



NTNU – Trondheim
Norwegian University of
Science and Technology

Norwegian Marine Energy Industry

To What Extent Can Norway Develop a Marine
Energy Industry with a Limited Home
Market?

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| Oppgavetekst/Problembeskrivelse The thesis will investigate the international development of environmental technology and utilize findings of the pre-project on the wave and tidal power industry in Norway. The approach of answering the master thesis will be to study relevant theory, present methodology, and conduct empirical studies before analyzing the results and present conclusions and implications. | |
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Preface

This master thesis is written during the spring semester 2012, and constitutes the final work of the Master of Science education program at the Norwegian University of Science and Technology (NTNU). The thesis is an in-debt study in the course TIØ 4912, in the master specialization, Strategy and International Business Development, at the Department of Industrial Economics and Technology Management. The purpose of the thesis is to analyze international development of environmental technology, more specifically the possibility of building a wave and tidal industry in Norway, given a limited home market. The work has been both challenging and rewarding, and has provided opportunities to study theory taught in earlier courses as well as further examination of the subjects elaborated in the introductory project fall 2011. The work has given us much enriching insight into Norwegian and global wave and tidal industry, as well as research in the field of strategy and international business.

We would like to thank our academic advisers, Professor Øystein Moen and PhD candidate Øvind Bjørgum, at the Department of Industrial Economics and Technology Management, for guidance and support. Further, we would like to thank the representatives of the case study companies, which have provided us with valuable information to base our study on.

Trondheim, 08. June 2012.

Ida Sølvsrudt and Birthe Sønning,

Abstract

This master thesis study to what extent Norway can build a wave and tidal (marine energy) industry with a limited home market.

Marine energy entails immense power potential and can become an important, infinite renewable energy source if the technology reaches grid parity. Norway has physical resources, R&D history within marine energy and need for a new industry to extend the offshore competences after the oil reserves are empty. Thus, marine energy could provide great opportunities for Norway in the future. While other countries introduce favourable demand-side policies to stimulate the development of marine energy industry, Norway only has supply-side incentives making marine power production impossible with current, immature technologies. Inexpensive hydropower and low unemployment rates lead to minimal domestic demand for marine energy, and Norwegian private actors are to a low degree involved in the industry. Thus, the limited Norwegian market for marine energy raises a question of whether Norwegian marine energy industry can evolve.

In order to investigate the importance of home market in existing theory, a literature review has been conducted. As there is little theory directly related to implications of limited home markets, three theory areas have been studied in depth, namely *trade theory*, *innovation systems* and *emerging industries*. In addition, four mini cases on similar renewable energy industries have been studied to cover potential shortcomings in theory. The thesis is primarily based on ten focused interviews with different marine industry and surrounding industry actors. In addition, we have performed research using leading energy publications and scientific reports, as well as attended conferences on marine- and renewable energy. Our combined data provides information on the development of marine energy industry and the current status of the Norwegian system for development of renewable energy.

Our findings suggest that building an industry with a limited home market could be possible, but it demands (1) willingness to develop the industry among industry and surrounding actors, (2) advantageous conditions in home nation, (3) accessible demand in foreign markets, and (4) cooperation among the industry and surrounding actors. Norway has relevant competence from the oil and gas and maritime industries as well as favourable natural resources, which could function as advantageous conditions for development of a marine industry. UK and other leading markets are in addition close and accessible to Norwegian companies. However, our findings indicate that considerable development of a marine energy industry in Norway is unlikely at this point as there is low willingness and cooperation among the Norwegian actors, leading to little collective progress. If Norway is to become a leading nation within marine energy, increased involvement and cooperation among the industry and related actors is needed to ramp up the development:

- Entrepreneurs need to increase cooperation in order to drive the technology development towards commercialization.
- Policy makers need to increase its focus on marine energy, develop a long-term strategy for development and communicate this to the industry and the public.
- Large companies need to extend involvement in the marine energy industry in order to increase legitimacy and contribute to diminish technical and financial challenges.
- Investors need to increase knowledge and involvement in marine energy and realize needs in critical stages.

Sammendrag

Denne masteroppgaven har studert i hvilken grad Norge kan bygge opp en industri innen bølge- og tidevannskraft (marin energi) med et begrenset hjemmemarked.

Enorme krefter gjør at bølge- og tidevannskraft kan bli viktige, fornybare energikilder hvis teknologien blir kostnadseffektiv i fremtiden. Norge har naturressurser, historie innen FoU på bølgekraft og behov for en ny industri som kan videreføre offshore kompetanse når oljereservene blir tomme. Dermed kan det ligge store muligheter i bølge og tidevannskraft for norsk industri i fremtiden. I motsetning til andre nasjoner som introduserer gunstige etterspørselsinsentiver for å stimulere utvikling av bølge- og tidevannsindustri, tilbyr Norge kun FoU støtte til tidlig teknologiutviklingsfase som gjør det umulig å drive kraftproduksjon i Norge med dagens teknologi. Billig vannkraft og lav arbeidsledighet gjør at det er lite etterspørsel etter ny fornybar energi i Norge og det er derfor et spørsmål om det er mulig å utvikle en norsk bølge- og tidevannsindustri.

For å utforske viktigheten av hjemmemarked i eksisterende teorier det gjennomført et litteraturstudie. Da det er lite litteratur direkte knyttet til et begrenset hjemmemarked, er tre ulike teorier studert inngående: *handelsteori*, *innovasjonssystemer* og *fremvoksende industrier*. I tillegg er tre mini-studier av liknende fornybare industrier studert for å dekke potensielle mangler i litteraturen. Masteroppgaven er primært basert på ti dybdeintervjuer av ulike aktører innen bølge- og tidevannsbransjen og relaterte industrier. Videre baserer studien seg på ledende energipublikasjoner og vitenskapelige rapporter samt erfaringer og materiale fra deltakelse på konferanser innen både marin energi og grønn teknologi. Datainnsamlingen gir informasjon om utviklingen av marin energi, samt status på den norske utviklingen av fornybar energi.

Våre resultater indikerer at det er mulig å bygge opp en industri med et begrenset hjemmemarked, men dette krever (1) vilje til å utvikle en marin industri både blant bransjeaktørene og aktører i relaterte industrier, (2) fordelaktige forutsetninger i hjemmenasjonen, (3) tilgjengelig etterspørsel i utenlandske markeder og (4) samarbeid mellom de ulike bransjeaktørene og aktører i relaterte industrier. Norge har relevant kompetanse fra petroleum- og den maritime industrien, i tillegg til gode naturressurser som utgjør fordelaktige forutsetninger for Norge til å utvikle marin energiteknologi. I tillegg er Storbritannia og andre ledende markeder nære og tilgjengelige for norske bedrifter. Resultatene viser at viljen til å utvikle marin energi derimot er liten blant norske aktører og at det også er lite samarbeid mellom aktørene. På dette tidspunktet er det derfor usannsynlig at det vil bli betydelig utvikling av bølge- og tidevannsindustri i Norge. Hvis Norge skal bli en ledende aktør innen bølge- og tidevannskraft, må engasjementet og samarbeidet mellom industri- og industrirelaterte aktører øke for å trappe opp utviklingen:

- Entreprenørene må øke samarbeidet for å lede industriutviklingen mot kommersialisering av teknologi.
- Politikere må øke fokuset på marin energi, utvikle en langsiktig strategi for industriutviklingen og kommunisere denne til industriaktørene og allmennheten.
- Store selskaper må øke deltakelsen i industrien for å øke legitimiteten og bidra til å lette økonomiske og finansielle utfordringer.
- Investorer trenger å øke kunnskapen om, og deltakelsen i, marin energi og forstå behovene i kritiske utviklingsfaser.

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1 Introduction

Worldwide energy demand is predicted to increase by one third from 2010 to 2035 (IEA, 2011). In addition, the greenhouse gas emissions increased more than ever during 2010, making the CO₂ concentration in the atmosphere reach the highest levels in 800 000 years (Andersson 2011). The European Unions' climate change objectives for 2020 include reducing greenhouse gas emissions by 20% and increasing the share of renewable energy to 20% (IEA 2011). The focus on renewable energy is growing and 20% of the global energy consumption in 2010 was supplied by renewable energy sources. Moreover, the investments in renewable power and fuels increased with 32%, to 211 billion USD from 2009 to 2010 (REN21 2011).

63 % of Norway's energy comes from renewable sources, which makes Norway the country with the highest share of renewable energy in Europe (Engen 2012). By 2020 Norway has committed to increase the renewable energy share to 67.5 %. Norway's high share of renewable energy is due to the fact that 99 % of the electricity production comes from hydropower (Statkraft.no 2011). Furthermore, the Norwegian society heavily relies on the oil and gas industry, which gives Norway a favourable economic situation. However, the petroleum reserves will eventually run out, making Norway in need of new industries.

1.1 Background

We will in this master thesis elaborate on the wave and tidal power industry, which has the collective term *marine energy industry*. Marine energy has great potential of becoming an important renewable energy source worldwide as it is based on large and infinite natural resources. Nevertheless, marine energy technology is not cost competitive with land-based renewable energy sources and has yet to reach commercialization. Norway has a history of wave power development during the 1970s and 1980s, when the oil crisis created an interest in alternative energy sources, which lead to substantial wave energy development. Kværner and Norwave installed two wave power plants during the 1980s, but both plants were shut down after accidents. The commitment to the development and research faded as the oil market recovered and the funding were cut off at the end of the 1980s (Nielsen, 2011). Consequently, wave power technology has had a slow development in Norway since then.

New governmental focus on renewable energy in Europe and the rest of the world has stimulated the growth of new companies, also within marine energy technology. The UK is said to have the leading market within marine energy and it is estimated that the global industry could be worth 3.7 billion pounds to the UK by 2020. The attractiveness of the UK market is largely due to government support in research, testing and production (RenewableUK 2010). UK has introduced subsidies that give a higher price for marine energy in order to help marine energy reach commercialization before reaching grid parity, namely producing power at costs that are equal or less than the price of power from the grid. At the current point in time, Norway has several companies developing both wave and tidal technologies, and some are among the world's leading technology developers. Compared to other European countries, the Norwegian government has in recent years been less active in renewable energy. If Norway is to keep the status as a renewable nation, the renewable energy activity has to follow the European activity levels. Thus, marine energy could be a future opportunity for Norway to further expand its competence in renewable energy.

As of January 2012, Norway entered a common green certificate market with Sweden. However, marine energy will not be able to compete at the green certificate market, as the green certificates favor the most cost competitive new renewable sources such as land-based wind. Ola Borten Moe, the Norwegian minister of energy and petroleum is not planning additional demand-side incentives and stated *"the green certificate market represents a shift in the energy politics by leaving behind a period with discussions of framework conditions and now focusing on the concession politics."* (Moe 2012).

Our introductory study conducted in the fall 2011, revealed challenges facing Norwegian wave- and tidal power companies. What became evident in the introductory study was that the industry is characterized by uncertainty at several levels. *"Companies show very different estimates for future goals, the policy framework lacks long-term goals and investors and large companies consider the industry too immature to invest in"* (Sølvskudt and Sønning 2011). Many of the entrepreneurial challenges were related to the limited home market. Environmentally friendly hydropower makes Norwegian electricity prices low compared to the rest of Europe, inducing little demand for additional renewable power and subsidies that increase electricity prices. The entrepreneurial companies are very dependent on support policies and funding, as they are small companies in a capital demanding and immature industry, which have yet to develop cost efficient technologies. The wave and tidal companies experienced sufficient

governmental support in the first stages of technology development, but had to look abroad for full-scale pilot testing of technology and energy production opportunities as leading countries have introduced demand-side policies to stimulate demand for marine energy technology.

1.2 Problem Statement

The high level of renewable energy and lack of subsidies in Norway lead to lack of domestic demand and thus a limited home market compared to other national markets. The results from the introductory study suggest that Norwegian companies need to be involved in other countries with greater home markets to be in front of the development. A viable home market seems to be a definite advantage, but what are the implications of not having a home market? In order to assess the development of Norwegian marine energy industry it is evident that we have to address the following problem:

To what extent can Norway develop a marine energy industry with a limited home market?

The problem statement considers whether it is possible to develop a viable marine industry in Norway and if so, what the Norwegian contribution could be. The thesis will elaborate on whether it is realistic that Norway takes a central role in marine energy development or if the Norwegian role is reduced to certain levels of the industry. The master thesis broadens the analysis compared to the introductory project assignment in the fall 2011 to include actors other than the entrepreneurs of wave and tidal power devices. The insight of surrounding and participating actors will provide a more balanced analysis of the industry and better the possibility to make rational predictions about the future of the Norwegian marine energy industry. As the marine energy industry in Norway is small and in an early development phase, we will include offshore wind power in some areas of the study. The offshore wind industry has many of the same challenges as the marine energy industry, such as a limited home market in Norway and immature technology that is not cost competitive with land-based renewables.

1.3 Structure

The thesis will follow a *linear analytic* structure with the following parts:

- An *industry review* chapter illustrating the current state of the marine energy industry.
- A *literature review* chapter investigating what existing theory says about home market and industry development. Furthermore, a presentation of four mini cases concerning renewable energy industries is included in order to see if there have been similar cases of industry development. We close the chapter by introducing research questions that will be answered through our further analysis.
- A *methodology* chapter presenting our research methods.
- An *interview* chapter consisting of summaries of the interviews performed to answer the research questions. We have interviewed ten actors related to the development of Norwegian renewable energy.
- A *discussion* chapter discussing the findings from the interviews.
- A *conclusion* chapter presenting our main findings, future scenarios and implications.

2 Industry review

The following chapter will present a brief overview of the wave and tidal industry. First, we will describe marine energy development in terms of costs and maturity level. Second, we will present policies and targets concerning renewable energy and highlight policies in countries with the most developed wave and tidal power industries. As our thesis concerns the Norwegian conditions, we will provide a more detailed presentation of the Norwegian policies within marine energy. Lastly, we will present a brief overview of the natural resources and potential in Norway. A technical overview of wave and tidal physics and concepts can be studied in Appendix A1. The industry overview is mainly based on the project assignment conducted in the fall 2011, the next sections are thus taken from Sølvsødt and Sønning (2011) with a few alterations.

The industry overview will provide industry data for the discussion and analysis, but also aims to provide the reader with a general understanding of the current situation of the wave and tidal industry.

2.1 Marine Energy Development

Ocean energy includes wave, tidal, osmotic power and ocean thermal energy conversion (REN21, 2011) and marine energy includes wave and tidal energy (Renewable UK, 2012). Marine energy is one of the least mature technologies within renewable energy, but has a great potential in large resources as well as placement of power plants outside the scope of user conflicts (Sandgren et al, 2007). Tidal barrage systems account for most of the world's installed marine energy capacity and is the only technology that has achieved commercial scale. As barrage systems intervene considerably with the natural surroundings, they are not likely to be installed in a country like Norway (Dalauhg, 2011). Due to essential differences from other marine energy technologies in both maturity level and interference in nature, the barrage technology will be left out of the analysis in this thesis.

There are several pre-commercial projects generating power within a range of technologies in the marine energy industry. By the end of 2010, many projects were under development and about 25 countries were involved in ocean energy development. Estimated total installed capacity by the 18 member countries of International Energy Agency (IEA) were 6 MW, of which wave accounted for 2 MW and tidal for 4 MW. There were more than 100 ocean energy development projects in 2010, exceeding 100 GW in cumulative capacity. Rising political and financial support in this period accelerated the development and infrastructure required to test new prototypes (REN 21, 2011).

2.1.1 Cost of Marine Energy

The largest challenge for renewable energy sources is development of technologies that can deliver power at cost competitive prices (Sandgren et al, 2007). Marine energy utilizes a free, non-adjustable energy source, and investments together with operation and maintenance decide the costs. Since both wave- and tidal technologies are immature, and thereby pre-commercial, there are large costs associated with building plants. Of offshore renewable energy technologies, wind technology is most developed. Figure 1 is based on an Enova report that evaluates potential in Norwegian marine energy, and shows cost per KWh in wave, tidal and offshore wind power based on experiences from UK (Sandgren et al, 2007). The cost is

calculated for three different scenarios due to yearly variations in possible production. High refers to the periods with high production; medium refers to the average level of power production, and low refers to periods with low production. With an average electricity price of 0.35 NOK/kWh and green certificates of approximately 0.20 NOK/kWh (Enova.no, 2012), the technologies cannot be realized without increased governmental support (Dahlhaug, 2011).

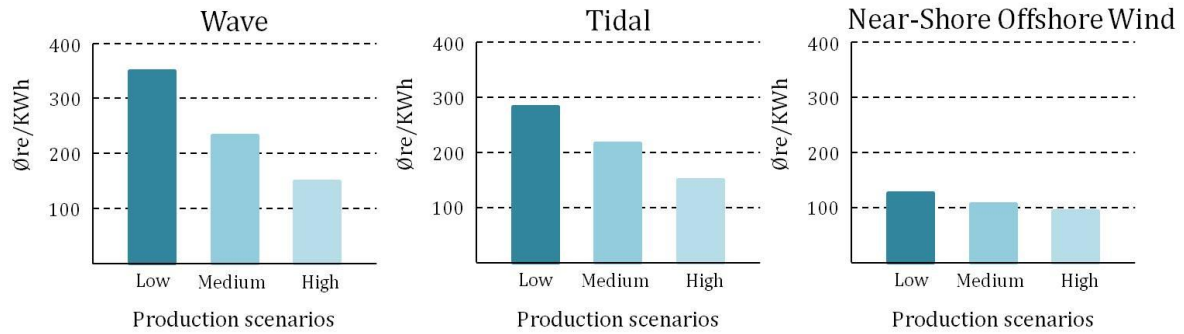


Figure 1: Cost per kWh in Wave, Tidal and Offshore Wind Power (Sandgren et al, 2007)

2.1.2 Maturity Level

Figure 2 maps renewable energy sources according to market maturity and technology maturity. If a technology is low on market maturity, more support is required for entering the market. If a technology is low on technology maturity, it is dependent on support for research and development. Not all technologies reach full commercialization on market terms, but stagnate somewhere along the dark blue line (Sandgren et al, 2007).

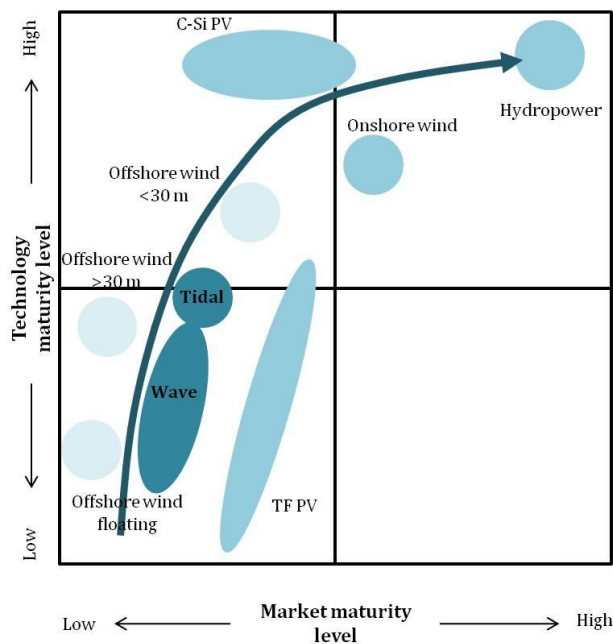


Figure 2: Technical and Commercial Development Level (Sandgren et al, 2007)

As illustrated in figure 2, wave and tidal power technologies are in the lower left square, indicating that the technologies are immature and that there are still steps to be made in order to reach commercialization. The technology and market immaturity make it hard to predict the technologies' technical and economic characteristics (Sandgren et al, 2007).

Figure 3 below shows that tidal development is slightly ahead of wave power development. Appendix A1 gives a brief overview of different technologies listed in the maturity curves of wave and tidal power.

