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Exploiting global renewable energy growth

Opportunities and challenges for internationalisation in the Norwegian offshore wind and solar energy industries

Håkon Endresen Normann and Jens Hanson

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By Håkon Endresen Normann and Jens Hanson
TIK Centre for Technology, Innovation and Culture
University of Oslo

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Preface and acknowledgements

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The contents and conclusions in this report are entirely the responsibility of the authors.

Contact:

Håkon Endresen Normann
PhD candidate
TIK Centre for Technology, Innovation and Culture, University of Oslo
+ 47 951 42 524
h.e.normann@tik.uio.no

Jens Hanson
Postdoc
TIK Centre for Technology, Innovation and Culture, University of Oslo
+47 934 36 573
jens.hanson@tik.uio.no

Executive summary

This report analyses the Norwegian offshore wind power (OWP) and solar photovoltaics (PV) industries, based on a survey executed in February 2015. This focus is motivated by the combination of large industrial potential and high global growth in deployment and investment levels. This growth has occurred almost exclusively in international markets. We have therefore been interested in how Norwegian firms can link up to these markets through internationalisation. The purpose of this report is to gain a better understanding of current activities of Norwegian OWP and PV firms, opportunities for internationalisation, and challenges associated with developing these industries in Norway. Key findings in the report are:

Many but small firms: We analysed responses from 151 firms, of which 128 have delivered products or services to the OWP or PV industries. However, most of these firms are small or firms with only minor engagement in these industries. Two-thirds of the firms dedicate less than five full-time equivalents (FTEs) to OWP or PV. For more than half the OWP firms, offshore wind represented less than five per cent of total revenue in 2014.

Related industries are important for the emergence of PV and OWP industries: Most of the firms have their primary activity in other industries than OWP and PV. Only 18 per cent of firms engaged in offshore wind see this as their primary industry. Nearly half of these firms consider oil & gas and maritime as their primary industries. 43 per cent of firms engaged in PV see this as their primary industry, with construction and materials representing important related industries. In addition we see that these new industries draw heavily on established industries in Norway.

Large diversity: Firms are distributed across diverse supply chains, offering different types of products or services within the OWP and PV industries. Moreover, we observe significant differences in terms of firm size and level of commitment to OWP and PV. We therefore posit that firms are likely to have different requirements, needs and goals for the engagement in these industries. This raises a question of whether diversity amongst firms may influence their ability to 'act together'.

Demanding to demonstrate products and services without a home market. Three-quarters of the OWP firms find it difficult to internationalise without a home market. It is particularly challenging to compete without a home market for smaller firms.

Experienced and expected growth: Around half of the firms reported growth in number of FTEs and share of total turnover dedicated to OWP and PV over the past three years. More than three-quarters expected increased turnover from OWP or PV in the next three years.

Contents

1 Introduction

This report analyses Norwegian offshore wind power (OWP) and solar photovoltaics (PV) industries, based on a survey executed in February 2015. These are two key new renewable energy industries in Norway, where there is lacking systematic empirical evidence on current characteristics. By industry we here refer to the set of actors (primarily firms) that have delivered or have ambitions to deliver products or services to the production of offshore wind or solar energy. We focus on the features and dynamics of these industries in Norway with a special focus on their internationalisation patterns and characteristics.

We focus on internationalisation for three main reasons. First, renewable energy is expected to grow rapidly globally and these growth markets thus provide new opportunities for Norwegian firms. In 2014 renewable energy (excluding large hydro) accounted for 48% of the net power capacity added worldwide (UNEP/BNEF 2015). Renewable energy is expected to account for 70% of the new generation capacity added globally by 2030 (BNEF 2013). As part of this the OWP and PV industries are both associated with significant global growth. At the same time building an industrial capacity for renewable energy technology (RET) development and diffusion is a central and global challenge (Jacobsson et al. 2009). The development in international markets for new renewable energy is also highlighted by the Energi21 strategy as the main reason for provision of public support for these industries in Norway (Energi21 2014, p. 27).

Second, a key characteristic of new renewable energy in Norway is weak growth in domestic deployment, despite vast resources, largely due to the dominant position of hydropower (Hanson et al. 2011). Thus, because Norway already has large shares of renewables in the energy mix, Norwegian suppliers to new industries such as offshore wind and solar energy have mostly been oriented towards opportunities provided by growth in international markets for these industries.

Third, in spite of the weak historic market situation for new renewable energy, Norway has fostered nascent industries linked to offshore wind and solar energy. Individual case studies have illustrated the role of existing industries, competences and resources from established industries that may be transferred to offshore wind and solar photovoltaics (Hanson 2013; Steen & Hansen 2014; Weaver 2012; Weaver & Steen 2013). The potential in exploiting established competence and knowledge and the large opportunities in international markets has been present in both industries since their conception in Norway.

The rationale behind selection of these two industries thus rests on the combination of high global growth in deployment and investment levels and the industrial basis for developing such industries in

Norway based on its actor and knowledge characteristics. The main objective of this report is therefore to analyse the build-up of these new Norwegian renewable energy industries with particular attention to their international ties.

Finally, the formation and growth of such new industries can be important by creating economic growth and contributing to a more sustainable society. The report thus ties up with the current debate on greening and revitalisation of the Norwegian economy in an era with climate change and declining activity in the oil & gas sector high up on the agenda.

Norwegian offshore wind and solar photovoltaics industries have been mapped and investigated in a number of previously published reports. In particular, firm activities in the offshore wind industry have been documented on several occasions with a special attention to links to the offshore petroleum sector. Both Volden et al. (2009) and Hansen and Steen (2011) have mapped the offshore wind supply industry in Norway and identified opportunities and challenges for firms in adapting existing offshore and maritime activities to offshore wind. The role of technological diversification in the oil & gas industry has been further explored by Weaver and Steen (2013), who in addition point to the importance of internationalisation in the renewable energy industries. Moreover, several reports have identified the Norwegian renewable energy industry as fragmented and with weak relations between firms (Multiconsult 2015; Thema 2013). Finally, several reports have estimated the number of Norwegian firms and full-time equivalents engaged in renewable energy technologies (Menon 2013; Multiconsult 2012, 2015). However, estimations on the size of the OWP and the PV industries vary considerably.

In sum, these findings have been helpful in constructing this report by providing a foundation for further investigation and for identifying particular areas of interest. The overall motivation behind this report is to contribute with knowledge about what characterises current efforts at developing green industries in Norway.

The report is structured as follows. We first briefly outline an analytical perspective on dynamics of new industry formation with an integrated focus on internationalisation in section 2. In section 3 we describe the methods, sample and population of the survey. In section 4 we present a brief overview of the two industries and their key characteristics. In section 5 we present results while section 6 sums up key findings and raises some points for discussion with regards to dynamics, challenges and opportunities for these industries in Norway.

2 Dynamics of new industry formation

The formation of new renewable energy industries is paramount to facing economic, environmental and societal challenges. A key insight from the field of innovation studies is that the innovation processes that underlie the formation of new industries are systemic in nature. That is, innovation occurs in the context of an “innovation system” or “innovation eco-system”. The basic premise behind this notion is that innovation – the introduction of new products, processes or services – is reliant on flows of knowledge and technology between people, businesses and other actors. This interaction can be direct or indirect, and affects the circumstances under which an idea can be developed into a product, process or service in the market place (Hekkert et al. 2007). A key dimension of this is that a range of actors needs to become involved in the generation, diffusion and use of new technologies. This broad set of actors, ranging from technology producers, researchers, policy-makers to end-users, together can be seen to be engaged in the process of industry formation. This interaction is guided by institutional frameworks, which refer to “hard” (formal) institutions such as policies and regulations and more “soft” (informal) dimensions which can be understood as the rules of the game (Hillman et al. 2008).

2.1 Key processes in industry formation

Recent developments in innovation systems studies stress that the overall process of development of a new industry normally is associated with a number of key sub-processes. These processes and their characteristics have been derived from a review and systematisation of the literature addressing the emergence of novel technologies, actors and industries (Johnson & Jacobsson 2001). We discuss a selection of these briefly in the following.

Development and exchange of knowledge

Innovation studies as a field underlines the importance of knowledge generation, learning and new combinations of existing knowledge, in development of novel technologies and industries. While traditional economic approaches focus heavily on knowledge generation via research & development (R&D), the innovation literature stresses that processes of knowledge development have multiple sources such as learning from use, trial and error, experience and imitation. Several studies underline the fact that R&D alone seldom drive innovation (Cohen et al. 2002; Kline & Rosenberg 1986). Mowery et al. (2010) point out how demand side factors, for instance programmes of public procurement and market creation, were highly important in some of the large-scale innovation programs coupled to IT, semiconductors and agriculture. Knowledge development linked to and enabled by the demand side thus constitutes an important dynamic for knowledge development (Mowery & Rosenberg 1998).

Similar points have been made by (Mazzucato 2013) who underlines that governments play a key role also in creating and shaping markets as part of processes of economic development.

Entrepreneurship, demonstration, and experimentation

The use and application of knowledge via processes of entrepreneurship, experimentation and demonstration are also important processes in industry formation (Carlsson & Stankiewicz 1991). In order for an emerging technological field to develop it is important that numerous experiments and demonstrations take place in order to secure variety, given that we seldom know in advance which technologies and business models that will succeed and prevail (Hillman et al. 2008). This relates on the one hand to new firms and business models, but also to technological demonstration that can display the viability of new designs. Experimentation and demonstration is highly uncertain and comes with large risks both in technological and economic terms given that it involves the introduction of new technologies and business models (Bergek et al. 2010).

Expectations and direction of search

In order for firms to become engaged in processes of new industry building, incentives or pressures can be important mechanisms that direct firms towards the new industry or technology. Expectations of (international) growth markets can be one such important driver that directs firms towards an emerging technology. Public sector involvement can influence this process through regulation and provision of incentives for investment (Hillman et al. 2008). The use of feed-in tariffs can for instance be seen as an important incentive mechanism driving investments in renewable energy.

This process influences entry into an emerging field, but also the manoeuvring of differing design options *within* a technological field. In emerging fields variety is typically large and the sharing of expectations with regards to the direction of development can be important for the alignment of actors. This alignment can be important both for learning processes but also in terms of critical mass in attempts to affect firms' environment.

Markets and users

The development of markets is a process intimately linked to formation of new industries because it enables links between users and suppliers, which in turn can trigger important knowledge development (Hillman et al. 2008). Processes of market formation are critical as important improvements in technologies usually arise in the aftermath of their initial introduction. Important improvements in technology can arise from the disparity between what technologies initially supply and what consumers de facto require (Georghiou et al. 1986). These improvements often change the economic significance of new technologies. However, markets for new technologies tend to be underdeveloped due to how new technologies rarely are mature at their initial introduction (Kline & Rosenberg 1986). At the onset markets may be very small, but so called "nursing markets" or niches can be very central to the development of a new industry (Erickson & Maitland 1989; Smith & Raven 2012). Governments can be important creators of niche markets in the shape of regulations, public procurement, tariffs and subsidies (Mazzucato 2013).

Mobilisation of resources

As new entrants engage and experiment with emerging technologies there is a considerable need for resources. Industry formation therefore involves the mobilization of human resources (skilled labour), financial resources (for instance venture capital, R&D funding and capital investments) and physical resources (such as natural resources and infrastructures) (Karltorp 2011).

2.2 Internationalisation and industry formation

Many countries are actively promoting growth of new renewable energy (RE) industries, as they foresee massive global growth for RE technologies. The dynamics of these industries thus have an international character, with some countries taking the lead. Germany and China have for instance been successful in building globally leading photovoltaic industries, while Germany and Denmark have taken the lead in the offshore wind power industry. The question is how countries that do not have leadership positions can link up with these global developments.

Building successful RE firms and industries is not straightforward as access to markets and resources is affected by geographical location (Coenen et al. 2012). For Norway, new RE industries have been lacking home markets. With regards to industry formation the importance of domestic markets for successful internationalisation in terms of market entry for manufacturing and services industries has been underlined (Castellacci 2012; Castellacci & Fevolden 2014; Fagerberg 1992; Lundvall et al. 2002). This literature states that *a lack of home market negatively influences the likelihood for success of international market entry for firms*. A key question is therefore how firms can tap into international markets by building required resources without a home market where they can demonstrate their skills and capabilities. In the following we discuss three factors that can affect the likelihood of compensation for insufficient home market deployment.

The first factor is firm size, which is particularly important when there is a weak domestic market as larger firms have the resources to overcome sunk export costs and trade barriers (Castellacci 2012;

Castellacci & Fevolden 2014). Thus, larger firms with longer operational histories enjoy higher levels of legitimacy by being able to show a larger set of previous experiences, and have access to more resources. We expect that access to international markets is larger for large firms than for small firms.

The second factor is the presence of related industries. We define relatedness as instances where two or more industries share, or there is an overlap between, actors, knowledge and technology (Bergek et al. 2008). In the absence of domestic market opportunities, RE firms may benefit from own activities, or other firms, in related industries, for instance by sharing activities in technology development, manufacturing, or marketing. In this way firms gain access to opportunities normally provided by a home market. This is a question of how new industries can emerge from old. A main mechanism in this process is that of branching, whereby firms switch to other albeit *related* industries (Boschma & Frenken 2011; Martin & Sunley 2010; Neffke et al. 2011). Moreover, Hanson et al. (2015) show how related industries can provide a range of complementary resources (knowledge, infrastructures, human and financial capital) for emerging industries.

The third factor concerns the maturity of the RE industry. The importance of geographical proximity in some instances is likely to be greater for nascent industries. When a technology moves into a mass market phase, actors in regions without local markets may be able to sell their products to markets in other countries more easily (Binz et al. 2014). Thus, the importance of a home market depends on the level of maturity of the technology (Fagerberg 1992, p. 271).

In sum, the overall process of industry building is related to a number of important processes. While these processes can be seen to develop globally, the extent of how firms that lack sufficient home markets can link up with these global developments depends amongst others on firm size, maturity and presence of related industries.

