Direction and legitimation in system upscaling – planification of floating offshore wind

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ABSTRACT

This research investigates the process of construction of visions and plans to accelerate emerging low-carbon innovations. We adopt the technological innovation systems perspective to focus on system building processes, including the establishment of constituent elements and performance of key innovative activities. We analyze national roadmaps that have been developed for a technology that approaches upscaling and market take-off: offshore wind energy in deepwaters, i.e., more than 50 meters deep where there is high potential of resources but whose technology is still immature. The roadmaps analysis informs on how actors prepare the growth of the system and perform critical innovation activities. The analysis shows the importance of influence in the direction of search (guidance) and legitimation in the transition to growth. It points to different types of guidance depending on the technological and institutional context, in particular the tendency for a higher external openness with the approximation of technology deployment and with government involvement. A survey of actors' opinion reveals that roadmaps tend to overinflate expectations and have a positive but limited impact on the technology development. Policy implications include recommendations for managing the process of formation of visions and legitimacy of emerging innovations. The analysis has implications for the operationalization of the functions guidance and legitimacy, as well as indicates limits to the current functional analysis and discusses future research directions.

KEYWORDS: Functions of innovation systems; industrial lifecycle; up-scaling; roadmaps; offshore wind energy.

HIGHLIGHTS:

- We operationalize the study of collective strategy building (guidance) and social acceptance (legitimation) through roadmaps analysis;
- We apply the framework to floating offshore wind technology which enters the up-scaling phase;
- Guidance and legitimation are important conditions for technology upscaling and take-off;
- Types of guidance towards external openness change with technological progress and government involvement;
- Survey indicates that roadmaps have a positive but limited impact on technological dynamics.

1. INTRODUCTION

The moment of transition to growth is crucial in the development of emerging innovation systems. They must attaint a certain degree of social acceptance and organization to make that happen. This question is particularly relevant in the context of climate change mitigation, as efforts to avoid catastrophic consequences call for the implementation of low-carbon innovations (IPCC, 2014). Technologies evolve in the early years of the life-cycle and eventually standardize, which typically shifts the focus from product innovation to process innovation (Abernathy and Utterback, 1978; Taylor and Taylor, 2012; Huenteler et al., 2016). At the same time, the adoption environment adjust to permit the transition to growth (Van de Ven and Garud, 1993; Dosi and Nelson, 2010; Markard, 2016). Research shows that scaling is a common heuristic in the process of technological development (Winter, 2008). Technology up-scaling precedes market take-off and mass commercialization of energy technologies (Wilson, 2012). Furthermore, up-scaling requires some degree of agreement among the actors on the anticipation of the future of both the technology (including standards) and markets.

The take-off of new technologies involves the formulation of collective expectations and visions. This process is addressed by the literature on technological innovation systems (TIS). This literature shows how several contextual structures affect the take-off of technological innovation systems, including sectorial, geographical and political contexts (Bergek et al., 2015). TIS studies also highlight the importance of key innovation processes (the so-called system *functions*) in the process of transition to growth, particularly the influence in the direction of search and legitimation (Bergek et al., 2008a,b; Hekkert et al., 2007). Influence in the direction of search (or guidance) refers to the existence and sharing of collective expectations that aim to improve the attractiveness of the focal TIS to actors from other activities (Hekkert and Negro, 2009). This expectations management can be based on roadmaps and policy action plans (Borup et al., 2013). Legitimation designates the degree of acceptance of the technology and the conformity with the existent institutions (Bergek et al, 2008b; Markard et al., 2016). The two functions are namely essential for the mobilization of resources, the formation of demand, and the acquisition of political strength that are necessary for technology up-scaling and growth (Aldrich and Fiol, 1994; Negro et al., 2012).

Roadmaps are instruments that support technology management and planning and thus can be seen as an important element in the governance of the system transition (McDowall, 2012; Phaal et al., 2004, 2011). Roadmaps convey a collective vision and strategy that may influence the direction of search. They can also contribute to form collective expectations and thus establish technology legitimacy. Roadmaps are particularly helpful in early years of random patterns by enabling to run "in packs with others to create new relationships and institutions for collective survival" (Van de Ven, 2017: 40).

Roadmaps are the result of a negotiation process that leads to a compromise between different anticipations of the future. They have the character of anticipatory coordination (Rip, 2012) by reducing the risk and uncertainty in technology growth. However, the compromise may reflect not only the differences in visions among the participant actors, but also their discursive power (capacity to frame an innovation), ideology and political cultures (Geels, 2014). In spite of this limitation, roadmaps provide a valuable setting to examine the perspectives and proposals for preparing the system development.

The literature recognizes the importance of the formulation (legitimation) and sharing (guidance) of expectations (Bergek et al., 2008b; Hekkert et al., 2007), but there is still little understanding on how these two crucial processes are formed along the transition to growth. This paper addresses this gap by analyzing the specific ways in which the construction of shared visions, in the context of roadmapping processes, contributes to the emergence of collective expectations and strategies. In particular, it assesses how roadmaps inform the unfolding process of TIS up-scaling through the performance of critical functions such as guidance and legitimacy.

Therefore, the main research questions are: What are the specific forms available to prepare the growth of new low-carbon innovations?; How these processes uphold the formation of a collective expectation and strategy that prepare for industry take-off?

We analyze the visions and guidelines that are materialized in roadmaps and documents alike. To validate the expectations that are formulated in the roadmaps, we perform in parallel a survey of actors' opinion. The empirical setting is the development of the offshore wind energy in floating platforms, a new technology which promises to unlock a huge resource potential in deepwaters (water depths of 50 meters or higher) (Firestone et al., 2015; European Commission, 2014). This technology presents a high potential to reduce emissions in the electricity sector, provided that it overcomes a number of technological and institutional challenges that prevent take-off (Wieczorek et al, 2013, 2015; Firestone et al., 2015).

Floating offshore wind energy is more than a simple extension of the offshore wind technological innovation system and thus can arguably constitute a TIS on its own right. In fact, it develops under a different environment that is marked by a specific sectoral, technological, geographical and political context. The supply chain is different from the offshore wind in shallow waters in the near-shore (Rodrigues et al., 2015) – and even more distinct from the onshore wind (Wüstemeyer et al., 2015). The technologies are different (e.g. floating foundations, size of turbines) and have a disparate structure of costs (Green and Vasilakos, 2011). The countries active in the development of floating offshore wind have in common large potential sites located in deep waters relatively close to shore (e.g. Norway, Japan and Portugal); and, thus, unsurprisingly, there is little overlapping with the countries that invest in the offshore wind in shallow waters (Kern et al., 2015). Finally, floating offshore wind has lower environmental impacts and lower interference with other activities than installations onshore and in the near-shore.

The contribution of this study for the literature is twofold. First, it improves the conceptualization of technology up-scaling and life-cycles in TIS, adding to the recent efforts in this area (see Markard, 2016). Second, it improves the analytical treatment and operationalization of the process of building both visions/expectations/strategies and public acceptance around a new TIS. This study particularly allows a better grasp of the main drivers of direction of search and legitimation.

The paper is organized as follows. Section 2 reviews the literature on the acceleration of growth of new technological innovations systems. Section 3 explains the methodological approach followed in the study. Section 4 presents the results of the roadmaps analysis and the survey. The conclusion section summarizes the findings and discuss their implications for the policy and the literature.

2. CONCEPTUALIZING THE UPSCALING OF TECHNOLOGICAL INNOVATION SYSTEMS

The research investigates strategies aiming to "change gears" and accelerate the development of low-carbon innovations, a crucial topic for decarbonizing the actual energy system. To understand the underlying processes, we take the theoretical perspective of technological innovation systems (TIS) (Bergek et al., 2008a; Markard et al., 2012) which is adequate to analyze the complexity around the innovation in energy technologies (Gallagher et al., 2012). This approach is complemented with insights from industrial and technology life-cycles (e.g. Taylor and Taylor, 2012) and roadmaps (e.g. Phaal et al, 2011).

2.1 Core concepts in technological innovation systems

Technological innovation systems (TIS) regards innovation as an interactive process involving actors (e.g., firms, users) and networks acting under a particular context of institutions and policies (Jacobsson and Bergek, 2011). In these terms, the emergence of a new TIS encompasses the establishment of structural components – i.e. technology, actors, networks and institutions - dedicated to the focal TIS or shared with other existing TISs (Markerd and Truffer, 2008). *Technology* is a key element of the TIS structure, including both artefacts and knowledge (Bergek et al., 2008b). *Actors* comprise individuals and organizations (e.g. firms) along the value chain. *Networks* are links established between actors to perform a given task (e.g. knowledge development and diffusion, political lobby). *Institutions* encompasses formal rules (e.g. laws and property rights, codes and standards) and informal norms (e.g. tradition and culture) that structure social, economic and technological interactions (North, 1990; Borrás and Edquist, 2014).

In addition to the establishment of the structural components, TIS scholars have been increasingly looking at the performance of key innovative processes (the so-called “functions”) that are needed for the development and growth of innovation systems (Figure 1). A number of functions were identified in two seminal papers (Hekkert et al., 2007; Bergek et al., 2008a).[1] Two functions are particularly important to accelerate the take-off of emerging innovation systems by their impact on the fulfillment of the other functions (Hekkert and Negro, 2009; Suurs et al., 2009; Bergek et al., 2008b): influence on the direction of search (or guidance) and legitimation.

Influence on the direction of search reflects the mechanisms that persuade new actors in the TIS to allocate innovation activities and investments between competing technologies and designs. This includes the combined effect of two factors (Bergek et al., 2008a): visions, beliefs and expectations in growth potential; and the actor’s perceptions of the relative advantage of the technology from indicators that include incentives and regulation (Borup et al., 2013).

Legitimation involves social acceptance and compliance with the concerned institutions (Bergek et al., 2008b). The creation of legitimacy is a socio-political process by which expectations are formed and shaped in favor of the technology (Borup et al., 2006). Technology legitimacy is also a matter of conformity with the institutional structures of the context (Markard et al., 2016). This includes the alignment of the regulation with the needs of the innovation. New technologies particularly have to overcome “the liability of newness” in a process that is often surrounded by the competition from established technologies (Zimmerman and Zeits, 2002). By affecting actor’s perceptions, legitimation also indirectly influences their strategies and thus the direction of search (Bergek et al., 2008a). Both functions (guidance and legitimation) are therefore crucial for emerging and existing technologies to attract new actors and mobilize resources necessary for expansion and functioning (Markard et al., 2016; Bergek et al., 2008a).

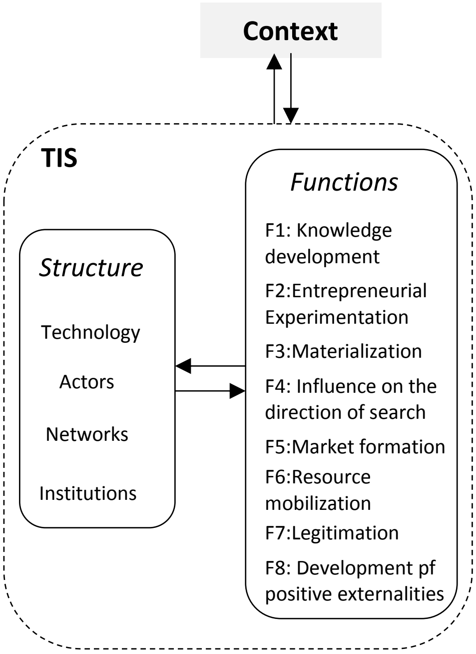
[1] The rest of the presentation adopts the list of functions as described in Bergek et al. (2008a,b). A group of researchers from Utrecht University has developed an alternative list of functions with slight changes to the previous one (Hekkert et al., 2007): entrepreneurial activities; knowledge development; knowledge diffusion through networks; guidance of search; market formation; resource mobilization, and creation of legitimacy.

Other functions are also important to build up new innovation systems. D*evelopment of formal knowledge* refers to the way that knowledge is created, combined, codified and shared, to form the scientific and technological base that allows the innovation to progress (Bergek et al, 2008a; Jacobsson and Bergek, 2011). *Entrepreneurial experimentation* refers to the development of more applied, tacit and explorative knowledge through risk-taking "entrepreneurial" actions, namely with the experimentation of a diversity of designs under a dynamic environment (Van de Ven, 2017). *Materialization* designates the early investment in capital stock or artefacts, including factories and infrastructures. *Market formation* refers to the creation of a demand around increasingly organized markets, from pilot projects to niches and bridging markets. Early demand opens crucial opportunities for learning, while reducing perceived risks with the adoption by consumers (von Hippel, 2010). *Resource mobilization* points out the need to attract human capital, financial capital and complementary assets from other sectors to gear up innovation systems. Finally, *development of positive externalities* refers to the strength of the system and the dynamics of growth, comprising the capacity to take advantage of spillovers from the fulfillment of system functions, as well as from the structures and resources extant in other TISs, in order to accelerate growth (Bergek et al, 2008b).

The functional analysis permit to identify the processes that challenge the development of the TIS (Bergek et al., 2008a; Hekkert et al., 2007). These challenges may require an intervention at the level of the supporting structure of the innovation system to address the failures in the system functions (Wieczorek et al., 2015). The type of intervention includes standardization (institution) to reduce technological risks or attraction of new actors from other sectors to bring resources that are needed for technology up-scaling.

Finally, the context influences the dynamics of the focal TIS through the interaction with the contextual structures (Bergek et al., 2015). These comprise institutions, actors and networks that surround the innovation system beyond the technology-specific structures, such as other technological innovation systems, national or regional innovation systems, and political systems (Bergek et al., 2015; Markard et al., 2016). Examples of TIS-context interactions include, in the sphere of legitimation, the deliberated action of actors to promote political goals (context structures) on the focal technology. In addition, complementarities can raise from the interaction between the TIS and the wider context. Complementarity refers to a positive interaction with two or more elements of the context (Markard and Hoffman, 2016). Complementarities are essential for the emergence and growth of new technologies as missing complementary components can negatively affect or even hamper the development of the system (Dahmén, 1988). Examples of complementarities include technological, organizational, institutional and infrastructural complementarities (Van de Ven, 1993; Markard and Hoffman, 2016). Technological innovation systems are therefore complex entities that interact with the context and evolve over time.

Figure 1 - Basic components of the technological innovation systems approach (Source: authors from Bergek et al., 2008a,b; Hekkert et al, 2007; Bergek et al, 2015)



2.2 TIS lifecycle

The TIS literature conceptualizes the dynamics of innovation systems typically in terms of the comparison of the state of the system at different stages of development. Bergek et al. (2008a) distinguish between a formative phase when "…constituent elements of the new TIS begin to be put into place, involving entry of some firms and other organizations, the beginning of an institutional alignment and formation of networks" (idem: 419) and a growth phase when "…the focus shifts to system expansion and large-scale technology diffusion through the formation of bridging markets and subsequently mass markets..." (idem: 420).

The formative phase involves four "key" features according to Jacobsson and Lauber (2006): "institutional changes, market formation, the formation of technology-specific advocacy coalitions, and the entry of firms and other organizations" (idem: 258). As regards " 'take-off' into a rapid growth phase", Jacobsson and Lauber (2006: 260) consider that a "necessary condition is … that larger markets are formed" in order to "setting in motion a process of cumulative causation".

Along the same lines, Markard and Hekkert (2013) suggest three stages in the TIS evolution: nascent, emerging, and mature.[2] These stages would present different characteristics in terms of technology maturity, key innovative activities (functions) and structural components (actors, institutions, networks) (Markard and Hekkert, 2013; Markard, 2016). A "nascent" (or formative) TIS is a period marked by a large diversity of ideas and concepts, as well as a structure formed by a relative small number of actors mainly organized around networks of knowledge creation and R&D. An "emerging" TIS (including up-scaling) features a lower cost and improved quality technology, which is supported by a gradually more structured system that includes a higher number, more diversified, networks of actors enjoying a stronger political strength, with a growing focus (guidance) on scaling-up the manufacturing base and the technology to reduce costs and open larger markets. Finally, a "mature" TIS comprises a high degree of structuration around a standardized mass-commercialized product, stable formal and informal technology-specific institutions and established networks.

A number of changes occur across the stages of development that can help us to understand the system dynamics, including at the level of the technology, system functions and institutions.

Technology follows temporal patterns that have been identified in the lifecycle literature, comprising the eventual emergence of a dominant design and the shift in the focus of innovation from product innovation in the era of ferment to incremental change in the more advanced stages (e.g. Abernathy and Utterback, 1978; Taylor and Taylor, 2012). However, empirical studies have also shown evidence of alternative patterns of innovation with little or no decline of product innovation across the technology lifecycle in the case of complex products and systems (Davies and Hobday, 2005; Huenteler et al., 2016).

Functions may change in the transition from the formative into the growth phase as it has been suggested by several authors (e.g. Bergek et al., 2008a). Key functions tend to evolve during this process from knowledge creation, legitimation and formation of expectations, in the nascent stage, to resource mobilization and market formation, in the later stages.

Institutional structures evolve from initial visions and collective expectations (cognitive structures), to more informal and formal types of technology-specific institutions such as

[2] Wilson (2012) proposes a similar terminology based on the analysis of the historical scaling dynamics of wind energy: formative phase, up-scaling phase and growth phase. In a more recent version of the paper, Markard (2016) adds a stage of declining TIS. This new stage is not considered in the rest of our presentation also because we are more concerned with the conditions required during the early stages of technology development.

technology designs (normative structures), to established standards (regulatory structures) (Markard et al., 2016). The consolidation of institutions enhances the degree of structuration of the system in terms of the emergence of an industry around the technology that comprises "the build-up of value chains, formation of markets, development of educational programs, alignment of regulatory structures, etc." (Markard and Hekkert, 2013: 7).

For example, in the case of offshore wind energy, further progresses arguably depend on the mobilization of specialized human resources and financial capital, formation of markets and investment in infrastructure and grid connection (Wieczorek et al., 2013, 2015; Jacobsson and Karltorp, 2013). These processes often involve complementaries between several system components including technology, institutions and infrastructures, which can take long to materialize and need proper planning horizons to accompany the development of the focal TIS and avoid creating bottlenecks (Markard and Hoffmann, 2016). This example shows how important it is to coordinate strategies between private and public actors in system upscaling.