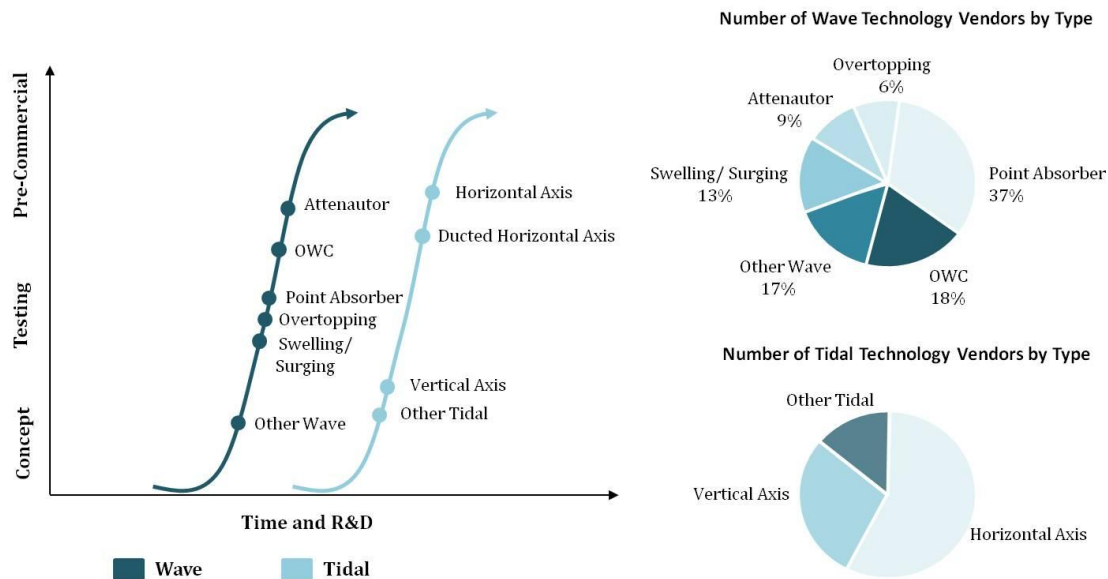


Figure 3: Marine Energy Technology Maturity Curves (EER, 2010)

The horizontal tidal turbine has reached the highest level of technology development, while wave energy is characterized by a wide range of technology designs (EER, 2010). However, there is larger resource potential in waves. Enova (2007) estimates that wave power eventually will generate a higher net income than both tidal and wind due to expected operational costs and yearly production profile.

2.2 Renewable Energy Policies

An increasing number of countries are implementing renewable energy targets. EU's target is to source 20% of energy from renewables by 2020 (REN21, 2011). Both Finland and Sweden reached their 2020 goals in 2010 and Scotland further raised its 2020 target for renewable share of electricity generation from 50% to 80%. Figure 4 shows countries with at least one national level renewable energy (RE) target, and/or at least one specific policy in 2005 and early 2011 (IPCC 2011).

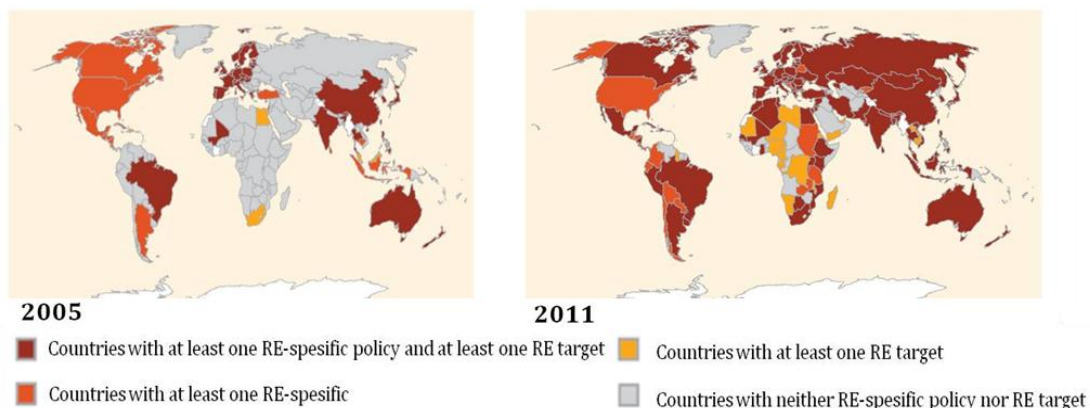


Figure 4: Policies and Targets from 2005 to 2011 (IPCC, 2011)

IPCC's (2011) report emphasizes that government policies play a critical role in renewable energy development. There is no one-size-fits-all policy and design and implementation are crucial in determining the efficiency of a policy's success (IPCC 2011). About 95 countries have some type of policy to support renewable power generation and many options are available to support renewable energy technologies (REN21, 2011). There exist government R&D policies for advancing technologies, namely *supply-side policies*, and deployment policies for creating a market for renewable technologies called *demand-side policies*. Although no globally agreed grouping of renewable energy policy options exists, both REN21 and IPCC use fiscal incentives, public finance and regulation in their categorization. *Fiscal incentives* are policies where actors (individuals, households or companies) are given a reduction via income or other taxes, or payment such as rebates or grants, due to their contribution to the public treasury. *Public finance* is public support such as investments, loans and grants. *Regulatory policies* provide guidance or control and include policies such as feed-in-tariffs¹, RPS², net-metering³, and green certificates (IPCC, 2011). One of the most robust findings from IPCC's (2011) report, from both theoretical and technology studies, was that R&D investments are most effective when complemented by other policy instruments, particularly policies enhancing demand for new technologies (IPCC 2011).

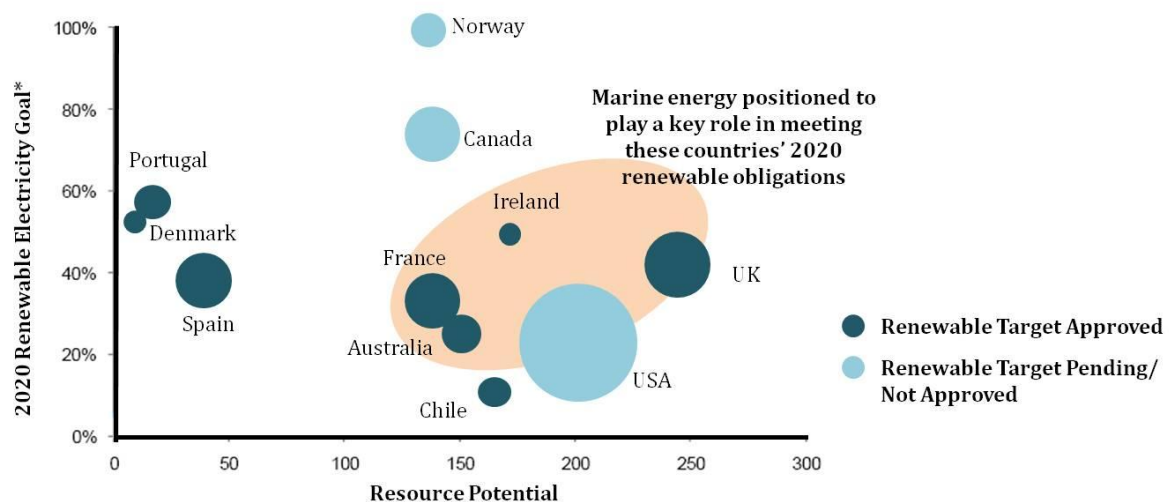
2.2.1 Policies Applied to Marine Energy

For the marine energy industry to evolve and scale up, direct policy support from governments are critical (EER 2010). It has been a renewed interest in marine energy in the last seven years. Although there has been a significant increase in legislative and governmental support for renewable energy, the majority of this support has focused on solar, wind, hydro, biomass and geothermal energy. In recent years the trend also includes marine energy (Harstidy, 2009). Less support has contributed to slower evolution. However, some countries with strong resource potential have high growth ambitions, such as UK and Ireland (EER, 2010). Figure 5 depicts in which countries marine energy has the greatest potential for meeting renewable energy targets, relative to resource availability (EER, 2010). In the countries within the orange oval, marine energy is positioned to play a key role in meeting the 2020 renewable targets. Norway is placed above the orange oval because of the high share of renewables in the energy mix. UK, Ireland, France and Australia have all approved renewable energy targets and have thus potentially high demand for marine energy devices in order to meet the targets.

¹ **Feed-in-tariffs** pay a guaranteed price for power generation from a renewable energy source. Feed-in-tariffs involve an obligation of the electric utilities to purchase electricity produced from renewable energy producers in their service area, at a tariff determined by the public authorities for a certain time period (Menanteau and Finon, 2002)

² **Renewable portfolio standards (RPS)** require that a certain percentage of electricity from each retail supplier/utility is generated by renewable sources. Policy design can be tailored to specific markets (Lewis and Wiser 2006)

³ **Net metering** allow electricity customers who generate their own renewable electricity to bank excess electricity to the grid in form of credits. Thus, the customer uses excess generation credits to offset electricity it otherwise would have to purchase from the utility (DSIRE 2011)



Note: Bubble Size represents total renewables added between 2020 and 2020, * For Canada and Norway, the percentage is 2008 renewable electricity

Figure 5: Renewable Energy Targets in Key Markets with Marine Energy Resources. (EER, 2010)

2.2.2 Norwegian Focus in Renewable Energy

2.2.2.1 Norwegian Priority Areas

The Norwegian government presented its new initiatives to reduce emissions of greenhouse gases April 25th 2012 through a white paper on climate efforts (Regjeringen.no, 2012). The government intends to reduce the greenhouse gas emissions and promote technological advances by establishing a new climate and energy fund, raising the CO₂ tax rate for the offshore industry to NOK 200 per ton, giving stronger incentives for offshore petroleum industry to use electricity generated onshore, and improving public transport. The white paper continue the targets set out in the 2008 agreement on climate policy (Regjeringen.no 2012).

The government has a mandate from the Ministry of Petroleum and Energy called Energi 21 which creates Norway's national strategy for the energy sector and sets out the desired course for research, development and demonstration of new technology for the 21st century. Energi 21 recommends six areas for further focus to the Norwegian government (Energi21 2012).

- Offshore wind power – industry development and resource exploitation
- Carbon Capture and Storage – value creation and value securing
- Balance power – increased resource exploitation by exporting electricity
- Smart energy systems - smartgrids
- Solar power – increased industry development
- Low thermal heat – conversion to electricity

Marine energy industry is not one of the major priority areas of the Norwegian government, but they still have a goal of supporting a wide spectrum of innovative projects, making some policy schemes available for wave and tidal companies.

Torger Reve's research project titled "A knowledge based Norway" analyzes 14 major knowledge based industries in Norway, one of them being renewable energy technology and services in a report written by Grünfeld and Espelien (2011). Grünfeld and Espelien (2011)

argues that Norwegian success within renewable energy industry is to a large extent found in companies that consistently operate with strong international ambitions and are a part of strong and dynamic knowledge hubs linked to central clusters in Norway. Companies that have managed to establish considerable sales in international markets without comprehensive competence and R&D commitment, quickly lose their competitiveness if they do not systematically monitor the development of new technology and services. Grünfeld and Espelien (2011) conclude with three policy recommendations: (1) *Strengthen the commitment to business oriented R&D programs in segments that have shown international competitiveness or potential to do so.* The study shows that the segments with largest potential for high international competitiveness have strongest relations to R&D institutions. (2) *Commit to the segments and companies that are linked to the large existing clusters in Norway.* Grünfeld and Espelien (2011) emphasize offshore wind power as a segment with potential for international growth, but a problem is the higher profitability in oil and gas that attract relevant actors. (3) *A more evident focus on further development of hydropower competence, with special commitment on challenges within balance of power and transmission.* R&D investment both in Norway and Europe show that hydropower is of low priority.

2.2.2.2 Public Finance

There are three main organizations that distribute financial policy schemes within technology and energy solutions, namely the Research Council in Norway (RCN), Innovation Norway (IN) and Enova, which cooperate in matters concerning support of renewable energy and energy efficiency improvements. Enova, IN and the RCN support different phases of a project through programs that are meant to complement each other. Figure 6 illustrates the distribution of support from the different schemes throughout the development phases.

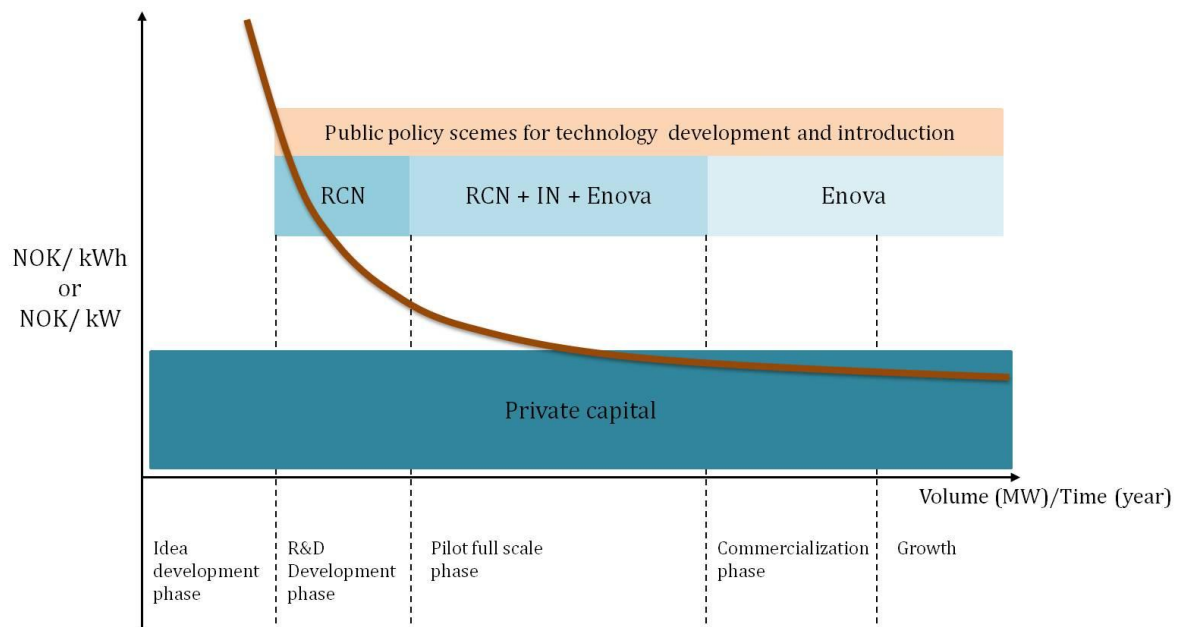


Figure 6: Financing in Project Phases (Skjølsvik, 2008)

Up until recently, Norway has had no special financial schemes or programs dedicated to marine energy, but marine energy is included in more general renewable energy and environmental technology programs (Holmberg et al., 2011). In 2010, the government started a policy scheme called “Miljøteknologiordningen”, which has a subunit tailored to wind and

marine power. The support scheme originally distributed support of 140 million NOKs a year, but the government decided to enhance the program to secure development of environmental friendly technology and granted additional 500 million NOKs to be distributed within 2011 and 2013 (Miljøvernsdepartementet og Nærings- og handels-departementet, 2011). The support is mainly distributed by Innovation Norway, but the Research Council in Norway and Enova also distribute some millions (Dahl, 2010). Further information about the different support schemes and regulation policies in Norway is enclosed in appendix A2.

2.2.3 Comparing Public Policies

The motivation for national programs for marine power is a combination of need for domestic renewable power, and need for a new industrial sector that will create jobs and export activity. Differences in countries' motivation cause differences in support regimes despite having similar energy resources (Holmberg et al., 2011). The Nordic policy systems tend not to differentiate between renewable energy sources. Table 4 below illustrates the marine energy electricity price for end costumers in different countries with developing marine energy industries. The "breakdown of electricity price" column describes the policy support contribution to the price in the respective countries. There is also considerable marine energy activity outside Europe, such as in USA, Canada and Australia (Holmberg et al., 2011).

| Country | Electricity Price | Breakdown of Electricity Price |
|----------|-------------------|---|
| Portugal | ~2 NOK/kWh | Feed-in-tariff |
| UK | ≥2.15 NOK/kWh | 5 ROC's* + whole sale price (~0.45 NOK/kWh) |
| Ireland | 1.7 NOK/kWh | Feed-in-tariff |
| Norway | 0.50 NOK/kWh | Whole sales price (~0.30** NOK/KWh) + green certificates with Sweden from 2012 of ~0.20 NOK/kWh |

*Renewable obligation certificate, floor price approximately 0.35 NOK/kWh although currently higher due to deficit certificates (2010~0.53 NOK/kWh)

** Source: ssb.no (2011)

Table 1: Policy Support (Holmberg et al., 2011)

Portugal

Portugal aims at becoming a proving ground for power plants, and provides dedicated areas for wave power, feed-in-tariffs of approximately 2 NOK/ KWh, and supporting facilities (Holmberg et al, 2011). In 2006, 30 million Euros was dedicated to renewable energy sources, which benefited among others the known Pelamis wave project (Holmberg et al., 2011).

UK

Currently, the UK is the world's leading market for marine energy with 5.6 MW grid connected capacity in 2011, an increase of over 90 % from 2010. It is anticipated a doubling of grid connected capacity in 2012 to reach a total capacity of over 11 MW (Renewable UK, 2012). UK also has 250 GW of theoretical wave and tidal resource potential off its coasts, which makes marine energy a key focus for UK when pursuing the 2020 targets (EER, 2010). UK exceeds the rest of the world put together in terms of public funding and other support for marine energy. Scotland is self-governing in matters relating to renewable energy. High availability of energy

sources, and employment issues have led to special Scottish initiatives that surpass rest of UK (Holmberg et al., 2011).

Ireland

The Irish government intends to make Ireland a world leader for research, development and deployment of marine energy. Ireland has already set out a four-phase strategy in order to reach their goal and has completed the first phase of constructing an offshore test facility for ¼ scale prototypes. In the second and current phase they have created a supervisor authority, the Ocean Development Unit that allocates approximately 200 MNOK to support device developers, develop a grid-connected offshore test facility and enhance primary R&D facility.

2.3 Potential and Quality and Cost

2.3.1 Comparing Potential

Wave power

The level of wave resource varies with time and distance from shore. Waves travel with small energy loss until nearing the shore where energy is lost through friction against the sea floor and breaking. The *theoretical resource* is the power flux crossing a line sufficiently offshore to be unaffected by the bottom friction. The *wave power potential* is how much of the theoretical resource that can be extracted from a technical point of view including wave power plant characteristics (Holmberg et al., 2011). Table 5 below shows the theoretical resource and wave power potential for a sample of countries.

| Country | Theoretical wave resource | Wave power potential |
|---------|---------------------------|----------------------|
| Norway | ~600 TWh | ~12-30 TWh |
| Ireland | ~500 TWh | ~28 TWh |
| UK | ~600-700 TWh | ~50 TWh |
| Denmark | ~35 TWh | ~5 TWh |

Table 2: Wave Power Theoretical Resource and Potential (Holmberg et al., 2011)

Wave resources, as well as wave heights, vary substantially throughout the year. The difference between extreme wave height and the average significant wave height in Norway varies from 5.5-6.5 to 9-10 meters. This makes it difficult to dimension the technology to handle both extreme and regular waves (Sandgren et al., 2007).

Tidal Power

Costal characteristics and geometry of the earth make individual location characteristics affect tide forecasting. However, for a given location the tide differences are relatively constant and predictable, as is the time of high and low tide is constant relative to other points at the location. Water has a higher energy density compared to that of air; A 6-knot tidal current has higher energy density than an equivalent 100-kph wind and the kinetic energy corresponds to over 300 kph in air. The theoretical global tidal resource is estimated to be 800 TWh/year (Sørensen, 2008). The local bathymetry greatly influences the tides exact time and height of a particular costal point and creates great differences across the earth. The Bay of Fundy, on the east coast of Canada, has the earth's largest documented tidal ranges, which are above 16 meters. Table 6 below shows some tide ranges of the global ocean.

| Place | Country | Tidal range |
|----------------|---------|-------------|
| Vardø | Norway | 0,334 m |
| Bay of Fundy | Canada | 16.2 m |
| Severn Estuary | UK | 14.5 m |
| La Range | France | 13.5 m |
| Gnat Cove | USA | 9.4 m |

Table 3: Tide Ranges of the Global Ocean (Dalhaug 2011)

In terms of natural conditions, North- West Europe has a large potential for tidal stream power development, particularly around United Kingdom and northwest France. The tidal potential is small in the south of Norway, but increases north of Bergen. There exist few inlets with the right angle for powerful currents between Bodø and Trøndelag, which indicate limited energy potential south of Bodø (Sandgren et al., 2007). Sandgren et al. (2007) estimate the realistic exploitable potential of tidal power in Norway to be 1 TWh/year.

