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TOWARDS A THEORY FOR TRANSITION REGIONS IN SUSTAINABLE ENERGY INNOVATION:

Comparing system innovation and innovation systems approaches

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Lars Coenen (*), Paul Benneworth and Fernando J. Díaz López

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Abstract:

Many of the findings in transition studies are interesting but have relatively little theoretical purchase, largely because of its linear logic and lack of spatiality. A lot of attention is directed to the so-called niche level because this is conceived as the level where innovations begin, which may subsequently influence socio-technical regimes and ultimately societal landscapes. This linearity runs the risk of reifying niche experiments by considering them as stand-alone agents of change which ignores that these experiments actually 'take place' over time and in context. As a result, transition theory and practice experiences severe difficulties to 'upscale' successful niche innovations towards broader and more widespread application in society. To address this lacuna, existing conceptual frameworks need to be enriched to capture the spatially uneven development processes engendered in transitions. Grounding transition theory in its spatial context will force it to address the question how and why sustainability experiments are performing differently in different geographical settings and, consequently, what the governance challenges are for translating localities into generalities and backwards and ultimately upscaling into mainstream regime practice. This poses a major theoretical challenge because there is a strictly limited literature on economic geography or regional innovation from a green perspective.

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1 Introduction

Securing a sustainable energy society is one of the 'grand challenges' of the 21st century (American Academy of Engineers, 2008). The world is facing twin energy-related threats: that of not having adequate and secure supplies of energy at affordable prices and that of environmental harm caused by consuming too much of it. This calls for a major decarbonisation of the supply and use of energy over the coming decades. Policy-makers, industry and academia are thus facing a formidable challenge: to resolve a carbon addiction that is deeply ingrained in society. The problem becomes further aggravated due to the fundamental role played by energy in our industrial and societal systems, it being at the root of most of human activity. Addressing these problems will fundamentally alter societies in a way that is reminiscent of an 'industrial revolution'

The present ecological crisis requires that the hydrocarbon paradigm that has underpinned industrial capitalism from the outset, itself needs transcending in a transition to a post-hydrocarbon age. The concept of 'transition' involves a broad, system-wide interaction and co-evolution of new technologies, changes in markets, user practices, policy and cultural discourses, and governing institutions. However, transition theory to date has largely focused upon a single level, drawing on detailed case studies of individual shifts which neither really reflects place-specific contexts nor can they be linked into broader systemic shifts. Accordingly, transition theory currently fails to recognise why certain concatenations of institutional, entrepreneurial and innovative interactions occur where they do and for what reason.

As a result, transition theory and practice experiences severe difficulties in understanding the processes of 'upscaling' whereby successful local niche innovations achieve broader and more widespread application in society. To address this lacuna, new (potentially multi disciplinary) conceptual frameworks are needed that capture the spatially uneven development processes engendered in the transition from the prevailing fossil fuel regime towards a sustainable energy paradigm.

Two literatures serve as a natural starting point to making this next conceptual step; firstly are those literatures on multi-level (niche, regime, landscape) system innovation, and secondly, the territorial innovation system literature. This provides a means to focus on how territorial context creates economic incentive regimes which may ultimately produce uneven landscapes of transition. Our paper reviews the disparate, state-of-art literatures on multi-level system innovation on the one hand, and innovation systems and regional innovation on the other.

This review previews a set of gaps and lacunae that sketch out an improved theoretical agenda for the energy transition, with a more nuanced perspective towards those challenges posed by uneven landscapes of transition towards renewable energy systems. Ultimately, this review paper positions such a theoretical agenda vis-à-vis with the current energy and territorial policy scenario. The content of this paper is divided as follows: the first three sections presents some conceptual shortcomings and blind spots in energy transition theory, the multi-level perspective approach and technological innovation systems. The fourth section posits the advantages and critical blind spots of regional innovation systems. Following, the fifth section briefly introduces the current state of the art in energy policies, so the relevance of an improved energy transition framework is set up. The final section presents a research agenda towards the transition regions for sustainable energy systems.

2 Conceptual shortcomings and blind spots in energy transition theory

The present ecological crisis requires that the hydrocarbon paradigm that has underpinned industrial capitalism from the outset, itself needs transcending in a transition to a post-hydrocarbon paradigm. The term transition entails the broad, system-wide interaction and co-evolution of new technologies, changes in markets, user practices, policy and cultural discourses, and governing institutions [1]. Transition theory, pioneered by authors such Rotmans (Martens and Rotmans, 2002) and Kemp (1994), aims to provide an analytical and policy framework to explain and govern these complex, co-evolving, structural societal changes. Policy makers are especially interested in transitions since incremental change is not believed to lead to sustainability (Elzen and Wieczorek, 2005).

