Stepping Stones

The role of pilot and demonstration projects for Norwegian firms' engagement in international offshore wind markets

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The role of pilot and demonstration projects for Norwegian firms' engagement in international offshore wind markets.

An embedded case study.

Abstract

This thesis explores the role of pilot and demonstration projects (PDPs) for Norwegian firm engagement in international offshore wind markets. The purpose of this thesis is to contribute to a better understand of what PDPs actually means to the firms who participate, as opposed to what policy makers suggest they mean. Global warming poses opportunities as well as challenges to an oil economy such as Norway and there is an expressed demand for oil and gas (O&G) industry reorientation. In absence of a home market, PDPs can function as stepping stones to international markets, by facilitating technical verification, a list of references, early mover advantages and interactive learning.

This study employs a qualitative approach, and data has primarily been collected through semi-structured interviews with a wide range of O&G supply firms, as well as researchers, developers and start-ups. There is also observation and content analysis of relevant documents, as complementary data sources. The aim is to acquire a fine-grained understanding of the individual firm motivations, access strategies and outcomes from PDP participation, in order to inform policy makers on how to better enable Norwegian firm engagement in international markets.

My empirical data indicates that PDPs are important for providing small and medium sized enterprises (SME) with a list of references. Larger companies typically had prior experience from commercial projects and were therefore somewhat less motivated to participate in certain types of PDPs. Policy instruments were considered crucial by small and large firms alike, and there was a broad consensus that the innovation support system was crucial for PDP participation. Technical capabilities and organizational experience from O&G were highlighted as important in the development of an offshore wind power (OWP) industry, and firm reputation was an important factor in how firms gained access to PDPs.

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I dedicate this thesis to the memory of my dear grandmother who passed away this spring.

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Abbreviations

PDP - Pilot and Demonstration Project

OWP - Offshore Wind Power

SME – Small and Medium Enterprises

ELE – Established Large Enterprises

RCN - The Research Council of Norway

R&D - Research and Development

EPC - Engineering, Procurement and Construction

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1 Introduction

Innovation has been identified as central to the development of new industries and economic growth and is a crucial part of the effort to mitigate global warming (IPCC, 2018; Ritchie, & Roser, 2020).

The world has been increasingly getting warmer since the mid 19th century. This increase in global temperature has been linked to anthropogenic CO_2 emissions and poses an existential threat to human beings (IPCC, 2018; Ritchie, & Roser, 2020). Since the mid 1800s the world has experienced an unprecedented period of economic growth (Ritchie & Roser, 2020) which can be understood as the result of technological change (Carlsson, & Stankiewicz, 1991) or several technological revolutions and their subsequent techno-economic paradigms (Perez, 2010).

While economic growth spurred by these technological changes has greatly improved standards of living and quality of life, it is also the source of current untenable levels of CO_2 emissions (IPCC, 2018). The energy sector is the greatest source of these emissions (Electricity, Heat & Transport 73.2%) (Ritchie, & Roser, 2020).

In order to mitigate and halt the existential threat posed by global warming, most nations of the world have signed the Paris climate agreement, including Norway. Through article 2 of the Paris climate agreement, Norway has agreed to pursue "…efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (IPCC, 2015). This poses opportunities as well as challenges.

Since oil was discovered on the Norwegian continental shelf, oil and gas (O&G) has been a key source of domestic economic growth (Fagerberg et al., 2009), and remains a crucial part of the Norwegian economy (Ministry of petroleum and energy, 2021b). The Norwegian government has been actively involved in creating a domestic O&G industry through regulatory measures created to ensure the development of domestic technological capacity (Thune, 2019; OECD, 2017). The state has also retained an active role since the very beginning. Policies and institutions have co-evolved with the development of the O&G industry, and the state remains the majority shareholder of the largest O&G company, Equinor (Mäkitie, 2019).

Climate change demands a shift away from the production and use of hydrocarbons. This requires that Norway must transition away from O&G related activities. This poses a challenge because of the importance of O&G to the Norwegian economy, and the jobs stemming from the O&G supply industry, which constitutes Norway's second largest industry in terms of income (Rystad Energy, 2020). However, the situation also poses an opportunity for reorientation and industrial development.

An important government goal is to redeploy resources from the O&G industry, and redirect existing O&G competences to new industries (Ministry of Finance, 2017, 115).

Since the discovery of oil on the Norwegian continental shelf, clusters of highly specialized supply firms have developed in order to meet the increasingly complex demands of extracting hydrocarbons in rough offshore conditions (Thune, 2019). These skills and capabilities have the potential of being utilized in related markets such as offshore wind power (OWP) (Hanson & Normann, 2019; Thune, 2019). However, since Norway has a well-developed hydropower energy system which covers the domestic need for electricity, there are limited incentives for policy makers to create a home market for OWP (Normann, 2015).

In the absence of a home market, pilot and demonstration projects (PDPs) can function as a 'protected space' for existing O&G firms and start-ups to develop the capabilities necessary to participate in international OWP markets (van der Loos et al., 2020).

In short, PDPs are useful stepping stones for technologies which have been proven to 'work' in an R&D environment, but it is still far from being a finished product in a commercial market. PDPs can also serve to showcase the utility and future promise of a technology to potential adopters (Klitkou et al., 2013). In order for the technology to be ready for commercialization, there are several barriers that must be overcome. These barriers can be technical, organizational, institutional and market related, and they are often emphasized differently in the various disciplines of the existing literature (Hellsmark et al., 2016; Frishammar et al., 2015).

This thesis is an attempt to contribute to a better understanding of what role PDP's have for Norwegian firm engagement in international OWP markets. While much has been written about the role of PDPs for technology development and innovation policy (Hellsmark et al., 2016, Frishammar et al., 2015; Klitkou et al., 2013, Macey and Brown, 1990; Bossink 2015; Bossink 2017), there is an expressed need in the literature to know more about the actor networks surrounding PDPs (Frishammar et al., 2015; Hendry et al., 2010).

Not only do we need to know more about how PDPs work to advance Norway's role in the international OWP markets, and to reach the goals set by the Paris agreement, we also need to know a lot more from a research perspective about how PDPs are understood from a firm's perspective, and what it means for engagement in international offshore wind markets.

In short, there is a need for a better understanding of what firms actually gain from PDPs as opposed to "what advocates suggest they should and what policy makers believe [they should]" (Hendry et al., 2010), 2).

This leads us to the overarching research question of this thesis: *What is the role of pilot and demonstration projects for Norwegian firms' engagement in international offshore wind markets?*

Since this question is quite broad, I will break this down into the following research questions that will structure the thesis:

RQ1: What **motivates** Norwegian supply firms to participate in OWP PDPs?

RQ2: How do Norwegian supply firms **gain access** to OWP PDPs?

RQ3: How do PDPs **contribute to innovation and market access** for participating organizations?

RQ4: In what ways does PDPs **contribute to learning** for participating organizations?

These questions are used to structure the empirical and discussion chapter of this thesis.

2 Literature review

2.1 Sustainability Transitions

In the following section I will place my topic in its theoretical context within the field of sustainability transitions. I will explain what sustainability transitions are, briefly comment on some key contributions, as well as central themes, concepts and theories.

In order to mitigate global warming there is a need for massive changes in how humans produce and consume energy. These changes involve new ways of producing energy, in the form of clean technological innovations such as wind power, solar PV, tidal and geothermal energy, as well as new grid solutions and energy storage solutions. It also involves new ways of organizing and structuring communities and societies (IPCC, 2018). The need for a transition towards sustainability is firmly documented by the IPCC, and global commitment have been formalized in the Kyoto agreement and later in the Paris climate accords (IPCC, 2015). Sustainability transitions studies aim to understand the relationships between social and technological processes in order to facilitate and govern these socio-technical changes (Köhler et al., 2019; Markard et al., 2012).

Sustainability transitions is a multidisciplinary field of study concerned with describing and governing a multitude of socio-technical processes in order to mitigate global warning and address grand societal challenges (Köhler et al., 2019). It is the study of several, (more or less), interrelated socio-technical processes occurring along different spatial and temporal dimensions (Markard, 2018). The field has been rapidly growing since its inception in the 90s, and early 2000s (Köhler et al., 2019; Markard et al., 2012). Markard et al. points out that early work, such as Rip & Kemp, 1998) and Geels, (2002), synthesized and developed concepts and perspectives from fields such as innovation studies and evolutionary economics, notably, (Carlsson & Stankiewicz, 1991; Dosi, 1982; Freeman, 1995; Nelson & Winter, 1982) as well as a wide variety of perspectives from Science and Technology Studies (STS), systems theory, political science and management studies (Markard et al., 2012). Later contributions have also emphasized and integrated other perspectives as well, such as power and politics (Geels, 2014) and spatial dimensions (Binz & Truffer, 2017) to name a few. One of the most studied topics in the field, is the transformation of the energy sector (this sector is the most CO2 emission intensive sector), and the transition to a zero-emission energy system (Markard et al., 2012).

Fundamental assumptions in the sustainability transitions field

The sustainability transitions field builds on a social constructivist understanding of technology, and a systems conceptualization of innovation. This means that technology is conceived of as being the outcome of social and technical processes over time (Rip & Kemp, 1998) and innovation is understood as an outcome (and process) of interactions between a wide range of actors, networks and institutions (Carlsson & Stankiewicz, 1991). In other words, innovation is understood as both "a collective and an individual act" (Hekkert et al., 2007, 414). Sustainability transitions rests on the proposition that the separation between technology, knowledge, and the social (economics, politics, institutions) is artificial, and that any given artefact or technology is held together in a "seamless web" (Hughes, 1986) and is the outcome of evolutionary socio-technical processes which constitute a "configuration that works" (Rip & Kemp, 1998). This in turn implies that in order to bring about socio-technical change, there has to be a re-alignment of the elements and interests that constitute "the configuration that works." This re-alignment process is difficult because of the path dependent and obdurate nature of the socio-technical regime (Köhler et al. 2019).

2.2 Socio-technical transitions

The concept of a socio-technical regime can be understood as a development of Nelson and Winters notion of a 'technological regime' which describes how firms in an industry, have evolved certain routines which guides and narrows their search for (scientific, engineering, technical) new knowledge and technology (Nelson & Winter, 1982) The sustainability transitions field elaborates on this concept by incorporating a wider set of actors such as policy makers, users and interest groups (Geels, 2002) and emphasize that the socio technical regime is characterized by 'path dependency' and 'lock in' mechanisms, which reproduce and re-enforce the existing and dominant technologies and institutions (Unruh, 2000). In simplified terms, once a socio-technical system has evolved and become dominant (such as the hydrocarbon energy system), the actors who benefit from the status quo are reluctant to want to change it, and innovation will therefore tend to occur incrementally and along certain technological trajectories (Geels, 2005). This makes the regime obdurate and path dependent, as the availability heuristics for change become increasingly narrower as the actor-networks and institutions co-evolve, reinforce, and continuously reproduce the conditions favorable to their own interest (Geels, 2005; Rip & Kemp, 1998).

In order for socio-technical change to occur, a 'window of opportunity' must arise, enabling new technologies to enter and reconfigure the regime, and thereby alter the trajectory and set the course towards sustainability (Geels, 2002; Geels et al., 2017; Geels & Schot, 2007). However, new technologies are expensive, and often have low technological performance (compared to the incumbent technologies) and are therefore not able to compete in the marketplace (Rosenberg, 1972). Because much of the improvements on a given invention happens after it has been introduced to the marked (Rosenberg, 1972) a 'niche' or a protected space is needed to allow for interactive learning and experimentation (Hoogma et al., 2002; Kemp et al., 1998). New technologies must be allowed to develop in these "protected spaces" or 'niches,' free from the selection pressures of the regime (Geels, 2002; Hoogma et al., 2002).

A niche can be described as a protected space consisting of several "loosely coupled demonstration projects" (Hoogma et al., 2002), 10). These demonstration projects are referred to as experiments (Hoogma et al., 2002). Through these experiments networks can be formed, social learning can take place, and expectations can be negotiated and coupled to solving existing societal problems which the incumbent socio-technical regime is not expected to be able to resolve (Hoogma et al., 2002). Markard and Truffer makes a distinction between two basic types of niches (market niches and technological niches), based on how its specific selection environment has evolved (Markard & Truffer, 2008). While market niches develop in association with 'unusual' application settings or user preferences (such as a demand for solar PV on cabin rooftops), technological niches are deliberately created and supported by actors and institutions (both outside and inside the regime) who aim to develop larger market niches (Markard &

Truffer, 2008; Schot & Geels, 2007). The degree to which a niche is considered compatible or complementary to the regime, may increase its chances of success (Markard & Truffer, 2008). In early scholarship, niches were often conceptualized as radical challengers to the incumbent regime (Geels, 2002), subsequent scholarship has however nuanced this portrayal by emphasizing that established and emerging regimes may be complementary and symbiotic (Geels & Schot, 2007; Hansen & Steen, 2015). An example of this is the case of O&G and OWP where there is a large degree of technological relatedness (Hanson & Normann, 2019). This overlap between technological systems might produce a symbiotic relationship, where the incumbent regime is inclined to accept the niche (Hansen & Steen, 2015). Understanding socio-technical transition involves studying the interactions between regimes and niches, or "the dynamics between established and emerging technologies" (Hansen & Steen, 2015), 3.)

Summary

I have now presented and discussed the topic of socio-technical transitions, and the relationship between the regime and the niches. In summary we can say that in order for the regime to change new technologies must be allowed to evolve in protected spaces. Pilot- and demonstration projects can provide such protected spaces and can be important for maturing technologies sufficiently so that they can compete with established technologies. In the following section I will briefly present the systems view of innovation, the TIS framework, and explain why this is useful tool for understanding how new technologies emerge. I will briefly present the structural elements and functions and I will then explain the role pilot and demonstration projects (PDPs) have in strengthening these functions.

2.3 Technological innovation systems (TIS)

The TIS approach has emerged as one of the major frameworks in the transitions field, and is concerned with explaining the conditions under which new technologies and industries evolve and develop (Markard, et al., 2012). A TIS can be defined as "a set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product" (Markard, &

Truffer, 2008, 611). Researchers have argued that one of the benefits of the TIS approach is that is allows us to study dynamics of the processes (functions) separately from the structural components (Bergek, et al., 2008a). In the following, I will first define the structural elements of the TIS, namely, the technology, the actors, institutions and networks. Subsequently, I will briefly present the main functions in a TIS, before discussing how pilot- and demonstration projects can contribute to different functions in the TIS.

2.3.1 The structural elements

Technology can be understood as both the material artefact, as well as the coded and embodied knowledge about the material artefact (Bergek, et al., 2008(a). Technology is understood as both a structural component as well as the output of the system (Hellsmark, 2011, 22).

Actors include all firms along the existing or (imagined) value chain (Hellsmark, et al., 2016) meaning upstream and downstream firms as well as the supply chain (Bergek, et al., 2008b). Actors in the TIS refers to both new entrants as well as reorienting incumbents (diversifying firms) (Hellsmark, 2011). Actors also include individuals, as well as organizations such as research institutes, universities, non-governmental organizations, industry organizations and standardization/verification organizations (Hellsmark, 2011).

Networks can be described as "an intermediate form of organization" (Carlsson, & Stankiewicz, 1991, 103) where information, knowledge and expectations are exchanged (Carlsson, & Stankiewicz, 1991; Hellsmark, 2011). Networks can be both formal and informal (Bergek, et al., 2008a). Formal networks are easily recognized (industry organizations, special interest groups, unions etc.) while informal networks are more difficult to delineate and might require more in-depth knowledge of the field (Bergek, et al., 2008a).

Institutions are often described as 'the rules of the game' (Fagerberg, 2004, 12) which regulate the relationships and interactions between individuals and groups (Hellsmark, 2011, 25). Institutions can be defined as "…the normative structures which promote stable patterns of social interactions/transactions necessary for the performance of vital societal functions." (Carlsson, & Stankiewicz, 1991, 109).

2.3.2 The functions

Functions in a TIS can be defined as the *key processes,* which have a positive or negative impact on the development, diffusion or use of innovations within a particular technological domain (Bergek, et al., 2008a; Bergek, et al., 2008c). The strength or weakness of these functions are influenced by the structural elements and their dynamics (endogenous dynamics) as well as exogenous events or pressures (Bergek, et al., 2008b).

Knowledge development and diffusion is often placed at the heart of the TIS, and concerns how new knowledge is added and new knowledge generated (Bergek, et al., 2008a). Knowledge and learning are intrinsically connected and are considered the most important aspects of the innovation process (Lundvall, & Johnson, 1994). Innovation is recognized as the output of interactive learning processes between actors in networks operating under a particular institutional infrastructure (Malhotra, et al., 2019). This function is therefore related to both how the current TIS generates knowledge as well as how this knowledge flows between the actors in the system (Bergek, et al., 2008a).

Influence of the direction of search describes the various factors and activities that serve as incentives or pressures, which lead firms and other actors to enter the technological field (Bergek, et al., 2008c). This can for example be, growing expectation, visions for the future of the technology, and a belief in the potential for growth (Bergek, et al., 2008c). The direction of search is closely related with *legitimation*, as both these functions "attract new entrants to the field" (Hellsmark, 2011, 31).

Legitimation is crucial for the successful development and diffusion of an innovation (Bergek, et al., 2008a). Legitimation, can be defined as the process of adjusting and strengthening the social acceptance and compliance of the technology with relevant institutions (Bergek, et al., 2008a).

Legitimation is not 'granted' but is rather negotiated in a dynamic process, shaped by the competing views and interests of actors in the TIS as well as by actors in competing TISs along with their associated frameworks (Bergek, et al., 2008c).

Resource mobilization refers to the degree in which actors within the TIS are able to attract various types of resources (Bergek, et al., 2008a). As a TIS evolves, so does the demands for complexity and thus a wide range of resources must be mobilized (Hellsmark, 2011). In other words, the closer a technology is to commercialization, the more human capital, financial capital and complementary assets will be necessary (Bergek, et al., 2008a).

Entrepreneurial experimentation involves a wide variety of firms testing out new technologies, applications and markets Bergek, et al., 2008(a). PDPs are crucial arenas for entrepreneurial experimentation (Kemp, et al., 1998). Through experiments, new opportunities and knowledge is generated through various forms of learning, which in turn reduces technological and market uncertainty (Bergek, et al., 2008a) as well as organizational and institutional uncertainties (Frishammar, et al., 2015).

Materialisation builds on the work of Thomas Hughes on large technological systems and has not been extensively explored in the TIS literature (Fevolden, et al., 2017). Materialisation can be defined as the development and investment in physical infrastructure, production plants and products (Bergek, et al., 2008b). PDPs can be understood as a specialized form of materialisation, important for the industrialization of a new knowledge field (Hellsmark, 2011, 34).

Market formation can be defined as the process of strengthening the factors which contribute to the diffusion of the technology (Bergek, et al., 2008a). Market formation describes the gradual process of technology development and demand articulation (Bergek, et al., 2008a). It is closely associated with the concept of a ‘niche market’ (Kemp, et al., 1998), which is understood as an early stage in the market formation process (Bergek, et al., 2008a). PDPs can sometimes take on the role of nursing or niche markets (Hellsmark, 2011).

The development of positive externalities refers to all the benefits stemming from investments and activities, which befall third parties 'free of charge' (Bergek, et al., 2008c). For example, one firm's effort to develop a specific product or process, might produce an outcome which another firm can appropriate for free. This gives an advantage to late entrants as they can learn from the mistakes of others, cost free (Hellsmark, 2011).

