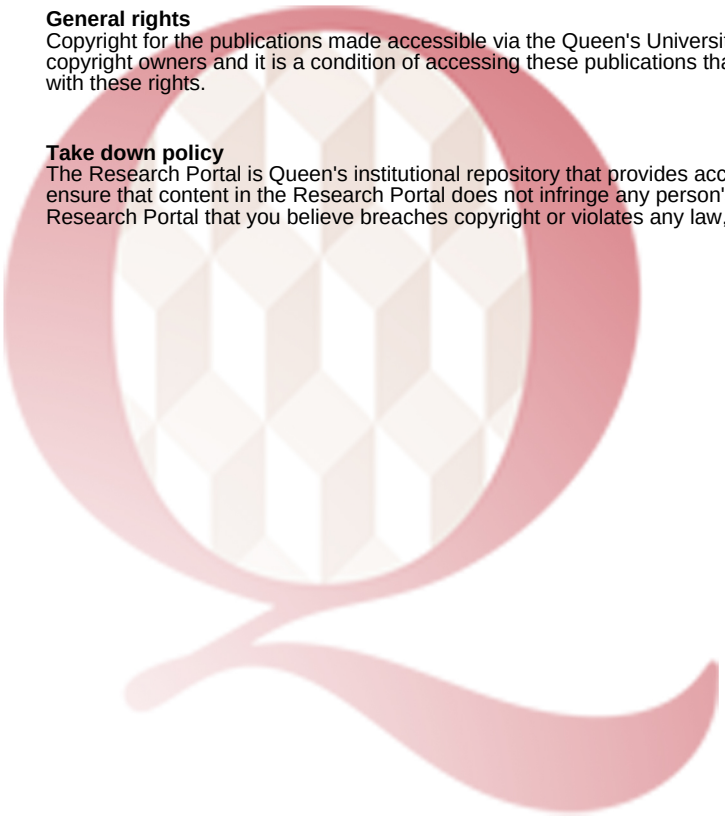
Working Paper 1: Society-wide Transitions



Working Paper 1

SOCIETY-WIDE TRANSITIONS

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CC Transitions is an 18-months desk study funded under the Environmental Protection Agency (Ireland) Climate Research Call 2014 (Ref: 2014-CCRP-DS.6). The project will develop an analytical framework for understanding energy transition in Ireland, which will help frame future EPA research in this area. The research will review existing work on transition management, examine a number of international case studies of energy transition and map the state of transition of specific technological sectors in Ireland. The overall aim is to benchmark Ireland's progress to a low carbon economy, identifying future research areas to support this aim.

Working Paper 1
SOCIETY-WIDE TRANSITIONS

Executive Summary

The purpose of this Working Paper is to describe the issues that have arisen from a systematic review of the academic literature on society-wide transitions. This contributes a robust understanding of the theoretical framings of societal-wide transitions to low-carbon sustainability, which will be taken forward as part of the project. The review builds on an earlier review by Markard et al (2012) and details of how it was undertaken is described in detail in an accompanying Review Protocol, theoretical framings of societal-wide transitions to low-carbon sustainability which is also available on the project website.

The paper discusses its objectives and then provides a general introduction to the transition perspective and its origins. It then discusses some of the key concepts that are used to theoretically understand the drivers, scales and processes involved in society-wide transitions.

The main concepts that can be used in the project include:

Systems perspective - an **energy transition** can be understood as the emergent result of changes in the dominant structures, cultures and practices of a societal system, which will be referred to heretofore as the **energy system**. The energy system is viewed as including technical, cultural, social, economic and behavioural elements and as providing a foundation for other societal systems such as transport, heating, electricity, food, and housing. As such, viewed from a socio-technical systems perspective, changing or steering the trajectory of the energy system is to steer the trajectory of societal development.

Vision - the establishing and co-creation of a broad vision of energy system transition is important, both in the process by which such a vision is created, and in terms of the substantive elements or goals of such a vision. Attention should be given to agreement on a broad, revisable and adaptable vision or narrative which can align expectations and roles, set out the parameters of the energy system transition (which may include ruling out certain technologies, for example or including certain social objectives, for example reducing fuel poverty), while leaving scope for and encouraging variety and diversity in how to achieve the vision.

Timeframe - socio-technical system-wide transitions, such as the energy system, take place over decades, and a 25-30 year timeframe is considered as typical within the literature.

Process - relating to the vision, energy system transitions require attention in the design of and support for processes, as much as for specific desired or expected outcomes.

Multi-level perspective - system wide transitions can be best analysed in terms of the dynamics between three levels - niche, regime and landscape. Here the **regime** level incudes the dominant structures, cultures and practices of the energy system; the **niche** level includes innovations which might catalyse change. The energy system is viewed as embedded in a broader **landscape** which includes the physical landscape and other related systems as mentioned above (such as transport, housing etc.).

Networks – in order to foster change, the literature emphasises the importance of co-ordinating, sustaining and encouraging networks, especially amongst niche actors, and maximising a diversity of experiments.

Social Learning – learning of different types at different levels is key to transition. This relates to creativity and process – for example, mutual learning amongst networks involving processes of communication, deliberation and trust building; formation of coalitions, and technical experimentation and innovation involving both 'learning by doing' and 'learning by diffusion'.

Creativity and innovation - this includes considerations for scaling up and diffusion of successful or promoting innovations, and support for 'full spectrum innovation' (social as well as technical).

Governance of system wide transitions - the importance of reflexive governance, and transition management as a form of reflexive governance

The paper concludes by highlighting that the multi-level perspective, and reflexive governance methods such as transition management, have the potential to provide a useful conceptual framework for analysing the Irish energy system. This approach can help identify the path dependent aspects of the incumbent energy system, characterised by 'carbon lock-in' at different levels which require change and provide some generic approaches which might help 'unlock' these, enabling the innovation of low carbon energy technologies. It can also provide mechanisms that can be used to drive multi-stakeholder change processes, particularly if combined with a range of insights from complementary theories (see section 6/7). However the limits to these approaches must also be borne in mind, particularly with reference to the Irish situation, where social learning processes and the science/policy interface are less developed. Thus, a much closer examination of the application of the transition management framework and other comparable approaches in particular national contexts is required to assess the transferability of these approaches to an Irish context.

"The reasonable man adapts himself to the conditions that surround him... The unreasonable man adapts surrounding conditions to himself... All progress depends on the unreasonable man". George Bernard Shaw

"Not seeing a tsunami or an economic event coming is excusable…building something fragile to them is not". (Taleb, 2012)

1. Objectives and Purpose

The question of how to meet the 2050 EU target for carbon emissions in Ireland forms one aspect of what can be conceptualised as a complex or 'wicked problem' with inter-linked scientific, economic, technical, ecological, social and political aspects. Despite the fact that no national target for emissions has been set, the 'National Transition Objective' (Government of Ireland 2015:5), requires analyses and knowledge bases, and related policy interventions based on that knowledge that are 'systemic' *as well as* sector- or issue-specific. At one level, energy consumption and carbon emissions clearly relate to broader patterns of production and consumption, which can be exposed through a deeper, more systemic analysis, using appropriate indicators and methods (e.g. Maguire and Curry 2008). These patterns, however are in turn impacted on by cultural and institutional factors, including regulations, infrastructure and habit, and there is a need for innovation of different types and at different levels to change these. Equally, chosen solutions may have unintended side effects. For example, the decision to focus policy on the development of onshore wind capacity for electricity generation, the consequent rapid growth of the on-shore wind industry[1], and the (related) need to build grid capacity for transmission have raised and are increasingly raising challenges of social acceptance (see, for example, NESC 2014). A further complication arises regarding the timing of new developments: a sustainability transition will typically take place over a much longer time period than the average duration of a government (25-30 years). This raises questions on how such longer term changes should be governed.

The interrelated, co-dependent and co-evolutionary character of modern societies and economies (especially under conditions of globalisation) means that decisions made at one policy sector affect other sectors, and form also complex negative and positive feedback loops among policy sectors and actors. This need for more holistic systems analyses and policies has become all the more necessary given that the increasing complexities of modern society have made it hard to predict consequences of policy actions (Taleb, 2012). In addition, successful innovations are often inherently systemic by nature, thus requiring a whole system policy framework for their support (Wieczorez and Hekkert, 2012). It therefore becomes highly important to consider how different forms of analysis can be combined within an integrative policy framework. As suggested by NESC such a policy framework should be one within which actions could be "developed, prioritised, agreed, implemented, reviewed, and evaluated" (2012:v), guided by an overarching vision but also subject to review and revision itself.

The aim of this paper is to draw out the key themes from a systematic review of the theoretical literature on society-wide transitions, thus helping to identify a conceptual framework for activity undertaken in later work packages and for the project as a whole. It establishes parameters for the later reports, in identifying, describing, and evaluating key concepts, dynamics, actors and trends that may be useful understanding and outlining further policy-relevant research on a low carbon energy transition in Ireland. In keeping with a whole systems approach, energy transitions are viewed as complex, co-evolutionary, multi-actor processes that require changes at different levels within prevailing sociotechnical systems or configurations. These include both the development of technical innovations and their use, including the attitudes and resultant

[1] 50% increase in wind capacity from November 2011 – March 2015 (Eirgrid 2015)

behavioural changes from those who use these innovations. However society-wide energy transition cannot be framed solely with reference to production, consumption and technological innovations. Unsustainable practices are deeply embedded and often 'locked in'; partly as a result of historic developments resulting in 'persistent problems' (Schuitmaker, 2012) and possible paths may be characterised by uncertainty and ambiguity. For these reasons, a detailed analysis and questioning of some of the fundamental assumptions underpinning existing systems is required, together with an identification of future possibilities and an appraisal of potential pathways and dynamics of change.

This paper builds on, updates and extends a systematic review of the transition literature carried out by Markard, Raven and Truffler in (2012), introducing a special issue of the journal *Research Policy*. Markard et al's aim in their review was to explore the origins of sustainability transition studies in the literature and conduct a quantitative literature survey. They define a sustainability transition as "a *fundamental transformation towards more sustainable modes of production and consumption*" (ibid.: **955**), which incorporate the examination of the " *institutional, organizational, technical, social, and political aspects of far-reaching changes in existing socio-technical systems"* (ibid.: **959**) such as transportation and energy supply. Whilst other approaches are acknowledged, they opted to confine their review and analysis to four (related) theoretical frameworks: namely, **transition management**, **strategic niche management**, the **multi-level perspective** and **technological innovation systems**. The reason given for this is that these "*adopt systemic views of far-reaching transformation processes of socio-technical systems*" (ibid.: 956). That is, these four approaches offer long-term (25-30 year), system wide (large-scale or societal) analyses of energy transitions.

We begin by giving a brief characterisation of the main ideas and an account of how research in this area evolved. The main concepts used in analysis will then be detailed and the main governance approaches discussed. These will be followed by a discussion of the main criticisms of the approach together with studies identifying the complementarity of using other approaches in conjunction with the transitions to address these shortcomings.

What needs to be changed through a sustainability transition in the energy system is much broader than modes of energy production and consumption, given the other (non-technological) issues that transformations in these modes might lead to or require. While the focus of this paper is conceptual, model building and therefore often abstract in engaging with the extant and relevant literature, it is written with a clear awareness of the Irish energy context and focus on Ireland as the overarching object of the project of which this paper is a part.

2. Methods

This paper draws on a systematic review of the academic literature on transitions theory. A detailed description of how this was undertaken is provided in the accompanying Review Protocol, which is also available on the project website. This builds on the earlier review undertaken by Markard et al (2012), which focussed on 20 of the most citied papers available in 2012. Following the same method, the 2012 review was updated to incorporate recent developments and to provide confidence that the project was built on a robust understanding of the theoretical field. The discussion below is drawn out of the review of this literature.

