carsharing	High	Moderate alignment: - no technological or policy challenge - behavioural change	Moderate to high, but capped	B with elements of A
Compact cities	Moderate (past)	Initially low but turned upside down	Very low (unsuccessful niche of the past	A but could have enabled B

The bulk of the document is concerned with assessing the 'breakthrough feasibility' of specific niche-innovations. This is mainly done with attention to a multi-dimensional understanding and evaluation of niche momentum-in-context, and in relation to the identification of specific opportunities presenting themselves at regime level. Given these evaluations of niche progress, we seek explanation as to the main barriers, mismatches, or misalignment with sustainability transitions dynamics in the mobility domain (see Table 18).

We then assess current and foreseeable regime dynamics, with specific attention to the kinds of regime reorientation activities and strategies that can be observed in automobility, but also public transport and cycling (see Table 19). This leads us to further specifying the scale of the transition challenge ahead.

Table 19: Assessment of regime trends in the mobility domain in the Netherlands (with indicative 'scores')

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Automobility	Strong	Moderate	Moderate (some incremental change towards 'greening of cars')	Continued political support No urgent threat
Public transport	Strong	Weak (integrated and coherent planning)	Strong (regime oriented towards leaner mobility) Potential for further improvements (low-carbon for motorized transport, 100% renewable electricity for rail-based)	Cost (travel and investment) Inconvenience in less dense areas
Cycling	Strong	Weak	Strong (zero-carbon option)	Inconvenience, particularly over longer distances (addressed via multi-modality and electric cycling)

The existing **automobility** regime in the Netherlands is deeply entrenched and relatively stable. It is stabilised by reinforcing initiatives and institutions that contribute to existing lock-in. These include: a powerful industry, continued technical improvements and sophistication, and supporting policies. Despite strong inherent stability, the automobile regime in the Netherlands is showing some signs of change. Recent trends point to increasing recognition of external pressures and challenges by the automobile industry itself, with greater attention to environmental and safety issues, innovation strategies geared towards lesser emissions (catalytic converters), fuel efficiency improvements, the exploration strategies with different alternative fuels, and the emergence of new business models for mobility. The emission intensity of new cars is steadily decreasing.

There are signs of change ahead, as the prevailing automobile regime is increasingly being challenged on environmental, convenience, safety, economic, and technological grounds, as well as a growing disinterest in car ownership among younger people in the

Netherlands. Most responses so far, however, are currently met by regime incremental responses, which points to an incremental regime change pathway, in a context of continued policy support and little urgency for radical transform.

Overall, **public transport** is an integrated and coherent affair in the Netherlands with a strong role for public planning and harmonisation. The Netherlands is striking in its ability to retain public control over public transport (from national government down to municipality), which is one main reason why lasting support and continuity can be expected. Multimodality has been successfully supported (e.g. through integration and simplification of ticketing and fares; increasing ease of connection between modes of transport). To date the emerging issues have been successfully addressed as they have emerged.

The Netherlands has the highest **cycling** rate in Europe; cycling is culturally deeply embedded and has profited from successful policy interventions. The Netherlands has a well-established extensive, safe and convenient cycling infrastructure network, all of which contributes to a strong stability of this regime. In recent years, e-cycling has been replacing some conventional bicycle journeys, particularly over longer distances and in older age groups. The cycling revival in the Netherlands over the past 4 decades can be seen as an exemplar of mobilisation and mobility transformation driven by 1) societal concerns (a mixture of safety and environmentalism), 2) strong policy involvement, and 3) the crucial role of infrastructure. It also is a telling (and hopeful) example of how leaner and greener alternatives may become deeply embedded in society. However, it is important to recognise that cycling (however widespread in the Netherlands) has not yet managed to substantially displace automobility although it may have contributed to the tempering of its growth.

We conclude by evaluating the foreseeable fate of niche-innovations, their potential for contributing to transitions dynamics (and qualification thereof), and reflecting on transitions dynamics in mobility in the Netherlands.