The industry review has briefly presented the global marine energy industry. As seen, is the industry in an early phase and has not reached commercialization. There is a great variety in design and the costs connected to development are high. Compared to other countries, the physical potential in Norway is large for wave power, but the demand-side policies are inferior to UK and other European countries. In the following we will present the main findings from the literature review.

3 Literature review

3.1 Introduction

Several economic and business theories are of relevance in the assessment of home market in relation to industry development. Through our research we found three areas of theory that were particularly interesting:

- *Trade Theory* as it concerns the importance of size and configuration of the home market to international success.
- The theory of *Innovation Systems* because of the broad discussion of the basis for innovation within a country, which in turn effect industry creation. Innovation is in addition immensely important in the marine energy industry as the technology is still in the pre-commercial phase.
- Theory concerning *Emerging Industries* in order to evaluate crucial attributes of the industry creation process, as the problem statement addresses industry development.

We will in the following chapters describe the three areas of theory before comparing them and discussing implications for our problem statement and potential shortcomings.

3.2 Trade Theory

In trade theory, trade among nations has been greatly discussed, figure 7 illustrates the main theories within international trade. The first ideas of trade policy evolved with the *mercantilism* already in the 16th century. Mercantilism demands that a nation should strive to have a positive trade balance, thus that a nation should export more than it imports. Adam Smith and later David Ricardo criticized the ideas of mercantilism. According to Adam Smith (1776), a nation should specialize in producing goods and services in which it has an absolute cost advantage compared to other countries. David Ricardo (1817) introduced the concept of comparative advantage where a nation should produce goods and products in which it can produce more efficiently relative to other countries. Two basic underlying assumptions of the Ricardian theory are constant returns to scale and perfect competition.

The theory of competitive advantage dominated international trade theory up until the 1970s when Paul Krugman introduced what is called the *New Trade Theory*. New trade theory is based on monopolistic competition and differs from traditional trade theory in the level of intra-industry trade. In addition, new trade theory utilizes what is called the *home market effect* to describe certain trade patterns. Porter (1990) questioned these existing theories of trade's ability to explain location advantages of nations and introduced a new theory to explain national competitive advantages; why some countries are more successful in particular industries than others.

Both home market aspects of the new trade theory and competitive advantage of nations are interesting in evaluating the importance of having a home market and how it affects trade and industry creation. We will thus elaborate further on these areas of international trade theory, marked with a darker shade of blue in the figure below.

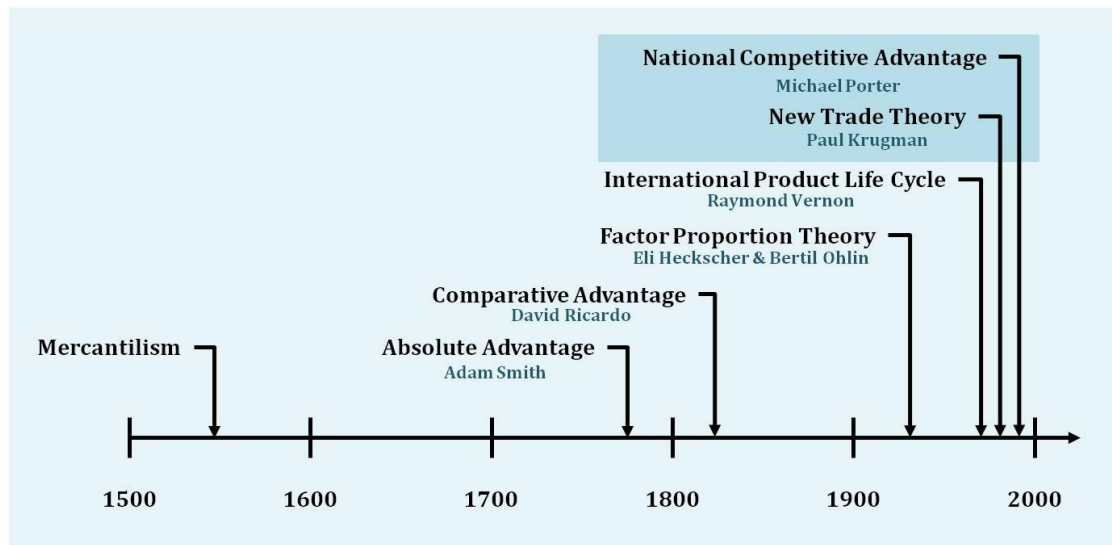


Figure 7: Evolution of Trade Theory

3.2.1 Theory of Home Market Effect

It is well recognized that companies tend to agglomerate geographically and there are many scholars that have tried to assess the reason for this phenomenon. While classical trade theories based on comparative advantage fails to explain the intra-industry trade patterns connected to agglomeration (Davies and Ellis 2000), new trade and new economic geography scholars believe the main engine of agglomeration is what they call the “*home market effect*” (Crozet and Trionfetti 2008). The home market effect is the relation between home market size and industrial specialization where a country with a large domestic demand within a particular good is more likely to be a net exporter of that good (Krugman 1980). The reason for this phenomenon is that “*by concentrating production in one place, one can realize scale economies, while by locating in larger markets minimizes transportation costs*” (Krugman 1980, p.955). An influential stand of researchers in the theoretical literature are affirmative of the home market effect and that market size matters for the national industrial structure (Davis 1997). Davis (1997) questions the robustness of the model and finds that its results depend on the relative size of trade costs in differentiated and homogeneous industries. Crozet and Trionfetti (2008) find that the home market effect is weakened when removing this assumption, and that it becomes non-linear implying that the home market effect is more important in very large and very small countries than for medium size countries. It is thus the *relative* market size that matters and a country will become a net exporter of a good whose domestic demand is larger than a global average (Crozet and Trionfetti 2008).

3.2.2 National Competitive Advantage

Porter (1990) proposes that the competitive advantage of a nation’s industries is determined by four attributes of the national location, referred to as the *home base*. These are *factor conditions*, *demand conditions*, *related and supportive industries*, and *firm strategy and rivalry*. The attributes constitute the corners of the *national diamond model* depicted in Figure 8. In addition to the four main attributes, *chance* and *government policy* are recognized as important factors that support and compliment the system of national competitiveness, although they do not create lasting competitive advantage (Porter 1990).

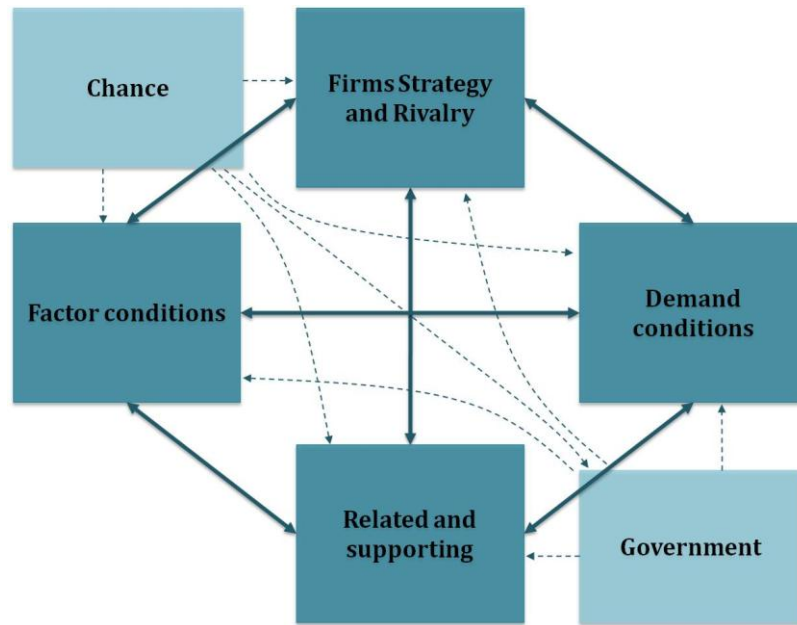


Figure 8: National Diamond Model (De Wit and Meyer 2010)

3.2.2.1 Factor Conditions

Factor conditions are the availability of resources necessary to compete in an industry and consist of human resources, physical resources, knowledge resources, capital resources and infrastructure (Porter 1990).

3.2.2.2 Demand Conditions

The demand conditions at the home base is an important attribute of a nation's competitive advantage according to Porter (1990). It is not only the size of the home market that matters, but also the sophistication of buyers. Especially in a global economy, the quality of the local demand matters far more than its size (Porter 1990). The sophisticated buyers' high standard will force companies to continually focus on innovation and ultimately provide a window into international market needs. Conditions of demand optimally consist of a home market that anticipate and lead international demand, an industry segment with a significant share of home demand, and sophisticated and demanding buyers (Smit 2010).

3.2.2.3 Firm Strategy and Rivalry

Porter (1990) believes that the environment in the home market strongly influences the strategic choices of foreign rivals. Thus, domestic rivalry is a critical driver of competitive advantage for a country's firms. Rivalry forces companies to be cost competitive, enhance quality and be innovative. However, it is also important to notice that competition and cooperation coexist among rivals as they are on different dimensions or because cooperation at some level is part of winning the competition at other levels (Porter 2000).

3.2.2.4 Related and Supporting Industries

In order to create and sustain competitive advantage, the presence of industries that are related or potentially related in terms of technology, channels, buyers or the way buyers obtains and use products are needed (Porter 1990). A nation's industries will be better set to compete on the international market if there are *clusters* of industries in the home base economy that are

linked to each other by vertical and horizontal relationships. These related and supporting industries are thus important sources of innovation.

3.2.2.5 Government

The role of government should be to challenge and encourage companies to move to higher levels of competitive performance, stimulate early demand for advanced products, simulate domestic rivalry by limiting direct cooperation, and focus on specialized factor creation.

3.2.2.6 Chance

The level of “chance” can affect the competitive advantage of a country. Random events as technological breakthroughs, shifts in exchange rates, climate crisis etc. can either benefit or harm a firm’s competitive position.

3.2.2.7 Clusters

The strength of the factors and the interaction between them determine whether the industry becomes a *cluster* (Grünfeld and Espelien 2011). In Michael Porter’s theory of competitive advantage of nations, clusters have thus a prominent role. Porter (2000, p.16) defines a cluster as *“geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate”*. He argues that clusters are becoming increasingly important in the modern world of industry development and that well-functioning clusters can be crucial to the level of innovation, growth and productivity. Clusters affect competition in three ways that reflect the different parts of the diamond model by (1) increasing the current productivity of constituent firms or industries, (2) increasing the capacity of cluster participants for innovation and productivity growth, and (3) stimulating new business formation that supports innovation and expands the cluster (Porter 2000).

It is more likely that advanced technology activities develop where there already is a base of less sophisticated activities in the field. Thus, clusters often form when one can build on an already set foundation of local advantages (Porter 2000). Porter (2000, p. 26) further argues that *“there should be some seed of a cluster that have passed a market test before cluster development efforts are justified”*.

3.2.3 Critiques of the Theories

Porter (2000) proposes that the influence of location in relation to competition has been based on simple views on how companies compete, and rests on cost minimization in relatively closed economies. Porter (2000) believes that actual competition is far different and emphasizes that competition is dynamic and rests on innovation and the search for strategic differences. The book *Competitive Advantage of Nations* (Porter 1990) was proclaimed to build a bridge between the theoretical literatures in strategic management and international economics as well as create a basis for improved national competitiveness policies (Davies and Ellis 2000). However, there are many critiques directed at Porter’s theory. The criticism mainly comes from two perspectives: from the management school and from the economic school.

The criticism from the management school suggests that the model is incomplete mainly because it does not incorporate the multinational activities. In Porter’s diamond approach a firm’s capabilities to tap into the location advantages of other nations is limited (Chang Moon, Rugman et al. 1998). Rugman and D’Cruz (1993) suggest that a double diamond model is much more relevant in small open economies where managers in fact build upon both domestic and

foreign diamonds to become globally competitive in terms of survival, profitability and growth. Figure 9 illustrates the double diamond where the outside square represents the global diamond, and the inside square represents the domestic diamond. The dotted square in between the global and the domestic squares, is the international diamond, which represents the nation's competitiveness. The difference between the domestic diamond and the international diamond is thus the multinational activities including both outbound and inbound foreign direct investment (FDI) (Chang Moon, Rugman et al. 1998).

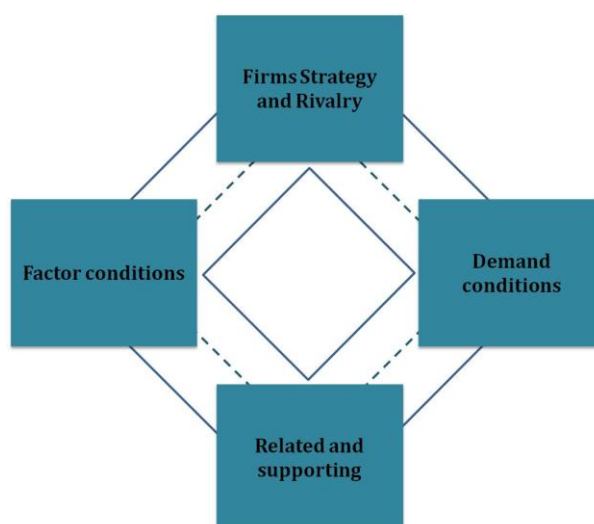


Figure 9: Double Diamond Model. (Rugman and D'Cruz, 1993)

Despite the critiques, Porter's (1990) theory is generally well accepted in the management literature because of the level of generality and applicability. The economic school on the other hand suggests that the diamond's generality tries to explain all aspects of trade, but ends up explaining nothing (Waverman 1995). Davies and Ellis (2000) believe that Porter has misunderstood the fundamentals in the difference between comparative and absolute advantage, and that *"the attempt to substitute competitive advantage for comparative advantage rests on a misunderstanding and a false analogy"* (Davies and Ellis 2000, p. 1199). Krugman (1996) emphasizes that trade theory is not concerned with the term "competitiveness" among nations, and that the notion that nations compete in the same manner as firms is a poor metaphor and conflicts with even the most basic international trade theory. Davies and Ellis (2000) also criticize the double diamond model, and propose that if firms in small open economies can benefit from diamonds in other countries, so can firms in the larger triad economies. Due to the larger size of the triad economy it does not necessarily need to draw on overseas diamonds as they are more likely to have four strong corners in the domestic diamond, but they may choose to do so. Davies and Ellis (2000) further argue that there are many industries that are internationally competitive without having a strong domestic diamond and when firms in one country are able to benefit from diamonds in another; the concept loses its content.

Even though Porter's national diamond has been the subject of much critique from different theory schools, the model provides a structured framework for analysing a country's sources of competitive advantage that companies can use to evaluate location-specific advantages across countries. At the same time it touches upon reasons for industry emergence and the role of already present industries which can trigger creation of new clusters. The framework is thus

relevant in the sense of recognizing the relevant attributes of nation's diamond within a specific industry, and assessing the importance of the domestic demand.

3.3 Innovation Systems

The system of innovation (SI) approach is closely related to cluster theory as the same concepts and actors are identified. However, the focus is different. While the SI approach mainly concerns innovation processes, the cluster approach addresses competitive advantage. Originally the cluster approach did not explicitly consider innovation, but innovation has later been included as a function of clusters. The SI approach also has a stronger focus on the political actors than the cluster approach, in which clusters consider the more general political frameworks and less the specific actors. The two approaches could thus be considered both overlapping and complementary (Spilling 2007).

Today, the innovation system concept is widely used by both policy makers at national and international levels (Lundvall 2007). The OECD, the European commission, the United Nations Conference on Trade and Development (UNCTAD), the World Bank and the US academy of science all use SI in their analytical perspective (Lundvall, Johnson et al. 2002). OECD defines SI as *"A complex set of relationships among actors producing, distributing and supplying various kinds of knowledge"* (OECD, 1997). A central idea in SI approaches is that innovation is an interactive process among a wide range of actors. The thought is that actors do not innovate individually, but in a collective process (Malerba 2005). The system can be illustrated in different ways. Figure 10 depicts OECD's model, which gives an overview of the most important actors, their relations and how politics influence the system.

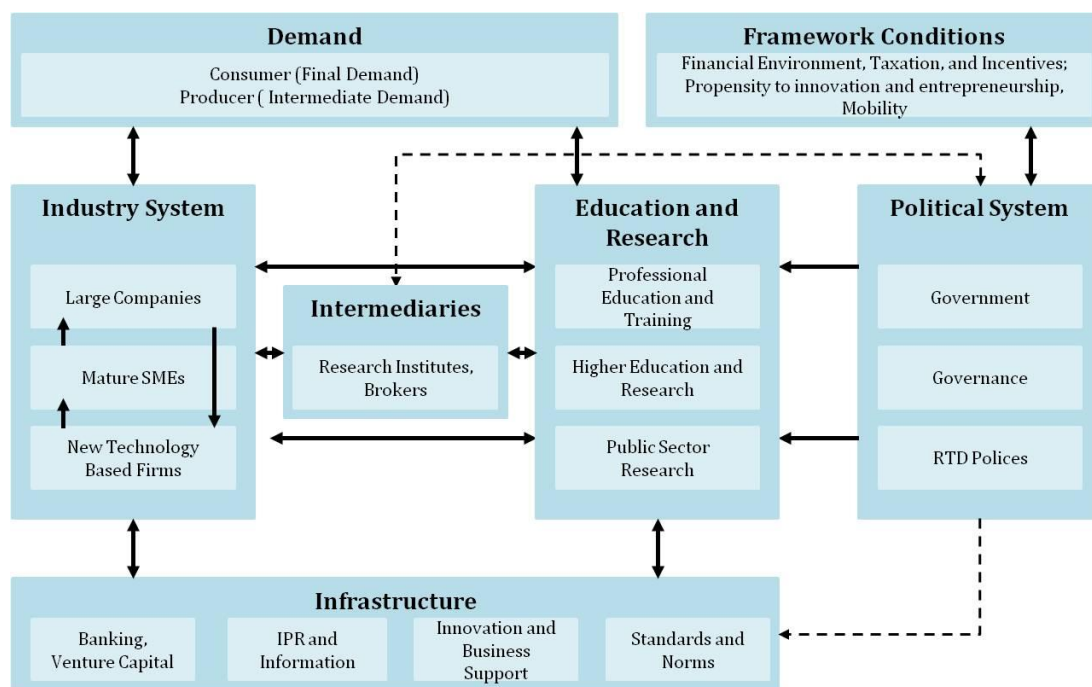


Figure 10: OECD National Innovation System Model. (Kuhlmann and Arnold 2001)

3.3.1 The Innovation System Approaches

The principles behind innovation systems can be traced to Adam Smith's (1776) work on the division of labour, which included elements such as knowledge creation in relation to productive activities, and the specialized services of scientists. Schumpeter's theories of

economic development and the entrepreneur as the most important actor, also contributed to the later innovation systems approach (Spilling 2007). Friedrich List (1841) challenged Adam Smith by presenting a concept of national systems of production and learning, included national institutions such as those engaged in education and infrastructure, and emphasized the need to build national infrastructure and institutions (Freeman 1995; Lundvall, Johnson et al. 2002).

An important contributor to the modern approach is Benkt-Åke Lundvall with his Ålborg group and their theory of national systems of innovation (NSI). Lundvall focuses on learning and knowledge creation, as well as organizations involved in innovative activities. Moreover, he defines the NSI as *“The elements and relationships that interact in the production, diffusion and use of new and economically useful knowledge... and are either located within or rooted inside the borders of a nation state.”* (Lundvall, 1992, cited in Al-Saleh 2010). Freeman also contributed to the diffusion of the NSI concept in his work on the innovation systems in Japan (Lundvall 2007). The collaboration between Freeman and the Ålborg group, in the early 1980s was essential in developing the earliest versions of the concept of NSIs (Lundvall 2007).