2.3 Legitimation and guidance in system dynamics

The transition to growth is a crucial moment in the development of emerging innovation systems. It requires the creation of expectations and collective strategies capable of mobilizing resources and other key innovative activities (functions) to accelerate growth (Wilson, 2012). The process of transition of TISs from emergence to growth remains relatively little understood (Markard, 2016). We posit that it is possible to improve our understanding about system upscaling and take-off by looking at the performance of two particular system functions: legitimation and influence in the direction of search (guidance).

Legitimation refers to the motivation and formation of expectations around a technology, whereas influence in the direction of search deals with the impact of expectations on collective strategies. Bergek et al. (2008a: 417) notes that: "Legitimacy also influences expectations among managers and, by implication, their strategy (and thus the function 'influence on the direction of search')". The two functions are therefore interrelated through expectations.

The sociology of expectations (e.g. Borup et al, 2006) is a stream in the literature that studies the processes that influence the development of new technological system. Expectations refers to real time representations of future technological situations and capabilities, combining views on the progress of the technology, its potential markets and its social context (Borup et al 2006; Van Lente, 1993). Thus, expectations constraint the agenda setting for the field and help creating a "mandate" for the actors involved in its development (Bakker et al, 2011). When widely shared, they can have an important role in aligning different actors around common objectives, effectively contributing to steer development. For this reason, expectations have been described as "performative", i.e. actively shaping the way new technologies evolve (Borup et al, 2006; Pollock and Williams, 2010, Konrad, 2006). This highlights the importance of processes, such as roadmaps, which lead to the articulation, voicing and sharing of expectations (McDowall et al, 2012).

Technology roadmaps materialize visions and guidelines for the future development, being increasingly used by advocacy coalitions and governments in emerging technologies or industries, particularly in the case of sustainable energies (Amer and Daim, 2010). Roadmapping has become "a powerful technique for supporting technology management and planning, especially for exploring and communicating the dynamic linkages between technological resources, organizational objectives and the changing environment" (Phaal et al, 2004: 5). This instrument started at organization level, but has also become frequent at technology and sectorial levels (Daim and Oliver, 2008; IEA, 2014).

In spite of its widespread use, roadmaps have been largely ignored by the literature on socio-technical transitions (McDowall, 2012) which can be explained by its frequent practitioner focus. The first attempts to conceptualize the role played by system level roadmaps in the governance of transitions start to appear (McDowall, 2012; Rip, 2012; Phaal et al, 2011). Following this emerging stream of research, we propose that the process of formulation and implementation of technology roadmaps can be indicator of both the content and effectiveness of the performance of system functions, especially influence in the direction of search and legitimation.

First, roadmaps are instruments for the articulation of shared visions and expectations regarding the future development of the technology, thus contributing to align key actors and to guide their future behavior (McDowall, 2012). They influence the direction of search as the collective strategy becomes more widely accepted. Roadmaps also contribute to improve the general perception about the technology as a result of their action upon several factors including public policy (Bergek et al., 2008a). However, roadmaps' effectiveness depends on how broad is the involvement of actors in their formulation and how inclusive is the consensus reached on the chosen path(s) (McDowall, 2012).

Second, roadmaps can provide additional legitimacy to the collective strategies, thus being an instrument of legitimation (Borup et al., 2013). Their implementation might contribute to the alignment of the technology with the institutional structures in force. This occurs namely by acting upon one of the three legitimation processes identified in Markard and Hoffmann (2016): i) the adaptation to existing structures and the gradual increase of technology-specific institutions in the TIS (e.g. standards); ii) the increase of technology legitimacy following a change in the context (e.g. low carbon technologies increase legitimacy with higher public attention to climate change); iii) the framing or re-positioning a focal technology in response to the new institutional structures (e.g. nuclear re-legitimation as a climate-friendly technology).[3]

As regards legitimation, the effectiveness of roadmaps depends on whether the proposals are acknowledged as being grounded in credible, good quality, analysis and if they result from a participatory process involving key actors (McDowall et al, 2012). Targets set by the government are naturally more credible; When Roadmaps result from the initiative of specific industry or technology advocacy coalitions, they can have an additional role of policy lobbying for changes in the regulation (Amer and Daim, 2010).[45]

Therefore, technology roadmaps that are produced by broad coalitions of actors or government-led partnerships are more likely regarded as the expression of shared visions and expectations (guidance) about the development of the system, as well as the reflection of chosen technology pathways more aligned (legitimacy) with current institutions. Both guidance and legitimation may result from a consensus reached along the roadmapping process, however with the limitations inherent to such consensus. On the one hand, the consensus may reflect the interests of more influential actors (e.g. powerful regime actors) who can use their position to steer the development in the direction that suits better their specific interests – by narrowing the range of possible paths or excluding some minority perspectives (McDowall, 2012; Bergek et al., 2013). On the other hand, expectations can be inflated especially when the roadmap departs from the initiative of an advocacy coalition to persuade public authorities (McDowall, 2012). Both limitations call for a careful interpretation of such documents, whose analysis should be complemented with other sources (e.g. surveys of actors' opinion) whenever possible.

[3] As noted by Smith et al. (2005: 1506): "The transition management literature places significant emphasis on the role of 'guiding visions' (Rotmans and Kemp, 2001; Berkhout et al., 2004), and it is clear that codified representations of technological expectations play a vital role in framing socio-technical problems, as well as motivating actors to seek to solve them (Brown et al., 2000)."
[4] As Jacobsson and Lauber (2006) concludes in their study of the diffusion of renewable energy technologies in Germany: "Legitimacy and visions are shaped in a process of cumulative causation where institutional change, market formation, entry of firms (and other organisations) and the formation and strengthening of advocacycoalitions are the constituent parts. At the heart of that process lies the battle over the regulatory framework." (Jacobsson and Lauber, 2006: 272).
[5] This is consistent with Suchman (1995), who reviews the strategic and institutional approaches of organizational legitimacy to identify three primary forms of legitimation: pragmatic, moral (normative) and cognitive (collective comprehensibility).

2.4 Roadmaps as instruments to accelerate growth

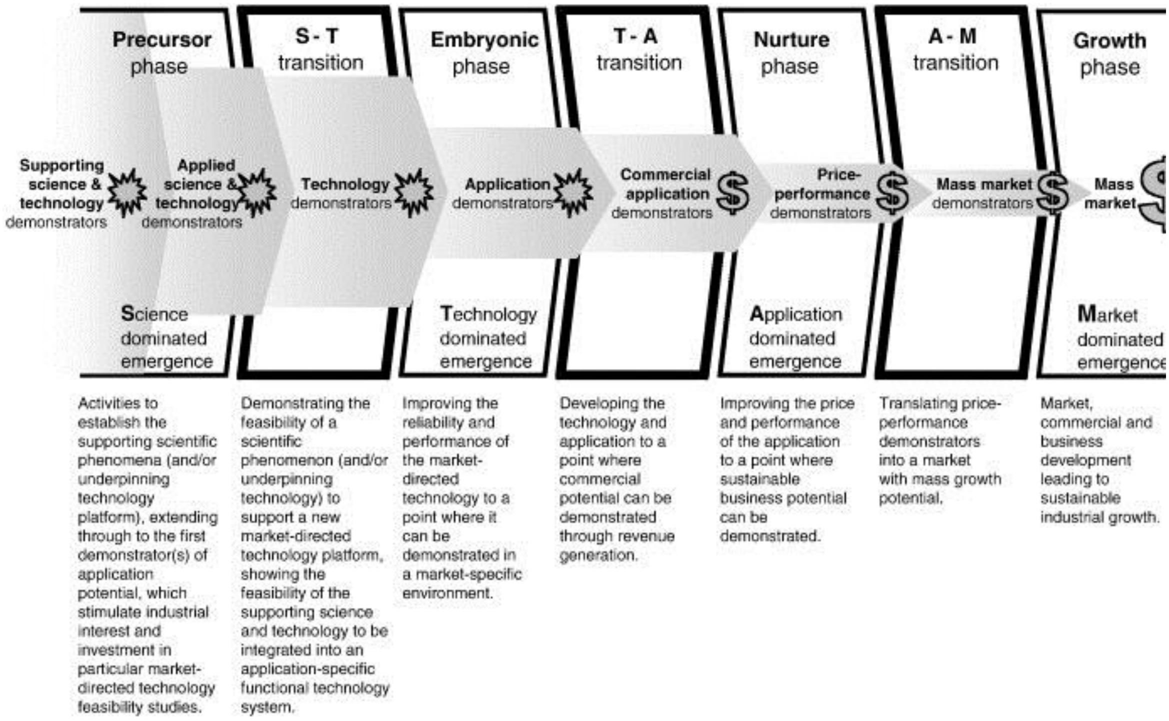
Technology roadmaps are instruments for mapping industry emergence that have been particularly used in new technology-intensive sectors to support strategy and decision making in innovation processes (Phaal et al, 2011; Smith et al., 2005). Such mapping is regarded as a basis for understanding the dynamics of the system and for acting upon those dynamics. Particularly, roadmaps might be able to identify focal points for action and make decisions concerning the most adequate strategies according to the stage of development of the technological system.

In these terms, Phaal et al. (2011) suggests a framework for mapping industry emergence that is inspired in technology lifecycle and evolutionary theories. The framework identifies common patterns in the transitions between phases based on the analysis of the emergence of 25 innovations (Figure 2). The authors define four phases (precursor, embryonic, nurture, growth) and periods of transition between them that are marked by key events, identified as “demonstrators”. The demonstrators are milestones in the innovation process and thus should be focal points for strategy development and goal setting. These include:

- “technology demonstrators” showing the feasibility of the underlying science (i.e. science to technology (S-T) transition) from precursor to embryonic phase;
- “commercial application demonstrators” demonstrating the potential for revenue generation (i.e. technology to application (T-A) transition) from embryonic to nurture phase; and
- “mass market demonstrators” displaying the economic advantages and market growth potential of the technology (i.e. application to market (A-M) transition) from nurture to growth phase.

These phases coincide to a large extent with the ones suggested in the TIS literature (Section 2.2). Precursor and Embryonic phases would enter into the Nascent TIS; Nurture phase presents similar challenges as of Emerging TIS; and Growth phase corresponds roughly to the Mature TIS. However, this framework focus mainly on technology development which is but a component of the entire system; It namely overlooks important challenges in the transition like the organization of the value-chain for scaling or the improvement of the public opinion about the innovation to stimulate demand and lower the risk of investments in production. Still this representation is helpful to highlight the technology-specific challenges that must be overcome to accelerate development. Therefore the roadmapping approach complements systemic theories (e.g. TIS) by outlining a number of key events that require attention in the transition to growth.

Figure 2 - An applied framework for roadmapping (Source: Phaal et al., 2011)



3. METHODOLOGICAL ISSUES

3.1 Research question and hypothesis

The research seeks to improve the understanding about the process of planning the up-scaling of new sustainable energy technologies.

Drawing on the insights from the revision of the literature, we advance the following hypotheses concerning the acceleration of technological development:

(i) guidance and legitimation are key processes to accelerate the growth of emerging systems (because of their role in the performance of the other crucial processes such as resource mobilization and market formation, as already shown in the literature) and their performance can assume specific forms in the transition process;

(ii) roadmaps are an element in the process of formation (legitimation) and share (guidance) of collective expectations;

(iii) the context influences roadmaps, namely in terms of the stage of technology maturity or the process of creation of a consensus.

3.2 Empirical setting and method

We take the case of offshore wind energy in deepwaters – more than 50 meters deep, where most of the potential is located but whose technology is more immature – in a number of countries, to give the empirical background for the discussion.

The definition of the boundaries of the TIS is very important to understand what is newly emerging in the wind energy industry. Studies have shown that offshore wind energy and onshore wind energy are two clearly separated TISs, namely having a different supply chain (Wüstemeyer et al., 2015). Floating offshore wind energy is more than a simple part of the offshore wind technological innovation system and can eventually constitute a TIS on its own right. First, the supply chain (including competencies) required to develop wind energy farms in deepwaters is different from the one in shallow waters in the near-shore (Rodrigues et al., 2015). Second, the technologies are also different, especially in what concerns the foundations (fixed versus floating structures) and the structure of costs (Green and Vasilakos, 2011). Thirdly, the countries that have been involved in the development of this technology are not the same as for the offshore wind energy in shallow waters (Kern et al., 2015); they have in common large wind resources potential that are located in deep waters relatively close to shore (e.g. Norway, Japan and Portugal). Finally, floating offshore wind tend to have lower environmental impacts and lower interference with other activities than installations onshore or in the near-shore and, in consequence, may face less external resistance.

The paper applies system theories namely TIS (Bergek et al., 2008a; Hekkert et al; 2007; Markard et al., 2012) to track the processes of structuration (e.g. creation of value-chains) of technological innovation systems that enter into the up-scaling stage. The analysis comprises the requirements of up-scaling in terms of changes in technology, actors, networks and institutions, at more structural level, as well as in core innovative activities or functions (including guidance and legitimacy), at more functional level.

To understand how these critical structural and functional elements unfold, we analyze roadmaps and equivalent national programs for floating offshore wind energy. As pointed earlier, roadmaps are the result of a process (presumably inclusive) that attempts to reach a certain consensus among the key actors about the future development of the technology, what they expect to happen and the paths that should be followed to achieve it. For this purpose, roadmaps often provide a diagnosis of the state of the art of the technology, as well as an identification of the main system players and emerging networks. Because roadmaps are an element in the process of formation and sharing of expectations, they can be an important *instrument* for the performance of system functions like influence in the direction of search and legitimation.

In addition to the diagnosis, roadmaps set out a vision of the future and identify needs and actions to be performed, at different levels, in order to fulfill it (McDowall, 2012). In other words, roadmaps reflect the actors' view on how to "change gears" and accelerate the development of the technology. So, they are good *indicators* (although partial) of the way that actors perceive and prepare the TIS growth.

Thus roadmaps analysis enables us to investigate the performance of the system functions like guidance and legitimation in the transition to growth. Although roadmaps are not the only instrument for collective construction of visions and strategies, they provide important insights about the creation and dissemination of expectations around the new technology (Borup et al., 2013). In addition, the comparison of roadmaps from different contexts may enable us to understand the influence of the context in their performance of the system functions.

Since roadmaps are only one element in collective strategy definition, we need to complement the analysis with additional information of the process. For that reason, we carry out separately an opinion survey among actors involved in the international development of floating offshore wind energy to assess the effectiveness of the roadmaps in the performance of the functions.

We compiled data from technological plans and roadmaps and organized them with the help of the typology of phases, transitions and key events (e.g. "demonstrators") proposed by Phaal et al. (2011). In the absence of a national development strategy, technology-based plans of key actors are analyzed instead. This procedure allows us to situate the technology in the innovation process - though acknowledging the non-linearity of this process – as well as to perform a comparative analysis of the strategies followed in different countries. Roadmaps also offer indications of the changes foreseen in the other structural elements of the system (actors, networks and institutions) and on the strategies to perform the system functions, as argued above. The relevant information is extracted from the documents following a specifically created framework that is presented in Appendix 1 to analyze roadmaps for floating offshore wind energy.

The work is therefore based on the examination of the extant literature in desk research, as well as on empirical research supported by documentary data. Table 1 lists the roadmaps (or equivalent documents) used in the analysis, encompassing 10 documents from 6 countries, from 2009 to 2014. The data extracted from the individual roadmaps, following the analytical framework devised, is presented in Appendix 2. The analysis is complemented with data from a variety of secondary sources. A non-exhaustive list includes official statistics, companies' press releases and other documentary sources such as websites or presentations at events. In addition, the roadmaps analysis are compared with the results of an opinion survey among the actors (companies, organizations, ..) involved in the growth of the technology innovation system in late 2015 and 2016.

Table 1 – Roadmaps and equivalent documents analyzed

Document	Country	Date	Type	Initiative	Code
Target & roadmap for Japanese wind power	Japan	2014	Roadmap	Wind Power Association	JA14
Demowfloat - Demonstration of the WindFloat Technology Roadmap (Windplus)	Portugal	2014	Project report	Organizational (companies)	PO14P
Technological Roadmap by the Technological Observatory for the Offshore Energies	Portugal	2014	Roadmap	Coalition of stakeholders	PO14R
UK Renewable Energy Roadmap Update 2013	UK	2013	Roadmap	Government	UK13R
Industrial Strategy: government and industry in partnership	UK	2013	Action plan/ Strategy	Government	UK13S
Rapport de la mission d'étude sur les énergies marines renouvelables	France	2013	Strategy/ Roadmap	Government (mission report)	FR13
A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the US	US	2011	National plan	Government	US11
Offshore Renewable Energy Strategic Action Plan 2012-2020	Northern Ireland	2012	Action plan/ Strategy	Government	NI12
UK Renewable Energy Roadmap	UK	2011	Roadmap	Government	UK11R
Concerning an Act on Offshore Renewable Energy Production (the Offshore Energy Act)	Norway	2009	Strategy (legislative)	Government	NO09

4. ROADMAP ANALYSIS: SHARED STRATEGIES FOR SCALING UP FLOATING OFFSHORE WIND ENERGY

In this section we apply the framework described above to analyze technology roadmaps in order to uncover the projected changes to the technology, the components of the structure and the functions of the innovation system. But first we provide a brief account of the evolution of floating offshore wind energy technologies in recent years.

4.1 Technology

4.1.1 The evolution of floating offshore wind energy

The emergence of offshore wind in deepwaters occurs in a dynamic context for wind energy in the more shallow waters. Offshore wind energy is rapidly growing in Europe with more than 8 GW installed and 41 GW projected by 2020 (Table 2). More than half of the new capacity is expected to be installed in the United Kingdom and Germany, consolidating the leadership of these countries. The European Wind Energy Association (EWEA, 2013) suggests that the capacity could reach 150 GW by 2030, meeting 14% of EU's final electricity consumption. Asian countries have also been active in offshore wind energy, with China currently having over 1.5 GW and planning 10 GW more by 2020 (FOWIND, 2014; IEA, 2011). Japan has already installed 50 MW, including 4 MW of floating turbines. The Japan Wind Power Association (JWPA, 2014) anticipates 700 MW by 2020, of which 100 MW in deepwaters. Korea and Taiwan have capacity targets for the coming years as well. The US has no offshore wind farms so far, but has announced plans to build 498 GW by the end of 2017, including 30 MW of floating turbines, and 54 GW by 2030.