3 Methods and data

Data for this report is almost entirely based on a survey executed in February 2015. Unless otherwise indicated, data is based on this survey. The sample for the survey was drawn from industry reports, membership of industry organisations, and desk research. The criteria for inclusion in the sample was that the firm had to be located in Norway, and that the firm had delivered, or had ambitions to deliver, products or services to either solar PV or offshore wind industries. The sample includes companies that develop and operate PV and OWP projects. Some of these companies will also be owners. However, we have not included companies that are only associated with these industries through power production. We refer to all surveyed firms engaged in offshore wind as offshore wind firms, even if their engagement in OWP activities is negligible. Similarly, we refer to all firms engaged in PV as PV firms. Thus while a firm may normally be referred to as for instance oil & gas or consultancy firm, we refer to them as PV or OWP firms given that our primary focus is on their activities in these industries.

Since we could not prior to contacting the respondents know whether the firms had ambitions in OWP or PV, the original sample totalled 243 firms and included a number of firms that responded that they were not engaged in these industries. The survey with these firms was not continued, and they were excluded from the sample. Following this exercise, the total sample consisted of 213 firms (155 OWP and 58 solar PV). 158 firms responded to the survey (108 OWP and 50 solar PV), with a response rate of 74%[1]. After cleaning up the data by removing responses that did not meet our selection criteria, we were left with 151 responses (71 %) for our analysis (102 OWP and 49 PV). In spite of a careful sample selection process there may exist uncertainties with regards to firms that have not been included in the sample. This may primarily be because it is difficult to know whether firms with primary activity in other industries are engaged in OWP or PV. As there may be firms that have ambitions in PV and OWP that we did not have in our original sample, it is difficult to estimate the exact total number of Norwegian firms with activities in OWP or PV. We do however believe to have sampled a significant proportion of relevant firms.

Survey respondents were CEOs or managers of OWP or PV activities. For some firms, these were owners or directors of the company, whereas for other firms respondents were head of divisions within a larger organisation. The survey was conducted via telephone and each interview lasted approximately 20 minutes.

The design of the survey involved multiple steps. First, we identified six key areas of interest based on the perspectives on industry formation and internationalisation discussed in section 2:

Firm characteristics: We here used different indicators to capture the relative importance of OWP or PV within the organisation (importance of OWP or PV to the organisation, number of full-time equivalents dedicated to OWP or PV, share of total turnover from OWP or PW). Further, based on the importance of related industries discussed in section 2.2 we included questions about primary sector and experiences that were relevant for activities in OWP or PV. Answers to questions on primary sectors and experiences from other sectors were aggregated into main sectors. Where necessary, ambiguous answers were standardised through additional desk research. Additionally,

[1] 7 of these firms responded that they had previously delivered products or services to the OWP or PV industries, but that they no longer had any ambitions to do so. Consequently, these firms were not asked to complete the survey.

based on the potential role of firm size, we added data on total sales revenue and employees available from the proff.no database as a proxy for firm size.

Supply chain: Firms in different places in the supply chain are likely to draw upon different types of knowledge and experience, participate in different parts of the markets for OWP or PV, and export different types of products and services. It was therefore important to us to place each respondent in the supply chains so that any commonalities or variations across the entire supply chains could be identified. We initially recorded which areas each firm offered products or services according to a pre-defined list put together based on previous studies of OWP and PV industries (Hanson 2013; Multiconsult 2012; Navigant 2013; Steen & Hansen 2014; Wieczorek et al. 2013). We subsequently aggregated the lists for OWP and PV to fit with a smaller set of supply chain categories, which we present in section 5.1.1.

For firms that deliver products or services to more than one part of the supply chain, we initially categorised these firms in multiple places along the supply chain (i.e. many OWP firms deliver both installation and maintenance services). However, for the purpose of our analysis we wanted to be able to categorise each firm in only one place in the supply chain. To do so, we used the initial response recorded in the survey in addition to available information about each firm (company websites, news archives, annual reports and public registries) to place respondents in what we judged to be the primary supply chain category. We recognise that there is a potential weakness in manually modifying the survey data in this way. Nevertheless, the categorisation that we have been able to do as a result opens up for new insights with regards to the distribution of firms across the supply chains and characteristics of firms in different categories

Barriers: From the literature on internationalisation and industry formation, we identified eight potential barriers and we asked the respondents to indicate whether they experienced these to pose challenges for their ability to succeed in the markets for OWP and PV. The literature on the role of home markets led us to include barriers related to testing and verification of products, distance to markets and access to customers. We also included potential barriers related to the mobilisation of different resources, such as capital, based on the potential importance of this as a process in industry formation.

Success criteria: The survey also included questions about the importance of different criteria for success. Based on ideas that industries or segments (parts of supply chain) that are comparatively more standardised rely less on a home market, we here included price and quality as two of these criteria. The rationale was that firms relying more on price than on quality (or other criteria) supply products with a greater degree of standardisation. Other criteria referred to different forms of flexibility and the supply of new technology.

Markets: Given the expected international orientation of many of the respondents, we asked about the degree of international or domestic orientation of the firm. Further, we asked all firms that had international customers (or potential customers) to list the three most important markets for their products or services.

Future expectations: Finally, we included a few questions about expectations for future revenues from OWP or PV and about future investments in products or services aimed towards the OWP or PV markets.

Having put together a draft of the survey, we distributed this to a set of external researchers with industry insights and industry experts for feedback. Based on this feedback, we made final adjustments to the survey.

4 The offshore wind and photovoltaic industries

Support for research, development and demonstration (RD&D) has been one of the main tools targeting renewable energy in Norway. RD&D spending in renewable energy increased drastically in 2009, in part linked to the establishment of so called research centres for environmentally friendly energy (FMEs) (NFR 2015). Energi21 – the national strategy for energy related R&D – has highlighted OWP and PV as two of its six prioritized areas for R&D (Energi21 2014). The main justification for use of public funding for R&D in these fields is related to developing internationally competitive business and expertise for the energy sector.

4.1 International market for OWP and PV

New renewable energy industries have seen substantial international growth in recent years. Figure 4-1 shows how annual new investments in wind (onshore and offshore) and solar have increased over the last decade. Even though offshore wind represents only a small share of total wind power investments, investments in offshore wind has increased significantly in recent years (EWEA 2015).

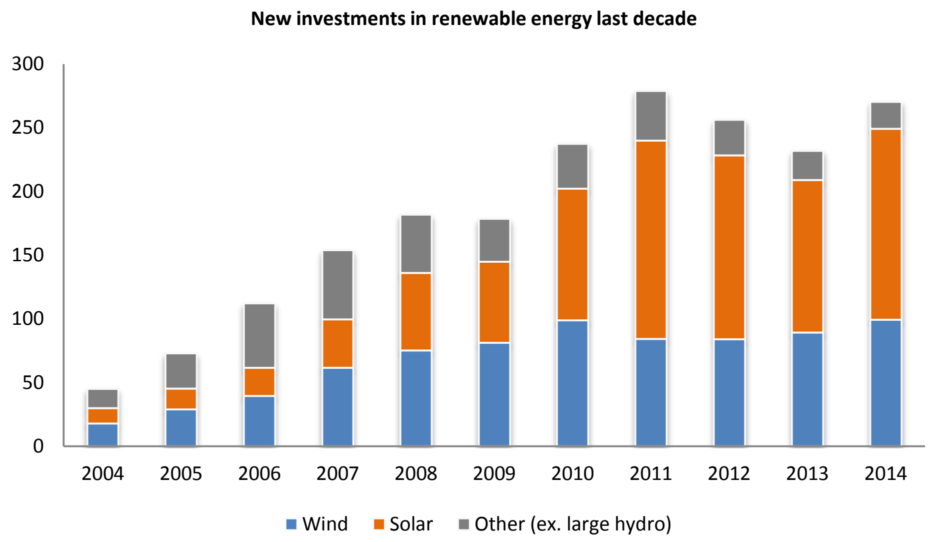


Figure 4-1 New investments in renewable energy excluding large hydro, 2004-2014, $bn. Includes estimates for undisclosed deals.
Source: UNEP, Bloomberg New Energy Finance

In the case of PV, this growth has resulted in dramatic reductions in cost of electricity (see figure 4-2), which in turn has further contributed to market growth. PV costs have been reported to have fallen with 80% since the end of 2009, with PV gaining competitiveness with fossil-fuel fired electricity costs in some regions (IRENA 2015a).

The development of offshore wind has followed a different trajectory. Although OWP is a technology with large potential, it is also a technology that has been confronted with difficulties. Despite increased investments in both R&D and deployment, the cost of electricity increased in the period between 2008 and 2013. This increase in costs can largely be explained by projects being developed further off shore in deeper waters, cost overruns due to harsh environments and complexity of construction at sea, increased steel prices, and lack of competition in the turbine market. However, estimated costs for recent projects such as the Horns Rev 1 project developed by Vattenfall shows that substantial cost reductions can been made (Danish Ministry of Energy 2015). Nevertheless, we note a significant difference between OWP and PV in that the value of the PV market and the estimated share of the total electricity market for PV is substantially larger than the market for OWP. Moreover, whereas OWP will depend on subsidies in order to compete with more cost-efficient technologies for some time, PV is today competitive without subsidies in some markets (IRENA 2015b).

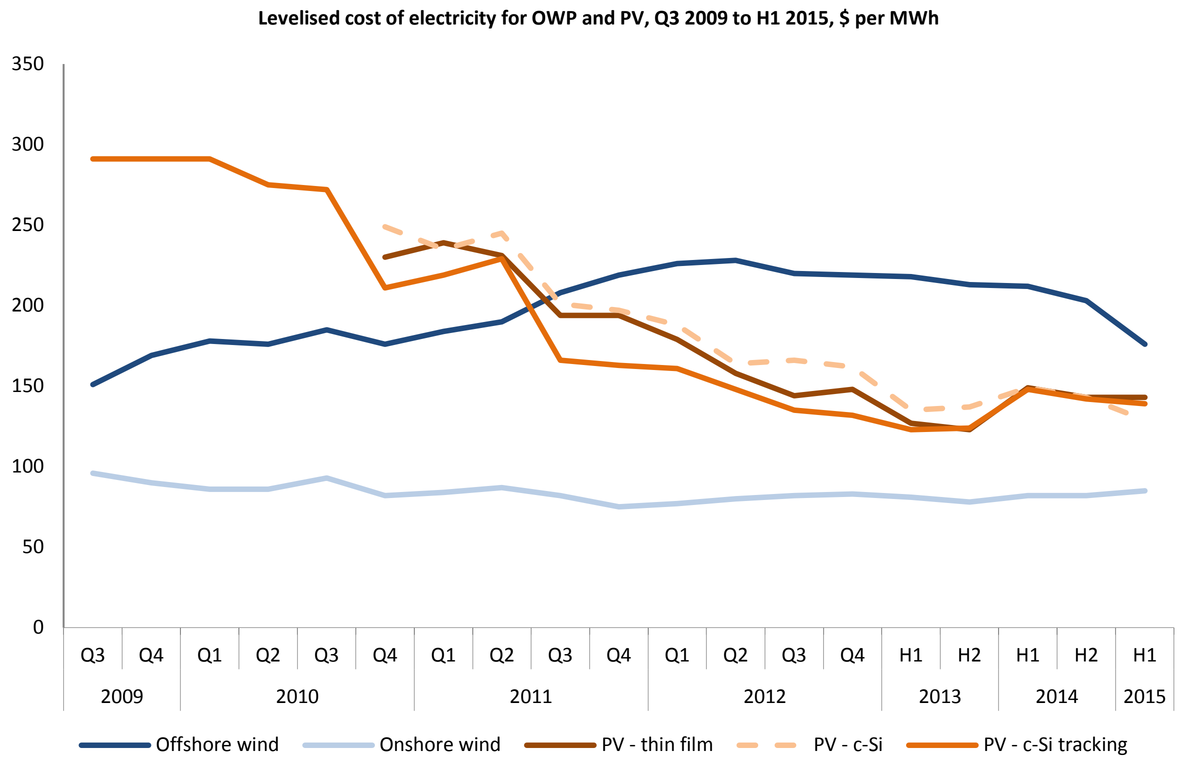


Figure 4-2 Global average levelised cost of electricity for wind and PV, Q3 2009 to H1 2015, $ per MWh.
PV-c-Si stands for crystalline silicon photovoltaics
***Source:* Bloomberg New Energy Finance**

The value of the global PV market for 2014 has been estimated at approximately 600 billion NOK, whereas the value of the offshore wind market in 2014 has been estimated at around 60 billion NOK. However, Norwegian actors have only captured a small share of these markets (Slengesol 2015a). Export Credit Norway estimate that in 2014 Norwegian suppliers sold products and services to international offshore wind projects worth around 3 billion NOK, which gives a market share of about 5 per cent (Slengesol 2015b). Norwegian exports to the PV industry have been estimated to 2-2.3 billion NOK, which equals to just above 0,3 per cent of the global PV market (Slengesol 2015a). Both these industries in Norway thus have a marginal share of global markets.

4.2 Offshore wind in Norway

As a European market for offshore wind emerged in the 2000s, a number of Norwegian firms started to explore opportunities in the offshore wind industry by developing products and solutions that exploited technology, resources, and competencies from the maritime and oil and gas industries (Hansen & Steen 2011; Normann 2015; Steen & Karlsen 2014). These firms included entrepreneurial start-ups such as Owec Tower and Sway, industrial actors such as Aker Verdal, as well as large energy companies such as Lyse, BKK, Statoil and Statkraft. This development gained momentum around 2007 and 2008 when the financial crisis and reduced offshore activity put pressure on the suppliers to the offshore oil and gas industry. In the period between 2007 and 2009, a number of firms with activities in the oil and gas and maritime industries therefore diverted attention to the growing international market for offshore wind. This increased attention was also given added political legitimacy as several members of government voiced strong support towards the development of a Norwegian offshore wind industry. However, efforts to realise a domestic market for offshore wind have either failed or have yet to be realised (Normann 2015). Yet, despite a weak home market, many of the largest Norwegian exporters to the renewable energy industries are firms delivering to the offshore wind industry such as Fred Olsen, DNV GL, Aibel and Draka Norsk Kabel (Teknisk Ukeblad 2015).

