Working Paper Sustainability and Innovation
No. S 02/2015

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Unpacking the policy processes for addressing systemic problems: The case of the technological innovation system of offshore wind in Germany

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Abstract

While empirical studies on technological innovation systems (TIS) usually focus on policy instruments and their suitability for curing identified weaknesses of such emerging systems, the underlying policy processes and their effects on these systems have been largely disregarded. We address this gap by exploring two crucial policy-making processes and their effects on the functioning and performance of the offshore wind TIS in Germany. Our findings indicate important positive and negative impacts of these processes on the TIS. For example, tardy reactiveness in policy action negatively influenced entrepreneurial activities, knowledge development and finally technology diffusion, whereas the incremental nature of the studied policy processes was necessary to improve TIS performance after it had been hampered by systemic problems. Based on our findings we derive policy implications and avenues for future research.

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1 Introduction

Analyses of technological innovation systems (TIS) focus on emerging technologies often in early phases of development (e.g. Jacobsson & Bergek, 2004). Typical for these early stages is the existence of a number of failures hindering the development and diffusion of the young technologies, so that it is particularly hard for them to compete with established technologies (Carlsson & Stankiewicz 1991). For overcoming these failures and allowing the technologies to become market-ready, government intervention is needed (Borrás & Edquist 2013; Klein Woolthuis et al. 2005).

Against this background, the goal of TIS studies is to identify such failures or systemic problems and, based on this, suggest concrete tools for policy intervention, so as to purposefully foster the technology (Jacobsson & Bergek, 2011). There exists a considerable number of studies having completed exactly such analyses. One of the first studies of this kind is Negro et al. (2008) that analyzes the functional patterns of the biomass TIS in the Netherlands identifying corresponding system failures and suggesting policy measures for addressing them. Further similar studies that examine systemic problems via a functional analysis of TIS and identify areas for policy intervention include Jacobsson and Karltop (2013), van Alphen et al. (2010), and Jacobsson (2008). While the analytical framework applied in these studies has helped policy makers by analyzing where policy intervention is needed and has suggested policy instruments, studies have focused much less on associated policy processes.

In this regard, recent studies identified a need for a better conceptual understanding of institutions in TIS, including the regulatory frame (Truffer et al. 2012) and tools for the selection of policies that address system failures (Coenen & Díaz López 2010). Related to that, the literature called for a more detailed understanding of the dynamics of policy intervention processes that result from addressing systemic problems (Hoppmann et al. 2014). These studies hint at the importance of more thoroughly examining policies in TIS, particularly policy processes. It is therefore the goal of this study to address this gap, analyzing policy processes that respond to systemic problems and exploring how the nature of these processes influences TIS functioning and performance (Bergek et al. 2008; Hekkert et al. 2007). That is, we analyze the impact of several characteristics of policy-making processes on system functions and on technology use and diffusion. Such an analysis might enrich TIS studies by so far largely unexplored aspects and contribute to a better understanding of TIS in general.

We examine the role of policy processes for TIS for the case of the technological innovation system of offshore wind in Germany. The main reason for choosing this case is that the TIS has experienced several systemic problems that were addressed by policy makers, ultimately contributing to the evolution of a complex policy mix as well as to some positive developments in terms of TIS functioning and performance (Reichardt & Rogge 2014; Reichardt et al. 2014). Methodologically, we combine expert interviews and desktop research to analyze the policy-making processes in which two crucial systemic problems were addressed. These problems posed the greatest barriers in the TIS in recent years and were thus decisive for the further direction of the TIS. In doing so, we shed light on the direct and indirect mechanisms by which the policy processes impacted TIS functioning and TIS performance.

In the following we will first review the literature on technological innovation systems and policy mixes, with a focus on policy-making processes and their relevance for TIS functioning and performance (section 2). We then provide a brief overview of the research case (section 3), and a delineation of our methodological approach (section 4). We subsequently describe the policy-making processes, characterize their nature and analyze their effects on the TIS (section 5). Finally, section 6 concludes.

2 Technological innovation systems and policy processes

The technological innovation systems (TIS) approach has been widely applied to the analysis of emerging technologies, among others in the field of energy technologies (Bergek 2012; Staffan Jacobsson & Bergek 2011; Truffer et al. 2012). The major goal of these studies is to detect system strengths and weaknesses by analyzing the structure and functions of the TIS. While structural analyses of TIS focus on describing its actors, networks and institutions and thus constitute static inquiries (Edquist 2005), functional analyses map a range of different activities taking place in the TIS. For doing so a number of key functions are applied (Hekkert et al., 2007, see Table 1). This functional analysis serves as prerequisite for explaining the performance of TIS in terms of the development and diffusion of innovations (Bergek et al. 2008; Hekkert et al. 2007). Based on the identified system strengths and problems, concrete recommendations for government intervention are given so as to improve system functioning. In doing so, studies often suggest which policy instruments might best be suited to remove the systemic problems (Negro et al. 2008; Wieczorek & Hekkert 2012).

In terms of policy, TIS studies have so far focused on policy instruments and their role for system building. That is, some studies show how policy instruments impact innovation systems (Kivimaa & Virkamäki 2013; McDowall et al. 2013), while other studies state which policy instruments may be effective in improving TIS performance (van Alphen et al. 2010; Negro et al. 2007). Another aspect that TIS studies consider with regard to policies is system building, such as how actors shape the build up of innovation systems and their institutions, including policies (Kukk et al. 2013, 2014).

However, policy processes are as yet largely neglected in TIS studies (Coenen & Díaz López 2010; Hillman et al. 2011). Policy processes consist of several interdependent activities called *phases of the policy process* or *policy cycle*. These phases encompass agenda setting, policy formulation, adoption, implementation, assessment, adaptation, succession, and termination (Dunn 2004; Dye 2008). Policy processes comprise complex rounds as well as backward and forward loops between the individual phases, and they do not necessarily occur in the “right” order that starts with agenda setting and ends with policy succession or termination (Dye 2008).