The Netherlands offers an interesting context for experimentation with low-carbon mobility. The Netherlands is characterised by a high degree of innovation along a ‘greening of cars’ trajectory, decades of successful (and world-leading) experience with alternative mobility modes (public transport, cycling, multi-modality), and a variety of local and national coalitions pressing for greater efficiency and sustainability of transportation. Together, these dynamic conditions and energies generate an enabling and hopeful stage for transitions towards low-carbon mobility. There is, nonetheless, a deeply engrained habit of supporting automobility in policy, which may stand in the way of or slow down these emerging trends by sending the wrong signals.

More radical pathways stepping away from automobility altogether are still difficult to envision at the horizon, as there is currently no materialisation of a fundamental questioning of automobility. Automobility is not challenged in mainstream discourse, and there is a relative shyness of policy to aggressively challenge a mobility mode that is still perceived as convenient by a majority of the Dutch population. There are promising exceptions to this (e.g. urban cores and younger generations, and general saturation) but these are not strong enough to overcome a generally risk-averse policy system that is generally happy to be seen actively promoting hopeful alternatives (EVs, multimodality) on discursive levels, but not yet ready to deliberately accelerate the destabilisation of automobility. In this context, we are likely to see Pathway A-type developments thriving, along with an increased contribution of new mobility modes, but may have to wait before we see a serious and unavoidable challenge to automobility in the Netherlands.

Nevertheless, the Netherlands is striking as a context that has made a head start towards sustainable mobility by 1) supporting the strong development of multiple modes of mobility, 2) seeking leadership in sustainable mobility innovation, and 3) hosting a variety of local and national coalitions pressing for greater efficiency and sustainability of transportation. These crucial developments are signs of a deep reflection within Dutch society about fostering greater flexibility of options for mobility, with particular emphasis on efficiency, accessibility (territorial and social), safety, and environmental concerns. A highly stable and effective public transport system, a mature cycling infrastructure, and an inclination towards multi-modality are deeply entrenched part of mobility practices in the Netherlands. They provide fertile ground for stepping away from unsustainable automobility. So, the Netherlands is perhaps best positioned in Europe to enable and support sustainable mobility transitions in the medium to long term. Crucial requirements ahead are greater policy clarity and coherence about no longer supporting automobility-as-usual, and embracing the sustainable mobility possibilities in the making.

2.8 Integrated analysis of the feasibility of transition pathways in the Dutch agro-food system

The purpose of this document is to make an interpretive assessment of the feasibility of sustainability transitions pathways within the Dutch agro-food domain. This document builds on the analysis of niche innovations and of regime stability in the Dutch agro-food domain, as presented in Deliverables D2.1 and D2.2 respectively.

Table 20: Breakthrough analysis of niche-innovations in the agro-food domain in the Netherlands

Niche-innovation	**Internal momentum**	**Strong, medium or weak alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B**
MSC fish label	medium	Strong	Is already becoming part of the existing regime	B
Dairy alternatives	Medium	Weak	Growing, but not about to break through	B
Algae for fish feed	Medium	Medium	Not likely to breakthrough	A
Flexitarianism	medium	Strong	Likely to breakthrough	B
Hybrid meat	Low	Medium	Not likely to breakthrough	A
Cultured meat	Very low	Weak	Not likely to breakthrough (very early phase of development)	A
Local food	Medium	Strong	Is growing and can break through (but is uncertain)	B
Organic food	Medium	medium	Very slowly growing, but not really about to breakthrough). Will become a stabilised niche next to the mainstream	B

First the breakthrough feasibility of the various niche-innovations is assessed. The niche innovations in the Dutch agro-food domain we have studied are: MSC fish label, local food, organic food, flexitarianism, hybrid meat, cultured meat, algae for fish feed and dairy alternatives. Of every niche the internal momentum is assessed, based on techno-economic, socio-cognitive and governance elements. The niches under study are Pathway B innovations, except for cultured meat, hybrid meat and algae. The niches have a medium to very low momentum. Table 20 shows the breakthrough analysis of the niche innovations studied.