2.3.3 The role of PDPs in TIS development

PDPs are crucial instruments which contribute to the dynamics of the TIS (Hellsmark, 2011), 348). In the sense that a PDP is a type of protected space for learning, and given that learning is the most important function in the innovation process (Lundvall & Johnson, 1994), one can argue that PDPs serve to strengthen all the functions of an emerging TIS. Previous work indicates that there are some functions which are especially strengthened by PDPs (Hellsmark, 2011).

I will now present these as well as briefly discuss how PDPs contribute to the development of a TIS. After that I will move on to the next part of the literature chapter where I will present what types of PDPs there are; what their aims, organizational form and functions are. Then I will discuss the motivations and outcomes for firm engagement in PDPs. After that, I will summarize and present the analytical framework I will employ to analyze my empirical data.

Hellsmark organizes the eight functions into three sets in accordance to what kind of knowledge they produce: "know how" and "know about" (Hellsmark, 2011, p. 37).

Table 1: Overview of TIS function sets and how they relate to the acquisition of knowledge

Set 1: acquisition of "know how"	*Knowledge development and diffusion*, *entrepreneurial experimentation and materialisation.*
Set 2: acquisition of "know about"	*Direction of search and legitimation*
Set 3: enables the acquisition	*Resource mobilisation, market formation and development*

of knowledge	*of positive externalities*

based on Hellsmark, 2011, p. 37

The first set of functions

PDPs can be understood as a particular type of materialisation which facilitates and strengthens the acquisition of 'know how', by allowing for entrepreneurial experimentation and enabling knowledge development and diffusion to take place (Hellsmark, 2011). Strengthening knowledge development and diffusion involves both research driven as well as interaction based learning. The latter of which is typically dependent on a degree of physical infrastructure, and projects of scale. In short, a lot of learning takes place beyond the R&D stage, and outside of the research lab. Therefore, there is a need for the materialisation of 'protected spaces' where entrepreneurial experimentation can take place and knowledge can be developed and diffused (Hellsmark, 2011).

The second set of functions

The second set of functions, direction of search and legitimation can be strengthened through activities which raise (positive) public awareness of the technology (Hellsmark, 2011). PDPs can strengthen this set of functions, by allowing actors to showcase themselves, the technology, as well as their visions for a future industry, which can strengthen the legitimacy of the TIS and attract new entrants (Hellsmark, 2011). PDP participants can actively strengthen these functions by engaging in various activities, such as publishing statements and reports, getting positive attention from the media as well as, using PDP participation as a selling point to attract new employees, or gain access to other PDPs or semi-commercial projects (Hellsmark, 2011). Exogenous events (such as the climate change debate, or oil price fluctuations), as well as developments at other system levels (technology, industry, nation) can also influence the direction of search and legitimation (Hellsmark, 2011, 40). For example, in the case of Germany's response to Fukushima, which resulted in a political decision to move away from nuclear energy, thus strengthening the direction of search and legitimacy of alternative TISs.

The third set of functions

The third set of functions are those that enable the acquisition of 'know how' and 'know about', and in that sense, they function to strengthen the rest of the functions in the TIS (Hellsmark, 2011). Without the strengthening of resource mobilization, market formation and the development of positive externalities, actors will not be able to strengthen the other two sets of functions (Hellsmark, 2011). PDPs can contribute to the third set of functions by taking on the role as a first protected market, where actors can interact and generate knowledge about the technology, as well as articulate demand (Kemp, et al., 1998; Hellsmark, 2011). PDPs can potentially also contribute to the development of positive externalities through the knowledge development and diffusion which take place in the actor networks surrounding the PDP. In short, the lessons learnt in PDPs can potentially be appropriated without cost by third parties.

Summary

I have now presented the TIS framework and the role of PDPs can have in strengthening various functions. In order to gain a better understanding of the relationship between PDPs and the development of a TIS, I will now present the different types of PDPs, how they differ, before engaging with how and why actors participate in them.

3 Analytical Framework

3.1 What is a pilot and demonstration project (PDP)?

A PDP is a temporary organization designed to improve a technological innovation by reducing risk through the facilitation of learning, and by showing the viability and potential of the new technology to potential adopters (Bossink, 2015). A PDP functions as a protected space, where a "technology is protected, supported, and enabled to grow" (Bossink, 2020, 5). A PDP 'sits awkwardly' (Nemet et al., 2018) in the 'uncertain middle' part of the innovation process, between R&D and commercialization (Hendry et al., 2010)

This 'uncertain middle' is also referred to as the 'valley of death' (Nemet et al., 2018). It is called the 'valley of death' because it is at this stage in the innovation process that many technologies fail, because of high levels of uncertainty, high capital requirements, and "weak incentives for investment" (Nemet et al., 2018, 154). It is because of these uncertainties that governments and international organizations such as the EU, intervene and stimulate PDPs through 'technology push' and 'demand pull policies' (Nemet et al., 2018).

In short, PDPs are needed when the technology has been proven to 'work' in an R&D environment, but it is still far from being a finished product in a commercial market. In order for the technology to be ready for commercialization, there are several barriers that must be overcome. These barriers can be technical, organizational, institutional and market related, and they are often emphasized differently in the various disciplines of the existing literature (Hellsmark et al., 2016; Frishammar et al., 2015).

3.2 The rationale behind publicly funded PDPs

The policy rationale behind PDPs is to mitigate risk for firms in order to increase the probability of successful commercialization of a technology deemed to have national or societal value in the form of national competence building, job creation, tax revenue, value creation, and a competitive industry (Forskningsrådet, 2019).

PDPs are considered central in the development of new sustainable energy technologies "with the potential to address climate change" (Hellsmark et al., 2016). Historically, PDPs have had an important role in finding solutions crucial to the development of new technologies as well as solving societal problems (e.g. fiber optics and penicillin) (Frishammar et al., 2015). The potential societal gain in knowledge and technological development achieved by a PDP can be great, but the risk for the innovating firm, or early mover, can also be very high, and competitors can potentially build on the lessons learnt and paid for by another company for a fraction of the cost (Frishammar et al., 2015). This tension between what is societally beneficial and what is commercially sound for a private firm constitutes what is described (in the first generation thinking on innovation policy) as a 'marked failure' (Technopolis group, 2019). Public policies should therefore support PDPs to correct for this failure.

3.3 Three streams of literature on PDPs

PDPs have been studied from different perspectives. In their 2015 article Frishammar et al. synthesis and distinguish previous literature on PDPs into three different streams of research: 1) from engineering and the natural sciences, 2) from technology and innovation management and 3) from the innovation systems perspective (Frishammar et al., 2015). I will in the following section briefly present the key perspectives from the various literature streams, and on which aspects of PDPs they tend to focus on.

The **first** literature stream is from an engineering and natural science perspective, where the purpose of a PDP is to verify and upscale technologies or processes. Learning here is often based on prior experience and testing at an earlier stage (Frishammar et al., 2015). The focus is often on technical and or economic feasibility, and on recognizing challenges and finding solutions necessary for upscaling certain processes or technologies. The focus is typically on technical learning and risk reduction through trial by error, testing prototypes and upscaling. Specific experiments and tests, as well as verification of products and processes are emphasized (Frishammar et al., 2015).

The **second** literature stream is the technology and management perspective, where the focus is on the firm level, and the importance of reducing (technological and economic) uncertainty as well as enabling firm level learning (Frishammar et al., 2015, 7). PDPs are a central tool in learning on the firm level about a new technology, and improving standardization, optimization and collaboration (Frishammar et al., 2015).

The **third** literature stream, the innovation systems perspective, takes a broader view on the role of PDPs and pays greater attention to the role of PDPs in developing the socio-technical system, as well as placing more attention on various forms of learning. The innovation systems perspective on the role of PDPs is associated with theoretical approaches such as TIS and SNM. In addition to regarding the role of PDPs as a pathway from basic research to industrial application, it focuses on the (socio-technical) system level where technology, markets, institutions and public attitudes must be aligned (Frishammar et al., 2015, 8). The 'function' or the purpose of a particular PDP must therefore be seen in its broader context.

In summary, and at risk of oversimplification, engineers focus on functionality and technical learning, firms and managers are concerned with reducing costs and increasing scale, and policy makers and social scientist are concerned with the socio-technical totality in order to design policy and further academic understanding of technical change and sustainability transitions.

3.4 PDPs as 'experimental' and 'exemplary'

In the broadest sense, and in what has been referred to as the first period of PDP literature, there was distinguished between two types of PDPs; "experimental projects" and "exemplary projects" (Klitkou et al., 2013, 2). This distinction is important for assessing whether a PDP has been successful or not. In order to assess success, it is helpful to know the criteria by which you are making that assessment. An **experimental** project is designed to test an invention under operational conditions, and an **exemplary** project is designed to show case the utility and future promise of the technology to potential adopters (Klitkou et al., 2013). These two types of PDPs are closely associated with the two sets of functions which I presented under the TIS section, namely the acquisition of 'know how' (experimental projects), and the acquisition of 'know about' (exemplary projects).

This distinction between technical experimentation and learning on one hand, and market diffusion and commercialization on the other, has been elaborated on and various typologies have been developed from empirical work in what can be referred to as the second period (Klitkou et al., 2013). The second period is associated with studies on the role of PDPs in developing sustainable energy technologies such as wind, solar PV, fuel cell technology. These studies have developed typologies illustrating the multiple and overlapping goals of various forms of PDPs (Hendry, et al., 2010; Harborne, & Hendry, 2009; Frishammar, et al., 2015; Brown, & Hendry, 2009; Hendry, et al., 2007).

3.5 Heterogeneous definitions of PDPs and differing PDP typologies

I have now briefly presented three streams of the literature on PDPs, and what these focus on, as well as explained the aims of two ideal types of PDPs - experimental and exemplary.

The areas of focus distilled by Frishammar et al. in the three different literature streams are somewhat associated with the aims of different types of PDPs. Macey and Brown, building on the two types of PDPs I have already presented (experimental and exemplary) added a third category - a second phase of exemplary PDPs aimed at reaching a broader range of adopters (Klitkou et al., 2013; Macey and Brown 1990). Macey and Brown suggest that this second phase of exemplary projects should not be assessed based on the degree to which the technology is adopted, but rather by studying the degree to which the project has influenced planning and efforts of implementation (Klitkou et al., 2013). After all, the time span between development and diffusion of an innovation can span several decades (Rosenberg, 1972) and it is therefore difficult to assess the outcome of specific projects.

Bossink, building on the work of Macey and Brown, employs a typology of three types of PDPs based on their aims in two extensive literature reviews of clean tech innovation and sustainable energy demonstration projects (Bossink, 2015; Bossink, 2017). These aims are described as follows: 1) technical/prototyping PDPs "to develop new prototypes and turn- prototypes-into-products". 2) organizational/organizing PDPs "to develop a production organization that is capable of producing large(r) quantities of the prototypes-turned-into-products." 3 market demonstration projects, "to find and explore (a) market(s) for the new prototype-based products." (Bossink 2015; Bossink 2017). This typology of three PDPs based on their aims are related to four different types of uncertainty reduction and learning (Bossink 2017).

These four types of uncertainty reduction and learning were distinguished by Frishammar et al. and are *technical*, *organizational*, *policy/institutional* and *market related learning* (Frishammar et al., 2015). While there will be various types of learning in different PDPs through feedback and feed forward loops, the different types of learning will tend to be more predominant in certain types of PDPs (Hellsmark et al., 2016). Simply put, it makes little sense marketing a product which is riddled with technical uncertainties or building a production organization for a product not ready for mass production. On the other hand, it makes little sense improving a product without having a market for it, which is why the 'exemplary' function of PDPs (the know about) are important to highlight.

3.6 Hellsmark's typology

Recognizing the balance between technological verification and creating a commercial market, Hellsmark et al. sets out to develop a typology of four main types of PDPs along **five analytical dimensions** in order to develop a framework to better understand the role of PDPs in technology development (Hellsmark et al., 2016).

The two first dimensions are **risk reduction** and **learning**. Risk reduction (or uncertainty reduction) and learning are broadly recognized in the literature as the most important outcomes of PDPs (Hellsmark et al., 2016; Frishammar et al., 2015; Klitkou et al., 2013; Bossink 2017; Bossink 2020). The remaining three analytical dimensions are **actors and agency**, **network**

performance and management, and **institutional preconditions**. These three dimensions are described as "the most critical preconditions for these outcomes to materialize" (Hellsmark et al., 2016, 1746).

The key analytical dimensions for analyzing the role of PDPs in technology development and innovation policy are risk reduction, learning, actors and agency, network performance and management and institutional preconditions (Hellsmark et al., 2016). Because this thesis is specifically dedicated to exploring the role of PDPs for the actors involved, and not for the technology development and innovation policy as such, I will not spend much time here elaborating on these five analytical dimensions as they are not equally relevant to my analysis. I will however give a short summary and return to risk reduction and learning later, as they are central to my analysis.

Risk reduction is important because developing a new sustainable technology is a highly uncertain process. There are four types of risks which are identified; technical, organizational, market related and institutional (Frishammar et al. 2015; Hellsmark et al., 2016). These various forms of risks will typically be associated with different PDPs and various forms of learning.

Learning is central to technological development and it is through various learning processes that risk and uncertainty is reduced. Various types of learning processes will be involved in reducing various types of risk. Technical, organizational, market related and institutional learning will typically be associated with different forms of learning, which in turn are associated with both research driven innovation as well as interaction based innovation. (Hellsmark et al., 2016; Jensen et al., 2007).

Actors and agency denotes the difference between actors as a structural element in the TIS and as an agent "with a capacity to take action" (Hellsmark et al., 2016, 1747). The actor networks around a PDP typically consists of a variety of public and private actors, such as firms, research institutes, government funding agencies (Hellsmark et al., 2016). As a technology progresses, PDPs will increase in scale and number of units, and the actor networks will also expand and increase in complexity as more actors enter (Hellsmark et al., 2016).

Network management and performance is important because as actor networks expand, so does the potential for varying interpretations and potential conflicts of interest (Hellsmark, 2016). While difficult to manage, the importance of governing and aligning the visions and interests of the various participants should not be underestimated (Hellsmark, 2016). Balancing risk/reward ratios between participants is important for the success of all types of PDPs (Bossink, 2015).

Institutional preconditions are the context in which actors and networks operate and where efforts to manage these interactions take place (Hellsmark et al., 2016).

I have now outlined the five analytical dimensions employed by Hellsmark et al. and I will now present the typology of PDPs.

These are the four main types of PDPs identified by Hellsmark et al. 2016:

*Type I: **high profile** pilot and demonstration plants*

"The role of high-profile PDPs is to create awareness and legitimacy for a specific application, product, process, or service" (Hellsmark et al., 2016, 1754). Type I PDPs are used to signal to policy makers that this is a possible trajectory. They are often funded and owned by an individual actor, thus making the management and network structure quite simple compared to other types of PDPs. Hellsmark et al. goes on to define this PDP type based on the analytical dimensions outlined above. For this type of PDP Hellsmark et al. argue that there is limited firm-learning from such a demonstration in regards to scalability and production processes.

*Type II: **verification** pilot and demonstration plants*

"The main objective of verification PDPs is to test, evaluate, and characterize different technological options for a certain application" (Hellsmark et al., 2016, 1754). There are two subtypes of the type II verification PDP. The distinction between the two types is based on size and what role they play in technology development: Type IIa (lab scale verification) and type IIb (industrial scale verification).

Type IIa: ***lab scale verification***

The primary function of this type of PDP is to reduce technical risk by developing new practical and scientific knowledge which can be applied in up scaled PDPs and commercialization. This type of PDP, prior literature suggests, is also owned by a single actor and therefore has the same simple management and network structure.

Type IIb: ***Industrial scale verification***

Industrial scale verification PDPs often have the aim of verifying new technology at a large but not necessarily commercial scale (Hellsmark et al., 2016), and it is at this stage and at this increased scale that the potential for supplier and university alliances can be formed and the potential for industrial capacity is created (Hellsmark et al. 2016). Industrial scale verification is often pursued by commercial actors and backed by public funding.

Type III: These PDPs are closely related to the market entry stage and field trials, and are divided into two sub categories.

Type IIIa: ***deployment*** *pilot and demonstration plants*

By gaining operating experience, these PDPs aim at lowering costs and and improving performance (Hellsmark et al. 2016) This type of PDP can function as a reference project for suppliers and can contribute to learning processes in the form of feedback from customers (Hellsmark et al. 2016, 1756) As the technology approaches the commercial phase, the actor networks become larger and more complex and there will be an increased need for institutional alignment. Deployment PDPs are important for 'learning by using' and 'learning by interacting', and for "reducing technical, market-related and organizational risk" (Hellsmark et al., 2016)

Type IIIb: ***market introduction of down-and up-stream auxiliary technologies***

This type of PDP bears resemblance to the type IIIa in that they both focus on marked entry (H. Hellsmark et al., 2016). However, they differ in certain respects. Namely, type IIIa takes auxiliary technological systems into consideration and "recognizes that many technological fields consist of a nested hierarchy of technologies" (Hellsmark et al., 2016, 1757). This means that as the actor network grows in size and complexity there is a need for an increase in alignment between "actors, technology and institutions" (Hellsmark et al., 1756). As the actor network expands, organizations and institutions get more defined roles in the innovation system, and product and organizational risk is reduced as the system becomes more stable and the value chain matures (Hellsmark, 1756).

Type IV: ***permanent test centers***

Permanent test centers allow a variety of actors to develop a mixture of knowledge. Both basic and applied research as well as proprietary knowledge, the latter increasing the possibility of conflicting interest (Hellsmark et al., 2016). Permanent test centers can be an already established part of a national or regional infrastructure, it can also develop "organically" as part of an innovation ecosystem as was the case of the Danish wind turbine test station (Garud & Karnøe, 2003; Hellsmark et al., 2016)

3.7 Firm characteristics

In order to better understand the role of PDPs for the surrounding actor network, it is beneficial to make some distinctions. I assume that firm size, product or service offering, as well as existing networks will be relevant to understanding the various motivations and outcomes from PDP participation, and I will therefore follow van der Loos et al. in this regard, and distinguish between established and young firms, as well as between large and small and medium sized enterprises (van der Loos et al., 2020).

Established enterprises are understood as firms entering OWP from a related industry and have a wide set of skills, an established informal network and available financial and human resources (van der Loos et al., 2020). Young firms are understood as firms with limited offshore experience, and a limited range of products and services (one or two specific products or services) as well as little or no reputation (van der Loos et al., 2020). Large Enterprises are defined as organizations with more than 250 employees, while small and medium size enterprises (SMEs) have less than 250 (van der Loos et al., 2020; OECD, 2019).

3.8 Learning

> *"If we take it seriously that knowledge is the most fundamental resource in our contemporary economy and that learning is therefore the most important process, what are the implications for the institutional set up of the economy?" (Lundvall & Johnson, 1994, 23).*

At a broad level of analysis, we can distinguish between four types of knowledge development, related to two ideal modes of innovation (Jensen et al., 2007). These four types of learning are *know-what* and *know-why,* associated with the science, technology and innovation mode of innovation (STI), and *know-how*, and *know-who* associated with the learning by doing, using and interacting mode of innovation (DUI) (Jensen et al., 2007). The STI mode of innovation is based on the generation and application of codified technical and scientific knowledge, whereas the DUI mode of innovation is based on experience and interaction (Jensen et al., 2007).

While all industries will to some extent be a combination of these two modes, one can clearly see the usefulness of the distinction when comparing industries. If we for example compare pharmaceuticals to OWP, it is evident that the methods by which products and processes emerge will be vastly different. The former, mostly through the application of scientific knowledge, and the latter mostly through interactive experimentation and optimization through action. i.e. learning by doing (Tsouri et al., 2021). These modes of innovation are ideal types, and any industry will consist of a wide range of technologies and competences and will as such rely on both modes of innovation (Jensen et al., 2007).