The study by Chung (2013) on technology and innovation policies in Taiwan is one of the first to focus on the analysis of policy processes in an innovation system context. It analyzes the link between the innovation policy-making process, the design of innovation policy instruments and the development of the innovation system, finding vital dependencies between these factors. However, what is still lacking is a clear link of policy processes to systemic problems and to system functions.

Table 1: Key functions of technological innovation systems

Function (function number)	Description
Experimentation and production by entrepreneurs (F1)	Entrepreneurs are essential for a well-functioning innovation system. Their role is to turn the potential of new knowledge, networks, and markets into concrete actions to generate – and take advantage of – new business opportunities.
Knowledge development (F2)	Mechanisms of learning are at the heart of any innovation process, where knowledge is a fundamental resource. Therefore, knowledge development is a crucial part of innovation systems.
Knowledge exchange (F3)	The exchange of relevant knowledge between actors in the system is essential to foster learning-processes.
Guidance of the search (F4)	The processes that lead to a clear development goal for the new technology based on technological expectations, articulated user demand and societal discourse enable selection, which guides the distribution of resources.
Market formation (F5)	This function refers to the creation of a market for the new technology. In early phases of developments this can be a small niche market but later on a larger market is required to facilitate cost reductions and incentives for entrepreneurs to move in.
Resource mobilization (F6)	The financial, human and physical resources are necessary basic inputs for all activities in the innovation system. Without these resources, other processes are hampered.
Creation of legitimacy (F7)	Innovation is by definition uncertain. A certain level of legitimacy is required for actors to commit to the new technology and execute investments, take adoption decisions etc.

Source: adapted from Wieczorek et al. (2013)

The policy mix literature has also recently stressed the importance of considering policy processes and has called for their explicit analysis in innovation studies. For instance, Flanagan et al. (2011) in their call for a reconceptualization of the policy mix for innovation point out that policy processes should be an integral part of policy mix analyses. Rogge and Reichardt (2013) also acknowledge the importance of policy processes in their policy mix concept for environmental technological change, based on their potential influence on policy mix effectiveness. This influence can be direct through the processes' style or nature, e.g. the way policies are designed, or indirect through shaping the policy mix elements, including the policy strategy and policy instruments.

The nature of policy processes has been characterized in several ways, ranging from very rational and structured policy-making models to very incremental approaches (Dunn 2004). At the rational end of the spectrum the *comprehensive economic rationality model* is located, according to which policy makers act as 'homo economicus' considering all available policy options, anticipating and assessing the consequences of each option and choosing the most efficient option (Dunn 2004). However, rationalist approaches to policy making in which policy makers are assumed to have complete information about the future and thus are able to plan in a comprehensive fashion rarely take place at all (Dye 2008). They were consequently assessed as rather unrealistic (Mayntz 1996), and alternative approaches were subsequently developed.

In contrast, at the incremental end of the spectrum models focus on policy making in small steps (Dunn 2004). Lindblom's *'science of muddling through'* (1959, 1979) is a typical example of such an incremental policy approach, which focuses on ills to be remedied rather than proactively seeking positive goals (Lindblom 1979; Rothmayr Allison & Saint-Martin 2011). Yet, it might lead to faster policy-induced changes than comprehensive policy making (Lindblom 1979). Another model at this end of the spectrum is that of *'adaptive policy making'*, which stresses the importance of adaptiveness in complex and uncertain environments, i.e. the reaction to changes as they occur, and makes explicit provisions for policy learning (Walker et al. 2001) (Marchau et al. 2010; Swanson et al. 2010). Such 'incremental' policy-making processes are likely to be more effective than rational processes aiming for 'optimal' designs, since they can adapt to specific situations (Bankes 2002).

Another important aspect for characterizing policy processes is the degree of involvement of diverse stakeholders in such processes (Stigson et al. 2009). Two important reasons for the increasing attention paid to this in the literature include a more tailored design of a new policy instrument to the particularities of target actors, and the increased acceptance of such an instrument by affected actors if these actors are already involved in the policy-making process. A key literature in this regard is that of *participatory policy making*, arguing for involving the actors affected by the policy mix in policy-making processes (Frantzeskaki et al. 2012; Stigson et al. 2009).

Given this increasing recognition of the importance of the nature of policy processes and its potential role for TIS functioning and performance, in this paper we study the policy-making processes at play in a TIS when actors – such as business and policy actors – attempt to solve systemic problems. In doing so, we will concentrate on those parts of the policy-making processes that cover agenda setting, policy formulation and adoption. Rather than looking at the actual policy instruments, we shed light on how these instruments come about or are being changed, and how the nature of such processes impacts TIS functioning and performance. Thereby, we take an important step towards incorporating policy processes in TIS analyses.

3 Research case

For studying policy processes in TIS, we chose the German offshore wind TIS for three major reasons. First there are ambitious targets in place for offshore wind in Germany, i.e. 6.5 GW of installed capacity by 2020 and 15 GW by 2030 (CDU et al. 2013), but the TIS still displays a poor performance with only 0.52 GW installed at the end of 2013 (EWEA 2014). This might be due both to the comparative immaturity of the technology with related high costs (Fichtner & Prognos 2013), and to the existence of systemic problems in the TIS. Second, an encompassing policy mix has been set up, implying that policy makers may somehow have attempted to address these problems. Third, offshore wind is a technology with great technological potential and growth prospects, and could thus play an important role in a decarbonization of the energy sector, not only in Germany but also globally (e.g. EWEA, 2013). This technological potential results from the strong and steady winds at sea and correspondingly many full-load hours (4,000 compared to 2,000-2,500 onshore) as well as the technology's large scale and associated great project sizes (EWEA 2009). Against this background, Germany is an interesting case since it is one of the fastest growing offshore wind markets worldwide (pwc & wab 2012), despite its currently low installed capacity.