Policy guidelines for transition governance are network management, interactivity, pluralism, multilevel focus and social learning t induce system innovation (Rotmans and Loorbach, 2008). Long-term visions and pathways to system innovation are translated to practice by concentrating on search and exploration processes in which firms, research institutes, universities and governments are navigating and negotiating their way forward, gaining knowledge and experience along the way. This puts a premium on real life experiments that address the technological, economic, social, cultural and institutional dimensions of the envisioned transition from a carbon fuel to a sustainable energy society. To highlight the heterodox and transitional character of these experiments, the term niche experiments is used (Raven, 2005; Geels, 2005; Kemp, et al 2001; Schot, 1994; Hoogma, 2002).

However, the real contribution of transitions is mainly descriptive and metaphorical. Many of the findings of this work are interesting but have relatively little theoretical purchase, largely because of its linear logic and lack of spatiality. Accordingly, transition theory fails to recognise why certain concatenations of institutional, entrepreneurial and innovative interactions occur where they do and for what reason. As a result, transition theory and practice experiences severe difficulties to 'upscale' successful niche innovations towards broader and more widespread application in society. This refers to increasing the scale, scope and intensity of those niches by building a constituency behind a new sustainable technology, setting in motion interactive learning processes and institutional adaptation, which helps to create the necessary conditions for the successful diffusion and development of those technologies [2]. In the words of Geels et al. (2008): *"There is a particular need to understand better how the process from the initial 'niche' to a large scale transformation can be accelerated. To understand this take-off dynamic, we need to learn more about positive feed-backs between endogenous processes and the influences of external contexts. This is not just a theoretical endeavour, but also a challenge for empirical work and case studies, particularly when regularities, patterns or robust findings can be derived" (p. 531).*

The next stage of theoretical development would, thus, explicitly focus on contextualising the co-evolution of niche developments in the energy transition. Such contextualisation has temporal and spatial aspects (Asheim, 2008). Co-evolution indicates that a complex, adaptive system changes over time along with its environment (which in turn consists of complex, adaptive systems). Following the multi-level perspective (Geels, 2002), current transition thinking identifies three conceptual levels to address system innovation: micro-level niches, meso-level regimes and macro-level landscapes (see below). This conceives transitions as processes of change at the micro-level of niches and the meso-level of socio-technical regimes both embedded in a broader landscape of factors at the macro-level. However, most focus is on the niche level because this is conceived as the level where innovations begin, which may subsequently influence socio-technical regimes and ultimately societal landscapes. This linearity runs the risk of reifying niche experiments by considering them as stand-alone agents of change which ignores that these experiments actually 'take place' over time and in context. Yet, even though it is acknowledged that niche experiments often are local in nature (Geels and Deuten, 2006), there is no theory or insight whatsoever on the question how geographical proximity can leverage niche experiments to stimulate wider bottom-up societal transitions

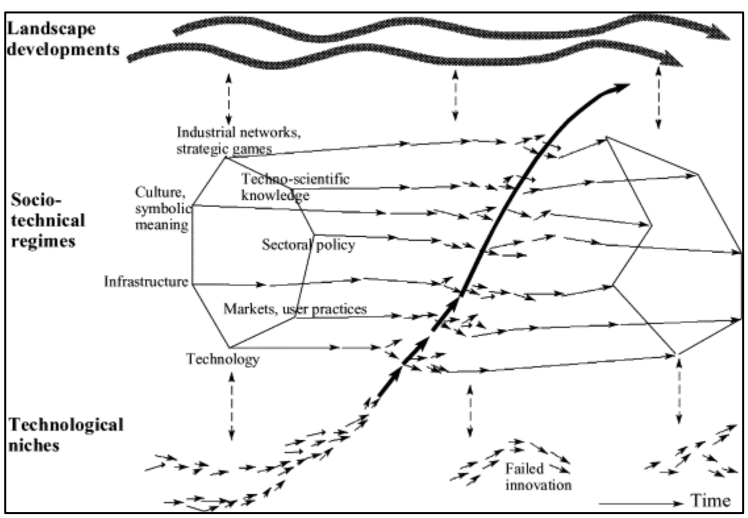
We argue that since the transition and multi-level perspectives currently do not have geography, they cannot move forward satisfactorily until they do. As they have no concept of space but they embrace the concept of 'innovation system', they are faced with a contradiction since much of the latter research focuses on spatial levels such as 'national' and 'regional' including notions of innovation leaders and laggards. A spatially-informed co-evolutionary transitions model would insist on recognition that new 'green' niches, regimes and ultimately the socio-technical landscape arise from an inherently asymmetric (in time and space) process of regional economic development. This poses a major theoretical challenge because fundamentally there is a strictly limited literature on economic geography or regional innovation from a green perspective (Bridge, 2007; Truffer, 2008).