The evolution of offshore wind energy has been summarized by Rodrigues et al. (2015, p.1132) as follows: "…the initial OWPs [offshore wind projects] mostly served as proof of concept. Hence, they were located in shallow waters close to shore and were composed of few wind turbines leading to low investment costs which were highly dependent on the number of turbines. Nowadays, commercial projects have higher installed capacities, are highly capital intensive and more complex to design, due to the larger seabed areas, higher number of turbines and longer distances to shore."

The average water depth and distance to shore have been increasing over time (Figures 3 & 4). Higher distances to shore are correlated with higher mean wind speeds that yield greater capacity factors (Rodrigues et al., 2015). However, the water depths tend to increase with the distance to shore, driving up installation and foundation costs, as well as operational and maintenance costs (Green and Vasilakos, 2011). Most future wind farms are likely to remain at a maximum depth of 50 meters, but there are still a significant number of projects expected for higher depths. This especially concerns countries that have deepwaters relatively close to the shore, such as Portugal, Norway or Italy. To exploit the huge potential in the deepwaters, a number of technologies are necessary, such as floating support structures, which are still in the pre-commercial stage.

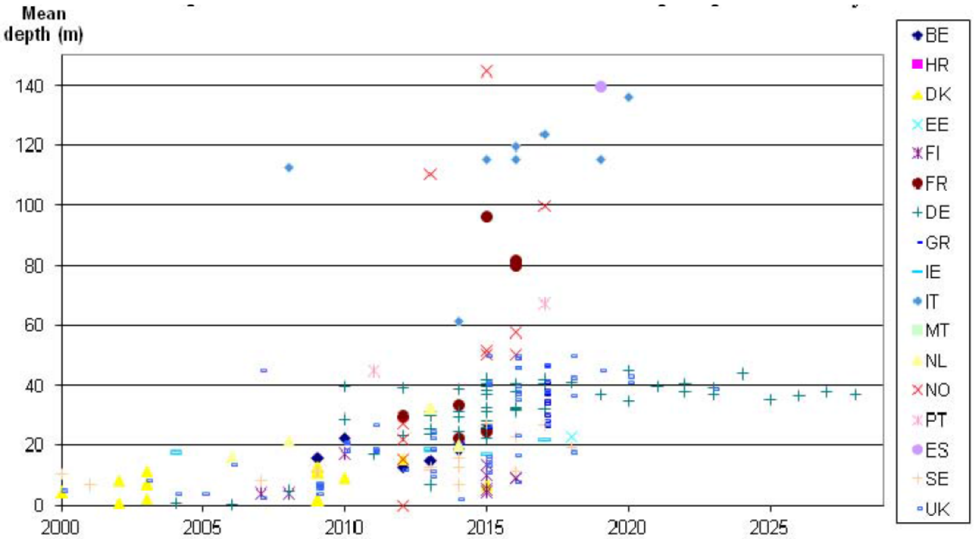
Table 2 - Offshore wind energy installed capacity and generation potential by Member State up to 2020 as described in the National Renewable Energy Action Plans (NREAPs)

	Installed capacity (MW)			Generated electricity (GWh)		
	2005	2010	2020	2005	2010	2020
BE	0	196.5	2000	0	189.6	6200
DK	423	765	1339	1456	1622	5322
DE	0	180	10000	0	210	31771
EE	0	0	250	0	0	563
IE	25	25	555	0	70*	1742
GR	0	0	300	0	0	672
ES	0	0	750	0	0	1822
FI	0	26[213]	900	0	73*	2500
FR	0	0	6000	0	0	18000
IT	0	0	680	0	0	2000
LV	0	0	180	0	0	391
MT	0	0	95	0	0	216
NL	0	228	5178	0	765	19036
PL	0	0	500	0	0	1500
PT	0	0	75	0	0	180
SE	23	163	182	62	450	500
UK	213.8	1341	12990	403	2847	44120
EU	685	2925	41974	1921	6226.6	136535

* Values estimated by the JRC-SETIS based on capacity factor values derived from the NREAPs.

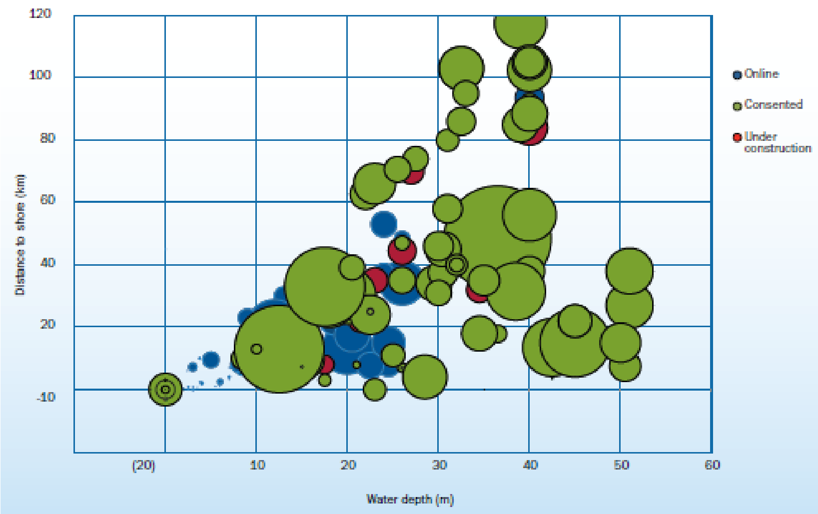
Source: European Commission, 2014.

Figure 3 - Mean depth of extant and planned European offshore wind farms



Source: European Commission, 2014.

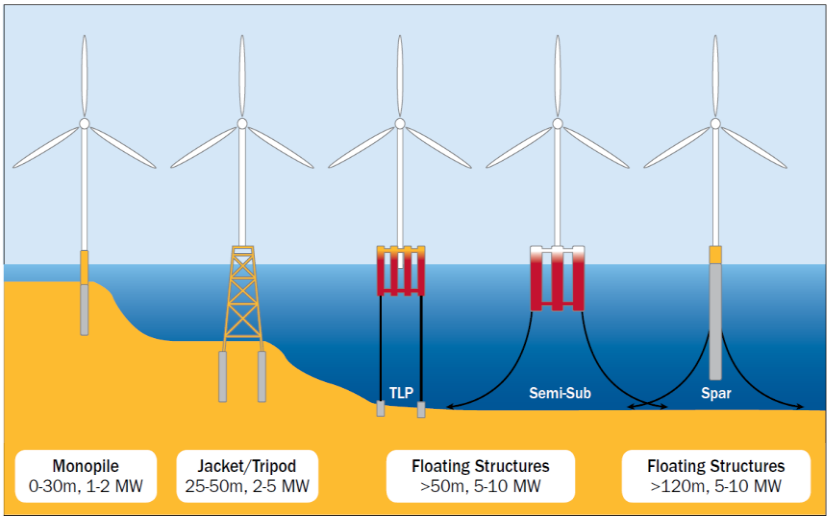
Figure 4 - Average water depths and distance to shore of consented, under construction and online wind farms



Source: EWEA, 2015.

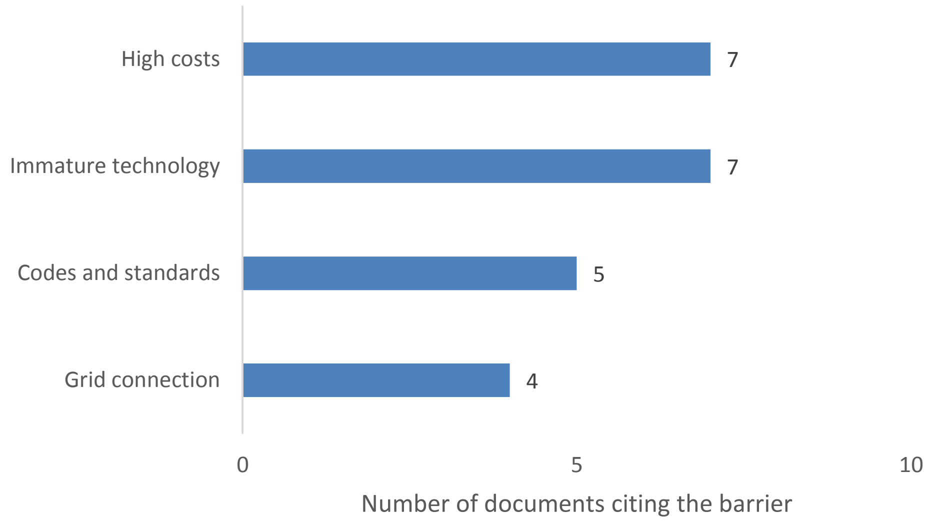
Figure 5 presents the main technical options for turbine foundations across various water depths, with a particular emphasis on the floating concepts that were adapted from the oil and gas industry (showing the complementarities or "couplings" with existing sectors, cf. Markard and Hoffmann, 2016). The designs of the structure and foundations of offshore wind turbines are different from those of land-based wind energy generators. Shallow waters and depths below 30 meters often employ monopile designs, while tripod and jackets are more used in transitional depths (between 30 and 50 meters). These designs can already enable projects from shallow waters until relatively far from shore. Semi-submersible and floating designs could have a greater potential for energy cost savings by unlocking wind potential in deepwaters. Three designs are particularly disseminated: tension-leg platform (TLP); semi-submersible tri-floater; and spar buoy. Although inspired from the oil & gas offshore know-how, floating designs need further adaptation to turbines and testing. They promise to reduce project costs through full assembly onshore and less complex installation, as well as environment impacts on the seabed. However, costs are still significantly high and should be reduced to become competitive against the other options (EWEA, 2013; Rodrigues et al., 2015).

Figure 5 - Options for offshore wind foundations



Source: EWEA, 2013.

Figure 6 – The most cited barriers to the development of floating offshore wind technologies according to the documents under analysis



The analysis of the national roadmaps reveals a number of perceived obstacles to the development of floating offshore wind energy (Figure 6). The most frequently mentioned barriers are: high costs (explicitly referred in 7 out of 10 roadmaps); immature technology (7); and the need of codes and standards (5).

Upfront costs are still high, what raises the output costs and constrains the market outlook for floating offshore wind (Battaglia et al, 2015). Pilot projects received slightly over 300 €/MWh in the United Kingdom through renewable obligation certificates or ROCs. More recently, the Japanese government also approved a feed-in tariff of 36,000 JPY (approx. 264 €/MWh) to support the deployment of floating offshore wind energy. This compares with an average levelized costs of energy (LCOE) of 180 €/MWh for offshore wind energy from fixed foundations (European Wind Energy Technology Platform, 2014; The Crown Estate, 2012). However, costs start to reduce and technology is improving as a consequence of the learning from the deployment of the first floating turbines. Therefore further cost reduction remains crucial to ensure commercial viability of the technology.

Standardization is another challenge that needs to be addressed before market takes off. This will require further investment in both R&D and demonstration (Phaal et al., 2011).

4.1.2 Commercialization plans

Roadmaps are frequently followed by more concrete announcements of experimental projects and demonstrations of small, pre-commercial, series. The decision to invest in demonstrators is often associated to a longer term perspective of the actors to commercialize the new technology. The current and planned experimentation projects with floating wind turbines can thus be analyzed as the intermediary steps that are taken to bring the technology to the market as in the Phaal's industrial emergence framework (Phaal et al., 2011). Thus these projects enable a first assessment of how roadmaps are impacting decisions on the short term.

Table 3 shows the currently active projects on deepwaters offshore wind energy worldwide. The type of projects is further discriminated into pilot, prototype and pre-production, coinciding with different demonstrators that mark the transition from science to technology (S-T), technology to application (T-A) and application to market (A-M), respectively, following the terminology proposed in Phaal et al. (2011). The table shows that the technology is clearly passing the prototype stage to enter into the pre-production stage which will be eventually followed by the serial production stage. The first floating offshore wind farms are expected to be installed and connected in 2017 in several countries in Europe and in the US.

At the same time, the maximum unit capacity of turbines is increasing with plans to install 7, 8 and even 10 MW in the next years. The installation of larger size turbines allows increasing the capacity of the wind farms (or alternatively reduces the number of turbines needed to install in order to reach the same nameplate capacity). Note that upscaling unit capacity was sign of the end of the formative phase and transition to large markets in the case of the onshore wind energy (Wilson, 2012).

The rhythm of annual installations, according to the projects surveyed, should accelerate from 10-17 MW per year in 2015 and 2016, to 143 MW and 127 MW respectively in 2017 and 2018 – assuming that all the projects remain within the timelines. The cumulative installed capacity would then raise from 35 MW in 2016 to 305 MW in 2018. These numbers compare with the DNV GL's forecast which expects a slower start for floating wind energy - 66 MW by 2017 and 120 MW in 2018 - but a higher capacity of 870 MW by the end of the decade.[6]

[6] http://www.wind-infotech.com/NL/paper/ehydt.html (accessed 10/8/2015).

Table 3 Selected active projects in deepwater offshore wind worldwide

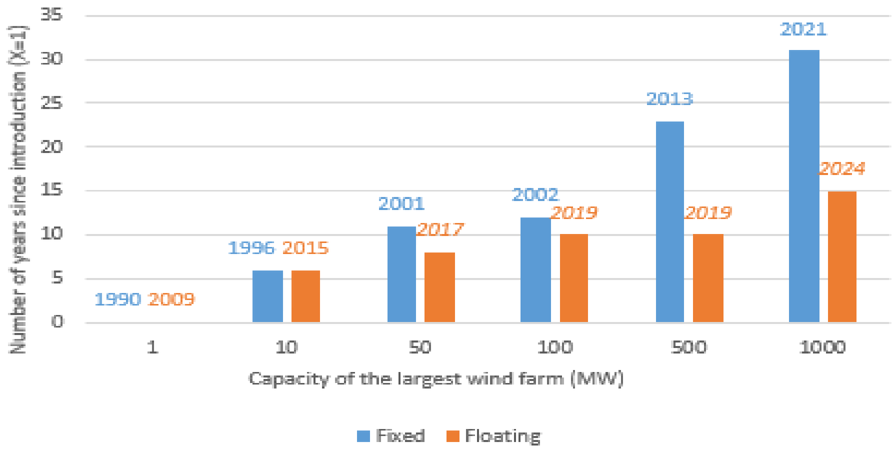
						(S-T) Demo/Pilot		(T-A) Prototype		(A-M) Pre-production/Serial		
No.	**Project name**	**Country**	**Company**	**Type of foundation**	**Minimum water depth (meter)**	**Scale**	**Year**	**Turbine size (MW)**	**Date of deployment**	**Capacity/Turbine size (MW)**	**Expected date of deployment**	**Status ***
1	Hywind	Norway	Statoil	Spar buoy	200			2.3 MW	2009			IV
2	Hywind Scotland Pilot Park	Scotland	Statoil	Spar buoy	95					30 MW (5x 6MW)	2017	I
3	Kinkardine	Scotland	Pilot Offshore Renewable,Ltd partnership with Atkins,plc	Semi-submersible	60					50 MW (8x 6-8MW)	2018	I
4	PelastarWave-Hub	Scotland	The Glosten Associates	Tension-leg turbine platform	55	0.1 MW	2011					V
5	Windfloat	Portugal	EDP,Principle, Power,Repsol	Semi-submersible	50			2 MW	2011	25 MW (4x 6-8MW)	2017	IV
6	Windfloat	US	Principle Power	Semi-submersible	120					30 MW	2017	I
7	Maine Aqua Ventus (DeepCWind)	US	Consortium (Maine Univ, NREL, AEWC, etc.)	Semi-submersible	n.a.	0.02 MW	2013			12 MW (2x 6MW)	2017	I
8	Goto Fowt (Kabashima Island, Kyushu)	Japan	Ministry (MOE), Toda, (leaders)	Spar	100	0.1 MW	2012	2 MW	2013			IV
9	Wind Lens (Hakata Bay, Kyushu)	Japan	Kyushu University	Floater (Semi-submersible)	n.a.	0.006 MW	2011	1MW	n.a.			IV
10	FORWARD Fukushima - phase 1	Japan	Consortium (Marubeni, Mitsubishi, Hitachi, Tokyo	Semi-submersible	100			2 MW	2013			IV
	FORWARD			Semi-	100			7 MW	2015			III

	Fukushima - Phase 2		University, Japan Marine United, etc.) supported by the METI	submersible								
				Spar buoy	100			5 MW	2015			III
11	Poseidon	Denmark	Floating Power	Floater (Semi-submersible)	45	0.03 MW	2009	5 MW	n.a.			I
12	Floatgen	France	Gamesa, Acciona, Ideol, etc.	Floater	35			2 MW	2015			II
13	Vertimed (Inflow, Vertiwind (1&2))	France	Nenuphar, EDF EN, (Technip)	Semi-submersible	50	0.035 MW	2009	2.6 MW	2015	26 MW (13x 2MW)	2018	II
14	Sea Reed - Groix	France	DCNS, Alstom	Tension-leg buoy	n.a.			6 MW	2017			I
15	Nautilus	Spain	Nautilus Floating Solutions SL	Semi-submersible	n.a.			10 MW	2016			I
16	Balea	Spain	EVE	Tension leg platform or Semi-submersible	20					26 MW (2x 5MW + 2x 8MW)	2018	I
17	FloCan5	Spain	Cobra, Gobierno de Canarias	Semi-submersible	50					25 MW (5x 5MW)	2018	I
18	Blyth Blyth Offshore Demonstrator	England	EDF Energies Nouvelles	n.a.	37					40 MW (5x 8MW)	2017	II

Status: I - Early planning; II - (Consent) Authorised; III - Under construction; IV - (Fully) Commissioned; V - Decomissioned.
Source: 4COffshore, 2015; EWEA, 2013; Main(e), 2013.

To assess the rate and extent of the planed deployment of floating wind energy, we compare with the growth of offshore wind in shallow waters and in the near-shore using fixed structures. Fixed-bottom wind turbines are the closest technology that is comparable to floating wind turbines. We use data on both historical and forecasted growth, i.e., the time taken to pass from several MW to dozens MW, hundreds MW, and thousands MW (gigawatt) wind farms. Figure 7 shows the results.

Figure 7 - Comparison of the growth of offshore wind farms with fixed-bottom (historically) and floating foundations (projected, as described in the demonstration plans)



Author's calculations using data from 4COffshore, 2015; EWEA, 2013; Main(e), 2013; Rodrigues et al., 2015.