4.3 Solar photovoltaics

Research activities in Norway related to the development of raw-materials for solar PV have been on-going since the 70s and 80s (Hanson 2013; Klitkou & Godoe 2013). Combined with expectations for solar PV markets in Germany and Japan (Jacobsson & Bergek 2004) the first PV manufacturing firm, Scanwafer emerged in Norway in the mid-90s. During the first decade of the 2000s the large global player Renewable Energy Corporation (REC) and a number of suppliers grew forth. At this point in time firm entry was mainly driven by expectations of growth in overseas markets and mainly oriented towards material and component supply. Annual global growth rates have been estimated to 44% in the period 2000-2014 (Fraunhofer-ISE 2015). A range of activities were directed towards development of new processes for production of silicon for PV purposes, such as those made by Elkem Solar. Following China's rapid entry to the PV industry, the dramatic increases in production capacity and rapid decreases in price challenged many of the established firms in the industry resulting in the termination of REC's activities in Norway as well as a number of its suppliers. During and in the aftermath of the global crisis and rapid price drop firms linked to PV deployment emerged. Scatec Solar for instance emerged as a large global player in projecting and operation of solar power plants (Hanson 2013). PV deployment in Norway historically has been marginal with below 500 kWp installed annually. Most installations were made off-grid on lighthouses and holiday cabins. In 2014 deployment levels increased to 2,2 MW with energy efficiency in buildings as the key driver also with expectations for future growth in this market (Energi og Klima 2015). Recent development such as Norwegian Crystals in Glomfjord and Elkem Solar at Herøya do also signal new activities in component supply (Nilsen 2015; Votvik 2015).

5 Results

In the following, we present results from the survey starting with a description of the respondents.

5.1 Firm characteristics

A vast majority of the firms in the survey have had a minimum of one delivery to the OWP or PV markets. Figure 5-1 shows that nearly all of the PV firms and about 80 per cent of the OWP firms responded that they have delivered products or services to the offshore wind and PV industries. The respondents that had not yet delivered products or services to the OWP or PV markets had ambitions of doing so.

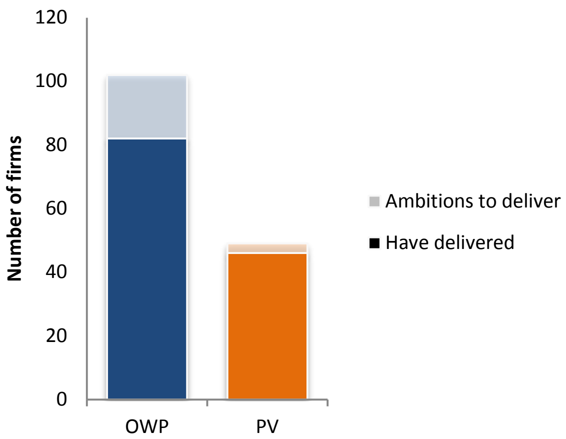


Figure 5-1 Number of OWP and PV firms that have delivered products or services to the offshore wind or PV markets

However, as figure 5-2 shows, a large share of the firms only had minor activities in OWP and PV in 2014. Many firms dedicate less than one full-time equivalent (FTEs) to OWP and PV and nearly two-thirds invested less than 5 FTEs in OWP and PV in 2014. Moreover, more than half the OWP firms report that offshore wind represents less than five per cent of their total revenue. Thus, it is clear that to the majority of firms, OWP and PV is a supplement to other activities. At the same time, more than one-third of the firms dedicate 5 or more FTEs to OWP and PV. In this report, we consider this group to have made *significant investments* in OWP and PV. Finally, we can also see that PV represents a larger share of the PV firms' total turnover, which suggests a higher degree of specialisation, as will be discussed below in section 5.1.3.

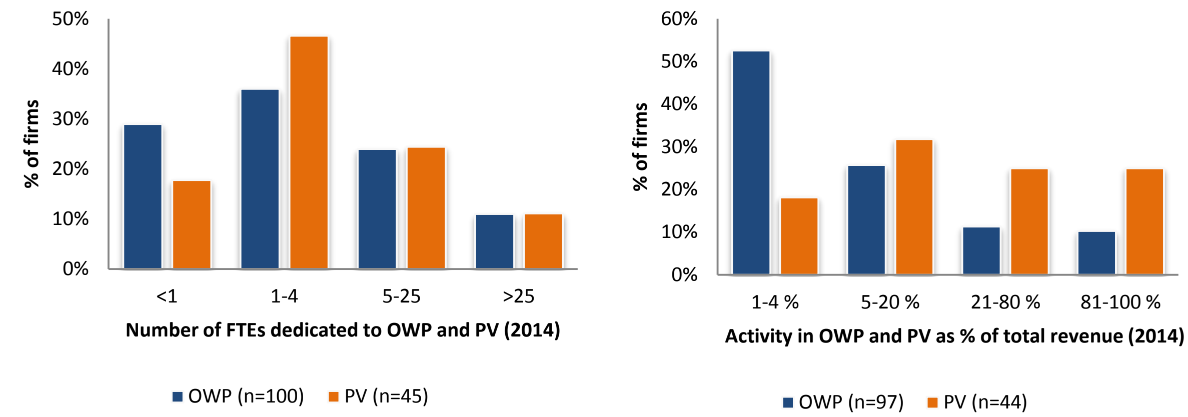


Figure 5-2 Number of full-time equivalents and percentage of company revenue in PV and OWP

We also asked the firms about when they first started up activities related to the offshore wind and solar PV industries. Figure 5-3 shows that there was little activity, in terms of new firm entry, before the year 2000, and that following a surge in activity in the period between 2005 and 2012 activity was reduced in the subsequent years. This is particularly visible for the offshore wind firms, and may be related to changing activity levels in the petroleum industry in the same period (Normann 2015).

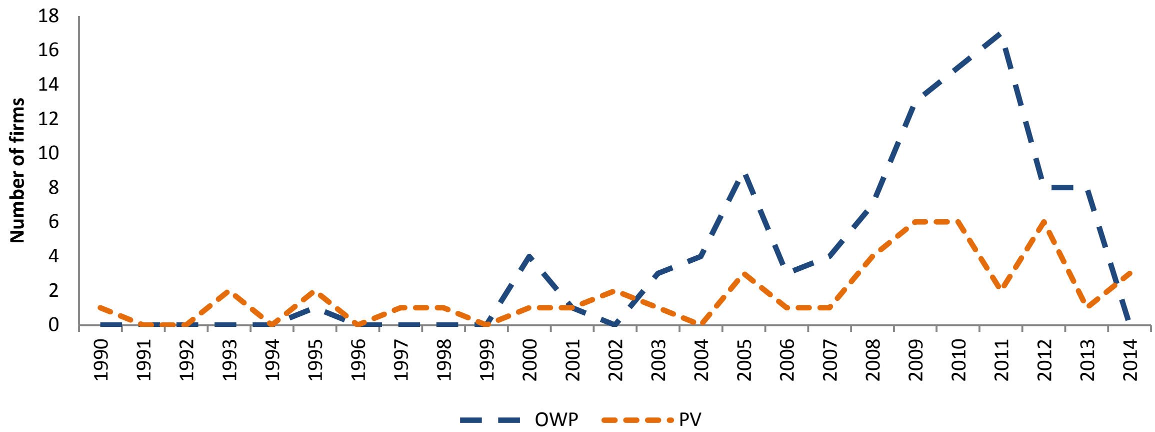


Figure 5-3 Annual number of firms starting activity in OWP and PV (1990-2014)

5.1.1 Supply chains

Both the offshore wind and photovoltaics industries consist of a variety of firms that supply different products and services[2]. An offshore wind farm is put together by three groups of manufactured components: topside, foundations and electrical infrastructure. The turbine is the main topside component and the single most expensive part of the OWP value chain, representing approximately one-third of the total costs of an offshore wind farm. This is however a significantly smaller share than

[2] Many of the firms reported to have activities in several categories in the supply chain. For the purpose of our analysis, we placed these firms in only one category in the supply chain (see section 3 for more details about this process).

for onshore wind where the turbine typically account for between two-thirds and three-quarters of total installed costs (IRENA 2015b). Thus, a large share of the value can be captured from other parts of the OWP value chain. For instance, the value of logistics and installation has been estimated to around 20 per cent, electrical infrastructure to around 12 per cent and foundations and support structures to around 25 per cent (Navigant 2013). A number of other services such as those related to meteorological and oceanography, maintenance and IT also contribute to the offshore wind supply chain. In this report, we use the following categories along the OWP supply chain: (1) topside, (2) foundation, (3) electrical and grid, (4) logistics, installation, vessels, (5) metocean, survey, subsea, (6) R&D, consultancy, IT (7), operations & maintenance and (8) other. We should here note that R&D, consultancy and IT services might contribute to all other parts of the supply chain.

Figure 5-4 shows that the OWP firms are spread across the entire supply chain, but with a large share of the firms engaged in logistics and installation. Many of these firms build or supply vessels for installation, maintenance and transport. There are also a number of firms that deliver services such as surveying, IT systems, metocean services (meteorology and oceanography) and consultancy. Finally, a significant number of firms also manufacture components that are part of the topside, foundation or electrical infrastructure of offshore wind farms. In addition to variation in terms of place in supply chain, we also see that firms deliver a broad variety of products and services within each category. For instance, within the topside category we find firms supplying products ranging from cable management systems and fiber reinforcements to specialised wind turbine technology.

Figure 5-4 also shows the share of firms in each category that have dedicated five or more full-time equivalents to OWP. From this, we can for instance see that the more than half of the firms in the foundation and O&M categories have made significant investments in OWP, whereas firms delivering topside products or services have for the most part dedicated less resource to this industry.

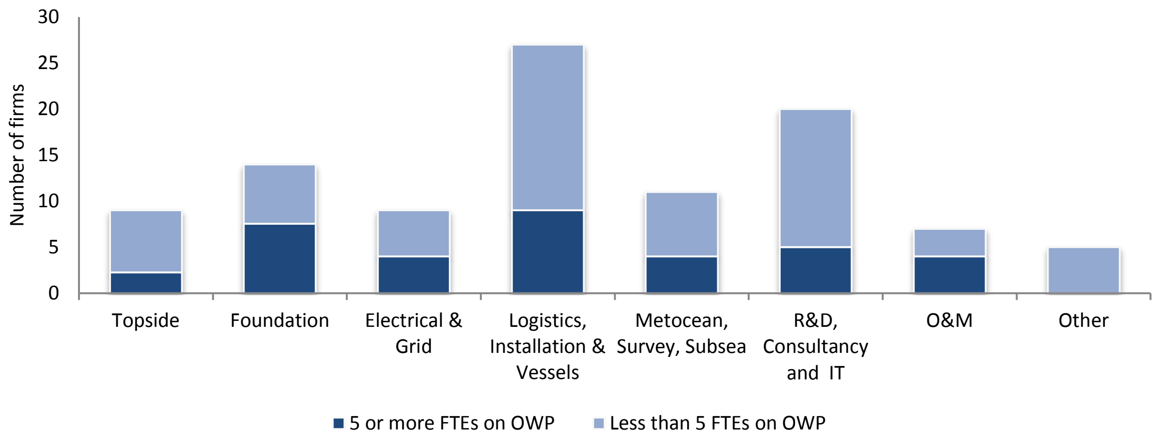


Figure 5-4 Number of firms across the OWP supply chain
Source: **Survey data and desktop research**

The manufacturing and use of PV modules is associated with a number of different steps. Firstly the conversion of light to electricity requires high purity materials. Silicon is the dominant material. Silicon is then molten into large crystal blocks (ingots) and sawn into thin wafers. These wafers are then chemically treated in a cell process and assembled into modules. Finally modules are installed and integrated into the electricity system (or used in off-grid applications). For our purposes we include the following categories of actors along the supply chain: (1) raw-material production, (2) ingots and wafers, (3) system, (4) machinery & equipment (5) investment & finance and (6) consultancy & R&D. A number of actors deliver production equipment and services along this supply chain. While 1-3 are associated with particular steps along the supply chain actors associated with group 4-6 may supply products and service to all levels.

From figure 5-5 we can see that most of the firms are placed in three categories: Raw materials, system, and consultancy and R&D. Firms producing raw materials produce primarily silicon though some also produce other materials important to the PV industry. System firms are firms that are connected to the process of installing PV systems, mostly on business buildings and private homes in Norway. There is only one firm in our set of responses that produce wafers and ingots, and no firms that currently produce modules in Norway. When we consider only firms that have made significant investments in PV, we can see that the majority of these firms produce raw materials and deliver consultancy and R&D services. The large group of system firms mostly dedicate less than five full-time equivalents to PV.

Similarly to OWP, there is a broad variety within each PV category. For instance, in the raw materials category there are firms supplying products and technology ranging from electrical conductive adhesive (glue) to silicon and silicon carbide.