Various forms of learning

We have already established that learning is at the heart of the innovation process as well as one of two key functions of PDPs, the other being showcasing the technology to potential adopters. In order to provide the reader with a fuller understanding of learning, I will now elaborate on this key function of learning.

I will follow Bossink in distinguishing between four types of learning which take place around PDPs. These are, technical learning, organizational learning, market related learning and policy learning (Bossink, 2017; Bossink 2020; Frishammar et al., 2015). However, because this thesis is specifically focused on the role of PDPs for the firm, I will not be addressing policy learning directly.

Technical learning is the acquisition of skills and knowledge needed to further develop and improve a technology (Bossink 2017; Bossink 2020). Technical learning is the most important reason why actors invest in sustainable energy PDPs (Bossink 2017). While technical learning is found to be important in all types of PDPs, it is especially the case in early phase PDPs such as lab scale and (single unit) industrial scale verification PDPs, as well as in permanent test centers (Hellsmark et al., 2016). Technical learning is associated with learning-by-searching, which is synonymous with R&D and learning-by-studying (Kamp et al., 2004, 1627).

Learning-by-searching often results in formalized knowledge in the form of articles or research rapports. (Kamp et al., 2004). Learning-by-searching is a broad category of learning which encompasses a wide range of activities from basic research, developing and improving codified knowledge, as well as optimizing designs and design characteristics to better suit the market (Kamp et al., 2004).

Organizational learning can be separated into two types. One is the acquisition of skills and knowledge needed to develop and organize a production organization which can produce larger scale and more units of the prototype-turned-into-product (Bossink, 2017). This type of learning is often the domain of the PDP developer and large project management firms, as they are in a position to experiment with cooperation forms, develop supply chains, and manufacturing infrastructure (Bossink, 2017; Bossink 2020). This type of organizational learning is associated with learning-by-doing, learning-by-manufacturing and learning-by-interacting (Bossink 2020, Hellsmark, 2016). The other type of organizational learning can be defined as the acquisition of and embodiment of skills and insights within an organization's routines, practices and beliefs (Attewell, 1992). While both types of organizational learning are associated with firm interaction around PDPs, the first type is typically the domain of lead developers and large project manager firms. This is because supply firms and other smaller actors are typically not in a position to build, or even necessarily influence, the development of a production organization.

Market learning is the acquisition of skills and knowledge that enables an actor to operate in a particular market, by understanding and adapting to various forms of feedback, demands, experiences and wishes from users and customers (Bossink, 2020). This type of learning is closely associated with learning-by-using and learning-by-interacting (Bossink, 2020). In practical terms, market learning involves understanding user and customer needs, technical standards, contract structures and balancing cost/reward risks between PDP participants (Bossink, 2017). Since market learning is so closely related to learning-by-interaction and learning-by-using, it is especially prevalent in large scale industrial and deployment PDPs.

3.9 Summary

I have now outlined central perspectives, key functions and definitions of PDPs from the literature. While these contributions are important for a better and more differentiated understanding of the relationship between various PDPs and technological development, they cannot provide sufficient answers as to the role of PDPs for the actors who participate. There is an expressed need in the literature for a better understanding of the motivations and outcomes of the actors who participate. Frishammar et al. calls for "a more in-depth understanding of the actor networks surrounding the PDPs…" (Frishammar et al., 2015, 14). Hendry et al. points out the "absence of substantial evidence on what companies actually gain, as distinct from what advocates suggest they should and what policy makers believe sponsored DTs [Demonstrations and trials] can achieve" (Hendry et al., 2010, 2). Other studies have pointed out that while the role PDPs have been studied and recognized on a systems level as crucial to the development and diffusion of radical new technologies, the question of why and how individual actors engage in PDPs remains less clear (Fevolden et al., 2017; Klitkou, 2013). Recognizing that the various actor networks around PDPs might have divergent motivations and incentives for participation, many scholars have emphasized the need for more detailed investigations (Frishammar et al., 2015; Hendry et al., 2010). This thesis is an attempt to contribute to a better understanding.

Hendry et al. point out that because the majority of PDPs are funded by public money, the agenda for what the role of PDPs should be, is usually set by "what advocates suggest they should and what policy makers believe sponsored DTs [Demonstrations and Trials] can achieve" (Hendry et al., 2010), 2) Hendry et al. therefore asks "So what do innovating companies really get from publicly funded demonstration projects and trials?". Uncertainty reduction and learning are the two most recognized outcomes of PDPs in all the literature we have reviewed so far. For firms participating in PDPs as a step in their innovation journey, this is also the case. We know however, that innovating firms are completely dependent on a wide set of actors in order to further their technological innovation (Jensen et al., 2007). It is therefore important to understand what different actors get out of PDP participation.

4 Methodological Approach

In the following chapter of the thesis I will present and discuss my methodological choices. I will explain why I have chosen a qualitative approach, why I have chosen a case study, and how I selected my case. I will emphasize the three methods I have used for my data collection and I will discuss the selection process for informants, the interview guide, and the interview process. I will also elaborate on my method of coding and analyzing the material. Finally, I will discuss validity and reliability as well as reflexivity and ethics.

4.1 Qualitative Research

My choice of a qualitative approach is due to the questions I am exploring. In order to answer my research questions, I need data on the subjective experience of actors in relation to various types of demonstration projects. I therefore chose a qualitative approach, because it is the best way to collect rich, detailed and nuanced data, which can help me answer my research questions (Yin, 2014). Because the topic of interest is 'how' an actor perceives a phenomenon, rather than for example 'how many' of the phenomenon there are and 'what associations can be drawn from this', a qualitative methodology was chosen (Yin, 2014). Stratford and Bradshaw point out a central distinction between extensive (quantitative) and intensive (qualitative) research, and notes that while extensive research is concerned with distinguishing differences and identifying patterns from large data sets, intensive research is concerned with providing detailed and specific information from smaller data sets (Stratford & Bradshaw, 2016).

In short, qualitative methods are useful in answering questions related to the subjective experience of a phenomenon, whereas quantitative methods are better suited for measuring differences, and proposing statistical generalizations (Yin, 2014, 21,).

4.1.1 Case Study research

A case study research approach is suitable when examining a contemporary social phenomenon (Yin, 2014). It is also a recommended method when the aim of the research is to examine a social phenomenon extensively and in depth, as opposed to a survey or an archival analysis (Yin, 2014).

Yin argues that case study research, just like other methodological approaches, has its strengths and limitations. Yin argues that a researcher should examine his or her area of interest in relation to three conditions, in order to decide on the most suitable method (Yin, 2014, 9). These three conditions for deciding on a method are: a) the type of research question, b) control of behavioral events, and c) the degree to which the phenomenon under study is contemporary or historical (Yin, 2014, 9).

For this thesis I quickly ruled out experiment, survey and archival analysis as potential methodological choices. An experiment requires control over behavioral events, something which I did not have, and survey and archival analysis are relevant for answering questions of "who, what, where, how many, how much", rather than "how" and "why" (Yin, 2014, 9). I did however, consider a historical approach to the question of how firms engage with PDPs and how that engagement has been experienced by the participants.

However, because the phenomenon under study is still very much unfolding, I believe treating it as an active and contemporary event to be more productive, then studying it historically. This thesis is not a single case study in the strict sense of the term. If I was studying the case of Hywind Scotland pilot park for instance, then this would be the case. However, since I am studying the role of PDPs for the firms who participate, it is not the PDP or the specific firm in itself that constitutes the case, but rather it is the interaction between firm and PDP which is the case. This means that there are multiple units of analysis (multiple PDPs and multiple firms), which constitutes "the case." This thesis can therefore be identified as a type of embedded single case design (Yin, 2014, 54).

4.1.2 Choice of case

Finding a theme

My interest in offshore wind and renewable energy came gradually, and as a result of several factors. During my time at *Technology, Innovation, Culture* (TIK) I have learned and read up on the topic of diversification and the prospects of building a Norwegian industry for OWP. I found this topic very interesting, and decided in January 2020, that I wanted to write about OWP. For my case I knew I wanted to explore a research topic that was considered relevant to actors in the Norwegian OWP industry, as well as something that could be considered academically relevant and contribute to ongoing research at TIK.

I quickly scheduled my first preliminary interview with an industry insider, to learn more about the industry as well as potentially interesting topics for a master thesis. Simultaneously I approached TIK researcher Håkon Endresen Normann and told him of my interest in the topic. He was very helpful and provided me with literature to read, as well as putting me in contact with another industry insider. This led me to my second preliminary interview. Through these initial conversations I gained a better understanding of the field and I also established contact with potential respondents, as well as a manager in a OWP cluster organization, who gave me access to several (members only) webinars. These webinars, conferences and and preliminary interviews were important contributing factors in influencing the direction of my search.

Choosing the case

After having decided on a topic as well as established contact with industry insiders I began exploring possible avenues for research questions. Initially I wanted to focus on firm diversification as this topic has been extensively examined by TIK researchers (Mäkitie et al., 2019; Thune, 2019). However, through conversations and preliminary interviews, I became increasingly interested in the role of the innovation support system for technological development, as several informants, as well as rapports suggested improvements were in order (Deloitte, 2019).

Through my initial research into the topic, and discussions with my supervisor the contours of a case study began to emerge. Several informants expressed their dissatisfaction with Norwegian policy instruments for OWP, and one informant suggested I should choose a particular firm and perform a single case study of one technology developing firm and its journey from concept to achieve a full scale PDP. While this case was interesting, it did not necessarily have the academic relevance I was looking for, and through careful deliberations with my supervisor, I decided to investigate the phenomenon more broadly and investigate what role PDPs have for the firms who participate.

4.2 Data collection

Collecting data from several sources is known as triangulation and is an important step in ensuring rigor in qualitative research (Yin, 2014). In other research methods such an experiment for instance, collecting data from outside the laboratory would not necessarily strengthen the findings of that particular experiment (Yin, 2014). However, the ability to employ many sources of evidence is "a major strength of case study data collection" (Yin, 2014, 119).

My research questions cannot be answered by other means than direct interaction with PDP participants. Therefore, semi structured in-depth interviews constitutes my primary method for data collection. In order to contextualize and challenge the data from these interviews I have relied on content analysis of documents, observation as well as preliminary interviews and informal conversations. Although these sources of data cannot confirm or contest the subjective experiences of my informants, they did allow for a contextualization of the provided information which in turn allowed me to analyze the interview data in a more rigorous manner (Yin, 2014; Stratford, & Bradshaw, 2016).

Early on in the process of writing this thesis, I decided to anonymize the informants and firms. This had the benefits of allowing informants to speak more freely, which provided me with rich (and presumably more honest) accounts of their experiences. However, this also had the disadvantage of not allowing for a more active use of secondary sources in the analysis, as this would have compromised the anonymity of the informants. Secondary sources I would have liked to include are quarterly and yearly reports, newspaper articles, public records and websites (Yin, 2014).

4.2.1 Selecting participants

My selection of participants unfolded in several ways. My methods for selecting relevant participants have been a combination of snowball sampling (Berg, & Lune, 2017) and criterion sampling (Dunn, 2016).

First, through my preliminary interviews, as well as through contact with the cluster organization, I gained insight into potential people and firms with the relevant characteristics and developed a short list based on that information. Second, I took notes during webinars and conferences of both the presenters as well as the attendees and participant firms (for example through the participant pane in MS teams) and then looked them up online. Thirdly, I looked at the membership pages of several cluster organizations in order to get oriented as to the firms involved in the industry. My second method of selection was done in cooperation with my supervisor who was helpful in consolidating my existing list of relevant participants. At this time, I had a list of around 20 names of firms and individuals with relevant characteristics, and I began conducting my first interviews.

Several of the interviews were conducted in tandem with a fellow student writing about a related topic and we therefore coordinated our criteria for selection. This was unproblematic and the collaboration was beneficial both to the interviewing process as well as subsequent analysis as it allowed us to challenge each other's biases and interpretations of the data.

The relevant characteristics for participant selection were quite simple; it had to be a firm based in Norway, engaged in OWP, and the firm had to have been involved in one or more PDPs. As the intention of this thesis is to explore the interactions of actor networks around PDPs, I set out to select participants with different roles or functions in the PDPs, such as a research institute as well as as two PDP developer, in addition to supply firms, which constitute the majority of my selection. This broad method of selection had two advantages. One, by including a wide set of actors involved in PDPs as relevant participants in my thesis I was able to examine the case from a variety of perspectives. As the snowball began to roll, this meant that I was able to interview actors who had been involved in the same PDPs, and thereby draw attention to the same phenomenon from several perspectives. This has helped strengthen the rigor of my findings, and is part of the triangulation strategy for my data collection (Yin, 2014; Stratford, & Bradshaw, 2016). Although the process of selecting participants was purposeful, in the end the selection will always be a mixture of “purpose and serendipity” (Stratford and Bradshaw, 2016).

4.2.2 Qualitative Interviewing

Interviewing is one of the most widely used data collection methods in qualitative research (Patton, 2002, 340). The quality of the data collected depends in part on the skill of the interviewer, which is why preparation and practice are important (Patton, 2002). Conducting several preliminary interviews was helpful in preparing me for the official data collection. Interviewing allows the researcher to gain access to the perspective and world view of the respondent, and to capture the thoughts, motivations and subjective experiences which might otherwise remain hidden, and inaccessible (Patton, 2002). In short, you cannot measure or observe someone’s subjective experience and perspective (Patton, 2002). Qualitative interviewing is often characterized into three types, structured, unstructured and semi-structured (Dunn, 2016). I chose semi structured interview as it allows for flexibility, while simultaneously structuring the conversation.

Preliminary interviews

Interviewing can be described as an art, as well as a skill or a science (Berg & Lune, 2017, 65-67). Regardless of the definition, it is an activity that involves interaction with others and can therefore be understood as requiring the acquisition of “know-how” through learning-by-doing. In recognition of this, I began my interviewing process early, and conducted a series of pilot interviews. This enabled me to both learn about the subject, generate a list of potential informants as well as develop my interview guide, and practice my interviewing skills. Following is an anonymized and descriptive overview of my preliminary interviews.

Table 2: A descriptive overview of preliminary interviews

Informants	Organization	Position	Interview setting	Date	Length
Informant 1	Established large enterprise	Management	Face to face	17/01/2020	1 hour
Informant 2	Financial advisory for industry export	Senior manager	Face to Face	27/08/2020	45 minutes
Informant 3	OWP Cluster	Manager	Video	07/09/2020	32 minutes
Informant 4	Venture development	Manager	Video	24/09/2020	43 minutes
Informant 5	OWP Cluster	Consultant	Video	27/10/2020	34 minutes

4.2.3 Interview guide

Developing an interview guide is an evolutionary process, and the questions will change as the research proceeds (Gioia, et al., 2013, 19-20). Because several of the interviews were conducted with a fellow student with a similar, yet slightly different focus, we had to adjust and adapt our interview guides to accommodate both our research goals. This process was useful as it provided an arena to discuss and clarify our questions. Throughout the interviewing process I reviewed and adjusted my interview guide after each interview, in an iterative learning process. I also did research on the individual firms before each interview in order to be able to ask more informed follow up questions.

There is a challenge when designing the guide and performing the interview that questions can be leading, and that theoretical categories from existent research is introduced in the conversation by the researcher, and that this can affect the answers (Gioia, et al., 2013, 17). Aware of this risk, I purposefully avoided introducing theoretical categories, and did my best to use plain language and ask open ended questions in an effort to not impose a priori explanations on their experiences (Gioia, et al., 2013, 17.) There was definitely a learning curve from my early preliminary interviews and towards the end of my data collection.

4.2.4 Conducting interviews

Due to the global Covid-19 pandemic, all interviews were conducted digitally. Telephone or digital interviewing can affect the ability to interpret non-verbal cues, which might be challenging for 'reading the room' and the flow of a conversation (Berg & Lune, 2017; Dunn, 2016). However, I did not experience this as a challenge. In my estimation the informants were used to video conferences and team meetings, and the format did not hinder our conversations except for the occasional glitch in the internet connection.

In advance of each interview I sent the informants an email (as well as in some cases a phone call), where I informed of my research project, and provided the necessary contact information, as well as informed them of their rights through a NSD consent form. All informants agreed to be part of the research project, and were informed of their right to withdraw their consent at any time.

The interviews ranged in length in part based on the schedules of the informants, and in part based on advice from fellow students and my supervisor. One informant however, took a special interest in my research topic and thereby was in a sense both an informant as well as served as a teacher. This is why one interview is nearly two hours long.

Following is a descriptive list of my primary interviews.

Table 3: A descriptive overview of primary interviews

Code	Actor Type	Value chain position	Date	Length
ELD1	Established large developer	O&G and OWP developer	20/01/2021	63 min
ESD1	Established SME developer*	OWP developer	19/11/2020	43 min
ELE1	Established large enterprise	EPC	14/01/2021	63 min

ELE2	Established large enterprise	EPC	26/11/2020	73 min
ELE3	Established large enterprise	EPC	15/12/2020	68 min
ELE4	Established large enterprise (DOF)	Offshore service vessels	08/12/2020	62 min
ESME1	Established SME	consulting, design and engineering + Foundation design	08/12/2020	63 min
ESME2	Established SME	Mooring solutions	19/11/2020	63 min
YSME1	Young SME	Engineering services and subsea operations	10/12/2020	59 min
SU1	Start-Up	Foundation design	18/11/2020	31 min
SU2	Start-Up	Foundation and installation factory concept	01/12/2020	70 min
ERI1	Established research	Geotechnical services	07/12/2020	115 min

Firm characteristics based on (van der Loos et al., 2020)

Interviewing experts

All of the informants knew vastly more than me about the topic of OWP and the case of PDPs, that is one of the reasons why I interviewed them. They were all highly educated (in most cases in engineering or business, and in some cases both). By being curious and transparent about my lack of expertise I allowed them to provide the answers and I asked the questions. In some cases, the informants did attempt to steer the conversation in a certain direction, in which case I let them, and then carefully shifted the conversation back to the topics in my interview guide. I did not experience this as a problem. It is because of their expertise and particular experience in the field that I wanted to talk to them, so the asymmetrical relationship between us did not come as a surprise and did not present a problem in my estimation.

4.2.5 Observation

While interviews have been my primary data source, I have complemented these with observations and informal conversation (Yin, 2014). This additional observational data has provided me with additional context to my interview findings (Kearns, 2016). The webinars and conferences I attended, primarily had the function of a learning arena, where I could get a better understanding of the OWP industry culture, as well as a sort of interactive presentation of the 'state of the art' of the industry. While attending these webinars and conferences did not directly provide data I could use in my analysis, they did give me a better understanding of several of the informants I ended up interviewing as I got an opportunity to see them 'perform' and discuss topics in a familiar setting.

Table 4: Digital seminars and conferences

Name	**Type**	**Date**	**Length**
Floating Wind 2020	Conference	24/06/2020	6 hours
Contracts in OW	Webinar	01/09/2020	4 hours
ONS 2020	Conference	01-02/09/2020	2 days
Havvindkonferansen 2020	Conference	20/10/2020	6 hours
Home market	Webinar	10/11/2020	2 hours

4.2.6 Content analysis

Qualitative content analysis allows the researcher to gather information on pre-defined topics (Dunn, 2016). I used this method extensively throughout my analysis. Both in order to add nuance to the information given by informants (such as when a PDP had taken place, who had been involved, how was it funded etc.) as well as understanding their involvement (what did they deliver, how was their engagement described by themselves and others in industry reports and websites). I analyzed quarterly reports, various renewable energy sites, I looked through government white papers, and strategies (Energi21, 2018; Energi21, 2012), firm responses to policy suggestions, as well as wide range of reports on OWP (Thema Consulting Group, 2020; Winje et al., 2019; Husebye 2020; Hanson & Normann, 2019). I engaged with this material continuously in order to learn about the topic and the case, and especially to look for conflicting or corroborating information to my primary data which I believe, in turn adds rigor to my analysis.