The two technologies (fixed and floating) take identical number of years (ca. 6 year) to pass from the construction of the first full-scale prototype (1990 and 2009 for bottom-fixed and floating offshore wind, respectively), to the first dozen MW farm (1996 and 2015 for fixed and floating structures, respectively). However, the transition to half hundred MW farms should be faster according to the plans for floating wind, i.e. 8 years instead of 11 taken in the case of fixed-ground farms. The rhythm accelerates for higher sizes of the wind parks up to the first gigawatt project, for which floating is expected to take 15 years or half the time expected for bottom-fixed farms (ca. 30 years).

This result seems optimistic and suggests that actors anticipate that floating offshore wind energy may benefit from spillovers (e.g. knowledge, supply chain) gained in the previous deployment in the near-shore. In any case, as pointed by Fowind (2014), coordination is important between actors and public authorities to avoid unrealistic timelines that can deter developers from applying for the available capacities.

4.2 Structural components

4.2.1 Actors

Roadmaps provide an overview of the actors that are already in the system, both as part of the diagnostics and through the reported actor participation. They can also inform about the perceived need to expand the number of actors and diversify activities and competencies.

The analysis of the proposed actions permits to identify the new types of actors (e.g. large energy firms, capital providers, community leaders) and the complementary areas that need to be involved. Several roadmaps mention the activities required to develop the value chain, in particular related to operating offshore, such as the marine or the oil & gas industries. The analysis equally permits to identify the new types of activities that have to be played by the actors already present in the system and the resources that may be required for that purpose, e.g.: from development to demonstration; from prototype building to larger scale manufacturing; from research to market development.

Some activities are considered critical and the actors providing them singled out as requiring particular attention. Besides technology improvement and cost reductions, other central activities include: training of human resources; setting- up infrastructures for demonstration and test; provision of financing by different type of actors (from government to private investors) and at different levels (from R&D to demonstration and to commercialization).

The roadmaps analysis also uncovers key players and the nature of functions they are expected to perform for the development of the system. While research organizations remain important, industrial actors assume an increasingly central role as the innovation matures and approaches commercialization. In fact, the roadmaps explicitly stress the need to mobilize industrial actors with competences that go beyond the “core” energy technology, focusing on expertise on the logistics of offshore operation or on advanced manufacturing. Policy actors are viewed as particularly critical in this stage of development. When the roadmaps are of government initiative, their involvement is automatically assumed. But when they are of the initiative of other system actors, such as sectoral associations like in Portugal and Japan, it is necessary to assess whether policy actors participated in the formulation and whether and how they are expected to adhere subsequently.

Roadmaps also elucidate about the motivation of the actors (private as well as public) in the development of the system. They often stress the importance of the country’s attempt to achieve an early positioning in the emerging system, thus gaining competitive advantages. This includes the need to develop a national industry across the value chain – or at least in some of its components – which requires the mobilization of national actors and existing competences in related sectors (sometimes redirecting or upgrading them). Although roadmaps generally recognize this is an international field, in only a few cases the competition from actors from other countries also "on the run" is taken into account (not least to call for a stronger public support for the technology).

4.2.2 Networks

The identification of the actors currently in the system permits to gain some insights into the networks that have already emerged. Roadmaps also give indications on the type of interactions that are deemed to be necessary for the development of the system.

At this level several roadmaps detail the value chain that needs to be built and the nature of the upstream and downstream relations that have to be established with complementary sectors (e.g. a variety of activities related to operating at sea). This often includes the networks that have to be reinforced among the actors already in the system, and between these and newcomers.

Several roadmaps provide indications towards wider, more formal, networks that favour actors' alignment and coordination. This includes the setting up of large demonstration projects, along with the creation of shared infrastructures that accelerate learning processes and the creation of interdependencies. They also call for the formation or reinforcement of collective organisations that provide an arena for identifying shared interests and for acting on their behalf. In this context, some roadmaps point to the need to develop international collaborations (e.g. knowledge networks).

The analysis thus permits to uncover the new types of networks that are expected to emerge in the process of structuration for system up-scaling. Examples include: research and technology, business, intermediation, policy lobbying, as well as larger networks that encompass a variety of actors and activities and have a system coordination role like the Offshore Wind Industrial Council (OWIC) in the UK, or the Offshore Wind Innovation and Demonstration Initiative (OSWindD) in the US.

Overall, the roadmaps anticipate an expansion in the number and variety of actors and an intensification of the relationships between them, often proposing actions and/or policy measures that foster such developments. They emphasize the need of diversification of the activities and competences in order to achieve a faster and more sustained development of the innovation system associated with the technology, and in some cases point to the necessity of greater coordination of the subsequent steps.

4.2.3 Institutions

The creation of institutions is recognized as a crucial part in the preparation for large commercialization and roadmaps present details about the institutional needs. The literature review shows that alignment with existent infrastructures increases legitimacy, and the creation of technology-specific institutions like standards marks the progress of the system in early years.

Roadmaps provide indications on the relevant regulatory aspects that emerge as constraints to system development. There is a broad recognition of the need to establish technology-specific regulation *ex ante* to accelerate growth. For that reason, they often propose the introduction of regulation at several levels, including: regulation of sea activities (e.g. marine spatial planning); permitting and licensing; grid connection, and codes and standards.

The way that roadmaps address policies depends greatly on the initiative of their formulation. When they are of government initiative, roadmaps are an element of the policy for the field and are likely to depict policy proposals already accepted by the government (legitimation). When roadmaps are of actor initiative, they tend to stress the need to gain the adhesion of policy makers to their vision and proposals, bringing about favourable policies. This is often accompanied by optimistic views about the potential of the technology to deliver a high amount of energy at affordable costs (e.g. 4 GW of floating wind energy in Japan by 2030 expected by the Japanese wind association). They also tend to present a national focus, namely highlighting the importance of stimulating the internal market for the development of an export industry (see also Normann, 2015) – we come back to this issue later.

The roadmaps emphasize the need to create a positive view of the technology in the community. They stress the advantages relatively to onshore wind in terms of environmental gains and of avoiding a negative reaction against the installations. The roadmaps often call the attention of local communities to the economic advantages derived from the new activities (e.g. new investments in the value-chain, job opportunities). But several roadmaps point to the need to prevent conflict with the other activities that share the ocean space (like with the powerful fishery industry in Japan). In these terms, roadmaps also act as instruments to raise public awareness and approval and, thus, legitimation.

4.3 Functions

This section aims to understand whether and how the roadmaps contribute to accelerate the transition to growth through the performance of the system functions towards which they are expected affect: direction of search and legitimation. Such core processes are indicators of, respectively, the social recognition of the technology and the attractiveness of the system to investments from other sectors (Bergek et al, 2008b). In particular, we hypothesized that the performance of legitimation and guidance can spur other system functions and by this way the dynamic of growth.

The analysis particularly examines whether and how roadmaps perform the aforementioned functions and contribute to fulfill the other key innovative processes, such as resource mobilization and market formation, which are necessary for growth.

4.3.1 Influence in the direction of search

Roadmaps can articulate expectations and provide guidance to emerging technological innovation systems, namely by raising the visibility of a technology or setting goals and timeframes for both technological and market development (Borup et al., 2013).

The roadmaps under analysis define and convey a vision of the future. They all contribute to improve, to a greater or lesser extent, the visibility of offshore wind. In addition, roadmaps set some guidelines for action which are more or less detailed depending on the cases. Greater detail are found in: more focused roadmaps (e.g. those that address specifically offshore wind in deepwaters instead of the broader class of marine renewable energy technologies); those originating from countries with greater previous involvement with the technology (e.g. the UK); or countries that strongly invest in knowledge development (e.g. the US). The roadmaps that are not one-off, rather follow-up from earlier documents, such as in the UK or Portugal, also end-up being more substantiated and detailed. Thus the analysis suggests that roadmaps adjust to the stage of development of the system at country level.

Concerning the operationalization of the vision, all countries define goals for technology development and six of them additionally set-up intermediate steps. The only exception is Norway whose "Offshore Energy Act" refers to targets to be set later. The plans of deployment range from 27 MW in Portugal to 100 MW in Japan by 2020, and up to 4,000 MW in Japan by 2030. Intermediate steps often refer to deployment, but there are cases where it relates to a technological target such as costs reduction (e.g. GBP 100/MWh in UK or $0.10/kWh in the US) by 2020.

The competition from other technologies appears in few roadmaps and is often associated with the acknowledgement of the high costs of floating offshore wind. This is more frequent in the cases of countries that already have a high share of renewables or when the document refers to more immature technologies (e.g. ocean energies) in order to make the case for the investment in offshore wind.As regards the national focus versus the acknowledgement of the international nature of the field, all documents have a strong national flavor, frequently pointing to the interest of developing the competitive capacity and eventually achieving first-mover advantages. They defend the need to develop or reinforce the value chain at country level, namely by profiting from existing strengths in complementary areas that are critical for the development of an "industry" around offshore wind. The roadmaps often emphasize the domestic production of a substantial number of components. They present these components as complementary activities that can provide opportunities for organizations from a variety of fields (including declining sectors like metallurgy) to broad their markets and to increase their export prospects.

The national focus appears nevertheless to be excessive considering the highly internationalized nature of the field, leading to some neglect of the potential competition from other countries with similar goals (the UK roadmap is a rare exception). In the limit, foreign organizations are never referred to like in the Japanese roadmap. This can be a side effect of roadmaps in the effort to mobilize national actors, which is explored in more detail later.

Therefore, the roadmaps and equivalent documents influence the direction of search in some way or another. At least, they contribute to foster the expectations on offshore wind in deepwaters. But the effectiveness of the guidance will depend on whether they have the capacity to attract actors from other sectors and to stimulate the other innovative activities, something we will look at in the following sections.

4.3.2 Legitimation

Legitimation refers to the socio-political process by which actors shape expectations around the technology (Borup et al., 2006). As regard the roadmap analysis, the determinants of legitimation include the participatory character of the process of roadmapping, and the formation of technology-specific institutions such as codes and standards.

As pointed out above, all documents define a vision and (more or less detailed) expectations, which are seen as catalyzing action. But the extent to which the roadmaps contribute to create legitimacy is expected to be related with the quality of the process that led to the development of these visions and expectations, particularly on how participatory and inclusive the process was (McDowall, 2012).

It is not always possible to assess these features from the documents, since they do not always detail the process followed in their elaboration. But, for those who do, we observe an attempt to achieve comprehensive diagnostics and projections and to resort to recognized experts in order to raise social recognition of the technology. In what concerns participation, it differs in extent and nature, which may influence future acceptance and engagement on the guidelines set. There is usually an attempt to involve key actors and achieve a wide diffusion (and sometimes debate) of the vision and proposals. In particular, the roadmaps of stakeholder initiative stress the need for government endorsement of the preconized visions and proposals – in what can be regarded as a documental piece of the lobbying activities to reinforce their legitimacy and influence on further development.

The origin of the initiative for the roadmap (private actors vs. public actors) affects their capacity to provide legitimation (and also guidance). If a large participation of private actors is more likely to generate broader consensus, the involvement of the government tends to ensure greater policy impact.

Documents differ in terms of the origin of initiative, breadth and level of actor participation. Most of them are from government initiative but in two countries they are of actor initiative (Japan (JA14) and Portugal (PO14R, PO14P)). They also refer to, at least, consultation with key actors. Most documents stress the need of extending the number and range of participants in the system as a condition for its development, and several define strategies for that purpose. This includes the promotion of specific initiatives, networks or infrastructures (e.g. setting-up demonstration sites, solving grid connection problems), often supported by financial incentives that signal preferable development paths and enable the alignment of actors along them.

Technology-specific institutions also appear as a priority in the generality of roadmaps. They recognize the need of setting up standards before market take-off. In addition, the roadmaps point to the need of regulation at various levels, such as of the interactions with other marine activities, to avoid social resistance. This recognition is sometimes complemented with specific recommendations, the most common being the urge for maritime spatial planning.

Public perception is an important issue in the documents under review, as well as preventing social resistance against offshore wind energy. The roadmaps tend to present floating offshore wind as avoiding some of the acceptance problems associated with fixed systems installed close to the coast (not to speak those inland), and thus less prone to resistance. They sometimes point to survey results to support these assertions (e.g. UK13S). There is almost always the preoccupation of anticipating and addressing eventual conflicts with activities and communities that share the ocean space, in what is a clear attempt to improve the public opinion on the technology.

Overall, these documents endeavor to set directions for action, and provide some instruments that aim at encouraging actors to engaging in activities along them - even if with different levels of specificity. The government origin of most of the roadmaps ensures their support (at least until the end of their mandate) to the directions set. However, the diversity in terms of actor involvement (type, level and nature), and the challenges this may raise to achieve a consensus around shared goals, suggests that roadmaps may vary in what concerns the legitimacy they provide. There is nevertheless an attempt to promote public acceptance and some preoccupation with the engagement of key actors, either during the formulation, or through actions that aim at bringing them into action and aligning their activities with the goals set.

4.3.3 Impact on the other functions

The literature suggests that the performance of functions, such as setting the direction of search and legitimation, is an important element in the system's structuration by triggering changes in the other functions, in particular resource mobilization and market formation, that are critical for technology upscaling (Hekkert and Negro, 2009; Bergek et al., 2008b; Wilson, 2012). We have seen so far that roadmaps can be an instrument of performance of both legitimation and guidance. In this section, we analyze how they address the fulfillment of the other functions, namely by comparing with the needs that have been identified in previous studies on offshore wind energy.

Roadmaps can impact the execution of several key innovative activities (e.g. knowledge creation, infrastructure building, investment in manufacturing plants) that are needed for transition. To understand the extent to which they affect the other system functions, we search in the roadmaps the elements where they recognize and address the barriers to the development of floating offshore innovations that were previously identified in the literature.

Former research identify several barriers to the growth of offshore wind energy (both in the near-shore and in deepwaters), including the lack of specialized human resources, grid connection and financial capital (Wieczorek et al, 2013; Jacobsson and Karltorp, 2013). These barriers relate to the underperformance of several system functions (the so-called "weak functions"), including resource mobilization and market formation.

Table 4 shows the policy challenges related to the development of these weak functions in the European countries that develop offshore wind energy in shallow waters (United Kingdom and Denmark) and compares them with those in a country that is among the pioneers in the development of floating offshore wind (Portugal).

Table 4. Comparing policy issues associated to the three weak functions blocking the development of offshore wind energy innovation systems at European level (including UK and Denmark) and in Portugal

	EU (including UK and Denmark) *	Portugal
Market formation	• Alignment of member states market opportunities	• *Slow increase in final electricity consumption* • *Support internationalization of activities* • Reinforce grid interconnections with other European countries (for RES electricity export)
Resource mobilization	• Formation of human capital • Ensure financial capital in innovative concepts • Ensure a stable regulatory regime for necessary grid infrastructure investments	• *Ensure that resources available from onshore wind activities (eg plants, human resources) are mobilized – also "enabler"* • Ensure financial capital in innovative concepts • Ensure that new competencies needed are timely formed

* cf. Wieczorek et al 2015, 2013 and Jacobsson and Karltorp, 2013.

Policy challenges in italic are more specific to Portugal and result from author's analysis, namely to the the surveyed documents (PO14R, PO14P).

It is worthwhile noting the importance given to the internationalization of the industry in both cases, as well as to the spillovers from the development of other maritime activities and to the complementarities with the existing sectors in the case of Portugal. These policy challenges depend on the motivation and formation of expectations around floating offshore wind, which interact with the legitimation process.

In particular, the table suggests that stable regulation (legitimation) can directly help with the mobilization of human and financial resources and indirectly contribute to market formation. The latter stems namely from the alignment of market opportunities in several member states, highlighting the international vocation of this technological innovation system.

Table 5 Support mechanisms and grid connection regimes for offshore wind energy in selected countries. Source: Higgins and Foley, 2015; Veum et al., 2011; FOWIND, 2014; Mizuno, 2014; www.res-legal.eu

Country	Main support mechanism	Support level (€/MWh)	Additional incentives	Responsibility for grid connection
European	*countries*			
Denmark	Tender + feed-in premium	1.05 DKK/kWh (approx. 14€/MWh) for first 20 TWh limited to 20 years (result of the last tendering process)	Capital grants for R&D co-funding for R&D and demonstration projects through tender process	TSO
France	Tender + feed-in tariff	15 – 200 €/MWh (result of the first tendering round)	Capital grants (e.g. "grand emprunt")	Developer
Germany	Feed-in tariff or feed-in premium	39-154 €/MWh according to the duration for a maximum of 20 years	Soft loans public German KfW bank for first 10 parks Training programs for installers Capital grants for RD&D	TSO
Netherlands	Tender + sliding feed-in premium	Difference between bided price and 2/3 of the long term average electricity price (up to a predetermined strike price corrected with factors for depth and distance to shore) over 15 years	Soft loans and tax incentives Support to training programs Capital grants for R&D	Developer (currently under debate)
Norway	Capital grants	Currently no support incentives for development of offshore wind parks. Joint Norwegian-Swedish certificate trading scheme introduced January 2012. However, the certificate price is too low (falling below 20€/MWh in the middle 2016) to be attractive for offshore wind energy (OWE) developers. Additional support for OWE not yet identified.	Capital grants for demonstration projects	Developer
Portugal	Feed-in-tariff	168 €/MWh (Portaria n.º202/2015, Portaria n.º 286/2011) (demonstration and pre-commercial phase)	Capital grants (e.g. NER300)	TSO (derogation for project Windfloat)
Spain	Either a feed-in tariff or feed-in premium (suspended since 2012)	Currently suspended	Support for training and education	Developer
UK	Feed-in premium (contracts for difference) replace quota obligation (ROC) in March 2017	1.5 Renewable Obligation Certificates (ROCs) per MWh over 20 years (2 ROCs typically in Scotland, raising to 3.5 ROCs for floating offshore wind demonstrator projects in Kincardine) average ROC price £42.73 (approx. 56€) (June 2014)	Climate change levy Capital grants	Developer
Non European	*countries*			
Japan	Feed-in tariff	36.000 JPY (approx. 264€) per MWh	NEDO grants for research and demonstration	Developer
US	no/n.a.	Power purchase agreement (last Cape Wind contracts with NSTAR and National Grid approved by Massachusetts Public Utilities Commission for 27.5% and 50% of production over 15 years)	DOE grants for RD&D and deployment	Developer

TSO – transmission system owner; RD&D – research & development and demonstration. n.a. – not available.