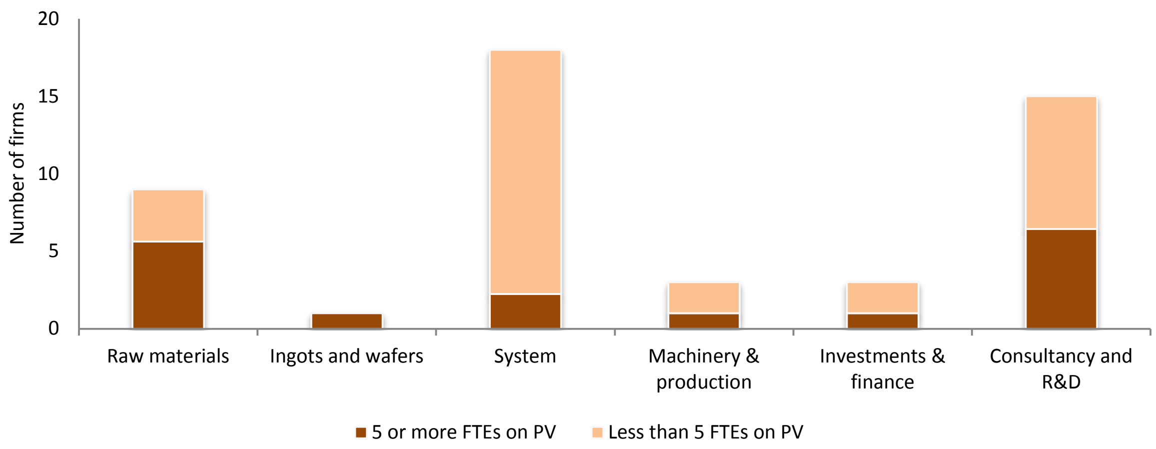
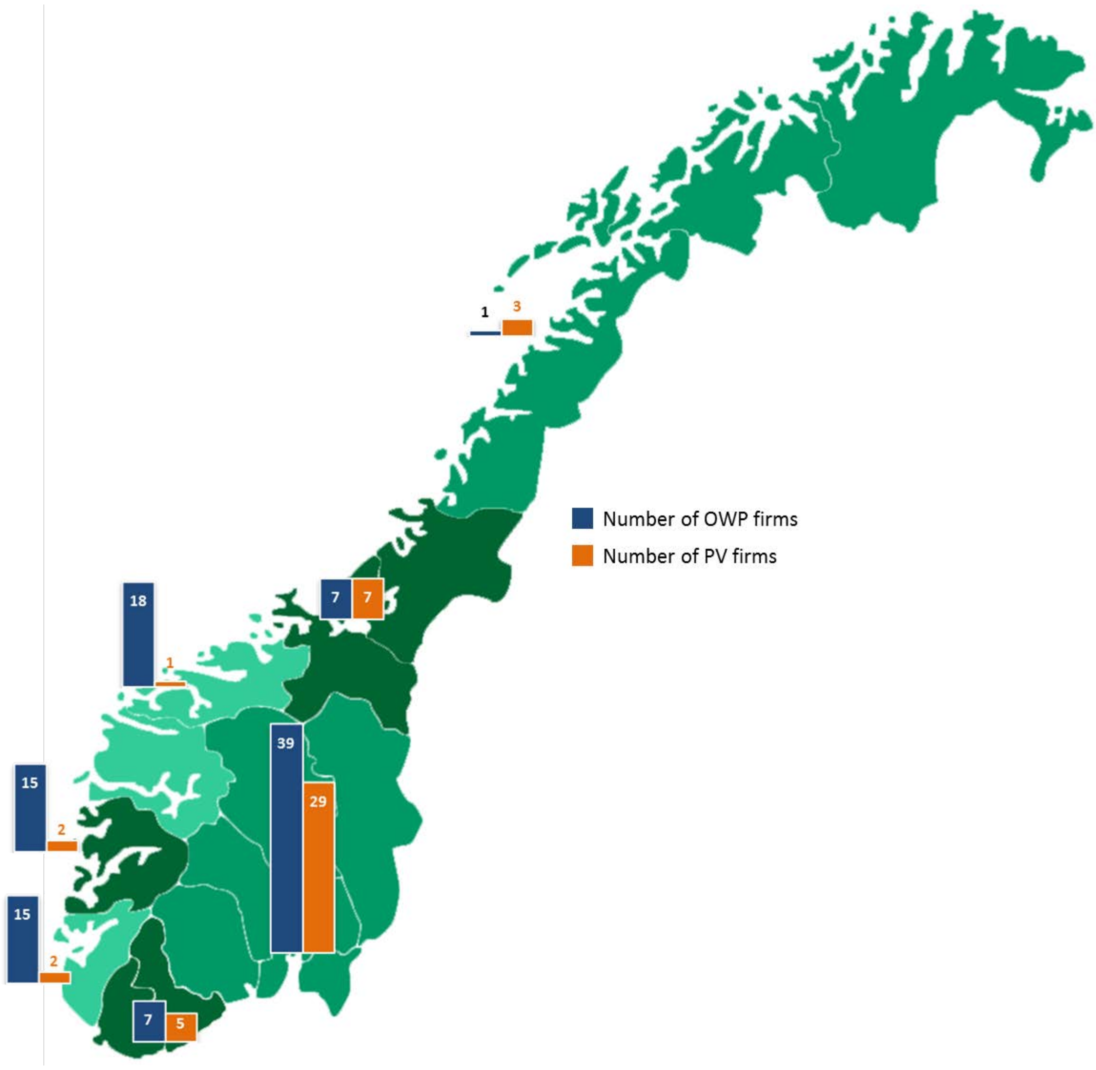


Figure 5-5 Number of firms across the PV supply chain
Source: Survey data and desktop research

Overall, we found that the majority of firms in both industries can be categorised as services firms (74 per cent of PV firms and 67 per cent of OWP firms). By that we mean that they deliver primarily services rather than manufactured products to the PV or OWP industries.

5.1.2 Regional clusters

We also mapped the location of firms' headquarters in order to identify the geographic distribution of OWP and PV activities in Norway[3]. From figure 5-6, we can see that a significant number of firms are located in and around the Oslo region. However, a large number of the offshore wind firms are also located in the regions that have traditionally been strong in oil & gas and maritime industries. For instance, 12 of the 18 OWP firms located in the Northwest region have their primary activity in maritime industries.



[3] Some of the firms will have production or R&D facilities in separate locations to the headquarter.

Figure 5-6 Number of firms with activities in OWP and PV in different regions.
Source: Data from survey and proff.no

5.1.3 Related industries

To further explore firm characteristics and given the potential importance of related industries for development of new ones we were interested in the extent and nature of links between related industries and OWP and PV. Figure 5-7 depicts the industry in which firms have their core business areas. For both industries we observe that a majority of firms have their core activity in other industries than OWP and PV. This is particularly evident for OWP, with only 18 per cent of firms having OWP as their core activity. The majority of the OWP firms have core activities in *maritime* industries, *other* industries including engineering and design, as well as *oil & gas*. We should here add that many of the maritime firms are oriented towards oil and gas. For PV the share of firms having PV as a main activity is larger, but 57 per cent of firms have their core business activity in *buildings and construction, industry and materials* and *energy*.

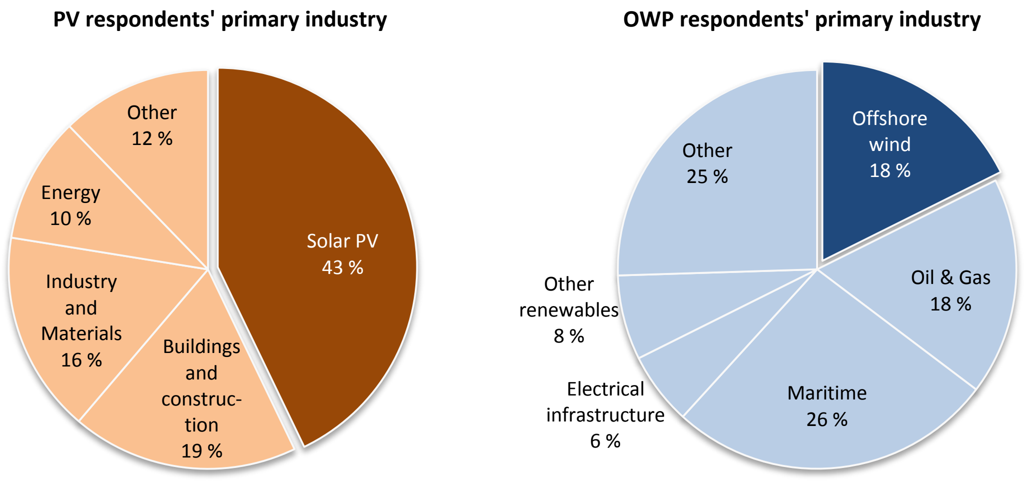


Figure 5-7 Respondents' primary industry
Source: Data from survey and desk research

Figure 5-8 shows the relationship between OWP firms' primary industry and their place in the supply chain for OWP[4]. The first thing to note is that the firms with *offshore wind* as the primary industry is a diverse group as we can observe these firms across the entire supply chain. Moreover, we can see that firms in the *oil & gas* industry deliver products and services to most of the categories in the supply chain. We find most of these firms in *foundations*, *logistics* and *operations & maintenance*. When we

4 The use of Sankey diagrams to display industry diversification was inspired by (Weaver & Steen 2013).

look at firms with primary activity in the *maritime* industries and *electrical infrastructure*, we can see that these firms primarily deliver to related parts of the supply chain for offshore wind.

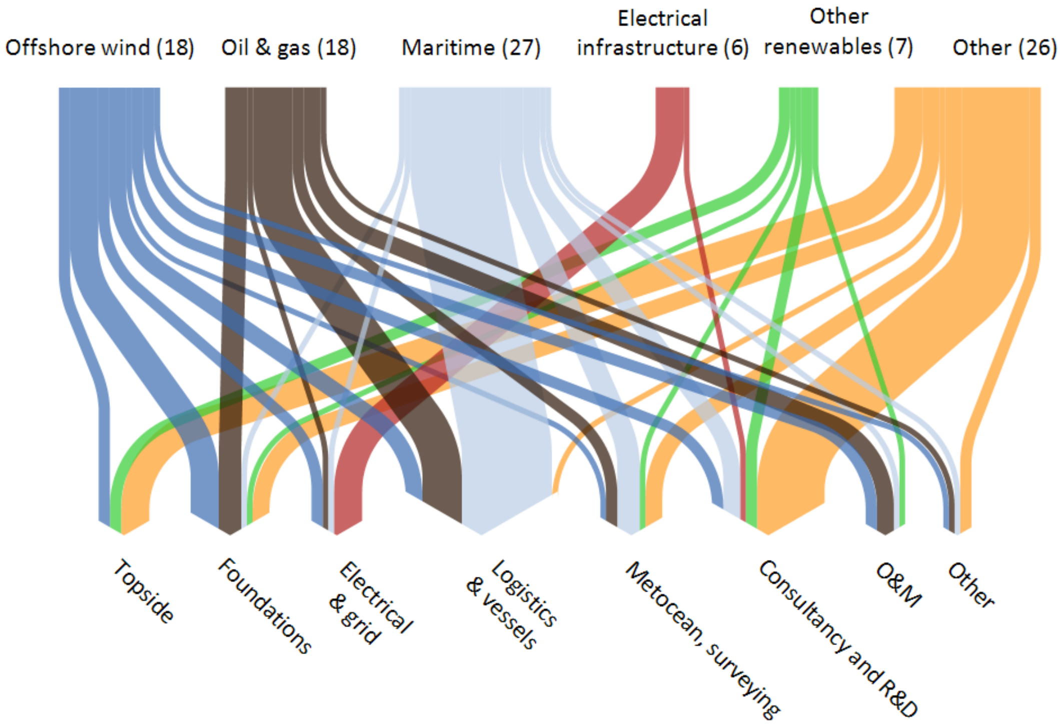


Figure 5-8 Relation between primary industry and OWP supply chain (number of firms)

Figure 5-9 shows similar data for photovoltaics, and it reveals a slightly different picture. Compared to the OWP industry, firms in different primary sectors are less spread out across the PV supply chain. For instance, firms producing raw materials have either *industry & materials* or *PV* as their primary activity. In addition we observe that many of the firms having PV as their primary activity are linked to *system* or *raw materials*.

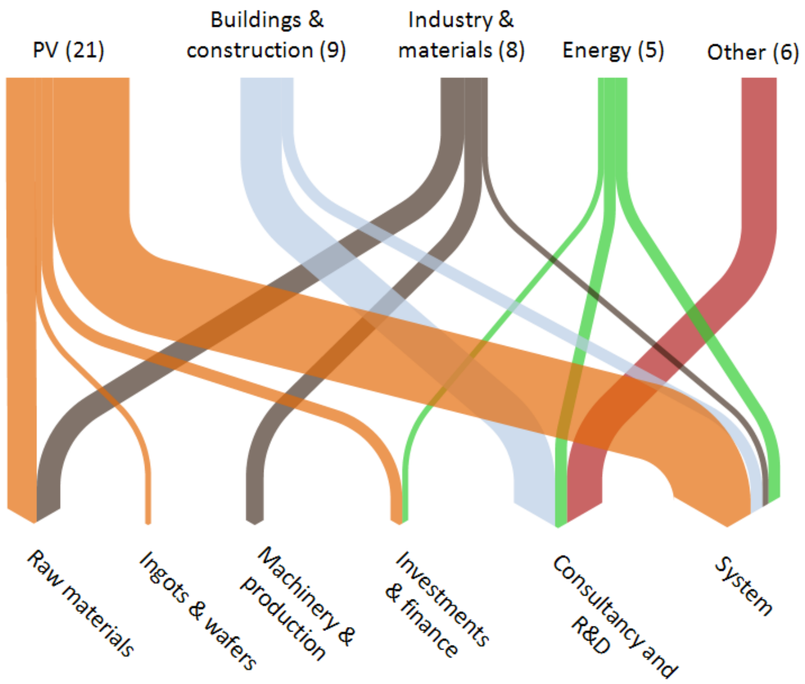


Figure 5-9 Relation between primary industry and PV supply chain (number of firms)

The key finding for both industries is that most of the firms have primary activities in other industries than OWP and PV, and we observe overlap between activities in OWP and PV and related industries on a firm level for a dominant proportion of firms. We interpret this to mean that firms have diversified their activities into OWP and PV coming from activities in other industries. Thus, most firms have initiated OWP or PV activities building on experience and activities in their primary industries.

The role of related industries is further underlined in figure 5-10, which depicts the industries from which firms state they have experiences relevant to their OWP or PV activities. For OWP the relation to *maritime* and *oil & gas* industries becomes more strongly pronounced with 82 per cent of firms stating these as industries from which they have relevant experience. This shows that many firms can benefit from experiences from for instance oil & gas without having this as their primary industry. For PV we observe that 45 per cent of firms state that they base products or services on experience from *industry and materials* in addition to *electrical and heating and cooling*.