Two core policy instruments of the German policy mix for offshore wind have been the Renewable Energy Act (EEG) with its technology-specific feed-in tariff and the Energy Economy Law (EnWG) regulating the grid access for parks. The Renewable Energy Act (EEG) has been put in place in the year 2000 with the goal to significantly increase the share of renewable energy technologies in Germany. For achieving this, it introduced – among others – technology-specific feed-in tariffs with a twenty year guaranteed payment per produced kilowatt-hour of electricity (EEG 2000). While in the initial EEG there was only one feed-in tariff (FIT) for onshore and offshore wind, the first offshore wind-specific FIT was introduced with the 2004 EEG amendment, since higher costs were expected for offshore than for onshore plants. This offshore wind FIT was increased – according to updated cost estimations – several times in the course of the years, besides in 2004 also in 2009 and 2012 (EEG 2009, 2012).

The grid access for parks was originally regulated in the EEG, according to which park operators were to finance the grid connection themselves (EEG 2000). This provision was changed with the Infrastructure Planning Acceleration Act (InfrStrPlBeschlG) in 2006, becoming part of the Energy Economy Law (EnWG). It shifted the responsibility of connecting offshore wind parks to the grid from the park operators to the transmission system operators (TSOs) and prescribed that this connection had to be available when a farm was ready to start operation (InfrStrPlBeschlG 2006). Due to several emerging problems, this grid access regulation had to be changed again, with a fundamental 'system change' occurring in 2012 (see section 5.5.1.2). An essential provision of this new system is that the operators are to negotiate a date with the TSO at which the grid access would be provided. If the TSO cannot adhere to this date, it is to financially compensate the operator for the standstill. In addition, TSOs are to put up a yearly offshore grid development plan detailing the location, timing and size of new grid connection cables (EnWG 2012).

For our analysis of policy processes we selected such processes that were crucial for addressing important systemic problems and that ultimately contributed to the further direction the TIS took. Therefore, out of five identified systemic problems (Reichardt et al. 2014) we selected those two that posed the greatest barriers in the TIS in recent years. These problems are, first, an insufficient level of support of the feed-in tariff for offshore wind in the mid 2000s and second, heavy delays in grid access provision for parks between about 2010 and 2012. The existence of the first problem can be traced back to the mismatch between the foreseen EEG feed-in tariffs for offshore wind and actual cost developments. The second problem was mainly caused by the ineffectiveness of the grid access regulation for offshore wind parks in the Energy Economy Law (EnWG) as evidenced by delays in grid access to be provided by TSO TenneT. Ultimately, the policy processes addressing these problems resulted in adjustments of these policy instruments.

4 Methodology

To investigate the nature of policy-making processes addressing systemic problems and how this nature influences TIS, we chose a qualitative approach. This allows for unpacking details of these processes, such as how certain decisions were taken and executed. In addition, it enables shedding light on these processes' impact (Yin 2009). Our methodological approach therefore is based on expert interviews and supplemented by desktop research providing secondary data for triangulating our interview findings.

Table 2: Overview of expert interviews

Actor type	Organization	# interviews
Government	Federal Environment Ministry (BMU)	3
	Federal Maritime and Hydrographic Agency (BSH)	2
	Federal Network Agency (BNetzA)	1
Public organizations	Reconstruction Loan Corporation (KfW)	2
	Center for Wind Energy Research (ForWind)	1
Transmission system operator (TSO)	TenneT	1
Industry associations	Offshore Wind Foundation	1
	German Engineering Association (VDMA)	2
	Wind Energy Agency (wab)	1
Non-governmental organization	World Wide Fund for Nature (WWF)	1
	SUM	**15**

For our expert interviews we selected stakeholders who – either in person or via their organization – played a crucial role in the respective policy-making process. This enabled us to get detailed 'insider' information on these processes and on the role they played for the TIS. We interviewed at least two experts for each process to allow for cross-checking expert statements. In total we conducted fifteen interviews with experts in the TIS under study, including representatives of the government, public organisations, the transmission system operator, industry associations and NGOs (see Table 2). [1] Interviews took place between July 2013 and January 2014and on average lasted about eighty-four minutes. All interviews relied on a semi-structured interview guide and were done by telephone. We transcribed and coded the interviews with codes for each of the two systemic problems, for the policy-making processes, and for different actors. In order to safeguard the interviewees' anonymity, throughout the results chapter we reference them with letters from A to N.

Building on the insights from the coded interviews and from the documents, we subsequently reconstructed the policy-making processes addressing the two selected systemic problems. This enabled us to thoroughly understand these systemic problems and to characterize at a sufficient level of detail the policy-making processes that occurred to address them. We finally analyzed the processes' impacts on the functioning and performance of the TIS.

1 These interviews were conducted in the context of a study on the German offshore wind TIS and the role of the policy mix for offshore wind on the TIS (Reichardt et al. 2014b).

5 Policy-making processes and their effects on the German offshore wind TIS

In this section we present our findings in three steps: we first describe the two selected policy-making processes – starting with their underlying systemic problems (section 5.1), subsequently characterizing their natures (section 5.2) and finally analyzing their effects on the TIS (section 5.3).