3. The Transition Perspective on Change in Socio-Technical systems

The shift to a low-carbon economy can be viewed as, not about achieving a definable end state, but as a ***process*** of *redirecting and steering* a wide range of factors (markets, energy technologies infrastructure, governance, individual behaviour) towards a more sustainable configuration (Berkhout, 2002). Such a process cannot be guided by a fixed blueprint, since given the timescales involved (usually at least 25-30 years), it will inevitably have to cope with uncertainties/surprises, ambivalent goals, political myopia, social resistance, institutional or cultural inertia, and a danger of 'lock in' (technological, policy or behavioural), amongst other factors (Kemp et al, 2007). Transition is thus more likely to be progressed through a process of using a long-term vision as a framework for formulating short-term objectives and policy evaluation orientated towards achieving that longer-term transition (Rotmans et al, 2001). Thus having a broad vision for energy transition is crucial:

> A change trajectory towards a more sustainable society can be initiated by an appealing and inspiring vision. A vision entails images and a narrative of desirable systems based on shared principles of sustainable development. *Coherent visions provide long-term orientation and guidance*. (Nevens, Frantzeskaki, Gorissen, and Loorbach, 2013: 114; emphasis added)[2]

Much current work in the area relates to the need to analyse what have been described as *persistent* problems (Schuitmaker, 2012) of *unsustainability* (Barry, 2012) within different types of co-evolving societal system (e.g. electricity, transport, buildings, the food system) and to develop appropriate governance mechanisms to guide them towards a more sustainable configuration. These persistent problems are often complex and are deeply embedded and reproduced as side-effects of existing systems, thus they are particularly difficult to understand, manage and grasp. They are often even more difficult, but not impossible, to change. Thus transitions towards more sustainable configurations of such systems can be viewed as complex multi-causal, multi-level, multi-domain, multi-actor and multi-phase processes (Loorbach, 2010), the emergent result of which may involve "profound change in various or all aspects of a societal system's functioning", namely structures, cultures and practices[3] (De Haan and Rotmans, 2011: 93).

This means that developing governance, management and policy-support mechanisms is no straightforward task. In terms of the management and governance of energy transition, one of the lessons from the literature is the advantage of adopting a 'reflexive governance' approach (Voss and Kemp, 2006; Hendriks and Grin, 2007; Walker and Shove, 2007; Voss et al., 2009). Reflexive governance refers to processes by which governance practices[4] are reflected on and revised in the light of persistent, complex problems, where the often unintended side effects of activities can be difficult to predict. Governing activities *themselves* are viewed as inextricably entangled in wider societal feedback loops and partly shaped by the (side-) effects of their own working (Voss, 2007). Taking into account factors such as complexity, ambiguity and uncertainty, and the need to incorporate multiple stakeholders and different knowledge bases and disciplines upon which to base policy, the emphasis then shifts from simplistic

[2] Related to vision is *foresight*, emphasising learning and vision-building for designing alternative possible futures within a system. Foresight also aids the communicative and social learning dimensions of visioning alternative socio-technical transitions (Könnölä, Unruh, and Carrillo-Hermosilla, 2006).

[3] Structures refer to the formal, physical, legal and economic aspects of functioning which restrict and enable practices; cultures to the cognitive, discursive, normative and ideological aspects of functioning involved in the sense-making of practices; and practices to the routines, habits, formalisms, procedures and protocols by which actors maintain the functioning of the societal system (De Haan 2010; De Haan and Rotmans 2011).

[4] In this context, Voss and Kemp define governance as "the patterns of processes by which society handles its problems and shapes its own transformation" (2006: 8).

'problem identification and problem solving' towards the "creation and maintaining of spaces for working towards solutions" (Rip, 2006:89). Governance mechanisms and implementation become more intertwined thus mutually influencing each other, as patterns enabling and constraining action evolve. Such a reflexive and flexible governance approach to socio-technical transitions stresses qualities such as reflection, social learning, wide inclusion of stakeholders and actors, revisability, provisionality and flexibility to change course. While not ruling out traditional state 'top-down' and 'command and control' approaches to governance and policy-making, such process-oriented governance does represent a challenge to state actors and policy-makers - challenging them to learn new ways of making decisions within and for entire systems. However, such approaches raise their own challenges, and these will be discussed in Sections 5 and 6.

3.1 Origins and Evolution of the Transition Perspective

The field of transition studies emerged from the area of science and technology studies (STS), through attempts to characterise the nature and dynamics of developments in technology (Kemp 1994, Rip and Kemp, 1998) using an evolutionary approach (most often based in evolutionary economics). Its development has been influenced by a number of existing disciplines (Grin et al, 2010: 52), such as science and technology studies, evolutionary economics, cultural studies, anthropology, history (including history of technology), geography, political, policy and governance studies. The theory was developed through the provision of narrative explanations for historic transitions in sociotechnical systems such as transport systems and mobility, public sanitation, lighting, electricity provision and large-scale agricultural changes (Smith et al, 2010).

The idea of a *regime*, or *sociotechnical regime* arose from Nelson and Winter's notion of a 'technological regime' (1982: 57), and Dosi's notion of a 'technological paradigm' (Dosi 1982: 152), mapping how technological development could be shaped or circumscribed by sets of factors, such as established practices and rules. These theories were built on by Kemp (1994) to enable the consideration of broader social and structural factors in the conceptualisation of technological change processes, more clearly characterising the essential relationship between technological innovation and the wider social dynamics within which innovation is embedded. The influence of evolutionary theory and evolutionary economics (Nelson and Winter, 1982; Geels, 2010) can be seen in the adoption of ideas of variation, selection and adaptation, providing additional insights into the workings of long-term processes, and macro-level patterns. Other areas of influence have included structuration theory (Giddens 1984) to incorporate the notion of dynamic interplay between social structures and human agency, at individual and collective levels (Grin 2010).

The use of these theories to address sustainability issues is not new. Kemp, for example, explores means of managing new *niche* technologies in addressing the crucial question of "how to achieve a swift and smooth transition away from the old hydro-carbon regime into the new regime of non-carbon or low-carbon energy sources and more energy-efficient technologies?" (Kemp, 1994: 1047) and Rip and Kemp (1998) discuss the role of technological change in addressing climate change. The strength of existing 'techno-institutional complexes' in inhibiting change was clearly illustrated through the introduction of the idea of 'carbon lock-in', introduced by Unruh to describe how complex systems of technologies develop through a "path-dependent, co-evolutionary process involving positive feedbacks among technological infrastructures and the organizations and institutions that create, diffuse and employ them" (Unruh, 2000: 818). This path dependence inhibits the development and further diffusion of carbon neutral or low carbon technologies,

due to countervailing selection pressures, constraining or preventing niche energy innovation, thus making a low carbon transition difficult (Safarzynska, Frenken and van den Bergh, 2012,: 1012, 1021). Thus, here echoing the later discussion of resilience, it is clear that a fundamentally *un*sustainable system (for Unruh, the dominant energy system) can persist. That is, whilst sub-optimal it has the power, legitimacy and 'cultural familiarity' of incumbency with a proven track record of delivering services, and thus constitutes a stable *regime* with the capacity to block low carbon energy evolutions. As Unruh points out, "Once locked-in", technologies and associated practices "are difficult to displace and can *lock-out* alternative technologies for extended periods, even when the alternatives demonstrate improvements" (2000: 818). This is due in large part to the increasing returns to scale from a co-evolved and inter-linked technological and institutional carbon-based energy system. As Bolton and Foxon put it;

> The socio-technical transitions approach argues that many contemporary infrastructure based sectors such as water, energy and mobility are experiencing lock-in to unsustainable trajectories *resulting from path dependent change and the presence of selection environment which promotes incremental rather than radical innovation* (2015, p.540; emphasis added) [5]

In this way, socio-technical transition studies provide an attempt to find ways of 'unlocking' a carbon-based sub-optimal, inefficient or undesired (in this case unsustainable) energy system, to open up new possible energy pathways.

More recently there has been a shift in emphasis in the literature with the identification of the need to address broader social aspects. As such, Jasanoff and Kim point out that,

> …changes in the fuel supply are likely to transform social infrastructures, changing established patterns of life and work and allocating benefits and burdens differently from before. Accordingly analysts should pay greater attention to the social dimensions of energy transitions, complementing more conventional analyses of economic and engineering issues. (2013: 189)

Building on this notion is the obvious, but powerful and important point made by Miller, Iles and Jones (2013), that understanding energy transitions needs to decisively move away from a focus on particular technologies or particular fuels (a dominant and historically based way of conceptualising and analysing energy transitions). As they put it:

> Thus, the key choices involved in energy transitions are not so much between different fuels but between different forms of social, economic, and political arrangements built in combination with new energy technologies. *In other words, the challenge is not simply what*

[5] It is also import to also point out that energy transitions are not only internally complex in terms of the socio-technical energy system, but that the foundational and ubiquitous character of that system means it is connected to other socio-technical systems of modern complex societies. "Energy is a harbinger for a new era in human history. We are now moving from an era of constructing large-scale technologies to one of re-constructing complex, socio-technological systems that link energy to a wide range of other systems such as water, transportation, food production, and housing. *This transition will challenge engineers, societies, policy-makers, and the social and policy sciences to develop new approaches to innovation that integrate both technological and human dimensions together*" (Miller, Iles and Jones, 2013: 146; emphasis added).

fuel to use but how to organize a new energy system around that fuel. (Miller, Iles and Jones, 2013: 139: emphasis added)

This is not a simple challenge and this is particularly the case in Ireland, given, for example, its heavy reliance on natural gas and privately owned motorised transport, coupled with increasing social resistance to large onshore wind developments. There is a need to use conceptual framings/theoretical perspectives to aid the *analyses* of complex situations, the outputs of such analyses being used to inform policy and to *design* and *revise* governance processes in the light of new challenges or evidence. In other words, we attempt to determine how we can "understand the dynamics in our energy systems based on the transitions perspective?" in order to determine the "possibilities of influencing these dynamics" (Verbong and Loorbach 2012:16). As such, insights from governance studies (in particular reflexive governance) have been adopted in attempts to develop frameworks to drive policy and action.

The most influential example of such a governance process has been transition management, (Rotmans et al 2001; Loorbach 2010; Foxon, 2013; Bolton & Foxon, 2015), which has been extensively used by policymakers in the Netherlands, initially as part of the fourth National Environmental Policy Plan, NMP4 (VROM 2001 cited in Van der Loo and Loorbach, 2012: 220). Here, the concept of "transitions" was used to explore the possibilities of systemic change related to persistent problems, and the "Transition management" governance model developed in a science/policy collaboration. As part of this, the Ministry of Economic Affairs (EZ) developed institutional, programmatic and societal structures and processes to influence the societal energy transition, known as the "Energy Transition Project" (ETP). A detailed examination of this process is given by Van der Loo and Loorbach (2012), who conclude that whilst the ETP managed to generate a broad set of innovative efforts and new strategies and projects, a fundamental societal and policy shift towards an energy transition has failed to happen in the Netherlands. Reflecting on the project, they note than energy transition requires processes of change in both society and government: the project created space, agendas and a shared discourse, but failed to impact the dominant industry and policy regime (ibid: 234). Given the importance of this case, it will be examined in more detail in a later paper; together with an assessment of the transferability of the approach to an Irish setting[6].

More recently, there has been a broadening of the application of transition theories, notably in areas such as water management (Bos and Brown 2012, Brown et al 2009,Van Der Brugge, 2009), regional and city planning (e.g. Nevens et al, 2013), urban housing (Dixon et al 2014), transport (Geels, 2012), tourism (Gossling et al, 2012), development (Jerneck and Olssen, 2008), healthcare (De Haan, 2010), higher education (Stephens and Graham 2011, Hume, forthcoming), and the science system (Schneidewind and Augenstein, 2012). The fact that all these types of system inter-relate, and that decisions made in one system might well impact or shape another is important to consider, and Working Paper 2 will assess how this has been achieved in practice through the examination of case studies.