4.3 Data analysis

As soon as possible after conducting an interview I wrote down my impressions and thoughts. This process is referred to as field notes or memos in the literature (Dunn, 2016; Cope, 2016). This process was beneficial in two ways. Firstly, it served as a sort of 'post game analysis' which enabled me to reflect on how to improve both my interview guide as well as my performance as an interviewer. Secondly, it allowed me to identify themes which were helpful in guiding my first round of analysis. All interviews were transcribed within a week of the interview taking place. Transcribing can be helpful in familiarizing the analyst with the data material (Dunn, 2016). I did not however find this to be the case. I preferred to view the transcribing more as a mechanical process which had to be done in order for me to fully immerse myself in the material. After transcribing all twelve interviews I printed them out along with my field notes, and took notes in the margins of the interviews in an attempt to identify themes. After this first preliminary round of analysis, I imported the interviews into NVivo and began organizing the data in a myriad of categories, using the informants own terms. This first round of analysis can be described as a first order analysis and is part of a grounded theory approach to qualitative research (Gioia, et al., 2013).

I have employed an inductive grounded theory approach in my analysis. This means that by retaining a certain "willing ignorance of previous theorizing", I began my primary data collection with less prior hypothesis bias than might else have been the case (Gioia, et al., 2013, 21). Instead of trying to organize my data material into predefined theoretical categories, I instead let these categories develop organically from the ground up, i.e. inductively. This is of course an idealized explanation. The analysis has been a continuous iterative process of wrestling with theory, coding structure, and the empirical data in an attempt to discover themes and identify similarities and differences (Gioia, et al., 2013). Gioia et al. argue that a certain balance between knowing and not knowing can be valuable and beneficial for the analysis Gioia, et al., 2013, 21). There were both pros and cons to this approach in my experience. A benefit, was that categories that developed during the first round of coding and analysis developed naturally from the material, which they perhaps would not have done had I developed questions from predefined set of categories. This allowed me to explore themes and categories in my second round of analysis, that I perhaps would have missed, had I used a different method. A drawback of this method has been that the analytical process has, honestly, been somewhat chaotic. I have on more than one occasion had to "look up and conclude, I am lost" (Gioia, et al., 2013, 20) However, all in all I believe this iterative oscillation between theory and data has made my analysis more rigorous.

4.4 Quality, rigour and ethics

4.4.1 Validity and reliability

Demonstrating rigor throughout the research process and analysis is crucial for the credibility of the thesis (Stratford, & Bradshaw, 2016). Validity can be described as the degree to which a study examines what it set out to examine, and the degree to which the conclusions reflect the data material (Hay, 2016). By defining the parameters relevant for the phenomenon under study clearly, it becomes easier for the reader to assess the degree to which conclusions stem from the data material, as well as the degree to which they are influenced by the subjective biases of the researcher (Yin, 2014). I have used multiple sources of evidence to test my assumptions and conclusions throughout the research process. By maintaining a reflexive and critical attitude to my own thinking and assumptions about the data material, I have continuously examined rival hypothesis before drawing any conclusions.

One recurring example of this in my data material has been the degree to which various learning has been the outcome of a PDP or a commercial project. In many cases the evidence has been ambiguous. In these cases, I have reviewed the statements in the context of the rest of the interview, statements made by other actors participating in the same projects as well as through a variety of data material and previous statements by the firm. This process has been continuous throughout the analysis and can be likened to a blacksmith hammering a glowing slab of steel, from every angle, in order to rid the material of weaknesses and inconsistencies.

4.4.2 Reflexivity and ethics

I have done my utmost through the research process to be reflexive and critical of my own biases and to not let my convictions and assumptions influence how I have phrased questions and interacted with the data material. One bias, however, which I think is somewhat unavoidable given the nature of the research field, is that I am positive to firms engaging in renewable energy and the prospects of developing a Norwegian OWP industry. I did my best not to let this attitude influence my interview guide, or interactions with the informants.

This project has been approved by the NSD and I have copied and followed all the rules and guidelines. All the firms agreed to be recorded and were promised anonymity. The audio recordings were stored and deleted in accordance with NSD guidelines.

4.4.3 Limitation and weaknesses

One limitation of this thesis is that I did not interview Sintef Ocean, Norwegian Energy Partners (NOWEP) as well as the Marine Energy Test Centre (MetCentre). I initially wanted to interview these two actors because I think they would have contributed to my overall understanding of PDPs and the Norwegian supply chain. However, given that the focus of this thesis is on firms, priorities had to be made, and I therefore focused on getting a wide selection of large, medium and small firms, which I did

5 Case description

Offshore wind power (OWP) is power generated from wind turbines mounted on the ocean floor, or on floating foundations moored to the seabed. The former is referred to as bottom fixed wind and the latter is referred to as floating wind. Bottom fixed wind has rapidly become an established industry, with projects being commissioned without government subsidies and value chains having become highly specialized (Hanson & Normann, 2019). The largest markets have so far been in and around the North Sea (notable UK and Germany), but the market is increasingly moving to other parts of the world such as Asia and the US (Hanson & Normann, 2019).

Floating wind is an emerging industry and the only projects commissioned so far have been pilots and demonstration projects (Tsouri et al., 2021). It is however expected to grow substantially over the next decades (Thema Consulting Group, 2020). While bottom fixed and floating are currently at different stages of maturity, they are expected to converge during the 2020s (Husebye, 2020).

Norwegian companies are expected to be able to take significant positions in floating OWP due to competence developed from O&G and maritime industries (Thema Consulting Group, 2020). This is somewhat more difficult in bottom fixed wind however, because of the maturation of the industry and the disadvantages associated with late market entry. There are, however, several Norwegian O&G supply firms who have taken positions in bottom fixed wind. Notable examples are Aibel, Fred Olsen Windcarrier as well as Equinor, who have developed several wind farms (Thema Consulting Group, 2020; Winje et al, 2019). The value chains between O&G, bottom fixed and floating OWP have several similarities which provide opportunities for Norwegian firms (Hanson & Normann, 2019). The areas which are believed to hold the most opportunities for Norwegian firms are project management, subsea cables, offshore substation structures, turbine foundations, installation of equipment and support services, maintenance and inspection services, and vessels and equipment (BVG Associates, 2019).

The firms engaged in OWP can be differentiated by their size as well as assumed level of ability to gain market access (van der Loos et al., 2020). *Established* firms can be defined as those who are entering OWP from a related industry such as O&G and maritime industries, and (van der Loos et al., 2020). These firms can also be described as following a related diversification strategy:

> "*A firm is said to follow a related diversification strategy if it diversifies to serve similar customer or market segments, employs similar resources (e.g., productive assets, raw materials), or utilizes similar capabilities in its business units (e.g., production processes, tacit knowledge and know-how, organizational structures, or dynamic capabilities)" (Knecht, 2014)*, 49)

Young firms can be defined as firms with limited offshore experience, who are trying to directly access OWP markets with a limited range of products and services (van der Loos et al., 2020). Start-ups can be identified as a particularly "young and and financially dependent subset of young firms" (van der Loos et al., 2020), 123). Firms can further be separated into two categories based on the OECD definition of firm size (OECD, 2019). Large firms have more than 250 employees, and small and medium size enterprises (SMEs) have less than 250 (OECD, 2019). The majority of Norwegian firms engaged in OWP - both floating and bottom fixed - have diversified from O&G and maritime industries (Hanson & Normann, 2019).

The O&G industry is Norway's largest source of income (energidepartementet, 2018). If accounted for as an industry on its own, the chain of suppliers delivering products and services to the oil companies counts as second largest industry in terms of income (Rystad Energy, 2020). Since oil was found on the Norwegian continental shelf in the 1960s, a highly competent domestic offshore O&G industry has developed (Ryggvik, 2013; Thune, 2019). This industry consists of a wide range of actors and firms providing products and services to the upstream oil majors such as Equinor. The Norwegian supply chain has been essential for innovation and finding solutions to all manners of problems associated with extracting petroleum in hostile offshore conditions (Thune, 2019). There is a high degree of technological relatedness between OWP and O&G (Hanson & Normann, 2019) and the pressures of global warming has led both oil majors and supply firms to diversify into related industries. There is an expressed political interest in developing an international competitive supply chain for OWP (Energi21, 2018). The pressures and demands of the green shift creates opportunities for national governments to align industry building ambitions with global and local environmental targets (Tsouri et al., 2021; van der Loos et al., 2020). Government policy can stimulate industry building through investments in R&D, PDPs and by stimulating demand by creating niche markets. (Smith & Raven, 2012; Tsouri et al., 2021). However, creating these subsidized markets is very expensive, and without an expressed domestic demand for clean energy, there has been weak incentives for doing so (Tsouri et al., 2021). There is no home market in Norway for OWP as of today, and there has only been installed one demonstration turbine in 2009 (Tsouri et al., 2021). Although Norway currently does not have a domestic demand for OWP, there is a broad industrial as well as political desire for the Norwegian O&G industry to "secure a new low carbon business model for the future" (Buli, 2021).

However, in order for this to happen, it is generally assumed that a protected space where DUI learning can take place, is needed (Tsouri et al., 2021). PDPs can serve as a protected space, for firms to get this experience.

6 Empirical Findings

In the following section I will present my empirical findings.
The structure of this chapter follows that of the research questions. I will therefore firstly outline what motivates firms to participate in PDPs, secondly how they gain access to them, thirdly what they gain from participation and finally what they learn from the participation in PDPs.

6.1 RQ1: What motivates Norwegian supply firms to participate in OWP PDPs?

In this section I will present the various factor that motivate firms to participate in PDPs. I will begin with a short introduction and will thereafter present my findings as they relate to market access, technological verification, early mover advantages, PDPs as marketing tools as well as their commercial value.

6.1.1 Introduction

Firms were motivated for a variety of reasons to participate in PDPs. For some it was understood as a stepping stone allowing for access to (what they consider to be) an emerging market, and for others it represented an essential step in their technology development. Motivations for participation seemed influenced by both firm size and firm characteristics (young vs established). One central motivation for PDP participation is building a list of references or track record in order to get access to an existing (bottom fixed) as well as imagined (floating) future markets.

It is not always easy to tell where motivation ends and outcomes begin. Therefore, I have chosen to deal with learning as well as commercial value in itself, under the outcome section, as not to make the same points twice.

6.1.2 Market access

6.1.2.1 Technological verification

Firms were motivated to participate in PDPs in order to get a track record of proven success. The firms described the importance of getting a track record in two ways, firstly, as a means to improve their competitive advantage in tendering for future projects and secondly, as a necessary step to verify a (both new and 'known') technical solutions in a new market. PDP participation as a means of improving competitive advantage was related to the perceived importance of being an early mover. SMEs as well as some ELEs were motivated to participate in PDPs in order to enter a promising market at an early stage of development, in order to benefit later on. Several SMEs were motivated to participate in order to later be able to access international markets, as they understood the importance of having proved themselves in a real market setting. For some SMEs this was unrelated to a specific innovation process (such as the development of a foundation concept, or a factory concept) while for SMEs engaged in technological innovation processes (technology in need of verification through demonstration) PDP participation was understood as both an advantage as well as a prerequisite for market engagement.

> "In order to gain access to the current international market, with a novel offering, you have to have some sort of proven success to show for, if not then you will have difficulties accessing the marked." [SU2]

The same message was expressed by another start-up company, who demonstrated a foundation concept in a single scale PDP, and who is currently engaging with international developers attempting to land commercial contracts.

> "In a way, it is a ticket of admission to gain access to the market, but it is by no means enough" - [SU1]

PDPs were also important for SMEs who did not have a 'novel offering' in need of demonstration, but who nonetheless considered it necessary to demonstrate a 'known technology' in a new market. This seems to be somewhat dependent on what the product or service is, and whether or not it is deemed critical by the developer. An ESME who supplied mooring solutions on a large scale floating OWP PDP pointed out that although the technology is known and has been used in O&G for many years, it is still necessary to prove that it works in its new application area. This is interesting because it might indicate that PDP participation has a third significance in a sense, in addition to being a market access strategy and being a part of the innovation process for untested technologies. The ESME points out that their technology has been used in several industries and is a well-established solution for offshore activities.

> "We are bringing known technology, putting it together in a slightly different way, but it is very known technology, you can use the same thinking on whatever it might be, whether it is a LNG storage unit in Russia, or floating wind or fish farming or whatever it is" - [ESME2]

However, the same firm also points out that although the technology is known and not novel, it is nonetheless important to be able to demonstrate, and have a track record, that it works in the new application area.

> "a list of references is important because this is critical equipment, so you have to in a way, have proof that this works" - [ESME2]

This is perhaps an indication that firms are motivated to participate in PDPs even if their technology has been demonstrated and in use in several other industries. While it can be expected that PDP participation is important for firms for verifying new and untested technologies, it might seem that the same motivation extends to firms with established technologies as well.

In short, technological verification seems to be a motivation for new as well 'known' technologies. This might of course present a challenge for young firms however, as market access requires a track record, and a track requires market access.

6.1.2.2 Early mover advantage

Being an early mover in an emerging industry can be advantageous. The value of being first was a motivating factor for ELEs as well as SMEs and firms developing an innovation (foundation concepts). However, larger companies tended to have commercial experience before or parallel to

PDP engagement. They are also arguably less dependent on niche markets to gain access to international commercial markets (van der Loos et al., 2020).

> "We recognize that we have something to contribute, and that we can be in the front seat of the development, we have to be involved from an early phase if we are to take our O&G competence and apply it in new business areas" - [ELE3]

For some firms, gaining an early mover advantage entailed investing time and resources into technology development and research projects, while for others the degree of relatedness between OWP and their other core markets (O&G, fish farming, maritime services) was so strong that their services were more or less directly transferable. In both cases however, firms expressed strong motivation to participate in PDPs in order to get early access to a promising market.

> "PDPs are important to us, because the ones who are a part of the first projects, get a track record, and a list of references and then it becomes a lot easier to get the next" - [ESME2]

> "We want to enter into a market early, which we believe, in time, will be commercially interesting, be one of the players who set the premises for how to operate in the market, and get a commercial advantage by being early." - [YSME1]

A third firm who has participated in a series of PDPs, both as a supplier as well as part of their own foundation development process, also emphasized being an early mover as a motivation.

> "We have invested quite a lot of money for being such as small firm…we have staked quite substantial spending on our renewable investments in order to stay ahead and gain access to the marked." - [ESME1]

6.1.3 PDPs as a marketing tool

PDPs can serve as promotional tool, and have an exemplary function, which firms can take advantage of in several ways. For developers a high profile PDP can create awareness and legitimacy for the technology and attract new entrants to the industry (Hellsmark et al., 2016). My empirical findings demonstrate that they also allow firms to profile themselves in a beneficial way. This profiling was a motivational factor, both in regards to how they are perceived in the market (and related markets) by competitors and and developers, but also how firms wished to capitalize on exiting projects, when when attracting potential employees.

> "The times when we have profiled ourselves, we see that what we use to profile ourselves with, is not necessarily our core competence, but rather these exiting things we are engaged in, such as the [high profile PDP] has been" - [ELE3]

The same sentiment was also expressed by a small firm, who also brings attention to the 2015 downturn in O&G.

> "We saw that O&G was on its way down, and another thing is also attracting talented people, young people today are perhaps not so interested in oil and gas anymore…however, we still do jobs in oil and gas, we have to live while we, I mean we have to be able to chew gum while we walk" - [ESME2]

In addition to being motivated by factors such as attracting talent to the firm, and company profiling, one firm was also motivated to participate in order to showcase a ROV technology to potential customers.

> "Although pilot projects constitute quite a small part of our turnover, it is nonetheless a signaling effect and a technology development legacy in our company, which is why we focus on it... we are also looking for PDPs where there will be customers interested in using technology early, and in that regard, it is very important for us to find projects where we can showcase this [technology]" - [YSME1]

6.1.4 Market development

Larger firms were perhaps not that motivated to participate in PDPs. Perhaps especially in early single unit projects. For large EPC firms whose core competency is in handling large system complexity and project management, PDPs were described more as a piece in a broader strategy to build a future industry for floating wind.

> "As an EPC supplier we are more interested in commercial projects, rather than demonstration projects, but we want to contribute to develop this industry and market for floating wind in general, so we are in dialog with developers who are looking at the opportunity for demonstration projects…" - [ELE2]

Several firms shared this outlook and emphasized that they are primarily motivated to engage in commercial projects, while retaining a certain openness to future PDP participation if related to specific technological solution, at the request of customers, or if a project was deemed to have specific strategic drivers, enabling them to engage in a new region, or with new customers.

> "Some customers are interested in doing demonstration projects moving forward also, where we see a strategic importance around it, strategic drivers, where we see there is a new customer or a new region or good possibilities for profitability in that type of project, then we will pursue it" – [ELE1]

This primary interest in commercial projects as opposed to demonstration projects, is perhaps influenced by previous commercial experience as well. The three EPC firms in my selection have all been engaged in various commercial bottom fixed projects before, and thus, already have a track record, as well as large international networks and financial resources which presumably makes it easier to access international markets as well as future floating wind markets.

6.1.5 Commercial value

For some firms, a PDP will always be a means to an ends, while for others, the PDP is an end in itself. While the motivations for participation are varied as has already been demonstrated, the degree to which actors were motivated to participate in a PDP was dependent on the size of the firm in relation to the size of the PDP.

In short, small firms can turn a profit from small contracts in lab scale or single scale PDPs, whereas larger firms are typically more motivated to participate in larger pre-commercial projects. Understandably, few were particularly motivated to engage in unprofitable projects by choice. I will deal with this subject at greater length in the outcome of participation section.

6.1.6 Summary

I have now presented and analyzed the various motivations firms have had for participating in PDPs. In the following section I will present how various firms gain access to PDPs.

6.2 RQ2: How do Norwegian supply firms gain access to OWP PDPs?

This chapter is organized after categories based on van der Loos et al. 2020. We will look at the role of policy instruments, strategic partnerships, informal and formal networks, mergers and acquisitions, reputation and legitimacy, as well as research projects.

6.2.1 Introduction

Firms employ different strategies and combination of strategies to gain access to PDPs. It was not always easy to get exact answers to how a firm became a part of a specific PDP. In some cases, the particular informant had not been a part of the particular project, in other cases the PDP was so far back in time, that the background for the participation was too multifaceted to draw conclusions. Several actors, when asked about their motivations and strategies for PDP participation, began giving descriptive accounts of their O&G activities and explaining the technological relatedness between O&G and OWP. I will not address this technological relatedness as a strategy for access, because it is not PDP specific but rather a general fact about the firms existing capabilities being important for OWP engagement. All the firms in my selection have a background in O&G except for the two start- up companies (although their competence base was developed in O&G and maritime industries). In addition to a shared industry background, all the actors (except for the two start- ups), have cooperated and in some cases co-evolved through decades in O&G, and the role of this existing network was emphasized as important for gaining access. The majority of firms have also been involved in PDPs led by the same Norwegian developer.