During the 1990s, newer concepts describing the systematic characteristics of innovation developed, which focus on other levels of the economy than the nation state (Spilling 2007). Technological systems of innovations (TSI) are innovation systems assigned to a specific technology or product (Markard and Truffer 2008). Regional systems of innovation (RSI) concern the sub-national systems that support innovation within the production structure of a region (Asheim and Gertler 2005). Sectorial systems of innovation (SSI) argue that different sectors and industries innovate differently (Malerba 2005).

3.3.2 Integrated Approaches

Several authors argue that technology seldom engages in just the system of one single nation or sector, it is involved in both the sectorial and national dimensions (Niosi and Bellon 1994; Hekkert, Suurs et al. 2007; Markard and Truffer 2008). Markard and Truffer (2008) delineate the relationship between NSI, SSI and TSI and emphasize the challenge in delineation and boundaries because different technologies and knowledge are intertwined and may be described as a continuum rather than separate fields.

Niosi and Bellon (1994) argue that all NSI are open systems of innovation (OSI) that relate to international and national environments, and that the links between national systems and their interdependence are essential in understanding the national characteristics. The degree and type of openness differ from country to country. Countries showing indifference to foreign influences have been isolated scientifically and technologically, while considerable open economies like the American NSI have experienced large inward and outward FDI, knowledge, and immigration of scientific and technical personnel (Niosi and Bellon 1994). Openness indicates to some extent convergence among different NSIs, but does not reach uniformity rather coexistence with diversity. Closed NSIs, like socialist nations, tend to diverge from other NSIs (Niosi and Bellon 1994). In their discussion on openness vs. globalization, Niosi and Bellon (1994) stress that globalization theories tend to understate that most technology is industry and resource specific and that present trends are pointing towards internationalization with specialization, rather than towards globalization. Their study shows that regional, national and open innovation systems coexist and interact. Figure 11 shows how innovation systems have developed as the globalization has increased.

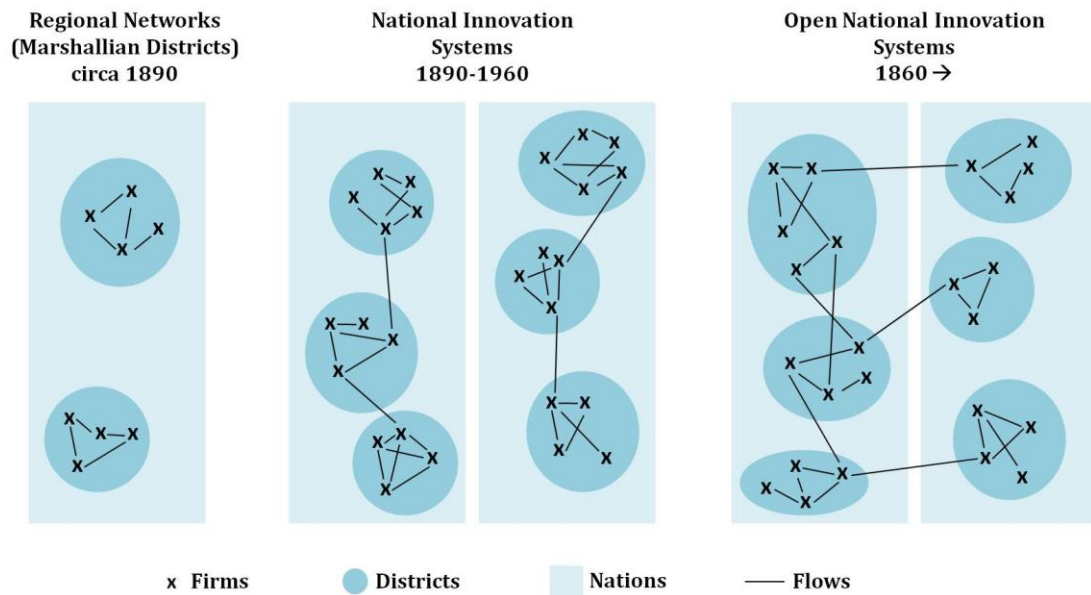


Figure 11: Development of Innovation Systems as the Globalization Increases (Noisi and Bellon 1994)

3.3.3 The Function Approach

The differences in focus and the lack of agreement of where to draw the line of the innovation system attract debate among leading scholars. The diffuseness makes up a barrier for further development towards a more theoretical concept (Edquist 2005). Several authors have developed *functions* to structure the approach (Johnson 2001; Bergek and Jacobsson 2003; Edquist 2005). Johnson (2001) has contributed a great deal to the function approach and define a function as a “*contribution of a component or a set of components to reach the goal ... The goal of a innovation system may be said to be to develop, diffuse and utilize innovations*” (Johnson 2001, p.2, 4) Johnson (2001) argues that the functions provide a tool for setting system borders, it also describes the system state and pattern so that mechanisms blocking the system can be identified and the performance of the innovation system can be assessed.

Several authors use seven functions, empirical tested by the Utrecht University (Hekkert, Suurs et al. 2007; Al-Saleh 2010): (1) Entrepreneurial activities, (2) knowledge development, (3) knowledge diffusion through networks, (4) guidance for the search, (5) market formation, (6) resource mobilization and (7) creation of legitimacy. Not all these functions are specific to a single innovation system since functions can be affected by other systems as well. In their work on the emergence of a growth industry; the wind turbine industry, Bergek and Jacobsson (2003) present five functions: (1) *Create new knowledge*, which can be viewed as the overall goal of a system. (2) *Guide the direction of search* includes recognition of growth potential and technological legitimacy of the technology perceived by various actors, as well as guidance of technological and market choice. Actors may be guided by mechanisms such as prices, customer relationships, regulations and policies. The function is especially important in new industry formation. (3) *Supply resources*, such as capital competence and other resources. (4) *Positive external economies* entail exchange of information and knowledge and the formation of networks and meeting places. (5) *Facilitate the formation of markets*, implies that market may need to be created, in which firms and governments have to initiate measures.

Bergek and Jacobsson (2003) further argue that functions can be used as a framework for evaluating an innovation systems contribution for industry development. All five functions need

to be served for a system to perform well, and the system should be evaluated in terms of how well the functions are served within that system. The functions are dependent on the phases of evolution an industry is in (Bergek and Jacobsson 2003). The industry evolution can be separated in to two main phases and the transition is often driven by the emergence of a dominant design. The first phase is characterized by experimentation, variety and legitimacy of technology. The second phase distinguished by diffusion, expansion and cost reduction.

Functions influence each other and interaction can lead to virtuous cycles enhancing development (Negro 2007), but can also lead to vicious cycles (Hekkert, Suurs et al. 2007). Bergek and Jacobsson (2003) recommend that all functions must be in place for an emerging innovation system to perform well, while Al-Saleh (2010) argue that one must also recognize that no theoretical optimum exist, since the possibilities for any economic activity is constantly changing.

3.3.4 Critique of the Theory

The newer concepts of SI have been interpreted both as alternatives and interactions to NSI. NSI was the first concept elaborated in literature and constitutes about 50% of the innovation system literature publications (Markard and Truffer 2008), but recent papers emphasize the degree of openness in systems across national borders. Many argue that modern innovation tend to cross national borders and that the national level not necessarily should be taken as given (Lundvall, Johnson et al. 2002). There are diverging views of how globalization might affect national innovation systems. Lundvall (2002) argues that *“as long as nation states exist as political entities with own agendas related to innovation, it is useful to work with national systems as analytical objects”* (Lundvall, Johnson et al. 2002), while Niosi and Bellon (1994) state that the globalization will lead to internationalization with specialization.

The definitions in innovation systems range from including only organizations performing R&D to including almost anything that affects learning (Johnson 2001). The functions are presented as a tool for drawing the system line and make it possible to get an overview of the performance of the innovation system. Function approaches can be viewed as a more normative approach and may thus be easier to apply, in contrast to the previous, more descriptive approaches. Moreover, if every definition of innovation systems and industry has their own functions there might be difficult obtain a more aggregate approach. Nevertheless, as different nations, regions, technologies and sectors are different and have various degree of interaction, there might not be possible to implement an aggregate solution. This wide approach may be a benefit of the innovation system theory, as organizations and policy makers worldwide adopt the approaches. The innovation system approach is still emerging and will probably continue to adjust as the globalization increases.

Most of the literature on innovations systems origin from developed countries as Lundvall and Freeman developed the theory in parallel in Europe and the US (Lundvall, Johnson et al. 2002; Lundvall 2007). Thus, the approach has a western foundation. Most of the literature concern analyses of developed countries, and some consider countries like Korea and Singapore with aggressive policies and technological learning (Intarakumnerd, Chairatana et al. 2002). Studies concerning developing industries have been conducted the recent decade and the amount could be expected to increase due to the increased focus on internationalization. The innovation system approach could be a useful tool to describe differences between developed and

developing countries and the research community could benefit from balancing the focus towards developing countries.

3.4 Emerging Industries

When evaluating the importance of a home market it is interesting to examine the underlying dynamics of how industries emerge, in particular the role of a home market. The field of emerging industries is a broad area of theory and it is thus difficult to get an overview of what the field does and does not include. Relatively few studies have explored the emergence of new industries, mainly because of the difficulty in evaluating empirical evidence. The empirical evidence is hard to identify until after the industry has matured or died, and scholars thus tend to stop asking theoretical questions related to the phenomenon (Forbes and Kirsch 2011). The theory is concerned with the industry creation process in terms of how it evolves, on what terms, and which key players are involved.

Theories of emergent industries are concerned with different periods of the industry creation. Figure 12, taken from Forbes and Kirsch (2011), illustrates a timeline that shows the periods before, during, and after industry emergence with four intervals that scholars might build their theories on. Interval A concerns studies of industry life spans and is relatively well-developed and easily recognized. Fewer studies are conducted from interval B which represents the theory concerning the actual emergence of an industry. Interval C and D include the period before industry founding and thus evaluate the phenomenon in broader historical context. The most relevant intervals in terms of the scope of our thesis are mainly interval B and C as they comprise the current stage of marine energy industry. Even though the amount of theory concerning these intervals is limited, we will in the following describe the most relevant parts of the emerging industry theory in order to discuss its implications for our problem statement, recognizing that we have not covered the whole field.

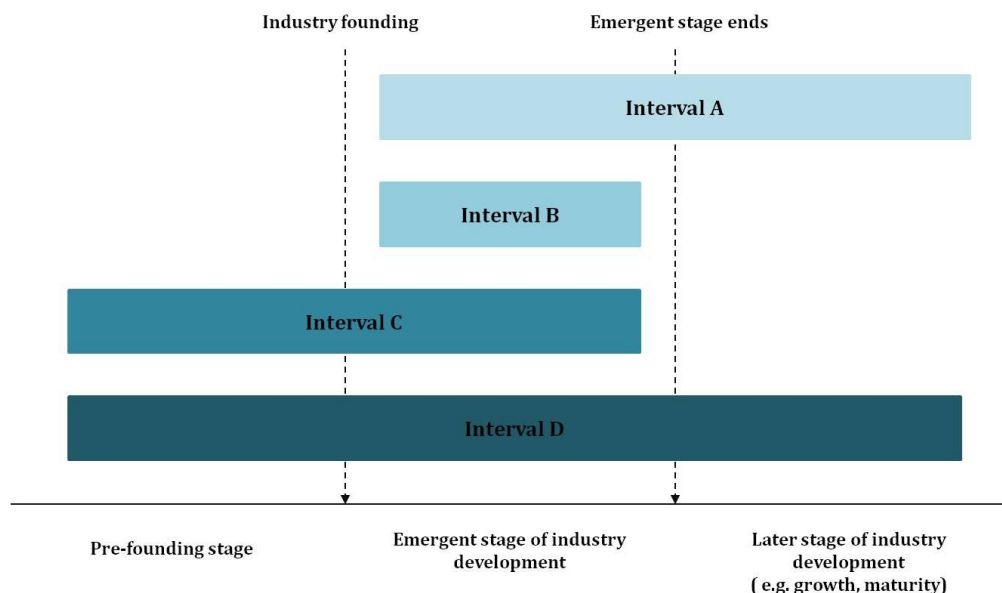


Figure 12: Industry Emergence Intervals. (Forbes and Kirsch (2011))

3.4.1 Industry Creation

An industry can be defined as a set of firms producing closely substitutable products, and emerging industries as industries in the early stage of development (Forbes and Kirsch 2011).

New emerging industries will form from collisions of technological innovation and market opportunity that will have an increasingly global character over time (Spencer, Murtha et al. 2008). According to Spencer, Murtha et al. (2008), firms need to reach out across borders in order to assemble knowledge, complementary assets, partners, suppliers and customers needed to create new businesses, but at the same time there will be benefits of geographic proximity, particularly in the industry emergence process, because of the accelerating pace of industry evolution. Research further suggests that even as emerging industries become more globally integrated, knowledge continues to circulate through national and regional communities more readily than global ones (Almeida and Kogut 1999).

According to Klepper and Graddy (1990) the prototypical new industries tend to develop as follows: Customers desired attributes of the new product are initially not well known. The early industry entrants are usually small and have experience in related technologies. In some cases the entrants are users of the new product or spinoffs of incumbent firms. Based on information about users' needs and technological means available to satisfy them, the entrants often introduce major product innovations. As successful innovators displace less efficient rivals, market shares often change rapidly. However, not all industries follow this pattern, neither do all firms within it. Klepper and Graddy (1990) find two factors that seem to have important effects on the pace of the evolution process described:

- The characteristics of the product technology; limited opportunity for technological change induces faster maturity.
- The nature of the buyers' preferences; larger variety in buyer's preferences induces longer time to mature.

According to Eliasson (2000) a whole chain of competent actors is needed in order to create a viable new industry. He calls this configuration of actors the *competence bloc*. The actors are listed below:

- (1) Competent and active customers.
- (2) Innovators who integrate technologies in new ways.
- (3) Entrepreneurs who identify profitable innovations.
- (4) Competent venture capitalists that recognize and finance the entrepreneurs.
- (5) Exit markets that facilitate ownership change.
- (6) Industrialists who take successful innovations to industrial scale.

The main function of the competence bloc is *"to guide the selection of successful innovations through its competence filter, induced by incentives and enforced by competition, and to move the innovations as fast as possible towards industrial scale production and distribution"* (Eliasson 2000, p. 222). The competence bloc thus need to attract competent investors, which in turn contribute positively to the attractiveness of the competence bloc (Eliasson 2000). The competence bloc will under these conditions develop faster than the sum of outputs from its actors as a result of synergy in terms of externalities or increasing returns to innovative search. Thus, in order for the competence bloc to become self-going into a growing industry, a minimum critical competence mass and variety is needed.

3.4.2 Timing of Entry

The decision of whether and when to enter an industry or not can be a crucial to the long-term survival of a firm. Agarwal and Bayus (2004) examined the difference in survival rates between

entrants before and after what they call the firm take-off and the sales take-off. Entrants in the pre-firm take-off stage are termed *creators*, entrants between firm take-off and sales take-off are termed *anticipators* and the entrants after the sales take-off are termed *followers*. The empirical results of Agarwal and Bayus' (2004) study imply that firm's survival in new industries is positively related to being involved in the creation of the industry. *Creators* have higher survival rates than *anticipators* and both of these entrant types have higher survival rates than *followers*. Agarwal and Bayus (2004) results also suggest that survival rate does not depend on when within the cohort group the firm enters, but is dependent on entry before or after the firm or sales take-off point.

3.4.3 Emerging Sustainable Industries

Russo (2003) has studied the emergence of sustainable emerging industries defined as: "*a collection of organizations, with a commitment to economic and environmental goals, whose members can exist and flourish (either unchanged or in evolved forms) for lengthy time-frames, in such a manner that the existing and flourishing of other collectivities of entities is permitted at related levels and in related systems*" (p. 319). Russo studied the wind energy industry in California and explored the determinants of where and when wind energy project should be established. His findings suggest that the nature of how sustainable industries will evolve in the future is connected to three related dimensions; site specificity, the speed with which traditional alternatives properly reflect ecological costs, and the level of threat posed by the sustainable industry to its corresponding traditional industry.

3.4.4 Critique of the Theory

The theory of emerging industries is a broad field concerning a range of different aspects of the industry creation process. The authors do not have major differences in opinions, mainly because they do not discuss the same subjects. Emerging industries literature is a mix of concepts that often relate to or build on other areas of theory. The competence bloc identified by Eliasson (2000) has for instance resemblances to the concepts of NSI and national competitive advantage but has a stronger focus on the industry creation phase. The concepts within the emerging industry theory is interesting and valuable separately, but seen as a unified theory, the concepts are not building on the same assumptions or theme and are thus difficult to exploit.

3.5 How is Home Market Handled in Literature?

The three areas of theory presented are all related in the way of trying to describe industry creation or attributes of systems stimulating industry creation and industry success. There are many resemblances between frameworks of the different theories; however, the impact of home market is discussed to different extent. The theory of home market effect argues that the relative size of the home market is decisive for whether a nation becomes a net exporter or importer; the larger the relative size of the home market, the more probable it is that a nation can gain a valuable exporting position. Thus, the home market is an important factor when looking at the industry successfulness within a nation. In the framework of competitive advantage of nations, Porter (1990) proposes that demand conditions is an important factor for the national competitiveness, and argues it is not only the size of the home market that is of importance, but also the sophistication of market participants. Ideally, the domestic demand should lead the international demand. The configuration of the home market is thus critical in terms of maximizing the national competitiveness.

Within the theory of NSI, consumers and their demand is noted as important factors. About 50% of literature within this field is focused on national systems and thus the national attributes such as home market. In addition, one of the functions of innovation systems is market formation, again an indication that the presence of a home market is important in terms of establishing a well-functioning innovation system. However, the configuration of the home market is not discussed in great detail.

The national diamond of Porter and the NSI theory both indicate that the presence of a home market is important to the creation and success of a national industry. The critiques of Porter stress that in addition to its domestic diamond, a nation can draw upon other countries diamonds and thereby their home market (Rugman and D'Cruz 1993). We find this debate within the SI field of theory as well, concerning the influence of globalization and the presence of open innovation systems where countries can build upon each other's systems. Niosi and Bellon (1994) argue that globalization will lead to internationalization with specialization, thus as nations become more specialized they are more dependent on each other's specialties. Both advocates for double diamonds and integrated innovation systems argue for a situation where at least the size of the home market is less important as long as other countries can provide accessible markets.

Theories concerning emerging industries are both new and differ substantially in scope. There are studies conducted concerning industry creation, industry entry, the government's role in emerging industries, as well as on sector specific industries. Most of the literature is descriptive concerning attributes of industry creation without necessarily taking the interests of specific nations into account. Eliasson's (2000) competence bloc shows resemblance to innovation systems as he lists actors that are necessary in order to bring forward innovations and create a viable new industries. However, Eliasson (2000) does not specify the boundaries of the bloc and whether the boundaries are national or international. Spencer, Murtha et al. (2008) propose that even though emerging industries grow more global, geographic proximity still is important in the creation process. Almeida and Kogut (1999) (Almeida and Kogut 1999)(Almeida and Kogut 1999)(Almeida and Kogut 1999)do not explicitly adress home markets, but their research shows that information and knowledge circulate faster within national communities, which resembles Porters cluster theory and competitiveness of nations.

Generally, emerging industries consider industry creation and do not take specific nations into account, while innovation systems and clusters consider nations but to a less extent phases of industry development. Nevertheless, Bergek and Jacobsson (2003) argued that functions of innovation systems are dependent on phases of industry evolution, where the first phase is characterized by experimentation, variety and legitimacy of technology. However, innovation systems and emerging industry approaches only evaluate certain aspects of the industry, as innovation systems assess industry actors, and emerging industry theories mostly has a firm perspective. Cluster theory considers several aspects of home markets in relation to competitive advantage of nations, but does not take evolution phases into account. Thus, different attributes may be of more importance in early phases of industry evolution, than those presented by Porter (1990).

As seen, the importance of home market in both size and content is discussed in theory, but there is little consensus on how attributes of the home market really affect international trade

pattern and competitiveness among firms and nations. However, the main findings from examining the three theories could be summarized as following:

- Having a large home market relative to other countries, will affect the industry successfulness positively.
- The sophistication of the market could be an important determinant for creating a viable industry and becoming a leading exporter.
- Companies can possibly draw on the home market of other nations, given that they are accessible for foreigners.
- Early entry to an industry could enhance the survival rate.