There has also been increased acknowledgement of the shortcomings of various approaches and the need for more pluralism (Stirling, 2011). As such, there has been increase in the attempts to address these. Particular attention has been paid to improve recognition of power issues such as the embedded power of existing energy actors to block or facilitate low carbon energy transitions (Shove and Walker, 2007; Genus and Coles 2008; Smith et al., 2005; Unruh, 2000, Van der Loo and Loorbach, 2012). There also have been attempts to address gaps or oversights in the transitions approach by appealing to insights from other

[6] See, for example, Kern 2012 for a discussion of the possibilities of diffusing the transition management model into other countries.

theories and disciplines. For example Meadowcroft (2011) makes the case for attention to the discipline of politics/political science, to incorporate awareness and analysis of unequal power dynamics by different actors at different scales and time in any transition process. Raven et al (2012) appeal to geography, on the basis that any sustainability transition may involve multiple and multi-layered processes of individual and social change, over different timescales and geographical spaces. Other developments have included the working out of many aspects of transition theories such as recognition of the importance of time and the timing, or phasing of interventions at different points in the transition process[7]; recognition of the importance of a shared energy transition vision and the significance of collective narratives or energy transition storylines (e.g. Dixon et al 2014, Rapoport 2014), social movements (Seyfang and Haxeltine, 2012), the importance of social learning processes (Bos et al, 2013), and the conditions (such as the formation of networks and shared spaces) enabling these to unfold (e.g. Smith and Raven, 2012) .

The review by Markard et al (2012) identify four broad perspectives that have been taken in transition studies; Transition Management; Strategic Niche Management; Multi-Level Perspective; and Technological Innovation Systems, and trace the origins of these from some of the literature covered above. This provides a useful framework for understanding the main concepts used in transition theory and is shown in Figure 1 below. The systematic review undertaken as part of this study (see WP1 Review Protocol available on the project website) confirms that these remain the dominant perspectives

Figure 1: Map of key contributions and core research strands in the field of sustainability transition studies (from Markard et al 2012)

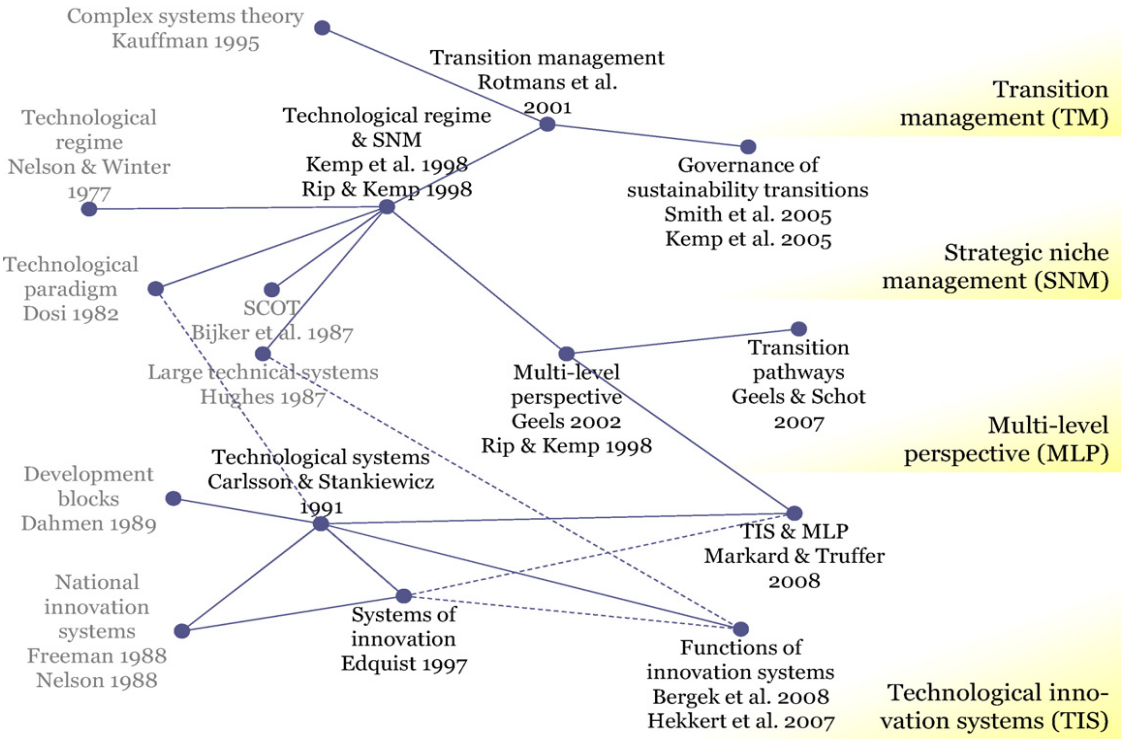


Fig. 1. Map of key contributions and core research strands in the field of sustainability transition studies.

The systematic review undertaken as part of this research broadly confirms that these remain the most dominant concepts. The following sections describe in more detail these concepts underpinning the transition approaches, and through which transition dynamics can be described: the multi-level perspective

[7] See Garud and Gehman (2012) for an argument regarding the importance of a "durational perspective".

together with a detailed exposition of each of the different levels: landscape, regime and niche; transitions; transition paths and transition phases. It will then consider the broader context for thinking about transitions and then offer a wider set of interlinked concepts for understanding the fields shown in Figure 2 above.

4. Key Concepts 1- The Multi-Level Perspective

4.1 Overview

Most socio-technical transition analyses utilise some variation on the 'multi-level perspective' (MLP), (Kemp 1994; Rip and Kemp, 1998; Geels, 2012), as a framing through which complex situations can be viewed. These levels include:

- A micro-level of ***niches*** representing innovative local practices, local actors and technologies, which can be viewed as: "a protected space where radical novelties emerge and have the opportunity to learn, develop and gain a critical mass of adopters" (Safarzynska, Frenken, and Van den Bergh, 2012: 1013).

- A meso-level ***regime*** relating to dominant technologies, practices, policies, rules, shared assumptions and discourse (Geels, 2002).

- A macro-level **landscape** comprised of social and physical environmental or infrastructural features within which the dominant regime and niches are nested and influenced by. This includes 'external' factors such as demography, the macro economy and the prevailing political and consumer culture (Geels, 2002).

Figure 2: The Multi-Level perspective

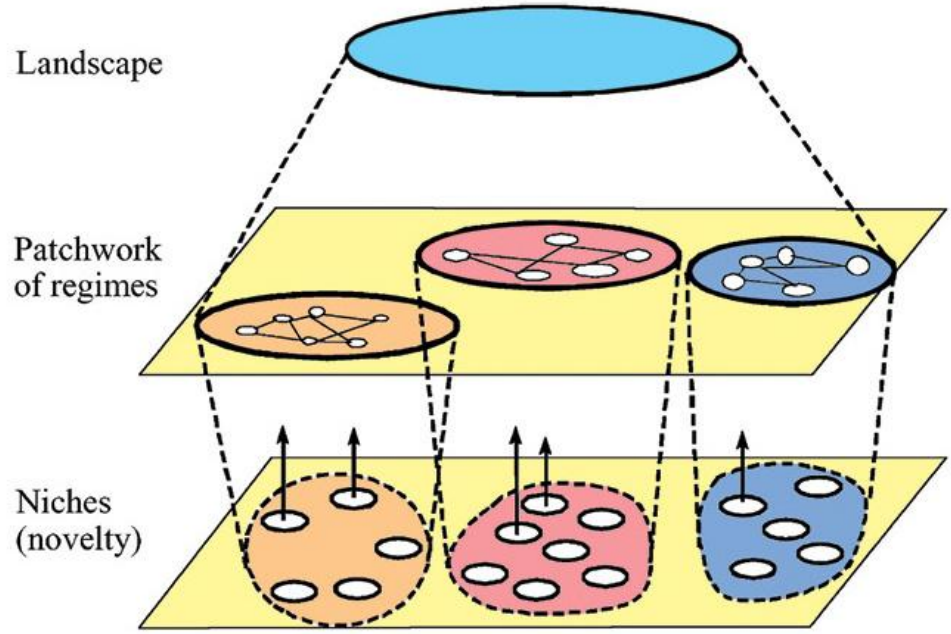


Figure 1: The multi-level perspective

From Geels (2012: 473)

It is important to note that this view of the MLP does not necessarily imply a 'nested hierarchy' view of the three levels i.e. that niches are located within a specific regime, which themselves are nested within a specific landscape. Rather, the three levels refer to 'different degrees of structuration of local practices', and as Geels suggest should be understood heuristically (Geels, 2011). In this way the levels refer only to differing 'degrees of stability' (and thus are contingent and open to intentional perturbation and steering).

These levels have been reinterpreted and redefined, (notably by Rotmans et al 2001, Loorbach and Rotmans 2009, De Haan and Rotmans 2011), to incorporate ideas from **complex adaptive systems.** This broadly uses the same level categorisations as the MLP but replaces the idea of a socio-technical system with the notion of a 'societal system' whose particular function (e.g. healthcare provision) can be viewed as an emergent property of the system (De Haan and Rotmans 2011, following, for example, Meadows 2008). The regime is the dominant manifestation (structures, cultures and practices) of how this function is fulfilled; niches provide innovative or alternative approaches. The 'landscape' is the environment of the societal system, incorporating other co-evolving systems. It also introduces the notion of a '**niche-regime**' as a strong niche that is a contender for being scaled up and passing a threshold of take up that it results in a macro-level shift or transition in the energy regime. This conceptualisation offers the possibility of viewing governance activities as coordinating actors from different scales and levels to steer the emergence of more 'sustainable' system states (Kemp et al 2005). Certain system states will preclude certain actions, and the effectiveness of certain actions will depend on the system state. However, the Transition Management literature has been criticised for the loose use of systems concepts (Van den Bergh et al 2011), and the flexibility in the literature in the way that regime, landscape and niche are defined. This makes it particularly important to clarify how terms are being used, as ambiguities can easily arise.

4.2 Transitions

Transitions can are broadly seen as emerging through the interplay between these three levels[8], involving what Grin et al describe as "mutually reinforcing flywheels" (2010: 265), where processes of change reinforce each other. It involves "profound change in various or all aspects of a societal system's functioning", namely structures, cultures and practices[9] (De Haan and Rotmans, 2011: 93), and can be viewed as the emergent result of processes and mechanisms occurring in a limited number of identifiable patterns (De Haan, 2010: 63). For example, Geels and Schot (2007: 400) describe a scenario where niche innovations build momentum and landscape forces put pressure on and destabilise the regime, providing a window of opportunity which enables niches to gain dominance. However, the strength of regimes means that transitions do not happen easily and the processes and dynamics of transition are inherently open ended, contingent and non-linear. Könnölä, Unruh and Carrillo-Hermosilla have suggested that:

