Environmental Innovation and Societal Transitions xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist

Trajectories of sustainability transitions in scale-transcending innovation systems: The case of photovoltaics

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ARTICLE INFO

Available online xxx

Keywords:
Geography of sustainability transitions
Innovation systems
Multi-scalar processes
Phase dynamics
Photovoltaic technology

ABSTRACT

This paper proposes that spatial dynamics of new environmental technologies can be better understood when positioned in a multi-scalar theoretical framework based on innovation system approaches. We combine territorial innovation system concepts with a technological innovation systems (TIS) perspective. The investigation of photovoltaic (PV) technology in Germany indicates that the relevance of different scales and actor constellations shifts in the course of a 'maturing' innovation system. First, the convergence of regional and institutional subsystems forms a temporary window of opportunity for a robust TIS formation within a national framing. Second, consolidation according to basic patterns of the underlying national innovation system takes place. This is illustrated by the robust performance of German mechanical PV equipment suppliers within a globalized PV value chain. The empirical findings allow for drafting a theoretical framework that offers a generalized view on this shifting spatial context pattern of an emerging environmental technology.

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http://dx.doi.org/10.1016/j.eist.2014.12.004
2210-4224/

1. Introduction

While the essential role of innovations as drivers of sustainability transition is widely acknowledged (Elzen et al., 2004; Coenen and Diaz Lopez, 2010; Jacobsson and Bergek, 2011), major mechanisms that link process fields and lead to an effective diffusion of new environmental technologies remain to be further explored both conceptually and empirically. We want to show how dynamics at different geographical scales need to productively interact to shape the generation, application and proliferation of sustainability-enhancing technologies and how these scalar configurations significantly change over time. This allows for addressing important facets of the spatial perspective on sustainability transitions (Coenen et al., 2012; Coenen and Truffer, 2012; Raven et al., 2012; Truffer and Coenen, 2012). We further enrich the debate by offering extended theoretical perspectives and an empirical case study. Drawing on the concept family of territorial innovation systems (Carlsson et al., 2002; Moulaert and Sekia, 2003; Asheim and Gertler, 2005; Edquist, 2005), we combine a multi-scalar view on innovation systems (Oinas and Malecki, 2002; Fromhold-Eisebith, 2007) with the technological innovation systems (TIS) approach (Bergek et al., 2008). Viewed from this angle, the empirically investigated innovation trajectory of the German photovoltaic (PV) technology provides instructive insights. While this case was introduced before (Dewald, 2012; Dewald and Truffer, 2011), we employ a novel interpretative framework in this paper.

The following three lead questions and considerations guide our reasoning, attempting to add value to recent debates on the geography of sustainability transitions (GOST):

1. How can the various territorial innovation system concepts be combined and connected with a TIS approach for establishing a multi-scalar perspective on innovation processes in sustainability transitions?

Instead of separating the arenas of regional, national and international innovation systems (Cooke et al., 2004; Edquist, 2005; Carlsson, 2006), we advocate a combination of these variants (in line with Bunnell and Coe, 2001; Fromhold-Eisebith, 2007; Hassink and Ibert, 2009). This links to earlier discussions on the multi-scalar nature of innovation (Lagendijk, 2002; Oinas and Malecki, 2002) that recognized the relevance of all territorial system levels. Truffer and Coenen (2012) recently revitalized this discussion in the context of sustainability transitions and already highlighted, for instance, the importance of interventions at different policy levels fostering sustainability oriented technological change. Moving ahead from these thoughts we further explore basic conceptual properties. This involves to interpret the different territorial scales of innovation systems as 'institutional spaces' that each offer a particular set of players, rules and routines that support innovation. Moreover, we suggest to expediently connect the territorial innovation system concepts and the TIS approach in order to capture the specific properties of environmental technologies within multi-scalar settings.

2. Which levels of influence and related institutional spaces mark the development of the German PV technology trajectory over the last decades, potentially indicating characteristic trends and phase shifts in geographical and actor constellations?

The recent rise and crisis of PV technology in Germany seems highly suitable for investigating the multiple spatial configurations and dynamic changes of a sustainability oriented innovation system, as holds for renewable energy technologies in general (Essletzbichler, 2012). An instructive case study can be presented (Yin, 2009), based on the following arguments (Dewald, 2012): first, German PV technology represents nearly 60 years of development and comprises various re-scaling dynamics in different process fields, such as research and development (R&D), technology production and market formation. Second, this advanced industrial lifecycle allows for studying the changing spatial setting of different processes over time. Third, the recent strong decline of the industry in Germany may be caused by an inappropriate scaling of processes. A focus on national markets, subsidies and protection laws might prevent actors from adapting to globalizing production systems and emerging Asian producers.

Please cite this article in press as: Dewald, U., Fromhold-Eisebith, M., Trajectories of sustainability transitions in scale-transcending innovation systems: The case of photovoltaics. Environ. Innovation Soc. Transitions (2015), http://dx.doi.org/10.1016/j.eist.2014.12.004