To address this lacuna, new conceptual frameworks are needed that capture the spatially and temporally uneven development processes engendered in the transition from the prevailing fossil fuel towards a sustainable energy regime. The literature on multi-level (niche, regime, landscape) system innovation and the innovation system literature serve as a natural starting point. Especially the exploitation of regional proximate advantages, which has greater reach than simply its geographical dimension, merits particular attention in this respect. In the following a review is given of the disparate, state-of-art literatures on multi-level system innovation on the one hand, and innovation systems and regional innovation on the other.

3 Multi-level perspective: landscape, regime, niche

The multi-level perspective is critically important for this proposal as it provides a conceptual toolbox to understand transitions in light of 'small' activities against 'large' challenges, such as climate change and resource scarcity. It consists of three main concepts: regime, niche and landscape. The central concept of this framework is the socio-technical regime, a coherent, highly interrelated and stable structure at the meso-level characterised by established products and technologies, stocks of knowledge, user practices, expectations, life-styles, norms, regulations, etc. From the evolutionary perspective, a regime represents the selection environment for technological development in a certain field or sector, thus exerting a significant barrier for heterodox, radical innovations to diffuse. Radical innovations may still occur, if they are protected by niches from the prevailing selection pressures. Niches represent the micro-level of innovation processes and are commonly referred to as protected spaces or incubation rooms, in which new technologies or socio-technical practices emerge and develop relatively isolated from the selection pressures of 'normal' markets or regimes (Geels, 2005; Kemp et al., 1998; Hoogma, 2002). The macro-level, the so-called landscape, includes a set of largely independent and autonomous factors that exogenously influence both regimes and niches. Coherence of the regime is supported by its fit to the contingencies posed by external factors from the landscape and niches. While under a strong and stable socio-technical regime, radical innovations have a hard time to diffuse beyond the niche-level, they may eventually break through when the regime is weak.

Figure 1. Multilevel perspective



Source: Geels (2002)

The strength of the multi-level framework is that innovation and transition processes can be explained by the interplay of stabilising mechanisms at the regime level and (regime-) destabilising landscape pressures combined with the emergence of radical innovations at the niche level. The most significant shortcoming in the multilevel perspective is that it is almost impossible to avoid having an implicit hierarchy of agency within the model. The approach is largely confined to the niche level it its analysis of emerging novelties (Markard and Truffer, 2008).

The problem that goes unaddressed in this formulation is the reality that the scales are imbued with different levels of explicative power, the macro may be seen as being big and powerful, whilst the micro is small and powerless (Law, 2004). The approach is less powerful when it comes to the roles and strategies different actors play, the interaction of actors and institutions or the agency enjoyed by different actors or actor groups (Smith, 2005). This is related to the issue how resources are distributed among actors, how resource endowments explain the development of networks and the innovation potential of actors. There is a conceptual 'missing middle', understanding how particular activities coalesce into 'regimes' – this is a multi-step process through which actors develop regularities and system capacities. These capacities in turn give those niche networks a set of characteristics which make them conceptually equivalent to (or at least not substantively 'smaller' than) regimes. However, this capacity building dimension is not notably significant within the multi-level perspective, and for that reason, it is necessary to involve additional theory which helps to explain the development of self-management and stabilisation capacities within clusters of interactive innovators.