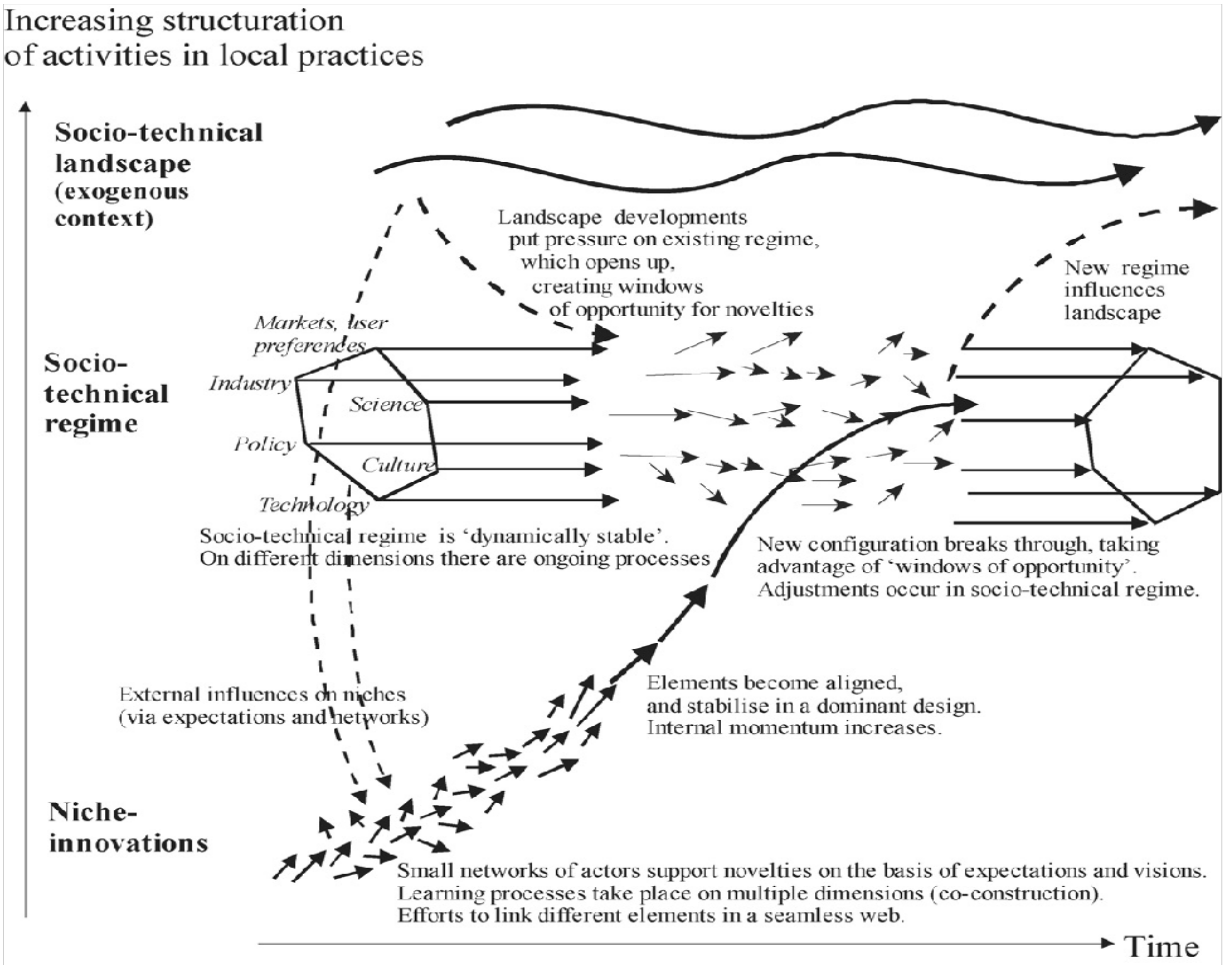
[8] **niche/regime**: the dynamics here vary hugely depending on the type of niche (e.g. grassroots social movement versus niche space created by regime (Van Der Brugge, 2009; Smith and Raven, 2012; Seyfang et al., 2011). **regime/landscape:** – the regime can influence the broader landscape, and failure to respond to landscape challenges can cause tension in the regime (De Haan and Rotmans, 2011). **niche /landscape**: niche can be better adapted to landscape changes putting pressure on the regime (De Haan and Rotmans, 2011)

[9] Structures refer to the formal, physical, legal and economic aspects of functioning which restrict and enable practices; cultures to the cognitive, discursive, normative and ideological aspects of functioning involved in the sense-making of practices; and practices to the routines, habits, formalisms, procedures and protocols by which actors maintain the functioning of the societal system (De Haan 2010,; De Haan and Rotmans, 2011).

> in the absence of exogenous shocks, escaping lock-in requires continuous learning among stakeholders and the inclusion of actors from outside the Technical Innovation Complex... *authorities [need] to initiate future-oriented stakeholder processes to generate alternative technological pathways for discontinuity type of technological changes* (2006: 249; emphasis added).

Thus even understanding and mapping these processes does not in any sense guarantee a simple 'command and control' management of transition towards one desired outcome: it is inherently contingent and open-ended, but amenable to steering and what may be called **'pathway editing'.** Thus, transitions analyses can be used to identify leverage points for steering, which can be later reviewed as necessary, as learning occurs. Different models of transition pathways will be discussed below, however first more detail will be provided on each of the levels: landscape, regime and niche.

Figure 3: Transition Dynamics (Geels and Schot 2007:401)



4.3 Landscape

Rip and Kemp (1998) introduced the idea of the 'sociotechnical landscape' as a landscape in both a literal and metaphorical sense in which regimes and niches are embedded. The landscape includes both social and physical/material elements, such as infrastructures, cultures, values, and worldviews (Rotmans et al, 2001), and can be viewed as providing a macro-level structuring context for the regime (Smith et al., 2010). The 'socio-technical landscape' is also used to denote broader structuration processes that influence niche-regime dynamics, but that are not open to unilateral change from actors within any single regime (Smith et

al., 2004).

Incorporating ideas of co-evolution, the landscape is also been viewed as "the patchwork of societal systems within which a societal system of interest might be embedded" (De Haan and Rotmans, 2011:93). Landscape forces originating in these systems may create *tension* in a regime, requiring changes in dominant structures, cultures and practices (De Haan and Rotmans, 2011; Frantzeskaki and De Haan, 2009). Identifying these tensions and how they are addressed helps map patterns of change. For example, Grin (2010) identifies and maps the effect of landscape forces such as privatisation, Europeanisation, globalisation, and individualisation on the Dutch agriculture regime. It is clear also that owing to particular landscape forces, the direction of change might be in an arguably less sustainable direction. For example, if tension in the Irish energy regime resulting from landscape requirements to address climate change, led to the adoption of nuclear power (with attendant change in dominant structures, cultures and practices, this (for many) would be a move *away from*, *not towards*, a sustainable energy system.

Here, the inclusion of other related and 'co-evolving systems' as part of the landscape clearly raises the need to map how their inter-relation with the regime of interest can influence patterns of change. This is one of the key areas of confusion within the transitions approach, as it is mostly assumed that the regime and niche can only affect the landscape in the much longer term. However, if a landscape consists of a constellation of other co-evolving systems it is clear that something like an energy regime might indeed have profound effect on some of these; and these effects might take place in different timescales. For example, co-evolving eco-systems might be polluted through energy regime practices; public opinion might be swayed by major disasters. Thus, taking Kemp et al's description of sustainable development as a process of co-evolution where we have "*cause-effect-cause* loops across different scales and systems, with effects becoming causes of other developments" (Kemp et al., 2005:4), and transition management as being "concerned with the coordination of interaction [between a diversity of actors at different levels] and co-evolutionary processes" (ibid: 4) it would seem to make sense that the *two-way* relationships between different levels (including regime and landscape) are key. However, Smith et al. (2010) have noted, there has been very little research examining on how dominant regimes or innovative niches might influence the broader landscape; most attention has been directed toward analysing how developments within and between niches and regimes take place against the background of broader social, economic, political and cultural changes.

Landscape Factors in Transport

Distinguishing between landscape and regime depends on where the boundary of the system of interest is viewed to be; this is not always clear, and can be adapted depending on purpose. If we examine the transport system in Ireland, it is clearly dominated by the private car. Here, if the regime is viewed as the dominant structures, cultures and practices of a societal system then factors such as the road infrastructure, filling stations, transport and motoring legislation, car dealers etc., driving habits and status associated with car ownership are all part of the regime.

Landscape factors affecting this regime thus include climate legislation, carbon tax, fuel prices and availability, economic recession, the knowledge or science system, and broader cultural values such as how environmental crises are perceived. Changes in the landscape can cause tension in the regime; thus, for example, a rise in oil prices might catalyse either the further adoption of alternative fuels, or a change in driving practices such as a move to public transport or car sharing.

4.4 Regime

Geels (2004) developed the idea of a 'sociotechnical regime' as a way of conceptualising the meta-coordination of particular inter-dependent regimes (e.g. science regime, policy regime, socio-cultural regime), or rule-sets affecting a particular sociotechnical system. Regimes provide stability but can lead to the entrenchment of specific path dependencies, and directing trajectories of change in a narrow range, thus making 'step-change', 'system-level' or 'breakthrough' innovation difficult if not impossible. Smith and Stirling (2008) argue the need to extend the concept of regime beyond rule-set, to include more material aspects such as the actors and artefacts whose practices develop these rule-sets; rules are re-enacted through networks of actors and artefacts engaged in socio-technical practices (Smith et al 2005).

Rotmans and De Haan (2011) see a regime as the dominant structures, cultures and practices of a societal system, which meets a particular societal need, for example the need for energy in general or electricity in particular. Regimes experience *tension* as landscape forces affect their abilities to meet these needs; or pressure from innovative niches which may more effectively address the societal need. Regimes are also subject to internal *stresses* (De Haan and Rotmans, 2011) and exist in dynamic inter-relation with other (landscape) systems (water, housing, transportation etc), as discussed above. Landscape forces, creating tension in regimes and spawning niches, may create the conditions for transition, as structures, cultures and practices radically transform or are displaced and replaced. The possibility of transition occurring through regime transformation rather than displacement has brought closer attention to the relationship between regimes and innovative niches and why niche protection is needed (Seyfang and Haxeltine 2012; Van Der Brugge, 2009; Raven and Smith, 2012).

Regime Example : Plastic Food Packaging

If we look at a technology such as the plastic packaging of food, the sociotechnical regime might include evolving legislation and associated informational infrastructures (packaging standards, sell-by dates, traceability); physical infrastructures such as packaging systems in factories; social expectations of "freshness"; vested interests in the plastics industry and so on. The more embedded these elements are, the more difficult it is for transitional change to occur. For example, here it might involve changing entire packaging and distribution processes, how items are labelled, what people perceive as "fresh", and loss of profit for the companies in the plastic production supply chain. Also, this technology itself is a component of other more complex sociotechnical systems – such as the entire system of food production, distribution and consumption, which in turn is an element within the broader economic system. Consequently, path dependence might also be influenced by "lock in" in these broader systems, such as the dominance of supermarkets as the primary means of buying food or an economic model which prioritises profit (see also Smith 2007, for a discussion of organic food)

4.5 Niche

In the MLP, as noted above, innovative change happens in protected spaces or 'niches' which enable learning processes, creativity and experimentation to occur. Geels and Schot have described niches as protected sites where "radical novelties emerge" (2007: 400), effectively where new socio-technical configurations can be established, often as a direct response to an unsustainable regime, experimented with, and developed, away from the normal selection pressures of the regime (Smith and Raven, 2012). De Haan and Rotmans (2011: 92) define niches as relatively powerless subsystems of a societal system (constellations) with different or deviant functioning which meet specific societal needs, maybe in unorthodox ways.

Niches can lead to forms of 'disruptive innovation', or in the Schumpeterian tradition of evolutionary economics, processes of 'creative destruction' (Schumpeter, 1942: 83), displacing dominant actors, products or processes, services, or the novel use of existing products of services, all culminating in the shift towards a new regime. Niche activity is characterised as a "process of mindful deviation" (Garud and Karnøe, 2001 cited in Geels, 2004: 913), which can only happen in a space less circumscribed by dominant regime rules, habits and practices. Thus protected, these niches can seed 'disruptive change', which can be developed, supported, scaled up and more widely disseminated. To do this, niche experiments have "to overcome the constraining influence of regimes, branch out, link up with wider change processes, and drive transformations in those same regime structures over the longer-term" (Smith et al., 2010: 440-1). Essential elements in this process are the formation of local and global networks between niche actors and activities, and links to other related actors and processes, (for example, links between energy system actors with those in other areas such as housing or transportation).

More recently, the niche concept has been broadened to include innovative social practices (Smith et al., 2010), thus adding 'social innovation' to the dominant focus on 'technological innovation' within transition studies. For example, Smith (2007) has examined the growth of 'green niches' such as organic food and ecohousing in the UK; Van Der Brugge (2009) has examined the role of 'policy niches' in processes of policy learning for Dutch water management; Seyfang and Haxeltine (2010) and Cato and Hillier (2011) have characterised the development of a grassroots social movement, transition towns, in the UK as a form of 'social innovation' of particular relevance to the transition to a low carbon society. Avelino and Kunze (2009) have examined the contribution of the ecovillage movement to that energy transition.

Further work has looked processes of niche formation in more detail. Smith and Raven (2012) examine the regime conditions which lead to the need for niche formation; different stages and activities of niche formation such as the creation of visions; formation of local and global networks; support mechanisms, including resources; and learning processes. They also further examine the relationship between regime and niche, distinguishing between *'stretch and transform'* niche activities, oriented towards altering the regime, in contrast to *'fit and conform'* ones, which do not challenge the existing regime structure.

