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Compulsive policy-making—The evolution of the German feed-in tariff system for solar photovoltaic power

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ABSTRACT

In recent years, policy approaches that build upon the notion of innovation systems have enjoyed increasing attention in science, technology and innovation policy. But while the usefulness of systemic thinking in policy-making has been demonstrated in a large number of empirical settings, we still lack a detailed understanding of the dynamics at play when policy makers address systemic problems. In this paper, we show how complex interdependencies and the uncertain nature of technological change shape the process of targeted policy interventions in socio-technical systems. Toward this end we analyzed the evolution of the German feed-in tariff (FIT) system for solar photovoltaic power, a highly effective and widely copied policy instrument targeted at fostering the diffusion and development of renewable energy technologies. We find that the policy has been subject to a considerable amount of changes, many of which are the result of policy makers addressing specific system issues and bottlenecks. Interestingly, however, often these issues themselves were driven by unforeseen technological developments induced by previous policy interventions. We argue that the pattern of policy serving as both a solution to and a driver of technological bottlenecks shows strong similarities with what Rosenberg (1969) called 'compulsive sequences' in the development of technical systems. By shedding more light on how the characteristics of socio-technical systems affect policy interventions, our framework represents a first step toward more closely integrating the literature on innovation systems with the work on policy learning.

1. Introduction

Environmental degradation, resource depletion and climate change are pressing societal problems that call for a redirection of economic growth toward a more environmentally sustainable pathway (UNEP, 2011). Such a 'sustainability transition' is likely to require the development and use of fundamentally new products, processes and services (Markard et al., 2012; Smith et al., 2010). Whereas this implies an altered behavior of a wide range of actors, such as corporations and private consumers, there is a broad consensus that public policy will have to play an important part in facilitating the transition. Considering the urgency of problems, it is argued that regulators should guide and accelerate the process of change by altering the institutional framework, breaking path dependencies and fostering the emergence of innovative, more environmentally benign technologies (Jacobsson and Bergek, 2011; Unruh, 2002).

In recent years, innovation scholars have strongly advanced our understanding of the role that public policy can play in fostering the transition toward sustainability. For example, the literature on innovation systems has identified so-called 'system failures' or 'system problems' that hinder the development and diffusion of new technologies (e.g., Klein Woolthuis et al., 2005; Negro et al., 2012) and has suggested a number of 'functions' or 'key processes' policy makers should support to overcome these issues (e.g., Bergek et al., 2008; Edquist, 2011; Hekkert et al., 2007). The practice of systems thinking has found increasing use in policy circles in recent years (Wieczorek and Hekkert, 2012). Up to this point, however, we lack a detailed understanding of how policy responses emerge from systemic imbalances and how they co-evolve with the system that policy makers intervene in Kuhlmann et al. (2010). The literature emphasizes the complex nature of innovation systems, with many interdependent actors and institutions (Faber and Alkemade, 2011). Yet, it remains unclear how this affects policy maker's ability to purposefully induce technological change. Studies in the field of policy sciences have stressed the emergent nature of policy processes and investigated factors that facilitate policy learning (Lindblom, 1959). However, when analyzing the drivers of policy evolution, typically these studies have focused on the political system as the intervening entity, rather than technological

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change and the characteristics of the system to be intervened in.

To gain more insights into the dynamics that result when policy makers try to purposefully intervene in socio-technical systems, in this paper we address the question of *how the complex dynamics of innovation systems shape the process of policy interventions targeted at inducing technological change.* Toward this end, we study the evolution of the widely copied German feed-in tariff (FIT) system for solar photovoltaic (PV) power as an instrument that has been highly effective in driving the development and diffusion of PV technology. In this context, we analyzed a large number of archival documents pertaining to the policy process such as legislative texts, protocols of parliamentary debates, expert studies and press articles. This archival analysis was complemented by interviews with policymakers and designated PV industry experts as actors in and observers of the policy process.

We show that the German FIT for PV has evolved in a highly iterative way with policy makers adjusting the policy design over time. Some of the policy changes were due to politics and policy makers correcting flaws in previously implemented legislations. More interestingly, however, we find that besides these factors the evolution of the German FIT for PV was strongly driven by – often unforeseen – developments in the technological sphere. Policy makers implemented policies that addressed particularly prevalent 'system failures' or 'system issues' hindering the development and diffusion of solar PV in Germany. Although these policy measures contributed to eliminating specific issues, we find that, by inducing unexpected technological developments, policy simultaneously contributed to the emergence of new issues which needed to be addressed in subsequent steps. We argue that understanding policy interventions in socio-technical systems in analogy to what Rosenberg (1969) described as 'compulsive sequences' of innovation, may help inform future interventions in innovation systems. The framework of 'compulsive policy-making' we propose goes beyond more generic frameworks of policy learning (e.g., Bennett and Howlett, 1992; Lindblom, 1959) by stressing the role of technological change and complex interdependencies in socio-technical systems as a driver of policy change.

