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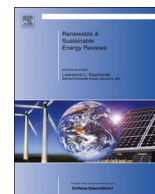
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# Unpacking policy processes for addressing systemic problems in technological innovation systems: The case of offshore wind in Germany



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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 have been largely disregarded. We address this gap by exploring the style of two crucial policy-making processes and how it influences the functioning and performance of a TIS, taking the case of offshore wind in Germany. Our findings indicate important positive and negative impacts of the policy style on the TIS. For example, the muddling through character apparent in one of the policy processes negatively influenced entrepreneurial activities, knowledge development and finally technology diffusion, whereas the participatory nature of both processes had a positive impact both on TIS functioning and performance. Based on our findings we derive implications on how to improve policy making so as to foster the development of an emerging TIS.

## 1. Introduction

Analyses of technological innovation systems (TIS) focus on emerging technologies often in early phases of development (e.g. [32]). 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 [10]. For overcoming these failures and allowing the technologies to become market-ready, government intervention is needed [38,8].

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 [33]. There exists a considerable number of studies having completed exactly such analyses. One of the first studies of this kind is Negro et al. [46] that analyzes the functional patterns of the biomass TIS in the Netherlands identifying corresponding system failures and suggesting policy measures for addressing them. Further studies that examine systemic problems via a functional analysis of TIS and identify areas for policy intervention include, for example, Jacobsson and Karltorp [34], van Alphen et al. [62], and Jacobsson [31]. 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 [61] and tools for the selection of policies that address system failures [13]. Related to that, the literature called for a more detailed understanding of the dynamics of policy intervention processes that result from addressing systemic problems [28]. These studies hint at the importance of more thoroughly examining policies in TIS, particularly policy processes. It is therefore the goal of this paper to address this gap by analyzing policy-making processes that respond to systemic problems and exploring how these processes influence TIS functioning and TIS performance in terms of technology use and diffusion [26,4]. In particular, we focus on the style of these policy-making processes – or policy style in short – as the policy style has been argued to be an important determinant for eco-innovation [35], and analyze the role of this style for the TIS. This focus on the role of the policy style allows for revealing vital information about the nature and impact of such policy processes, which in turn enables us to

*Abbreviations:* BMF, Federal Finance Ministry; BMU, Federal Environment Ministry; BMWi, Federal Economics Ministry; BNetzA, Federal Network Agency; CDU, Christian Democratic Union; DOTI, German Offshore Test Field and Infrastructure Society; EEG, Renewable Energy Act; EnWG, Energy Economy Law; FIT, feed-in tariff; InfrStrPIBeschlG, Infrastructure Planning Acceleration Act; OW, offshore wind; SPD, Social Democratic Party; TIS, technological innovation system; TSO, transmission system operator; VDMA, German Engineering Association

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derive concrete policy recommendations for how to improve policy making so as to foster the development of an emerging TIS.

For our analysis we frame policy processes as part of a comprehensive policy mix concept [53]. It is these processes that shape the elements of the policy mix – that is the policy strategy and various instruments. Thereby the processes can have an indirect impact on innovation. However, it has been argued that policy processes may also directly influence innovation, yet with few empirical studies investigating this link.

We address this gap in the literature by examining the role of policy processes for technological innovation systems, taking the case of offshore wind in Germany. The main reason for choosing this case is that the German offshore wind 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 [50,51]. 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 style of these processes impacted TIS functioning and TIS performance.

In the following we will first review the literature on technological innovation systems and policy processes, 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). Subsequently we describe the policy-making processes as well as the associated policy-making style and analyze the 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 [3,33,61]. 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 [15], functional analyses map a range of different activities taking place in the TIS. For doing so a number of key

functions are applied ([26], see Table 1). This functional analysis serves as prerequisite for explaining the performance of TIS in terms of the development and diffusion of innovations [26,4]. 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 [46,65].

In terms of policy, TIS studies have so far focused on policy instruments and their role for innovation systems. That is, some studies show how policy instruments impact innovation systems [37,44], while other studies state which policy instruments may be effective in improving TIS performance [45,62]. Another aspect 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 [39,40].

However, policy processes have as yet been largely neglected in TIS studies [13,27], although their importance for innovation has recently been stressed, e.g. in the policy mix literature. For instance, Flanagan et al. [24] in their call for a reconceptualization of the policy mix for innovation point out that policy processes should be an integral part of policy analyses. Rogge and Reichardt [53] acknowledge the importance of policy processes in their policy mix concept, based on their potential influence on policy mix effectiveness, for instance regarding innovation.