5.1 Description of the policy-making processes

5.1.1 The policy process addressing the problem of insufficient level of support of the 2004 offshore wind feed-in tariff

Systemic problem

The adjustment of the offshore wind FIT in the 2009 EEG amendment was the consequence of a severe systemic problem, which developed and increased after launching the first technology-specific FIT in 2004. At the time of its introduction as part of the 2004 EEG amendment, this FIT appeared to be adequate given the state of knowledge and most projects being still relatively far from their realization (Interviewee M). Also, a Danish project planner ensured to be able to immediately start construction with such a FIT, as this interviewee recalls: *'if we fixed the offshore wind feed-in tariff like we then actually did in the law, [...] then they [Danish project planner] could make the decision tomorrow to start construction'* (Interviewee M). Nonetheless, soon after the FIT's enactment project planners realized that its level of support would probably not be sufficient and called for its increase (Interviewees E, K). In particular, during the planning and realization process of Alpha Ventus it became clear that this FIT level was actually too low since project realization costs turned out to be considerably higher than expected (Interviewee L). Although the responsible policy makers from the Federal Environment Ministry (BMU) well knew about the problem they did not change the FIT before the next EEG amendment in 2008. Therefore in the years between approximately 2006 and 2008, this low FIT was a major reason why relatively well developed offshore wind projects were not started. This considerably delayed the further development of the German offshore wind TIS and therefore constituted an important systemic problem. In the following we zoom into the policy-making processes that addressed this problem and that led to the offshore wind FIT adjustment in the 2009 EEG amendment.

The policy-making process addressing the systemic problem

Although many stakeholders, e.g. industry lobby groups, had called for a higher FIT soon after the 2004 EEG amendment, the offshore wind FIT was not adjusted until 2009: the German government did not even want to make small changes within the EEG, fearing that in such a case all different technology interest groups also wanted their FIT or other EEG regulation adjusted (Interviewee M). Waiting with such an adjustment had thus been a political decision. It had to do with the relatively formalized overall EEG amendment processes, in which the EEG is regularly adjusted as package for all technologies it covers. Each amendment is usually preceded by a so-called experience report on the functioning of the current EEG. This report is required by law every three to four years (see §65 EEG) and is to be done by the government. In fact it is drafted by the environment ministry mainly based on scientific studies that evaluate the effectiveness of the current EEG. After parliament has noticed the report and the government has released it, the environment ministry elaborates an EEG amendment draft, which again needs to be enacted by the government and is then fed into the parliamentary process to be adopted. While the experience report is mandatory by law, the EEG amendments are not. Yet due to stakeholder pressure – mainly by industry associations such as the German Engineering Association (VDMA) – to fix the aspects that needed improvement according to the experience report, and probably also to improve the situation for their constituency, policy makers have so far always amended the EEG following such a report (Interviewee M).

In the particular amendment process for the 2009 EEG, the environment ministry elaborated the regular experience report in 2007, whose offshore wind part was mainly based on studies that the ministry in 2005 had contracted to the operator consortium of the demonstration project Alpha Ventus, the German Offshore Test Field and Infrastructure Society (DOTI), and to the Deutsche Windguard, a German consultancy for wind energy. Already in the process of developing the experience report, industry associations tried to take influence. However, they were excluded from the official drafting of this report (Interviewee M). Instead the environment ministry (BMU) and the Federal Ministry of Economics (BMWi) closely collaborated when elaborating the report, discussing it “sentence by sentence” (Interviewee M) during about six to eight months. The report was released by the federal cabinet in November 2007, and given to parliament for notice. It proposed to raise the initial offshore wind FIT – at that time 9.1 ct / kWh for twelve years – to a level ranging between 11-15 ct / kWh and after twelve years lower it to 3.5 ct / kWh (BMU 2007a). Independent from the experience report, interest groups had also posed their claims for a new FIT. Most prominently, the Offshore Wind Foundation in June 2007 had published a statement on how to alter the FIT, demanding a raise of the initial remuneration to 14 ct / kWh and after twelve years a lowering to 6.19 ct / kWh (Offshore Forum Windenergie et al. 2007).

As is usually the case, after release of the 2007 EEG experience report the political pressure to amend the EEG rose. Thus, the environment ministry in 2007/8 worked out an amendment to the EEG suggesting an increase of the offshore wind FIT corresponding to the range proposed in the report (BMU 2007b). Following the formalized policy-making process, this amendment draft was again discussed with the involved ministries, i.e. the environment and economics ministries and the Federal Ministry of Finance (BMF), as well as with the federal chancellery during several months before it was enacted by the federal cabinet and sent to parliament. The FIT in this parliamentary version from February 2008 was set to 12 ct / kWh for the first twelve years with an additional 2 ct / kWh for projects starting operation before 2014 (Deutscher Bundestag 2008). This FIT level is exactly within the range proposed in the first EEG draft (BMU 2007b).

As a next step, the responsible parliamentary committee dealt with the EEG draft, before it went back to be finally discussed within the coalition parties (CDU, SPD) and the three involved ministries (environment, economics, finance). These last negotiations were *'an emotional discussion in which all involved actors wanted to bargain the best deals for their clientele'* (Interviewee M). Regarding offshore wind, pro-offshore government members were able to increase the FIT by one additional cent compared to earlier propositions, achieving 13 ct / kWh (plus a "sprinter bonus" of 2 ct / kWh). Figure 1 illustrates this process, with the systemic problem as starting point, the moments of problem identification by project planners and policy makers, and an indication of the period of inaction by the latter actor group. It further depicts the stepwise changes in the FIT and ends with the altered policy mix element, i.e. the EEG amendment with the final level of support granted by the adjusted offshore wind FIT.