This familiarity between actors is a recurring theme in the interviews and can be assumed to play a role in the search heuristics of PDP developers, as well as enabling smaller firms to 'piggyback' on larger firms in order to gain access. In short, existing informal networks from O&G can be assumed as a relevant factor for how firms get access to OWP PDPs.

> "I would almost say its a 80/20 rule, that 80 percent of the suppliers and partners are known in O&G and then you have 20 percent new ones" - [ELE3]

6.2.2 The role of policy instruments

Policy instruments and funding were emphasized by all the actors as crucial to PDP participation. Public funding is important because of the high risks and uncertain returns associated with innovation and immature technologies.

> "It is make or break…if you do not have a policy instrument portfolio which can make these projects profitable, there won't be any projects." [ELD1]

For developers and suppliers alike, policy instruments were described as necessary for PDPs to be developed. Out of the 23 identified PDPs the actors in my selection have been involved in, only one was wholly privately funded. This one exception was a European single unit PDP entirely funded by private energy companies.

> "There was no public funding involved…it ended up as a commercial delivery where a consortium of three large energy companies collaborated… and perhaps paid somewhat

> more for it then they normally would have done had they built it with a run of the mill technology already in mass production…" - [SU1]

The rest of the projects were a combination of public and private financing, both directly through funding schemes such as Enova, the RCN or similar international organizations, as well as through support schemes such as feed-in-tariffs, green certificates or contract for differences (CfDs), or a combination. Despite the exception, government intervention was widely agreed upon by all firms as more or less a general precondition for PDP participation. Several firms pointed out, that without direct public financing, or subsidized demand there would not be any projects.

> "It is clear to us, that this support, that has come from governments has been essential, without it there, it simply would not have happened." - [ELE3]

How can supply firms influence policy instruments to get access to PDPs?

Policy instruments and public funding are considered necessary for PDPs to materialize, and as several firms have pointed out, without public support there won't be any projects. However, in cases where there are sufficient incentives for a PDPs to be developed, this does not necessarily mean that suppliers will be able to get access. So how can suppliers use policy instruments to gain access to PDPs? This varies both, in regards to PDP type as well as firm size.

Lab scale PDPs can be part of international research projects, which have clear demands and criteria on the constellation of actors, as well as articulated goals for the project. This gives a degree of predictability and transparency which allows firms to assess where they might be able to fit in in a project. However, lab scale PDPs also have limited actor networks, and are often built around specific research intensive goals and are therefore not relevant for many of the firms in my sample. Only two actors participated in lab scale PDPs (ESME1 and SU2). In larger scale verification and deployment PDPs, the criteria and roles might not be as identifiable, and thus strategies for access less clear.

> “We would like to be involved, but it is difficult to know how to reach a position besides being part of large multi-disciplinary research projects…and of course keeping good contact with clients…I don’t know what else we could be doing… we cannot really influence if [a large deployment PDP] takes place” - [ERI1]

One ESME did however, attempt to directly influence the innovation policy support system in order to gain access to a multi-unit deployment PDP.

> “We have tried to use [policy instrument] to influence [ELD1] to choose a Norwegian supplier. Since there is a political goal to establish a Norwegian supply chain for OWP, and when you receive [substantial funding] in support to develop the project, you should choose a Norwegian supplier if you ask me” - [ESME2]

These process is however ongoing, so it is not possible to say whether or not their strategy will yield results.

6.2.3 Strategic partnerships

Firms employ a variety of strategies to gain access to PDPs. Engaging in various forms of partnerships was an important strategy for small and large firms alike.

In order to gain access to verification and deployment PDPs, several firms engaged in different types of alliances (partnerships, consortiums, and joint ventures). Some alliances were project specific, while others were preexisting strategic partnerships, allowing both parties to benefit from each other’s competence and strengthen their competitive advantage.

> “We are experts on ROV technology and underwater robotics, and [medium sized marine surveying company] core competence is data collection and analysis, and you need both those elements to have a complete product, so you can say there is a mutual dependence there…” - [YSME1]

Strategic partnerships were important for several ELEs in gaining access to PDPs. In one case this partnership was preexisting and had originally been established a decade earlier.

> "[the partnership] has played a very important role, we wanted to keep building on our collaboration towards these offshore wind projects, so that has been an important factor behind our engagement" - [ELE2]

ELE4 and ELE1 created a specific partnership in order to tender for a specific multi-unit deployment PDP.

> "…we wanted that contract, and we worked a good deal in preparation of the tender by positioning ourselves, and among other things by establishing this joint venture with [ELE1], with their competence on fabrication and assembly and our fleet and experience with towing and mooring, we make a pretty god team." - [ELE4]

Due to the size and scope of contracts in multi-unit PDPs, it is not always possible for SMEs to gain direct access, and they typically interacted with the large EPC suppliers in order to get a contract.

> "…It was obvious that we could not tender on our own, the scope was to big and it was multidisciplinary, so we came in under [ELE2] who tendered…" - [ESME1]

Existing informal networks were an important factor in enabling this form of PDP access.

6.2.4 Informal networks

Existing informal O&G networks was emphasized as important by a majority of firms (all but the start--up firms). It is however difficult to say anything specific about the role of this network in firms gaining access to PDPs. However, since this O&G network has developed in close relation to a few major oil companies and EPC firms, it is perhaps reasonable to assume that it has an influence on the search heuristics of these large incumbents as they reorient themselves towards OWP.

> “[ELD1] has engaged a lot of people with an O&G background, and that has been useful because we have had existing relationship with [ELE1 and ELE2]. So that has been positive…since [a large utility company] retired from all things related to OWP, we have been very dependent on [ELD1] in order to be a part of those processes.” - [ESME1]

The importance of informal networks was also emphasized by larger firms

> “It is probably easier for us to get underneath the skin of [ELD1] or these other oil companies, it’s a longer climb uphill for people without a background in O&G.” - [ELE4]

There were also cases where a supplier’s activities with the developer in O&G were so similar to the ones in OWP that their engagement in the former led to engagement in the latter

> “it was quite a straight forward involvement in a way…we have been doing this so long …with [ELD1] for offshore oil and gas” [ERI1]

For a small firm providing mooring solutions, it was their O&G activities that led to the opportunity of being considered for a deployment scale PDP

> “We worked on technology qualification with [ELD1] for a few years [on a O&G project] …and that put us on a list, and then we were requested for this one and this one [two different technological solutions] and we won the contract for one of them.” - [ESME2]

In summary, while it is difficult to say specifically how informal networks allowed suppliers to gain access to a particular PDP, it seems reasonable to say that existing informal networks from O&G have been important in providing opportunities for suppliers to position themselves for PDP participation.

6.2.5 Formal networks

Membership in various formal OWP and O&G networks such as Norwegian Energy Partners (NORWEP), Norwegian Offshore Wind Cluster (NOWC), and Norsk Industri were also emphasized as important. In addition to the value of informal networks from O&G, firms also pointed to the value of formal network organizations in allowing for interaction and building contacts and increasing visibility and facilitating for cooperation. In general, the answers derived from questions about the role of formal networks did not yield much information on PDPs in particular, but was rather more a general assessment of the value of membership. No one reported getting access to PDP through formal networks, however many firms considered them beneficial for network building as well as for learning.

> It is a good early phase arena for discussion, sharing experiences, learning, and especially as a network building factor. We are present in several conferences where we both speak [hold lectures] and where we meet industry actors who might be positive for our development and for others [ELE2]

Several small SMEs also found these formal networks useful

> "These clusters have been useful. we are a part of some of these clusters that gives us opportunities for visibility and cooperation" - [ESME1]

> "We have benefitted greatly from being a part of these cluster organizations. For us as a small company these clusters have been very important" [SU2]

6.2.6 Mergers and Acquisitions

Some firms gain access to PDPs through buying their way in. The road from idea to commercialization can be long, and for some actors, access through acquisition can be a preferred strategy to pursuing in-house development. This might especially be the case for late entrants, who might find it strategically advantageous to access the market at a time when various forms of uncertainty have been reduced, and the prospects for profit seem more probable.

While several firms have undergone mergers and acquisitions since their first PDP engagements, there is only one company in my sample who gained access to PDPs strictly through ownership of another company. This firm began by developing their own floater technology but after engaging with potential customers decided that the process was too long.

> "We designed a semi-submersible unit, a foundation. A semi submersible, and than we checked with a few relevant potential customers and the response was - great product, but in order to get in position you have to have done numerical models, tank testing, building a prototype, having it in operation for a few years before you have some thing you can deliver, so for us, that would take more time then we had in mind, so we seized the opportunity to see what technologies were in the market and then we bought our way in" - [ESD1]

While this is the only firm in my sample from the purchasing side of the table, ESME1 was recently acquired by larger European developer, intent on making headway into OWP industry.

Access-by-acquisition, is however, not a strategy that is typically available to smaller firms and start- ups.

6.2.7 Reputation and legitimacy

While existing informal networks seemed to play an important role for facilitating access to PDPs, firms reputation and legitimacy (based on track record in O&G and other related industries) seem to have been important for firm participation in PDPs. For some firms, specialized competencies were developed in O&G in such a way that they could be easily transferred to a OWP industry without much modification. This was especially the case for service providers (site surveying and geotechnical services), and was emphasized mostly by SMEs.

However, as we have previously discussed, having a track record in the same industry is important to get contracts. For several firms, their access to PDPs come from having a OWP track record (either from earlier PDPs or from commercial projects). For several firms, it was a sort of a snowball effect, where one project led to the next through recruitment in a sense, and by virtue of their reputation.

A small start-up company who was originally started in order to develop commercial OWP, has through these planned but (as of yet) not materialized OWP projects, built up a knowledge base on on how to build a factory and manufacturing process for concrete foundations.

> "We made the cost calculations between concrete and steel floaters, there were several actors involved in the steel side, but we were the preferred actor for concrete… We have been working with this earlier so we did have the competence" - [SU2]

One small subsea firm who has been involved in several offshore PDPs in several renewable technologies, explained that, through participating in a variety of projects over the past 8 years, they have built a competence and project understanding, which has made them attractive for developers initiating small renewable offshore PDPs (both OWP and other renewables)

> "It is in many ways a different tendering process than our usual contracts … many of these PDPs are typically financed by research funds … and are often facilitated by start-ups, and then it has been because we have a name and reputation as forward leaning and heavy on technology and competence, which has been the reason why they contact us" - [YSME1]

Another SME, who's been involved in several OWP PDPs for almost two decades, was asked to participate in almost every project they have been involved in. Her are quotes pertaining to three different PDPs to illustrate the point:

> "[Participation] was a request from [large energy company] at the time, and then later by [ELD1] …We were requested in the first project… We received a request to be part of an EU project intent on building a demonstrator" - [ESME1]

These requests to participate can perhaps be traced to their involvement in one of the first floating PDPs, which in turn was perhaps the result of having one of the key designer from that project working part time in the firm as a consultant.

> “To my understanding it was motivated by us having one of the main designers behind [high profile PDP] with us” - [ESME1]

This early participation had a snowball effect and caused them to get involved in several projects.

For a large EPC firm, its was through having partial ownership of a patent for a technology (originally developed in O&G) which provided them with their first engagement in a OWP PDP, and also set the stage for their participation in a second project.

> “…part of the reason why we became a collaborative partner with [ELD1] on the first project [high profile PDP] was that we were partial patent owners of the [floating] technology, and then you can say that the next phase [deployment PDP] was a natural continuation of that.” - [ELE3]

6.2.8 Research projects

Participation in research projects and joint industry projects is also a way in which smaller firms position themselves to get access to lab scale and single unit PDPs. Sometimes these PDPs are part of what Hendry et al. refers to as ‘programmatic demonstrations’ (Hendry et al., 2010) where several technologies are being tested and compared simultaneously. This was the case for ESME1 whose participation is one such project help set the course for subsequent PDPs, both as part of their technological development strategy as well as a way to gain market access.

> “Participation in these EU projects have been part of strategic decision to gain access to the market… what we notice internationally is that you have to make a mark. We have managed that through these EU projects…” - [ESME1]

For a research institute with substantial commercial experience, PDP participation was also an important motivation for them when taking on new projects.

> "we try to be part of research projects where [PDPs] that might be an outcome" [ERI1]

6.2.9 Summary

I have now presented the various ways in which firms gain access to PDPs. Access is in many cases difficult to attribute to a single factor and is in many cases a combination of factors such as existing relationships in various networks, reputation, policy instruments, research programs, and regular tendering processes. For some firms PDP participation is a part of their overall strategy to diversify towards OWP, while for others it might be the spark that ignites a "silent revolution" - [ELE3] in the company and that sets a course for future OWP engagement. In the following section I will present the data on what firms get out of PDP participation.

6.3 RQ3: How do PDPs contribute to innovation and market access for participating organizations?

6.3.1 Introduction

In the following section I will present and discuss the various outcomes firms have had from PDP participation, such as establishing a track record, getting access to niche markets and commercial markets. I treat learning as an outcome of participation in the next chapter. I will begin this section with discussing some of the different ways in which actors value and define PDPs, as this is relevant in order to understand the role of PDPs for participating firms.

6.3.2 Commercial projects

Establishing experience and gaining a record of accomplishment in a market of interest, presented itself as both an important motivation as well as outcome for firm participation in PDPs. By participating in PDPs several firms reported that they got the 'stamp of approval', they needed to later engage in commercial projects. While I have not focused much on distinguishing between bottom fixed and floating wind projects up until this point, it is relevant to do so here. Bottom fixed wind is already a commercial industry in some regions, such as the in the North Sea basin. Floating wind on the other hand has not yet been built at commercial scale. Therefore, whereas participation in a floating OWP PDPs can result in commercial project participation in bottom fixed, it cannot happen the other way around.

There are also differences in perspectives on what constitutes 'commercial' and what constitutes a 'PDP'. For instance, whereas OWP developers and large EPC firms typically discussed projects from an industry building perspective, (where a commercial project is considered 450-500MW and consisting of approximately 50 turbines), smaller firms did not necessarily make these same distinctions. This means that, although floating PDPs has not yet led to any floating 'commercial' projects in the industry building sense, participation in one PDP has led firms to get access to other PDPs, which might constitute significant commercial value. In simplified terms, large firms need large projects to turn a profit, while small firms can make more with less.

Two SMEs involved in single unit PDPs exemplify this

> "We managed to make money there as well…we were a very small company so in that respect there need not be much activity before it became profitable." - [YSME1]

> "It [single unit PDP] was a purely commercial project in a sense… it has been important for us, given us footing and the opportunity to develop our own concept." - [ESME1]

Whereas single unit PDPs are typically not as commercially interesting for larger firms, verification and deployment PDPs can be profitable to SMEs, and one could therefore argue that PDPs constitute a commercially viable, although temporary market.

> "Getting a contract is success, so the more of them we can get, the better" - [ESME2]

As a technology matures and PDPs increase in scale and number of units, they can also constitute significant commercial value to larger firms as well. When one ELE was asked if their firm distinguished between commercial and demonstration projects they simply responded

> "No, we don't make a distinction" - [ELE4]

In short, the commercial attractiveness of a PDP depends on the size of the firm relative to the size of the PDP and the scope of their engagement. This means that a firm's motivation to participate as well as their assessment of the outcome from participation might in some cases not differ much from other 'commercial' projects.

6.3.3 Market access

Gaining a competitive advantage through having a list of references and being an early mover, as well as verifying technology were both important outcomes as sell as motivations from PDP participation. PDP's enabled firms to easier engage with actors in international markets and attempt to sell their products and services. This was reported by both large as well as small and medium sized firms.

> “Since we already had a track record and experience from OWP, we were in a more advantageous position then many of our competitors to engage with the customers in that market” – [YSME1]

The same message was also emphasized by a large maritime supply firm

> “It’s about building experience, to have bragging rights when you go out and bid, and discuss similar jobs around the world… having one under the belt is definitely an advantage” - [ELE4]

For another SME who had engaged in a large multi unit PDP, the importance of having a list of references was emphasized.

> “Demos are important for us because the ones who are a part of the first projects get a track record and a list of references and that makes it much easier to get the next, so it has been extremely valuable for us” - [ESME2]

6.3.4 Technical verification

Two Young SMEs who have developed various foundation related designs, explained the significance of having demonstrated their technology as well as showing the company's ability to follow through on a project. They pointed out that one outcome of their participation in a PDP, was the ability to be considered as a viable option, in the various stages of commercial developments.

> “If you are to succeed in this market then we have to find pilots…if you go to the bank and say you have a good project which you believe in, then it is not always that the bank is willing to finance that project, which means the customer who is conservative, will say no. So if we don’t have something that has been already tried and tested, it is difficult to make it happen… this has to be done, in my opinion, in order to ensure that the marked will accept the product…” [SU2]

SU1 was involved in a single unit PDP which was important for both in regards to their innovation process as well as in allowing them to pursue sales activities and interact with potential customers. The CEO of the start-up, emphasized that although having a PDP under the belt was important for verifying the concept, and demonstrating that it works under operational conditions, it was important in opening the door for sales, not however, any guarantee for success.

> "We have done one demonstration project and it is absolutely crucial for our credibility, it demonstrates both that the technology works, as well as our follow through, but it is by no means sufficient" - [SU1]

The importance of technological verification through demonstration was corroborated by an ESME with experience from several PDPs (with their own foundation concept as well as in providing engineering and consultancy services). The firm also brought attention to bankability as a potential barrier to market access, for technologies that have not been demonstrated.

> "There is a lot of discussion about whether you need to be bankable or not. We see that it is as a demand from many actors, not all actors necessarily, but many of them think that it is necessary in order to invest in the technology, especially when you are building fifty or a hundred units in the next phase" so for us it makes the market bigger by having a demonstration project realized." - [ESME1]

The variations in emphasis on the importance of PDP participation seems to be both related to firm size as well as value proposition. In short, for the firms engaged in technological development, PDP participation was considered a precondition for market access, while suppliers (without a specific innovation) emphasize it more as a competitive advantage. Verification is associated with bankability, which is a demand from some developers and their financiers, and therefore an important criterion to meet for firms who provide "critical equipment" such as foundations, cables and mooring solutions (see section 5.2.1).

6.3.5 Bankability

Bankability was commented on as important goal to achieve (from an industry building perspective) by developers. For developers, bankability is important in building large commercial scale projects, and for suppliers, bankability is important for the same reason as policy instruments are important, because without it, there will be less projects to gain access to.

Bankability refers to the probability of financial institutions being willing to fund projects. For a supplier with a novel concept (or critical equipment applied in a new context), this can mean that having verified the technology in an operational setting, can be crucial when attempting to sell the concept to a OWP developer (who in turn must convince the financiers). For a developer and for the further commercialization of the industry bankability is crucial becomes of the dizzying sums involved in developing a commercial park. While early PDPs can be financed by a single firm, pre-commercial PDPs are however typically funded by a consortium of several energy majors, as well as subsidized through various policy instruments. Having predictable and easy access to capital is seen as important on an industry building level, something which was underscored by a large established developer

> "The first projects where taken over the bottom line in the firm, but now we will of course go out and ask for bank financing, and then you have to prove that you have a rigidity in the company and that the company has the right rating, that is important" - [ELD1]

And was also emphasized by a newly established developer.

> "What is critical for [floating] offshore wind now, is to get projects which are bankable, because there are enormous investments needed" - [ESD1]

6.3.6 A tale of two organizations

The further you are removed you from an event or a series of events, the more difficult it becomes to establish causality with any degree of precision. For some firms I have interviewed, their first OWP PDP took place maybe ten or fifteen years ago, others are currently involved in their first, or have been involved in several, as well as commercial projects.