The study by Chung [12] on technology and innovation policies in Taiwan is one of the first and very few ones 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 an analysis of the direct impact of policy processes on the innovation system.

In order to address this gap an important starting point is to clarify what is meant by policy processes, given the multitude of definitions that have been used [29]. Due to our focus on policy in the context of innovation we rely on Rogge and Reichardt [53, p. 1625] who, in their policy mix concept for innovation, define them as “political problem-solving process among constrained social actors in the search for solutions to societal problems”. Besides the crucial role of actors, this definition stresses an important aspect for this study, namely the fact that policy processes aim at solving (societal) problems.

Policy processes with their plethora of diverse actors with hetero-

**Table 1**

Key functions of technological innovation systems.  
Source: adapted from [66].

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.

geneous interests and often long time horizons are usually extremely complex [55]. In order to analyze and better understand such complex processes different theories on the policy process have been developed that explain how these processes shape policy outcomes [55]. However, the objective of this study is not to explain how or why certain policy outcomes, such as policy instruments, or changes in these, come about by policy processes but to study the role of such processes for the technological innovation system. We therefore need an analytical concept for capturing these policy processes, which then enables us to analyze their impact on the TIS. For this purpose the concept of policy style – first introduced by Richardson [52] – seems appropriate since it captures the nature of policy processes, i.e. the “operating procedures for making and implementing policies” [52].

In his seminal work Richardson [52] proposes describing national policy processes by contrasting anticipatory versus reactive and consensus-oriented versus impositional policy styles. More recent studies have built on this generic policy style typology, analyzing policy styles, often of particular countries, and describing them in terms of, e.g., the degree of consensus in policy formulation, the role of expert advice or the extent to which policy making occurs unilaterally in a top-down manner [5,60,9]. In this paper we build upon and extend Richardson's generic typology of policy style by drawing on three approaches reflecting policy styles that can often be found in real-world policy processes and that seem to be particularly relevant in the context of emerging TIS: the science of muddling through, adaptive policy making, and participatory policy making. In combining these, we rely on a more differentiated typology serving as our analytical concept to describe the style of policy processes..

The first approach is Lindblom's [41,42] *science of muddling through* or incrementalism, which purports that rational-comprehensive decision-making is hindered by constraints in intellectual and informational capacities as well as time and resources. Rather, when changing existing policy instruments administrators compare a limited number of similar alternative instruments and thus design policy in an endless process of incremental but easily reversible steps. Policy making in this manner is assumed to bring about only incremental changes compared with the status quo. Lindblom argues that a continuous sequence of incremental steps nonetheless might lead to faster policy-induced changes than any comprehensive policy-making approach. More recent studies evaluated Lindblom's approach in the light of scientific advances since it has been developed, concluding that in parts it does no longer hold to a globalized, networked and rather conflictual policy-making world, which can be described by more far-going models of the policy process with greater explanatory power. Yet its basic idea of incremental steps in policy making still applies today [1,48].

The second approach considered, which is in part related to the idea of incrementalism, is *adaptive policy making* [64]. It assumes that policy instruments are usually designed for a certain future scenario and that in fact often another scenario occurs, so that the original instruments do not fit any more. Therefore, it is argued that policy instruments should not be tailored to a particular scenario of the future but should be able to adapt to changing circumstances. Such policy instruments should consist of components with the potential to shape the future and components that preserve the needed flexibility. That is, policy instruments should make explicit provision for learning and respond to changes over time. They should also leverage the self-organizing potential of all kinds of actors and the decentralization of governance to detect emerging policy issues and design the needed adaptations in policy instruments [43,59]. Overall such adaptive policy-making processes are likely to be more effective than rational processes aiming for ‘optimal’ designs, since they can adjust to specific situations [2].

Finally, the third approach is that of *participatory policy making*, which has been conceived as the degree of involvement of diverse stakeholders with their stakes and values in policy processes [25,58].

This stakeholder involvement is deemed to be necessary particularly in the context of sustainability transitions – such as the German energy transition, for which the emerging offshore wind technology is playing a role – since a plethora of actors are needed for such a transition to be accomplished. Involving them in policy processes might also contribute to maintaining social equity and cohesion [25]. Participatory policy processes are likely to lead to policy instruments with designs better tailored to the particularities of target actors and which are thus more accepted by affected actors.