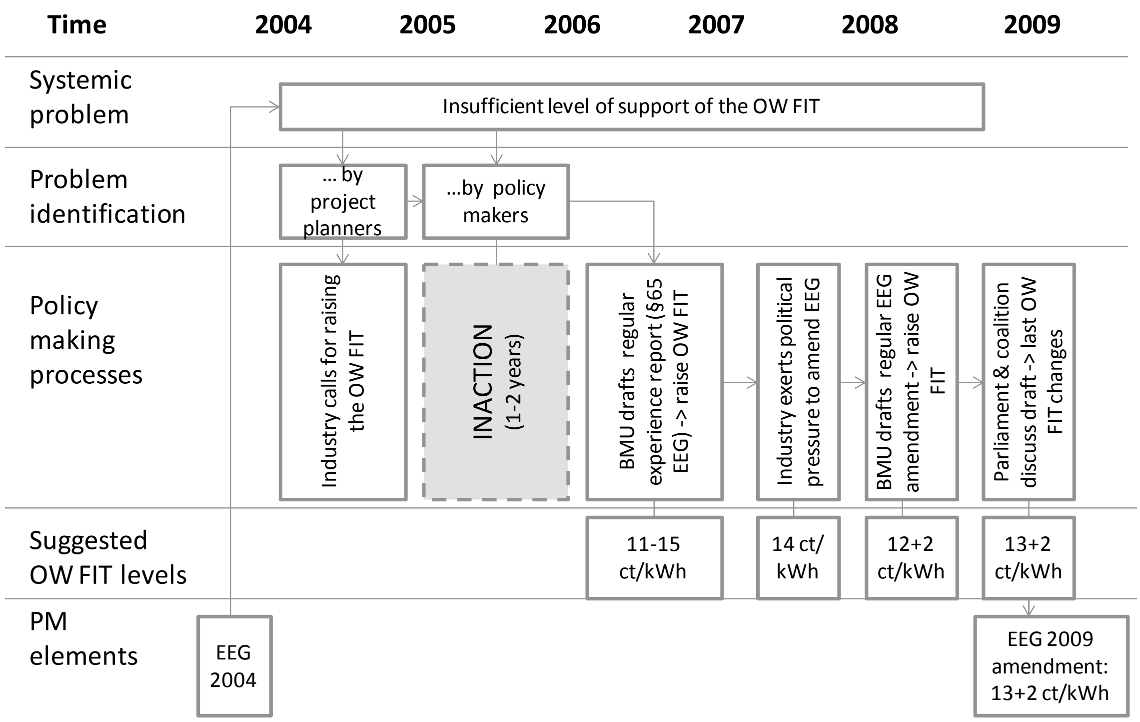

Figure 1: Policy-making process adjusting the offshore wind FIT in the 2009 EEG amendment

This implies that the policy-making process leading to the 2009 EEG amendment was a rather lengthy process (almost five years) with interaction particularly between different government actors, and with industry groups trying to influence the FIT according to their interests. Within these frequent interactions the level of the proposed offshore wind FIT changed several times – over several political rounds it was increased step by step, with the highest level being finally adopted.

5.1.2 The policy process addressing the problem of delayed grid accesses after 2009

Systemic problem

The grid access regulation from 2006 left undefined which park should be connected in which order by the transmission system operators (TSOs), which is why the TSO TenneT – in charge of grid connections in the German North Sea – put up a list of criteria the projects had to fulfill in order for the TSO to become active (Interviewee H). These criteria on the one hand made the situation clearer, but on the other hand led to a new problem for project planners, known as the chicken-egg-problem. It referred to the mutual dependence of the grid access and finance commitments – each one was only possible to be attained against production of the other one (Interviewees H, J). The Federal Network Agency (BNetzA), in charge of implementing the grid access policy instruments, addressed the problem in a position paper in 2009, in which it clarified the criteria that the project planners were to deliver so that the TSO had to start constructing the grid connection (Interviewee J). This facilitated a first wave of investment decisions for around three GW of installed capacity that were, besides this position paper, mainly triggered by the then increased FIT for offshore wind (Interviewee J).

However, this improved grid access situation did not last long. When planning and implementing cables for this first wave of parks, TenneT began to encounter a number of problems (Interviewees J, L; Spiegel Online, 2011). First, technical difficulties occurred, e.g. with converter stations for which TenneT’s suppliers were responsible. Second, crossing the Wadden Sea National Park implied conflicts with nature protection and thus was accompanied by high administrative requirements TenneT had to fulfill. Third, TenneT experienced financial bottlenecks as well as shortages with human resources. These problems were the reason why the whole process of cable planning and realization by TenneT took much longer than anticipated and in most cases was not finished when the offshore wind farm was ready to start operation. As a consequence, offshore wind projects were delayed causing high costs for the planners, which risked to render their projects inefficient. This also meant that the future of the offshore wind TIS remained highly uncertain (VDI Nachrichten 2013). This problem, which can be said to have its roots both in inappropriate regulatory provisions (originally in the InfrStrPlBeschlG from 2006, which did not sufficiently clarify grid access criteria for parks) and in bottlenecks with TenneT, constituted at that time the most severe systemic problem. As a consequence, in 2011 and partly in 2012 many TIS developments were put on hold (Interviewees I, J), despite the just recently resolved problem of an insufficient FIT level. In other words, solving one important systemic problem was not enough to get the TIS development going again since another systemic problem had come up. This situation can be described as inconsistency between the EEG and the grid access regulation, in which the latter policy instrument hindered the working of the former one.