Finally, a point made by Geels (2010) is significant, namely the sheer multiplicity and variety of actually existing and potential 'green innovative niches'. As he puts it: "current transport, energy, agri-food and other domains are characterized by multiple 'green' niche-innovations. *This variety deviates from many historical transitions that were characterized by one, two or sometimes three niche alternatives*" (Geels, 2010: 507; emphasis added).

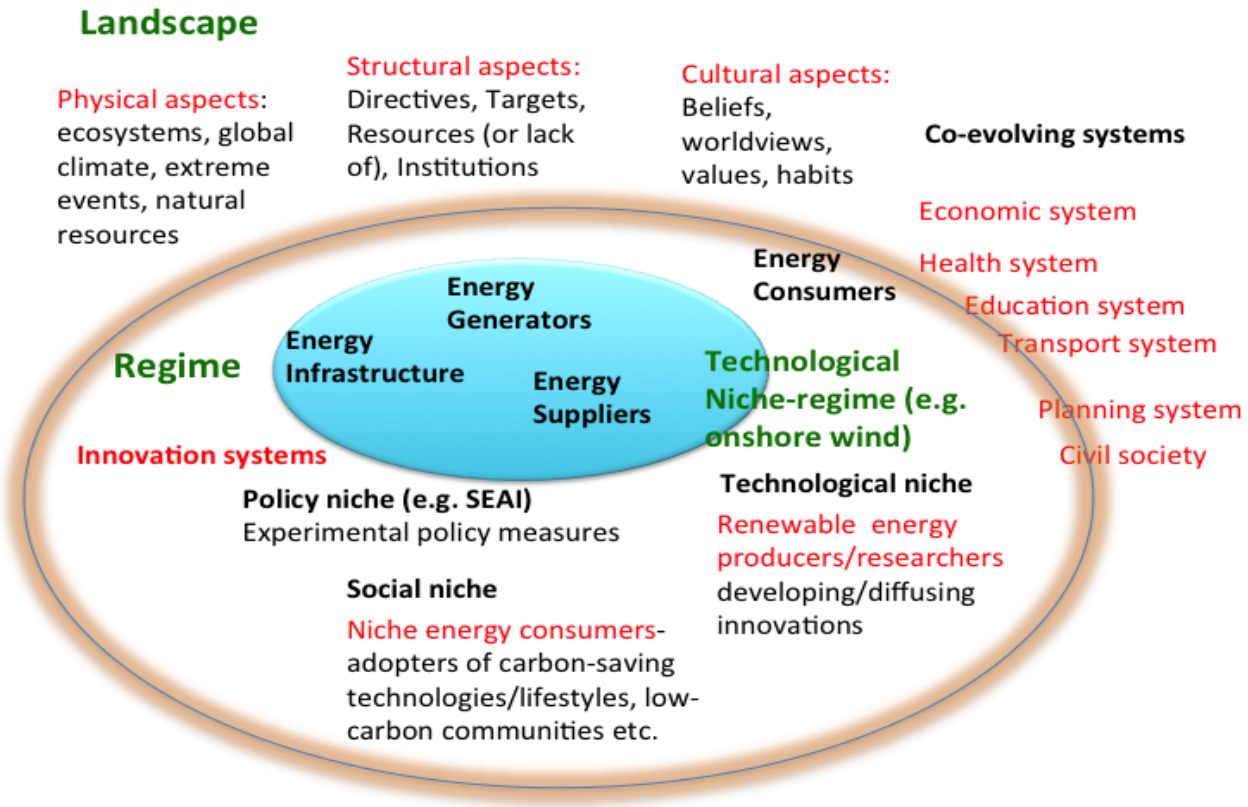
Social Niches

The need for a broader perspective on innovation has been acknowledged by Seyfang and Smith (2007) who use the term 'grassroots innovations' to describe community-based sustainability initiatives, which more directly respond to social problems. The term niche has thus been broadened to incorporate social movements such as Transition Towns (Haxeltine and Seyfang 2009), and renewable energy communities (Doci et al 2015). Transition Towns (Hopkin 2008) works to build resilience in local communities through encouraging changes in energy practices, local food production and the preservation of local skills. Renewable energy communities can be described as "grassroots initiatives that invest in 'clean energy' in order to meet consumption needs and environmental goals" (2015:85), which can include environmental protection, supporting the local economy and the value of working for the community. According to Doci et al, social niches can be seen as complex systems where technological and social innovations develop simultaneously and, during a transition entire niches link up with the regime. In social niches, technologies serve more as tools and social innovations, such as new energy production practices and new behaviours play an important role.

4.6 Niche-regime

De Haan and Rotmans (2011: 92) have also characterised powerful constellations providing competitive or viable functioning compared to the regime as 'niche-regimes' which may become dominant through a regime shift or transition. This could occur, for example, if an existing regime became obsolete due to a change in landscape changes or wider exogenous environmental or global economic conditions (for example rapid climate change, or an unforeseen disruption to global oil supplies with consequence rapid and high increases in prices and decrease in security of supply), and a new one better adapted to changing circumstances emerged and replaced the old energy regime (De Haan and Rotmans, 2011: 93).

Figure 4: A Multi- Level Perspective on an Energy System



4.7 Trajectories of Transition – transition paths

Relationships between niche, regime and landscape levels are important in the unfolding of the transition and possible *transition paths* or *trajectories* that emerge, and these have been conceptualised in different ways. Examining the dynamics in particular situations thus provides a possibility to determine potential trajectories of change and identify where change can be influenced. As discussed above, transition may occur through a transformation of a dominant regime, or through its displacement by a growing niche. The type of transition is also influenced by where the major impetus for change occurs; for example, the

introduction of legislation or targets could drive a preferred energy transition from the top down. There have been a number of categorisations of transition paths, in an attempt to map patterns of change, notably:

Berkhout et al (2004), Smith et al (2005) provide a categorisation based on:

- whether change is primarily envisaged or actively coordinated from above, or occurs as the emergent outcome of co-evolutionary behaviour of regime members;
- whether responses to selection pressures are based on resources available within or outside the dominant regime.

Geels and Schot (2007) outline a four-fold typology of possible transition pathways deriving from a range of possible niche-regime interactions:

- whether niches are sufficiently well-developed to compete with regimes;
- the extent to which disruptive (as opposed to reinforcing) landscape pressures are exerted on regimes.

Frantzenkaki and De Haan (2011), and **De Haan and Rotmans (2011)** examine the conditions for change, and how these can be used to construct narratives from sequences of patterns. They define three types of force which can act on a regime:

- Tension – top down pressure on the regime from landscape forces;
- Pressure – pressure on the regime from a niche that better meets a societal need;
- Stress – internal inconsistencies in the regime.

Here, mapping the type and origin of forces enables different patterns to be identified. For example, we could witness a *reconstellation*, where, for example, legislative changes in the landscape forces regime reconfiguration, or *empowerment*, where niche activities are resourced or enabled, as promoted by Transition Management and Niche Strategic Management. Further details of transition pathways have been articulated in other work, such as that by Smith and Raven (2012), discussed above.

4.8 Transition Phases

Unfolding transitions in complex adaptive systems go through ***phases***, which can determine the speed of transition. Alongside the MLP, temporal dimensions of transition processes are important to understand and integrate into any analysis of energy transition. The most common way this is conceptualised in the literature is to view any transition as going through four broad phases: "(1) *pre-development phase*, during which structural change is not yet visible; (2) *take off*, when the process of structural change gains momentum; (3) *acceleration phase* of these processes; and (4) *stabilization phase*, after which a new dynamic equilibrium is achieved" (Safarzyn´ska, Frenken, and van den Bergh, 2012: 1016).

Table 1. Sample Integration of MLP and Phasing of Transition

	Pre-Development	Take off	Acceleration	Stablisation
Landscape	Landscape forces create tension in regime		Niches may influence aspects of landscape; support given for niche development	Some degree of transformation in landscape
Regime	Support from Landscape	Increased tension, stress building as function not adequately fulfilled and regime practices "locked –in"	Either the regime adapts or remains tightly locked in.	New or transformed regime
Niche	Niche actors begin to address landscape challenges	Niche networks are formed, visions constructed, learning occurs	Dominant niche may become niche-regime Widespread take up of niche innovation	Niche becomes regime Establishes itself as the new normal

In summary, the multi-level perspective, aided by insights from complex adaptive systems theories, provides a framework which can be used to describe particular types of sociotechnical system, such as an energy system. Major actors, structures, cultures and practices in the regime can this be identified; key landscape influences mapped and described; and accounts given of existing niches. Analyses of processes of change helps identify possible phases and trajectories or roadmaps for transition and where, for example, lock-in might be occurring or change might be blocked or driven in a less desirable direction. These analyses thus provide insights to inform the timing and nature of policy interventions, and can be incorporated in the design of reflexive governance processes.

5. Governance Approaches related to the MLP

As discussed above, these approaches have been used, particularly in the Netherlands, to analyse transition processes and inform governance experiments. Section 3 discussed the idea of reflexive governance, which acknowledges the need to address unintended side effects of governance processes and the need to accommodate the views of multiple stakeholders. Box 5.1 lists the key elements of reflexive governance and provides an example of the governance of food security in Brazil (Sonnini et al 2014). The key challenge with reflexive governance is the tension between the need to 'open up' governance processes to enable the accommodation of multiple perspectives and to 'close down' these processes to enable efficient decision-making to occur. Further challenges relate to power and politics – for example, who decides and whose input is ultimately included when decisions are made.

Box 5.1 Reflexive Governance and Food Security in Brazil

Voss et al (2006b) cite six key features of reflexive governance:

- Integrated knowledge production.
- Experimentation and adaptivity of strategies
- Anticipation of long-term effects
- Interactive, participatory goal formation
- Interactive strategy implementation
- Settings for interaction appropriate to problems (e.g. transition arenas of transition management, or certain niche spaces).

An example of how this might work in practice is given by Sonnino et al (2014) who outline a multi-levelled approach to reflexive governance used to develop and implement food security in Brazil, centred round school meal provision. Key aspects described include the provision of participative spaces for deliberation and learning, and mechanisms through which insights can be translated into policy revision. In 1994, this included the establishment of a number of bodies at different levels which were integrated into a new governance framework- the National System for Food and Nutrition Security (SISAN).

National Conferences for Food and Nutrition Security (CNSAN) take place every four years and are responsible for identifying the national priorities for food and nutrition security. These facilitate a regular bottom-up flow of information and feedback between the local and the national level and involve a wide range of participants including representatives from civil society and the public sector who are members of regional food and nutrition security councils. Four days are spent where working groups deliberate over a pre-prepared document draft, and set priorities. A National Council for Food and Nutrition Security (CONSEA), again with broad representation, discusses these and uses them to formulate directives. These are presented to an inter-ministerial body (CAISAN), who turn these into policy. Thus policy is formulated and adapted, and side-effects noted.

In addition to these, at a local level, school committees (CAEs), ensure civil society input into nutrition and these also work with farmers to ensure locally produced food is used. According to Soninno et al, these encourage key school food system actors to adapt their frames, structures and patterns of action in ways that take into account alternative understandings of the problems. They also note that the different arenas within SISAN provide "identifiable arenas of deliberation where food producers and consumers, institutions and practitioners, scientists and policy-makers can share their experiences and negotiate their priorities. " (ibid:9) However questions have also been raised about the predominance of certain social groups and the absence of others.

Source: Sonnino, R. Torres C., Schneider, S. (2014) Reflexive governance for food security: The example of school feeding in Brazil , Journal of Rural Studies 36 (2014) 1-12

Two major governance frameworks: strategic niche management and transition management will be discussed below. These approaches are not without criticism (see section 5 below); however there have been many attempts to address shortcomings and these are also discussed.