4 Technological Innovation Systems

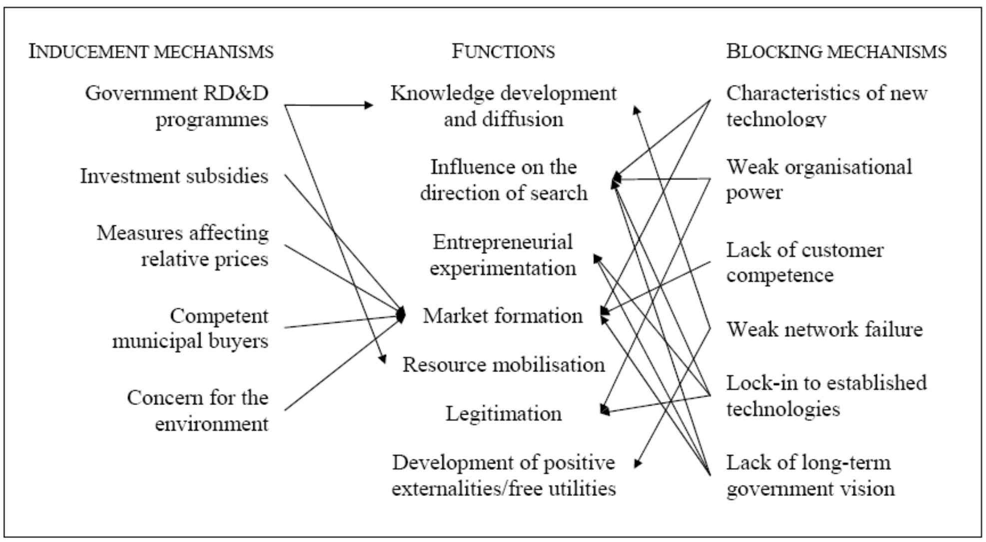
In contrast, the innovation system perspective is better equipped to deal with actor strategies and agency. It underscores the networked nature of innovation processes by acknowledging that innovation is both an individual and collective act (Edquist, 2005). An innovation system is defined as networks of organisations and institutions that develop, diffuse and use innovations (Edquist, 1997). Organisations typically encompass private firms, governmental and non-governmental agencies, universities, research facilities, venture capitalists, associations, etc. Institutions, on the other hand, can be regarded as the rules of the game, comprising 'hard' laws, regulations, standards and 'soft' socio-cultural as well as technical norms, use patterns, shared expectations. A key characteristic of the approach is that actors are embedded in an institutional context. However, actors may also deliberately change or adapt existing institutions or create new ones. How such mutual embeddedness (Edquist and Johnson, 1997) plays out in space and over time remains a topic that receives a lot of attention in ongoing studies of innovation systems. This has in recent years lead to an increased focus on the dynamics of the innovation in terms of functions or activities besides the traditional structural approach in terms of 'mapping' organisations, institutions and their interrelations. Even though there is still considerable debate and uncertainty about which key processes are relevant, innovation system researchers in both the Netherlands and Sweden have agreed on a list of seven main processes that can serve at least as a heuristic to arrive at a more dynamic oriented approach to innovation systems (Johnson, 1998; Rickne, 2000; Johnson, 2001; Johnson and Jacobsson, 2001; Hekkert et al., 2007; Bergek et al., 2007) (1) knowledge development and diffusion, (2) influence on the direction of search, (3) entrepreneurial experimentation, (4) market formation, (5) legitimation, (6) resource mobilisation and (7) development of positive externalities.

The innovation system concept has been defined at different levels for different purposes of analysis. National systems of innovation was the first concept introduced and elaborated by Lundvall (1992), Freeman (1997) and Nelson (1993) to explain different technological and economic performance patterns across countries. Later on, regional systems of innovation (see below), sectoral systems of innovation and production (Breschi and Malerba, 1997; Malerba, 2005) as well as technological systems were developed on a similar theoretical basis as complementary perspectives. Of these the technology specific perspective has been most used to analyse radical innovation processes, as is the case for the energy transition under study.

The technological innovation system approach explains why technological change is often a protracted process and why it is difficult to change. Technological progress often proceeds along certain trajectories because the prevailing technology and its design have already benefited from all kinds of evolutionary improvements, in terms of costs and performance characteristics, from a better understanding at the user side, and from the adaptation of the socio-economic environment in terms of accumulated knowledge, capital outlays, infrastructure, available skills, production routines, social norms, regulations and lifestyles (Kemp, 1994). To temporally contextualise the development of new energy technologies, studies by Bergek and Jacobsson (2003), Jacobsson and Bergek (2004), Bergek et al. (2008) have identified different phases in the evolution of a technological innovation system. This evolution starts with a formative phase, followed by a growth phase, and finally a mature stage. The formative phase is characterised by high uncertainty in terms of markets and technologies (Van de Ven, 1993) which calls for experimentation and variety creation. Firms and other organisations enter the new technological domain, and, in order to reduce uncertainty levels, heterogeneous networks are created and institutions aligned. At some point in time, certain technological trajectories may be able to shift gear and evolve into a growth phase. The focus changes to system expansion and larger-scale technology diffusion through the formation of bridging markets and subsequently mass markets.

Based on numerous studies of technological change, the TIS framework has proven to be very resourceful to analyse how various elements in the system, i.e. actors, institutions and technology co-evolve over time. Moreover, applying the functional approach (see above) has added highly relevant policy lessons to stimulate and influence the rate and direction of technological change by finding a set of inducement and blocking mechanisms where intervention has most effect (Bergek, Jacobsson and Hekkert, 2008; Rickne, 2001; Hekkert et al, 2008, Alkemade, 2007; Jacobsson, 2004; Negro, 2008).