The policy-making process addressing the systemic problem

The above described grid access problem was not seriously addressed by the responsible economics ministry (BMWi) and over time became so severe that it escalated in an urgent letter (a so-called "Brandbrief") to the government by the TSO TenneT in November 2011. In this letter TenneT argued it would be no longer able to connect offshore wind farms to the grid under the current circumstances, and asked for political help. Being forced to react due to TenneT's inaction and thus a standstill of projects waiting for grid access, the economics ministry finally took action – together with the environment ministry – and convened a high-level meeting with the ministers in charge, Rösler and Röttgen (Interviewees H, J). They discussed possibilities for solving the grid access problem with the result that both ministries set up a working group with all affected actors, the so-called working group 'Acceleration' ('AG Beschleunigung')[2] (Interviewee J). The reason for addressing the problem in such a working group was to come up with a joint solution to which all relevant stakeholders agreed. The Offshore Wind Foundation constituted a central actor in this process since it volunteered to moderate this group (Interviewees E, L). Under the moderation of the Foundation, this working group met several times discussing possible improvements for preventing such delays in the future and working out concrete suggestions. Involved actors described the atmosphere in the group as very cooperative with much support from all sides, since actors were interested in a timely solution to this then pressing problem. Moreover the discussions were characterized as a joint dialogue aiming to address different interests (Interviewees H, J). Probably due to this strong joint aim of finding an appropriate solution, the working group in only eight weeks elaborated a proposition for improving the grid access regulation, which the Offshore Wind Foundation formulated into a policy paper by March 2012 (Stiftung Offshore Windenergie 2012).

In this paper the Foundation made detailed and concrete suggestions for a system change in grid access, which industry representatives had long been calling for (Interviewee E). The responsible ministries took this paper as basis for changing the grid access regulation, adopting most of its suggestions and partly

2 These actors were: the environment (BMU), economics (BMWi) and finance ministries (BMF), the network agency (BNetzA), the Federal Maritime and Hydrographic Agency (BSH), the two affected TSOs and their suppliers (Siemens, ABB, Alstom), planners, operators, investors, the German Engineering Association (VDMA) representing technology providers, and other associations.

further developing some of them, and feeding the proposal into the formal political process. This process resulted in an amendment of the EnWG in December 2012, which was very positively absorbed by affected actors despite some remaining uncertainties regarding its effectiveness. Figure 2 depicts this amendment process with the systemic problem and its escalation, the identification of the problem by policy makers and the main steps in the policy-making process that finally ended in an amendment of the Energy Economy Law (EnWG).

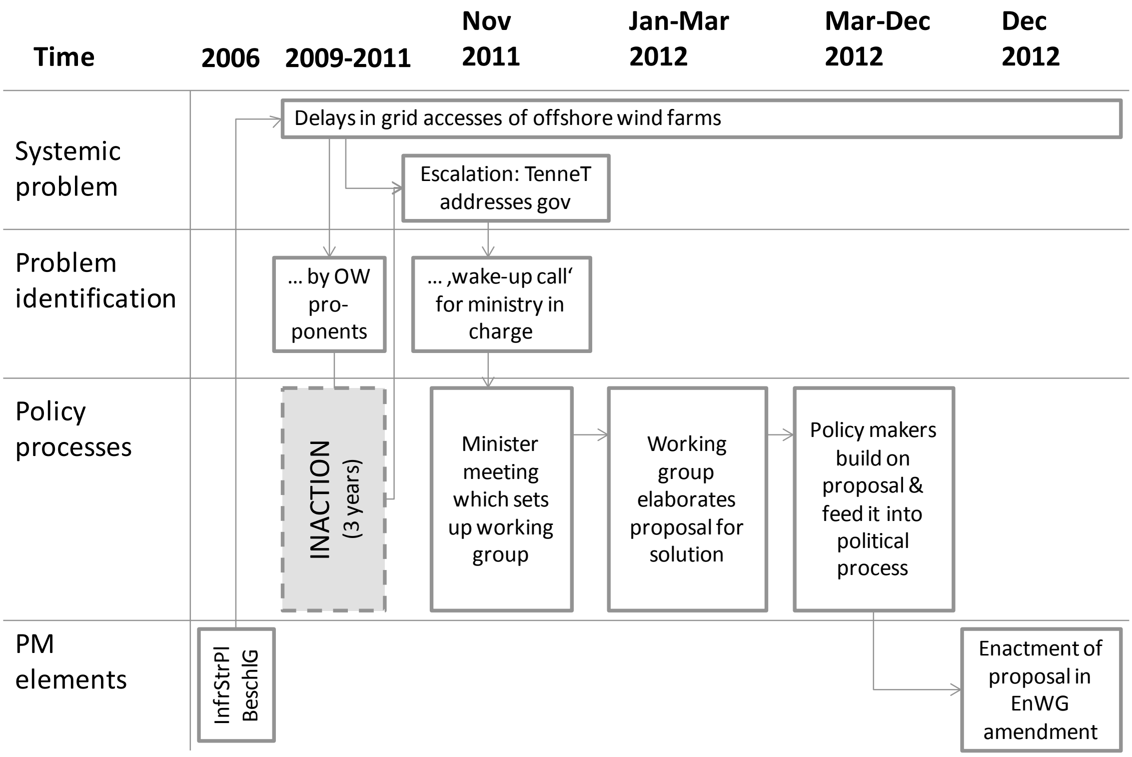

Figure 2: Policy-making process leading to the 2012 EnWG amendment

In sum, the policy-making process addressing the problem of delayed grid access is characterized by relatively long inaction (three years) despite problem awareness but comparatively quick – about one year's time – action subsequent to problem escalation. Next to the Offshore Wind Foundation as central actor, mainly affected industry stakeholders were involved in developing this solution – with the responsible economics ministry and the environment ministry accompanying the process.