[a] http://www.capewind.org/when/timeline

Table 5 reviews the incentives schemes to offshore wind energy, including in deepwaters. The most active countries in deepwaters – UK, Portugal and Japan – have set clear targets and timelines for deployment (Appendix 2). They approved feed-in tariffs (with and without tenders) above 150 €/MWh and attribute capital grants for R&D and demonstration. Yet developers must pay for the grid connection in all countries with the exception of Portugal, where the developer obtained from the government the support to the costs with the connection of the offshore farm to the electricity network.[7]

In summary, the existence of official targets and timelines typically accompanies the enactment of incentive mechanism which are intended to support the formation of the early markets. More research is still needed to understanding the capacity of roadmaps to affect the performance of the other key functions for system up-scaling, namely resource mobilization and materialization, whose fulfillment could be assessed with more data in the future.

4.3.4 Methodology to map legitimacy and guidance

The previous section shows the importance of both functions legitimacy and influence in the direction of search to accelerate the growth of emerging innovation systems. However, these two processes are difficult to measure quantitatively and the analysis remains mainly qualitative.

We propose to advance one step further in our content analysis and operationalize the study of the effect of roadmaps in both guidance and legitimation. For that purpose, we take the attractiveness of the sector to companies from other sectors (especially from other countries) as indicator of direction of search, and the degree of regulatory alignment and participation as indicator of legitimation (Bergek et al., 2008a; Borup et al., 2013). We draw these indicators directly from the definition of the functions. In particular, we use government participation in the roadmapping as a proxy of legitimation. We acknowledge the problem of regulation simultaneously signaling legitimation and influencing the attractiveness of the sector (potential endogeneity issue), but we come back to this issue later. The analysis compares the roadmaps in these two dimensions and relates them with contextual information concerning the plans for the size of the system and timing for deployment.

As regard guidance, it is interesting to note that the roadmaps present different expectations concerning the involvement of foreign companies. Although every roadmap aim to develop a strong and internationally competitive local technological innovation system, the foreseen degree of participation of foreign players varies among countries, with the most opened

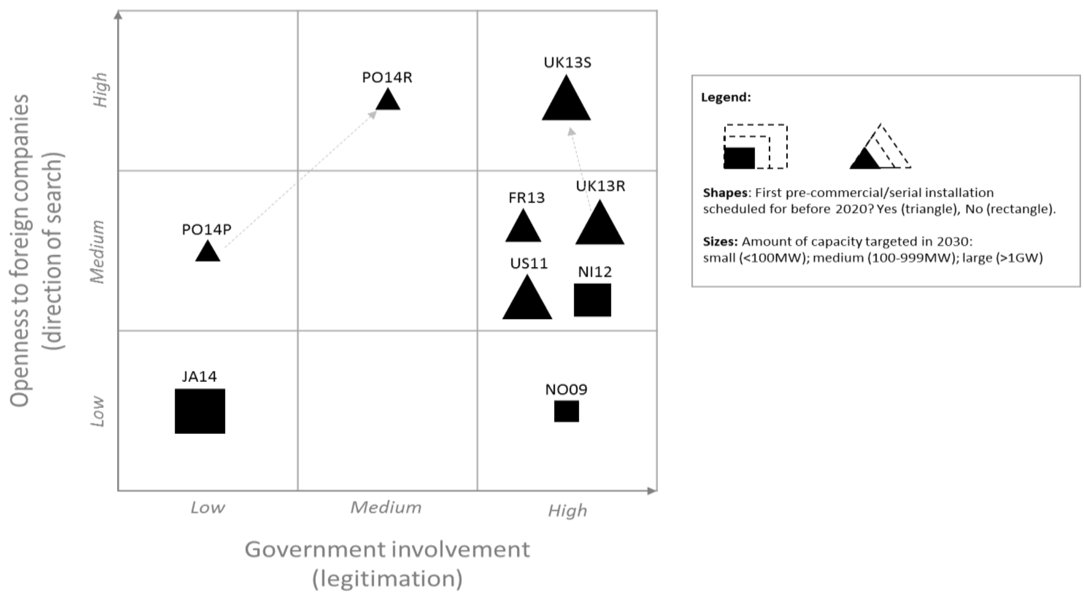
[7] cf. Resolução do Conselho de Ministros 81-A/2016, 9 December 2016.

plans in the UK and the closest ones in Japan. As a consequence, the attractiveness of the sector changes depending of the nationality of the actors what should influence the development of the local systems.

The initiative of the roadmaps affect their legitimation role. In terms of the origin of the initiative – government or actors' coalitions – there may be a trade-off between policy effectiveness and achievement of broader consensus. Government-led roadmaps are more likely to conduct to supportive policies. However, they may be more top-down processes - even if some have a broader participation - thus being less effective in committing actors with the paths proposed. Actor participation and large consensus are two factors that enhance the credibility of roadmaps (McDowall, 2012). In some circumstances, an official entity takes the role of "system builder" and steers the development process in collaboration with the actors. Kern et al. (2015) mentions the positive role that the Crown Estate in the UK had in coordinating development and actors, what arguably favored the boom of offshore wind energy in this country.

Therefore, we classify the roadmaps and technological plans in terms of the government involvement in their creation (boosting legitimation) and the degree of openness to foreign actors in the guidance (Figure 8). The latter reveals important information concerning the country level strategy for the development of the system.

Figure 8 - Stylized representation of the roadmaps and equivalent documents according to the government involvement in their creation and openness to foreign companies



Source: roadmaps and documents alike listed in Table 1. Countries were sorted in terms of "Openness to foreign countries" according to the stated preferences for domestic manufacturing and expected development of actors & networks, reported in Appendix 2. Regarding "Government involvement" in the roadmap creation, countries were sorted following the information in the line "Initiative" of Appendix 2.

Two main insights can be drawn in this respect. First, the position of the document in the figure is independent from the technological advance of the country – see, for instance, the change from PO14P (*project*) to PO14R (*roadmap*). Nor the expected capacity of the system (size of the symbols) explains the degree of openness of the strategy adopted in the roadmap.

Second, government involvement and proximity to deployment increase the openness to foreign companies – compare, for example, JA14 with UK13R (*roadmap*) and UK13S (*action plan/strategy*). Note the evolution of the UK's position from the roadmap (an updated version of the 2011 document) to the more concretely defined action plan. The degree of openness is higher with the proximity of deployment (shape of the symbols); note that no triangle appears in "low" openness. Therefore, the results seem to reinforce the earlier conclusions about the influence of contextual structures (Bergek et al., 2015), particularly concerning the political involvement and the effect of more advanced technological contexts.

The analysis provides a first approximation to operationalize two crucial system functions such as legitimation and influence in the direction of search. It focuses on key differences in the strategies preconized by the roadmaps and relates them to the initiative of the documents. This allowed us to draw useful insights about the content and effectiveness of the functions. The evidence analyzed here raises valuable hypothesis to be investigated in future works, namely concerning the determinants of the openness of emerging technological innovation systems.

The conclusions are still preliminary and have some limitations. For instance, the number of observations is naturally small and constrained by the availability of roadmaps and technology plans available. The results can reveal cultural differences towards the international openness of the country rather than specific strategies concerning the floating offshore wind technology. Other factors may also intervene such as the evolution of expectations over time. The opinions of the actors can diverge from the stated expectations for several reasons (e.g. low participation process, type of actors, inflated expectations). For that reason, we compare the findings from the roadmaps analysis with the results from a survey in section 5.

The analysis suggests that the fulfillment of one function (legitimation) can change the content of other function (guidance). This result holds if the strategy of companies can be analyzed separately from the government involvement, i.e. if the influence in the direction of search and legitimation are really two separated functions (ontologically differentiated). The theory assigns public opinions and institution preferences to legitimation, and policy action plans and collective strategies to guidance. However, this distinction is still unclear at the conceptual level, and more so for the analyst in the practice. More research is needed in the substance and interdependencies of these two functions.

5. CONFRONTING THE OPINION OF ACTORS WITH ROADMAPS

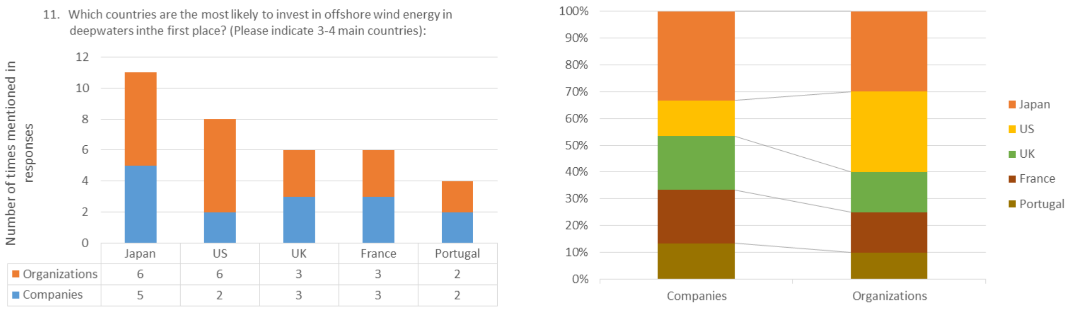
We performed an opinion survey to understand the actors' expectations about the up-scaling of the technological innovation system and to compare with the roadmaps analysis.

The questionnaire goes along the same lines of the roadmap analysis - inspired in the basic TIS framework of structural analysis and functional analysis - with questions about the expectations on development, strategies pursued to overcome the challenges and perceived role of roadmaps (see Appendix 3). We acknowledge the problems with the qualitative subjectivity of individual valuations in questions that, for instance, ask actors about their assessment of the effectiveness of roadmaps in a scale from 1 (very low) to 5 (very high). Even though this fact limits the generalization of the findings, these questions provide valuable information about the perceived influence of roadmaps in the practice that would be difficult to extract otherwise.

We have identified a total of 68 active entities in the field of offshore wind energy in deepwaters worldwide. The entities comprise companies (e.g. technology providers, developers) but also organizations (e.g. research centers, government agencies, consultants). These entities were chosen because they were members of demonstration projects, reported interest in the technology in newspapers, or even published reports in the field. The sample is representative, but not exhaustive, of the main actors that operate in this emerging technological innovation system globally. The rate of responses is 18% overall (12 replies), which varies according to the type of actors: 7.4% for companies (5 replies on 40 contacts) and 25% for other entities or organizations (7 replies on 28 contacts). Companies are more careful to release information that could reveal their strategy in this emerging business.

In comparison with the roadmaps analysis, the surveyed actors' opinions converge with the roadmaps in several points. Technology development is at pre-commercial stage according to both sources. The barriers to overcome are similar and mainly deal with cost reductions, access to financial capital, standardization and grid connection. The actor's opinions also agree with the roadmaps in that the first markets should be in Japan, United States and United Kingdom (ca. 70% of the opinions) (Figure 9).

Figure 9 – Countries were commercialization will first start



The actors' opinions converge on the perception about the capacity of roadmaps to influence both policies and the system development (not shown, see directly in Appendix 3). Despite the subjectivity of valuation in a scale of five points, the average mean is 3.4 (standard deviation: 1.1) which is the same for both companies and organizations. This value is far from the two extremes 1 (very low effect) and 5 (very high). Therefore the general perception is that roadmaps have a positive, though limited, impact on technology development.

The main differences in opinion appear in the responses to central questions given by companies and other entities (hereafter: organizations). Companies are clearly more optimist than organizations concerning the availability of system resources (Figure 10). No company mentions the lack of core resources or the absence of a coherent system. Companies also expect relatively faster and more important cost reductions which would allow floating offshore wind to become competitive more rapidly (Figure 11). As a consequence, they are more optimist concerning the commercialization, which they expect to start before 2020 (Figure 12). In contrast, 70% of the organizations report that the competitiveness of floating is very uncertain or will never happen at all. In addition, companies and organizations differ on the prime movers that pull the investment in deeper waters (Figure 13). Companies underlines the higher wind resource potential as the main driver, whereas organizations primarily points to the lower social resistance to installations.

Figure 10 – Availability of system resources

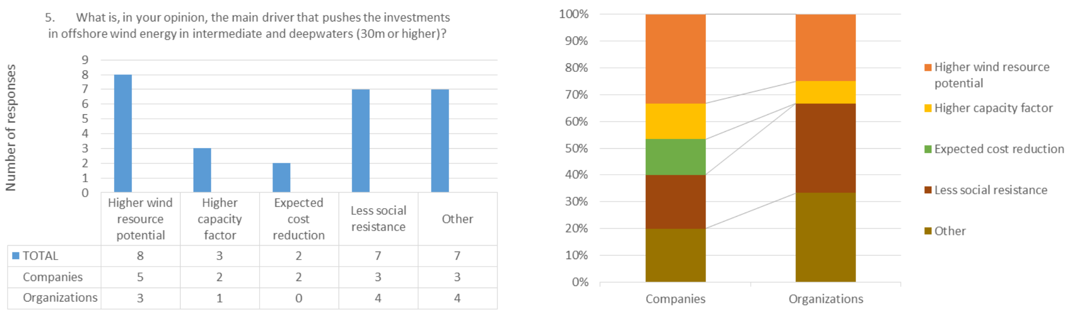


Figure 11 – Cost reductions and technology competitiveness

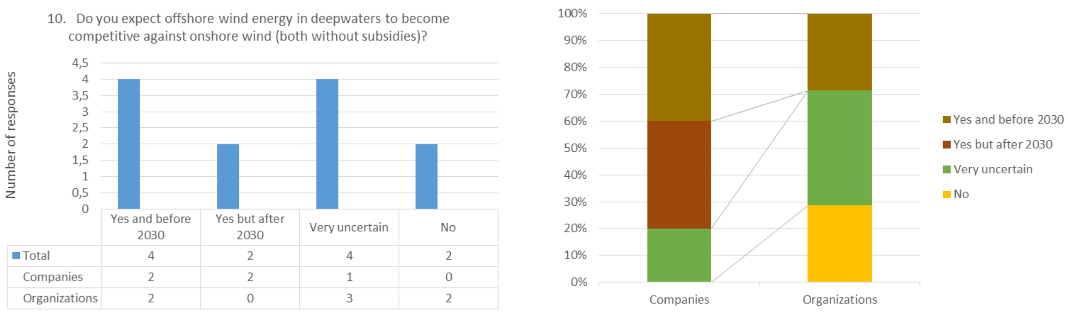


Figure 12 – Expected year of commercialization

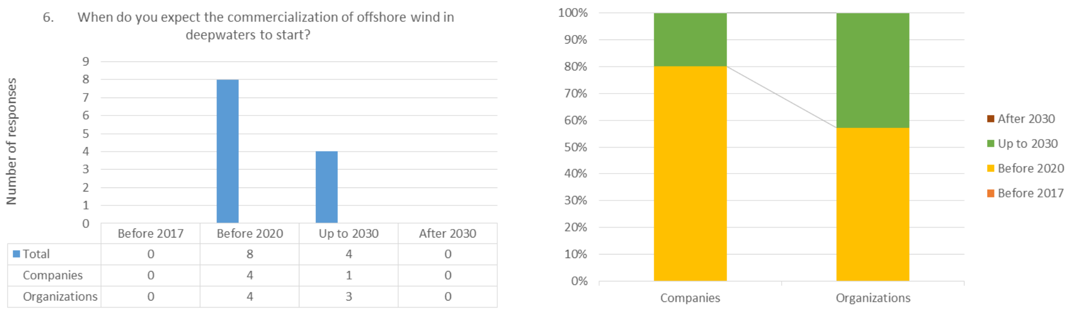
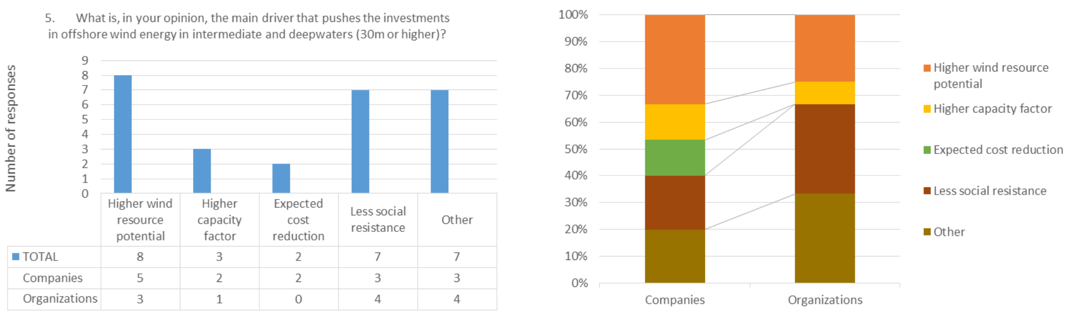
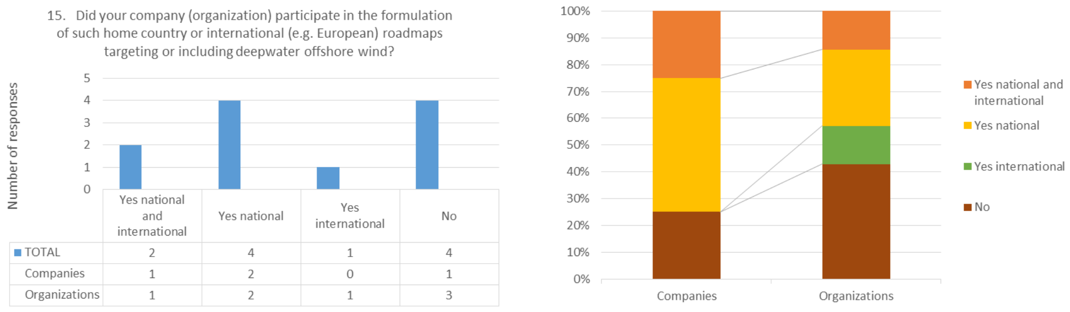


Figure 13 – Drivers of investment



Overall, we find that, along with the general perception that roadmaps have a positive (though limited) impact on technology development, the opinions of companies are more closely aligned with the visions and strategies expressed in the roadmaps. Their positions may have prevailed in the consensus that was in the basis of the roadmaps. Participation contributed to this result since the surveyed companies were relatively more active than the organizations in the formulation of the roadmaps (Figure 14).

