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# Energy transitions in small-scale regions – What we can learn from a regional innovation systems perspective

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## HIGHLIGHTS

- We highlight the importance of spatial and regional aspects for transitions.
- We draw upon regional innovation systems' subsystems to describe energy transitions.
- We show how actors and institutions interact in and coordinate transition processes.
- We present evidence from two small-scale regions in Germany: Emden and Bottrop.

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## ABSTRACT

The prevalent theories in the debate on sustainability transitions have been criticised for not sufficiently addressing energy change processes at the local level. This paper aims to enhance our understanding of local energy reorganisation processes. Drawing on the Regional Innovation Systems (RIS) approach, we argue that local development dynamics result from the interaction of various subsystems: science, politics, public administration, industry, finance, intermediaries and civil society. The analysis of the involved subsystems and their interaction shows how energy transitions are shaped by different individual and organisational actors as well as institutions on the local level. Empirical evidence from case studies on the German cities of Emden and Bottrop illustrates our theoretical conceptualisation of energy transitions. We conclude by presenting characteristic interaction patterns for energy transition drawn from the two cases.



## 1. Introduction

Numerous contributions have dealt with decarbonisation, decentralisation and the resulting shifts in politics and society as central elements in energy transition processes (Markard et al., 2012). In this context, several of the dominant theories, such as the Multi-Level-Perspective (MLP), the Technological Innovation Systems (TIS) approach and also strategic niche management, have been criticised for not sufficiently addressing spatial issues. This criticism refers particularly to the processes of transition at the local level (Coenen et al., 2010; McCauley and Stephens, 2012; Truffer and Coenen, 2012). The lack of attention to this level is surprising given the significant differences that characterise local energy transitions (Coutard and Rutherford, 2010; Rutherford and Coutard, 2014). While some cities and regions are strongly committed to becoming pioneering energy regions – for instance "low carbon" and "smart" cities or "100% renewable energy regions" – others remain reserved. Most literature in the debate on sustainability transitions addresses the deployment of specific technologies (e.g. wind and solar energy, Jacobsson and Bergek, 2004; biogas, Raven and Geels 2010). The complex, local, institutional change processes which sustain (or hinder) individual projects are only rarely analysed. There is thus a need to explore local energy transition processes in a more comprehensive way by taking into account the diversity of actors and the different subsystems involved. The objective of this paper is to contribute to such a better understanding of local energy-related reorganisation processes, regarding both energy generation and demand.

Sustainable energy transitions can be defined as encompassing socio-technological transformation processes leading to low-carbon patterns of energy production, supply and consumption (Cherp et al., 2011; Coutard and Rutherford, 2010; Verbong and Geels, 2007). In order to enhance our understanding of these

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processes at the local level, we draw upon ideas from the literature on regional innovation systems. Based on this evolutionary and institutional approach, we suggest distinguishing between various subsystems (science, politics, public administration, industry, finance, intermediaries and civil society) to capture the full complexity and interactive nature of the involved changes. We understand transitions as the outcome of the interaction of these institutional subsystems. Our question is: How do the various subsystems trigger, push or hinder regional change, and how do they interact with each other in local energy transition processes?

This paper analyses these questions based on empirical evidence from two local energy transition processes. It is structured in the following way. Section 2 introduces small-scale regions as a key level of transitions and shows how RIS subsystems can be used to enhance our understanding of small-scale regional change. Section 3 outlines the methodology. The main section of the paper (Section 4) presents case study results from the German cities of Bottrop and Emden. We provide a brief picture of individual and organisational actors and institutions that make up each of the introduced subsystems, and then present findings on characteristic interactions patterns for both cases. Subsequently (Section 5), we compare the results from the Emden and Bottrop case studies in terms of four analytical dimensions. The paper finishes with a brief conclusion.

## 2. Small-scale regions as a key level in understanding transitions

Energy is a topic that cannot be assigned to a single spatial scale. "(A)ctors and institutions at multiple spatial levels interact to create 'spaces for innovation'", as Raven et al. (2012: 64) observe. This multi-spatial engagement resembles a "multi-territorial approach" to innovation (Heidenreich et al., 2012: 267) and implies significant interconnectivity (Truffer et al., 2012). Despite this observation, transition theory still appears under-theorised regarding how different spatial levels shape transition processes and how these interact with each other (cf. also Raven et al., 2012).