Figure 2. Inducing and blocking mechanisms of TIS functions



Source: Johnson and Jacobsson(2001) *the*

However, an important shortcoming of the perspective concerns its limited capacity to explain more radical change and renewal at the level of the system itself. This is caused by its inward orientation. The success of innovations is predominantly regarded as an endogenous consequence of the performance of the corresponding innovation system. This leads to a tendency to do away with the environment that lies beyond the narrow boundaries of the technological innovation system (Cooke, 2008, Markard and Truffer, 2008). Related to this, analysts of technological innovation system run the risk of treating the emergence and development of a technology at the head of a pin while insufficiently recognising that economic agents are situated in external contexts of social and institutional relations. As a result, technological innovation system analysts may render a mechanical impression of the dynamics of the system that invoke a reified, ‘cartoon-like’ system of innovation. To resolve the risk for a myopic, narrow technology-oriented perspective, it is necessary to involve a broader conception of the organisations, networks, institutions and processes involved in the energy transition. By virtue of its system delineation, the territorial innovation system perspective holds the potential to do exactly that.

5 Regional Innovation Systems

Even though territorial innovation systems acknowledge that technologies usually cut across geographic boundaries its central proposition is that organisations and institutions are inherently characterised by their territorial sphere of influence and interaction. It is a popular misconception that the global nature of technological change would imply that technology evolves and diffuses uniformly or randomly across the geographical landscape (Asheim and Gertler, 2005). The development, diffusion and use of innovations exhibit a very distinctive and uneven geography. Moreover, this geography is fundamental, not incidental, to the innovation process itself. To unpack this geography, the regional innovation system concept has proven to be more resourceful than the national innovation system concept. On the national scale, the innovation system is in most cases overly complex, involving a plethora of actors and institutions (Asheim and Coenen, 2005; Hekkert et al., 2008). Historicity, industry specificity and region specificity need to be taken into account to arrive at disaggregated, empirically grounded 'reduced-form innovation systems' (Miettinen, 2002). Lundvall and Borras (1997), two typical NIS proponents, hint towards this when they argue that "the region is increasingly the level at which innovation is produced through regional networks of innovators, local clusters and the cross-fertilising effects of research institutions (p. 39). Also two early pioneers in the TIS community acknowledge that "high technological density and diversity are properties of regions rather than countries" (Carlsson & Stankiewicz, 1991, 15).

The popularity of the argument that regions are designated sites of innovation can be traced back to various empirical studies of regional success stories such as industrial districts (Piore and Sabel, 1984; Asheim, 2000), the exemplar industrial system of Silicon Valley (Saxenian, 1994) as well as other examples of successful regional clusters in most developed as well as developing economies (Porter, 1990). Regional innovation systems (RIS) are durable networks which exist between various actors involved in innovation, and which produce and exploit unique local knowledge assets. An important rationale for a regional innovation system perspective stems from the existence of technological trajectories that are based on "sticky" knowledge and localised learning within the region (Asheim and Gertler, 2005). Cooke (2005) has recently emphasised the theoretical and empirical necessity of distinguishing between two subsectors within RISs, between knowledge-production and knowledge-utilisation circuits, because of the very different settings within which their wider networks are articulated. Over time, spontaneous and bilateral interactions settle down into systemic linkages and collective assets, 'territorial knowledge pools', or 'territorial learning competencies' (Lawson, 1999; Lorenz, 1999). These collective assets boost other local firms' competitiveness, and the unique, territorial nature of the knowledge produced helps to attract outside customers and investors, upgrading their status within particular global production networks (Cumbers, 2000). In this conceptualisation, the locality's role is to provide system-building capacity: particular infrastructures, institutions, knowledge, and cultures which will increase the likelihood of local actors working productively together (Oinas and Lagendijk, 2005). The heuristic is of a virtuous circle of global knowledge flowing through the region and out into global markets, thereby ‘refilling’ the local knowledge pool, creating beneficial spillovers for local firms, and attracting outside investors. A stylised depiction of this is given below.