Figure 14 – Participation in roadmapping



6. SUMMARY OF THE FINDINGS

The roadmaps analysis reveals great similarities in the way they foresee the system's transformation. Similarities can namely be found in what concerns:

- expectations regarding the acceleration of innovation (more "linear" visions of succession of pilot stage, pre-commercialization stage and commercialization stage);
- main barriers and obstacles to address;
- focus on technological requirements: demonstration of full-scale operating systems; cost reduction and standardization; development of an industrial value chain (even in countries where the innovation system is more immature);
- recognition of the need to expand networks (size and scope) and align actors in order to create the value chains;
- priority areas of action, including the development of competencies and standardization;
- critical role of policies to achieve goals;
- focus on domestic development (frequently seeking for prime-mover advantages).

These similarities denote a convergence of visions and of generic strategies to achieve them. They signal a shared perspective on the "structuration" of the innovation system, as part of the process of up-scaling and transition to the main markets. Interestingly, this convergence is also visible in the case of countries whose system is still in a more embryonic stage, but whose visions and proposals take as reference the processes taking place in more advanced contexts (e.g. France in relation to Japan and the UK).

There are nevertheless some differences in the more specific goals and strategies set up by the countries, which can be related to different internal conditions. These include, namely, the weight of renewable energies, the performance of offshore activity (e.g. offshore wind or oil & gas), industrial specialization (e.g. level and type of activity in complementary sectors along the value chain), country resources that can be mobilized and organization. While the roadmaps are always overtly optimistic, they appear to attempt to propose visions and paths that are adjusted to the stage of development of the system and that might be "reasonably" pursued given the country specific conditions. As mentioned above, they foresee different levels of involvement of foreign companies. There are also differences concerning the origin of the initiative and actor inclusiveness, which, as pointed out above, can influence the role of roadmaps as sources of legitimation.

These findings provide support to the hypothesis under which the strategies convey in roadmaps are determined by the technological and socio-economic context (Bergek et al., 2015). The roadmaps analysis shows that roadmaps are one important instrument, even if not the only one, for the performance of key system functions, such as legitimation and guidance, in the transition to growth. The analysis further suggests that these two functions are crucial for technology upscaling, mainly through their influence in the performance of the other functions, but more research is still needed on the nature of the underlying processes. The survey of actors' opinion already provides some insights into this question. The survey indicates that roadmaps have a positive but limited influence in technology development. In particular, it reveals that roadmaps tend to align more closely with the visions of companies, and the tendency to overinflate expectations often associated with the predominance of this type of actors.

7. CONCLUSION

Despite the large recognition of the role of visions and legitimacy in technology development, there are few studies focusing on these factors that determine the upscale of emerging energy innovations. This paper seeks to understand the process of preparing the acceleration of growth of new technological systems.

We take a systemic approach by using evolutionary inspired theories of socio-technical transitions, especially technological innovation systems. The TIS framework takes into account the interdependencies and institutional requirements in the formation of new technologies. It particularly underlines the establishment of constituent structures and the performance of key innovative processes or functions, including the influence in the direction of search (or guidance) and legitimation. The literature suggest that these two functions are particularly important for the mobilization of resources, the formation of demand, and the acquisition of political strength that are needed for technology up-scaling and growth (Aldrich and Fiol, 1994; Negro et al., 2012; Wilson, 2012).

We operationalize these two key processes in the context of technology growth through the analysis of roadmaps. These are instruments of creation (legitimation) and sharing (guidance) of collective strategies. Roadmaps are not the only tools for the coordination of visions and strategies, but they can provide insights into the process of preparation for technology upscaling. We apply this framework in the analysis of the development of offshore wind energy in deepwaters (or floating), an emerging technology that is entering the upscaling stage.

The contribution to the literature is twofold. First, this paper contributes to the understanding of the TIS dynamics and especially the period of transition to growth. In so doing, the paper helps in the recent efforts to conceptualize lifecycles in the TIS theory (Markard, 2016). Second, the paper provides an empirical contribution by developing a methodology to analyze roadmaps and their role in the performance of legitimation and direction of search.

We have hypothesized that: i) guidance and legitimation are critical functions in the transition to growth, and can assume specific forms as part of this transition; ii) roadmaps are good indicators of these functions; and iii) the context influences roadmaps (the roadmapping process) and the fulfillment of the critical functions.

First, the analysis supports the expectation that influence in the direction of search and legitimation are crucial functions in the transition to growth. These functions have been identified in the theory as especially important to accelerate system building by helping to fulfill other functions, such as resource mobilization and market formation. In the case of floating offshore wind, we provide evidence of the materialization of collective visions and strategies through a process of "agenda setting" and codification in reports and roadmaps, which contain recommendations that aim to establish the guidelines for growth as well as to influence the regulatory framework.

Second, the results show that roadmaps are reasonable indicators of legitimation and guidance. They inform on how the actors expect the system to structure (e.g. build up of value-chains). Roadmaps convey a strategy - more or less consensual, depending on the roadmapping process and the degree of actor involvement - for technology growth and aim to improve the attractiveness to actors from other sectors, thus influencing the direction of search. Roadmaps are also indicators of legitimation which can be more formal (official) or informal (lobbying) depending on whether the initiative of the roadmap originates from, respectively, the government or the companies.

According to the literature, the effectiveness of the roadmaps rely on the quality of analysis and actor inclusiveness (McDowall, 2012). Roadmaps are intrinsically optimistic and there is a risk of overpromising which may undermine their credibility and utility (Brown, 2003). In addition, less inclusive roadmaps risk to reflect the interests of specific groups (excluding some others). The origin of roadmaps - government led versus actors' initiative - affects their content and capacity to influence the regulation. We find that roadmaps vary in both these respects (quality and inclusiveness).

We compared the expectations stated in the roadmaps with the actors' opinions obtained from a survey. We find that roadmaps align in several domains (e.g. system readiness, market take-off, cost reductions) with the vision of companies, whose opinions may have prevailed in the process of collective vision building. In addition, the general perception is that roadmaps have a positive, though limited, impact on technology development.

Third, we find that the socio-economic and technological context determines the visions and strategies conveyed in the roadmaps. For example, the roadmap analysis points to different types of guidance, in particular to an increasing degree of external openness with government involvement in roadmapping and approximation of technology deployment.

The results have several implications for technology policies. Policy-makers should pay attention to the process of formation and dissemination of expectations. Roadmaps reflect shared visions and strategies to accelerate system development, and thus they can be instruments of transition policy (McDowall, 2012). In case of roadmaps from government initiative, policy-makers should ensure a highly participatory and inclusive process. Otherwise, if the roadmap originates from the companies initiative, policy-makers should consider the promises in the roadmaps with caution given the risk of overinflated expectations. Policy-makers should also be aware that roadmaps may reproduce the opinions of the most powerful companies whose preferences often prevail in the negotiation process. Therefore, gathering information on the process of roadmapping (e.g. participation), as well as comparing the chosen strategy with alternative technological paths is highly recommended.

Future research should investigate in more detail the process of elaboration of roadmaps. The quality and degree of inclusiveness of roadmaps impact on their capacity to contribute to the performance of critical system functions. For example, in the future, it would be possible to relate the quality of the roadmaps to the structuration and development of the TIS around floating offshore wind. This would allow us to understand to which extent the TIS development was driven by the roadmaps and national plans, on the one hand, or by dominant trajectories and fortuitous events (path dependency), on the other hand.

In addition, we find some circularity in the definition of the functions. In particular, regulation is an indicator of the function "legitimation" at the same time that affects expectations and strategies of companies, and thus the function “influence in the direction of search”. This problem is clearer in the analysis of the indicators and events associated with these two functions in the practice. The reasons for their separation are far from obvious and more conceptual and empirical research is needed on the ontological roots of this distinction.

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9. APPENDIX

APPENDIX 1. FRAMEWORK TO ANALYSE ROADMAPS

ROADMAP FEATURES

Type of document (Roadmap; National Plan…)

Focus (Floating offshore; Offshore wind; Ocean energies, etc.)

Initiative (government, stakeholders' coalitions, companies, etc.)

Indicate who participated in formulation?

Date (start & publication if available)

Follow-up procedure?

CONTEXT

Identify main national policies concerning energy and climate change? (including renewable energies)

Identify electricity market reform as a driver?

Estimate benefits? (resource potential, job creation, etc.)

Define (contextual) obstacles to deep offshore wind? Strategy to address them?

FUNCTIONS

Influence on the direction of search

Document helps networks of actors and institutions improving the visibility of the offshore wind development? How?

Set technology development goals and time frame?

Define steps? (Y/N) Establish goals or milestones for different steps?

Present future outlooks of offshore wind energy against competing technologies?

Preference for domestic manufacturing (explicit)?

Legitimacy

Did roadmap formulation process and proposals contribute to increase legitimation? In particular, by helping in the formation of a vision and expectations?

Is the regulation (e.g. codes and standards) sufficiently developed and aligned with the needs of technology up-scaling?

How much resistance is faced by the technology before and after receiving permit?

Knowledge development

Are there gaps in (national) knowledge and competences needed for the growth and acceleration of the innovation system?

Are the number and diversity of actors involved in knowledge development enough?

Entrepreneurial experimentation

To what extent did technology start to be up-scaled?

Are there enough actors active in the emergence and up-scaling?

Are the actual plans of experimentation adequate?

Resource mobilization

Is financial capital (public and private) sufficiently available?

Is there enough human capital in number and diversity?

Materialization

Are there already plants for equipment production?

Is the physical infrastructure already (or in a timely manner) in place?

Market formation

Are market prospects sufficient to sustain innovation and entrepreneurial experimentation?

Is the size of the internal market sufficient to develop floating offshore wind?

STRUCTURE DEVELOPMENT

Technology

Sepecify technological specific goals? (efficiency, reliability, etc.)

Identify development phase of system? (Phaal's framework)

What type of barriers are preventing a more rapid technology up-scaling? Costs? Low standardization?

Actors

Which actors are presented as necessary to accelerate process/achieve goals?

- Already in the system?

- Needing to be involved (why?)

Refer to the involvement of society: e.g. social acceptance and participation?

Identify key actors? Explain the roles to be played?

Identify leadership?

System dimension?

Networks

Identify value chain that needs to be built?

Types of alliances that are referred as needing to be established: within the system; with actors external to the system; with other systems? (why?)

Nature of networks: business; research & technology; intermediation; policy lobby; (or mixed)

Refer to network's coordination? (e.g. actors with central role in networks)

Explicitly refer to the need to align actors?

Institutions

Have policy makers been involved in the process of development of roadmap/plan (as participants; only consulted over proposals)?

Indicate policies that need to be introduced? (when; how if not government-led)

Refer to regulation that needs to be set up (technology specific; complementary – e.g. ocean energy/marine spatial planning)?

Refer to the need to establish new standards? How?

APPENDIX 2 – ROADMAP ANALYSIS

A1 - Roadmaps from stakeholder initiative – features and context

	Document	**"Technological RoadMap by the Technological Observatory for the Offshore Energies" (OTEO)**	**"Demowfloat - Demonstration of the WindFloat Technology"**	**"Target & roadmap for Japanese wind power"**
	Country	**Portugal**	**Portugal**	**Japan**
	Code	**PO14R**	**PO14P**	**JA14**
Roadmap features				
	Type of document (Roadmap; National Plan…)	Roadmap	Project report (presentation)	Roadmap
	Focus (Floating offshore; Offshore wind; Ocean energies, etc.)	Ocean energies (including deep offshore wind)	Floating wind offshore	Wind power (onshore and offshore)
	Initiative (government; stakeholders' coalitions; companies, etc.)	Partnership between a coalition of stakeholders (OTEO - Technology Observatory for Offshore Energies)	Organizational roadmap (companies)	Japanese Wind Power Association
	Indicate who participated in formulation?	OTEO partners as well as private and public organizations that integrated a "consultation committee" or participated in workshops	Project partners: EDP Inovação, A.Silva Matos, LNEG, WAVEC, ISQ, CaixaBI, Principle Power, Repsol, Vestas, Damen Shipyards, SgurrEnergy	Wind power industry
	Date (start & publication if available)	2014 (project started in 2011)	2014 (project 2011-2014)	2014
	Follow-up procedure?	Yes. Defines issues to be further developed in next stages; software tools for follow-up; is the follow-up from a previous roadmap	No	No
Context				
	Identify main national policies concerning energy and climate change? (incl. renewable energies)	EU targets defined in SET plan, 2050 Roadmap (e.g. 75% share of marine energy on final energy consumption by 2050) and Europe 2020 (e.g. 20% of renewable energy), and national pilot zone, ENE2020 (60% of renewable electricity and 31% of green energy), PNAER 2013, national strategy for the sea (2014)	No	JPWA's target for (all) wind energy: 20% of total electricity supply by 2050
	Identify Electricity market reform as a driver?	No	No	Yes
	Estimate benefits? (resource potential, job creation, etc.)	Refers to job creation, security of supply improvement, creation of an industry cluster, technological leadership, future low cost and clean energy	Mentions resource potential (high offshore wind resource and with less turbulence)	Yes. Available offshore wind energy estimated at 156GW (fixed turbines) and 300GW (floating turbines). Direct costs estimated JPY2.3 trillion; economic benefits estimated at JPY4.5 trillion with creation of 290,000 jobs, by 2050. Potential of CO2 reduction estimated at 99 million ton-CO2 (equivalent to 7.7% of the 5-year average in 1st commitment period of the Kyoto Protocol) (estimates for onshore & offshore wind)
	Define (contextual) obstacles to deep offshore wind? Strategy to address them?	Excess of generating capacity, financial crisis. Strategy to address the excess of production through interconnection reinforcement with central European power markets	No	Yes. Most important bottleneck: power grid constraints. Strategy: action on power grid operation/better inter-regional coordination, grid strengthening and wind power output prediction; adoption of output control systems in wind farms.

A2 - Roadmaps from stakeholder initiative – Functions & Structure

	Document	"Technological RoadMap by the Technological Observatory for the Offshore Energies" (OTEO)	"Demowfloat - Demonstration of the WindFloat Technology"	"Target & roadmap for Japanese wind power"
	Country	**Portugal**	**Portugal**	**Japan**
	Code	**PO14R**	**PO14P**	**JA14**
Functions				
Influence on the direction of search	**[document] Helps networks of actors and institutions improving the visibility of the offshore wind development? How?**	Builds on vision created in earlier Roadmap (cf.FCT, 2013) to identify actions, costs and timelines. Visibility improved through actors' participation in formulation of proposals and their communication	Yes, by stating the drivers for deep offshore and demonstrating the concept's feasibility	Yes sets a clear and justified framework that aims to influence the official targets which are to be announced soon
	Technology development goals and time frame?	27MW by 2020 (NREAP) but needs targets to 2030 and 2050 ideally coherent (and stable) with European goals	24-28MW installed by 2017 (funded by NER300)	Offshore wind could cover half of the total wind capacity by 2050 (75GW) with 19GW using fixed-bottom turbines and 18GW by floating turbines
	Define steps? (Y/N) Establish goals or milestones for different steps?	No	2MW floating turbine successful demonstration of the first (phase 1, accomplished)	Offshore wind only: 0,7GW (of which 0.1GW of floating) by 2020; and 10GW (of which 4GW of floating) by 2030
	Present future outlooks of offshore wind energy against competing technologies?	No	No	No
	(explicit) Preference for domestic manufacturing?	Yes (70% national inputs is arguably possible)	Yes ("industrialization" as a main objective)	Yes. The participation of foreign companies is never mentioned along the roadmap.
Legitimacy	**Did Roadmap formulation process and proposals contribute to increase legitimation? In particular, by helping in the formation of a vision and expectations?**	Yes, since the roadmap formulation involved key actors, was informed by reliable analysis and its proposals are clearly justified. But stresses that vision & proposals need to be endorsed by government	Yes by defending a technological deployment plan	Yes. This roadmap helps to establish the vision for the development of the sector
	Is the regulation (e.g. codes and standards) sufficiently developed and aligned with the needs of technology up-scaling?	n.a.	No	n.a.
	How much resistance is faced by the technology before and after receiving permit?	Mentions the need to avoid resistance by involving communities and diffusing more information	Not mentioned (but attempted to avoid resistance by actions directed to population, (e.g. "interpretation center" in location)	Not mentioned (but independent reports point to the potential resistance of the powerful fishery industry)
Knowledge development	**Are there gaps in (national) knowledge and competences needed for the growth and acceleration of the innovation system?**	Yes. Low experience in offshore energy, limited resource assessment, lack of competences in some of the complementary sectors along the value chain	Oil & gas competencies need to be transferred and optimized for offshore wind. Improve technology reliability in aggressive environments. Improve learning on manufacturing, installation and O&M	Strong knowledge and research assets in core components such as turbines and structure foundations
	Are the number and diversity of actors involved in knowledge development enough?	Yes. But need to further strengthen and diversify extant skills with new competencies such as from the offshore oil & gas	n.a.	Yes. Extensive number of local companies with diversified competencies in the manufacturing of components , installation, covering a large range of the all supply chain
Entrepreneurial	**To what extent technology started to be up-**	Moving from prototype installation (1x 2MW) to pre-	Moving to pre-commercial phase, from 2MW	2 full-scale floating turbines in operation;