The question still left unanswered is whether the lack of a significant home market makes it impossible to compete in the global market. This could be identified as a possible gap in the literature as it is rarely covered, and hardly ever covered in relation to the pre-commercial phases of the industry creation. Nevertheless, the theories provide frameworks for identifying attributes of the Norwegian system and are also valuable in terms of assessing differences between nations.

In order to investigate the effects on home market configuration beyond the inadequate findings in theory, we will in the following section examine the role of home market in four mini cases from the renewable energy industry. The solar power industry in Norway and Germany, as well as the wind power industry in Denmark and the UK will be assessed briefly, followed by a discussion on how the mini-cases relate to results found in literature.

3.6 Mini Cases

3.6.1 Solar Power Industry in Norway

Norway has an insignificant domestic market in photovoltaic (PV), but has still managed to build up one of the strongest PV industries in the world (Lund 2009). The Norwegian PV companies such as REC and Elkem are among the largest in the wafer industry in which 25% of all solar wafers in 2006 originated from Norwegian companies (Wood 2006). The origin of the Norwegian solar industry can be traced to Alf Bjørseth who started the company Scanwafer, which led to the Renewable Energy Cooperation (REC). As a chemical engineer in Elkem Mr. Bjørseth recognized the opportunity of exploiting the Norwegian world leading competence in metallurgy and ferrosilicon to further develop silicon plates called wafers (Halvorsen 2006). Norway's long history in silicon production has been possible due to cheap hydropower in the manufacturing process of silicon. REC's founders took advantage of Hydro's closure of their silicon facilities in Glomfjord, a location with extensive access to energy and cooling water. By the closing down of Hydro, people with competence in silicon were out of a job and made available to REC. A large part of the founding came from adjustment capital provided by Hydro to secure their old workers a new job, as well as favourable local government support as traditional industry was shut down. The acquisitions were also made possible due to capital from external capital communities, especially utilities (Grünfeld and Espelien 2011). The ratio of public to private R&D allocations is estimated to 1:10. There was also generous government subsidies granted to investments in manufacturing facilities to reduce capital risk (Lund 2009).

RECs strategy was to find a customer before asking the government for financial support to build facilities. REC built manufacturing facilities both in Norway, namely Glomfjord and

Herøya, and abroad. Essential for REC's success were the feed-in systems in Germany and Japan. These systems subsidized the power prices and were not restricted to local content. The market increased rapidly under the feed-in-tariff regimes, and Germany experienced as much as a 100% market growth in 2004 (Wood 2006). The increase in demand led to a shortage of silicon, which created a great market for REC, being one of five or six wafer producers worldwide. Later the Norwegian solar industry has grown to include the whole value chain in solar cells and module production (Halvorsen 2006).

Elkem solar is another important contributor to the Norwegian solar industry and are one of the world's largest producers of silicone for solar cells. Elkem has developed an energy saving and cost effective metallurgical process, which makes their production facilities near Kristiansand one of the most energy effective silicone producers in the world. Several new companies have emerged around REC and Elkem and the industry now has its own industry organization, Norwegian solar power union. In addition, several research organizations like the university of Oslo and SINTEF have been leading actors within research of silicon based solar cells.

In 2011 REC shut down their manufacturing facilities in Norway, making 700 workers unemployed. 24. April 2012 the rest of their wafer production in Norway closed down, affecting 450 employees. The closing was a result of competition from Asia and cost reductions due to improvements technology (REC 2012). As the industry matures, parts of the supply chain become more standardized and thereby driven by cost factors, which make companies move production to more cost effective locations (Grünfeld and Espelien, 2011). The activity in China has grown tremendously, from 5% in 2006 to 60% today of the world's wafer production (Arbeiderpartiet 2011).

Lack of domestic demand for solar power made the Norwegian market limited, but the Norwegian solar industry still managed to become a world-leading actor. *"The Norwegian sun power industry has to a high degree proved that abundant amounts of raw materials, exploitations of effective technology and access to relevant competence, can be enough to break through in an international market in which some countries are willing to subsidize solar power"* (Grünfeld and Espelien 2011). However, the closing of REC's operations in Norway raises a question regarding the sustainability of the industry in the limited home market.

3.6.2 Solar Power Industry in Germany

Despite their geographical location, Germany is the world's top installer of PV power. Germany has almost as much capacity as the rest of the world put together, with 25 000 MW installed power (Connolly 2012). Today, solar power constitutes slightly above 1 % of the total German power production (Grünfeld and Espelien, 2011). During the oil crisis in the 1970s, coal and nuclear energy grew to large dimensions in Germany. The dependency on coal and nuclear energy led to environmental movements in the 1970s and 1980s, which resulted in support regimes for renewable energy (Mez 2004). Their current large amount of renewable energy production, from both wind and solar power in Germany, is primarily a result of the feed-in tariffs established in 1991, which was amended in 2000 in order to guarantee stable feed-in tariffs for up to 20 years (Wood 2006; Frondel, Ritter et al. 2008). The feed-in tariffs make the utilities obliged to accept power delivery into their grid from independent renewable energy producers. In this way, the utilities pay considerably more than their production cost, which again is reflected in the electricity price for industrial and private consumers (Frondel, Ritter et al. 2008). Compared to other renewable energy technologies in Germany, solar electricity was

guaranteed the largest financial support per KWh. Large financial support was necessary for creating a position in a market with low technological efficiency and an unfavorable geographical location. The high industry growth rate led to both shortage in silicon, and made the domestic production unable to satisfy the demand. Thus, most of the modules were imported in 2004 and 2005 (Fronzel, Ritter et al. 2008).

Germany's support system is considered to be successful by many, and has been adopted by several other countries. The German prices decreased by more than 45 % in 2011, largely due to Chinese competition and cost reductions. The massive growth in the solar industry has caused the German government to plan a reduction in subsidies by up to 30% (Blau 2012). Although Germany has reached market leadership through the feed-in tariff system, many argue that the high support level is unfavourable. Fronzel, Ritter et al. (2008) argue that there is minimal contribution of reduced emissions and that the net employment balance is negative due to high opportunity cost of supporting PV. The fact that PV technological efficiencies are below the theoretical potential makes Fronzel, Ritter et al. (2008) argue that funding R&D in order to obtain technology improvements should be done before supporting market penetration.

Germany does not have the best physical conditions for solar power, but created a home market by implementing favourable demand-side policies focused on solar power. The subsidy created home market led to high industry growth and made Germany industry leaders within solar energy.

3.6.3 Onshore Wind Power Industry in Denmark

Denmark has a long tradition of using windmills in agriculture and has leveraged on this competence in order to create and sustain a comparative advantage in the wind power industry. Denmark has limited conventional energy resources and has historically had an energy mix that relies heavily on imported fossil fuel (AquamarinePower 2010). In order to explore other energy options, Denmark was one of the first European countries to introduce support to wind electricity already in the late 1970s (Lund 2009). Denmark introduced R&D support that helped standardize the design to a three-blade turbine in which the industry coalesced around (AquamarinePower 2010). The government had an early political vision within wind power including financial support mechanisms and priority grid access. In 1985, the Danish government prohibited development of nuclear power plants and at the same time put in place a system of fixed incentives. This system favoured early development by independent investors in cooperation with local communities and lasted in almost 20 years (Lund 2009). The system provided security for private investors and made them contribute to the development of wind energy on a commercial basis. The Danish Wind Turbine Testing Station (DWTS) was established early on, and engaged in iterative processes for producers seeking to upgrade their products. The DWTS enabled publicly available test data, encouraged openness and interaction among producers and users, and thus became a critical test centre of knowledge (Spencer, Murtha et al. 2008). In addition, the government introduced subsidies for turbine ownership, provided that the equipment met the certification standards, which reinforced the influence of the DWTS (Spencer, Murtha et al. 2008).

The development efforts made by the government and private actors created a strong home market compared to other countries. While some of the large international markets, such as the American (mostly Californian), took a hit when subsidies terminated abruptly, Danish

companies survived because of its secure home market (Spencer, Murtha et al. 2008). The early technological support, fixed and long-term incentive system, and experience in large scale commercial wind installations, gave the Danish wind power industry a first mover advantage (AquamarinePower 2010). During the late 1980s and early 1990s the Danish market represented 20% of the world capacity, helping the domestic industry in the expansion phase (Lund 2009). Danish companies thus formed a strong international reputation for innovation, efficiency and reliability during the 1980s, which has sustained to this day.

Today, the Danish market is saturated with about 20% of the electricity consumption coming from wind power, and is thus mainly export driven. The share of export has always been high and in 2009, almost every second wind turbine worldwide was Danish (Lund 2009). The Danish wind power industry today employs about 28,000 workers and contributes €1.5 billion in Gross Value Added (GVA) to the national economy each year (AquamarinePower 2010). The industry's impact on the Danish economy makes it evident that the wind power industry has provided Denmark with many benefits, other than clean electricity.

The case of Denmark indicates that there is a strong correlation between industrial success and a viable home market, and exemplifies how a small country can become a world actor within a new energy industry by mastering the commercialization process (Lund 2009).

3.6.4 Onshore Wind Power Industry in the UK

The UK also tried to build up an industry around onshore wind in the 1980s, but did not manage to capture the full economic benefits as Denmark in the preceding case (AquamarinePower 2010). The UK had a different energy outlook in the 1980s; the North Sea being plentiful and some coal reserves remained, while nuclear power and austerity were on the agenda. Thus, the industry was not considered a great priority even though some R&D investments were made (AquamarinePower 2010). UK was too long in the inception phase (Phillips 2012), and capacity grew very slowly (AquamarinePower 2010).

In 1985, the British company, WEG, launched a direct competitor to Denmark and Vestas' success turbine V27. WEG was at this point in the forefront technologically, but lacked a home market as the Danes and Germans had protected their markets (Phillips 2012). Another UK manufacturer, Howden who had specialized on the Californian market because of the limited domestic demand, had to withdraw from the wind power industry in 1988 after technical difficulties. In retrospect, questions have been asked whether the same decisions had been made if there were a home market to prop things up (Phillips 2012).

Eventually, a home market emerged at the very end of the decade when the government introduced the Non-Fossil Fuel Obligation (NFFO) scheme in 1990. The scheme was originally intended to support nuclear energy as a part of a move to privatize the industry, and provided a price support mechanism for energy developers to compete for premium priced energy contracts (AquamarinePower 2010). The NFFO contracts made electricity pricing highly competitive as the bidder with the lowest price received government allocated capacity. This mechanism drove the average price of wind energy down from 11 to 2.9 p/kWh over the first decade. In addition, the NFFO scheme put a strain on existing manufacturers as the developers had a fixed period of time to maximize energy production under premium prices. This resulted in developers being forced to import turbines that could be rapidly deployed. In the period between 1980 and 2000 the UK invested nearly as much resources on R&D as Denmark, but

failed to provide a stable market pull-mechanism; Denmark spent about €950 million on market incentives (between 1980 and 2000), compared to €285 million (between 1990 and 2000) in the UK. Thus, the timing and design of the NFFO pull-mechanisms proved to be poor, as both Denmark and Germany already had gained a competitive advantage. The result was that the majority of the economic benefits was lost to other countries (AquamarinePower 2010), which is bitterly regretted by British industry and considered a lost opportunity (Phillips 2012). Although there were technical failures present in the British wind power development, many believe that it was the absence of a protected home market that led to the failure.

The case of UK shows the importance of timing and proper support policies in the development of a new industry. The home market was present, but the pace of development in other countries combined with insufficient policies resulted in UK's onshore wind industry development being considered a failure compared to its competitors.

3.7 Discussion of Theory and Mini Cases

The mini cases give new insight to the findings in literature concerning the importance of a home market in building a new industry. This section will compare the literature findings in light of the mini cases before presenting research questions for further study.

The literature concerning home market effect argues that a country will become a net exporter of a good whose domestic demand is larger than the global average. Through a successful political regime for wind energy, Denmark managed to create a major domestic onshore wind market and became a world leader. In contrast, Norwegian REC was one of few silicon companies in the world around 2004 with no home market for solar power, but benefited from the closing of Hydro's metallurgical business in Norway.

Both Porter's cluster theory and innovation system theory discuss demand conditions and market formation. The mini cases had different demand conditions: Norwegian metallurgical industry needed new initiatives to utilize the competence and unemployed workers. Denmark and Germany, whose energy mix consisted of coal and nuclear power, required cleaner energy sources. However, Denmark and Germany did not have optimal natural conditions. Germany is far from one of the sunniest countries in the world and Denmark has poorer wind resources than both Norway and the UK. Moderate physical resources resemble Porter's argument of a sophisticated and demanding market, as developers must create more efficient solutions. Nevertheless, the mini cases prove that Denmark and Germany managed to create home markets mainly through political actions that formed well-functioning innovation systems. Germany and Denmark are cases where home markets created by subsidies led to international success. Despite favourable wind conditions, the UK failed to establish a home market. UK did not have the same pressure for establishing a renewable energy industry as the focus were on nuclear power, and thereby created a poorer innovation system with their subsidies. Porter presents the government as an important attribute for support and compliment of the system of national competitiveness, but not as an attribute that creates lasting competitive advantage. However, it may seem that when building a renewable energy industry, traditional cluster attributes might not be as decisive for success as the right subsidy regime as well as having a strong local pressure for change. The mini cases show that policy regimes are important to create a home market within renewable energy, but when the market is matured the other attributes might be of more importance. Thus, other factors than the ones presented in cluster

theory are decisive before the industry has developed cost competitive technology, as policies are crucial factors in the mini cases.

Theories concerning double diamonds and open innovation systems argue that nations can utilize foreign markets. This is the case of the Norwegian solar power industry. REC used the Norwegian metallurgical competence and utilized foreign markets with beneficial subsidy regimes, not restricted to local content. When REC signed with German and Japanese customers they got additional support from the Norwegian government to build facilities. UK did not have the same opportunity for exploitation of other markets, as both Germany and Denmark had protected home markets. Consequently, other markets must be accessible in order for nations to access attributes lacking in their home market, which indicates that double diamonds and open innovation systems can be used to describe development of renewable energy industries.

Emerging industry approaches argue that industries get more global as they mature and that the timing of entry may be of importance for later success. Both Germany and Denmark were first movers within their industries, while the UK actors view the national entry as too late. REC was a first mover in silicone for the solar power industry, but their customers were mainly in foreign markets. The example from the solar power industry in Norway and the wind power industry in Denmark indicate that early international entry is of significant importance to the successfulness of a national industry. The theory of Agarwal and Bayus (2004) concerning timing of entry at firm level could thus be considered relevant at country and industry levels as well.

As the solar industry has evolved, market prices have declined and competition, especially from Asia has increased. Even though REC managed to become an industry leader with a limited home market, it closed down production in Norway when competition increased. In contrast to Norwegian solar power industry, Denmark found security in their home market when the rest of the industry struggled. Thus, a viable home market may be favourable in relation to stability and changes in the industry.

The literature did not give a clear insight of whether the lack of a significant home market makes it impossible to compete in the global market. The mini cases have given us additional insight by demonstrating that nations without optimal factor conditions can create successful markets with policy regimes, and that it is possible to become an industry leader with a limited home market, but this position may be hard to retain as the industry matures. To summarize, the theory and mini cases lead us to the following main findings:

- In a nation without optimal conditions, a market can still be created by devoted support mechanisms, but this will require the right policy, priority, demand, local pressure and timing. Denmark and Germany succeeded and UK failed when trying to create a home market based on support mechanisms.
- To participate in the development of an industry with a limited home market, another competence might be necessary. This was the case with the solar industry in Norway and the established metallurgical industry.
- It is possible to have international success with a limited a home market as long as there are other markets available with a strong demand. Germany and Japan had favourable support regimes, not restricted to local content. The solar industry also experienced a shortage of silicon, creating a high demand in international markets, where REC was one

of few suppliers. However, if an industry is created despite a limited home market, it is more sensitive to changes in the industry and it might be difficult to keep the industry in a nation without demand. This is illustrated in RECs closing in Norway, in contrast to Denmark's security in their home market when the rest of the industry struggled.

- Early entry could constitute an important factor to successfulness of a national industry. Early entrants reap the benefits from support schemes and demand before considerable competition is present, thus giving the industry an important technological lead. This is indicated by Germany and Denmark's success in onshore wind, compared to the laggard UK industry.

3.8 Research Questions

Based on the previous discussion and main findings, we will in the following bring forth some key questions to further assess to what extent Norway can develop a marine energy industry with a limited home market. The first question considers how the Norwegian system affects development of marine energy industry and presents the political system and other central actors. The second question further assesses the Norwegian conditions and whether there are favourable conditions in Norway that may be utilized. The third question discusses other favourable markets that may be exploited, and the last question investigates the importance of timing, that is, when involvement should happen and evolve.

As the mini cases indicated, policy regimes are a prominent factor in development of renewable energy industries. There is also a need for pressure for renewable energy and implementation, or other initiatives that shape the industry, such as private initiatives like REC in the Norwegian solar industry. Innovation system theories assess different actors and their collective contribution for innovation, which underline the importance of evaluating the whole industry. Important actors are the political system, including government and support scheme organizations, entrepreneurs, large companies, investors as well as the general public.

1. How is the contribution from Norwegian system actors in the development of marine energy industry perceived? - System actors being the political system, investors, large companies, entrepreneurs, and the public.

The Norwegian solar industry mini case indicated that it is possible to develop industry with a limited home market by altering an already existing industry. The marine energy industry is characterized by research and technology development and is in need of innovation and new ways of thinking. If Norway enhances competences that are applicable to the marine energy value chain, it could be possible to develop a Norwegian industry despite a limited home market.

2. Are there any advantageous conditions in Norway that can compensate for a limited home market?

As Norway has a limited home market, other nations' national diamonds and open innovation systems may be utilized as a strategy for Norwegian participation in developing the marine energy industry. Foreign will thus be addressed.

3. What markets can Norwegian companies exploit to succeed with a limited a home market?

Emerging industry theory is consistent with evidence from the UK mini-case, and suggests that it is favourable to enter in the early phases of industry development. If Norway wants to be a major contributor in the future, timing could be an important question.

4. How important is timing for the development of a Norwegian marine energy industry?

The questions concern actors *who* affect industry development, *what* favourable conditions that may exist in Norway, *where* favourable markets are and *when* involvement should happen. Figure 13 illustrates the problem statement and the different research questions. The two first questions address the Norwegian conditions for developing marine energy industry with a limited home market, question three assess opportunities related to foreign markets and question four consider issues related to timing and involvement in the marine energy industry.

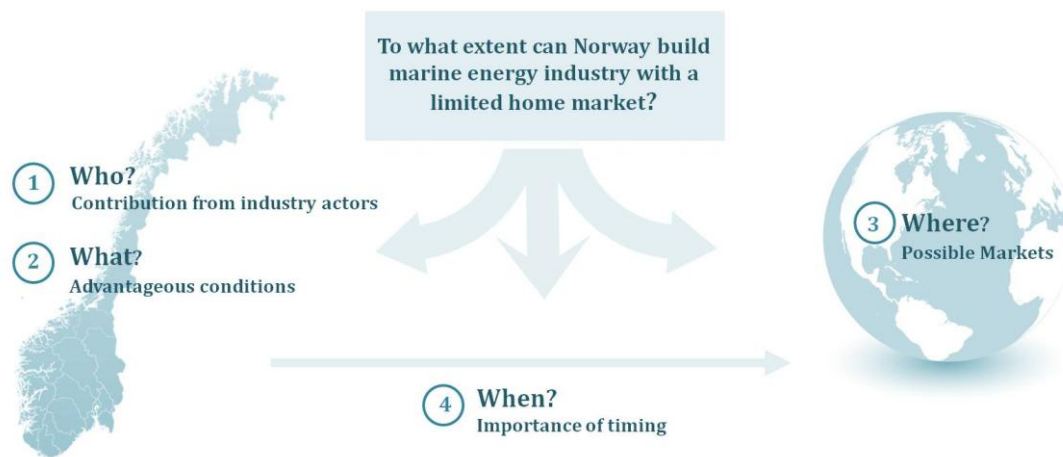


Figure 13 Illustration of research questions

To obtain first-hand information and opinions concerning the prevailing state and future of the industry, we conducted interviews with different actors in the Norwegian industry as well as some interviews with Scottish representatives. The methodology for the work executed in this master thesis will be elaborated further in the next chapter, before highlights from the interviews are presented in chapter 5, and finally chapter 6 contains the analysis where we discuss and answer the research questions.