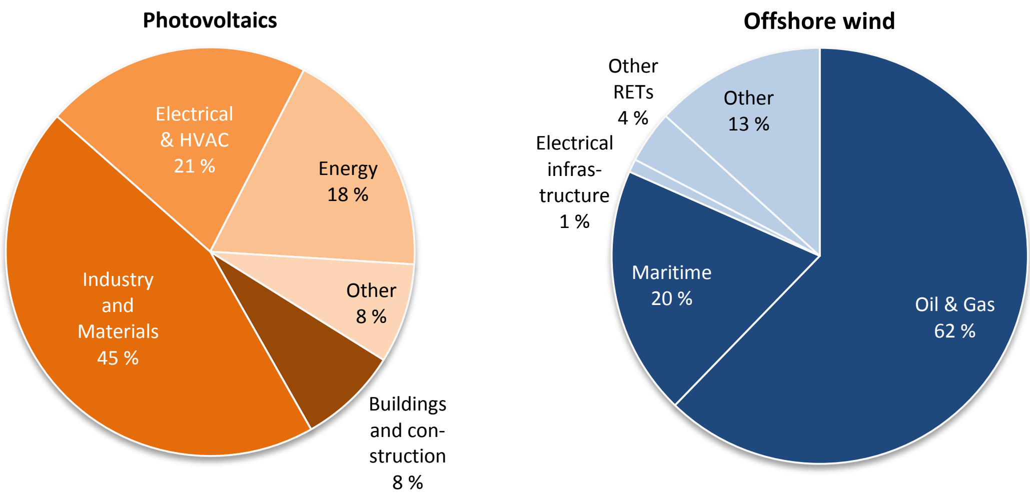


Figure 5-10 Other industries from which firms build their activity in OWP or PV upon

Figure 5-11 shows the relation between the experiences firms draw upon for their OWP activities, and the places in the supply chain in which they deliver products or services. Most strikingly, we can see that the link between OWP and oil & gas becomes even more pronounced as we can see firms across the entire supply chain that build upon experiences from the oil & gas industry. For instance, we can now see that a significant number of firms that deliver *consultancy and R&D* services build upon experiences from *oil & gas*. Moreover, we observe that more than half of the firms that deliver *topside* products or services build upon experiences from either *oil & gas* or *maritime* industries.

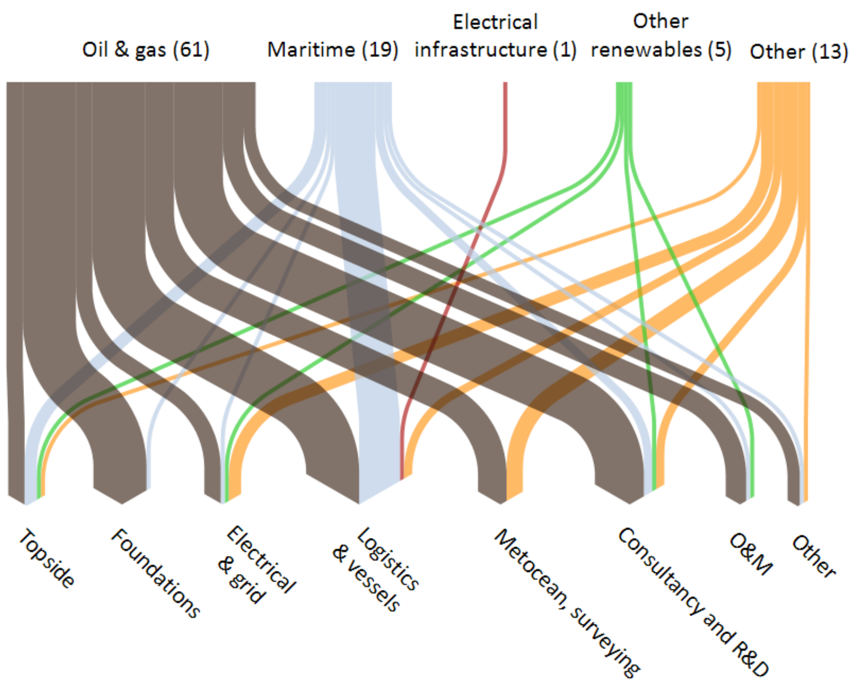


Figure 5-11 Relation between experience from other industries and OWP supply chain (number of firms)

Figure 5-12 shows the relation between the experiences firms draw upon for their PV activities. Here we observe that firms in *raw materials*, *ingots and wafers* as well as *machinery* draw their experiences from *industry & materials* entirely. It is also worth noting that experiences *from industry & materials* are distributed across most segments along the supply chain, with exception of the *system* segment. Firms in the system segment draw on experiences from several industries including *electrical and HVAC* as well as *energy*.

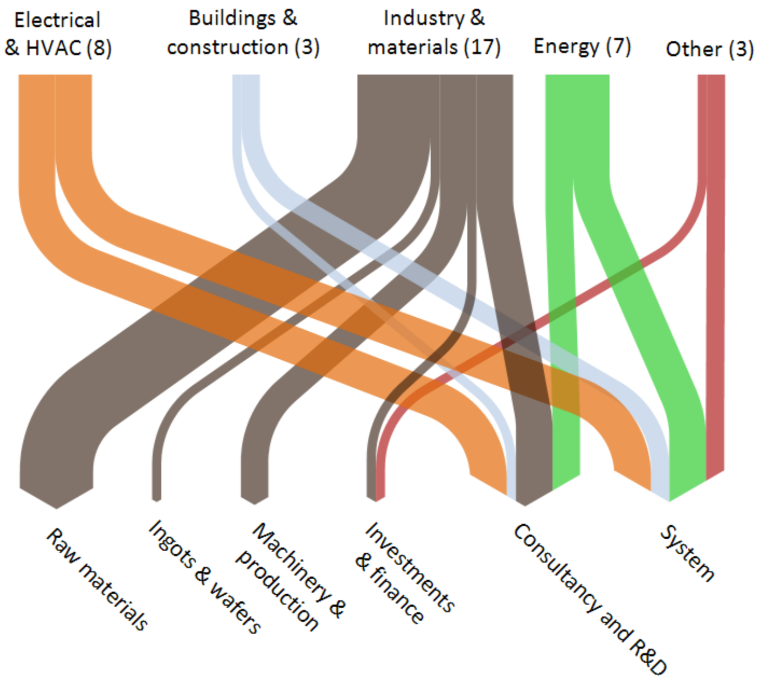


Figure 5-12 Relation between experience from other industries and PV supply chain (number of firms)

We also asked respondents whether experiences were transferable from primary to new industry applications with *minor*, *some* or *significant* changes. The dominant share of firms (72 per cent for OWP and 77 per cent for PV) state to have made some changes in order to cater to the OWP or PV markets. This means that even if firms have relevant experiences they do not move into OWP or PV without making any changes to the products or services. Given that the firms build on rather different areas of experience, we see it as interesting to explore the degree of variation of transferability depending on experience from which firms build their activities in OWP and PV upon. From Figure 5-13, we can see no significant variation for OWP. Figure 5-14 shows that there is some variation for PV firms as firms with experience from *electrical & HVAC* as well as *industry and materials* respond that transferring experiences involves more significant changes than the rest of the sample.

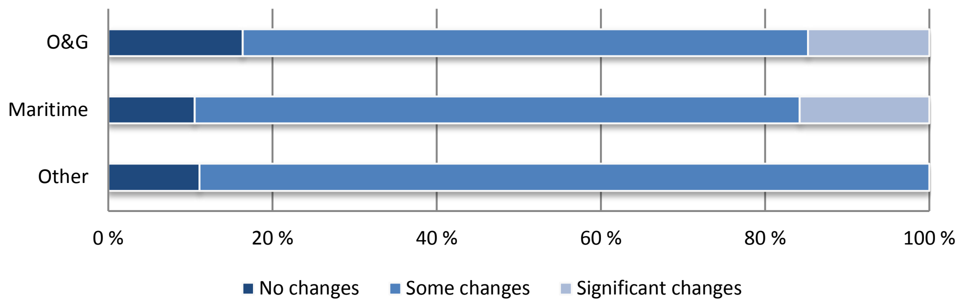


Figure 5-13 Respondents perception of degree of transferability of experience from other industries to offshore wind power (n=98)

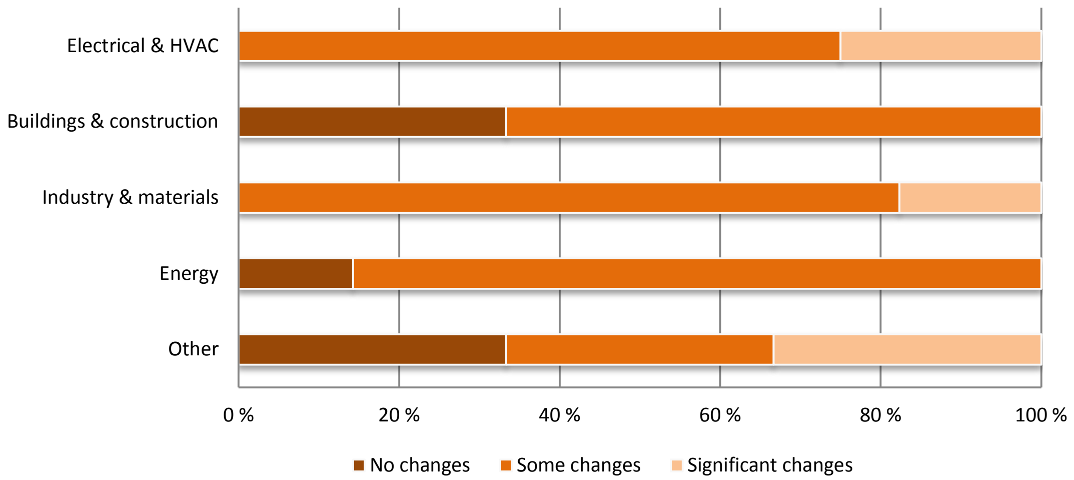


Figure 5-14 Respondents perception of degree of transferability of experience from other industries to photovoltaics (n=38)

In summary, this section has illustrated that related industries play a key role for OWP and PV industries in Norway. We find this both on a firm and competence level. A significant number of firms have moved into OWP and PV while having their main activities in other industries. Many of these firms could be seen as diversifiers. That is they have activities in OWP and PV as an addition to primary activities in other industries.

5.2 International collaboration

In the survey we asked the respondents about the importance of international collaboration and the type of actors they collaborate with. Four of five firms responded that international collaboration is important. This is not surprising, given the international orientation of both OWP and PV firms, as illustrated in section 5.3.

In figure 5-15, we can see that both offshore wind and photovoltaic firms participate quite extensively in international collaborations. Moreover, we can notice that collaboration with customers is particularly important, especially for OWP firms.

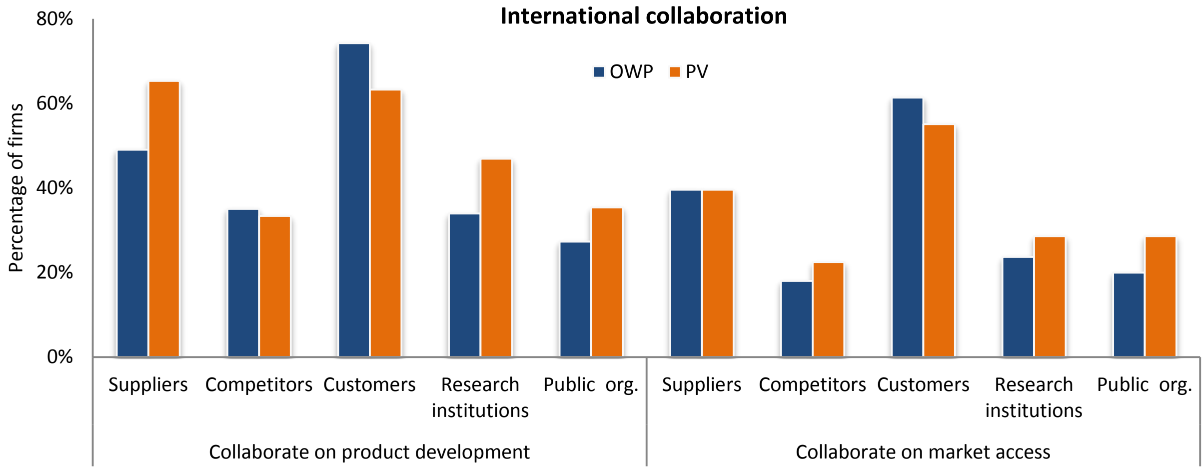


Figure 5-15 Percentage of firms that reported to collaborate with different international organisations on product development and market access (answering *yes* or *no*).

Considering the perceived importance of international collaboration, it is interesting to note that 13 OWP and 7 PV firms have no collaboration with the international organisations that we asked about in the survey. The PV firms can be explained by the fact that all of these firms are oriented exclusively or primarily towards a domestic market. Many of the OWP firms, however, target primarily international markets in the North Sea. For all but two of the firms with no international collaboration, OWP and PV represent a very small share of the firms' total revenue. This strengthens the impression that even though there are a significant number of Norwegian firms participating in the OWP market, many of these firms dedicate limited resources to activities in this market.

Figure 5-16 shows that whereas there is no relation between domestic collaboration and size of investments in OWP and PV (in terms of FTEs), firms with significant investments in OWP and PV also collaborate with a wider set of international organisations.

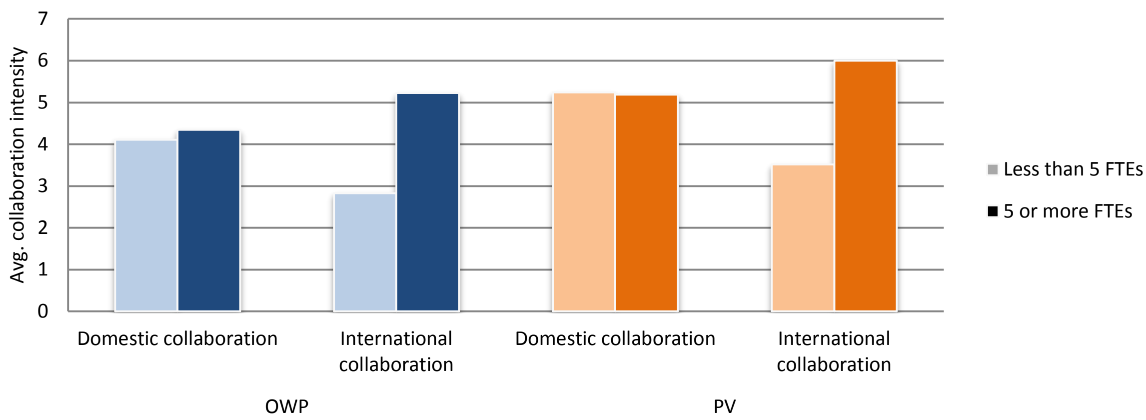


Figure 5-16 Average total number of different types of organisations the respondents have collaborated with on product development and market access. Split between firms with less than 5 FTEs and firms with 5 FTEs or more invested in OWP or PV.