Based on these three approaches, which extend Richardson's seminal typology, the nature of policy-making processes can be described in terms of muddling through (which we also refer to as incrementalism), adaptiveness and participatory policy making. Analytically, we are interested in shedding light on how the policy-making style – captured by these three categories – influences the functioning and performance of a technological innovation system. Here, by functioning we refer to the seven TIS functions elaborated by Hekkert et al. [26] while by performance we mean technology use and diffusion. By analyzing this link between policy-making style and TIS we take an important step towards incorporating policy processes as part of a broader policy mix in TIS analysis.

### 3. Research case

For our analysis we selected two policy processes in the German offshore wind TIS. In the following we explain why we chose this research case.

Regarding the TIS in focus, 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 [11], but the TIS still displays a poor performance with only 0.52 GW installed at the end of 2013 [22]. This might be due both to the comparative immaturity of the technology with related high costs [23], 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. [21]). This technological potential results from the strong and steady winds at sea and correspondingly many full-load hours (4000 compared to 2000–2500 onshore) as well as the technology's large scale and associated great project sizes [20]. Against this background, Germany is an interesting case since it is one of the fastest growing offshore wind markets worldwide [49], despite its currently relatively low installed capacity.

Regarding the chosen policy processes addressing systemic problems, out of five identified systemic problems [50] we selected those two that posed the greatest barriers in the TIS in recent years and whose resolution essentially contributed to the further development of the TIS. 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 and is therefore closely linked to the Renewable Energy Act (EEG). The second problem was mainly caused by the ineffectiveness of the grid access regulation for offshore wind parks specified in the Energy Economy Law (EnWG) and evidenced by delays in grid access to be provided by TSO TenneT. Since these two policy instruments were decisive for the existence of the systemic problems, we will shortly introduce them.

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

**Table 2**  
Overview of expert interviews.

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

guaranteed payment per produced kilowatt-hour of electricity [16]. 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 [17,18].

The grid access for parks was originally regulated in the EEG, according to which park operators were to finance the grid connection themselves [16]. 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 [30]. Due to several emerging problems, this grid access regulation had to be changed again, with a fundamental ‘system change’ occurring in 2012 (see Section 5.1.2). 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 [19].

#### 4. Methodology

To investigate policy-making processes addressing systemic problems and how they influence TIS, we chose a qualitative approach. This allows, first, for a detailed analysis of these processes and their style, such as how certain decisions were taken and executed, and for an in-depth investigation of the processes’ impacts on the TIS. Second, such an exploratory approach is particularly suited for areas of research that have not yet been systematically studied, which is the case for the relevance of the style of policy processes for TIS [67]. Our methodological approach therefore is based on expert interviews and supplemented by desktop research providing secondary data for triangulating our interview findings.

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 two groups of stakeholders: The first group were experts that were themselves deeply involved in the policy-making processes. Second, we interrogated various other actors who were involved in or knowledgeable about the systemic problems, so as to obtain a detailed understanding of the problems and their contexts. In total we conducted fifteen interviews with experts in the TIS under study, including representatives of the government, public organizations, the transmission system operator, industry associations and

NGOs (see Table 2).<sup>1</sup> Interviews took place between July 2013 and January 2014 and on average lasted about eighty-four minutes. All interviews relied on a semi-structured interview guide and were conducted by telephone. We transcribed and coded the interviews with codes for each of the two systemic problems, the policy-making processes, and different actors. In order to safeguard the interviewees’ anonymity, throughout this text we reference them with letters from A to N, which were randomly assigned to the interviewees.

In addition, we complemented our interview data with secondary data. For this, we screened relevant documents related to the policy-making processes and their underlying systemic problems. These documents included position papers by industry associations, press releases by involved actors such as the environment department and draft versions of the two legislations.

Building on the insights from the coded interviews and from the documents, we reconstructed the policy processes addressing the two selected systemic problems by identifying common themes from our data. This enabled us to thoroughly understand these systemic problems and to describe at a sufficient level of detail the style of the policy processes that occurred to address them. Finally, this data analysis allowed for identifying patterns of the processes’ impacts on the functioning and performance of the TIS.

#### 5. Policy 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 processes, starting with their underlying systemic problems (Section 5.1) and subsequently analyze their style (Section 5.2), and finally we examine their effects on the TIS (Section 5.3).

##### 5.1. Description of the policy processes

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

**5.1.1.1. 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

<sup>1</sup> This data collection was embedded in a larger analysis of the German offshore wind TIS (see [50]).