experimentation	**scaled?**	commercial farm (3-4x 6-8MW)	to 25MW	plans for deployment at a higher scale
	Are there enough actors active in the emergence and up-scaling?	No. Need test center; to develop maritime transport and attract actors from all areas along the value chain	n.a.	Yes
	Are the actual plans of experimentation adequate?	Yes. Provides a rationale for the categorization of technological readiness levels provided	Yes	Yes
Resource mobilization	**Is financial capital (public and private) sufficiently available?**	Financial charges compose roughly half of the cost of offshore wind energy because of perceived risks. Access to finance could be improved namely by streamlining permitting and clarifying legislation. Mentions need to increase public support	Yes. EU-NER300 and Portuguese environmental agency (but needs to be matched with private capital which in some cases may be challenge to raise)	n.a.
	Is there enough human capital in number and diversity?	No. Qualified workforce is presented as a national advantage but training and education programs (especially at operational level) still required	No ("understand necessary skills" as another goal of the project)	This should not be a problem considering the number and the diversified nature of companies already active in the field
Materialization	**Are there already plants for equipment production?**	Yes (perspectives)	n.a.	Yes
	Is the physical infrastructure already (or in a timely manner) in place?	Ports and shipyards available, electricity grid near the coast (but expensive new offshore interconnection), pilot zone, shipbuilding and repair	Expand an existing test field in the North of Portugal	No. Connection to offshore farms and inland grid reinforcements are needed
Market formation	**Are market prospects sufficient to sustain innovation and entrepreneurial experimentation?**	No. NREAP decrease from 75MW to 27MW by 2020	Yes (financing of pre-commercial phase as a bridging market)	Yes
	Is the size of the internal market sufficient to develop floating offshore wind?	It may not be sufficient. Search for output and services export	No mention (but previous presentation from '10 refers to the need of offshore to maintain 20% penetration of wind in PT)	Yes
Compontents	***Structure development***			
Technology	**Sepecify technological specific goals? (efficiency, reliability, etc.)**	4M€/MW in pre-commercial phase and reduce annual O&M costs to 3.5-4% of CAPEX	100 €/MWh (competitiveness, more long-term goal)	No
	Identify development phase of system? (Phaal's framework)	Nurture to A-M transition (economic validation demonstrators)	Nurture to A-M transition (show price-performance demonstrators)	No
	What type of barriers are preventing a more rapid technology up-scaling? Costs? Low standardization?	High capital costs: Windfloat prototype 11,5M€/MW to 4M€/MW expected in the pre-commercialization phase (vs 3-3,9€/MW of fixed offshore wind). LCOE is currently 0,15-0,20€/kWh	More aggressive offshore env. turn reliability even more challenging	Technological validation, grid constraints
Actors	**Which actors are presented as necessary to accelerate process/achieve goals?** **- Already in the system?**	Utility/developer (EDP), system operator (REN), research (e.g. LNEG, INEGI), companies with previous experience in wind energy or in ocean energies; ocean related agencies; foreign companies: technology provider (Principle Power); oil company with offshore experience (e.g. Repsol)	n.a. (though existing developers, complementary infrastructure (metal construction) and ports cited in previous presentations)	Arguably sufficient number of companies in the manufacturing and installation of wind turbines
	- Needing to be involved (why?)	Organizations with experience in the offshore - e.g. oil & gas companies or organizations operating in areas such as shipbuilding, logistics, transportation;	Oil & gas (when said based value chain and logistics need to be optimized)	No

		companies in other areas (e.g. mechanical construction, electrical equipment) whose activities can be partly redirected to offshore wind		
	Refer to the involvement of society: e.g. social acceptance and participation?	Yes	No	n.a.
	Identify key actors? Explain the roles to be played?	REN and EDP. Coordinate cluster creation: pilot test zone (REN); exports (EDP). Wavec: offshore association that integrates most key players in the field and participates in several international networks.	No	Government (METI, NEDO)
	Identify leadership?	Not clearly. But mentions need to define it.	No	No
	System dimension?	Small but growing	Small consortium	Large network (JPWA)
Networks	**Identify value chain that needs to be built?**	Refers to test centers, maritime transport (installation, operation and maintenance offshore), port logistics, manufacturing (including towers, cables)	No	No
	Types of alliances that are referred as needing to be established: within the system; with actors external to the system; with other systems? (why?)	Public / private collaboration (including formal partnerships). Alliances involving external actors from complementary areas (to bring them into system); synergies between various offshore energies	No	JPWA
	Nature of networks: business; research & technology; intermediation; policy lobby; (or mixed)	Observatory/intermediary (OTEO), collective org./ policy lobby (e.g. WAVEC); research networks (also international), business (supply chain) certification	No	Intermediate
	Refer to network's coordination? (e.g. actors with central role in networks)	EDP and REN, WAVEC. But refer to the need for greater coordination and leadership to achieve goals.	Demowfloat project promoters (project coordinated by EDP)	No
	Explicitly refer to the need to align actors?	Yes. Align national with European financial support, the variety of actors along the value chain, and government with stakeholders' vision and proposals	No (but project is described as an opportunity to engage national competences in various areas)	No
Institutions	**Have policy makers been involved in the process of development of roadmap/plan (as participants; only consulted over proposals)?**	Report addressed to policy makers. Representatives from relevant government agencies involved through consultation / participation in workshops	No (but Project supported with public funds – national and European)	No
	Indicate policies that need to be introduced? (when; how if not government-led)	Fund R&D for more immature concepts, support early deployment with capital subsidies and FIT, soft loans to develop supply chain, create test center & complete set-up of pilot zone, training programs. Policy makers asked to adopt the vision & support proposals.	No	Adopt this vision and support the deployment of capacity in the timelines suggested. Investment in grid reinforcement and wind integration
	Refer to regulation that needs to be set up (technology specific; complementary – e.g. ocean energy/marine spatial planning)	Conflicts of use expected to be solved by the new law (LBPGOEM). Need to overcome non-technological barriers by establishing clear rules (permitting, environment impacts)	No	No
	Refer to the need to establish new standards? How?	No	No	No

A3 Roadmaps from Government initiative – Features & Context

	Document	"Concerning an Act on Offshore Renewable Energy Production (the Offshore Energy Act)"	"UK Renewable Energy Roadmap 2011" [2013 Update]	"Industrial Strategy: government and industry in partnership"	"A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States"	"Offshore Renewable Energy Strategic Action Plan 2012-2020"	"Rapport de la mission d'étude sur les énergies marines renouvelables"
	Country	**Norway**	**United Kingdom**	**United Kingdom**	**United States**	**Northern Ireland**	**France**
	Code	**NO09**	**UK13R**	**UK13S**	**US11**	**NI12**	**FR13**
Roadmap features							
	Type of document (Roadmap; National Plan; etc.)	Strategy (legislative)	Roadmap	National (action) plan/Strategy	National plan	Action plan/Strategy	Strategy/roadmap
	Focus (Floating offshore; Offshore wind; Ocean energies, etc.)	Offshore renewable energy	Renewable energies	Offshore wind energy	Offshore wind energy	Offshore energies	Offshore renewable energies (excluding bottom-fixed wind)
	Initiative (government; stakeholders' coalitions; companies, etc.)	Government (Ministry of Petroleum and Energy)	Government (DECC)	Government	Government	Government (DETI)	Government (mission report)
	Indicate who participated in formulation?	n.a.	Office of Renewable Energy Deployment, industry, financiers, Devolved Administrations (among others)	Partnership government (DECC, BIS, UKTI) industry around newly formed Offshore Wind Industry Council (Scottish Power's CCO)	Federal agencies (DOI), industry stakeholders, public (possibly consultation level)	Governmental departments, stakeholders (incl. Marine sectors), public	Stakeholders (e.g. developers, manufacturers, fishery association) and experts were auditioned
	Date (if available start of process and data of publication of results)	2009	2011 [2013]	2013	2011	2012	2013
	Follow-up procedure?	Yes. Revised strategy expected in 2012 (but it's still not done in 2015)	Yes. Government updates the roadmap in an annual basis [Updated 2013]	No (but uses metrics to track progresses)	No (but uses metrics to track progresses)	Yes. Mid-term review in 2016. Other reviews expected post-2020	No
Context							
	Identify main national policies concerning energy and climate change? (including renewable energies)	The Norwegian climate compromise/agreement to achieve carbon neutrality by 2030	EU 2020 targets (15% of renewable energy or 30% in total electricity consumption) and 80% cut in emissions by 2050. The Scottish Government introduced a target of 100% renewable electricity by 2020	2008 Act and 2009 EU Renewables Directive translates into 30% of total electricity needs by 2020. UK carbon budget and EU ETS, with national carbon floors of 30GBP/t in 2020 and 70GBP/t in 2030.	2011 Obama's call for 80% of US elec. from clean sources by 2035	Strategic Energy Framework 2010 and the target of 40% of renewable electricity by 2020	Yes. Energy transition law (reduce 40% of CO2eq. emissions by 2030 and 75% by 2050; increase to 32% the share of renewable energy in final energy consumption by 2030 and 40% in electricity production)
	Identify Electricity market reform as a driver?	Adopts the principle that developers/generators	Yes, arguably designed in a cost effective way to meet	Yes	No	Yes, but with some adaptations to better	No

		and not should pay the offshore transmission grid rather than final electricity consumers	energy and climate goals and limit higher electricity prices to consumers			support deployment	
	Estimate benefits? (resource potential, job creation, etc.)	Technical potential is "very large" but no estimate is provided	Estimates 33-58 TWh of electricity production in 2020 (the highest range from the 8 RET identified that could provide 90% of the 15% renewable energy target to 2020)	Up to GBP7 billion of gross value added (excluding exports) and 30,000 direct jobs by 2021 . GBP 18 billion in 2050.	2,450GW offshore wind potential in water deeper than 60m (60% total). 54GW would create 43k permanent jobs in O&M.	900MW could potentially be tapped up to 2020	Potentially high considering the extension of the French maritime space (2nd in the world)
	Define (contextual) obstacles to deep offshore wind? Strategy to address them?	The electricity generation is already based on renewable energy (60% of energy consumption) and there are still cheap potential to tap on land	n.a.	This strategy broadly follows the recommendations of the Offshore Wind Cost Reduction Task Force report (2012).	High capital costs, energy cost; technical and infrastructure challenges; lack of site data experience in permitting processes. Strategy: OSWinD Initiative focus 3 areas: technology development, market barrier removal, advanced technology demonstration	Technological obstacles. As technology advances, areas in the North West coast with deeper waters may open in future leasing rounds	No

A4 - Roadmaps from Government initiative – Function & Structure

	Document	"Concerning an Act on Offshore Renewable Energy Production (the Offshore Energy Act)"	"UK Renewable Energy Roadmap 2011" [2013 Update]	"Industrial Strategy: government and industry in partnership"	"A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States"	"Offshore Renewable Energy Strategic Action Plan 2012-2020"	"Rapport de la mission d'étude sur les énergies marines renouvelables"
	Country	**Norway**	**United Kingdom**	**United Kingdom**	**United States**	**Northern Ireland**	**France**
	Code	**NO09**	**UK13R**	**UK13S**	**US11**	**NI12**	**FR13**
Functions							
Influence on the direction of search	**Helps networks of actors and institutions improving the visibility of the offshore wind development? How?**	To a limited extent. Establish key principles for planning/ construction but no target for capacity deployment	Yes. Set a timeline for potential deployment. Work with forum of developers to support creation of supply chain	By clearly setting the size and timing of future market developments, particularly up to 2020	DOE's funded (university) research on public acceptance	Yes. Set goals defining development areas and leasing rounds Streamline consenting process	Yes. Suggests a potential timeline for demonstration and deployment.
	Technology development goals and time frame?	No	13-18GW	18-39W by 2030 (upper limit); GBP125 /MWh (lower limit). Costs could reach GBP60/MWh by 2050	54GW at $0.07/kWh by 2030	600MW by 2020 and beyond	First 100-300 MW floating wind farms could be operational by 2025 (call for pilot plants to be published 204-2015)
	Define steps? (Y/N) Establish goals or milestones for different steps?	No	upper bound (18GW) if cost reduce to GBP100/MWh by 2020	8-16W by 2020 at GBP100/MWh	10GW at $0.10/kWh by 2020	No	No
	Present future outlooks of offshore wind energy against competing technologies?	Decision dependent on reduction of costs and competitiveness against other technologies	Yes, costs compare (negatively) with other RET. Refer to need to reduce them	No	Yes	Not directly	Selection mechanisms will retain the most technically efficient & economic offshore RET
	(explicit) Preference for domestic manufacturing?	Yes	Yes	Yes. Aims to get sufficient UK content to deliver 70% CAPEX	Yes	Yes	Yes. Development of the national offshore energy sector
Legitimacy	**Are actors and institutions contributing to increase legitimation? In particular, by helping in the formation of visions and expectations?**	Broad principles are set in the Bill, which might not be sufficient to construct a vision on the development of offshore wind	DECC and OWDForum work together to construct a vision for development of sector: increase security of supply; open business opportunities, create jobs, increase exports.	Yes. The strategy sustains an underlined vision for the UK offshore wind industry	Government establishes this guide (vision)	Government present s (shared) vision for the development of offshore renewable energies	Proposes a series of strategic orientations which, if endorsed by government, should define the vision for sector development,
	Is the regulation (e.g. codes and standards) sufficiently developed and aligned with the needs of technology up-scaling?	The adoption of standards for technical structures is authorized and should be started	n.a.	No. Standards are still needed to drive progress and develop the supply chain	No. Needs to develop regulation (e.g. codes, environmental procedures)	n.a.	No. Simplification of legislative/administrative processes. Coordination with other .usages

	How much resistance is faced by the technology before and after receiving permit?	n.a.	Aims to prevent potential conflicts with oil and gas explorations.[Acknowledge low public resistance]	Mention the need for improving public perception to reduce resistance to offshore	n.a.	n.a.	Good public acceptance. Minor conflicts with other sea activities & environment associations
Knowledge development	**Are there gaps in (national) knowledge and competences needed for the growth and acceleration of the innovation system?**	Yes, some. Purposeful commitment to R,D&D projects to continue building expertise. Impact assessment on activities at sea, should be initiated.	n.a.	Strong R&D capability but no turbine manufacturer	Yes, some gaps recognized - e.g. resource characterization	Need of more generic research to reduce financial burden on investors in terms of data collection, surveying and monitoring requirements	High investment in research in last 5 years but gaps: in-depth resource assessment and environment impacts. International R,D&D collaborations are recommended to accelerate develop
	Are the number and diversity of actors involved in knowledge development enough?	Yes. Norwegian players already participate in foreign projects as technology providers, equipment suppliers and developers	Yes. Implicit when referring to the establishment of a coordinated portfolio approach to the support of innovation in offshore wind, including new grants to existent actors	Yes. Expertise in advanced manufacturing and offshore. Can transfer knowledge from sectors such as offshore oil & gas (e.g. structures, installation, O&M, contracting models)	Universities and research centers are involved & bring knowledge and test centers	Existing universities, research centers and industry could be involved in offshore wind	University and research centers; world-level industry players, e.g. offshore oil, shipbuilding, turbine manufacture. Regional competence poles emerging near the resource (Marseille, Brest)
Entrepreneurial experimentation	**To what extent technology started to be up-scaled?**	First full-scale floating wind turbine is being deployed	Wind turbines up to 15MW planned to be tested at NaREC (completed); 6MW tested in Gunfleet Sands; 7MW in Scotland.	Moving to the demonstration of first full-scale floating turbines and deep offshore farms.	Tests at laboratory scale; field test of a 100kW floating in the Gulf of Maine, (at least)	n.a.	Several projects for demonstration and pre-commercial floating turbines waiting for funding
	Are there enough actors active in the emergence and up-scaling?	n.a.	No. Suply chain lacks capacity; competition is needed to reduce costs of production of key components; required manufacturing sites and port infrastructures	Supply chain companies not always cost competitive, or able to meet procurement conditions and volumes required	Inexistent at all levels (transmission, supply chain, installation and maintenance infrastructure)	n.a.	Proposed timeline for experimentation in the short term
	Are the actual plans of experimentation adequate?	Yes, but the strategy is not clear about the next steps after the first full-scale demonstration project. The recently established Enova demonstration plan should be re-evaluated in 2011 (thus, no stable plans)	Yes. UK leads in offshore wind experimentation. Sites have been reserved for demonstration and funds committed for test facility (NaREC in Blyth). Established the Offshore Renewables Technology and Innovation Centre (TIC)	Yes. Demonstration sites in development, (Aberdeen and Blyth); specific leasing rounds for deepwater technologies	n.a.	n.a.	Yes. Several experimental projects are in the pipeline and some have already secured European and national funds (e.g. Vertimed)

Materialization	**Are there already plants for equipment production?**	n.a.	The equipment and construction supply chain, the manufacturing sites, are still in development stage	Yes	No	The world's largest developer (DONG) invested GBP50million in a logistic terminal in Belfast	No
	Is the physical infrastructure already (or in a timely manner) in place?	No. Requires the development of the infrastructure for electricity transmission. Technical solutions to be harmonized to permit a gradual interconnection of offshore wind farms with the grid on land	Need to develop the port infrastructure and ensure a coordinated development of the grid (Offshore Transmission Coordination Project). Estimate costs to connect the capacity leased in the Round 3 GBP10million.	No. Ports/waterside infrastructures to install manufacturing sites are insufficient to fully meet sector's requirements. Guarantees Scheme could guarantee up to GBP40billion in investments	Stresses the need to develop the infrastructure (grid connection, ports and heavy industry facilities, maritime transport).	Good port infrastructures. Connection to a robust grid identified as critical: high investments required (by 2020) for network reinforcement and specific RET developments	2 experimentation sites : Fos sur Mer and Groix. Grid connection should be planned in anticipation by the system operator (RTE). Need a plan to adapt Ports to manufacturing components and perform O&M
Market formation	**Are market prospects sufficient to sustain innovation and entrepreneurial experimentation?**	No. Approval of license applications will be partly dependent on technology development and cost reductions	Yes. Leases granted for potential offshore wind deployment in 3 rounds (which were updated upwards in 2013) and also for Scotland and Northern Ireland. Provides a timeline for development. UK likely to remain the largest market up to 2020.	Yes. Largest installed capacity. Price support through ROCs and then CfD. Announced deployment of 8-16GW by 2020, and 18-39GW by 2030 dependent on range of factors including cost reductions	Yes (4,150GW offshore wind potential, 4 times the current total generating capacity of the US)	600MW will be part of a (subsidized) leasing round in the short term	Actors arguably wait for the government strategy that sets the timetable for the development of the sector (expected 2015)
	Is the size of the internal market sufficient to develop floating offshore wind?	No. Decision depends in part on European demand of power	Round 3 comprises projects in deep waters	Yes. In particular, several demonstration leases are expected for floating turbines	Yes. 60% of the resource is in deep waters	Yes, given the type of technologies considered: tidal & wave, less developed than offshore wind.	Yes
Resource mobilization	**Is financial capital (public and private) sufficiently available?**	No	Mentions developers' perceived uncertainty about public support. EMR should give more long term visibility for investments. Green Investment Bank (GIB, publicly backed), is expected to help developers and investors to access investment capital and de-risking project finance [EMR will provide guarantee prices up to the	Arguably yes. Incentives for energy production (tendered feed-in premium); public support to innovation (Offshore Catapult with GBP46million) and to develop supply chain (e.g. GBP20million for SMEs under GROW program). Access to finance through GIB. Other programs (e.g.	Provide more public funding for R&DD	Innovation funds in the UK could potentially be accessible to local organizations. Less clear in terms of the access to finance for deployment	Vertimed obtained European funding (NER300) and national public funds to build an experimental floating wind farm (13 turbines and 26 MW capacity). Public funds support SMEs development. But the feed-in tariff (163€/MWh) not sufficiently attractive to start deployment