Finally, we asked the respondents about why international collaboration is important. From figure 5-17, we can see that international collaboration is particularly important for *access to markets*. Access to *new technology* is an important motivation for collaboration for PV firms.

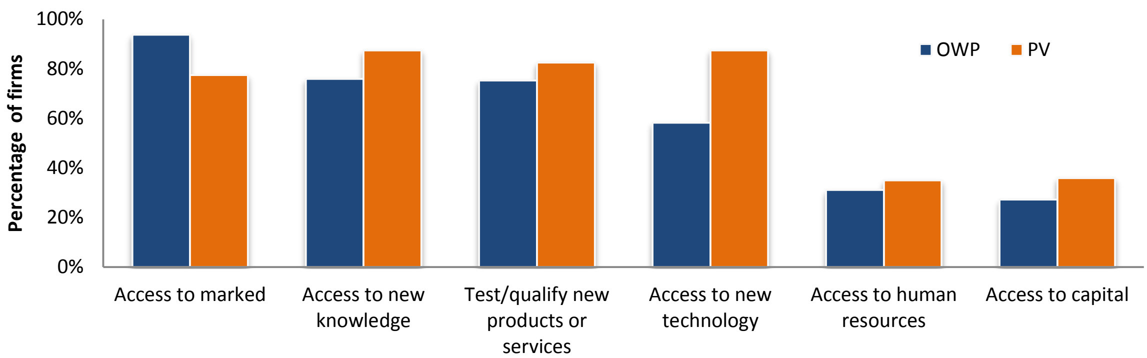


Figure 5-17 Firms responding to why international collaboration is important (*yes* or *no* on each option)

We can also note that *access to capital and human resources* is not an important motivation for international collaboration. However, we can from figure 5-18 see that access to capital is an important motivation for international collaboration for firms that have made significant investments in PV.

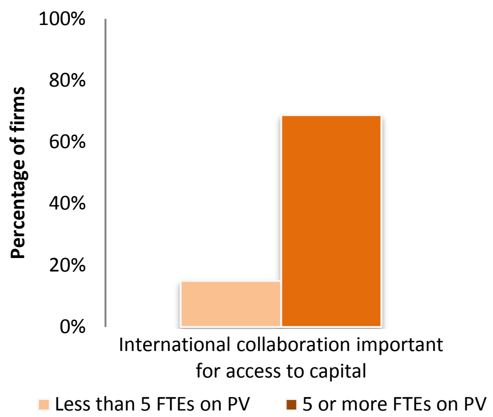


Figure 5-18 Percentage of PV firms reporting that international collaboration is important for access to capital (*yes* or *no*). Split between firms with less than 5 FTEs and firms with 5 FTEs or more invested in PV.

5.3 Where are the customers?

Prior to conducting the survey, we assumed that OWP and PV firms would be mostly oriented towards international markets. From figure 5-19, we can see that this is confirmed for OWP but less so for PV firms. This can be explained by the large number of system suppliers that are mainly small firms (see figure 5-5) oriented towards a nascent domestic market.

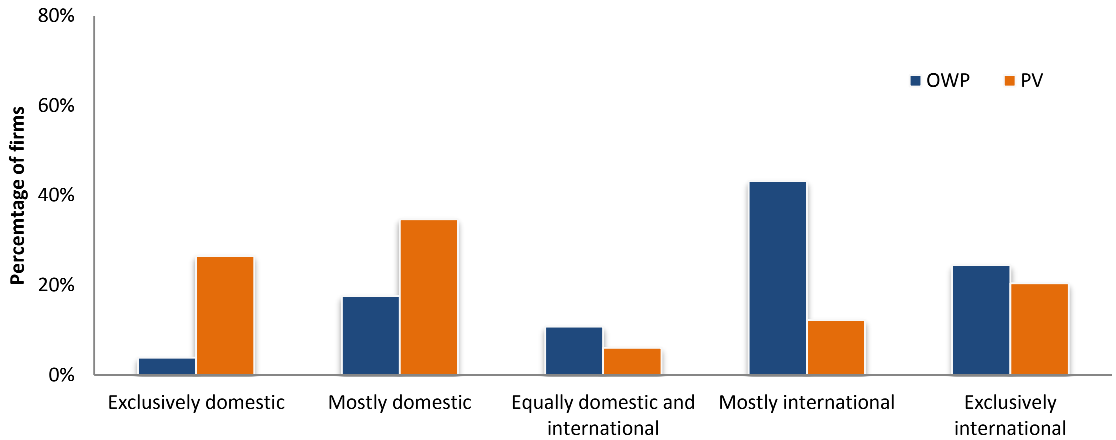


Figure 5-19 Location of actual or potential customers. Percentage of firms.

Figure 5-20 shows that when we count total number of full-time equivalents dedicated to OWP or PV instead of number of firms, the international orientation becomes more pronounced. From this, we recognise that the larger PV firms are oriented towards international markets. Thus, in terms of resources, we can observe that both industries mainly target markets abroad.

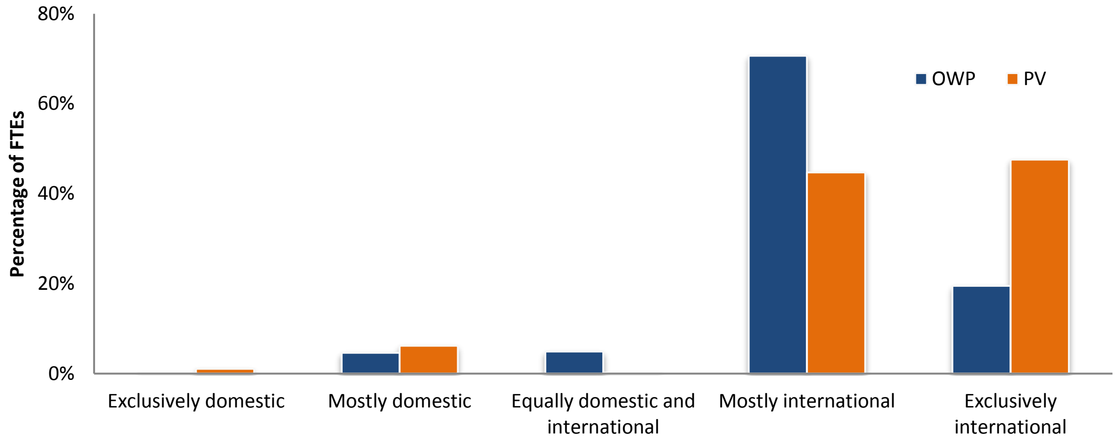


Figure 5-20 Location of actual or potential customers. Percentage of total FTEs dedicated to OWP or PV within firms in sample.

Given that most of the OWP firms and many of the PV firms primarily target international markets, it is interesting to look at where these markets are. Figure 5-21 and figure 5-22 show that the PV firms have customers in most parts of the world, in particular countries like China, Japan, USA and a wide range of countries in Africa and Europe.

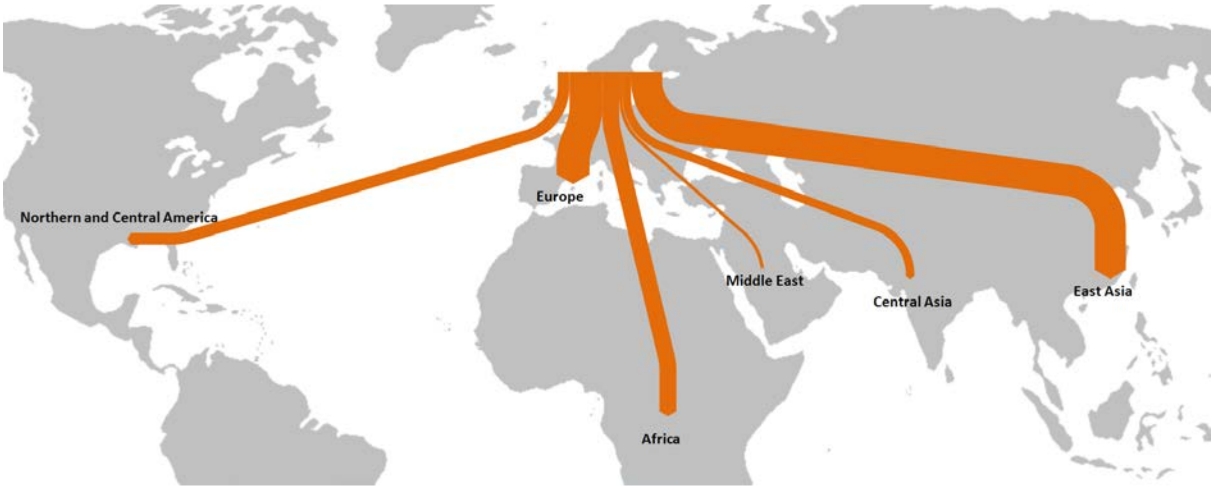


Figure 5-21 Location of the most important existing and potential customers for Norwegian suppliers to the international PV markets.

The OW firms are highly concentrated around the markets in the North Sea. This is not surprising considering that the majority of the international offshore wind market has developed in this area, and given the Norwegian offshore firms' historical presence in this region.

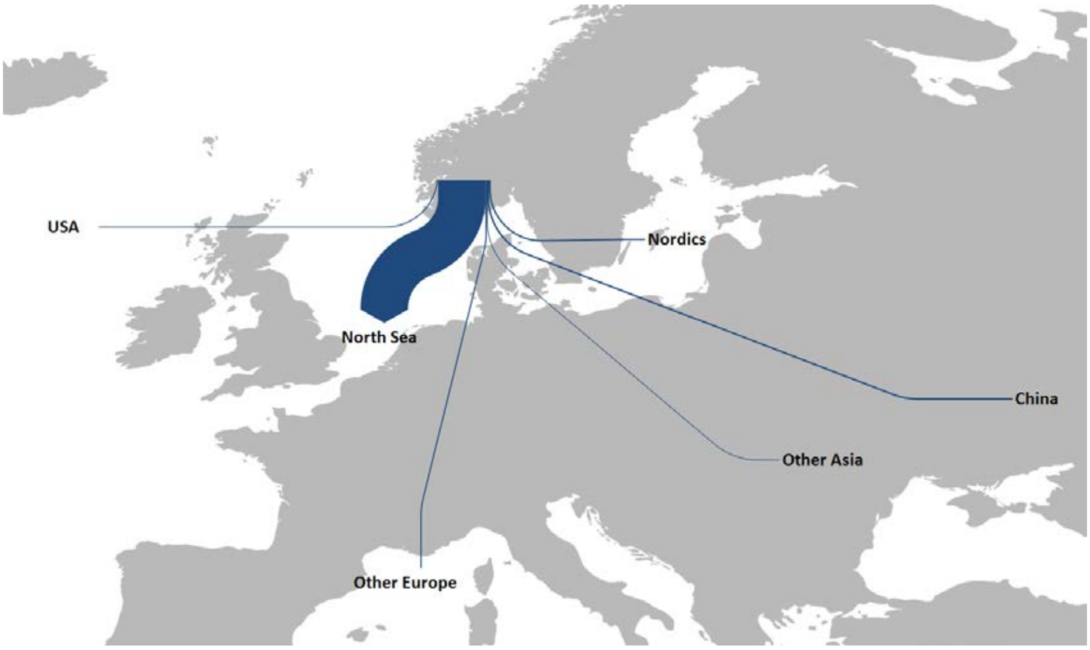


Figure 5-22 Location of the most important existing and potential customers for Norwegian suppliers to the international OWP markets.

5.4 Success criteria

In the survey, we asked respondents what they considered to be the most important factors for their business to succeed in the markets. From figure 5-23, we can see that *price* is considered as the most important criteria for success, with *quality of product or service* as the second most important criteria. *New technology* is considered less important. That price and quality are the two most important criteria is not surprising. It does, however, point to the importance of incremental improvements for innovation, as discussed in section 2. Increasing product efficiency and competitive advantage may often be achieved through continuous improvements in quality or reductions in costs, rather than as result of major research breakthroughs. This may also be the case for many of the firms in the OWP and PV industries.

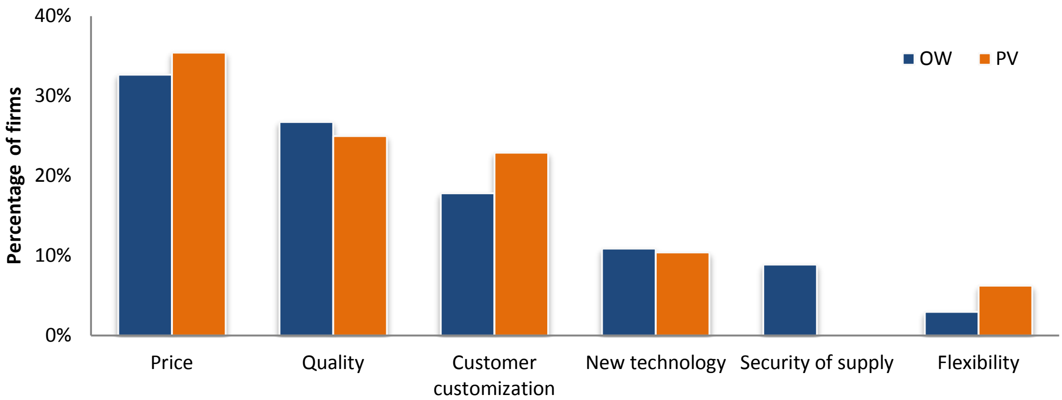


Figure 5-23 Most important success criteria.
Respondents listed the single most important criteria, based on a pre-defined list.

One motivation for the question on success criteria was to see if we could observe differences between the importance of price and quality depending on industry or place in supply chain. We assumed that price will be more important for products and services that are more standardised and in industries that are more mature. Figure 5-23 shows that there is only a small difference between OWP and PV on price as a criterion. Moreover, figure 5-24 shows that there are only minor variations within the PV supply chain.