5.1 Strategic Niche Management

Building on constructive technology assessment, strategic niche management was developed as a governance mechanism to encourage and steer niches in technological innovation through experimentation, using open learning processes (Hoogma et al, 2002; Schot and Geels, 2010). Steering is enacted by a range of 'niche' actors such as users or societal groups, for example, new actors might be added to broaden the range of insights instigating or specific learning processes or practical experiments might be instigated. Schot and Geels stress that niches in SNM "are not inserted by governments, *but are assumed to emerge through collective enactment*" (2010: 538; emphasis added). They also note the importance of 'hands-on', real-life experiences in demonstration projects, based on the assumption that actual implementation and specification of visions in experimental settings are most conducive for niche development. SNM research has evolved from a focus more on the internal working of niches towards the relationship between niches and their broader environments, such as the development of global niche networks (for example, see Raven, 2012; Smith and Raven, 2012).

Key elements of Strategic Niche Management include:

- The clear articulation of expectations and visions. These need to be specific enough to provide guidance and a broadly shared vision, but not too rigid so as to dampen creativity and flexibility. Building in space for creative and surprising responses is essential in thinking about and designing governance/policies for the future transformations of an energy system which may be unpredictable.

- The building of social networks. These need to be broad and include multiple stakeholders beyond the state and energy providers. The inclusion of outsiders is more likely to permit second order learning (where basic assumptions are questioned), but if networks are too broad, focus may be lost, or if inadequately resourced innovation through collaboration lost or stunted.

- Learning processes - both first order (facts and data) and second order learning (enabling changes to cognitive frames and assumptions) and the emergence of a shared (if loose) 'community of practice' (Wenger, 2000) and culture (Schot and Geels 2010: 540-1; McCauley and Stephens, 2012).

Early experimentation with these processes raised the need to consider more explicitly the co-evolution of niche experiments with their contexts: "the transformative power of experiments is small unless they are linked to *long-term strategies for structural change involving policy makers*" (Kemp et al., 2005: 20). Transition management evolved as a mechanism to address this need.

5.2 Transition Management

Transition Management combines aspects of reflexive governance and complex adaptive systems theory (Loorbach 2010, Loorbach and Rotmans 2010, Van Der Loo and Loorbach 2012, Safarzyn´ska, Frenken, and van den Bergh, 2012), and as discussed above, has been used and developed by the Dutch government for over a decade. Loorbach and Rotmans define transition management as a "deliberative process to influence governance activities in such a way that they lead to accelerated change directed towards sustainability ambitions" (2010: 239). Based on complexity theory, analyses of transitions are used to stimulate and support problem-structuring processes, help build reflexive capacity and inform social learning to create the conditions for change to occur. A four step operational cycle of activities includes an initial integrated systems analysis[10] to structure the problem; visioning and networking activities (via a 'transition arena'); and evaluation. Through debate, structured evaluation, assessment and research, issues are continuously structured, reframed and dealt with. Four different types of governance activities provide a recursive framework for implementation ensure coordination at different levels (Loorbach 2010; Loorbach and Rotmans, 2010: 239). These are:

1. **Strategic activities** take into account a long time horizon, relate to structuring a complex societal problem and creating alternative futures;
2. **Tactical activities** at the level of subsystems relate to build up and break-down of system structure;
3. **Operational activities** relate to short-term and everyday decisions and action where actors either recreate system structures or they choose to restructure or change them; and
4. **Reflexive activities** relate to evaluation of the existing configuration at various levels and their interrelation or misfit.

As shown in Figure 5, Transition management can be envisaged as a cyclical process, which according to Loorbach (2010), works most effectively in early phases of policymaking processes or in deadlocked processes where breakthroughs and 'disruptive innovations' are required. The extent to which this governance mechanism is transferable to other contexts is also subject to question (see, for example, Kern, 2012 for a discussion of how the extant science/policy interface in a country might be a determinant in this).

[10] Taanman (2012) reflects on the use of innovation systems analysis here in policy monitoring, and this will be discussed below.

Figure 5: Transition Management Cycle (source: Loorbach and Rotmans 2010:238)

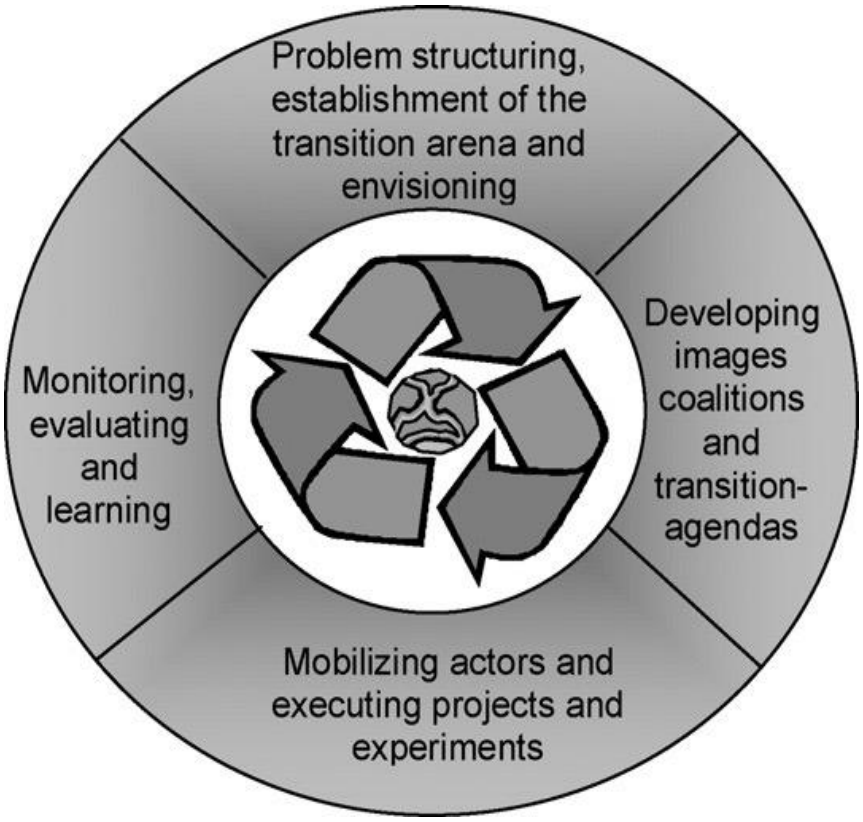


Table 2. A possible mapping of some actors and dynamics of transition within the MLP.*[It is important to note that the landscape is diverse : it includes dominant co-evolving systems such as the global economic system – but can also include radical public opinion – thus tension in a regime could caused by contradictory landscape forces*].

	Actors	**Institutions**	**Governance logic**	**Resources**	**Knowledge/ scientific basis**
Landscape	EU actors, civil society,	Culture, state and industry bodies	Risk management	Legitimacy	Dominant worldview as normal science,
Regime	State, established energy providers, researchers	'Industry standard'	Maintenance of status quo, limited innovation (replication)	Finance, recognition, 'the norm', familiarity, insider status	Normal science 'Commonsense'
Niche	Some HEI research and development, small low carbon energy groups/innovators in industry, civil society and R&D		Disruptive innovation	Limited finance, status, recognition, 'buzz' of novelty, outsider	Mode 2 science Post-normal science Paradigm shifting science Interdisciplinarity

6. Key Criticisms of Transitions Approaches utilising the MLP

6.1 Lack of consideration of power, agency and realpolitik

In both the study of sociotechnical transitions (Smith and Stirling, 2010; Meadowcroft 2011; Avelino, 2011; Smith et al 2010; Smith et al 2005; Smith and Stirling, 2010; Shove and Walker 2007), and in the governance experiments based on them (Shove and Walker, 2007; Kern, 2012), there can be a tendency/temptation to neglect, downplay or ignore issues of power and asymmetrical agency. As Swyngedouw points out:

> "there is a politics to transition management, a playing out of power of when and how to decide and when and how to intervene, which cannot be hidden beneath the *temporary illusion of 'post-political' common interest claims of sustainability.*" (Swyngedouw, 2007: 18; emphasis added).

Smith and Stirling state that it "is unclear how transition management processes sit in relation to prevailing policy institutions and political activities" (Smith and Stirling, 2010: 9). And as Kern argues: "If transitions are to a large degree political processes resulting from decisions by multiple actors, *then political dimensions should be at the heart of the analysis*" (2010: 26; emphasis added). Yet, to a large extent, most transition studies are silent on the non-technological political dimensions of system change or only implicitly integrate these into their analysis.

Perhaps because of the origins of Transition Management within technological and later evolutionary economics studies, coupled with a positivistic and quantitative social science epistemology and an objectivist methodology, TM's self-understanding of itself was originally as an ostensibly less "political" analytical approach[11], where, being concerned with the longer term, it could transcend democratic accountability via standard political processes, whilst serving as a tool that could be used by state actors and policymakers. Yet this is both misleading and naive, given both the high political stakes of any transition and also the highly political context, actors and dynamics that characterise any large-scale, system wide transition process in modern society. The lack of attention within the framework to issues of power, special interest lobbying etc., has meant that transition and system change can be viewed as operating within the tramlines laid down by a more politicised understanding of the landscape and regime. That is, from a naive apolitical perspective of sociotechnical transition, only system changes which do not disrupt the dominant political status quo are permitted or even 'thinkable' i.e. deemed both legitimate and possible.

Advocates of transition management, however, have challenged this view. Jhagroe and Loorbach (2014) argue that TM can potentially be more democratic than institutionalised democracy, calling for the exploration of how alternative democratic models such as "discursive and agonistic (conflictual) versions of democracy" (Hendriks, 2009: 357) could be incorporated into a more democratic version of transition management. Swyngedouw argues that

> "democratic transition management should not simply adhere to informal networks with architects, professionals and policy makers (as elitist technocracy). Rather, it should direct its

[11] "Transition management is not a strategy of incremental politics but is rather *an incrementalist strategy for changing functional systems*" (Kemp et al., 2005:17).

> democratic potential beyond traditional frameworks of democratic governance and highlight how a different framing of time-horizons, problem spaces, and new socio-technical, socio-economic and socio-ecological combinations could render possible more democratic transformations (Jhagroe et al 2014:14)".

There is a link here not simply to suggestions that transition management can increase, extend or deepen democratic decision-making in infrastructural areas such as energy or housing for example, but also that transition requires the use of 'post-normal science' discussed below.

Further to this, Jhagroe and Loorbach (2014) note that these approaches also address issues of temporality at different systemic levels and localities, in that they highlight the conflicts and tensions that can emerge between planning embedded in (traditional) democratic institutions (which may be short-term in focus), and reflexive governance that is linked to sustainability-led and thus long-term transformations. These are very important (and messy) issues to be considered in the context of the Irish political system.

6.2 Ideology, Norms and Worldviews: Transition Management and Ecological Modernisation

Popa et al. (2015) argue that a weakness in transition management lies in its "lack of critical reflexivity on normative/ideological orientations guiding social transformation processes" (2015: 51). This raises the risk, as also noted by Kern (2012) and discussed above, of transition management being co-opted by prevailing vested interests or being too narrowly circumscribed by the 'tramlines' of the dominant regime as suggested above (see also Paredis, 2011). Van Der Loo and Loorbach (2012), reflecting on the Dutch experience with transition management, note the core problem that national government *itself* is a member of the incumbent fossil-fuel based energy regime (and thus also requires transition management). This may lead to 'path-dependent' as opposed to 'path-creation' (Garud and Gehmann, 2012) innovations or a lack of attention being paid to grassroots/social innovation and non-technological understandings of or dimensions of innovation.

Much of (though by no means all) of the transition literature could be said to favour a broadly 'ecological modernisation' (Barry, 2004) or 'ecomodernist' normative commitment, that is the 'greening' of the prevailing socio-economic order as opposed to a transition beyond this order. In particular there is an implicit, if not explicit acceptance of the goal of continuing orthodox economic growth (Barry, 2012) within the transition literature, while also neglecting the role of energy as a prime causal factor not a consequence of that economic growth (Ayres, 2013; Ayres and Warr, 2010). For major transition figures such as Geels, there is a closer link between the MLP approach for example to transition, and evolutionary and 'reformist' approaches (including business/corporate management studies), which seek to 'green' or 'ecologise' the existing socio-economic order, rather than social analyses based on conflict and power for example (Geels, 2010), which may require landscape level changes. Indeed, as Paredis (2011) has noted, landscape-level changes, such as EU regulations or international resource shortages tend to have a much more marked influence than particular transition management approaches, and thus have much more traction in catalysing change.