5.2 Characterization of the policy-making processes

Both of the studied policy-making processes fit the “incremental’ end of the spectrum of policy process models. More specifically, the EEG amendment process resembles the adaptive policy-making model: policy makers set a certain FIT level, monitor and evaluate its effects, and subsequently adjust it to actual developments (Marchau et al. 2010; Walker et al. 2001). The particular 2009 offshore wind FIT adjustment process occurred within the formalized, regular and thus foreseeable overall EEG amendment process. Yet, policy action was tardily reactive: although the problem of the FIT’s too low level of support was long known, policy makers sticked to the foreseen EEG amendment process and therefore only reacted after this problem had hindered a number of investors in their offshore wind activities. Furthermore, the process was participatory in a rather ‘classical’ sense – e.g. by incorporating stakeholders in the amendment process via hearings and statements. Thus, the EEG amendment process was a formal, government-led process that was open for input from stakeholders. As the outcome shows, particularly industry associations were quite successful in exerting influence, for which an important reason may have been the potential contribution of offshore wind to the achievement of climate, renewable energy and industry policy objectives (evidenced also in the UK by Kern et al. (2014)).

In contrast, the policy-making process that addressed the grid access delay problem resembles Lindblom’s (1979) ‘muddling through’ since policy makers from the economics ministry were preoccupied with remedying a huge problem rather than proactively seeking positive goals, such as much earlier establishing a well-functioning grid access regulation. The reaction to this problem occurred with great delays – only when it had escalated and nothing worked any more – and in an ad-hoc fashion. Yet, once taken up the political process of identifying a solution to the problem was particularly participatory and cooperative, with an important reason probably being the high pressure to alleviate the situation. All affected stakeholders were involved in a working group and they jointly worked out a solution. Therefore, this solution-oriented process equally involved non-policy makers and policy makers, with the latter ones by and large adopting the outcome of this participatory process when designing the new grid access regulation.

In sum, the studied policy-making processes have several commonalities but also some differences: they were similar in being tardily reactive, incremental and participatory. Yet while the EEG amendment process was rather formalized and involved stakeholders in a classic way, the EnWG amendment process occurred ad hoc but with proactive stakeholder involvement (see Table 3). In the following section we will discuss the implications of these processes for the technological innovation system.

Table 3: Nature of the studied policy-making processes ‘EEG’ and ‘EnWG’

<table>
<tr><th></th><th>Policy-making features</th><th>EEG</th><th>EnWG</th></tr>
<tr><td rowspan="3">Commonalities</td><td>Tardily reactive</td><td colspan="2">✓</td></tr>
<tr><td>Incremental</td><td colspan="2">✓</td></tr>
<tr><td>Participatory</td><td colspan="2">✓</td></tr>
<tr><td rowspan="2">Differences</td><td>Formalized vs.
Ad hoc</td><td></td><td>
✓</td></tr>
<tr><td>‘Classic’ vs.
Proactive stakeholder participation</td><td>✓
</td><td>
✓</td></tr>
</table>

5.3 Effects of the policy-making processes on the TIS

5.3.1 Effects on TIS functioning

When looking at effects of the characteristics of the policy-making processes on TIS functions, two important aspects need to be considered. First, effects of the policy-making characteristics on TIS functions tended to occur in combination with other factors, such as policy instruments or policy mix characteristics. Second, this interaction of policy-making characteristics and other factors affected entrepreneurs by making them more cautious or more enthusiastic. Subsequently, through chains of effects and feedback loops within the TIS, this had negative or positive impacts on several – rather than individual – system functions.

Yet, while there is no simple model of cause and effect, we find some general patterns of how policy-making processes are impacting TIS functioning (see Table 4). One is that the *tardy reactiveness* had, even in combination with more positive factors such as the overall predictability of the EEG, negative effects. It increased uncertainties among entrepreneurs regarding the outcomes of the systemic problems. This in turn had negative implications for TIS functions, particularly for entrepreneurial activities (F1) and knowledge development (F2) (Interviewee L).

A second pattern concerns the *participatory nature* of policy-making processes and the related actor influence in these processes. This participation contributed to increased trust by actors in the political commitment towards offshore wind and reconfirmed expectations in the creation of supportive policy instruments. These effects then positively contributed to several TIS functions, especially to entrepreneurial activities (F1) and knowledge development (F2) (Interviewees A, H, J). The tight actor contact in the working group and the severity of the problem also positively influenced TIS functioning (Interviewees H, J). However, overall these positive implications appear to have been overcompensated by negative effects arising from the other more detrimental policy-making characteristics, such as the tardy reactiveness.

A third pattern is associated with the *formalized nature* of the EEG amendment process, which should have made changes in the EEG more predictable, but only to a limited extent contributed to higher planning certainty for entrepreneurs, probably in contrast to initial expectations. There are two main reasons for the remaining uncertainties. First, uncertainties could not be removed due to tough debates on the contents and design features of the amendments and corresponding feed-in tariffs, which had long left open the outcome of these debates. The second reason is that the relatively short amendment cycles paired with inconsistencies in the instrument mix increased uncertainties, since they implied very short periods in which particular contents and design features were actually applicable (Reichardt and Rogge 2014). These uncertainties about investment conditions negatively affected system functions, among them entrepreneurial activities (F1) in the form of started offshore wind projects (Interviewees H, J).

Table 4: Main effects of policy-making characteristics of the EEG and EnWG amendment processes on TIS functions (F1-F7)

	EEG & EnWG		EEG		EnWG	
	Tardily reactive	Partic-ipatory	For-malized	Classic stake-holder involve-ment	Ad hoc	Proactive stake-holder involve-ment
F1 (entrepre-neurial activi-ties)	-		-	+		+
F2 (knowledge development)	-	+	-			+
F3 (knowledge exchange)						+
F4 (guidance of the search)		+	-	+		+
F5 (market formation)						
F6 (resource mobilization)	-	+	-			
F7 (creation of legitimacy)		+		+		+

In addition to these three patterns we find that the overall uncertainty caused by the nature of policy-making processes is strongly correlated with the function guidance of the search (F4). This is so since some guidance is inherent in these processes and their nature, so that they might be conceived as determinant of this function. For example, the long time of inaction in the EnWG amendment process signaled a lack of guidance, since the grid access problem was not addressed timely and systematically but rather sporadically. When political action was finally taken, i.e. the EnWG amendment process initiated, this positively contributed to the guidance function for its signal of the still existing political will (Interviewees A, J).

