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3.1.1 Co-evolutionary dynamics of policy and system development: the case of marine renewable energy technologies

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The transition to a sustainable energy system is a major societal challenge requiring profound transformations in existing socio-technical systems (Markard et al, 2012). These processes have been addressed by the sociotechnical transitions literature that called the attention to the role played by radically new technologies, being developed in niches, which have strong transformative potential (Kemp et al, 1998; Schot and Geels, 2007). These technologies and the socio-technical systems developing around them often need temporary protection against the selection pressures of the established regimes (Smith and Raven, 2016); and supportive policies are a fundamental mode of protection (Kivimaa and Kern, 2016). In the case of sustainable energy technologies, policy support is further justified by the need to accelerate the transition process (which is usually a long term process), given the urgency of fighting against climate change (IPCC, 2014).

The process of sustainable energy transition has been characterised by the emergence of a variety of renewable energy technologies evolving at different paces (Ellaban et al, 2014), which co-exist but also compete for attention and resources (Verbong et al, 2008). This variety has implications for policy, since the definition of supportive policies involves decisions regarding the role played by different renewable technologies in a broader policy strategy, and regarding the definition of a mix of policy instruments that takes into consideration the specific requirements of individual technologies, but also accounts for the complementarities between them (Rogge and Reichardt, 2016). The outcome of these policy making processes has consequences for the development of the new socio-technical systems being built around the different technologies. Thus, in order to understand how policies can

contribute to the development and eventual take-off of sustainable energy technologies, it is necessary to gain a better grasp of the processes that influence the definition and change of the policy mixes addressing them.

The innovation policy literature has increasingly pointed out that policy making is influenced by a variety of factors and shaped by a multiplicity of actors, internal and external to the policy space (Flanagan and Uyarra, 2016). Given the emergent nature of the technologies (and of the policies supporting them) policy making is also a dynamic and potentially non-linear process, where changes in actors' expectations/perceptions about the technologies (Bakker and Budde, 2012) or actual changes in technology/niche trajectories (Geels and Raven, 2006), can have important impacts upon decisions regarding (modes of) policy support.

Against this background the paper proposes that an understanding of the process of policy definition and change will require examining three interrelated dynamics: i) the impact of policies on the conduction of the socio-technical processes that can drive niche development and breakout (Rothmans et al, 2001); ii) the impact of niche-level processes on policy making - either directly through niche actors purposive advocacy (Raven et al, 2016), or indirectly through the way niche trajectories affect policy makers perceptions of technologies' growth potential and/or contribution to broader economic and social goals (Normann, 2015); iii) the impact of "external shocks", e.g. events originating in parallel niches, in contiguous systems, or at the landscape level that may have unanticipated effects, inducing changes in system development trajectories and/or in policy makers views (Hoppman et al, 2014). In other words, it is necessary to address the co-evolution between policy making processes and system building processes and the ways they affect each other. However, while the co-evolution between policy making and technological change is increasingly referred in innovation policy research (cf. this call), empirical analyses that address such co-evolution and provide an understanding of the actual processes taking place and the type of factors that shape them, are still scarce (e.g. Hoppman et al, 2014; Reichardt et al, 2016; Matti et al, in press).

The paper addresses this gap. It analyses the process of formulation, implementation and change of a policy mix aiming at fostering the development and diffusion of marine renewable energies, focusing on the interplay between the processes that took place at policy level and the dynamics of the niche(s) where technologies were being developed. The objective is to investigate how such interplay can contribute to explain a cycle of policy support, policy divestment and policy re-orientation; and its impact on the non-linear development of a new socio-technical system. These processes are also positioned in an context characterised by the presence of other renewable technologies, discussing both the influence on policy formulation of previous experiences with a more mature technology, and the changes induced by the emergence of a new technology that share the same space.