To attribute any one firm's current OWP engagement to a particular project is not realistic. However, there are some events and specific projects which seem to have been especially important for guiding the trajectory of two organizations.

Participation in PDPs can be useful for firms to get access to emerging markets and provide firms with early mover advantages. For two actors, with quite different motivations, this was the case. While both actors deliver services related to geotechnical data collection and site surveying, one actor is a research institute with around a hundred employees, while the other is a private firm with around fifty employees (under twenty-five at the time). Both actors are research intensive, and have a competence base from O&G. The firm was a start-up at the time (in the early 2010s) and wanted access to the O&G market, which was booming.

> "When we started in 2012 the O&G market was rosy, all the established suppliers were operating exclusively in O&G, and were completely uninterested…so these small marginal niche markets were important when we were a start up company…that is where we were born really" - [YSME1]

For the other actor, the research institute, the move towards OWP was more intentional, and based on a high degree of transferable competence, a broadly recognized expertise, and an existing network of clients who were diversifying.

> "We have been doing installation of offshore structures and monitoring for a quite a while, so in a way we had an expertise that allowed us to position ourselves quite quickly in the [bottom fixed] offshore wind market, and we did that both through commercial projects and by being involved in probably the first projects that could set the basis for future projects" - [ERI1]

The firm decided to pursue PDPs in wind, tidal and wave energy, in order to get a track record, which would enable them to get access to the O&G market. The firm explained that their early

PDP participation in these immature renewable markets, gave them access to the profitable O&G market, and it also gave them a significant track record in various "marginal" renewable industries, which would later be beneficial. In 2015, when the oil price plummeted, this firm had built up a significant track record in offshore renewable energies, which allowed them to take a position in OWP, somewhat unintentionally.

> "It was our way in, to get experience and to get a track record. I must honestly admit that it is not like we had the foresight to see that offshore wind was going to be very important in 2020." [YSME1]

The research institute on the other hand had been working in O&G with major oil companies for decades with a design concept and methodology for installing structures in various soil conditions. It was on the basis of this design and track record from O&G that the they got their first contract, in what the respondent referred to as, an "industry pilot project", meaning it was the first commercial (by the standards of that time) park in a particular region. Participating in that pilot project helped them establish a track record which seems to have had a significant effect on enabling them to participate in subsequent projects employing similar technological solutions.

> "This was the first… after that it came a lot of projects where this was done in a way…I had a chat with the project manager that did this project and he says that essentially we have been pretty much involved in all the suction bucket projects after that one" - [ERI1]

In addition to the vast number of commercial projects the research institute has been involved in after the first one, they were also recently (2018) engaged in a multi-unit deployment PDP which the respondent described as a 'political pilot project for the EU', which according to the respondent, has contributed to opening up the Asian markets for their concept and installation methodology.

> "…I think this has really also opened up for China, our markets in China and Korea, so we are getting now, yeah, so, we are also being involved in projects in China and Korea related to suction bucket jackets due to this, in a way" - [ERI1]

These two examples clearly illustrate some of the outcomes, early mover advantages and snowball effects, that can result from PDP participation. For one, somewhat more intentionally, than for the other.

It is interesting to note, that in the case of the research institute, which has consistently been involved in commercial projects for the last ten years, it was recent participation in a large-scale PDP which served to open up the Asian markets. This seems in line with one of the key insights in the PDP literature, namely that in addition to reducing uncertainty through learning, the other key function of a PDP is to have an 'exemplary' function and "demonstrate the utility of the innovation to potential adopters (that is, to diffuse the innovation)" Klitkou, 2013, 2).

6.3.7 Summary

While these two examples are interesting on their own, it is difficult to draw any broader conclusions. These two firms started early and therefore it is easier to draw a line between what has been and what has come after. That is not the case for many others, who have only recently participated in their first PDPs. The importance of PDP participation for contributing to setting a trajectory is also exemplified by some firms, while for others, who have only recently been engaged in a PDP, or where the project is ongoing, it is too soon to discuss the implications of the outcome. For one firm, the role of early participation in a floating wind PDP and a EU research project, would eventually result in them pursuing their own foundation design concept, as well as having a snowball effect were this firm was recruited to participate in later PDPs on the basis of their track record.

I have now addressed some of the various outcomes firms have had from PDP participation, such as establishing a track record, and benefitting from being an early mover such as getting access to commercial projects, as well as commercially beneficial PDPs. In the next section, I will present and discuss the role of various forms of learning for firms participating in PDPs.

6.4 RQ4: In what ways do PDPs contribute to learning for participating organizations?

In this section I will outline the several ways in which PDPs has contributed to technical, organizational and market learning. Firstly, I will present my findings related to technical learning in PDPs, secondly I will present my finding related to organizational learning and finally as they pertain to market learning.

> "Learning is important, de risking is important, de-risking the concept, the execution and the operations, and especially that the industry and the suppliers see that this is something that works, and that can contribute to them becoming national and international suppliers in the same way as we have done in O&G." - [ELD1]

6.4.1 Technical Learning

What is the role of technical learning for firms participating in PDPs?

6.4.1.1 Introduction

Reducing technical uncertainty through learning is one of the most widely recognized functions PDPs have in the development of a new technology (Bossink 2017; Hellsmark et al., 2016). learning-by-searching, and learning-by-researching are key forms of learning in the lab scale, and early phase PDPs, whereas in later stages of development, and in larger scale PDPs, technical learning tends to be more dominated by learning-by-doing, learning-by-manufacturing, and learning-by-interacting (Bossink 2020; Hellsmark et al. 2016). During my data collection and analysis, I noticed quite a difference between how various organizations emphasized the importance of learning. Technical learning was not emphasized as much as I expected (given its central position in the PDP literature) It was mostly brought up by a large established developer, a foundation developer ESME and a research institute.

Although technologies such as turbines in onshore wind and foundation concepts in O&G; floaters, tripods and semisubmersible solutions had already been developed and employed in onshore wind and O&G respectively, combining and applying these technologies to OWP, require adjustments. For innovating suppliers, verifying technology through PDPs is crucial in order to be considered a viable option when tendering for commercial projects and engaging with international OWP developers. For one major developer however, PDPs represented important arenas for learning about the technology and improving designs.

> "First and foremost, it's about technological development, its about improving our understanding of what works and what needs further development…and furthermore to test and verify the design and technology as well as perhaps test out new technology." -[ELD1]

6.4.1.2 Learning in a lab scale PDP

Although many technologies build on competence from established and more mature industries (primarily O&G and onshore wind) this does not mean that this can be transferred directly to OWP. The road from having a known concept to a commercial product is long and uncertain and requires substantial effort for a known technology to meet (as well as create or define) the requirements of a new marked. One innovating firm, with a vast experience in similar technology application from O&G, emphasized that lab scale PDP participation had been important in facilitating technical learning through interaction.

> "It has been very useful being able to discuss with other concept developers, also going through various qualification processes, although they haven't been formal, they have raised a good deal of questions and there has been a good deal of reviewing risks and technical matters." -[ESME1]

6.4.1.3 Learning in deployment PDPs

There are many specific technical uncertainties that need to be addressed in the upscaling process. The bigger in scale a PDP is, the more complex the project will tend to be in terms of interacting technologies. This increase in scale will tend to follow the reduction in technical uncertainty. In short, as developers learn more about the technology, the less of a (technical) risk it became to scale up. This also means that technical learning will occur differently in different PDPs, as new problems require new solutions. Early phase PDPs, in the overlapping phase between R&D and lab scale, tend to be more dominated by STI types of learning. Learning -by-searching, learning-by-researching, whereas industrial and deployment scale PDPs tend to be more dominated by DUI learning. One developer who has also developed an in-house floating foundation technology been, elaborated on this process and the progression in technical learning goals and outcomes for each one.

In the first project which was a single full-scale pilot, the focus was on verifying the concept and the technology, i.e., making sure it worked as expected. In addition to verifying their concept, they also verified their analytical models, which further enabled them to develop their own system methodologies. So, verifying that the technology works as they thought it would, as well as verifying and improving on their way of arriving there. The firm also developed a system and a controller for stabilizing the structure, for which they took out a patent.

> "It has been important to test that the technology worked as expected. We developed what we refer to as an active damper controller which controls the turbine and the pitching of the blades to stabilize the floater [without this controller the whole system might collapse]" - [ELD1]

Their second project (a pilot park) deployment PDP involved a series of learning processes related to up scaling, 'heavily instrumenting' the structures in order to collect and analyze data for optimization through iteration.

> "We tested for what we call wake effects, this means that when you have turbines in a park and a wind passes one turbine and reaches the next, then the wind has been reduced and therefore you get reduced production from the turbine in the back" - [ELD1]

Technical learning not an important outcome from PDPs

For participants in PDPs without a product or a service in need of demonstration, technical learning was not quite as important. This should also not come as a surprise. We know that the reduction of technical risk through learning is especially important in the early-stage PDPs (lab scale and single pilots), whereas organizational and market related learning becomes more important as the actor network increases, following upscaling and system expansion. For many of the non-innovating firms involved in the PDP, the modification of existing services or products were in many cases minimal, and their operations in OWP where from a technical and operational point of view pretty much the same as in their other core industries (typically O&G):

> "You can use the same thinking on whatever it might be, whether it is a LNG storage unit in Russia, or floating wind or fish farming or whatever it is" - [ESME2]

> "When we execute an operation, we use the same tools, the same boats, the same ROV systems, the same people, the same procedures, everything is the same for us, whether we work in the one market versus the other" - [YSME1]

> "…I mean, you can call it a transition, or call it what you want, but for us, it is the same work assignments, the same project execution, except it is for installing floating wind instead of a floating FPSO for example, we have the same scope" – [ELE4]

> "From a geotechnical point of view, floating doesn't really require that much research or that much development because, the anchoring, which is the way you would actually secure that these floating wind turbines don't go away, is a technology that was developed in the 90s and is well developed for the offshore oil and gas market" [ERI1]

6.4.1.4 The cost of learning

Capturing intellectual property rights and patents are recognized as an important part of PDP participants learning strategies (Bossink, 2020). The two developers in my selection, gained access to their core in-house technologies (floating foundations) through mergers and acquisition. One through a merger and the other by acquisition. Whereas the first developer gained access to the technology at an early stage of development, the second developer intentionally sought out a mature concept in order to avoid the costs associated with technology development.

> “We designed a semi-submersible foundation unit. The response from potential customers was positive but they said that in order to get in position you need numerical models, tank testing, build a prototype and have it in operations for a few years, before you have a product to deliver. That was a longer timespan than we had envisioned, so we looked at the technologies in the market and decided to buy our way in” - [ESD1]”

While two of the smaller innovating companies, applied for patents as part of their own technology development process. For one small and one large firm PDPs, patenting came as a result of early phase PDP participation, perhaps illustrating the continual feedback between the R&D and PDP stages of the innovation process, whereas for another firm, it was through the participation in a lab scale PDP (as part of a EU research project), that they first saw the potential for developing their own technology.

> “Based on what we saw in the first EU project we participated in, we saw that we could make one, first we gained confidence in the type of technology that was used there, a type of semi-submersible floater, and then we saw that it could be built more efficiently in concrete, in our opinion, so we started sketching up that concept and applied for a patent around 2011/2012” - [ESME1]

The outcome of PDP participation motivated them to pursue their own design

In lab scale PDPs, such as the EU project the respondent mentioned, there is always a risk and a balance needed (from the perspective of the leading organization, which is often a public-private consortium, led by a research institute) between the goals of the various participants. While the stated intentions of such projects are often explicitly to generate and diffuse knowledge which will further the development of the technology, there is also a risk that participating firms, will build on or be inspired by knowledge generated in the project (Bossink, 2020). However, my impression from the data is that there is, for many actors, what one firm described as an “O&G mindset” around technological development, where, sharing knowledge and experience is seen as a positive. Not to say that this is always the case of course, wind turbine manufacturers, for instance, have been notoriously protective of their design (Richard, 2020).

> "[the developer] does not see it as a challenge that we are working with our own concept parallel to helping them with theirs. I think quite the contrary they see it as a synergy, along the lines of that classic O&G philosophy where collaboration and making use of the best possible technology is in the forefront" - [ESME1]

6.4.1.5 Learning and experimentation

Innovating firms typically develop a product or process for years through R&D (private and publicly funded) and need to test and verify their calculations, designs and assumptions in a scale and environment gradually approaching the intended application area. However, because a full-scale PDP is an enormous, expensive and highly complex system where different technologies must work together under demanding offshore conditions, all critical technology must meet a certain set standard i.e., have a certain TRL level before a developer will allow it as part of a project:

> "…we are very interested in attracting the right suppliers with the right technology, and so we have a technology qualification process which needs to be completed… when we make investment decisions, in order for you to make it through our technology qualification process, we need a certain TRL level" - [ELD1]

This demand for a certain technological maturity, can be difficult for smaller firms, in that they might need a demonstration to validate their product, and yet can't gain access to a demonstration until their technology has been validated. This can be related to firm size and firm resources (only a firm with deep pockets and a tolerance for risk can fund their own PDP), in that they don't have the means to drive this development forward without support. For one foundation producing firm, this technology maturation was addressed through participation in a series of national and internationally funded research projects, which provided them with lab scale testing in wind tunnels and ocean basins testing.

> "…There was quite a thorough review of the technology and the solution through that project which was useful for us, and of course the model tank test, which is a very useful milestone in any [technological] development" - [ESME1]

Demands for technological maturity depends, however, on the technology in question, and the role it plays in the system. Whereas a mooring, floater or a cable solution (not to mention the turbine) is critical to the integrity of the system, and must therefore be qualified early on in the development process, there is, some indication that there is more leeway for experimentation (when it comes to non-critical equipment) in PDPs than in commercial projects. One subsea firm, involved in a large scale deployment PDP, used the "greater … openness" of PDPs to experiment and demonstrate their new autonomous ROV technology:

> "We see that they [PDPs] have their own drivers and a greater degree of openness to test out new things, so it has been a bit of a sandbox for us really, testing out new ways of doing things." - [YSME1]

For other participants, while PDPs certainly did provide them with technical learning, there was little data to indicate that this was PDP specific. Meaning that, they might have learned as much, and in some cases more from commercial project participation. This was perhaps especially the case, for the larger EPC firms whose core capabilities involves managing large complex projects, and understanding and optimizing technological systems. For these firms, uncertainties and learning, was often more organizational and market related then purely technical.

For the research institute some commercial projects represented a great deal of technical learning, as they were the location for a great deal of experimentation and post-installation instrumentation. Instrumentation, data collection and analysis, is associated with the study of how structures behave over time in response to physical forces. This is not just a feature of PDPs, but is also more and more used on both commercial OWP, as well as O&G structures. The research institute, supplied instrumentation on several commercial parks, after they had been all ready installed and commissioned, in order to facilitate learning for the developer, as well as motivated by developing better methodologies for understanding soil and structural behavior. Because of this research institute's expertise within geotechnical matters and soil conditions, they were often asked to be a part of early industry commercial projects, which the respondent referred to as "political pilot projects", where new installation and instrumentation methodologies, as well as foundation types were tested in tandem with more standardized solutions.

6.4.1.6 Summary

In conclusion, technical learning was not emphasized as a strong motivation or outcome for many of the firms. The developer on the other hand emphasized technical learning and risk reduction consistently, and the responses were very much in line with existing literature on technical learning in PDPs. There is a high degree of technological relatedness between OWP and O&G, and many of the firms pointed out that there is not much modification to their products and services. This might indicate that for actors with established products and services, PDPs are not primarily important for technical learning.

The actor who emphasized technical learning the most, was undoubtedly the developer. The lack of reported technical learning must also be understood in relation to the types of PDPs various firms have participated in. Technical learning is especially important in lab scale and single unit PDPs, and less so in multi-unit deployment PDPs. Since many of the firms in my sample have only been engaged in deployment PDPs the lack of reported technical learning might be related to that. The organizations (one developer and one ESME) which reported the most technical learning as an outcome of PDP participation are both engaged in developing floating foundation concepts, which have not yet been commercialized. For ELEs, their engagements are typically in large scale multi-unit PDPs, and learning can therefore be expected to be more related to developing a production organization, i.e., organizational learning.

6.4.2 Organizational learning

What is the role of organizational learning for firms participating in PDPs?

6.4.2.1 Introduction

Organizational learning occurs through feedback and feed forward loops in all PDPs as well as commercial projects. However, it is particularly in the larger scale PDPs (moving from one unit to several), where this type of learning is most prevalent. There is a need to establish supply chains and bring down cost through process innovation and standardization. This requires larger and more complex actor networks, and knowledge development is often characterized by learning-by-doing, learning-by-manufacturing, and learning-by-interacting (Bossink 2020; Hellsmark et al., 2016)

Organizational learning can be separated into two types. One is learning about how to develop and organize 'a production organization' i.e., the expanding actor-network around a PDP. This is often about experimenting with different cooperation forms, developing supply chains, infrastructure, and manufacturing. This type of learning is often the domain of OWP developers, and large EPC suppliers, as they are in a position to directly influence the establishment of such a production organization, whereas smaller suppliers are often not. The other type of organizational learning is the forms of learning taking place *within* the participating organizations (EPCI, and PDP developers included) and can be defined as the acquisition and embodiment of skills and insights within an organization's routines, practices and beliefs (Attewell, 1992).

This distinction is not meant as an empirical description, nor as an analytical tool, but rather as a clarification due to a certain bias in the literature to focus on the perspective of the lead innovating firm and not as much on the surrounding network of participating firms (Bossink, 2020; Frishammar, et al., 2015; Hendry et al., 2010).

A third distinction can also be drawn between the role of PDPs for industry building - i.e., the role of PDPs in emerging TIS's (Hellsmark, 2011) and the role of PDPs for lead innovating firms (Hendry, et al., 2010). There has been a lot of research on the role of PDPs in industry building and technological development, less on their role for lead innovating firms, and even less on the role of PDPs for the wide range of (typically SMEs) suppliers involved.

Because I am interested in what PDP participation means for participating firms this clarification is helpful, in that suppliers are often not in a position to directly influence or "develop a production organization that is a capable of producing large(r) quantities of the prototypes-turned-into-products" (Bossink, 2017, 6). They are however crucial in building up the 'accumulated experience' necessary for achieving production cost reductions (Bossink, 2020, 6). Building a production organization that can manufacture products at a lower cost, requires creating and developing supply chains, building infrastructure, and streamlining the manufacturing process. This industry building perspective is illustrated by the following quotes from two large EPC suppliers:

> "Scale is the big crux here. Developing a supply and implementation chain sufficiently robust to produce enough units"- [ELE1]

> "You need to do this in scale, OWP development, you will never make money from building five, ten windmills out in the ocean. You need a scale that is above and beyond, you are really talking about fifty, hundred, a thousand floating turbines out in the ocean" - [ELE3]

6.4.2.2 Upscaling (unit scale and industry scale)

Upscaling and organizational learning in floating wind is subjected to and affected by developments in other industries. Beyond landscape pressures such as fluctuations in oil price, shifting political interest, and investor appetite for green investments, it is also a question of specific technological developments in technological domains such as turbine manufacturing. Turbine manufacturing is a standardized industry dominated by a few large companies, who provide turbines to onshore and bottom fixed offshore wind industries at commercial scale, globally (BVG associates, 2019). The technology as well as industry can be described as being standardized and beyond the "extended period of experimentation and learning with small unit-scale technologies and a diversity of designs" (Grubler, 2012, 14). Both turbine size as well as wind farms have been growing rapidly in scale over the past twenty years (Hanson, & Normann, 2019). From 2002 to 2017, offshore wind turbines tripled in size from 2MW to 6MW, and the average size of a bottom fixed project increased from 79.6MW in 2007 to 561MW in 2018 (Hanson, & Normann, 2019). In short, both unit scale and project scale has been rapidly growing. The literature indicates that this process of unit upscaling will continue until the "scale frontier is reached" (Grubler, 2012, 14). These developments in related industries have consequences for the development of floating wind PDPs.