4 Methodology

This master thesis is a follow-up on the introductory project assignment conducted fall 2011. The project assignment was concerned with identifying challenges met by Norwegian wave and tidal companies and the results from the project analysis lay the basis for the problem statement in this master thesis. One of the main challenges identified for the Norwegian companies was the lack of a viable home market. This thesis thus aims to clarify if and how it is possible to build a marine energy industry in Norway with a limited home market.

The work conducted in this master thesis can be identified as a case study examining the marine energy industry in Norway. Yin (2009) describes case study research as a linear, but iterative process of plan, design, prepare, collect, analyze and share. Case studies often include qualitative studies, which comprise many variables and small sets, are context-sensitive and understand complexity (Jensen 2011). This chapter will present our case study methodology by describing our research processes, and a brief evaluation of possible shortcomings.

4.1 Plan

The purpose of this master thesis is to explore the Norwegian marine energy industry and the actors that influence the industry in order to examine the importance of a home market in industry creation. As the marine energy industry is pre-commercial and not clearly defined, the research question is similar to *exploratory research* (Yin 2009). A case study is often used when the research question addressed are how, why or what (when exploratory), when examining contemporary events in a real life context, and when one has little control over events where the context boundaries are unclear (Yin 2009). Thus, case study is a suitable research method for our purpose.

4.2 Design

The study can be described as using a *multiple-case design* for assessing the importance of a home market in building a viable marine energy industry, in which individual companies have different opinions on the matter. Each firm is the subject of an individual case study, but the study as a whole covers several firms and in this way uses a multiple case design (Yin 2009). By having multiple cases, a *replication approach* can be utilized, in which the convergent evidence is sought regarding the facts and conclusions for each case (Yin 2009). Thus, we have learned new elements from each case, which have provided both congruencies and differences regarding findings from earlier cases. Identifying different views on the future of the Norwegian marine energy industry in each case firm can be described as an *embedded design* in which subunits of analysis is incorporated (Yin 2009).

4.3 Data collection

Yin (2009) discusses six sources of case study evidence; documentation, archival records, interviews, direct observation, participant-observation, and physical artefacts. To maximize the benefits of these six sources of evidence (Yin 2009), and increase the *credibility* and *reliability* of the study (Bryman 2008), we have triangulated data from multiple sources of evidence, and cross-referenced our findings in order to create a *chain of evidence*.

The primary sources of our project assignment are:

Interviews:

- Support scheme organizations
- Investors
- Large industrial companies
- Interest organizations
- Wave power companies
- Tidal power companies

Documents:

- Journal articles
- Scientific publications
- Conference proceedings
- Reports from interest organizations
- News articles and news clippings
- Home pages
- Lecture material
- Personal, confidential documents from some of the companies

Direct Observation:

- Conferences

4.3.1 Interviews

4.3.1.1 Case Study Subjects

Our main source of case study information is the ten interviews we conducted in the time period from February 29th to March 19th 2012, as well as the nine interviews conducted in the project assignment in the fall 2011. The method for selecting interview subjects can best be described as a mix of *quota sampling* defined as “a sample that non-randomly samples a population in terms of the relative proportions of people in different categories” (Bryman 2008, p.697), and *snowball sampling* defined as “a non-probability sample in which the researcher makes initial contact with a small group of people who are relevant to the research topic and then uses these to establish contact with others” (Bryman 2008, p. 699). When preparing the initial list of interviewees, the majority of the interviews were selected through *quota sampling* as we wanted to produce a sample that reflected the variety of actors and attitudes toward the marine energy industry in Norway. *Snowball sampling* was used in some incidents when people in the industry introduced new actors that could be of interest to our thesis. This was the case when deciding to interview SN Power after listening to partner in Northzone venture, Tollef Thorleifsson’s, presentation on the Enova conference in January 2012.

When deciding upon which companies to interview, we wanted to ensure *internal validity* by including as many industry representatives as possible. We already had the opinions of a broad spectre of entrepreneurs from the marine energy industry from the project assignment fall 2011 and thus wanted to include supporting actors such as the support scheme organizations, government representatives, researchers, investors, as well as other renewable energy companies that could figure as a potential partners, model companies or provide opinions from a large company’s perspective.

In the project assignment conducted fall 2012, many of the company representatives referred to UK as the leading country within wave and tidal energy and we thus wanted to talk to British industry representatives in order to identify differences in both system and focus in relation to home market. We contacted several UK firms, but most of them declined our request for a focused interview and invited us to visit them at their exhibition stand at the Renewable UK Wave and Tidal conference 2012. However, we managed to get an interview the wave and tidal development manager in Renewable UK, David Krohn, who has extensive understanding of the marine energy business sector in the UK. During the conference we also conducted a short interview with Tore Gulli from Fred Olsen, which was one of the interview subjects in the project assignment fall 2012. Tore Gulli provided his opinion on the new problem statement.

In total we interviewed ten companies in depth listed in Table 4 below:

| Company | Location | Interviewee | Type of company |
|-------------------|-----------|---|-------------------------------------|
| CICERO | Oslo | Asbjørn Torvanger | Research centre |
| Scatec | Oslo | Jan Magnussen and Jørgen Dale | Incubator and some venture activity |
| Rambøll | Oslo | Espen B. Christophersen | Technical consulting |
| Forskningsrådet | Oslo | Tor Arne Hafstad | Support scheme organization |
| Northzone Venture | Oslo | Tellef Thorleifsson | Venture fund |
| SN Power | Oslo | Marianne Hauge Olsen, Jarl Kosberg and Olav Hølland | Renewable energy company |
| Innovation Norway | Trondheim | Bergny Irene Dahl | Support scheme organization |
| ENOVA | Trondheim | Øyvind Leistad | Support scheme organization |
| Renewable UK | Edinburgh | David Krohn | Special interest organization UK |
| SAE Vind | Telephone | Anders Gaudestad | Wind power company |

Table 4: Companies Interviewed Spring 2012

In the project assignment 2011 we used a form of *quota sampling* of the Norwegian marine industry as the selected companies represented the generality of the population. We interviewed four wave companies, four tidal companies as well as a special interest organization, all listed in Table 5. Summary of these interviews are enclosed in appendix A3 and serve as data for this thesis in addition to the interviews conducted spring 2012.

| Company | Location | Interviewee | Type of Company |
|-----------------------|------------|-------------------------|-------------------------------|
| Langlee Wave Power | Telephone | Cathrine Bryøen | Wave Power |
| Pontoon Power | Trondheim | Nils Myklebust | Wave Power |
| Fred. Olsen | Telephone | Tore Gulli | Wave Power |
| NLI (OWC) | Lillestrøm | Anders Tørud | Wave Power |
| Tidal Sails | Haugesund | Are Børghesen | Tidal Power |
| Hammerfest Strøm | Telephone | Harald Johansen | Tidal Power |
| Aqua Energy Solution | Oslo | Cathrine Torvestad | Tidal Power |
| Norwegian Ocean Power | Trondheim | Kent Thoresen | Tidal Power |
| NORWEA | Oslo | Carl Gustaf Rye-Florenz | Special interest organization |

Table 5: Companies interviewed Fall 2011 in the Project Assignment

4.3.1.2 Terminology Used on the Different Actors in the Norwegian Industry

To easier discuss the Norwegian marine energy industry and its actors, a clarification of the terminology is needed. Figure 14 shows a simplified illustration of the Norwegian innovation system, based on the OECD model by Kuhlmann and Arnold (2001). The actors depicted in the figure can all affect the development of marine energy and will in the following be referred to as *system actors*, while *industry actors* are referred to as all system actors that are engaged in marine energy. The system is divided into four attributes: *demand*, *industry system*, *education and research*, *political system* and *infrastructure*. The case study companies are placed under their respective heading in the figure.

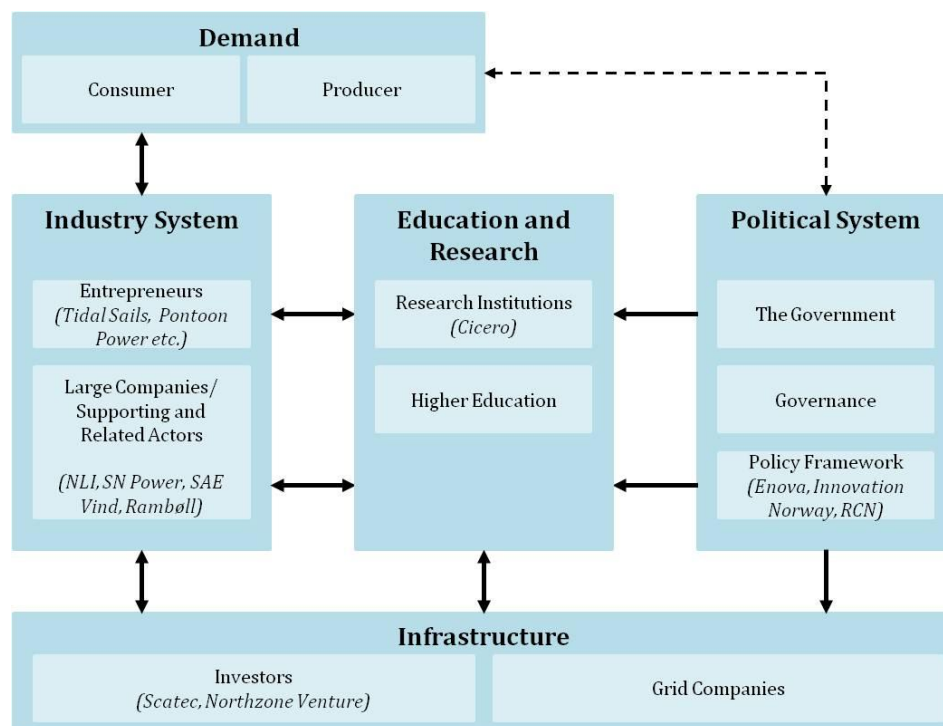


Figure 14: Overview of the Norwegian Innovation System for Marine Energy

The industry system includes the *entrepreneurs* and *large companies*. By entrepreneurs we refer to the device developing companies interviewed in the project assignment during fall 2011 (Appendix A3). “Large companies” is a wide label referring to the larger companies involved in the wave and tidal industry, as well as companies in related industries such as petroleum, maritime, hydropower and other renewable industries that are contributing or could potentially contribute to the marine energy industry. Large companies thus include large utilities, oil production companies, supply companies to petroleum and maritime operations and shipbuilders to name a few. Among the case study companies, NLI, SAE Vind, Rambøll and SN Power are classified as large companies.

Education and research includes *research institutions* such as Cicero, CenSes, SINTEF, CREE, and CICEP, as well as *higher education* institutions including universities and academies. Education and research institutions provide the marine energy industry with knowledge both in terms of human capital and project support.

The political system constitutes of the government that develops the *policy framework*, which decides funding and priority areas for the *support scheme organizations*. The case study companies Enova, Innovation Norway and the Research Council in Norway are classified as support scheme organizations.

Infrastructure refers to the companies with infrastructural functions such as *investors* providing financial resources, and grid companies organizing possible utilization of the power devices. Northzone Ventures and Scatec are categorized as investors. Northzone Ventures is labeled a venture capital firm and Scatec an incubator with some venture capital activities (appendix A6).

Demand refers to costumers of marine energy devices, both intermediary companies and end costumers. As all Norwegians and Europeans utilize electricity, the potential end customers will be referred to as the *public* in the discussion chapter.

4.3.1.3 Interview Design

When preparing for the interviews, we created an interview guide based on topics we considered relevant to our problem statement. The type of interview conducted can best be described as *focused interviews* defined by Yin (2009). The interviews were conducted in a short timeframe, about an hour, and the questions were open-ended. The topics prepared in the interview guide were covered in all interviews, but the formulation of questions and focus varied among the interviews as the interviewees had different perspectives and interests.

All interviews were face-to-face interviews apart from the interview with SAE Vind. However, the procedure was the same for all interviews. We recorded every interview in order to provide a more accurate rendition and to be able to be more flexible during the interview. We were careful to ask the interviewees of permission to use the recorder to assure that they were comfortable with the interview setting.

During the interviews, we both asked questions and took notes when we felt it was needed. However, most of the note taking was done after the interview when listening to the recorded material. On the basis of our notes, we made summaries of the interviews, which include all the topics relevant to our case study. The summaries were sent to the interviewees for approval in order to assure *construct validity*. The summaries are included in the empirical part of this thesis.

The short interview with Tore Gulli from Fred Olsen was of a more informal character and was not recorded. A summary of the interview was nevertheless sent to Mr. Gulli for approval in order to assure *construct validity*. The interview is a part of the conference summary enclosed in appendix A4.

4.3.2 Direct Observations

We attended two conferences related to renewable energy; the Enova-conference “The green gold” held in Trondheim January 24th – 25th 2012, and Renewable UK’s Wave and Tidal Conference 2012 March 14th and 15th. The Enova conference was concerned with the future of Norwegian development of renewable energy and energy efficiency on a general basis, while the Renewable UK conference was focused merely on the wave and tidal industry. The conferences gave us the opportunity to observe the industry closely and learn about the different opinions that are present within the sector, which helped us to ensure *internal validity*.

4.3.2.1 Conference Preparations and Execution

Before attending the conferences, research on the key speakers was conducted to better understand the speaker’s point of view, as well as research on the main discussion topics. During the conferences we both took notes in order to document our main findings from the event. A written summary of the UK Wave and Tidal conference and the Enova conference program are enclosed in the appendix A4 in order to ensure *reliability* of our findings.

4.3.3 Documents

In this case study we have used documents related to theory discussing the importance of home market and industry development, documents concerning development of renewable energy industries, as well as documents available about Norwegian and foreign marine energy industry.

4.3.3.1 Literature Search

We have used *analytical generalization*, in which a previously developed theory is used as a template to compare results (Yin, 2009). In order to answer the question of the how the absence of a home market affects the likelihood of developing a viable industry, we have used literature to identify the effect of home market as well as key factors in successful industry creation.

4.3.3.2 Search Strategy

We first used two main databases in search of articles, ISI Web of Science and SCOPUS (Elsevier), as these were the recommended databases from our supervisors. Keyword search was chosen, as we did not know what research fields we had to study before finding the first relevant articles. Keywords that was believed to prevail relevant articles were identified, these keywords were “Home market”, “Domestic demand”, “National innovation”, “Industry creation”, “Renewable energy and governmental support” and combination and variants of these. Two established literature fields was found, namely theories on *New Trade Theory* and theories on *Systems of Innovation*

In order to recognize whether there was conducted newer research on the importance of home market that was not covered in the leading journal found in the more credible databases, Google Scholar was used with the same keyword search. Through search via Google Scholar, theory on *Emerging Industries* was discovered as a third field of literature relevant for our thesis, as well as newer literature on new trade theory and theory on systems of innovation.

4.3.3.3 Selection of Articles

In total, 47 articles were selected for a review. The articles were found in journals of varying standard; the standard of journals related to New trade theory and National Innovation Systems were generally of high standard as they represent well-documented areas of literature. The field of Emerging Industries is less studied and the articles were thus newer, and not mere from leading journals. However, the journals with the most citations were chosen to ensure *construct validity*. After a thorough review, 16 articles were left out as they did not contribute to better understanding of the problem statement of the master thesis. In total, 31 articles were used in the literature study.

4.3.3.4 Review Procedure

After reading each article, summaries were written in order to assess the content of each article in a more manageable format. The literature was supposed to provide a basis for finding relevant research questions that could divide the main problem statement into smaller, less complex sub problems. However, the literature proved to be vague in answering what the effects of a limited home market could be and we thus found it necessary to inspect real life cases of development of other renewable energy industries in order to put the literature into context.

4.3.3.5 Documents Concerning Development of Renewable Energy Industries

Four industries were chosen as mini cases for assessing the literature findings; the solar power industries in Norway and Germany, and the onshore wind industry in Denmark and the UK. When selecting our data sources, a mix of journal articles and industry reports was utilized. The same method described for the literature search was used to find relevant journal articles with the search keywords “Denmark Wind power”, “Vestas”, “Norway Solar power”, “REC”, “Germany solar power”, “UK wind power”, and variation of these. Industry reports were selected from sources considered credible and rival explanations was investigated to ensure *internal validity*.

4.3.3.6 Documents Concerning the Marine Energy Industry

When conducting industry research, data sources were carefully selected as there is much information available about the wave and tidal power industry. To get an overview of the industry, we selected data from sources considered credible such as industry reports from the well-known research institutions ENOVA, ELFORSK, Renewable Energy Policy Network for the 21st Century (REN21), International Energy Agency (IEA) and International Panel on Climate Change (IPCC). In addition, we have utilized conference proceedings, such as various industry reports from the Renewable UK wave and tidal conference. Less credible sources such as newspaper articles, news clippings and internet pages were also utilized. For each data source we did an evaluation of objectivity and tried to find additional sources if we were uncertain of the credibility.

4.4 Evaluating the Research Design

For judging the quality of research design Yin (2009) mentions four common tests that apply to our study; *construct validity*, *internal validity*, *external validity* and *reliability*.

The *construct validity* of our study is believed to be quite strong. First, the chances of actually measuring the concepts we study are improved by using multiple firms, different documents as sources as well as direct observations from the conferences. We interviewed subjects with rival explanations, which gave us the opinions of the majority of industry actors and supporting

actors in the industry. Second, as we recorded all the interviews we avoided, to a large extent, losing or misinterpret information. Third, by sending the representatives the summarized interviews at the end of the research period, we got detailed response down to sentence level, as well as obtained additional information that had been left out from the interview. The companies' review also provided new information on the firms' current status, which was included in the paper.

The *construct validity* of the literature study is to some degree reduced due to the limited number of articles within the three different literature areas as well as the search strategy. Relevant articles could have been overlooked due to limited number of databases, keyword utilized and personal bias in the selection of articles. In addition, the literature on emerging industries is very scattered and diverse in scope. As it was challenging to get an overview of the theory, the literature review on the area might have been less intricate than for the other two theories. However, to ensure that the articles represented the most important and trustworthy sources in the field, we chose the articles most cited and looked for cross-references to ensure interrelation.

The *internal validity* could be reduced due to personality of interview subjects and personal bias. However, we have throughout the case study tried to pursue rival explanations by interviewing a wide spectrum of industry actors to unravel possible outcome of the Norwegian marine energy industry.

The use of multiple firms increases the *external validity* by providing a broader basis than just one case firm (Yin 2009). The assessment of the British special interest organization, as well as general observations at the Renewable UK wave and tidal conference, increased the *external validity* beyond the Norwegian context. In addition, the empirical study of several mini cases increased the *external validity*, by extending the study to regard the marine energy industry development in the light of other renewable energy industries. Interviewing companies involved in other renewable energy areas also increased the *external validity* by providing opinions from actors not directly involved in the marine energy industry.

Yin (2009) stresses the importance of communicating according to the preferences of the potential readers. When possible, the most desirable solution is to present the identities of both the case company and the individuals. In doing this, the reader can recollect any other previous information about the case and make it easier to review the references (Yin 2009). By documenting summaries of the interviews and conferences, and providing the identity of both the firms and individuals, others can more easily repeat the study to find the same results. Thus, the *reliability* of the thesis is considered strong. However, due to the dynamic nature of the marine energy industry, our findings are compatible to the current situation and are likely to change over time.

4.5 Analyzing Case Study Evidence

"Data analysis consists of examining, categorizing, tabulating, testing, or otherwise recombining evidence, to draw empirically based conclusions" (Yin 2009, p. 126). The analyzing strategy we have used in this thesis can best be described as a mix between *relying on theoretical propositions* and *developing a case description* identified by Yin (2009). We started by defining a problem statement based on the introductory project of challenges in the Norwegian marine energy industry conducted in the fall 2011. We did not create specific propositions on possible

findings from the marine energy case study. However, as we reviewed literature and conducted further research on similar industries, we divided the main problem into four research questions that were examined thoroughly on the basis of interviews, direct observations and documents in order to discuss the main problem.