However, there are however some studies which do address this issue. For example Azar and Sandén (2011) point out that there may be instances where it is not possible to bridge contradictions between orthodox economic growth by structural improvement and transition objectives which might be detrimental at least to currently dominant concepts of economic growth. This leads, as suggested by Weber & Rohracher (2012) to greater stress on and need for more flexible and responsive institutions and policies governing any energy transition process, since it opens up major differences in opposing objectives.

As they put it, "the aim of reconciling structural and transformative policies might open an arena for interaction, dispute and negotiation, thus stressing the need for strengthening reflexivity in the governance of policies for transformative change" (2012: 1046), thus requiring more attention to identification and management of conflict resolution, mutual adjustment and social learning and agonistic negotiation (Barry and Ellis, 2012).

Thus, if we embrace Unruh's call for extending stakeholder engagement and networking beyond the 'usual suspects', who may largely share a similar worldview, values and analyses of the energy system and its future transition, thus making it a smoother, more stable and more consensual process, there is a need for new processes of engagement. In including new (potentially and indeed hopefully disruptive) actors with perhaps radically different worldviews, values and analyses informing their very different energy vision, explicit attention needs to the paid to expecting and welcoming robust exchange between new energy system actors and more established ones as a positive, not as something negative to be downplayed or avoided. In this sense, what is needed are 'difficult' and 'uncomfortable energy conversations' and welcoming, and, more importantly, positively *facilitating* conflicting, agonistic exchange in order to help produce breakthrough innovations.

6.3 Discourse and social learning

Geels (2010) has also argued that the complex nature of sustainability transitions requires further consideration of the importance of narrative and discourse. See Genus (2014), Pesch (2014). As Safarzyn´ska, Frenken and Van Den Bergh note:

> "A regime shift cannot occur without changing worldviews, institutions, and technologies together as an integrated system. Learning is an essential mechanism behind preference and institutional change. As a consequence, in transition research, much emphasis is placed on the process of social learning through which knowledge develops during interactions between various stakeholders…Social learning is crucial to the governance process where facts are uncertain and values are in dispute as in the context of sustainability transitions. *This implies that learning needs to go beyond knowledge acquisition, i.e. it may require to change how we perceive problems*." (2012, p.1019; emphasis added)

This is linked to the contribution of a 'post-normal science' approach and how this can 'add value' to the socio-technical transition perspective. A post-normal science approach, as Bernstein, Foley and Bennett (2014), document can help decision-makers avoid the pitfalls of 'complexity exclusion'. That is where the stakes are high, where value-systems are relevant and in competition if not in out-right conflict, where the 'facts' themselves may be contested, and the issue is characterised by high levels of uncertainty (Funtowicz and Ravetz, 1993). In such contexts we need to move beyond the usual and normal solutions offered by applied science; here, we need the insights of post-normal science, bringing in new stakeholders, integrating rather than excluding normative points of view and extending appropriate expertise beyond those normally viewed as the appropriate experts. Here, there is a clear role for the higher education system and the media.

6.4 Civil Society/grassroots innovation

Haxeltine and Seyfang (2009) address limits encountered in attempts to extend the theory, which developed through examining mainly technological innovations in commercial markets, to examine civil

society movements. They note the theory is often used to steer transitions through a top-down governance framework. However, this is clearly different to examining how transitions could emerge 'from the bottom up', through civil society movements, especially those innovations that are less about technological innovation, but more on social innovations (Cato and Hillier, 2011; Avelino and Kunze, 2009); and are demand-side as opposed to supply-side focused. This clearly points to the need for further consideration of issues of the asymmetrical distribution of power and agency within the energy system, as discussed above. It also links to the possible supplementing of a transitions approach with insights from new social movement theory, as suggested below.

6.5 Space and Scale

Overlooking the critical role of spatial aspects to change and failing to explain why spatial contexts matter has been another major criticism of transitions approaches (Smith et al., 2010; Raven et al., 2012; Coenen et al., 2012; McCauley and Stephens, 2012). Reason et al. (2009) also make the point that definition of 'landscape' in sociotechnical transition theory does not often refer to the physical landscape (though it is not explicitly excluded). To address this, Raven et al suggest an extension to the transition framework, to take spatial issues into account. Example analyses of the significance of scale and spatial considerations include, McCauley and Stephens' regional study of green energy clusters in the US (McCauley and Stephens, 2012) does explicitly focus on sub-national scale and the regional level as important analytical considerations to explain the effectiveness of clustering of green energy industries and associated research and development and civil society initiatives. As they point out, "Regional sustainability clusters can be conceptualized as *conveners and coordinators of a collection of niche activities in a region*, i.e., by supporting the development, demonstration, and implementation of new, experimental technologies and social practices" (ibid.: 218-9; emphasis added). Given the importance of networks between niches this regional dimension and clustering are important spatial considerations to be taken into account in any analysis of energy system transition, not least in relation to the relatively small geographical scale which characterises a country such as Ireland.

6.6 Supply-side bias: Beyond a 'What will keep the lights on?' framing of energy transitions

The dominant focus of Transition Management is on supply-side solutions and innovations. In terms of energy, for example, the focus is on what socio-technical innovations in new low carbon/less carbon intensive energy technologies can increase or maintain the existing supply of energy. This framing of the energy transition thus downplays or removes from analysis a focus on energy efficiency and conservation or more radical ideas around 'energy descent planning' (Hopkins, 2008). However, some authors discuss these demand or consumption-side issues, notably those for whom social innovation is as (if sometimes not more) important than orthodox technological-based innovation within the energy system (Cato and Hillier, 2011, Seyfang and Haxeltine 2011; Shove 2010; Avelino and Kunze, 2009). Within this literature, we find a focus on individual and collective cultures and habits around the consumption of energy, especially electricity. How to change cultures of energy consumption, how to 'nudge' or incentivise individual and collective behaviour around reducing the use (and especially waste) of energy and electricity are the main foci of research (Simcock et al, 2014).

6.7 Lack of attention to crisis-induced transition, analysis of the system's stability and vulnerability i.e. externally imposed transition due to some external crisis (rapid climate change, war/civil insurgency, collapse of secure imported carbon energy etc.).

This criticism relates to resilience approaches and contingency planning that is, having plans in place to deal with a range of possible emergencies/external disruptive events likely to result in long-term system transformation as opposed to short-term shock and return to the *status quo ante*. Here a key issue is the need to comprehensively assess the fragility and vulnerability of a system (in this case the energy system as a socio-technical system), rather than focus or try to predict a particular event that will expose that fragility. Thus there is a need to move beyond the dominant approach to analysing systemic threats and risks, such as investing more resources into developing better predictive models (which in a world or increasingly complexity deliver less and less returns). What is needed is to shift the focus towards developing more resilient and robust systems which are able to cope with and bounce back from external shocks and contingent surprises. This relates to the notion of 'adaptive capacity' (see, for example Giddens 2009). As mentioned earlier, Ireland's high reliance on private transport and natural gas as a fuel source renders it highly vulnerable to energy shocks i.e. it has little 'headroom' for manoeuvre and change, and therefore lacks resilience. In any decision to be made on energy, the capacity to adapt to (by definition inevitable) future shortages of non-renewable resources should be a core determining factor. In the context where we cannot control /predict the shock/surprise, we should try and plan/control for the system-level response to those surprises. This has implications for the evaluation for many shorter-term potential energy solutions.

6.8 Methodological Issues

According to Smith et al. (2010) the 'allure of the MLP' lies in its ability to simplify complex situations, using a terminology which can aid in organising a diverse array of considerations into narrative accounts of transitions. However several authors have raised the issue of methodology with regard to the MLP. Genus and Coles (2008) assert that undue emphasis has been placed on uncritically accepted historical case studies in the development of theory, thus transition characteristics may have been derived from the flawed use of secondary data sources. Seyfang et al. (2010: 6) note that the development of sociotechnical theory through *retrospective* analysis of historical events has meant that a *post-hoc* definition of radical niche and regime is possible whereas present-day conditions are far harder to delineate, and boundary-setting between MLP levels is far from straightforward. This underlines the importance of clarity and reflexivity in how the concepts of niche, regime and landscape are applied in any study (Smith et al., 2010), as views of this will differ. There is also a need for further empirical work.

7. Related Approaches: complementing and addressing the gaps in the transitions approach

In parallel with the development of transitions approaches, a number of other theoretical perspectives have addressed sustainability issues: three will be singled out as being of particular relevance here, as they specifically address some of the shortcomings of the transitions approach identified above and can be considered as complementary : innovation systems, social practice theory and social-ecological systems theory.

7.1 Innovation Systems: Identifying blockages to innovation.

According to Hekkert et al, the concept of innovation systems provides "a heuristic attempt, developed to analyse all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation" (2007: 414). The innovation systems approach has been used in the monitoring of transition management (Taanman 2012), and work has been done on integrating the two approaches (notably Markard and Truffler, 2008; Weber and Rohracher, 2012). Innovation systems provide more analytic power through elaborated frameworks of structural and functional analyses (described below) at niche and niche/regime levels, but provide less detail on overall transition dynamics, and lacks attention to the innovation system's environment (Markard and Truffler, 2008:610).

Adopting this broad approach, different forms of analysis can be conducted, depending on the scope or scale of the object of analysis: 'National innovation systems' focus on innovation within a particular country, for example, OECD studies[12] reviewing national innovation policies, while 'technological innovation systems' studies address particular technologies.

Markard et al note that a primary application of work in this area was has been in informing policy making, thus typical tasks involved identifying a range of drivers and barriers to innovation, utilising frameworks for systemic analysis which enable more specific policy recommendations to be made (Bergek et al., 2008; Weber and Rohracher 2012; Wiezcorek et al,, 2012). The comprehensive nature of these approaches makes them clear candidates for comparative or national studies such as the national innovation policy reviews mentioned above, although the major focus of most studies in this area has been in adapting systemic contexts to foster innovation to spur economic growth and international competitiveness. This is in direct contrast to MLP approaches, such as transition management which are more concerned with innovation and transformation of the systemic context itself towards particular goals such as sustainability (Weber and Rohracher, 2012).

Innovation systems analysis involves identifying the key processes or functions, which need to run smoothly for the system to perform well (Hekkert et al., 2007). Bergek et al (2008), define a detailed scheme of analysis for Technological Innovation Systems (TIS), beginning with a clear and explicit identification and communication of analytic focus. This is followed by a description of what they term the *structural* components of the TIS (actors, networks, institutions); identification of seven key processes to provide an "achieved functional pattern" and an evaluation of *how well* these functions are fulfilled - this enables the setting of process goals in terms of a "desired" functional pattern.

[12] www.oecd.org/innovation/reviews

Key Processes in Innovation Systems Analysis (Bergek et al 2008)

1. Knowledge base and diffusion
2. Influence on the direction of the search
3. Entrepreneurial experimentation- variety of experiments taking place
4. Market formation
5. Legitimation
6. Resource mobilisation – capital, hr etc.
7. Development of positive externalities- external economies

Blocking and inducing mechanisms towards this desired functional pattern are identified, thus key policy issues addressing these can be specified. Wieczorek and Hekkert (2012) focus on complementing such a functional analysis with a more detailed structural analysis in order to provide more precise policy recommendations. Four key structural dimensions: actors, institutions, interactions and infrastructure are identified in analysis. *Blocking mechanisms* (e.g. lack of trained staff, lack of infrastructure such as grid capacity) are categorised as particular types of systemic problem, and a detailed framework is supplied to enable such problems to be diagnosed, hence enabling policy instruments to be more accurately targeted. Instruments prescribed range from public-private partnerships, network formation, awareness-building activities, public debates, research initiatives, regulation, and procurement.