One established large developer noted that their upscaling in MW size from one project to the next, was not so much by choice as it was due to availability in the marked. Because turbines have been increasingly getting bigger, PDP developers have to buy what is in the market, and thus *unit up-scaling* happens by virtue of a "forced development"

> "The upscaling of the projects… it is actually a forced development. Just like you cannot buy a Golf anymore, now it is the ID3 and ID4, so the turbines from 10 years ago, they are not for sale anymore... So there is a development on the turbine side, which necessitates that you can buy the turbine that is available in the marked, and that is what you have to deal with" - [ELD1]

These changes in size and technological developments thus also require firms, such as foundation developers, to factor in potentialities and contingencies related to organizational and market related dimensions already from an early stage of development.

6.4.2.3 Organizational learning in lab scale PDPs

Early attention to building a production organization

Learning how to produce units at a low cost is typically a learning-by-doing and learning-by-manufacturing activity which takes place in "subsequent and parallel tranches of [large scale] demonstration projects" (Bossink, 2020, 6). However, in my empirical findings, this learning by doing and manufacturing was preceded by learning-by (re)searching in EU research projects resulting in lab scale PDPs. Several firms emphasized that they are good at thinking multidisciplinary and in long development trajectories, when it comes to technological design. Meaning that there was a focus in small scale PDPs and for some SMEs already from an early development stage, on supply chain, local content requirements as well developing process innovation for establishing economies of scale.

> "We have designed a production facility for the foundation, which is maximized for efficiency and adjustable, not just for Norway, but for several places. One can build a factory to produce up to fifty units a year" - [SU2]

Another firm involved in the same research project stated

> "We have looked into how we think we can build this. That was a big part of this [EU research project/lab scale PDP], looking at the manufacturing potential, manufacturing tempo and method… we think there is a great potential given that the main material is concrete. We are not locked to concrete, it will in certain markets still be relevant to build the structure in steel, but if we look at concrete, we think there is an untapped potential for mass fabrication, increased efficiency and processes, that to a certain extent have already been realized with steel."- [ESME1]

6.4.2.4 Industry building perspective

learning-by-doing and creating shared visions for the future

This attention to scale and manufacturing processes from an early stage might be an indication of the confidence actors have in the technology due to its relatedness to bottom fixed. Bottom fixed wind has experienced dramatic cost reductions over the last ten years (IRENA, 2020, 84). Gaining experience, understanding supply chain requirements, and developing partnerships came across as key outcomes from larger scale PDP participation as well:

> "A lot of the scope in Norway, on the demonstration part, is on, call it a virtual project, looking forward in time and seeing how we can enable logistics, building these things for 500MW or more and how we can get the costs down to something that is possible and acceptable in order to compete with bottom fixed and other types of energy." [ESME1]

The importance of understanding the supply chain and production organization was also emphasized by a large supplier, who has participated in a multi unit deployment PDP.

> "I think the most important thing we get from this, is that, you get an understanding of the totality of the technology and the supply chain requirements… we build valuable partnerships that allows us to master great tasks out in the ocean" [ELE3]

A second EPCI contractor also involved in the same multi-unit deployment PDP also emphasized the value of early involvement as well as operational experience for an imagined future floating OWP market.

> "We have gained an operational experience within this segment that has been very important for us and has given us a lot of inspiration for future market opportunities. Furthermore, we have developed our mindset and to use that for further development in in-house projects and later in how we can improve this over time…and contribute to making this more cost efficient in the future so that it can be a commercial industry of scale in the future. This is of course not something we can do by our self, but this has enabled us to develop in that direction" - [ELE2]

Developers emphasized the importance of PDPs to allow for the development of suppliers and the surrounding ecosystem, as well as gaining operational as well as risk management experience

> "We have gained experience with project management, and how to execute this type of project, gaining control of the project execution as well as risk factors" - [ELD1]

Operational experience was also pointed out by a large EPCI supplier with ambitions of becoming a OWP developer

> “We have gotten a foundation, we have gotten the competence, and now it is about moving this further… were we must set our self apart is with our competence with installation and how to design, and then all these other products that are a part of building full scale systems” - [ELE3]

6.4.2.5 Organizational learning from bottom fixed commercial projects

While these examples clearly indicate the role PDPs have in generating organizational learning for the involved firms, the role of bottom fixed commercial project participation was also emphasized by several actors as a source of much learning about how to develop a production organization.

The differences between bottom fixed and floating are several. For example, since the water depths are different, this has implications for what types of ships can be used and, what types of vessels are cost efficient. Installation methods are different. Bottom fixed projects are installed in sufficiently shallow water to allow jack up ships to reach the ocean floor and use cranes for installing the turbines, while floating foundation are assembled onshore and transported out to the installation area. Deeper waters also (in floating projects) require floating converter platforms to be built and installed (which has not yet been done) and methods for maintenance routines will likely also differ from bottom fixed due to rougher conditions in deeper waters.

However, there are also many similarities between the two industries (or market segments, depending on who and when you ask) and therefore also transferable lessons between them. For large manufacturers and developers, previous experience from commercial bottom fixed projects seem to have provided transferable lessons in regard to manufacturing methods.

> “Planning for, and actually managing to take out the synergies and learning effects in producing batches that big, a large number of units, was extremely valuable and we use that a lot moving forward and it will have a positive effect, in how we work with one off projects… having fabricated in large scale gives you an understanding and teaches you how you can optimize your execution when you are building one and one” – [ELE1]

Learning from bottom fixed commercial projects was also emphasized by the large established developer. In the following quote he is referring to one of the first bottom fixed projects they were in charge of developing.

> "You need competent project leaders, and of course project personnel who understand the assignments and understand the risks, it is to a great extent about managing risk…competence is important, it is right to say that we, of course, did not have the full and complete competence in developing large wind parks…so in bottom fixed we had the responsibility for [a large commercial wind park], and there we took a lot of learning, lots of challenges and lots of learning" - [ELD1]

Floating OWP is still in such an early phase of development, that the total global installed capacity is less than a single commercial bottom fixed OWP project (Thema Consulting Group, 2020). This lack of volume entails a limitation on possible organizational learning, as there simply has not been that much opportunity for learning-by-doing and learning-by-manufacturing in multi-unit projects. The empirical data gives the impression that a good deal of knowledge about how to build a production organization for floating OWP was developed through bottom fixed projects as well as in O&G.

While several firms emphasized the importance of scaling up, and provided descriptive accounts of how to manage a large-scale PDP, there was surprisingly little data on what firms actually learned from this, as opposed to what they already knew, from commercial OWP engagement as well as O&G. This does not imply of course that these firms did not gain valuable organizational learning from participation. But there was perhaps more uniformity in their replies to questions about their motivation for engaging in OWP, where their experience and capabilities in large scale project management was emphasized. This can perhaps be interpreted as an indication that for EPC(I) contractors, existing competence, was more of an underlying motivation for OWP engagement, then perhaps, organizational learning can be said to have been an outcome.

6.4.2.6 Potential institutional and geographical barriers to the transferal of lessons from projects.

Existing competence, geographical presence and infrastructure came across as very central to ELEs engagement and involvement with floating OWP PDPs. These firms are used to operating (and developing) supply chains in different countries, from their involvement in O&G. Because many of the tasks as well as actors are similar in the two industries, pre-existing competence and capabilities were of course useful.

For large EPC firms as well as developers, similarities in project management and execution were however not necessarily applicable due to the market related differences between O&G and OWP. OWP is however, vulnerable to shifting marked and institutional demands, such as local content requirements, public policy, and the demands of various interest groups. This makes it difficult to separate organizational, from institutional and market related uncertainties as market and institutional conditions are closely linked with, (and often dictate) technical and organizational choices such as materials, manufacturing sites and choice of suppliers.

This means that, while there is a need for standardization in both manufacturing methods, and technologies in order to bring down costs, there is also a need for a built-in flexibility, and adjustment to shifting, regional, national and local requirements.

This need for flexibility can be related to several factors such as political local content requirements as well as geographical differences between markets (water depth, ebb and flow). For firms developing floating foundation concepts this will have implications for their choice of material as well as construction and transportation methods. For a concept such as Equinor's Hywind design, which is dependent on deep waters for launching and is therefore potentially not a viable option in regions with shallow waters. A SME engaged in developing a manufacturing method for foundations, emphasized geographical differences between ebb and flow, and how these influence production methods.

> "The challenge in Ireland is that there is an enormous difference between ebb and flow, which has implications for how to launch the foundations in the water. Here in [the south

> of] Norway there is almost no difference between ebb and flow and we are independent of water depths…not all places are equally suited for building this type of factory. So when it comes to designing the [foundation] factory, our design allows us to move the production facility overseas if necessary, so we are flexible in that regard. We see that we have to be, because it is not given that we can produce everything in Norway, so that is not something we can just assume." - [SU2]

Another floating foundation developing firm emphasized the importance of local content requirements

> "Local content is important. We see that both in Scotland, and also in Korea and Japan that it is very important to have local content in the projects in order to get political approval. Everyone wants to build a domestic industry around this market and that can be challenging if you cannot demonstrate that the technology can be easily exported. This is one of the advantages of concrete." - [ESME1]

This might indicate that it is somewhat artificial to separate the reduction of organizational uncertainties through learning from marked and institutional uncertainties, because aspects of the organizational learning gained from one PDP might be unique and non-transferable from one context to another. These variations might, as for one PDP involving several of my respondents, be related to specific transportation methods, and natural conditions, which might manifest itself quite differently in another geography at a later stage in the development of the industry. Meaning that, materials, methods and suppliers might evolve in ways which limits the transferability of PDP specific learning.

6.4.2.7 Organizational competence from O&G

Although organizational learning is highly contingent on institutional, market related and geographical factors, there are several transferable aspects of organizational learning that was emphasized by the participating firms. Large scale project execution, multi-disciplinary large systems understanding, as well supply chain development capabilities. It was however difficult, (as it often is with attributing learning), to attribute to which extent this organizational competence could be attributed to OWP PDPs as opposed to commercial OWP projects or decades long experience in O&G. We have already examined some of the learning outcomes from PDP, now let us contextualize it with what was expressed about their background, preconditions and motivations for engagement

> "…we see that, one thing is to put out a single demo, a single wind mill, but when you put this in a system, how you are going to operate it, then we are back to this automation and systems understanding my colleague mentioned earlier, which we have worked with for over 30 years…where we supply complete system set ups…" - [ELE3]

Another large EPC supplier emphasized their existing global network as well as infrastructure as an important strength in OWP.

> "Competence is important, but we also have so called assets in the form of wharfs and partners we have used…We use our wharfs in Norway as part of the execution. We use our people who work at this wharf, we used the organization we have. They are used to travelling around the world building concrete structures. And it is the same people we are using. When it comes to projects we are working on moving forward… these projects are founded on the same project management and implementation model as we have used in O&G." – [ELE1]

6.4.2.8 Exemplary effects of PDPs in expanding the actor network

It is difficult to attribute learning to a specific project, activity or industry, the organizational learning firms gained from multi-unit PDP participation had inspirational and motivational effects. It showed both lead developers that cost reductions could be made, this laying the groundwork for the next phase pre-commercial PDPs. This had a signaling effect on suppliers and helped activate and expand the actor network. This signaling effect can both be from developer to suppliers, as well as internally in a firm. One large developer emphasized how things changed, after they commissioned their large-scale PDP. It had several effects, within the developer organization as well to the industry. Within the organization, both in installation methods, as well as through heavy instrumentation, the capacity factor (the percentage of energy produced compared to maximum possible energy output) of the PDP exceeded their expectations and calculations, and they gained confidence in the speed in which cost reductions could be achieved.

> “In regards to floating wind, there were very few who were interested, right up until we commissioned [multi-unit Deployment PDP], then something happened, we saw companies such as [ELE1] showing a much greater interest in being suppliers to future floating OWP. We are very dependent on a supply industry who can deliver smart solutions and can contribute to that cost reduction curve which we are dependent on to get profitability [ELD1]

For a large EPC supplier involvement in the same project, (as well as a single unit PDP for the same developer), participation laid the groundwork for much of the organizational floating wind competence. It was also beneficial for attracting talent to the company. Furthermore, the firm points out how PDP participation can positively affect the development of the industry by facilitating knowledge transfer.

> “Those two PDPs have created a lot of the foundation and the competence, as well as we attracted a lot of young people who worked on this, and who developed a real passion for floating wind, and we see also that a lot of them have moved on to [ELE1 and ESD1], and you get a little spillover in the market, where the competence flows over, which I think is good, because suddenly people come back right and they bring along new ideas, and we see that the general competence in the market is in the process of increasing, which is very good” - [ELE3]

A small subsea firm with a wide experience in renewable energy industrial verification PDPs reported that their experience with so many PDPs have at times rendered them to the role of consultant. They point out that some developers (typically new entrants without background from O&G), do not have as much experience as desired with offshore operations and PDPs

> "In several of the PDPs we have participated in, we have had a consultancy role, in that we have brought in competence that the PDPs have lacked, and that our function has been just as much as facilitating for good operations as actually doing them, so that has provided us with learning and we have seen that we have had useful knowledge that these PDPs have needed, so there has been an element of that" – [YSME1]

6.4.2.9 Summary

In this section I have analyzed the role of organizational learning in PDPs. My empirical data indicated that organizational learning takes place in lab scale PDPs, in deployment PDPs as well as in commercial projects. For SMEs organizational learning was an outcome of lab scale PDP participation and was conceptual. After all, small and medium sized enterprises do not have the financial or human resources to build a production organization. However, for large EPC firms and developers large multi unit PDPs were emphasized as sources of organizational learning. ELEs reported that they gained an improved understanding of supply chain requirements as well as valuable operational experience. For ELEs, commercial project participation, as well as O&G experience was also emphasized as important sources of organizational learning. Learning-by-manufacturing was emphasized as an important lesson from a commercial project fro one large EPC supplier and the role of existing network and production organization came across as important.

6.4.3 Market learning

How does PDP's help firms learn about the OWP market?

6.4.3.1 Introduction

Understanding market characteristics such as contract structures, sales processes and the risks associated with the market is important for Norwegian firm engagement in international OWP markets (Hanson & Normann, 2019). Market learning is primarily associated with large multi-unit PDPs (Hellsmark et al., 2016; Bossink 2017) and involves both learning-by-using and learning-by-interacting (Bossink, 2020).

6.4.3.2 The exemplary effects of PDPs as a marketing tool

In the literature on PDPs there are two broadly recognized functions of PDPs, namely reducing uncertainty through learning as well as the exemplary effects PDPs have in showing potential adopters the viability of the technology and creating visions for the future (Klitkou et al., 2013; Fevolden et al., 2017).

Being a part of PDPs has enabled several firms to present themselves in beneficial ways to potential customers in the new market, as well as also potentially strengthening their position in existing related markets. In addition to the positive effect PDPs can have on strengthening the competitive advantage of an individual firm, PDPs also have the role of demonstrating the viability of the technology to a variety of actors who are all needed in order to further develop the industry. This 'exemplary' function of a PDP or signaling effect helps build up the actor network of suppliers, regulators, financiers, interest groups and users needed to further develop the industry. The literature emphasizes the importance of having PDPs run consecutively, and gradually increase from technical or prototyping, to organizational to market. Conversely, a start stop approach can have adverse effects.

I interviewed one large project developer, who has led three consecutive PDPs in which many of the supplier have participated. The developer's description of these three PDPs fell very close to the definitions of technical/prototyping, organizing and market PDPs found in the literature (Bossink, 2015, Bossink 2017).

The project developer explained the significance of the second project in building up the actor network, and creating supply and demand networks and creating a vision for other firms to engage in. The developer explained that when they first had designed and developed their floater concept, they had done so in concrete because they believed the material to be cheaper and better suited. However, because of the immaturity and the perceived risk of engagement, they could not find any domestic concrete firms willing to do it, so they settled for steel. While the first project was a single full-scale PDP and was useful in reducing technical uncertainty through learning, the second project was described as a turning point where they were able to attract a vast array of actors and garner enough support for the technology to help them develop the third project which is an ongoing pre-commercial park, by their own definition.

While O&G and OWP have high levels of technological relatedness, the two are very different industries in terms of their market relatedness (Hanson, & Normann, 2019). Several firms pointed out the differences in safety culture, in supplier competence, and contract structure and risk distribution. For supply firms engaging in the market for the first time, there are many uncertainties and potential barriers that might arise. Several firms indicated that there was a lack of predictability and standardization (at the time of their engagement) which needed to be resolved, and that PDP's played a role in enabling interaction and market learning. Large established firms typically placed more emphasis on commercial project participation, where market learning had at times had been acquired at a steep price to the company.

One small supply firm, who has developed its own foundation concept, did however, point to the complexity of the OWP market and the value of participating in a PDP for practicing and learning about the market.

> "We have gotten a lot of experience, not just the technical, but we have seen, how a project actually works in practical terms. We have gotten experience from being project managers, and that has been very important. In an offshore wind project, it is not just a case of deciding to build it, and then you build it. There are public authorities who need to be applied concessions from, and give environmental permits and there are banks and

insurance companies involved, as well as certification companies who need to vouch for your solution etc. and so we have had the opportunity to practice that interaction." - [SU1]

A newly started and ambitious developer, who has been involved in several PDPs through their ownership of a smaller technology company, emphasized the role of PDPs in expanding the actor network around the technology, as well as enabling interaction.

> "We have never doubted that the technology for floating OWP will work, but we are dependent on having an ecosystem around it, public authorities, banks, and industry, and in that respect these pre-commercial projects have played a part." - [ESD1]

A large EPC firm who has been involved in two PDPs also emphasized the role of PDP participation for market learning

> "I think the most important thing is the understanding of the commercial terrain we are entering, understanding where the industry stands technologically, what is needed and building valuable partnerships with other firms. We don't get anything done alone anymore, in the societies in which we operate." - [ELE3]

The degree to which firms gained access to OWP PDPs can be seen in relation to the market learning firms reported. If a firm's way of accessing OWP projects is through existing networks and partnerships from O&G, the need for market learning is not necessarily as pressing as it is for a firm who engages directly with international OWP actors, with whom they might not have existing relationships with. Both SU1 and ESD1 gained access to international PDPs not led by Norwegian developers. This was not the case for the majority of organizations in my sample, who were mostly engaged in PDPs led by a Norwegian developer with whom they had a previous relationship. This might be an indication that there is more market learning when engaging in projects led by international developers.

However, direct engagement with international markets require resources, that young SMEs and especially start ups might not have (van der Loos et al., 2020). While understanding the rules and demands of a new industry is crucial for international market engagement, it is perhaps less so for firms who are ‘piggybacking’ on larger companies (with whom they have an existing informal relationship) in projects led by domestic developers.

6.4.3.3 Market learning from commercial OWP projects

Many firms reported that they did more or less the same in one industry as the other. They also pointed out the importance one understanding the needs and requirements of the OWP industry, and not bring along ‘the baggage’ from O&G, of spending too generously on technological solutions which would have the adverse effect of pricing you out of the market. Understanding the risks involved in a project and understanding the contract structures and regulation demands of the new industry was also emphasized.