M). Nonetheless, soon after the FIT's enactment project planners realized that its level of support would probably not be cost-covering 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 processes that addressed this problem and that led to the offshore wind FIT adjustment in the 2009 EEG amendment.

**5.1.1.2. The policy 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 and 15 ct / kWh and after twelve years that a plant had received this FIT lower it to 3.5 ct / kWh [6]. 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 [47].

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 [7]. Following the formalized policy 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 [14]. This FIT level is exactly within the range proposed in the first EEG draft [7].

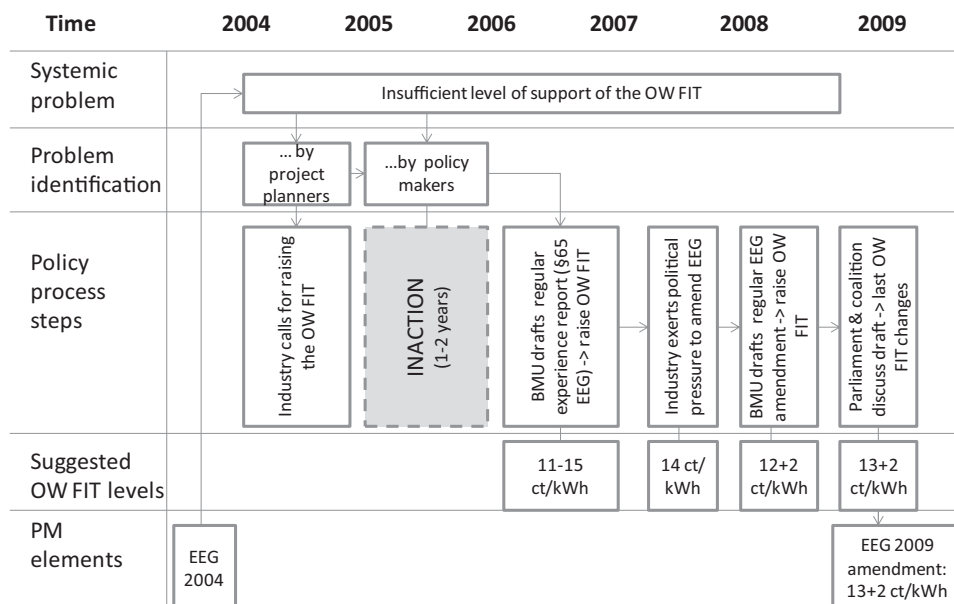


Fig. 1. Policy process adjusting the offshore wind FIT in the 2009 EEG amendment.

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). Fig. 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.

In sum the policy 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

5.1.2.1. 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 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; [56]). 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 [63]. This problem, which can be said to have its roots both in inappropriate regulatory provisions (originally in the InfrStrPIBeschlG 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.

5.1.2.2. The policy process addressing the systemic problem. The above described grid access problem was not adequately 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 –

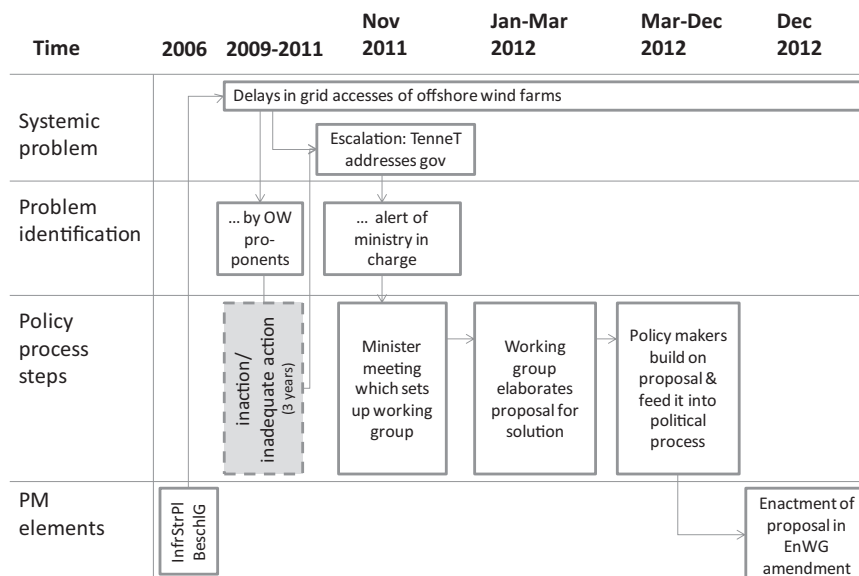


Fig. 2. Policy process leading to the 2012 EnWG amendment.

together with the environment ministry – took a decisive step convening 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’)<sup>2</sup> (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 the 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 [57].