The agro-food system consists of various, largely interlinked regimes, both at the production side and partly at the processing and retail side. At the production side, there are regime as the dairy regime, the beef regime, the egg regime and crop regimes, such as various types of horticulture. At the consumers' end, there are regimes as the supermarkets regime, and the food service regimes.

Other than in the energy-related regime, a complete regime-shift is not very likely within the agro-food system. The current food production, based on extensive land use, and inputs such as water, marine resources, and minerals will not be replaced by a complete different system (as for example in the electricity sector where fossil fuels are expected to be replaced by renewable energy). Only more or less gradual adaptations are possible, as for example increasing crop yields (in a sustainable way), reducing or even halting the use of pesticides or a transformation to more multifunctional land use. Only a complete shift from partly meat and dairy based diets to a plant-based diet could be regarded as a 'true' transition. This transition would have large implications for land use within the EU.

The description of the related regimes and landscape elements shows what elements of the regimes are influenced by the niche innovation, and what the possibilities are that a niche will break through. The regimes in the agro-food domain are dairy, meat, fish and retail regimes. The regimes have a strong lock in, except for the fish regime. The cracks and tensions are moderate (see Table 21).

Table 21: Assessment of regime trends in the agro-food domain in the Netherlands (with indicative 'scores')

Regime	**Lock-in, stabilizing forces**	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Meat regime	Strong	Moderate	Moderate (some incremental change)	Has to do with habits that are hard to change. Large, long term investments
Fish regime	Moderate	Moderate	Moderate (some incremental change)	Discussion on the label system. Global character of the issue
Dairy regime	Strong	Moderate	Moderate (some incremental change)	Milk prices are under pressure
Retail regime	Strong	Moderate	Limited (BAU)	Some big players involved that are hard to change
Vegetable farming regime	Strong	Moderate	Moderate (some incremental change)	Reducing energy use, maintaining water quality and reducing the use of pesticides and over-use of minerals

Based on this analysis we can conclude that in the agro-food domain there are hardly niche innovations that are about to breakthrough at the moment. The niche innovations in Pathway A (Algae, Hybrid Meat and Cultured Meat) seem to be in the experimentation phase, and do not have a high momentum yet. While the niche innovations in Pathway B (MSC, Dairy alternatives, flexitarianism, local food and organic food) seem to create a growing momentum. These innovations address the issues rose in society and therefore can be able to break through or generate an increasing interest. One could argue that MSC is the niche innovation with the highest momentum, and did become a part of the stabilised regime. The sector has strong lock-in forces, for example the dependency on land, the high investments in buildings and machines, the cultural aspects in consumer behaviour, the huge role of the agro-food sector in the Dutch economy and the strong lobby. There are many interests at stake, what makes discussions on substantial changes often very hard.

There is no transition unfolding yet in the agro-food domain. In the agro-food domain we can argue that 'radical incrementalism' is occurring, meaning that change is occurring, but only in small steps, such as improvement of production efficiency. This is mainly because the agro-food sector is organised in a complex chain from production to consumption with many actors in between. For example increase in production efficiency, reduction of manure application, reduction of pesticides use. It seems that niche innovations do only have a minor effect on land use, greenhouse gas emissions and biodiversity, but in the agro-food sector a small step is already an improvement.

2.9. Integrated analysis of the feasibility of transition pathways in the Hungarian agro-food system

The report assessed the breakthrough feasibility of 4 agro-food niche-innovations (*localized food systems, community supported agriculture, organic agriculture, and vegetarianism*) and the chances of agro-food regime reorientation. The niche-innovations have some internal momentum, but it is only enough for experimentation (Table 22). This means that a transition does not appear to be imminent in these domains without further strong policy support and broad stakeholder cooperation. The niche-innovations represent transition pathway B and their momentum is low on a five-point scale (very high, high, medium, low, and very low).