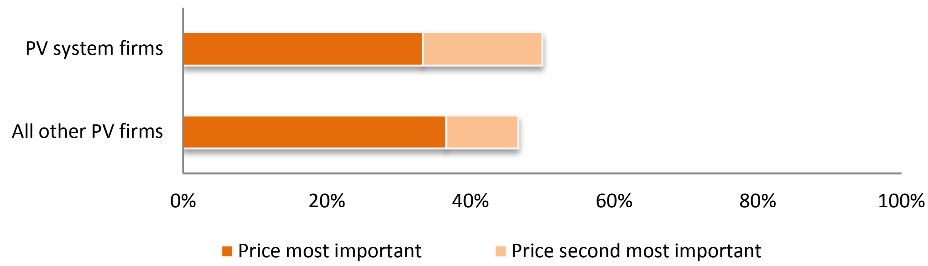


Figure 5-24 Importance of price as success criteria for PV firms, split between system firms and all other PV firms (n=48). Respondents listed the two most important criteria in prioritised order, based on a pre-defined list.

However, when we look at the OWP supply chain in figure 5-25, we can see that firms that deliver to *metocean, survey and subsea* and *R&D and consultancy* rely less on price compared to other parts of the supply chain.

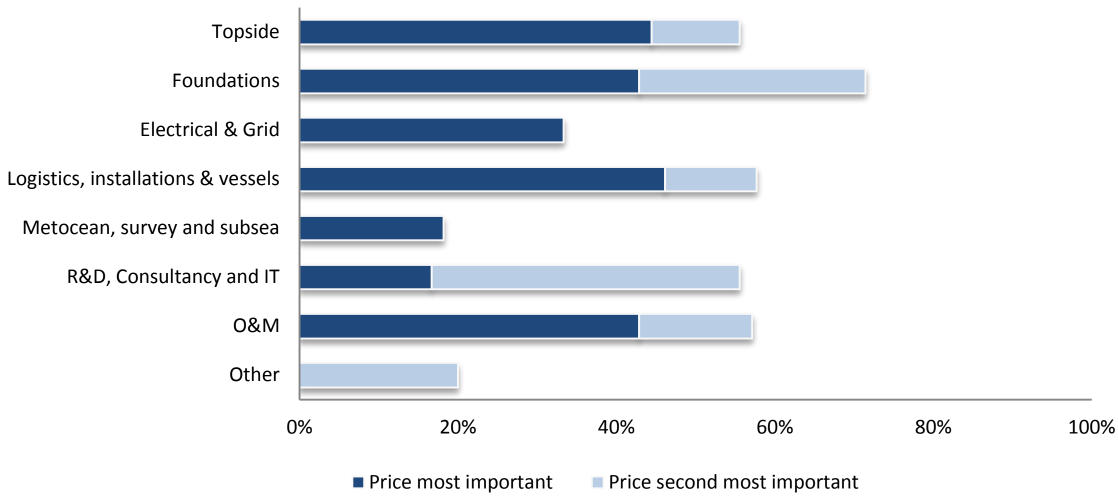


Figure 5-25 Importance of price as success criteria, spread across OWP supply chain (n=99). Respondents listed the two most important criteria in prioritised order, based on a pre-defined list.

Most of the firms in these parts of the OWP supple chain deliver services, and we can see from figure 5-26 below that the relative importance of price and quality also varies depending on whether the respondents deliver manufactured products or services.

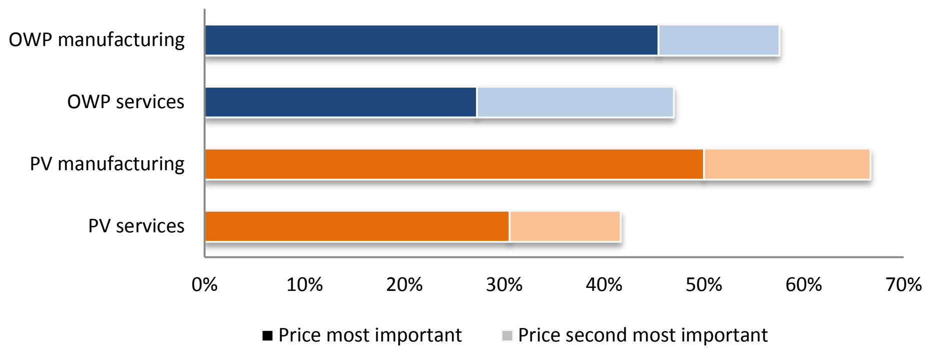


Figure 5-26 Importance of price as a success criteria, split between services and manufacturing
Respondents listed the two most important criteria in prioritised order, based on a pre-defined list.

5.5 Perceived barriers to internationalisation

In the survey, we asked the respondents what they see as main challenges for their business.

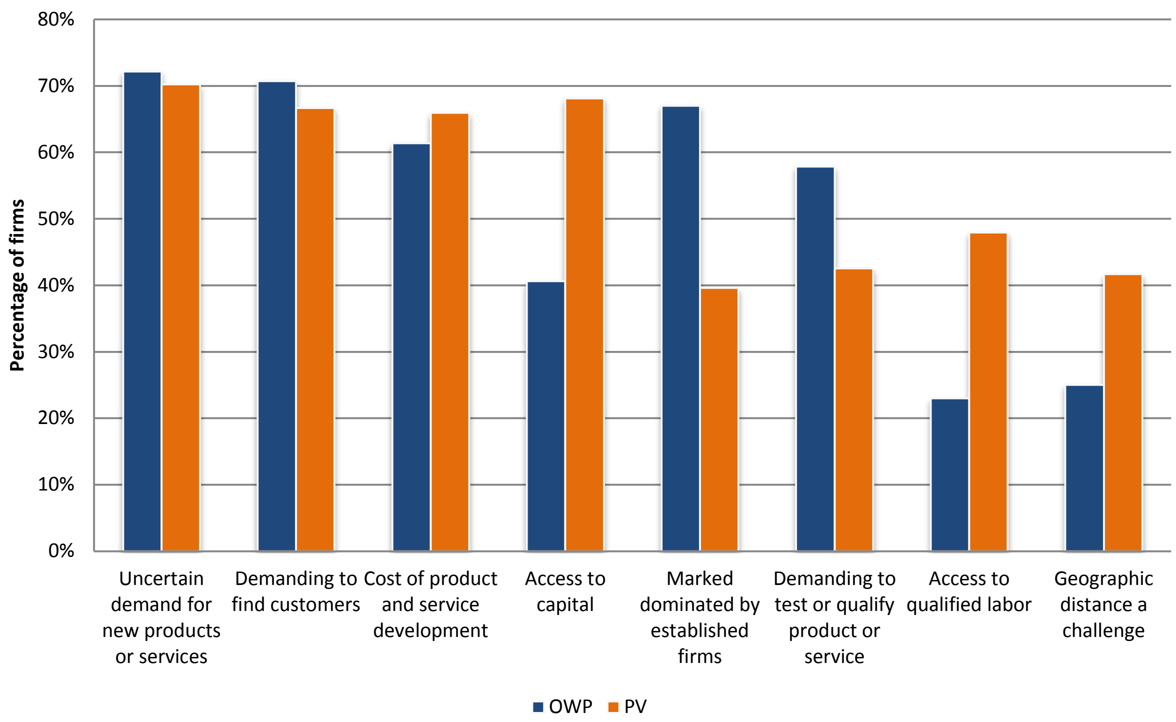


Figure 5-27 Perceived importance of different barriers for OWP and PV firms.
Respondents answered *yes* or *no* on whether each potential barrier was challenging for their activity in OWP or PV.

Figure 5-27 shows that firms in both industries find it *demanding to find customers* and experience *uncertain demand* as a significant challenge. Both these barriers are linked to market access. This may be related to the weak domestic markets for offshore wind and solar PV. We can also see that *cost of product and service development* is a significant challenge in both industries, which may point to a need for better financing alternatives. At the same time, we can observe that a lack of *access to resources* such as labour and capital represents a bigger challenge to PV firms than to OWP firms. We also observe that a larger proportion of OWP firms experience that their markets are dominated by established firms than for PV. This is surprising given that PV could be seen as a more mature industry than offshore wind.

Figure 5-28 shows the same barriers for the PV industry, split between PV system firms and all other firms (delivering components and services to the PV supply chain). Here, we can see that the second group (which consists mostly of firms producing silicon and other raw materials as well as firms delivering consultancy and R&D services) to a greater extent than the system firms respond that the *market is dominated by established firms*. They also find it comparatively more *demanding to test and qualify products or service*. Some of the firms producing raw materials have introduced novel products and processes on the global market (Hanson 2013), which could explain a greater need to test and demonstrate these products. However, as these firms are mostly oriented towards international markets, this difference could also be explained with the importance of a home market for testing and demonstration.

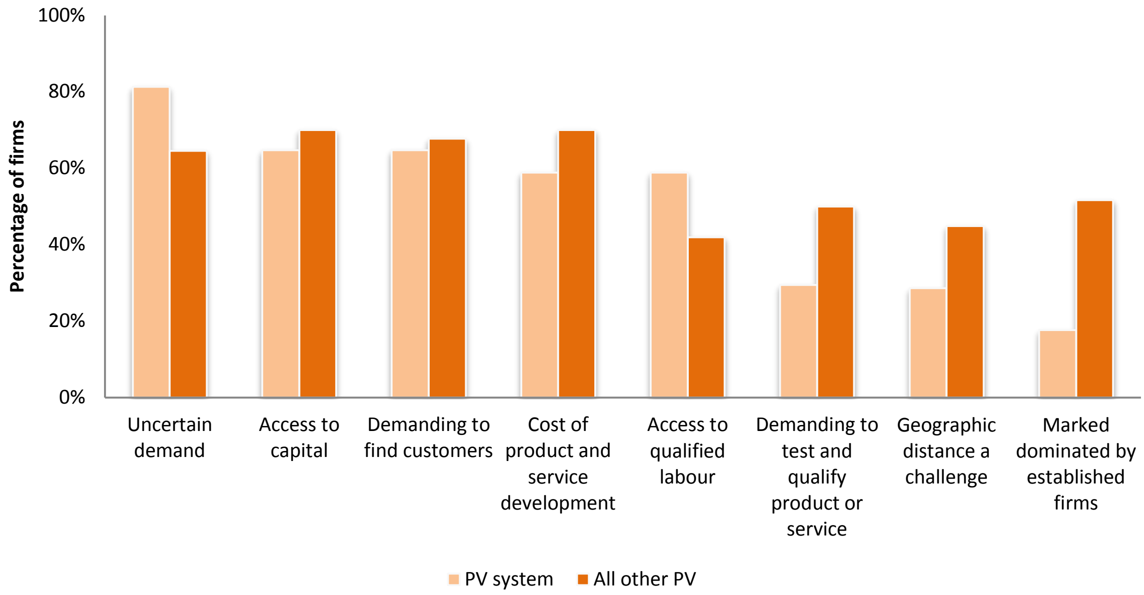


Figure 5-28 Perceived barriers for PV firms. Split between system firms and all other firms. Respondents answered *yes* or *no* on whether each potential barrier was challenging for their activity in PV.

Moving over to offshore wind, we can only find minor variations across the supply chain. However, figure 5-29 shows that OWP firms with maritime as the core industry perceive *costs of product and service development* as less of as a barrier compared to firms in other segments along the supply chain. We interpret this as indicating that maritime activities in OWP are fairly similar to maritime operations in other industries, and that costs of entry from maritime industries to OWP might be lower than for firms with core activities in other industries.

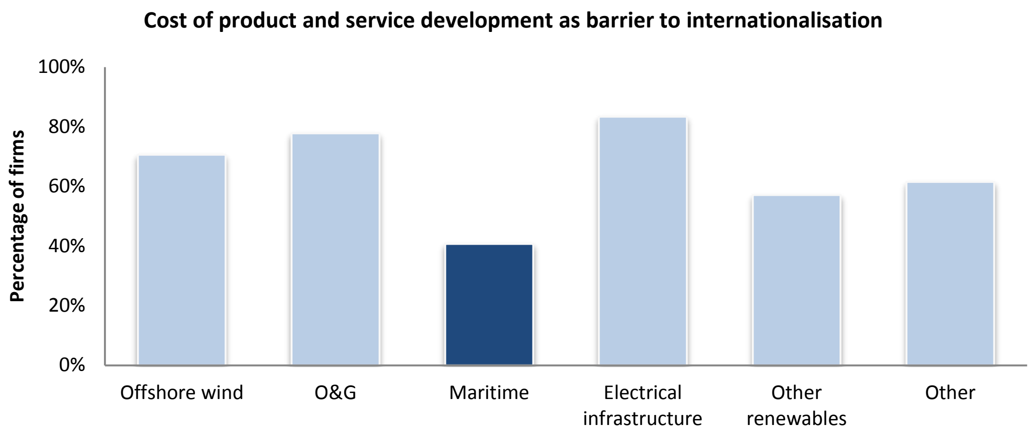


Figure 5-29 Percentage of OWP firms that perceive cost of product and service development a barrier to internationalisation. Split across primary industry. Respondents answered *yes* or *no*.

5.5.1 Lack of domestic market for offshore wind as a barrier

The section on markets showed that nearly all of the offshore wind firms are oriented towards customers in international markets. For internationally oriented industries a domestic market is considered important for export success. Previous studies of the Norwegian offshore wind industry have also pointed to a demand within the OWP industry for a small domestic market (Hansen & Steen 2011; Nillson & Westin 2014; Normann 2015). We therefore wanted to explore this particular area for offshore wind.

Figure 5-30 shows that three-quarters of all offshore wind firms see the absence of a home market as a challenge to their ability to succeed in international markets. We have not found any notable variance on this barrier across firms with primary activity in different industries (oil & gas, maritime, offshore wind, other). However, we can observe some variation on this barrier across the offshore wind supply chain.