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 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. Fig. 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 process that finally ended in an amendment of the Energy Economy Law (EnWG).

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

### 5.2. Style of the policy processes

The style of the EEG amendment process greatly resembles the adaptive policy process approach: policy makers set a certain FIT level, monitor and evaluate its effects, and subsequently adjust it to better fit actual developments [43,64]. The particular 2009 offshore wind FIT adjustment process occurred within the formalized, regular and thus foreseeable overall EEG amendment process. Yet policy action was not flexible enough in a dynamically changing TIS: although the problem of the FIT’s too low level of support was long known, policy makers stuck to the foreseen EEG amendment process and therefore only reacted after this problem had already prevented several offshore wind developments. Furthermore, the process was participatory in a rather formal way, i.e. by incorporating stakeholders in the amendment process via official hearings and consultations. Thus, the EEG amendment process

<sup>2</sup> 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.

can be described as a formal, government-led process that was open for input from stakeholders. As the outcome suggests, 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. [36]).

Somewhat differently, the policy process that addressed the grid access delay problem shows parallels to Lindblom’s [42] ‘muddling through’ approach 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. Concerted reaction to this problem was tardily reactive: it occurred with great delays – only when it had escalated and nothing worked any more – and in an ad-hoc fashion. This tardy reactivity might partly be explained with constraints in time and resources. 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, a commonality of the style of the studied policy processes is that they both can be characterized as participatory. Yet while the EEG amendment process involved stakeholders in a formal way, the EnWG amendment process in a later phase featured particularly proactive stakeholder involvement (see Table 3). Furthermore, while the EEG amendment process was adaptive (albeit to a limited extent), the EnWG amendment process with its ad-hoc character and tardy reactivity very much resembled muddling through. In the following section we will discuss the implications of these processes for the technological innovation system.

### 5.3. Effects of the policy processes on the TIS

#### 5.3.1. Effects on TIS functioning

For the examination of the effects of the style of policy processes on TIS functions we consider two important aspects: First, such effects on TIS functions tend to occur in combination with other factors, such as policy instruments or policy mix characteristics. Second, this interaction of the style of policy processes and other factors affects entrepreneurs by making them more cautious or more enthusiastic regarding innovative activities. Through such chains of effects and feedback loops within the TIS, policy processes can have negative or positive impacts on several – rather than single – system functions.

Therefore, rather than presenting a simple model of cause and effect, we will discuss some general patterns of how the policy processes were impacting TIS functioning (see Table 4). One is the *participatory* style of both policy 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

**Table 3**  
Style of the studied policy processes ‘EEG’ and ‘EnWG’.

	EEG	EnWG
Muddling through (tardy reactivity)		✓
Adaptiveness	✓	
Stakeholder participation	✓	✓



**Table 4**  
Main effects of the style of the EEG and EnWG amendment processes on TIS functions (F1–F7).

	Stakeholder participation (EEG, EnWG)	Muddling through (EnWG)	Uncertainties in adaptiveness (EEG)
<b>F1 (entrepreneurial activities)</b>	+	–	–
<b>F2 (knowledge development)</b>	+	–	–
<b>F3 (knowledge exchange)</b>	+		
<b>F4 (guidance of the search)</b>	+		–
<b>F5 (market formation)</b>			
<b>F6 (resource mobilization)</b>		–	–
<b>F7 (creation of legitimacy)</b>	+		

working group of the EnWG process paired with the severity of the problem motivating actors to strive for a quick solution 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 style aspects, notably the tardy reactivity in the EnWG process and negative aspects of the adaptiveness of the EEG process, which will be explained in the following.

A second pattern concerns the tardy reactivity of the EnWG amendment process, i.e. the long time until (concerted) action was taken to address the problem, and the overarching *muddling through* character of this process, which had – even in combination with more positive factors such as the participatory style – 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 third pattern is associated with the *adaptiveness* of the EEG amendment process, which, by the fact that the EEG is adapted to changed circumstances from time to time, might have contributed to higher planning certainty. Yet the particular nature of this adaptiveness only to a limited extent contributed to such higher planning certainty for entrepreneurs – rather to the contrary: First, uncertainties remained 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. Second, 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 [51]. 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).