Table 22: Breakthrough analysis of niche-innovations in the agro-food domain in Hungary

Niche-innovation	**Internal momentum**	**Alignment with broader regime**	**Chance of breakthrough**	**Pathways**
Local food systems	Low	Medium	Growing sector with potentials to break through	B
Community agriculture	Low	Medium	Growing sector with potentials to break through	B
Vegetarianism	Low	Low	Not growing, breakthrough not expected	B
Organic food	Low	Medium	Stabilized and not growing, breakthrough not expected	B

The domain itself cannot be characterized by a single regime, but by multiple interlinked regimes (often along value chains ranging from farm to fork). As for the degrees of lock-ins and cracks in the agro-food domain in Hungary the *beef, pork and retail* regimes have been analysed as these are regarded as the most polluting sub-sectors, that create the highest environmental impact, and also these are the most embedded in the global food system and thus the most vulnerable to the global food crisis. In terms of a three point-scale (strong, moderate, weak) the stabilizing lock-in forces are 'strong' which means that incumbent actors are still committed to them and are not reorienting themselves towards any major transition towards sustainability. Some tensions/cracks are assessed as 'strong' only in the pork regime where conflicts are mainly economic, related to price squeezes, competition and struggles for economic survival by Hungarian pig farmers – and have not much to do with decarbonisation (table 23).

Table 23: Assessment of regime trends in the agro-food domain in Hungary

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Beef regime	Strong	Moderate	Moderate (some incremental change)	Nudge factor can have some impact only on the long term
Pork regime	Moderate	Moderate	Moderate (some incremental change)	Embedded into a global value chain
Retail regime	Strong	Moderate	Very limited	Concentration of the sector is hard to change

Based on our analysis we can conclude that in the Hungarian agro-food domain we do not find green niche innovations that are about to breakthrough or affect the overall patterns of land use radically. The niche innovations in Pathway B (vegetarianism, local and organic food, community agriculture) seem to create a radically incremental (step-by-step) growing momentum. These social experiments are acting as *early market niches* in a stabilised agro-food regime and managed to gain recognition and policy acknowledgment for their socio-environmental achievements. Several factors have been identified that lock-in the development: concentration of land, investment and infrastructure need of the small-scale food enterprises, very limited consumer markets, etc. Transition pathways are expected to open in the future only when broader coalitions of stakeholders urge radical land use change, decarbonisation, and reduction of GHG emissions in the agro-food domain.

2.10. Integrated analysis of the feasibility of transition pathways in the Portuguese land-use system

This report assesses the present feasibility of a sustainable transition pathway to occur in the land use domain for Portugal under the current socio-economic circumstances. The assessment analysis builds on work developed on previous reports: identification and analysis of niche innovations and regime stability analysis for the land use domain in Portugal, as presented in Deliverables 2.1 and 2.2 respectively. The feasibility assessment will firstly evaluate the various niche innovations likelihood to breakthrough. Secondly, this report will appraise how the niche innovations relate to the dominant regimes identified for the land use domain for Portugal and how reasonable a process of reorientation for each of the main land use regimes is. This report concludes with a general discussion of the findings.

The land use domain is the realm that analyses land systems and the changes within it and typically involves the analysis of land cover and land use. The land use domain often includes different use regimes. In Portugal, land use domain is characterized by four use regimes: forestry, agriculture, nature and urban. Such regimes may be more or less stable and may hence, need smaller or bigger changes to achieve sustainable land use. Niche innovations are essentially movements whose action counters the existing mainstream way, and which may influence and shape a regime. Niche innovations can originate a regime re-configuration brought about by small pool of actors, which nurture a re-alignment of processes. The actors push for a re-configuration of a domain by addressing the cracks and tensions within it while trying to implement a *modus operandus* that “works”.

Seven niche innovations were identified for the land use domain in Portugal. An important characteristic of these niche innovations is their multifunctional use of the land but also, that all of them address points of tension within the dominant land use regimes identified in Portugal (agriculture, forest, nature and urban). The internal momentum for every niche innovation is assessed in this report, based on techno-economic, socio-cognitive and governance elements. All niche innovations are classified to belong to pathway B, with few niches showing elements of pathway A (Table 24).