7.2 Social practice theory: Addressing energy demand

> "What people do in the privacy of their own bathrooms is environmentally vital; sociotechnically embedded and subject to processes of multiple causality and co-evolution." (Shove and Walker, 2010: 472)

Shove and Walker (2010) point to deficiencies in the sociotechnical paradigm in its almost exclusive focus on technology and a supply-side focus. To address these deficits, they have developed theories of practice to also conceptualise the dynamics of demand, consumption and use. They thus look at the dynamics of social practices, for example, how current practices – such as daily showering – have emerged, how older practices have disappeared or diminished, and how and where particular policy, cultural or technological interventions have influenced these dynamics. Whilst the role that practitioners themselves play in enacting and reproducing everyday practices is foregrounded, these practices are also part of a bigger picture with multiple causes. Hence various interconnected 'elements of practice' also need to be examined, meaning, as they put it that, "focusing on practices, their trajectories and their interconnections, obliges us to attend to processes of ongoing transformation, feedback and related circuits of reproduction" (Shove and Walker, 2010: 476). An Irish example is the on-going EPA Consensus project which explores such practice issues in more detail, using public exhibition spaces (the Science Gallery) and the media to raise awareness of showering practices.[13] As mentioned above, through social learning processes, there are possibilities of these practices extending via "communities of practice" (Wenger, 2000) that is scaling up and diffusing niche innovations in technology and its use (and related energy practices) throughout the socio-energy system. Hargreaves has argued for the complementarity of social practice theory and transition management (Hargreaves et al., 2013).

[13] See also the EPA- funded CONSENSUS project : www.consensus.ie

7.3 Social-Ecological Systems: Building resilience

There have been a number of papers comparing the sociotechnical transition and social-ecological systems approaches (Smith and Stirling, 2010). Both address complex and dynamic systems, work at different scales and consider issues of adaptivity and transformability. However they differ in that the focus of sociotechnical systems tends to be on social, technical and economic factors, whereas social-ecological systems analyses are situated in particular contexts and address issues of social-ecological resilience. Resilient systems contain components needed for renewal and reorganisation, are characterised by diversity and 'in build redundancy' or slack/headroom, and thus can absorb and respond to shocks or surprises. They also have the capacity to adapt and learn (Folke et al., 2002), usually from negative or *balancing* feedback mechanisms and dynamics. In contrast, unsustainable 'locked in' carbon energy system dynamics are characterised by positive feedback mechanisms (Unruh, 2000).

A particularly salient point is made by Hodbod and Adger (2014), who draw our attention to the role of *intention* in resilience. A regime which lacks resilience and adaptive capacity might undergo an *unintentional* transition. For example, whilst an *unsustainable* regime (such as the current energy regime) might prove to be resilient in the shorter term, in the longer term (as non-renewable means just that), if the energy system does *not* build adaptive capacity it might be subject to unplanned, non-endogenous i.e. externally imposed (and perhaps radical) change. They argue for the integration of ecological and social-ecological dynamics and ideas of resilience in energy systems research (Hodbod and Adger, 2014). In much current energy research, ecological costs are externalised, and thus can more easily be discounted. Conceptualising energy systems through the resilience framework internalises *ecological* variables and frames them as equally important as economic, technological and political factors. It also allows for differentiation between different contexts and closer examination of thresholds or tipping points in energy choices. They also call for the integration of insights from **political ecology** to address the power dynamics in social-ecological systems. This and some other approaches which may be of relevance are detailed in the following section.

8. Other Approaches

The approaches briefly outlined below to some extent address Stirling's call for more explicitly pluralist and open-ended approaches to transition (Stirling, 2011). They describes an approach to systemic innovation, adopting methods of praxis which acknowledge critical, reflexive and constructivist perspectives, and enable engagement with shifting issues of politics and power.

8.1 Political Ecology: Power, space and civil society

Lawhon and Murphy (2011) describe how the inclusion of insights from political ecology into a refined transition framework can address some of the social, political and spatial dynamics, which are insufficiently covered by sociotechnical transition theory. Four key critiques are addressed:

1. The emphasis on technological artefacts at the expense of context-specific social and political relations;
2. A bias towards elite actors against more participatory decision-making processes (particularly in transition management);
3. Naivety with regard to geography- how space and scale are conceptualised, the problem of the transferability of insights from case studies in specific contexts;

4. Insufficient attention to politics and power.

Four steps are identified:

1. Identifying interrelated problems and competing interventions: How problems are formed and how different actors frame them can shape solutions – this allows for different sets of arguments to be considered;
2. Considering a broader range of actors and their knowledges: beyond the 'rule of experts';
3. Power relations and their influence on human-environment relations – examining who wins and who loses in different transition scenarios (this is important in terms of assessing the social in/justice impacts of particular energy transition pathways or scenarios);
4. Explaining socio-technical transition outcomes and their impacts: political ecologists also examine wider outcomes of decision-making processes, particularly the (re)alignment of power relations.

8.2 Social Learning

Particularly at a micro-level, such as within a community, where particular interventions are being designed, there is a need to design multi-stakeholder learning processes. To this end, Colvin et al describe a number of mechanisms for designing systemic innovation for sustainability using approaches based on systems methodologies (Checkland 1981; Ison, 2010), inquiry-based research (Colvin et al., 2014); applied learning (Blackmore et al., 2012) and action research (Reason and Bradbury, 2008).

8.3 New social movement theory (Seyfang and Haxeltine 2012)– used to bridge the gap between grass-roots social movements as niches and regime change. This links to those approaches to transition that stress social innovation, as outlined above. It also has relevance to more regional/sub-national spatial scale case studies such as McCauley and Stephens, who note,

> 'Given the importance of cultural and behavioral change for a sustainable energy transition, *generating local buzz may be particularly important in this sector.* Perhaps most importantly, economic cluster initiatives have emphasized trust-building, and our study confirms the importance of trust between multiple, diverse stakeholders in regional sustainability initiatives.' (2012: 223; emphasis added)

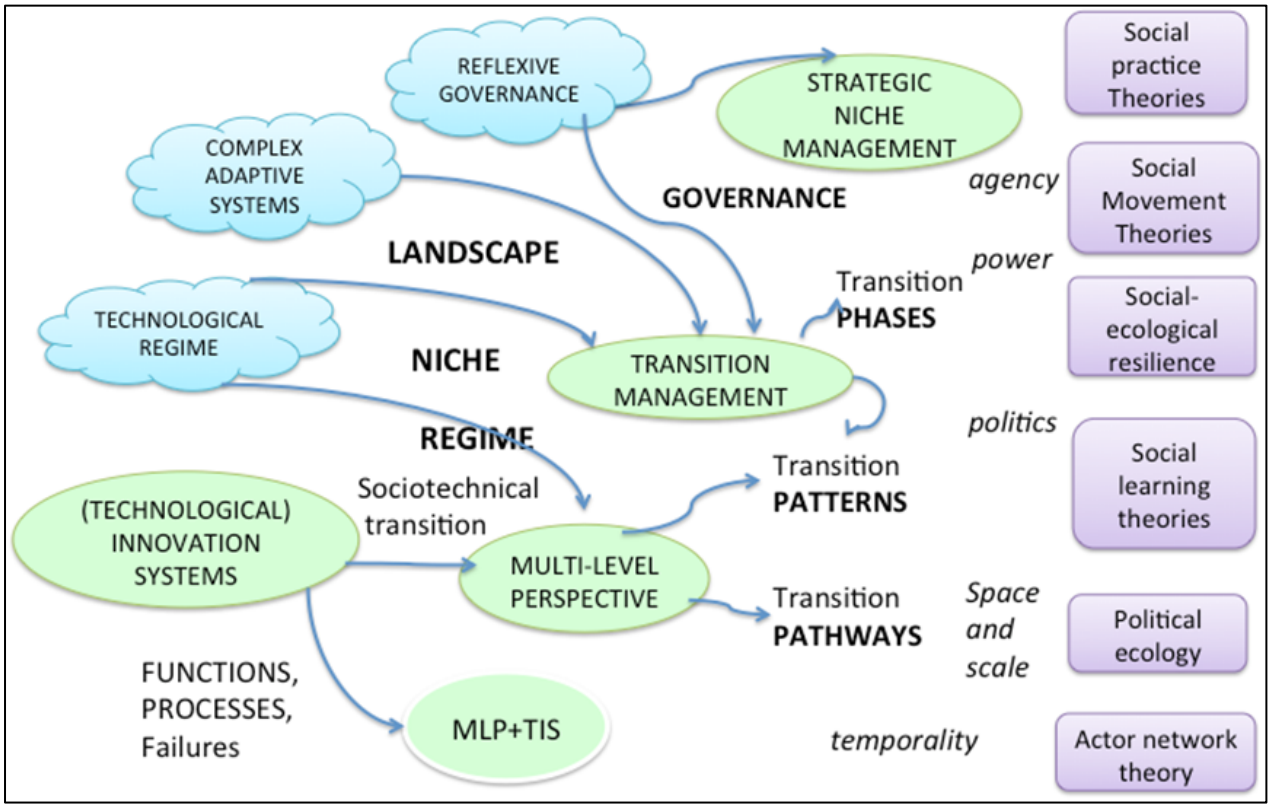
That is, while social movement theory is usually viewed as confirmed to civil society, it is possible for new movements and cultures of production and consumption to characterise economic or socio-technical relations between consumers and producers. While some of this might simply be 'hype' and 'public relations/marketing', nevertheless we need to be open to the possibility of movements for transition existing within the economic/technical sphere and not simply confined to civil society actors and activities. Just as we noted above that 'innovation' cannot be confined to technological innovation, likewise 'movement' analysis cannot be confined to 'new social movements' and non-technological actors and activities.

9. Summary, conclusions and recommendations

Our aim here was to provide a broad exploration of a variety of theoretical approaches that have been used to view society-wide sustainability transitions, in particular energy transitions. The paper offers a summary of the main concepts, origins, debates and associated authors and schools of thought within the study of socio-technical transitions. In particular, the Multi-Level Perspective and the related Transition Management approach to Governance are two major contributions from this body of scholarship and research, which add to aiding our conceptualisation and understanding of the complex socially-embedded and technologically-constituted energy system.

On this basis of this review, we suggest that it is useful to take Markard et al's (2012) original conceptualisation and place this in a wider context, linking the origins of the dominant concepts in transition theory *(see Figure 1), with the wider critiques of the field. Areas where the transitions framework may be lacking (as identified in criticisms articulated in the main paper) are shown in italic and alternate theoretical perspectives, which have been suggested to address gaps are shown in the boxes on the right hand side.

Figure 6: A revised map of core research strands in the field of sustainability transition studies.



The review of the literature on socio-technical transitions presented here also confirms Hess's view of the centrality of the state and public policy in energy transitions. As he puts it, "All studies point to the crucial role of government policy and dispel the myth that major, long-term transitions of energy systems are mostly or only market driven" (Hess, 2013: 198). While energy market and civil society actors and stakeholders are significant, it is the state after all that governs and steers energy transitions. This is particularly so if we take into account how previous energy transitions, while intuitively attractive in analysing and thinking about the present transition context, are often of limited use. Firstly, such

reflections unduly narrow the analysis to fuel and technology and neglect the social, political and cultural dimensions of the 'energy system'. Secondly, the current energy transition challenge is much more politically charged, in that it is connected to reducing carbon emissions to combat climate change, herald the creation of a new green economy and associated jobs, investment and global competitive advantage, or provide energy security in an increasingly unstable world. For these reasons the state and energy transitions are inexorably linked.

The multi-level perspective, and reflexive governance methods such as transitions management, by providing a whole systems approach, have the potential to, if integrated with spatial and innovation systems analyses, provide a conceptual framework which can be used to analyse the Irish energy system, as currently constituted and taking into account historic developments. It can help identify the path dependent aspects of the incumbent energy system, characterised by 'carbon lock-in' at different levels which require change and provide some generic approaches which might help 'unlock' these, enabling the innovation of low carbon energy technologies. It can also provide mechanisms that can be used to drive multi-stakeholder change processes, particularly if combined with a range of insights from complementary theories (see section 6/7). However the limits to these approaches must also be borne in mind, particularly with reference to the Irish situation, where social learning processes and the science/policy interface are less developed. Thus, a much closer examination of the application of the transition management framework and other comparable approaches in particular national contexts is required to assess the transferability of these approaches to an Irish context. To this end, Working Paper 2 provides a comparative national study.

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