Figure 3. A model for regional innovation system

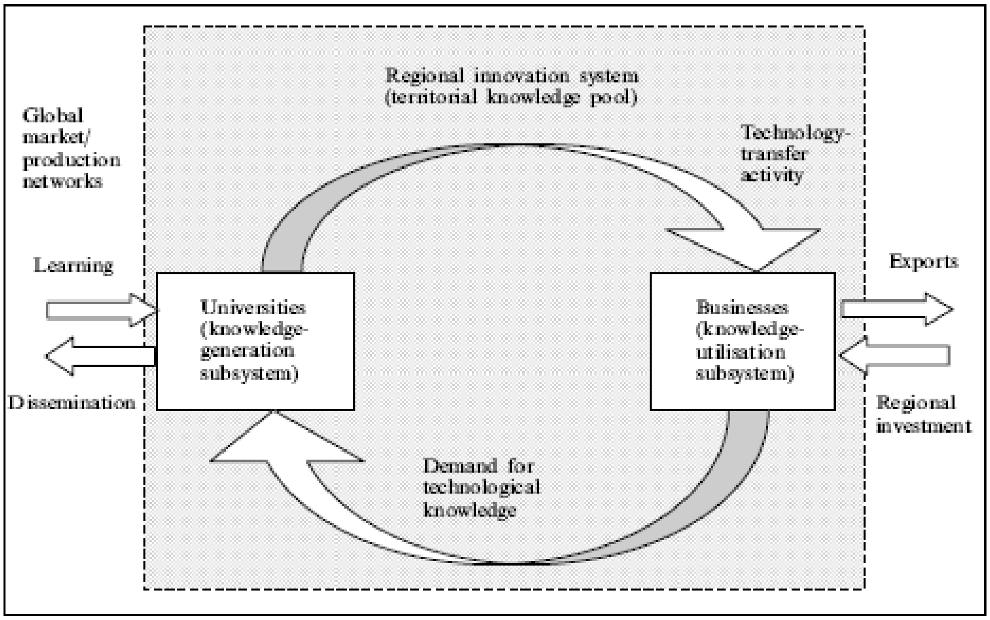


Figure 1. The regional innovation system as a local circulation between globally connected regional innovators (source: Benneworth, 2005, after Cooke and Piccaluga, 2004).

The concept of region is not unproblematic. A clear definitive meaning of regions, similar to the unequivocal connotation given to ‘nation’ is probably impossible to achieve. It is, for example, common to distinguish between administrative and functional boundaries of a region (Malmberg, 2003). The perspective that is employed here conceives of a region as a territorially based nexus of processes nested in a wider geographical context (Howells, 1999; Cooke, 2005). In this, the concept of region highlights an important level of governance of socio-economic processes at the meso-level. In order to reflect its conceptual variety and empirical richness three RIS typologies are distinguished (Cooke, 1998): grassroots, network and dirigiste.

In grassroots RIS, firms base their innovation activity mainly on localised, inter-firm learning processes stimulated by the conjunction of geographical and relational proximity without much direct interaction with knowledge generation organisations. The best examples of grassroots RIS are networks of SMEs in industrial districts. The second typology, networked RIS, adds to this a regional supporting institutional infrastructure. Through a stronger, more developed role for regionally based R&D institutes, vocational training organisations and other local organisations involved in firms’ innovation processes, these systems have a more planned character involving public-private co-operation. In a dirigiste RIS, (parts of) industry and the institutional infrastructure are more functionally integrated into national or international innovation networks. The clustering of R&D laboratories of large firms and/or governmental research institutes in planned 'science parks' and technopoles are examples of this. Due to a lack of local embeddedness, these initiatives have generally failed to develop innovative networks based on inter-organisational co-operation and interactive learning.

The RIS perspective is intrinsically related to ongoing discussions about the role of geographical proximity on innovation based on inter-organisational knowledge relationships. Boschma (2005) introduces four notion of proximity: cognitive, organisational, social and institutional proximity. Cognitive proximity refers to the overlap in knowledge and competence base between organisations. A certain level of cognitive distance is necessary to exchange knowledge that gives rise to the emergence of novelty. However, too much cognitive distance precludes mutual understanding. Organisational proximity refers to the extent to which relationships are shared in an organisational arrangement under common hierarchical control. Social proximity is based on friendship, kinship, or mutual experiences, and increases mutual trust. Institutional proximity refers to similarities in the rules of the game of actors. Until now, only a few studies have actually tried to empirically disentangle different types of proximities in understanding the role of geographical proximity for innovation (Ponds, et al 2008).

How a RIS analysis is carried out empirically depends on whether a top-down or bottom-up perspective is taken (Howells, 1999), even though both perspectives are complementary to each other (Howells, 2005; Iammarino, 2005). The top-down approach focuses on the specific way(s) that the dynamic interaction between the knowledge exploitation and knowledge generation subsystem is organised. As a result of this vantage point, it emphasises macro to micro analysis and is carried out through an identification of the institutional and structural characteristics of the RIS and their interplay. These characteristics are, among others, the type and intensity of inter-organisational relationships, the role of the public sector and innovation policy, the administrative, financial and legal framework, the industrial structure and the spatial structure (Howells, 1999). These characteristics are shaped on the regional, national and international level and draw attention to the multi-level governance context of RIS (Cooke et al., 2000). The bottom-up approach, on the other hand, is more concerned with the actual knowledge and learning dynamics between actors in the regional knowledge network (Howells, 1999). In this perspective, the RIS is analysed in terms of the capability of the regional knowledge network to generate, absorb and diffuse knowledge. It draws on research that has outlined the importance of processes of localised learning for regional competitiveness (Asheim, 2000; Maskell et al., 1998; Maskell & Malmberg, 1999; Morgan, 2004; Lorenz, 1999). According to this literature, the actors within the region often share a common framework of understanding based on common behavioural practices as well as a 'technical culture' – a way to develop, store and disseminate knowledge, technical 'know-how', norms and values – that is linked to the specific type of economic activity. Despite the term 'localised learning', this literature has increasingly recognised the need to consider both local as well as extra-local sources of knowledge (Bathelt et al., 2004). Through processes of co-evolution, the knowledge dynamics of the RIS and its institutional and structural characteristics reinforce each other resulting in particular regional development trajectories and industrial specialisations.