Table 24. Breakthrough analysis of the 7 niche innovations for the land use domain in Portugal.

Niche innovation	**Momentum**	**Alignment with broader regime characteristics and developments**	**Likelihood of breakthrough**	**Pathway**
1.Biodiverse cities	Medium to Low	Low to Moderate Agriculture and urban regimes are fairly stable but there is a window of opportunity for better alignment lying with better policy alignment and more public engagement.	Low Niche is growing slowly. The stability of the regimes involved and low internal momentum hinder the break through.	B
2. Business & Biodiversity	Medium to Low	Low to Moderate Agriculture regime is more stable than the nature regime. Issues related to the Nature have also in policy a low degree of priority in general. There are nonetheless windows of opportunity pushed by commitments of the national government to meet foreign policy as well as increased societal pressure on businesses to account for their impacts on nature.	Low Regimes are relatively stable and improved socio-knowledge transfer and financial assurance hinder the growth of the niche.	B with elements of A
3. Multifunctionality for renewable energy	Low	Low Agriculture and forestry are the two main regimes in Portugal and are relatively stable. Windows of opportunity lie with policy long-term commitment and	Low Regimes are stable and there are technological and operational constraints for the niche to break through.	B

		improved scientific support.		
4. Fire resilient landscapes	Medium	Moderate Developments at he agriculture and forestry regimes in Portugal and this niche are strong as far as fire is concerned.	Growing, but limited perception of its development due to time constraints	B
5. Land sharing and Integrated Territorial Interventions (ITI)	Medium to Low	Low to Moderate Alignment with developments at the agriculture and nature regimes is relatively positive. Better scientific evidence supporting the niche proposed actions and long-term commitment from the government.	Low Regimes are stable and there is operational constraints for the niche to break through.	B
6. Rewilding	Low	Low Need for more public engagement but also from the government and institutions of the nature and agriculture regimes.	Low Low degree of interest from the public and government.	B
7. Biodiverse Pastures	Medium to Low	Low to Moderate Alignment with developments at the agriculture and nature regimes is relatively positive. Better scientific evidence supporting the niche proposed actions and long-term commitment from the government.	Low to Medium Regimes are well aligned to the niche but financial long-term sustainability and improved scientific support evidence hinder the niche break through.	B with elements of A

All the niche innovations for the land use domain in Portugal present a low to medium momentum, except for the fire resilient landscape niche innovation. The former shows medium breakthrough potential. It shows highest momentum of breaking through, if not already *en-route*. However, since the benefits will only be visible on the long run, broadleaved species take about 50 years to grow, hence the perception is that no transition is happening. Moreover, public interest and debate has lost importance. This niche suffers from a time-perception constraint.

The analysis of the regimes and external elements (Table 25) allows identifying how the niches are influencing the regimes and how likely the niches will break through. The land use regimes (agriculture, forest, nature and urban) show a moderate to strong degree of lock in. The land use domain is assessed to be moderately stable. At the current state of affairs, a breakthrough from the niche innovations is thus, unlikely, except for the fire resilient landscape niche. Nonetheless, even without instability within the regimes, niche innovations will most probably continue to emerge and penetrate causing incremental disruption at the regime level. Incremental changes to address environmental challenges inside the regimes have been adopted, denoting an open attitude from the dominant regime actors to change.

Table 25. Assessment of regime trends for the land use domain in Portugal.