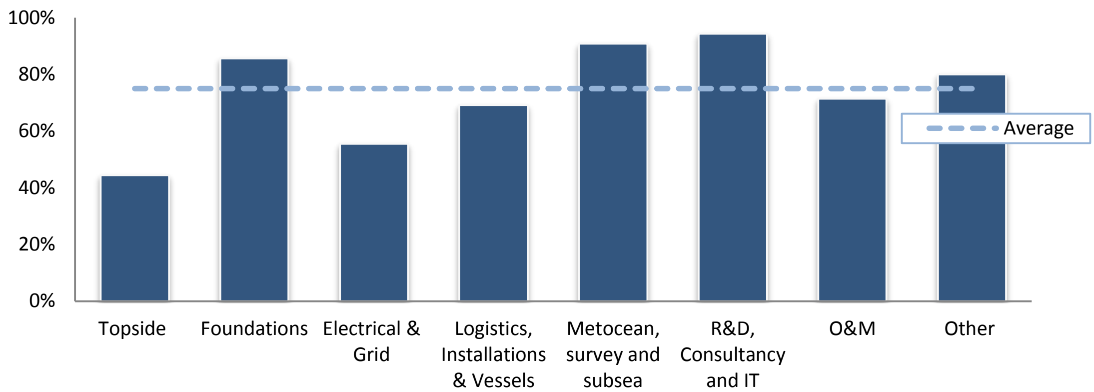


Figure 5-30 Percentage of OWP firms that responded that a lack of a home market makes it difficult to succeed in international markets.

In the literature on internationalisation, firm size has been found to be of importance to firms' ability to export products or services to international markets. Figure 5-31 shows that smaller firms (measured by both number of full-time equivalents and revenues) consider a lack of a home market as more challenging than larger firms.

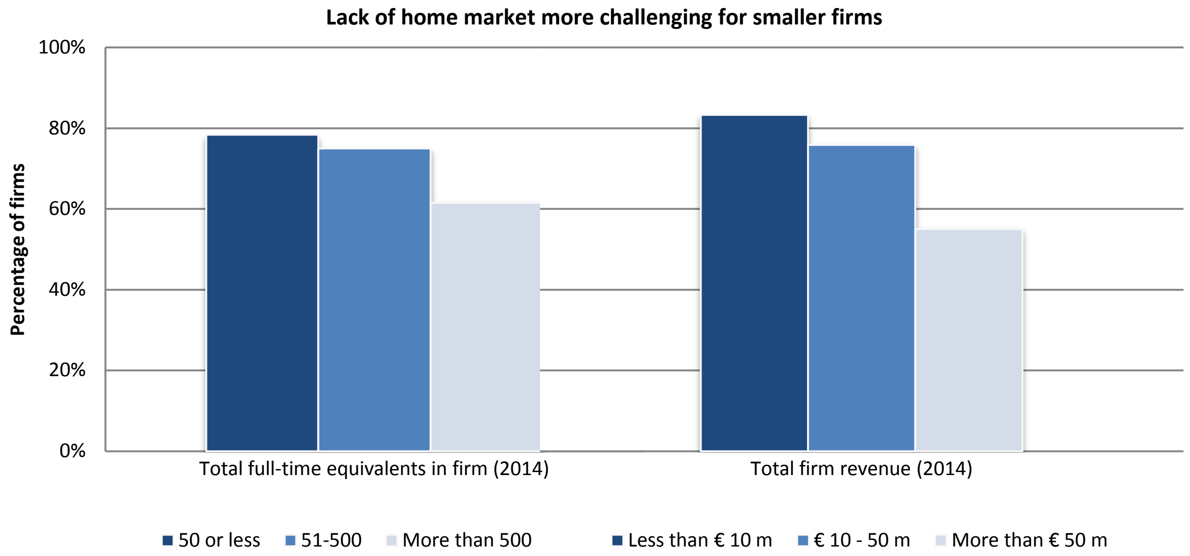


Figure 5-31 Percentage of firms responding that lack of a home market makes it difficult to succeed in international markets. Depending on firm size measured by firm FTEs and revenue.
Source: Data from survey and proff.no

A home market is considered important for a number of reasons, such as geographic proximity, access to technology, knowledge about market trends, and for testing new products and services. Considering the relative importance of different barriers presented in figure 5-27 in section 5.5, we find that the lack of home market as a barrier is probably less influenced by increased geographical distance to markets but perhaps stronger linked to the challenges associated with testing and verifying technology and products.

The observation that geographical distance to markets is not a significant challenge (see figure 5-27) may be explained by the fact that the main international market for offshore wind is located on the Norwegian doorstep in the North Sea. Figure 5-32 shows that just below half of the firms responded that the North Sea fully or partly replaces the need for a domestic market for offshore wind in Norway. However, this still leaves us with more than half of the firms responding that close proximity to the North Sea (keeping in mind that many of the firms already have activities in the O&G industry in the North Sea) does not alleviate the barrier raised by a lack of a domestic marked.

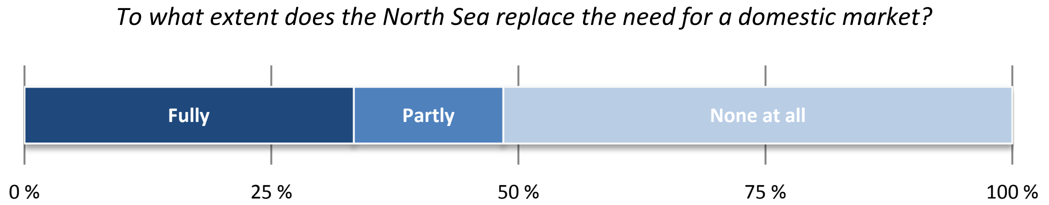


Figure 5-32 Percentage of firms that fully or partly consider the North Sea as a domestic market for offshore wind

In conclusion, we make two main observations based on the data presented in this section on the role of home markets for offshore wind. First, a large number of firms do experience the lack of a domestic market as a barrier to internationalisation. Second, the finding that larger firms depend less on the presence of a domestic market (see figure 5-31) is perhaps not surprising. Large firms have more often established international activities and are better equipped to handle risk. However, the Norwegian industry structure consists of mostly small and medium-sized enterprises. The potential for these firms to succeed in the international market for offshore wind may depend particularly on national policies that target barriers to internationalisation encountered specifically by smaller firms.

5.6 Expectations for future development

The level of activity in both offshore wind and solar PV amongst the surveyed firms has increased over the last 3 years. Figure 5-33 shows that about half of the surveyed firms report that the number of full-time equivalents dedicated to OWP and PV has increased, whereas around 20 per cent of the firms report that this has declined. Moreover, figure 5-34 shows that the turnover from OWP and PV as a share of total turnover has also increased for approximately half of the firms.

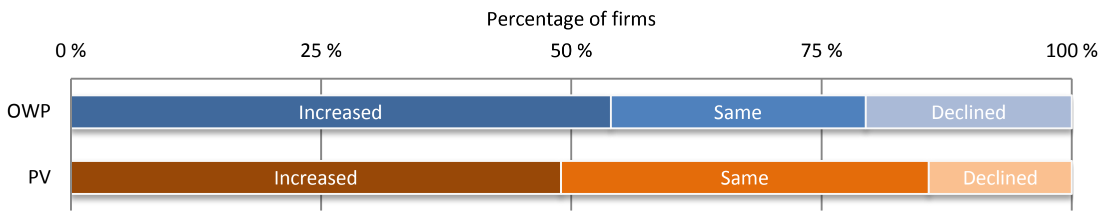


Figure 5-33 Development of number of full-time equivalents over the last three years

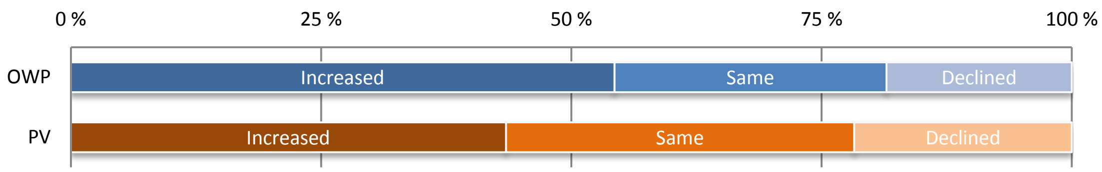


Figure 5-34 Turnover from OWP and PV as percentage of total turnover. Development over last three years.

A significant majority of the firms expect to increase their turnover from OWP and PV in the next three years. From figure 5-35 we can see that 90 per cent of the PV firms and 75 per cent of the OWP firms expect increased turnover. Further, more than half of the surveyed firms expect to invest in increased production capacity.

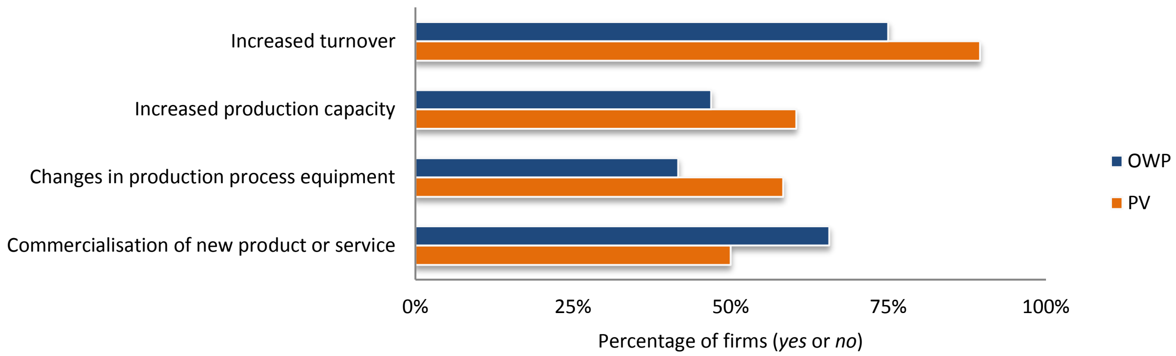


Figure 5-35 Firms' expectations for turnover and investments in OWP and PV for the next three years.

6 Summing up key findings and conclusions

In this final section, we summarize the main results from the survey and discuss some implications on the potential for internationalisation of the Norwegian offshore wind and photovoltaic industries.

One first thing to note is that the results describe how most firms base their activities in OWP and PV on knowledge and experience from other industries. In particular the results exhibit the close relationship between the oil & gas and maritime industries and offshore wind. We also observe relations between raw materials in the supply chain and experience from industry and materials. In both cases this underlines the role of related industries in processes of new industry formation. We also observe this relation with regards to overlap between actors, in that many firms have activities in OWP and PV and related industries. We find that this close relationship may offer opportunities and possibilities to offset some barriers related to weak domestic markets. Many of the firms benefit from competences and experience from existing offshore and mainland industries in Norway. These benefits may include the provision of resources, access to international markets and opportunities to develop and test products and technology. Thus, we see that a transition to renewable energy production may involve incumbent firms in addition to new entrepreneurs. However, we also see some challenges for the internationalisation of Norwegian offshore wind and solar firms, some of which can be linked to the relatedness between existing and new industries. In brief, we can group these into three main challenges:

- Mostly small firms or smaller parts of larger firms that invest in offshore wind or solar PV.
- Diversity amongst firms may influence industries' ability to 'act together'.
- Demanding to demonstrate products and services – especially without a home market.

While we have identified a significant number of Norwegian firms we see that many of the firms dedicate very limited resources to OWP and PV. That is, even though many of the respondents represent medium or large firms, the percentage of turnover that comes from OWP or PV remains negligible. This is particularly true for offshore wind. This raises the question of to what extent these firms are capable of tapping into the growing international markets for products or services that are only at the fringe of the core activities of the firm.

We see a related challenge in that we observe that the activities of OWP and PV firms are distributed across long and complex supply chains and that there is a large diversity in the products and services that firms offer. Moreover, these firms vary considerably in size and geographic location. The firms also vary substantially in their commitment to OWP and PV as compared to their core activities. While variety can be positive it also raises the question of whether actors in the industry are sufficiently organised in order to effectively promote and communicate their interests.

Further, we want to underline some general barriers to internationalisation identified in the survey data. The surveyed firms are mostly oriented towards international markets (except most of the PV system suppliers). Whereas the PV firms have customers spread across the globe, the OWP firms are highly concentrating their attention on the markets in the North Sea area. International collaboration is considered important, and in general firms seem to collaborate quite extensively with international partners. However, we note that there are also a significant number of firms with no international collaboration on OWP or PV, which points to some potential difficulties for some firms in gaining access to international partners. This is further underlined by the observation that in both industries barriers related to market access are considered as the most challenging.

The majority of the surveyed firms provide services. We find this interesting for two reasons. First, this underlines the fact that the OWP and PV industries comprise of much more than the components we see in a fully commissioned offshore wind or solar energy park. Second, services firms have often been regarded as less innovative than manufacturing firms. However, these firms provide services that involve a high degree of innovation and complex technology. Nevertheless, these firms may engage in different innovation activities that depend on different policy instruments than typical manufacturing firms. We think this is important to keep in mind as OWP and PV services can represent a significant potential for value captured by Norwegian firms. Moreover, innovation in services will be important to continue cost reductions, in particular in offshore wind.

Finally, while we observe that firms report growth in number of FTEs and turnover, we also observe that the number of new firms entering OWP and PV has been declining since 2012. Linked to challenges of small firms and industry size, this may indicate problems with securing sufficiently vibrant entrepreneurial experimentation in particular in a period of rapid technological development and high growth in international OWP and PV markets. For PV, intense international competition and the rapid price drop could however also contribute to explain the declining activity. For OWP, increased activity in the offshore petroleum industry in 2011-2013 may explain reduced offshore wind activity in the period (Normann 2015; Weaver & Steen 2013). With the recent decline in the petroleum industry, this raises the question whether we will see an increase in the number of firms entering OWP for 2015 and 2016.

Summing up, we have some final reflections. The results from this survey lends strength to the argument that there is considerable potential in the Norwegian offshore wind and photovoltaic industries, but that both industries experience barriers to internationalisation related to weak domestic markets. This seems to be particularly true for smaller firms.

Given the dominance of services firms, but also the heterogeneity of firms, and thus variety in needs within both industries, we think supplementary instruments in addition to support towards R&D are required. This support could be through demonstration parks or programs, but there may also be other instruments that help firms to demonstrate and verify products or services. We also think that it would be worthwhile to investigate further to what extent instruments should be tailored towards specific parts of the supply chain (i.e. to cater for different demands between industries, between services and manufacturing, or between different categories in the supply chains). Finally, we see a demand for strengthening industry collaboration and programs dedicated specifically to help smaller firms link up with the larger firms, reach international markets and collectively be able to influence their local framework conditions.

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CenSES

CenSES — Centre for Sustainable Energy Studies
Faculty of Humanities
Norwegian University of Science and Technology (NTNU)
7491 Trondheim
Norway

www.censes.no
censes@ntnu.no

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