The remainder of this paper is structured as follows: Section 2 presents a brief overview of the work on innovation systems and discusses potential mechanisms shaping policy dynamics suggested in the literature. Research case and method are outlined in Sections 3 and 4. Section 5 describes the evolution of the German FIT system for PV, followed by a discussion of the underlying technological dynamics and the theoretical framework we derive in Section 6. We conclude with a brief description of the study's limitations, suggestions for future research and a summary of the main contributions.

2. Theoretical perspective

2.1. Innovation systems analysis as a means to inform policy interventions

In the last two decades, the concept of innovation systems has gained increasing importance in informing policy interventions in the field of science, technology and innovation policy (Edquist, 2011; Smits and Kuhlmann, 2004; van Mierlo et al., 2010). It builds upon the idea that the development, diffusion and use of technologies results from the interplay of a large number of actors (e.g., firms, policy makers), networks (formal and informal), technologies (e.g., knowledge and artifacts) and institutions (e.g., norms, values or regulations) within a socio-technical system (Carlsson and Stankiewicz, 1991; Edquist et al., 2005). To foster technological change, the literature suggests carefully analyzing the socio-technical system to identify so-called 'system failures' or 'system problems' as the focus of policy interventions. Previous work has clustered failures into categories, such as 'institutional', 'network' or 'capability' failures, and suggested systematic procedures for their identification (Carlsson and Jacobsson, 1997; Klein Woolthuis et al., 2005; Negro et al., 2012; Smith, 1999). In the latter context, a number of 'functions', 'key processes' or 'key activities' have been proposed that policy makers should focus on when searching for systemic failures that may prevent technology development and diffusion (Bergek et al., 2008; Edquist, 2011; Hekkert et al., 2007). It is suggested that, to devise technology-specific policies, policy makers should measure the extent to which different processes are present within an innovation system, detect mechanisms inducing or blocking these processes and implement policy measures to remove potential system bottlenecks (Bergek et al., 2008; Wieczorek and Hekkert, 2012).[1]

The analysis of innovation systems has proven a powerful heuristic for identifying starting points of policy interventions and explaining the success or failure of technology development and diffusion. However, since the focus of innovation system studies is on analyzing the socio-technical system as a whole rather than the details of policy processes, we lack a sufficient knowledge about how policy responses emerge from systemic imbalances and how they co-evolve with the system that policy makers intervene in Kuhlmann et al. (2010). While the innovation systems literature itself does not intend to provide a detailed explanation of the policy process, a better understanding of the link between system failures and policy-making could be fruitful as it may help (a) uncover the underlying dynamics of innovation system evolution and (b) improve the practical relevance of policy recommendations made. Therefore, in the following we take a closer look at two mechanisms affecting the dynamics of policy interventions in innovation systems that have been discussed in the literature.

2.2. Potential mechanisms shaping the dynamics of policy interventions in innovation systems

As one important mechanism shaping the dynamics of policy interventions in innovation systems, early studies in the field have investigated the role of *politics and interest* (Jacobsson and Bergek, 2004; Jacobsson and Lauber, 2006; Jacobsson et al., 2004). In line with the literature on the politics of sustainability transitions it has been pointed out that the transformation of socio-technical systems is an inherently political process influenced by mindsets, framing and power struggles (Kern, 2011; Meadowcroft, 2009, 2011; Scrase and Smith, 2009). Politicians anchored in an existing regime are unlikely to show strong support for emerging technologies and may resist related political initiatives (Kern and Smith, 2008). Moreover, policy makers may hold differing opinions on what constitute the most important system failures and how to remove them (Meadowcroft, 2009).

A second mechanism that is likely to shape the dynamics of policy interventions aimed at removing specific system failures is *limited capacity and foresight of policy makers*. Even if there is a political consensus regarding the goals and means of policy-making, the inherent complexity of socio-technical systems may limit the degree to which consequences of policy interventions can be accurately foreseen (Faber and Alkemade, 2011). As expressed in Lindblom's (1959) 'science of muddling through', policy makers

[1] The logic of identifying and removing system bottlenecks appears similar to 'Liebig's law of the minimum' in agricultural science. According to Liebig's law, which was originally developed by Carl Sprengel in the early 19th century, the performance of a system consisting of a number of interdependent elements is limited by the scarcest resource.