The critiques which apply to innovation systems generally for their static nature apply equally – and in some cases more so – to regional innovation systems. There can be a tendency to regard institutions, culture and capabilities as something given and immutable, apart from a limited number of 'exceptional cases' which have managed to overcome significant barriers and change their own economic trajectory. There has been much less attention given to how 'ordinary regions' can exert agency and create new innovative opportunities for themselves, and downplaying the tensions and problems which exist in such a situation (Oïnas & Lagendijk, 2005; Sotarauta, 2006).

This criticism is particularly salient around the issue of the practicalities of constructing RISs. A sweeping criticism of RIS policy has been based around its frequent reduction to a process of system mapping, hole identification and hole filling. This is based on the implicit assumption that there is a single, optimal system structure applicable to all kinds of institutional environments and capacity endowments. The is a growing recognition that that effective RIS policy is itself constructivist and develops new institutions which support emergent sectors (Nauwelaers & Wintjes, 2003).

A problem in terms of the energy transition is that there is nothing for policy makers to begin working with. In the absence of strong markets expressing demand, innovative businesses and supportive institutions, there are no 'hooks' on which to hang policy interventions. The only avenue open to policy-makers is to try to stimulate experiments which develop all these various innovative elements simultaneously. To gain an insight into this, we consider one area where it has been possible to construct miniature technological systems *de novo*, that is around the experimental introduction of niche technologies.

6 Implications for sustainable energy transition and territorial policies in Europe

The need to ensure a sustainable energy society transcends the theory, as it affects a number of different policy domains. Harnessing low-carbon renewable energy technologies is vital to achieve not only the long term objectives of the EU's energy (strategic) plans [3], but also for adapting to climate change [4] and achieving the Kyoto objectives [5], reducing greenhouse gases emissions [6], meeting the 2^{o}C objective (compared to pre-industrial levels) [7] and boosting the Union's sustainable innovativeness and competitiveness (EC 2004a, 2004b, 2004c, 2006, 2007f, 2008b) . For achieving the above, ambitious targets and visions have already been set – for 2010: 12% use of renewables in EU-15 [8]; for 2020: a 20% GHG emissions reduction (compared to 1990 levels); 20% reduction from energy primary sources, and 20% use of renewables; for 2050: the EU's objective is to reduce its carbon emissions by 60 percent or more and the total de-carbonisation of the energy system [3]. This (combined) policy urgency and ambitious targets supposes a major paradigm shift away from fossil fuels dependence, where the key component would be the acceleration and deployment of renewable energy technologies, both ready-for the market and (radically) new innovations.

The European Strategic Energy Technology Plan (SET-PLAN) has been the European Union's response to the need of a dedicated policy to ensure the above. Derived from this ambitious plan, the political vision of Europe is clear [9: p.4]: *"The vision is of a Europe with a thriving and sustainable economy, with world leadership in a diverse portfolio of clean, efficient and low-carbon energy technologies as a motor for prosperity and a key contributor to growth and jobs. A Europe that has grasped the opportunities lying behind climate change and globalisation and that is contributing to the global energy challenge…".* However, there is a danger that the territorial nature of innovation is somehow being disregarded in the current (energy) policy approach. One underemphasised dimension of energy policy is that of its impacts on territorial cohesion. A competitive, sustainable Europe depends on willingness for collective action to address problems, and is underpinned by territorial solidarity, namely those that do not directly benefit from European unity are assisted to improve their benefits. Currently, one-third of the EU budget is spent on regional policy, to support territorial cohesion. Territorial policy has become increasingly identified with regional innovation and competitiveness, and consequently, the energy transition will have consequences for territorial solidarity and cohesion, and consequently, the effective functioning of Europe. It is clear that the EU needs means (e.g. concepts and methods) to unpack this issue of territorial solidarity in an age of energy insecurity, while supporting the creation of new policy tools and instruments to promote balanced sustainable European regional development (DG REGIO, 2008).

From the short policy review above it is clear that a clear lacuna around what kinds of regional economic development policies are necessary in order to deal with fostering sustainable energy systems and helping combating the effects of climate change. This review paper stands for contributing to filling up this gap, by paving the way for a transition regions research agenda –as introduced below.