As spatial issues inherently shape transitions, it is furthermore crucial to focus on particular spatial levels to better understand the inherent spatial dynamics (Hodson and Marvin, 2010). In the emerging debate in economic geography that does adopt a spatial perspective, the chosen level of analysis usually is national (Raven et al., 2012). However, this paper instead focuses on the small-scale regional level. The choice of this level of analysis is based on several considerations. First, there are clear indications of the growing importance of the small-scale, the regional and the local levels in energy transformation (Hodson and Marvin, 2010; McCauley and Stephens, 2012; Schönberger 2013).[1] Municipalities are often the starting point of systemic transformations and have been characterised as "initial seedbeds for transition" (Geels, 2011: 22). Second, two trends from energy-related industries underline the importance of small-scale regions for energy transitions: there are increasingly decentralised small initiatives (singular windmills, photovoltaic installations on private homes etc.) that contribute to the production of renewable energy (cf. e.g. McCormick and Kåberger, 2005), and there is a growing empirical evidence on spatial clusters in clean-tech industries (McCauley and Stephens, 2012; Cooke, 2010; Chapple et al., 2011; Fornahl et al., 2012).

The lack of focus on spatiality is mirrored in the dominant debates on sustainability transitions. The MLP describes transformations as interplay between the three levels *regime*, *landscape* and *niche* (Bijker et al., 1987; Geels, 2002, 2004, 2005; Loorbach and Rotmans, 2006; Verbong and Geels, 2007). These levels are regarded independently from spatial scales (Hodson and Marvin, 2010), although regimes are frequently attributed to the national level (Raven et al., 2012). The *regime* represents the dominant socio-technical configuration, which is stabilised by the interplay of existing material elements (technologies, infrastructures), social groups and actor networks as well as cognitive, normative and regulative rules. These regimes are embedded into *landscapes,* which are defined as "external", overarching elements such as global markets, geopolitical pressures or demographic evolutions. *Niches* are small-scale socio-technical arrangements in which different settings – alternative combinations of material elements, actors and rules – are tested (Geels, 2002, 2005). Change occurs when the landscape evolves ("external" developments) and exerts pressure on the regime, and when bottom-up alternative solutions at the niche level challenge the dominant socio-technical configuration. Most of this change is incremental, i.e. the regime incorporates some elements of emerging niches without changing its fundamental rationales. Only in rare cases do windows of opportunity for radical change open, allowing system "lock-ins" to be overcome and leading to a realignment of the socio-technical regime (Geels and Schot, 2007; Verbong and Geels, 2010). Based on the general neglecting of spatiality, the MLP has not yet provided a systematic conceptual framework for concrete local conditions favouring the growth and spread of alternative socio-technical configurations (Coenen et al., 2010; Markard and Truffer, 2008; Truffer and Coenen, 2012), especially since the role of local action cannot be equated with niches (Späth and Rohracher, 2010). In this way, "classical" MLP contributions do not offer insights into how energy transitions are rooted in small-scale regions (Hodson and Marvin, 2010).

Similarly, TIS analysis is not focused on space, but concentrates on technological sectors. Carlsson and Stankiewicz (1991: 93) define TIS as a "network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion and utilisation of technology. Technological systems are defined in terms of knowledge/competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks." As TIS analysis focuses on interactive interplays between actors in different locations, it strives to include all the technologically relevant actors and conceptually explicitly avoids spatial restrictions (Binz et al. 2014; Truffer et al., 2012). The TIS approach does not consider the role of regions (Truffer et al., 2012). Instead, as Binz et al. (2014) highlight, empirical analyses often implicitly interpret nation states as the natural size of TIS.[2]

More recent contributions from strategic niche management and transition management (cf. e.g. Schot and Geels, 2008; Caniëls and Romijn, 2008) acknowledge the importance of spatiality and particularly highlight the importance of small-scale analyses. Nevertheless, studies which are explicitly concerned with small-scale regions remain scarce (cf. however Geels, 2011; Quitzau et al., 2012). The strand of literature in transition theory which is most concerned with this aspect is the debate stemming from urban studies. Here, cities are regarded as particularly important sites for energy transitions (Hodson and Marvin, 2010), especially with regard to their strategic role in paving the path for transitions (Coutard and Rutherford, 2010). Several contributions have outlined the different roles that cities hold in transition processes (Bulkeley et al., 2011; Hodson and Marvin, 2010, 2012). Hodson and Marvin (2012: 424) characterise cities as "an actor in its own right, a niche for experimentation to think about new ways of

[1] In the following, we will use the terms"regional" and"local" interchangable, referring to the outlined small-scale region.

[2] We are grateful to an anonymous reviewer for drawing our attention to this.