However, what was somewhat unexpected was the degree to which both the ELEs and the developer emphasized commercial project participation for these lessons about the market. This learning was often also the result of failures and unintended costs produced by a lack of market understanding, in early engagement with commercial OWP market. While some such events prompted firms to temporarily leave the industry, for others, the commercial learning-by-failure projects were pursued in parallel to their floating OWP PDP engagements.

One large EPC firm learned a lot from producing and delivering foundations to three early commercial projects.

> “It was a different time for the industry and different types of contracts, and we learned a lot, both good and bad from those projects. So that was very useful operational learning and very useful and expensively purchased commercial learning.” – [ELE1]

The firm also pointed out how, having the experience of manufacturing at scale is something that is also useful when producing smaller quantities, as for example the later PDPs they were involved in. They further said that the risk distribution in the contracts were a problem.

> "It was commercial contracts that placed a great deal of risk on us as a supplier. It was a dearly bought experience. It is important when you enter this industry that you understand the contracts and the risks which are there, and that you have a fruitful discussion with the customer about who should carry which risk, otherwise you are not set up for success." – [ELE1]

The firm then points to one commercial project where they delivered the foundations for a sizeable commercial park, and emphasize the lessons they learned from that particular commercial project

> "So that is something we spend time on now [after that project], we do not take risk, which we first, do not understand, and second, which we cannot control. So that is important principles and learning from that contract and that project" [ELE1]

The large established developer emphasized market learning gained from an early commercial project, which took place in parallel to their first PDP.

> "you have to go out into the market very early and ask for offers from the suppliers on turbines, foundations, marine operations, and cables, and what is new is that we have to make those decisions much earlier…with greater uncertainty and so you have to change the risk assessment." – [ELD1]

The developer goes on to point out the importance of understanding the institutional context and the various risk factors such as costs, NGOs and interest groups which have the power to shut down the project if the environmental assessment reports have not been done right. The developer then went on to emphasize three large commercial projects that they have been involved in as developer and the role these projects have had in teaching them how to improve.

> "Competence is important, and it is correct to say that we did not have the full and complete competence to develop large wind parks, so we have gone down the road of floating and bottom fixed, and on bottom fixed we had the responsibility for [300-

500MW commercial wind park], and we took a lot of learning there, a lot of challenges and a lot of learning." - [ELD1]

6.4.3.4 Market related teaching

Firms did not only engage in market learning, but several both SMEs as well as ELEs emphasized that they believe O&G has a lot to offer OWP, and a lot to teach. When engaging in an immature market, many of the actors expressed a desire to be able to shape the industry and not just gain access to it. These ambitions were both expressed by SMEs as well as ELEs.

One firm who has been involved in several OWP PDPs supplying monitoring and site surveying services emphasized that some of the developers they had dealt with, did not have the long-term perspective and experience that you get after twenty, thirty years in O&G. This lack of experience showed itself in how the developer sometimes made decisions on what the supplier perceived to be short term criteria, and a lack of understanding of the technological interplay over time.

> "We see clearly that those actors who are [our] customers in OWP, they tend to not have so much competence in ordering the services they need, they lack competence about the technology and the services they actually need, and this means that you have a breadth of somewhat insincere players, or low end actors, who get access to the market, because the main criteria is price…"- [YSME1]

The role of O&G competence in OWP was emphasized by several other firms as well, and there seems to be a good deal of consensus that while O&G actors should not bring their "belt and suspenders approach" [ELE1] to spending, they should however bring the extensive competence in project management and offshore operations that the OWP industry was perceived as being in need of.

> "It is the case that this market is very different from O&G, and I believe we have a lot to offer this industry as an O&G company… I think we can contribute with innovation,

production methods, materials, safety culture and an ability to execute large projects. I believe we have an enormous amount to contribute" – [ELE3]

6.4.3.5 Summary

Many of the firms I have interviewed were involved in commercial projects before or parallel to their engagement in PDPs. It is therefore not surprising that firms would point to engagement in commercial projects as a source for market learning, as opposed to a protected market setting such as a PDP. After all, it makes sense that actors learn more about the market by engaging directly with the market. Also, there is a big difference between a lab scale, a single pilot and a pre commercial park with 10 or 12 turbines. For many of the firms, the PDPs they have been involved in have been floating wind, while the commercial projects have been bottom fixed. Bottom fixed wind has been built in commercial scale in the North Sea basin for more than ten years, so it has been a while since the first bottom fixed PDPs took place.

There are several other potential reasons why many firms emphasized other arenas than PDPs as a source of market learning. One of them is the role of existing networks in engagement. Several smaller suppliers participated in PDPs developed by a large developer they already knew. Either as a sub supplier in conjunction with another firm they already knew or, as part of a work package under a large EPC supplier, with whom the firm also had existing ties from O&G. Whereas in international commercial projects, firms where more likely to engage with new actors, and less familiar or not familiar developers. As well as potential differences in industry culture, contract structures, standards, project execution and regional requirements. It is perhaps not unreasonable to assume that engaging with unknown international actors will create more uncertainty and thus more room for learning.

The risks and uncertainties of engaging in new commercial markets is one of the rationales behind PDP, and since learning is by definition a reduction of risks and uncertainties, so it follows that there are more opportunities for learning in a commercial market than in a shielded one.

After having discussed the empirical findings of this study as it pertains to the four sub-question of the master thesis I will now move on to the discussion chapter.

7 Discussion

In the following section I will discuss my empirical findings in light of my analytical framework and existing research. For simplicity the chapter is divided into sub-sections based on my research question and empirical section. I will therefore firstly discuss what motivates firms to participate in PDPs, secondly how they gain access to them, thirdly discuss what they gain from participation and finally discuss what they learn from the participation in PDPs.

7.1 RQ1: What motivates Norwegian supply firms to participate in OWP PDPs?

The overarching motivation for PDP participation was for a majority of the firms influenced by a desire to diversify their portfolio by engaging in related markets. Several firms mentioned the slump in the O&G market in 2015 as a turning point in which they began looking for other industries to engage with, but this was not the case for all of them. Several actors, both SMEs and ELEs, began their OWP engagement in the early 2010s, and a few others only began diversifying towards OWP in the last three years. Two ELEs were also in the process of developing strategies for OWP at the time of the interviews. A commonality between all the firms is a high degree of technological relatedness between their activities in O&G and in OWP. This was the case for both diversifying incumbent firms as well as YSMEs and start-ups. For the two start-ups however, OWP was their only area of focus. Their competence base was however developed in O&G and maritime industries and absorbed into the firm through hiring and partnerships.

Firms were motivated to participate in PDPs in order to get a track record, or a list of references. Acquiring this list of references was in turn motivated by gaining access to existing bottom fixed markets, as well as gaining an early mover advantage to imagined future floating markets. The contracts in large scale verification and deployment PDPs were however considered as commercial valuable in itself, and some SMEs as well as one ELE did not distinguish between niche markets and mass markets when pursuing contracts.

Market access as a motivation for PDP participation can be divided into four types. Firms motivated to participate as part of a technological innovation process, firms motivated to participate in order to verify an existing technology for use in a new market, firm motivated by gaining an early mover advantage, and firms motivated to participate in order to position themselves for industry building. These motivations need not be in opposition to one another and were held both simultaneously and individually. Large EPC suppliers with existing experience from commercial projects were typically less motivated to participate in PDPs.

The policy rationale behind PDPs is to mitigate risk for the firms involved in order to produce value beneficial to the public. This rationale indicates a willingness for firms to take short term losses for long term wins. However, both developers, large firms and SMEs emphasized the commercial value of projects as important prerequisites for participation/development. This is perhaps an indication of the importance of public policy in balancing risk and incentives for industry building.

For firms developing a novel technology PDP participation was described as a necessary step in their innovation process, and the firms can therefore be described as motivated by innovation. However, they usually expressed this in terms of market access and not technological development. This might be because they considered the latter to be self evident. In addition to technological development, verification and market access, some actors also emphasized a motivation to gain access in order to set the premises and shape the development of the industry. ELEs were perhaps more motivated by industry building than SMEs. The exemplary function of PDPs was also expressed by several respondents. Both SMEs and one ELEs mention PDPs as a method for attracting talent to the company and to build a company profile in the market. Large EPC firms with commercial experience were less motivated to engage in PDPs, unless it was driven by customer demand, or provided strategic opportunities, in addition to long term industry building ambitions.

7.2 RQ2: How do Norwegian supply firms gain access to OWP PDPs?

Gaining access to PDPs took many different forms, and involved a series of strategies. Policy instruments came across as a common factor, which was deemed necessary by both developers, ELEs as well as SMEs both young and established. Whereas SMEs were able to get access to single unit verification PDPs and lab scale PDPs directly they were typically dependent on an ELE for access to multi unit deployment PDPs. Informal networks and previous relationships from O&G were brought up as important in positioning firms for access, although it is difficult to attribute access to network directly. 7 out of 10 (minus two developers) firms in my sample were engaged in PDPs for the same large developer. All the firms knew this developer from O&G and had existing relationships. However, their ways of gaining access varied. It is challenging to group the firms according to strategy because there were quite significant differences between them. I would however, say that three strategies set themselves apart, and were somewhat more common. These were strategic partnerships, project specific collaborations and recruitment by reputation.

As a more general point, policy instruments were considered crucial to all participants for PDPs to exist. Strategic partnerships were both PDP specific as well as long term partnerships for OWP. Several firms were recruited to be a part of projects based on patent ownership and specialized skills developed in O&G, as well as in one case, on partial basis of a highly sought after employee. One other firm (ESD1) gained access to PDPs through partial ownership in an international technology company. The fact that a majority of the firms in my sample were engaged in PDPs for the same Norwegian developer, in combination with the expressed importance of existing informal O&G networks might indicate the importance of policy which enables domestic PDPs, in lieu of a home market. However, it is difficult to make that assessment based on my data. Several of the SMEs as well as SU1 have engaged with international OWP markets. SU1 was able to demonstrate their foundation concept without domestic government funding, and has subsequently engaged directly in international markets, YSME1 engaged directly with international PDPs in order to gain access to the O&G market. Several of the ELEs had also engaged in commercial bottom fixed projects, and already had a track record before participating in PDPs.

7.3 RQ3: How do PDPs contribute to innovation and market access for participating organizations?

In the following section I will discuss in what ways PDPs contributed to market access and innovation for participating firms. PDPs can constitute a temporary market for small and medium sized firms, and multi unit deployment PDPs can be considered commercial valuable for larger firms as well. It is difficult to make generalizations about the role of PDPs, because of the heterogeneity of my sample. However, there were a few commonalities between the participants.

PDPs were considered important in providing firms with a list of references in existing markets as well as early mover advantages in emerging markets. For firms developing new technology, PDPs were considered crucial in verifying their technology. This seems also to be the case for suppliers of 'critical' technology, although this technology has been applied commercially in other industries. This process of technical verification implies learning in the case of novel technology, and PDPs were described as a necessary step in the technology development process.

For SMEs and start- ups with only one or two products or services, getting access to a PDP can be understood as a necessity. While for firms with existing technology, PDP participation might perhaps be closer to constituting a competitive advantage, than a necessity for market access. However, I do not have enough data to say this definitively. For many of the firms I have interviewed it is difficult to assess the outcome of their participation as the project might still be ongoing or has only recently ended. In the case of two actors, however, one research institute and one SME, the effects of being an early mover was exemplified by the snowball effect of projects stemming from initial engagement in PDPs. The value of being an early mover, in terms of getting access to PDPs is also demonstrated in the case of ESME1 who also reported a snowball effect of requests, one building on the one before on the basis of a primary PDP. For large EPC firms, being an early mover, was not always deemed a positive, and some of the ELEs had themselves taken losses from early engagement in OWP. These early engagements were however from commercial projects and not PDPs.

7.4 RQ4: In what ways does PDPs contribute to learning for participating organizations?

7.4.1 Technical learning

The literature indicates that technical learning is important in all PDPs, and especially in the early phase PDPs (Bossink 2017; Bossink 2020; Hellsmark et al., 2016). Given this fact, I was surprised to find in my data material that technical learning as a motivation and outcome from PDP participation was not mentioned more often and by more actors. What was interesting to note is the degree to which the large developer emphasized technical learning, while small innovating (foundation solutions, and foundation factory concept) firms did not. This might be due to the specific role of the developer as the one on top with the bird's eye view of the operation. The large developer pointed out that floating OWP is a combination of two known technologies (turbines and floating foundations). While the suppliers involved in a project do not necessarily have to do anything particularly new, (they deliver what they delivered in O&G), the developer has to combine these known elements into a new combination and make it work - an innovative process by definition. This could explain the greater degree of emphasis on technical uncertainty reduction and learning from the developer. Also, given the strict demands for technological maturity (for new solutions as well as critical equipment) it might also be the case that suppliers need to have reduced technical risk through learning to such a substantial level as to be allowed access to full scale verification or deployment PDPs. There is some indication of this, in that ESME2 referred to various EU research projects and lab scale PDPs when discussing technical learning.

7.4.2 Organizational learning

Organizational learning is especially associated with an expanding actor network and large scale PDPs, although it does occur through feedback and feed forward loops as well (Bossink 2020; Hellsmark et al. 2016). Organizational learning is associated with various types of DUI learning (Bossink 2020; Hellsmark et al., 2016). My empirical findings indicate that both lab scale as well as deployment PDPs contribute to organizational learning. In lab scale PDPs this occurred through concept development and was undertaken by both research intensive SMEs as well as by

SMEs with previous experience from a series of planned but (as of today) unrealized commercial projects. For the developer as well as for large EPC firms, participation in multi unit deployment PDPs provided them with valuable understanding of the totality of a project, and the supply chain requirements involved with unit upscaling. Although large scale PDPs came across as important for both ELEs as well as the developer, these firms also had commercial experience which was also emphasized as important for understanding how to build a large scale production organization. Because of the technological relatedness between O&G and OWP, and furthermore the relatedness between bottom fixed and floating OWP, it is not so surprising that firms learned more about aspects of large scale production from commercial projects with a higher volume. However, the data does indicate that PDPs were beneficial and important to ELEs and developers in building the supply chain needed for future commercial projects. Although a majority of the firms in my selection had existing relationships from O&G, this does not necessarily mean that SMEs get to be a part of commercial projects. The data indicates that technology development as well as technology verification are important motivations as well as outputs from participation. In that regard, it is important for both suppliers and developers to interact at an early stage in the industry development in order to build a cost efficient supply chain. Full scale verification and deployment PDPs seem to contribute to this interaction and supply chain development. One could however argue that similar interaction and learning takes place in commercial projects as well. However, the literature indicates that young SMEs and start- ups have more difficulties accessing international markets than established SMEs and large incumbents (van der Loos et al., 2020). This might indicate that the chances of SMEs building a list of references and verifying technology through engagement in international commercial markets is slim, compared to them doing so in a protected niche space. Especially so perhaps, given the capital intensive and conservative character of the OWP sector (van der Loos et al., 2020).

In addition to enabling organizational learning, PDPs were also important for expanding the actor network of the industry and strengthening the knowledge base. The exemplary effect of PDPs was clearly demonstrated by the effects of a multi unit deployment PDP. Both the developer as well as a large EPC supplier from the same project emphasized that this project functioned as a turning point in a sense, and that it resulted in an increase in interest for the technology from surrounding suppliers, as well as making the industry (as well as the individual firms) more attractive to potential future employees. Lastly, there might be some indications that organizational learning from a particular PDP might not be as transferable to another region or market, because of demands for local content as well as geographical differences. However, both developers and EPCs emphasized the value of their existing competence from O&G in developing supply chains and partnerships across the global, so these differences in demand might be equally challenging in commercial projects.

7.4.3 Market learning

Learning how to operate in international OWP market is considered critical if Norwegian suppliers are to succeed (Hanson & Normann, 2019). PDPs can function as temporary markets and can allow firms an opportunity to 'practice' interactions with actors in the new market (Hellsmark, 2011). There were variations in the informants' experience of PDP participation for market learning. Some firms emphasised market learning as an important outcome from PDP participation, while others (typically established large enterprises) placed more emphasis on previous commercial engagements. Two of the three firms who did emphasize market learning as an outcome of PDP participation had participated in PDPs with international developers. This might be an indication that there is more potential for learning when engaging in PDPs led by international developers than by domestic ones (with whom firms already have an established relationship). For several ELEs as well as the established developer, previous commercial engagements where emphasized as sources of market learning. Early international market engagements were described as a 'dearly bought lesson' by one ELE and it is perhaps not unreasonable to assume that engaging in a commercial market implies more risk and therefore more potential for learning. The risks associated with being an early mover in the international OWP market was pointed out by several large enterprises, either on the basis of their own experiences as well as by observing other diversifying firms from O&G. For small firms with limited resources, learning by failure is perhaps not a realistic option, given that failure at an early stage could mean bankruptcy.

8 Conclusion

The objective of this thesis has been to contribute to a better understanding of the role of pilot and demonstration projects for Norwegian firms' engagement in international offshore wind markets. I have approached this general question by articulating four sub questions.

RQ1: What motivates Norwegian supply firms to participate in OWP PDPs?

RQ2: How do Norwegian supply firms gain access to OWP PDPs?

RQ3: How do PDPs contribute to innovation and market access for participating organizations?

RQ4: In what ways do PDPs contribute to learning for participating organizations?

I have investigated these questions through in-depth interviews with a varied selection of supply firms, as well as through observation and content analysis. First, the research questions were anchored in the field of transition studies and innovation systems literature. I explained how PDPs contribute to strengthen various TIS functions. Thereafter, I presented and discussed previous literature on PDPs, the role of PDPs for various forms of learning, before directing attention to the need for more in-depth understanding of the role of PDPs for the surrounding actor networks (Frishammar et al., 2015). In my methodological chapter I explained why I decided to conduct an embedded case study and how I had proceeded with my data collection and analysis. This thesis employed an inductive approach, which is beneficial for allowing categories to develop from the ground up (Gioia et al., 2013). In my empirical chapter I presented my findings and explored the motivations, PDP access strategies and the role of PDPs for contributing to innovation, market access and learning. The main findings from my analysis were treated in the discussion chapter.

In section 7.1, I explained how firms had varied motivations for participation. A desire to gain access to international markets as well as imagined future markets was important to them. Technological innovation as well as verification of existing technology were important motivational factors. I noted that certain PDPs were considered to be commercially valuable. The value of PDP participation provided an early mover advantage which is an important factor. SMEs and start- up companies emphasized the importance of having a list of references when engaging in international markets.

In section 7.2, I discussed the importance of policy instruments for PDP participation and how this was emphasized not only as important by SMEs but also by ELEs as well as developers. The role of existing informal networks, resources and reputations are important ways for firms to gain access.

In section 7.3, I discussed how PDPs contributed to innovation and market access. I discussed the case of two specific firms, and how their early PDP engagements had contributed to setting a trajectory for their development.

In section 7.4, I discussed the role technical, organizational and market related learning in PDPs. In section 7.4.1, I noted that technical learning is especially emphasized by the developer and argued that this might possibly be related to the bird's eye view of a developer. I also pointed out that several firms explicitly stated that their products or services were pretty much the same in all markets.

In section 7.4.2, I discussed how organisational learning is an important outcome for large scale PDPs, lab scale PDPs and commercial projects. Firm size and the degree of previous experience from OWP are relevant factors for how much organisational learning was gained from PDP participation. In this section I also discussed the functions of PDPs, and how they were contributing factors for production organization and expanding the actor network.

Section 7.4.3, discusses the role of market learning as an outcome of PDP participation. Two of three participants in PDPs emphasized that involvement in international projects increased market learning as an outcome. My empirical findings suggest that large firms believe that participation in commercial projects is a greater source of market learning than participation in PDPs.

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