Throughout the analysis we have tried to attend to all sources of evidence to best cover the key research questions and leave no loose ends. Moreover, we have tried to address all major rival interpretations by presenting as many opinions on the problem as possible. By dividing the main problem into four research questions grounded in theory and real life cases from other industries, we believe that we have addressed the most significant aspects of the case study and avoided detours concerning lesser issues.

4.6 What Could Have Been Done Differently?

Looking back at the case study work, we could have done some parts differently. Whether this had improved our thesis is uncertain, as we are confident that the approach we have utilized has been satisfactory for the intended purpose.

We could have included government representatives in our interviews to get their perspective on the Norwegian policy. Unfortunately, we did not manage to get in touch with any ministry representatives. However, the minister of petroleum and energy was head speaker at the Enova-conference and talked about the future of renewable energy development in Norway, which gave us valuable insight in the government's focus. Furthermore, we could have contacted additional potential industrial partners and utilities to the industry such as Statoil. By including such actors we could have gained a more balanced view of the industry, and increased the *construct validity* of the master thesis. In addition, we could have conducted additional follow-up interviews of the wave and tidal entrepreneurs interviewed during the fall 2012, in order to inspect whether their opinions on specific matters have changed and get their view on the new problem statement.

A weakness of the case study method is that the outcome is bounded to the case study subjects and the results might have been different if we interviewed other surrounding actors. We could thus have extended the number of case study subject in order to increase *internal* and *construct validity* further. However, we believe that the number of case studies and the variation of case study subjects are sufficient for the scope of our thesis.

We could have conducted *in depth interviews*, where the relationship between the interviewer and interviewee continues over a longer period of time with several interactions (Yin, 2009), in order to analyze the challenges of the case study in more depth. However most of the case study companies were too very occupied, making them unlikely to contribute to such a study. Moreover, many of the interview subjects did not yet operate in the marine energy industry, or not on a regular basis, which made any interview beyond the initial less interesting to our thesis. We could also have conducted *survey-like interviews* instead of *focused interviews* where all the firms got the same questions. The questions and answers could have been included, making it easier for different readers to compare answers and make up their own opinion (Yin, 2009). A survey could also have been included to get a quantitative element in the research and verify our findings. However, the companies interviewed differed immensely in character and it would have been difficult to create questions that would be appropriate for all companies.

We created extensive summaries of the companies and included them in the thesis instead of tabulating the interviews and enclosed them in the appendix. By including tabulation of the interviews, the reader would have been able to evaluate the answers given by the case study companies for themselves and regard the interviews in their entirety. However, by sending the interviews to the case study companies for validation, possible misinterpretations are avoided.

During the interview with Espen B. Christophersen in Rambøll, the tape recorder memory turned full ten minutes into the interview, in which we did not notice at the time. From a technical point of view, we should have assured that the tape recorder memory was sufficient before starting the interviews. In this way we would not have lost the recorded interview with Espen B. Christophersen from Rambøll and his opinions would be better documented. However, we noticed the accident immediately after the interview and manage to write down the key points discussed. The interview summary of Rambøll is nevertheless not as detailed as for the other companies.

5 Interviews

5.1 Center for International Climate and Environmental Research – Oslo (CICERO)

Name: Asbjørn Torvanger
Position: Senior Research Fellow
Date, place: 29.02.2012, Oslo

5.1.1 Organization background

CICERO was established in 1990, and is a research center dedicated to work with one topic, namely climate. CICERO's main tasks are to conduct climate research as well as communicate information about every aspect of the climate issues: the climate system and human impacts on the climate system, the consequences of human impacts and how to reduce impacts through mitigation of greenhouse gas emissions or adapt to climate changes. CICERO has been in rapid growth and employs 60-65 researchers. The center has a strong academic base and focus on getting published in recognized journals, which is important in order to secure funding. CICERO's main source of funding is the Research Council in Norway. Mr. Torvanger has conducted research on whether one should support development of green technology and if so, how. He has especially been working with Carbon Capture and Storage (CCS), which Norway has invested heavily in.

5.1.2 Outlook of Renewable Energy in Norway

5.1.2.1 CO₂ Emission Trading

The most important factor in policy frameworks for green technology is the price on CO₂ emissions. High prices are the most effective instrument to drive emissions down, either through systems of emissions trading or taxes. It is important that the systems are stable, long term and that the CO₂ price increases over time. Norway has a large share of renewables in the energy mix compared to other countries, but the CO₂ emissions from oil and gas as well as transportation have had a stable and quite distinct increase over a long period of time. It is not easy to drive down these emissions, but they can be compensated with international emission trading.

The price for CO₂ emissions is currently too low, especially considering the low cost of coal power. Only when the emission price is sufficiently high, will development of expensive green power sources become of interest. In addition, there are no guarantees that the next government does not change or dissolve the policies. It is thus not only a natural risk in green technology projects, but also a political risk and Mr. Torvanger does personally not believe that this risk is avoidable, but it could be reduced by introducing systems that make it difficult to change policies. It could be possible to establish a climate agreement that guaranteed a certain price for a certain period of e.g. 20 years. The basis of such an agreement is of course that one considers the climate crisis to be a serious challenge.

5.1.2.2 Government Involvement

There exist good arguments for governmental support of green development beyond the CO₂ prices. When a company decides to develop green technology, the benefits for society are larger than for the company alone. As the private actors do not consider the whole value of the project,

the government should offer support to make up for the lost investments. There are two other reasons for the government to engage in the development of green technology: (1) There could be specific barriers to develop green technologies that demand specific action, such as network activities; the demand for hydrogen cars is not just reliant on the price of the car, but also the availability of fuel stations. The government should thus coordinate the development of infrastructure and other activities that are needed for a green technology to be successful. (2) There could be that the government has a strategic interest of the development of a specific green technology.

5.1.2.3 Design of Policy Framework

It could be a problem that Norwegian companies “shop for policies” and move abroad, but it depends on what the goal of supporting green technology development is. There are three phases of the technology development: (1) R&D phase with laboratory testing etc., (2) Innovation phase where the technology are developed in full scale, and (3) implementation phase where it is commercialized, taken into use and compete on price. The R&D phase is well supported in Norway. If the government’s primary target is to contribute to the global development of green technology, there is no problem in only supporting phase (1), but the innovation phase could also be supported. However, if they have a strategic interest and want to develop exporting industry, they should extend the support to the innovation phase. If the innovation phase is not sufficiently supported, the risk is that the competence is lost to other countries. Policy makers should recognize two functions when evaluating efficiency of frameworks; type of technology and development phase. As there are different challenges connected to the three phases, as well as variation between technologies within different industries, the policy instruments should also vary.

5.1.2.4 Focus on CCS

Norway has used a lot of resources on the development CSS compared to for instance wind or wave energy. Mr. Torvanger believes that the governmental dedication to CSS is based on the strategic benefits connected to this technology; there are close connections between the offshore and maritime industry and CSS, and if CSS becomes successful it could be a way to sustain the value of oil and gas in the future. If the climate policies were to become stricter in the future, for example increased emission trading prices in Germany, part of the economic rent from oil and gas sales will be lost to Germany. Nevertheless, CSS technology would give less reason to increase the emission-trading price, which in turn would give Norway a larger profit on sale of oil and gas. Thus, extensive CCS investments are a result of Norwegian attempts to be an international pioneering country within climate, and at the same time a leading oil and gas nation, which could be considered as a challenging combination. CSS could thus be regarded as political glue that unites the two interests, as well as interests linked to the maritime and petroleum sectors, development of a new industry, and regional work places. The Norwegian focus on CSS is reasonable, but it is possibly too focused on CSS compared to other areas of green technology. There is for instance put little effort into wave and wind energy, which Norway has good conditions for developing, both in terms of natural resources, electricity production and industry creation. Mr. Torvanger does not argue that the government should cut resources to CSS, but the government could possibly assign more support to other green technologies such as wave and offshore wind.

5.1.2.5 Green Certificate Agreement and Feed-in-Tariffs

The green certificate agreement between Norway and Sweden is a demand-side incentive that will contribute to development of green technology to a certain extent, but Norway is in a special situation because of the large share of hydropower. Analyses predict that the agreement will not have a significant effect on wind power in Norway, but rather on small sized hydropower plants. Projects that are set off because of the new system are those on the tip of commercialization. Technologies that are far from commercialization, such as wave and CSS will not be affected by the agreement and many of the supported projects will go to Sweden.

The integration of the electricity market in Northern Europe has led to significant changes. Earlier, when there was little capacity in transmission great variation in price could appear because of dry years. Two things have now happened with an integrated market; (1) the price has increased in Norway as a result of the high electricity prices in Europe, and (2) there is less variation in price. The growth in demand for energy will most likely continue and if the climate policies get stricter, the demand for green energy will increase. This could be an advantage for Norway due to its large amount of natural resources, also beyond hydropower, that are yet to be developed. Building more green power production will thus become more attractive and Norway could possibly function as a “green battery” and serve parts of Europe with green electricity at a higher price (compared to the current Norwegian market price).

Feed-in-tariffs and green certificates are different from CO₂ emission prices as they reward green technology instead of punish those with the highest emissions. Feed-in-tariffs will also have an effect, but it will be less effective than CO₂ emission prices. It might sound paradoxical, but awarding green technology could over time create a type of rebound effect; expansion of green energy will drive down the electricity price and thus increase the consumption – it will produce the reverse of the desired effect. However, politically it is difficult to introduce a high enough CO₂ emission price so the solution becomes to award green technologies.

5.1.2.6 Private Actors

The private market's interest is that the public take on as much risk as possible involved with a green technology project until it reaches commercialization. Within CCS technology, private actors have an incentive to exaggerate the costs connected to development to receive more financial support. Public actors taking all the risk could be unfortunate as (1) it can lead to private investors being less effective in their spending. *“When others pay, the incentives to perform a good job decrease”*. (2) It might be regarded as unreasonable that Norwegian taxpayers have to take on the costs of raising private companies when the shareholders later end up with the profits. The government is interested in developing green technology, but it has to be within reason and it is important to maintain sensible incentives for the investors. The perspective within oil and gas could be kept in mind; Private actors must have sufficient profit for operating, but the natural resources should benefit the Norwegian people, and the oil and gas sector is thus taxed 70 - 80%. Renewable energy is also a type of natural resource and a clear balance between the public and the private interests is needed.

5.1.2.7 Home Market and Timing

In order to build competence on company level within wave energy and floating wind turbines, the government needs to set up a long termed strategy, which clearly recognizes the presence of the climate challenges and introduces a proper carbon price that will increase over time. Politics and the policy framework are thus the most important and the large investments need to be

initiated by private actors that are profit driven. There are two reasons why the Norwegian government may want to build up a marine energy industry, given the existing strategic focus on CCS. Firstly, Norwegian conditions are favourable for strategic marine energy investments to be successful in competition with other countries. Secondly, since there are significant risks involved in future paybacks from the large investments in CCS, diversifying investments into another technology such as marine energy will reduce overall risk.

Investment in a national industry with a limited home market is expensive and involves great risk, but there are many benefits connected to enter in the early stages of the learning curve and possibly become a leader. It could be less expensive to enter the industry later when the technology is more mature, as one can benefit from the experience of others, but there is a risk of missing out on valuable learning and ending up in a less desirable position. It would be more attractive for Norway to build up competence within marine energy if a higher level of demand, and higher electricity prices, was in place. Nevertheless, Norway has in many ways a cluster within petroleum and marine industries, which could be expanded. In that matter, Norway might be ahead of Scotland, which could be an argument for building this type of industry in Norway. The synergy between oil and gas and offshore renewable energy should however not be exaggerated; it is still challenging to construct marine energy devices.

5.2 Scatec

Name, position: Jan Magnussen, CEO Scatec Adventure
Jørgen Dahle, Business Development Manager

Place, date: Oslo, 29. February 2012.

5.2.1 Organization Background

Scatec is an industry incubator that starts businesses within renewable energy and advanced materials. Alf Bjørseth founded Scatec in 1987 and Mr. Bjørseth also started the companies that became REC through Scatec. Mr. Bjørseth is one of very few people in Norway that use all his time and capital wealth on developing new businesses and Scatec's main business areas are still within solar power. Scatec has a silicon wafer facility in Årdal (Norsun) and a downstream company: Scatec Solar, which builds solar power plants and is one of the largest downstream solar actors in the world. Scatec Solar has activities on nearly all continents. Scatec is also co-owner of three companies within wind power and has a portfolio of other companies that they have developed, as well as some venture activities in addition to the incubation activities.

5.2.1.1 Business Strategy

Scatec is not financially set up to develop companies to full industrial scale and is involved in the first phase, the seed phase, which bears most of the risk. It is always difficult to exit after the first funding rounds since venture capitalists rarely invest in companies where the founders or their seed partners sell out. Hence, more often than not Scatec also participate in the venture phase. Scatec realizes created values when the companies go public or there is an industrial sale.

Scatec does not have a strategy for projects to be located in Norway. It would have been nice, but they more often than not find investors and support abroad. If Norway does not have competitive advantages, the industry will not produce in Norway. Moreover, Scatec has a tendency of trying to keep things located nearby during the start-up and seed phase. Close proximity makes it easier to follow up the company. In terms of collaboration partners Scatec

tends to choose based on where they know people, but the most attractive partner companies are often international. Scatec's venture activity has been reduced to industries where Scatec's knowledge gives them a competitive advantage. Scatec is currently fully booked with projects and have experienced that the most successful projects are the projects they have put a lot of work into. The portfolio companies in general require more work, more money and longer timelines than the founders anticipated when they first started their business.

"Scatec is very little involved in trying to influence the Norwegian politicians, maybe too little involved" (Mr. Dahle). Scatec has had many meetings with politicians, but Scatec is no lobbyist. Scatec's contact with politicians is in general when the politicians want to attend the opening of a solar park or if they want Alf Bjørseth as a well-known name at some of their arrangements. Mr. Magnussen and Mr. Dahle believe that Alf has given up trying to influence Norwegian politics.

Scatec's advantage is execution speed; the ability to make fast decisions of what and where to invest. The team's knowledge about the renewable energy industries is Scatec's most valuable asset. Alf Bjørseth is exceptional at trends and analyses and Scatec is very concerned with timing and macro trends. Scatec is searching for technologies that are expected to grow with 5 – 10 % over a number of years and aims at entering when the technologies become commercial to avoid waiting for several years. Scatec advises their portfolio of companies on potential partners, investors, market trends etc. Mr. Magnussen and Mr. Dahle know of no other companies like Scatec in Norway, but there are some venture capital companies that are similar.

5.2.2 Outlook for Renewable Energy in Norway

5.2.2.1 Solar Success and Offshore Opportunities in Norway

During the founding years of the companies that later became REC, Alf was described as a man with a crazy idea and a big straw in the national treasury. No one believed that one could create a solar industry north of the Arctic Circle and Mr. Dahle and Mr. Magnussen admits it does sounds a bit absurd when one thinks of it in that way. When REC made international success, the feed-in-tariffs in Germany and Japan were not restricted to local content. Back then, it was more focus on free trade than today, since today's industry has experienced the financial crisis. Countries like India, Brazil and Canada are restricting subsidies to local content. When the world is experiencing recession, nations become more and more protectionist.

The Norwegian Solar industry had perfect timing; the metallurgical industry made capital, competence and labour available when closing down, and Germany and Japan had favourable support regimes. The offshore wind industry can be viewed as an analogy to the history of REC and the solar industry. Norway has a lot of offshore competence and speciality in building structures for the seabed. Norway has a knowledge cluster, a large service sector and world leading competence in building and designing advanced support vessels. However, there is no home market for wind for the next 20 years. Offshore wind does not have standardized elements and thereby require more technology development than the solar industry.

5.2.2.2 Test market

It is not important that Norway pursues offshore wind, as an important part of our energy production, but the developers need demonstration projects to qualify their technology. It is very hard to enter markets without proven technology. Norway has a handicap in this matter, as there are few facilities to test devices. Germany does not have a lot of sun, but stated that they

were going to be world leading in the solar industry and implemented a feed-in regime that got the industry involved. Norway could have done the same thing for offshore wind, but there is a big difference: we have to export subsidized power, while Germany could downsize their coal power. *“Politically, it is extremely hard to justify subsidy of power production in one country and thereafter selling it cheap to another country. It is no use in suggesting something that is not politically sustainable”* (Mr. Dahle).

Another issue is that Norway has to build another industry than oil and gas, and has to consider areas that are extensions of existing competence. To build new industry Norway has to invest in pilot projects to help technology qualification in the market. Norway could establish a large test project for offshore wind in which 10 to 20 turbines is put up and made available for suppliers to test foundations, installations, maintenance etc. A test project would have been a lot better than the solutions today, but it might be too late as actors may already have moved to other markets. A large test project was conducted in Sweden in 1991, England in 2000 and Denmark in the 1980s. Norway would have to act now to get satisfying effects.

5.2.2.3 Roles in the Value Chain

If Norway were to take a major role in the development of the offshore renewable industry several roles in the value chain could be possible. Norway could specialize in marine energy constructions and under water operations. Maybe some of the advanced vessels could be built in Norway. Other value chain activities could be engineering design and maintenance. It is too late to start building wind turbines. Value chain initiatives can make Norway an industry leader within offshore renewables, but depends on the politicians. Norway does not realize that the wind industry was built in the 70's.

5.2.3 Political Will

Statens Energiplan does not perceive renewable energy to be a priority area for the Norwegian government, who shows little signs of concern towards Norway's dependency on oil and gas, especially due to the new oil findings and the associated time horizon. There is little help in the prime minister, and the Norwegian Labour Party (AP) whose opinion is that Norway does not have room for anything else than oil and health services. The only political party that has an agenda of renewable energy is the Socialist Left Party (SV). Norway was required to implement green certificates due to the EEA agreement. The government was imposed to produce more renewable energy, but has resisted the whole time. There is no support for building industry in Norway except from Innovation Norway, but Innovation Norway does not have much backing.

The general opinion in Norway among industry actors and the rest of the population is that solar and wind power is a new and small industry. In Germany and Denmark, solar and wind power industries are extensive, create a lot of work places, trade for billions of Norwegian kroner, and are becoming mature industries. Denmark exports more related to wind power than Norway export from oil and gas.

5.2.4 Conflict of Interest between Oil and Gas and Renewable Energy

If the government believes it is important to have another industry than oil and gas, they should start regulating the pace of development of the sector. It is no regulations regarding yearly investments in the North Sea. 360 billion NOK is invested in the North Sea and if these resources had been invested in other areas, it would have met critique concerning inflation effects. However, people never mention inflation in relation to investments in the North Sea. The

investments give the industry an extreme ability to pay high wages. It is almost impossible to develop industries on shore with the immense investments in the oil and gas sector. If the government wants to play safe and not move all Norwegian industry to the oil and gas sector, they have to implement a concession process that secure stable development, and not a doubling of investment amount in 3-4 years as experienced today. The government has to realize that the petroleum investments cause inflation in salaries. At a macro level, there exists a conflict of interest between oil and gas and renewable energy industry. Both industries use the same engineers, which makes it incredibly hard to become competitive as one has to pay the same salary as Statoil is willing to pay, due to development of an future oil field that gives a return of 30-40%.

5.2.5 The Norwegian Support Regime

Mr. Magnussen and Mr. Dahle do not perceive the Norwegian support regime as optimal. The government should give renewable industry as favourable loans as they give the shipping industry. Favourable loans only exist for large export goods like ships, but should have been available for smaller goods as well. The government should also put more money into R&D for universities and research communities.

The politicians should assess the possibility of Norwegian companies moving abroad after the R&D phase without contributing to value creation in Norway. The government has focused on establishing systems for the pilot testing phase with Investinor, a fund with 150 MNOK, and Enova. However, the pilot-testing phase is probably the least successful area of the support regime. Money has been available, but the government will not take action on its own and is therefore waiting for an industrial actor to step into the forefront. A small company cannot take the lead, thus a company like Statoil or Statkraft have to take charge if something is to happen. Other countries have developed renewable energy projects on their own to get the industry started, instead of waiting at the existing industry. Mr Dahle and Mr Magnussen believe that a large industrial company at the forefront in developing a new technology and industry rarely works, but that it is necessary with large investors. Joint stock companies are required by law to maximize profit. The politicians and the rest of the society have to decide focus areas and make laws accordingly that the companies must follow. Scatec is not a joint stock company and has an owner that invests differently than these companies.