A key element of the learning that takes place in these changes relates to policies for local economic development. There is the need of a research agenda which makes a direct contribution not only to the scientific state-of-the-art, but also to contribute to important debate over the evolving nature of European territorial cohesion policy. In the last twenty years, there has been a growing acceptance into the mainstream paradigm of local economic development policies based around the promotion of innovation. This has seen the promotion of territorial innovation models supporting clusters, knowledge pools, untraded inter-dependencies and institutional thickness.

These policies emerged as a working-through of the issues which first became evident in Europe in the 1980s which went by the short-hand of "Eurosclerosis", namely that supporting new high-technology industries to compete with Japanese and American firms systematically disadvantaged particular regions which had a low capacity to absorb the benefits of increased EU investment in science, technology and innovation. The aim of innovation policy was to make sure that every region enjoyed the benefits of the single market, and that some regions were not asked to bear an unreasonable amount of the costs of a Single Europe; policy-makers at the European scale correctly foretold that growing resentment in these 'loser regions' would undermine popular support for the European ideal of free movement of people, goods and capital to the detriment of European competitiveness.

The energy transition is a similar threat to territorial cohesion in that a publically supported transition package will benefit some regions more than others, in particular those with extensive renewable resources over those with higher energy demands because of their territorial context. What the next generation of intelligent territorial cohesion policies at the regional and local scale needs to reflect is to provide all regions with the capacity to benefit from the transition. It is therefore imperative to look at regions that potentially stand to lose from the energy transition – they may be remote, poor, industrial – with high energy demands, so transition poses a grave threat to their economic livelihood. The focus for local policy must lie in shaping the transition to make advantages out of those characteristics, to give potential 'loser' regions the opportunity to thrive from the benefits of a European transition.

Previous attempts to produce a coherent set of local policies have failed in two main ways. One approach was too optimistic and generalist to have sufficient local salience. The Local Agenda 21 emerging from the Earth Summit in Rio made a powerful political statement, but local and regional authorities found it offered no basis for taking the hard decisions and reconciling competing interests that effective transition to sustainable societies demands. A second set of policy 'failures' are a set of relatively successful, small scale experiments that succeeded because of place-specific features, that in turn offered no general model for local economic development towards a sustainable, secure future. The result is the complete absence of a nuanced policy understanding of the changed requirements of local economic development which ensures competitiveness within the constraints imposed by these new conditions of energy insecurity.

The desired policy agenda should aim to address this specific shortcoming by stimulating a dialogue with regional and local partners in regions that have attempted to stimulate a niche in renewable energy for economic purposes. In addition, it should attempt to create a co-learning community between academics and policy-makers to begin to try to reconsider what kinds of policy are necessary for effective local economic development in these conditions of energy insecurity, and moreover what national and European policy makers can themselves do to contribute to better territorial cohesion and solidarity. Currently, there is a gap, highlighted by North (2008), in the policy toolkit for climate change which tends to reduce the problem to one of promoting sustainable development or of reducing energy consumption. A number of territorial models of new energy economies have emerged, such as Transition Towns, but these suffer from being unique, not easily replicable, utopian and without a wider societal relevance.

7 Preliminary conclusions

The next stage of theoretical development would, thus, explicitly focus on contextualising the co-evolution of niche developments in transition. Contextualization has been a key concern and basic rationale for the sub-discipline of economic geography (Asheim, 2006). Grounding transition theory in its spatial context will force it to address the question how and why sustainability experiments are performing differently in different geographical settings and, consequently, what the governance challenges are for translating localities into generalities and backwards and ultimately upscaling into mainstream regime practice (Smith, 2007). Hence, connecting geography and transition studies holds the potential to reveal why certain networks, technologies and institutions manage to transcend the local niche context and 'go global' while others don't. A spatially-informed evolutionary transitions model would insist on recognition that new 'green' niches and ultimately socio-technical regimes arise from an inherently asymmetric (in time and space) process of regional economic development. This poses a major theoretical challenge because there is a strictly limited literature on economic geography or regional innovation from a green perspective (Bridge, 2007; Cooke, forthcoming; Truffer, 2008) .

Future research and practice should seek to progress these debates by focusing specifically on the dynamics of exemplary regional energy niches which have delivered traction at a higher level, at the level of the regional and national energy systems. Studying successful and failing examples closely would provide the basis for a better informed dialogue with regional policy makers around the instruments and toolkits necessary to marry the twin challenges of dealing with the long term climate change challenge and ensuring short-term economic competitiveness. This would enable stakeholders both to intervene on the supply side but, more importantly, develop strategies on the demand side to stimulate producers to create eco-innovation niches that may assist Transition Regions to evolve towards 'green regimes' suited to their mix of eco-innovation assets.

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