In order to investigate the interplay between the policy making process and the building of the new socio-technical system, the paper combines theoretical contributions from socio-technical transitions and policy studies. Regarding the former the paper draws on the strategic niche management literature, in particular recent advances to this literature which address the processes that enable niche development and breakout (Geels and Raven, 2006; Smith and Raven, 2012; Kivimaa and Kern, 2016). Regarding the latter, the paper draws on broader conceptualisations of policy mix for sustainability transitions that integrate policy strategies, instrument mixes and policy processes (Rogge and Reichardt, 2016); as well as on critical approaches to innovation policy that highlight its emergent and complex nature (Flanagan and Uyarra, 2016). Following both streams, particular attention is given to policy processes and, in particular, the role played by a multiplicity of actors, with diverse interests and positioning, on the conduction of these processes. To strengthen this approach, we also draw on contributions from the policy studies literature that address actor roles in policy making and in policy change (e.g. the advocacy coalitions framework: Sabatier and Weible, 2007; Markard et al, 2016) and from the literature on expectations (Bakker et al, 2011; Bakker, 2014), as well as on insights from cognitive psychology on sense-making and creative adjustment processes (Perls et al, 1951).

The empirical research focuses on the processes that took place, over the past two decades, aiming at building an "ocean energy system" in Portugal. Adopting an historical perspective, it examines the process of policy mix formulation, implementation and change; and confronts it with the process of

construction of a wave energy technological niche (emergence, apparent take-off, hype, decline and slow recovery), and with the sudden emergence of a competing/complementary technology - floating offshore wind - and its subsequent take-off. The analysis of the policy making process is based on policy documents and interviews (conducted in 2015-2016). It examines: the early strategy definition; the design of a purportedly “systemic” instrument mix; the difficulties confronted with its implementation; the partial abandon of the “systemic” approach; and a substantial policy re-orientation. The analysis of the system dynamics draws on and extends previous research on the development trajectory of wave energy and offshore wind (Fontes et al, 2016; Bento and Fontes, 2017). The research identifies and attempts to explain key turning points, focusing on critical periods/events at policy and system levels, and on the behaviour of actors/coalitions of actors that had a role in policy definition and policy change.

The results show that the initial decision to support marine renewable energy technologies, the process of formulation and implementation of policy mixes, and the changes in level and modes of policy support were effectively subject to a variety of influences, internal and external to the “policy space”. They uncover a diversity of interactions between that “policy space” and the “socio-technical space” being built around the new technology, as well as between these and broader political or socio-economic developments. In particular, the research shows that policy processes “internal” to the policy space are in fact strongly influenced by processes taking place in the socio-technical space. These include the proactive behaviour of different groups of system actors (sometimes with divergent interests), who attempt to shape the policy making process by matching positive visions of future system development with broad policy goals; who act in answer to the announcement or the implementation of policies (or its lack) producing particular outcomes that may lead policy makers to adjust their perceptions on the (value of) the technology, or on the effectiveness of the policies; who attempt, over time, to capitalise on positive developments or to defuse the effects of the negative ones, including the impacts of “external shocks”, by interpreting and making sense of changing conditions, re-articulating expectations and lobbying towards the re-setting of policy agendas.

Overall, this case suggests that policy making to foster the development of new socio-technical systems is a more complex and non-linear process than it is sometimes assumed in the innovation policy literature. Not only policy level and system level processes are shown to be multifaceted and uncertain in their own right, but they also interact over time influencing (positively or negatively) each other dynamics. Moreover, the development of new socio-technical systems takes place in broader political and socio-economic spaces, which means that other dynamics and sudden external events can have unexpected effects on either policy making or system trajectory, introducing added complexity and non-linearity.

This paper adds to recent research that moves beyond the analysis of the impact of innovation policies on the development of new technologies, acknowledging that policies (both design and change) do not emerge from abstract processes, but are shaped by the interests and efforts a variety of actors from inside and outside the policy space. Thus, the paper answers to the call on the need to investigate “how do policy mixes emerge over time, how do they impact on STI, and how do these impacts influence the further evolution of policy mixes.” More generally, it adds to the broader debate on the co-evolution between policy making and technological change.

Finally, the paper brings into focus the frequently overlooked policy dilemmas associated with the presence of a variety of technologies that propose different paths in the process of sustainable transition, contributing to a discussion of how to integrate this variety into policy design.

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