In addition to these three patterns we find that the overall uncertainty inherent in any policy process seemed to be particularly high in the studied processes due to their *muddling through* character and their adaptiveness. This observed policy making style appears to have strongly influenced the function guidance of the search (F4). 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 concerted political action was finally taken, i.e. the EnWG amendment process initiated, this positively contributed to the guidance function as it was interpreted as a signal of the still existing political will to support offshore wind (Interviewees A, J).

### 5.3.2. Effects on TIS performance

As is the case for the impact of the policy processes on TIS functions, their impact on TIS performance does not correspond to a simple model of cause and effect. Therefore, we focus our discussion on

three main patterns, which emerged from the data. First, the question arises whether the perceived *muddling through* character of the policy process addressing the grid access issue, where only incremental steps were taken towards problem solution, or problems were fixed only when they became unbearable, has been disadvantageous for TIS development. On the one hand, 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 taken earlier concerted action. Even more, a certain degree of incrementalism or *muddling through* may generally be unavoidable due to incomplete foresight regarding effects of policy measures [54] or of technological or other innovation system developments. On the other hand we argue that a more systemic and forward-looking but also proactive perspective would have been beneficial in the overall grid access policy process since it may have prevented the grid access delay problem from escalating [51].

Second, in both examples policy makers reacted with considerable delays to the systemic problems (tardy reactivity), which negatively affected technology diffusion. 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 concerted action when addressing the grid access problem significantly contributed to delays in offshore wind projects, thereby increasing project costs and delaying technology diffusion [51].

A third effect is the positive influence of the participatory nature of the two policy 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 processes may impact innovation without explicitly changing the policy mix elements such as specific policy instruments [53].

## 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 processes with other factors. We identify two sets of emerging patterns of how the style of the analyzed policy processes impacted the TIS: First, regarding system functioning we find negative implications of the *muddling through* character (especially the tardy reactivity), rather positive implications of the participatory nature of the policy processes and rather negative effects of the formalized adaptive style of the EEG amendment process. Thereby entrepreneurial activities (F1) and knowledge development (F2) appeared as particu-

larly affected functions. Second, with respect to TIS performance the incremental ad hoc style of the EnWG amendment process was at some point vital for a further successful TIS development and may generally be – at least to some extent – unavoidable given inherent uncertainties in emerging TIS, which call for frequent policy mix adjustments. Yet a more systemic perspective would have been beneficial. Furthermore, the tardy reactivity in concerted policy reaction had a rather negative influence and stakeholder participation 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 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 in terms of its institutions, i.e. how well specific problems can be brought 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 processes reveal that the underlying problems were long known by most actors and that they were actively debated, indicating a good ability of the TIS to put problems on the political agenda. Yet policy makers – particularly from the economics ministry – long did not seriously enough address these problems. When they finally took concerted action, 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 (concerted) reactions to problems are an aspect of malfunctioning of the TIS.

Our findings entail two key implications for TIS scholars. First, understanding policy processes in TIS reveals important additional information on how the TIS functions. By analyzing how systemic problems are being addressed by policy makers the existing scheme of analysis for TIS is taken one step further than 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, accounting for policy processes will allow for supplementary recommendations on a suitable policy-making style. For example, recommendations on the introduction 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 designed in terms of their style.

Building on our findings we derive three main implications for policy makers interested in promoting emerging technologies. First, an implication from the negative effects of tardy reactivity of the policy processes is that systemic problems should be addressed faster and in a more pro-active manner, thereby striving for effective solutions early on. Such solutions might sometimes only be possible when they tackle the problem in an encompassing and systemic manner. While this might prevent these problems from escalating, for political reasons such problem solving may not always be feasible. Second, a precondition for such faster reactions to problems seems to be a regular monitoring of the appropriateness of existing policy instruments regarding actual TIS developments, which was lacking in the EnWG amendment process. Such an adaptive policy style might be prescribed in the regulation of the policy instrument. However, as evidenced in the EEG amendment process, adaptiveness alone is by no means a guarantee for preventing problem escalations but might help accelerating problem awareness by policy makers. Third, the set up of a temporary technology-specific expert task force could speed up policy processes and increase policy acceptance. This might be particularly useful for jointly addressing systemic problems and finding compro-

mise solutions.

Clearly, our exploratory analysis of two exemplary policy processes within the technological innovation system of offshore wind in Germany is not free from limitations, and thus points to future research needs. 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 processes and their outcomes.

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