5.3.2 Effects on TIS performance

As is the case for the impact of the policy-making processes on TIS functions, their impact on TIS performance does not correspond to a simple model of cause and effect. Still indications for three main patterns emerged from the data. First, the question arises whether the perceived *incrementalism* of the studied policy-making processes, where only one problem is fixed at a time, or the problem is fixed only when it becomes unbearable, has been disadvantageous for TIS development. On the one hand, adaptiveness in policy making was absolutely necessary in our two examples to alleviate severe systemic problems. Particularly in the process addressing the grid access issue, ad hoc action was at some point the only alternative to solve the urgent problem, which, however, would certainly not have been the case if the economics ministry had reacted earlier. On the other hand, such incrementalism may generally be unavoidable due to incomplete foresight regarding effects of policy measures ((Rothmayr Allison & Saint-Martin 2011)) or technological or other innovation system developments. Yet we argue that a more systemic and forward-looking but also proactive perspective would have been beneficial especially in the overall grid access policy-making process since it may, e.g., have prevented the grid access delay problem from escalating (Reichardt & Rogge 2014).

Second, in both examples policy makers reacted with considerable delays to the systemic problems (*tardy reactiveness*). That is, having been bound to the formalized EEG amendment process caused delays: offshore wind might have taken off earlier if policy makers had not been restrained by fears of opening the whole EEG – which treats all renewable energy technologies in one package – for adjusting it for one technology only, but instead had reacted immediately. Also, the belated action when addressing the grid access problem significantly contributed to delays in offshore wind projects, thereby increasing project costs and delaying technology diffusion (Reichardt & Rogge 2014).

A third effect is the positive influence of the *participatory nature* of the two policy-making processes on TIS development, i.e. on investors' activities in offshore wind and thus on the use and diffusion of the technology. This influence largely occurred via strengthened guidance of the search in the form of trust, credibility and positive expectations. It is thus another example of how policy-making processes may impact innovation without explicitly changing the elements of the policy mix (Rogge & Reichardt 2013).

6 Conclusion

Our analysis of policy processes in TIS suggests that such processes impact the functioning and performance of emerging TIS. However, this influence does not occur in isolation but rather through the interaction of policy making with other factors. We identify two sets of emerging patterns of how policy-making characteristics impacted the TIS: First, regarding system functioning we find negative implications of the tardy reactiveness, rather positive implications of the participatory nature of policy making and rather negative effects of the formalized nature of the EEG amendment process. Thereby entrepreneurial activities (F1) and knowledge development (F2) appeared as particularly affected functions. Second, with respect to TIS performance the incrementalism of both processes was vital for a successful TIS development given inherent uncertainties in emerging TIS, which call for frequent policy mix adjustments. Yet a more systemic perspective would have been beneficial particularly in the grid access policy-making process. Furthermore, the tardy reactiveness in policy reaction had a rather negative influence and stakeholder involvement a rather positive one on TIS performance.

In addition to their impacts on TIS functioning and performance, further aspects justify an increased consideration of policy processes in TIS analyses. First, a focus on policy processes sheds light on how policy makers interact with the rest of the innovation system. For instance, for the studied policy-making processes policy makers were closely involved in what occurred in the innovation system. Nonetheless problems were addressed with considerable delays, having negative implications for the functioning and performance of the system. Second and as a consequence of the former point, analyzing policy processes elucidates how well an innovation system is organized, i.e. how well it is able to bring specific problems to the surface, how seriously these problems are taken by policy makers and how policy makers finally deal with these problems. For example, the two studied policy-making processes reveal that the underlying problems were long known by most actors and they were actively debated, indicating a good ability of the TIS to put problems on the agenda. Yet policy makers – particularly from the economics ministry – long appeared to not take these problems seriously since they did not act in a consequent manner. When they finally became active, they dealt with the problems in a cooperative and rather constructive fashion. That is, although the interaction between policy makers and the remaining TIS can be assessed as good and the discussion culture as open and cooperative, delays in reactions to problems are an aspect of malfunctioning of the TIS.

Our findings entail two key implications for TIS scholars. First, understanding policy-making processes in TIS reveals important additional information on how the TIS functions. By analyzing how systemic problems are being addressed by policy makers the scheme of analysis is taken one step further than just studying TIS functions and proposing adjustments in the instrument mix. Second, while the feasibility of implementing policy recommendations has often been disregarded in TIS studies, these recommendations might take on a different character if policy processes were accounted for. For example, recommendations on the design of a novel policy instrument for grid access should be accompanied by guidance on how the processes for the set up, monitoring, evaluation and amendment of the instrument should be organized.

Building on our findings we derive two main implications for policy makers interested in promoting emerging technologies. First, an implication from the negative effects of tardy reactiveness of the policy processes is that systemic problems should be addressed faster and in a more pro-active manner. While this might prevent these problems from escalating, for political reasons it may not always be feasible. Second, the set up of a temporary technology-specific expert task force could speed up policy making and increase policy acceptance. This might be particularly useful for jointly addressing systemic problems and finding compromise solutions.

Based on our study on two exemplary policy-making processes within the technological innovation system of offshore wind in Germany we derive the following implications for future research. Future TIS studies should consider policy processes and their implications more systematically, e.g. by zooming into 'institutions' or by labeling policy issues as 'policy mix issues', thereby indicating the consideration of both policy mix elements and processes. Regarding the latter, studies should not only analyze processes responding to systemic problems but, for instance, also those occurring in a proactive fashion. Finally, greater attention should be paid to politics and actor positions and how they influence policy-making processes and their outcomes.

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Karlsruhe 2015