Regime	Lock-in, stabilizing forces	Cracks, tensions, problems in regime	Orientation towards environmental problems	Main socio-technical regime problems
Agriculture	Moderate to strong	Strong	Moderate (some incremental change)	e.g. long term policy assurance, subsidy dependence, high long term investments from farmers, cultural & historical attachment to the land
Forest	Strong	Weak to moderate	Moderate (some incremental change)	e.g. market demand for pulp, paper and cork.
Nature	Strong	Moderate	Moderate (some incremental change)	e.g. need for more investments, society interest, better policy integration
Urban	Strong	Weak	Moderate (some incremental change)	e.g. Physical contraints, political apathy, need for better policy integration, more investment

The likelihood of a breakthrough in the present time is unlikely, either due to limiting internal aspects or due to the overall stability of the land use domain and the relatively strong regime lock in. The incumbent land use regime actors have shown to be taking incremental changes to address environmental challenges and appear to be open for re-organization of the system. Instability of the land use domain does not appear to represent a barrier for the niche innovations to initiate a transition pathway. A distinguishing feature of the land use domain is in fact the high level of dynamic interactions it allows for: different regimes which are dynamic on their own (intra-regime changes) and between them (inter-regime changes) as well as allowing for niche innovations underlining more than one regime. Niche innovations will most probably continue to emerge and penetrate causing incremental disruption at the regime level.

2.11. Integrated analysis of the feasibility of transition pathways in the Dutch land-use system

The purpose of this document is to make an interpretive assessment of the feasibility of sustainability transitions pathways within the Dutch land use domain. This document builds on the analysis of niche innovations and of regime stability in the Dutch land use domain, as presented in Deliverables D2.1 and D2.2 respectively.

First the breakthrough feasibility of the various niche-innovations is assessed. The niche innovations in the Dutch land use domain we have studied are: Business and biodiversity, Agricultural nature conservation, Resilient landscapes, Renewable energy, Urban farming and Tourism. These niches are all examples of multifunctional land use, and are therefore positioned on the edges between two or more regimes. For every niche the internal momentum is assessed, based on an analysis of techno-economic, socio-cognitive and governance dimensions of the niche-innovations (Table 26). The niches under study are all examples of regime transformation (characterised as pathway B in the Pathways project) niches and have a medium to low momentum.

Table 26: Breakthrough analysis of niche-innovations in the land use domain in The Netherlands

Niche-innovation	**Internal momentum**	**Strong, medium or weak alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
Business and Biodiversity	Medium	Strong	Growing and can break through in the future	B
Agricultural nature conservation	Medium	Medium	Stabilized niche	B
Resilient landscapes	Medium	Strong	Is incorporated in the existing regime	B (elements of A)
Renewable energy	Medium	Medium	Growing and can break through in the future	B
Urban farming	Low	Medium	Growing , but is not likely to breakthrough	B
Tourism	Medium	Medium	Niche that can grow, but will remain a niche	B

A description of the related regimes and landscape elements makes it possible to see what elements of the regimes are influenced by the niche innovation, and what the possibilities are that a niche will break through. The four regimes in the land use domain are agricultural, nature, water and urban regimes. The regimes have a strong lock in, except for the nature regime (Table 27). The cracks and tensions vary among the different regimes: the nature regime has strong cracks and tensions, while agriculture, water and urban show weak to moderate cracks and tensions.

Table 27: Assessment of regime trends in the land use domain in The Netherlands (with indicative 'scores')

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Agriculture regime	Strong	Weak to moderate	Moderate (some incremental change)	Large, long term investments
Nature regime	Moderate	Strong	Moderate (some incremental change)	Discussion on who has to pay for nature and how to reward it. Uncertainty regarding subsidies.
Water regime	Strong	Weak	Limited; regarding floods, safety is still the main issue addressed.	Institutions have strong traditions/ways of working.
Urban regime	Strong	Moderate	Very limited (some attention for green in the city, but not much)	Build up area is not so much under discussion.

There is no transition unfolding yet. The niches described are in the early market niche phase, except for resilient landscapes. Room for the river, the example of resilient landscapes, did already become part of the existing system. In the land use domain we can argue that ‘radical incrementalism’ is occurring, meaning that change towards sustainability is occurring, but only in small steps. So, it is more likely there will be further diffusion, than a whole-sale transition in which there is a breakthrough and the system is replaced.