			2030s]	business finance partnership for SMEs)			(developers call for a tariff similar to the UK)
	Is there enough human capital in number and diversity?	Expertise is available and has been employed in international projects, qualifications development is encouraged	n.a.	More education and training is needed to avoid deployment bottlenecks, using extant government & industry-led programs	Mentions workforce development activities without specifying	No. Lacks of specialized skills particularly in offshore wind installation and O&M	Yes, implicit in the description of the industrial competencies in offshore energy
Compontents	***Structure development***						
Technology	**Sepecify technological specific goals? (efficiency, reliability, etc.)**	No	GBP100/MWh target	GBP100/MWh target	No. Seeks to "quantify" supply chain needs	GBP100/MWh target	No
	Identify development phase of system? (Phaal's framework)	Embrionary stage (e.g. considers "too early…for regulating" in 2009)	Nurture to A-M transition (offshore "not yet developed" needing to "overcome the remaining engineering challenges, lower cost, improve the reliability of technologies used")	No	Embrionary (or "infancy" as reported) to T-A transition (full-scale demonstrators to start soon)	No	T-A transition to Nurture phase ("tests and demonstrators" and "justifying the installation of experimental farms")
	What type of barriers are preventing a more rapid technology up-scaling? Costs? Low standardization?	Early stage of development, high costs, cheap alternative renewable energies, relatively small internal market	Very high cost, immature technology, underdeveloped supply chain, offshore grid investment, connection needs, high investment risks with limited finance access. [Need significant cost reduction]	Limited testing and tech deployment hindering move to larger turbines; low access to finance limits the speed of deployment and supply chains ability to scale up quickly	Costs, absence of infrastructure (including supply chain), technical challenges. Lengthy permitting processes.	Offshore wind costs twice as much as conventional generation	Costs and technological development needs
Actors	**Which actors are presented as necessary to accelerate process/achieve goals?**						
	- Already in the system?	n.a.	A number of players in the equipment and construction supply chain	UK-based suppliers, development services (incl. consultancy), offshore installation and O&M, oil & gas companies	US developers; research organizations	n.a.	Large equipment manufacturers, energy companies, developers
	- Needing to be involved (why?)	n.a.	Ports and manufacturing investors. Sectors with relevant experience, e.g. oil and gas, maritime transport	Top tier one equipment suppliers, particularly foreign turbine manufacturing, but	Manufacturers (e.g. turbines, foundations), transmission, financial	Local companies to grasp more economic benefits of the investment in offshore energies	n.a.

				strong international competition	actors, maritime transport O&M at sea		
	Refer to the involvement of society: e.g. social acceptance and participation?	The Bill was subject of public consultation as part of the legislative work	No. [But offshore wind has the highest positive public opinion (72%) after Solar PV (82%), among 6 technologies analyzed]	Establish strategies to promote the offshore renewable energy sector	Yes. Public acceptance issues and possible interference w/other activities. Need to involve community in sitting and permitting processes.	Plan was subject to public consultation	Good public acceptability
	Identify key actors? Explain the roles to be played?	Government is the proponent (strategy to be update later when more information on technology and demand is available)	Government (DECC) and industry (e.g. OWDF)	Yes. Government and industry	Government (specific departments)	Government (DETI) and industry (e.g. OREF)	France Énergies Marines and IFREMER are key actors in research and can help strengthening coordination and collaborative projects
	Identify leadership?	No	No	Offshore Wind Industry Council (OWIC)	No	No	IFREMER
	Dimension?	n.a.	n.a.	Large (partnership between government and industry)	n.a.	n.a.	Limited (actors around research center) expected to grow in near future
Networks	**Identify value chain that needs to be built?**	No	Yes. Manufacturing sites for components and port infrastructures. [Scottish Offshore Wind Expert Support Program set-up to help companies entering the offshore wind business],	Yes. Attracting tier one equipment suppliers, particularly turbine manufacturers	Yes	Generic: Attract more local companies to develop the supply chain	No
	Types of alliances that are referred as needing to be established: within the system; with actors external to the system; with other systems? (why?)	n.a.	Establish industry Task Force to set out a path and action plan for reducing the costs of offshore wind to £100/MWh by 2020. [Offshore Wind Developers Forum became Offshore Wind Industrial Council (OWIC) to include supply chain members: major role to boost industry development and address barriers to deployment]	Offshore Wind Programme Board (OWPB). Offshore Wind Investment Organisation (OWIO) formed by the UKTI to promote inward investment in gaps identified in supply chain; to showcase UK's competencies in overseas	Government and private companies partnership around the Offshore Wind Innovation and Demonstration Initiative (OSWindD)	The Offshore Renewable Energy Forum established in 2011 to advise DETI on the implementation of the ORESAP. Establishment of the Global Wind Alliance to develop business and local supply chains	Proposes the creation of a new council (Comité national d'orientation des énergies marines) to ensure the application of the strategy and the deployment timelines
	Nature of networks: business; research & technology; intermediation; policy lobby; (or	n.a.	Research and technology network. DECC will work with the Offshore Wind	Research & technology: implement recommendations to	Public-private partnership	Intermediate (OREF) and business (Alliance)	Intermediation

	mixed)		Developers Forum (OWDF) to promote the development of the national supply chain [Also intermediation networks]	reduce costs. Foreseen – more business-oriented networks: consortia of supply chain companies with complementary skills to open export opportunities, with public support from UKTI			
	Refer to network's coordination? (e.g. actors with central role in networks)	No	Government (DECC) [Shared between Government and industry (through OWI and OWPB, which reports to OWIC)]	OWPB established between public and representatives from developers and the supply chain	OSWinD initiative is coordinated by DOE in partnership with DOI	Government (DETI) coordinates OREF which includes key stakeholder groups (e.g. fishing sector, ports)	Government (Secrétariat Général de la Mer) and industry (CNI)
	Explicitly refer to the need to align actors?	No	Implicit when mentions the need to support supply chain development and business-oriented networks	Yes, the strategy act as a "blueprint" to guide actors' action	Implicit in OSWindD Initiative	Implicit when refers to the role of Alliance in local business/supply chain development	Yes
Institutions	**Have policy makers been involved in the process of development of roadmap/plan?**	Yes. Promoters	Yes. Promoters	Yes. Actively involved as participants	Yes. Gov initiative through departments	Yes. Lead the process	Yes. Report produced by government agencies
	Indicate policies that need to be introduced? (when; how if not government-led)	Establish 3 research centres for environment-friendly energy, relevant for offshore, to address technological challenges. Legal provisions and statutory regulations are needed to be put in place before financial support for generation become relevant	Financial mechanisms to support offshore deployment. Coordinated portfolio of incentives to innovation in offshore wind: GBP30million grants to promote cost reduction through development and demonstration; GBP60 million to support the development of the supply chain focusing on manufacturing facilities at port sites (plus GBP70 million in Scotland), in addition to GBP25million from Energy Technologies Institute	Yes. Technology specific (market incentives, innovation support, etc.)	The publication of this strategy document; the OSWinD initiative. Loan guarantees and technical support to build supply chain. Funding, technical assistance and gov coordination to demonstration projects (chosen in a competitive process). DOE allocated \$90M to R&D and test facilities (2009-2010)	2 ROC's for offshore wind, to be reduced,, in an anual basis, to 1.8 ROCs in 2016/2017	Open calls for innovation projects on all offshore RET. Suggests a timeline for demonstration and deployment projects selected in public auctions with a guarantee price for winners (feed-in tariff) (support up to 50% of project costs) . Calls for simplification of licensing process with creation of a "one stop shop"
	Refer to regulation that needs to be set up (technology specific; complementary – e.g. ocean energy/marine spatial planning)	Provides legal framework for issuing licenses and regulating conditions related to planning, installation, operating and	Publish Offshore Strategic Environmental Assessment and manage consenting delays to consider and solve potential impacts on the	No	Technical inputs expected from the OSWinD Initiative. Regulatory aspects, e.g. sitting and	UK Marine Policy Statement (2011) is reference to marine planning system. UREGNI (Utility regulator) decides	Need of a maritime spatial planning and of the creation of a legislative regime specific to offshore energies

		decommissioning of offshore facilities	marine environment and other users of the sea		permitting. DOI's Smart from the Start initiative (for federal waters) could shorten lengthy permitting times by around half the time.	whether investments in grid reinforcements are recovered in the network charges. Memorandum of Understanding (MoU) between UK and Ireland to delimit marine borders. Government works to streamline consenting process	
	Refer to the need to establish new standards? How?	Yes. Authorizes the establishment of standards for technical structures	Yes. Developers should learn with other sectors (eg. Oil & gas) to implement standardized contracts.	Yes. Catapult is expected to drive standards in the offshore wind industry	Yes. Plans to develop new codes to reduce technical risks and costs	No	Yes. Support the establishment of standards

APPENDIX 3. RESPONSES TO THE OPINION SURVEY

Sector/activity	Technology provider	Developer /installer/ operator	Developer/ owner	Project integrator/ developer	Tech.provider	Ministry	Research center	Research institute/ tech. consultant	Professional association	Consultant	Research center	Consultant	**TOTAL**	**Companies**	**Organizations**
Company	1	1	1	1	1								5	5	
Organization						1	1	1	1	1	1	1	7		7
Questions															
I - Readiness to up-scale and start commercialization															
1. How do you characterize the state of development of offshore wind technologies in deepwaters (>50m)?															
Prototype			1							1		1	3	1	2
Pre-commercial	1	1		1	1	1	1	1	1				8	4	4
Nearly mature											1		1	0	1
Mature													0	0	0
Other													0	0	0

2.	**Do you expect towed systems to be deployed in depths below 50m in the near term?**															
	Yes	1	1	1	1	1	1		1	1	1	1		10	5	5
	No							1					1	2	0	2
3.	**Is the industry ready to support the large commercialization of offshore wind energy in deepwaters?**															
	Yes		1											1	1	0
	Mostly yes, but still non-core resources lacking	1		1	1	1	1					1		6	4	2
	No, core resources lacking							1	1		1			3	0	3
	No coherent system yet												1	1	0	1
	Other									limitation in ports				1	0	1
4.	**Which types of barriers are preventing the up-scaling of offshore wind farm projects? Lack of:**															
	Knowledge/experience	1	1	1	1		1	1	1		1		1	9	4	5
	Human resources							1						1	0	1
	Access to capital	1	1	1	1	1	1	1	1	1	1		1	11	5	6
	Codes and standards				1		1	1				1	1	5	1	4
	Infrastructure				1	1		1		1		1		5	2	3
	Industrial capacity					1		1						2	1	1
	Other?:							Takes time						1	0	1
II - Creation of large scale markets																
5.	**What is, in your opinion, the main driver that pushes the investments in offshore wind energy in intermediate and deepwaters (30m or higher)?**															
	Higher wind	1	1	1	1	1	1		1	1				8	5	3

	resource potential															
	Higher capacity factor			1		1	1							3	2	1
	Expected cost reduction			1	1									2	2	0
	Less social resistance	1		1	1		1	1	1		1			7	3	4
	Other		sites availability		Most of the offshore resource is in deep waters	Lack of acceptable shallow water sites		Siting opportunities in new markets		More relevant sites available in atlantic and pacific coasts		Proximity and easy access to load centers	Lack of alternative RES (Hawaii, Japan,etc.)	7	3	4
6.	**When do you expect the commercialization of offshore wind in deepwaters to start?**															
	Before 2017													0	0	0
	Before 2020	1	1	1		1		1	1			1	1	8	4	4
	Up to 2030				1		1			1	1			4	1	3
	After 2030													0	0	0
7.	**How much capacity do you expect will be installed worldwide in the first year of commercialization?**															
	1 GW or more		X				1	1						2	0	2
	between 100 MW and 1 GW	1	X		1	1					1			4	3	1
	between 10 MW and 100 MW		X	1					1	1		1	1	5	1	4
	less than 10 MW		X											0	0	0
8.	**How important is the expected deepwater offshore wind market in your (company's) home country?**															
	Very large (most of the capacity expected to be	1				1		1					1	4	2	2

	installed in the home market) (1 GW or more)															
	Large (more capacity expected to be installed in the home market than abroad) (between 100MW and 1GW)								1	1		1		3	0	3
	Limited (more capacity to be installed abroad) (less than 100MW)		1	1	1		1				1			5	3	2
	Absent (all market expected abroad) None													0	0	0
9.a In which countries do you expect to install more wind energy systems in deepwaters? (Please indicate 2-3 main countries):																
	Country 1	Japan	Japan	Japan	US	UK	X	X	X	X	X	X	X	5	Japan	X
	Country 2	France	France	France	UK	France	X	X	X	X	X	X	X	4	France	X
	Country 3	Taiwan	UK	UK	Japan	US	X	X	X	X	X	X	X	4	UK	X
	Country 4	X	X	X	X	Japan	X	X	X	X	X	X	X	2	US	X
9.b Are there companies from your home country developing or investing in deepwaters offshore wind technologies?																
	Yes	X	X	X	X	X	1	1	1	1	1	1	1	7	X	7
	No	X	X	X	X	X								0	X	0
III - Strategies to manage the transition																
10. Do you expect offshore wind energy in deepwaters to become competitive against onshore wind (both without subsidies)?																
	Yes and before 2030		1	1					1	1				4	2	2

	Yes but after 2030	1				1								2	2	0
	Very uncertain				1		1	1			1			4	1	3
	No											1	1	2	0	2
11.	**Which countries are the most likely to invest in offshore wind energy in deepwaters inthe first place? (Please indicate 3-4 main countries):**															
	Country 1	Japan	Japan	Portugal	Japan	France	Japan	US	US	US	Japan	US	Japan	Japan	5	6
	Country 2	Taiwan	UK	Japan	Portugal	US	US	Portugal	Japan	Japan	Korea	Norway	US	US	2	6
	Country 3	Scotland (UK)	X	US	Norway	Japan	Korea	Spain	UK	France	X	Portugal	Korea	UK	*3*	3
	Country 4	France	X	UK	X	X	China	Japan	France	UK	X	Spain	UK	Franc e	3	3
	Country 5 & more	X	X	France	X	X	France	China, UK, France, Korea	X	Norway, Portugal	X	X	X	Portu gal	2	*2*
12.	**What do you think are the main drivers sustaining market growth in offshore wind energy in the countries referred in the last question?**															
	Environmental regulation		1	1	1		1		1		1		1	7	3	4
	Raising energy demand	1				1								2	2	0
	Technology progress	1	1	1		1	1	1		1		1		8	4	4
	Industrial policy			1				1		1			1	4	1	3
	Other				sites availabili ty							Short continen tal platform		2	1	1
13.	**What types of measures are more effective to promote the development of the offshore wind in deepwaters' industry and market?**															
	Investment grants	1	1		1				1					4	3	1
	Energy-production	1	1	1	1	1	1	1		1		1	1	10	5	5

	support (e.g. feed-in tariffs)															
	Infrastructure provision					1				1		1		3	1	2
	Funding of R&D						1	1	1	1				4	0	4
	Funding of demonstration			1		1	1			1	1	1		6	2	4
	Human resource training													0	0	0
	Other?:													0	0	0
14.	**Which type of strategies & instruments can better raise awareness and promote confidence on the potential of the technology?**															
	Setting a vision, roadmaps and targets (by government or industry)	X	X	X	X	X	1	1	1		1	1	1	6	X	6
	Improve connections and coordination among relevant actors	X	X	X	X	X	1		1	1				3	X	3
	Articulation of demand by a leading user	X	X	X	X	X								0	X	0
	Promote the alignment of regulation (incl. standardization, marine planning)	X	X	X	X	X				1		1		2	X	2
	Opinion of experts	X	X	X	X	X								0	X	0
	Studies and technical reports	X	X	X	X	X	1	1	1	1		1		5	X	5
	Public events and debates	X	X	X	X	X								0	X	0
	Policy lobbying	X	X	X	X	X								0	X	0
	Other?:	X	X	X	X	X								0	X	0
15.	**How effective are the national roadmaps in influencing policies and the development of the value-chain for deepwater offshore wind energy?**															

(Please indicate a number from 1 (ineffective) to 5 (very effective):	3	4	4	3	3	3	5	4	2	1	4	5	3,417	3,400	3,429
16. Did your company (organization) participate in the formulation of such home country or international (e.g. European) roadmaps targeting or including deepwater offshore wind?															
Yes national and international					1						1		2	1	1
Yes national	1	1						1				1	4	2	2
Yes international										1			1	0	1
No				1		1	1		1				4	1	3
16.1 If Yes, in which areas:	France	NREP (National Renewable Energy Plan)			Offshore Wind Technology Development and Cost Reduction Pathways			R&D development needed to make deep water a success		nautical safety	resource assessment; RES maritime spatial planning	policy support	7	3	4
17. What type of arguments can attract actors from other sectors to invest in offshore wind in deepwaters? (Please indicate at least two arguments):															
1	ROI (Return on Investment)	Low risk	Building opportunities	Best spots onshore are becoming rare	Transferrable skills	first-mover advantage	oil and gas needs deepwater wind to transition it workforce	profit potential	few players	safety	define a pathway to sustainable LCOE	long term logic for demand			
2	Greenwashing	ROI	Engineering opportunities	Higher wind resource and less turbulent are in deep waters areas which	finance and insurance	RES near demand	governments need to align ocean observations with energy production	low risk	large potential worldwide	technical	present a real LCOE for conventional energy	articulated by government			

					are ample											
	3	X	X	X	technolo gical evolutio n namely the increase of the turbine output (>7MW	X	X	X	X	X	feasibili ty	X	X			

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Please use the following lines to let us know your ideas that may help to understand the future perspectives for deepwater offshore wind energy:	-	Alternative RES technology, expected low costs in medium term and high energy potential	-	pre-commercial projects and scaling turbines leading to technology expansion	two pre-commercial arrays 25-50MW (Hywind Scotland, WindFloat Atlantic), needing to improve bank acceptability for floating to become commercial	-	Commercial competitiveness and acceptable risk needs to be demonstrated	Need a lot of research but "in the end it will be a success"	Different countries will be involved compared with fixed offshore; floating platforms too large for typical infrastructures (contraints); much larger potential worlwide and in more locations	-	"It will be in the 21st century what the oil was in the 20th"	There needs to be stepping stone market to get the technology commercialised				