Scatec perceives Innovation Norway (IN) and the Research Council in Norway (RCN) as having a positive attitude towards their activities and has received a lot of support from RCN and loans from IN. The application process is demanding, but *“our people have developed great skills in writing these applications, it has become a knowledge in itself that is worth nurturing”* (Mr. Magnussen). Great difference is experienced in whether companies within Scatec’s portfolio receive support or not. Scatec does not know the reason for this; maybe the companies that receive support better fit the requirements or perhaps they exploit their opportunities better.

5.2.6 Foreign market opportunities

5.2.6.1 Off-grid Markets

Scatec has grown to adopt an analytical approach for assessing markets that will reach grid parity first. In recent years, Germany, Spain and the Czech Republic have been markets with favourable and changing policies. In addition, everybody is waiting for changes in Italy, South Africa, Japan and USA. China’s renewable industry is growing at a high rate. Scatec is currently

also assessing the market in Chile, who has reached grid parity in the desert. There are other markets like Hawaii and Mali that do not have a grid. Hawaii's energy mix consists of 80% diesel and the North of Chile is dependent of diesel and natural gas. With today's oil prices, it is not very surprising that the Hawaiian government has a goal of 80% renewable energy by 2020. These markets do not need subsidies to be attractive.

5.2.6.2 Wave and tidal

Mr. Dahle has previously worked with wave power and has very little faith in the technologies. Wave power has too many phases and it is too hard to reap energy. If one calculates KWh per year the result is poor as there are strict requirements to get the construction to hold. Scatec has no current plans of investing in wave or tidal power, but if they are going to assess new areas they might consider tidal power. Tidal power could make a good investment case for a company with an investment horizon of three to five years.

5.2.6.3 Export of Effect

The UK is going to build 5000 windmills. If Norway cooperates with the UK, the UK can deliver wind power to Norway when it is windy and Norway can power the UK when it is not windy. In such a regime, one could have developed wind power at the Norwegian side as well. Norway could have built wind power on shore, which is cheaper. Mr. Dahle argues that it is very reasonable of Norway to have a "battery" way of thinking. If so, Norway has to have a clear strategy of becoming a supplier of effect, not energy to Europe. Norway can exploit this opportunity by thinking strategically about building cables now and collaborate with Germany and the UK. Building cables are a relatively manageable project and not very labour intensive. Like the gas industry, T-intersections can be built at locations favourable for offshore renewable energy. When building oil and gas platforms in the future, it could be required to report possibilities for getting power from offshore wind. The government can set a limit; if the gains of using carbon intensive power to electrify the platform are less than 20% of using renewables; they have to choose offshore renewable energy. This solution creates a small home market. This is a viable solution today, but is not pursued as the oil companies are very limited in engineering capacity and the process of utilizing renewable energy on platforms is more complicated and requires more resources.

Adjustable power increases in value as the level of non-adjustable power rise, but opportunities related to export of effect only exists for a certain period of time. Each country is planning development of grids and if you don't participate in this planning, the possibility of exporting renewable energy will be locked in because the European countries have made use of other solutions. Grid installations usually last for 100 years. *"You're either in now, or you wait 100 years until you get the same opportunity"*. Norway has no strategy for developing such grids. A group that where to assess the possibilities for an offshore grid were established, but Norway did not even register the group establishment and had to apply for membership at a later stage.

5.3 Rambøll

Name: Espen Borgir Christophersen
Position: Senior Advisor, Rambøll Energi
Date, place: 29.02.2012, Oslo

5.3.1 Personal Background

Mr. Christophersen has worked three years in Enova as head of the wind power program, and one and a half years in the Research Council of Norway (RCN) with R&D and innovation projects within wind and marine energy. Mr. Christophersen works as senior advisor in Rambøll with main focus on wind and ocean energy. Currently, he is working in a team evaluating the possibility for including renewable energy generation in bridges, primarily wind energy. Mr. Christophersen is also working with development of onshore wind projects in Norway.

5.3.2 Outlook of Renewable Energy in Norway

5.3.2.1 Policy Framework

Mr. Christophersen believes that industry projects that apply for funding by the RCN should be obliged investor capital because of the importance of market relevance to the successfulness of the project. He believes that the market mechanisms should decide what projects to be awarded support, which makes support from an investor very important. The government will probably not “choose” one sector and focus solemnly on that sector. –That is the job of the market forces. Some of the applicants claim it is easier to attract investors when one has received funding from the support regime. This is not true however as the support organizations (RCN, Innovation Norway and Enova) do not perform thorough analyses of the technology to the same extent as the investors and potential partners. The government’s role is to be a facilitator and coordinate the development. In the commercialization of electrical cars, it is important that the government provide beneficial incentives for buying an electrical car, such as lower taxes or free parking, in addition to coordinate construction of fuel stations.

Mr. Christophersen believes that there is an attitude among companies that they are entitled to governmental support if they have a solution within renewable energy. This attitude can hinder companies in being creative in both creating effective solutions and getting support elsewhere.

The cooperation among the support organization has improved greatly the last years, partly because of “miljøteknologiordningen” that went across all the organizations and made cooperation a necessity. The support regime, through RCN, Innovation Norway and Enova, does not try to lead the industry in certain directions; the different entities only follow their individual goals. The support regime’s portfolio of supported industries and technologies is thus broad. The RCN, Innovation Norway and Enova do look to other countries when developing support mechanisms, but there are few countries, that Mr. Christophersen is aware of, that have such solid support mechanisms as one has in Norway.

5.3.2.2 Test Market

Enova could initiate a test market. However, Enova are struggling with distributing all of their resources as too few projects apply for grants. Renewable energy is very capital demanding, and Mr. Christophersen believes the capital requirements are the main reason why the entrepreneurs are struggling to find investor capital. Nevertheless, there are many projects that cannot expect investor capital, due to lack of quality both on the product and the project team. There are some test sites in place already where different actors are welcome to try their equipment or devices. Havsul I is an example of such a site in Sandøy, Møre og Romsdal within offshore (near-shore) wind.

5.3.2.3 Home Market

Mr. Christophersen believes that it is possible to build an offshore renewable energy industry in Norway despite a limited home market, but it will be difficult - The unemployment rate is too low and there is competition in capturing competence. If one believes in cluster theory, home market is important. Competition among companies is crucial for industry development. However, both the government, its organizations (especially RCN and Innovation Norway) and the FMEs (Norcowe and Nowitech) have not managed to agree and communicate long, strategic goals within offshore wind. A common long-term goal for all these organizations would have been a major benefit for all actors in the Norwegian offshore wind sector. There are in addition few incentives for focusing on the industry at this point, as it is less demanding and more profitable to invest in expansions within oil and gas. He does not believe it is too late to become an important player within offshore wind, but the investments hold up for too long, it will be.

5.4 The Research Council of Norway

Name: Tor Arne Hafstad
Position: Works with the RENERGI program on the field of hydropower and offshore renewable energy
Date, place: 01.03.2012, Oslo

5.4.1 Organization Background

RENERGI (Clean energy for the future) is a program within the Research Council of Norway (RCN) that distributes most of the support to renewable energy. They support three types of projects: (1) Projects where companies apply, typically product development projects in the early development stages, where RCN supports up to 50% of the project cost. (2) Research projects aimed at universities and research institutions where the RCN can provide up to 100% of the project cost. (3) Projects performed from commissioned from industry actors, but performed and applied for by research institutions, where the RCN can support up to 80% of the project cost. Normally, they distribute support once a year. Everyone can apply and be evaluated, but the resources available are limited. The RENERGI has a budget of about NOK 350 million a year, but as some projects run over several years, they announce project support for about NOK 200 million each year.

5.4.1.1 Application

A jury of external professionals that the RCN assembles evaluates the applications. The panel of experts evaluates the applications on the basis of certain categories: The degree of innovation, the level of research, the level of commercialization, earning potential, international cooperation, the quality of the application (how its written etc.), the likelihood of realization and the socio-economic benefit of the project. The experts give points within each category and the projects with the best overall score receive support. RCN does not have clear targets as Enova with number reduction in KWh each year, but is established to support projects that would not be carried out otherwise. The project should therefore involve a certain degree of innovation and risk. Companies that are awarded support are imposed to report propulsion and results two times a year and economic updates once a year. The follow-up is somewhat modest because the RCN wants most of the resources to be utilized on R&D rather than administration.

It is important for RCN that companies receiving support cooperate with other actors. Many of the projects involve a certain risk of failure and some of the companies go bankrupt if they do not succeed. It is thus decisive that the entrepreneurs have cooperated with others for the

learning and competence not to get lost. The level of global initiatives and network is also evaluated to ensure that the effort made through the project in question is not developed other places in parallel. Research institutes are in addition encouraged to cooperate with industry actors for the research to be better linked to market needs.

5.4.1.2 New Program and Allocation

A new program will soon replace the RENERGI program. When developing the new program, the RCN has been in contact with several actors in industry and trade to get feedback on possible improvements to the program. They have gotten a lot of positive response, but there is always room for improvements. The critique has mostly been connected to imbalances in allocation of support. However, there are no unison complaints in that matter. The challenge is rather that the RCN has limited resources and the RNC questions whether they should focus more on certain sectors. In their search for improvements however, they did not get any feedback on what sectors they could focus less on, only suggestions to new areas to support in addition to the present portfolio.

The government can place a lead to how much of the resources should be dedicated to sectors, but they are normally not that strict. Energi21 has given some recommendations that they try to follow. Wave and tidal energy is not discussed in the Energi21 report, but is still considered an interesting field where Norway can contribute. However, it is important that Norway does not focus too much on prevailing conditions for development; the solar industry would probably not have emerged 15 years ago with such a focus.

5.4.2 Outlook of Renewable Energy in Norway

5.4.2.1 Activity and Framework

Most of the development today within offshore renewable energy is driven by financial support systems, and the current electricity prices are too low for the technology to be profitable. The Norwegian policy framework for building offshore renewable devices is in addition quite modest compared to other countries. Norwegian companies have thus started to build devices in the UK where the support systems are more lucrative. Today, it is unrealistic to build up large wind or marine power resources in Norway because of the high costs related to both construction and generation. Thus, many of the projects RCN supports are dedicated to cost reduction. Mr. Hafstad believes that the situation will alter if the industry succeeds in driving the costs down, as the natural resources are enormous.

The number of applicants to the RCN has increased quite immensely the last years. The available resources have also increased, but not to the same extent as the applications. They are starting to reach a stage where the number of qualified applications is higher than available resources. Only about 20% of the applicants receive support. This is unfortunate as many companies put a lot of effort into the application. Especially within projects on offshore wind the number of applications has increased since the government indicated a focus on this field. The quota for support to offshore wind has increased the last years. In addition, two offshore wind power research centres have been established which receive NOK 20 and 15 million a year in a period of five years. The research centres are supported and administrated by the RCN and established by the industry together with the research institutes SINTEF and Christian Michelsens Institute. However, the government has not affirmed any production goals within offshore wind. They have mapped the potential, which is quite enormous, but it is not realistic

to develop all of it. The green certificate agreement between Norway and Sweden provides demand-side incentives, but it is too early to say how it will affect development of offshore renewables.

5.4.2.2 Test Market and Political Will

There have been some initiatives in starting a test market in Norway. There are test plants for floating windmills in Norway (Hywind and Sway) as well as a tidal turbine (Hammerfest Strøm), but no test parks or market as in Scotland where companies can come and test their equipment/devices. RCN recognizes the benefits of having a test market, but there is uncertainty connected to where the initiative to support such a project should come from (RCN, Innovation Norway or Enova). The support organizations would probably have to divide the costs between them. Nevertheless, the resources available to build such a test market are limited. There is political will to drive innovation and development, but it remains to be seen whether the government wishes to see it through and provides support to a test market.

Part of the challenge is that Norway has 99% hydropower and does not have the same pressure from the public to increase the share of renewables in the energy mix as many other countries. It is not certain that Norwegians are willing to have large wind turbines or grids set up outside their houses or in the sea if the primary target is export to other countries in Europe. Nevertheless, Norway has CO₂ emissions in the North Sea due to the oil and gas industry and to reach environmental goals, export of renewable energy could be of interest. The politicians need to become better at explaining the reasons for exporting electricity. Norway should enlarge the export capacity to Europe. As one can export electricity during the day at high prices and import it at night at low prices, increased export could be very beneficial for Norway. However, most Norwegians do not see the bigger picture; people are used to low electricity prices and thus find the exporting solution unattractive. What the public should understand is that most of the electricity price is charges and taxes that go back to the community.

5.4.2.3 Oil and Gas Industry

Mr. Hafstad does not believe that there is a conflict of interests between the oil and gas- and offshore renewable energy industry, as they do not utilize the same resources. On the opposite, the competence in the oil and gas sector could be a benefit when producing marine energy devices or components. The challenge however could be to have the right focus when transferring the competence of oil and gas to marine energy. There are very high standards and requirements connected to safety and operating time on oil platforms as well as profits are high. Within marine energy on the other hand, the focus is rather to drive down the costs. The Norwegian competence within oil and gas is nevertheless useful in the development of marine energy technology. In periods when there is a dip in the oil market, RCN notices an increase in activity within offshore renewables from supply companies in the oil and gas sector, especially installation companies that started to develop undercarriages to offshore wind mills.

5.4.2.4 Timing

Mr. Hafstad does not believe it is too late for Norway to be a part of the marine energy industry. Within tidal Norway has been on schedule and deployed a couple of demonstration plants to learn from. Hammerfest Strøm for instance, has a beneficial position in Scotland where they partner with Scottish Power. Development within wave power has been carried out for some time, but there is still no consensus of superior technology design. Thus, the wave industry is

still very open. Norway is probably too late to become a major contributor when it comes to development of close-to-shore wind power, while it is still possible within floating wind power.

5.4.2.5 Home Market

Mr. Hafstad believes that Norway can contribute to the offshore marine energy industry in certain areas despite the limited home market; by developing ground work for floating and rock solid devices with the competence from the oil and gas industry and also operational work based on competence from the maritime industry. There are few countries that have progressed further in the development than Norway within the wave and tidal industry, but the question is as mentioned, how much will remain in Norway? Norwegian companies deciding to register abroad could be a problem, but RCN does not regard it as “losing” companies to other countries; some parts could still remain in Norway, either as project competence, component suppliers etc. *“That we don’t build up offshore renewable sites, does not necessarily mean that the industry could not be a positive thing for Norway”*. However, for Norway to become a leader within offshore renewables and experience another “offshore adventure”, it needs a home market to catalyze the development and activity. However, there are many ways to do this; Statoil and Statkraft utilize Norwegian suppliers when they operate internationally. Nevertheless, it is obvious that it is beneficial to have a home market to learn from before one internationalize.

5.5 SN Power

Name, position: Jarl Arve Kosberg, Executive Vice President, Projects & Operations

Kristin Sandtorv, Valuation Manager

Olav Hølland, Vice President, Project Implementation

Date/place: 02.03.2012, Oslo

5.5.1 Organization Background

SN power, originally named Statkraft International, started as a project within Statkraft trying to internationalize the hydropower business. In 2002, they decided to establish an independent company with Statkraft and Norfund as owners. SN Power’s core business is to develop hydropower in emerging markets.

5.5.1.1 Structure and Operations

SN Power is organized very much like a consulting company with expert groups that are responsible for different areas. For instance, they have many teams that affect the economical parts of a project; a very competent project finance team that manages to secure favourable financing, and a team that focus on Clean Development Mechanisms (CDM) including carbon certificates which can provide up to 5% more earnings on a project and thus may become a make or break factor in decision making, as well as a marketing team that analyze path of price movements up to 2050 as the investments are very long term perspective.

When SN Power starts new projects, they optimally want a local partner with experience and knowledge related to the market in question. Having a local partner often enables cooperation with regulators and politicians and thus makes the process of building or taking over a hydropower plant more efficient. The structure of partnership varies depending on tax regulations, but they often establish a joint venture with a local company with a 50/50 ownership structure. In order to learn about local markets and decrease the risk related to expanding into new countries, SN power often invest in and operate existing plants before they

take on larger and more risky Greenfield projects. The investments are very long termed, and they make acquisitions and build up plants on the basis of keeping the project as long as it is economically viable. When initiating new projects, the investment should be commercial with a given rate of return. How they choose projects vary, but they act opportunistic to a certain degree and try to find projects that are technically, politically and economically beneficial. SN Power is very concerned with building local competence so that the power plant in question can become self-governed in the long run. At a newly acquired power plant for example, SN Power can appoint about three Norwegians with broad experience to operate the plant in the early phases. The goal is that the local competence level eventually will rise to a level where the Norwegians are no longer needed.

5.5.1.2 Competence and Cooperation

Statkraft has office only 100 meters from SN Power in Oslo and the two companies have close cooperation. SN Power can draw on Statkraft's great experience with hydropower, which is an important resource in the global competition. Nevertheless, SN Power is an independent company that develops its own competence, and uses Statkraft only on service agreement level. SN Power has wide experience in entering new markets, which is extremely important in order to be successful. In immature markets, a development of the sector in cooperation with the local government is needed to be able to see the project through. In these cases, SN Power can take advantage of its Norwegian background. Norway has one of the most liquid markets in the world, has long traditions within hydropower and level of corporate social responsibility (CSR) and health security and environment (HSE) are equivalent to the best international standards. SN Power meets challenges in foreign markets that are not present in the Norwegian market and thus develop competence beyond the traditional Norwegian expertise. SN Power's operation is thus important for further development of hydropower.

SN Power shares to some extent their experiences with other Norwegian companies in local chambers of commerce etc., but the cooperation is more related to political conditions. However, they use Norwegian consultants, suppliers and academic environment in different projects abroad and their operations thus create considerable ripple effects in Norway. SN Power has no stated objective of using Norwegian suppliers, but it natural to use Norwegian companies because they have good hydropower experience and very often offer the best services. When Norwegian suppliers fail in providing the best offer, they use international ones.

5.5.1.3 Competition

There are some international competitors within the energy industry, but there are no actors that are clear hydropower specialists to the same extent as SN Power. There are two types of companies that could be considered competitors; strategic investors such as SN Power, which hold the competence of hydropower development and drive the project, and financial investors that are pure owners. In many of the projects they experience competition from small local actors as well, but in large expensive projects, it is mainly large international players involved.

5.5.1.4 Focus Areas

The portfolio within renewable energy has varied the last years because of changes in strategy. About three years ago, Statkraft was very active in other renewable power sources such as solar, osmotic and wind power. Then there was a change in Statkraft's strategy affecting SN Power: they adopted a more focused strategy with fewer technologies and wind only in selected markets. Thus, wind power is no longer an area of great priority to SN Power. SN Power

believed that wind power was going to take off, and hoped to experience synergies between wind and hydropower, but it has not been as lucrative as proposed as wind power still is dependent on subsidies and varies with political regimes. SN Power has 46MW installed wind power and the company has recently acquired a portfolio with 100 MW wind power, but they realize that in order to profit on wind, generating economies of scale is crucial.

5.5.2 Outlook of Renewable Energy in Norway

Norway has with no doubt a great opportunity to expand its hydropower production, function as a green battery for Europe and regulate other renewable energy to a greater extent than today. To seize this opportunity should be a matter of course, but there is a lot of resistance in Norway concerning expansion of grids etc. Nevertheless, the possibility to enlarge the hydropower production is a definite opportunity that will not disappear.

5.5.2.1 Home Market

The experience from the Norwegian home market has been important to the success of SN Power, and has functioned as a competence basis when expanding abroad. However, such a basis does not necessarily need to be 100 years of experience from an industry; it could be experience in technology development or other things. In terms of exporting technology and competence, the Spanish company Ibedrola Renovables has been very successful. They started by building wind parks in Spain with great success between 2000 and 2005 and used that competence to expand to other markets. They started this process early and have thus managed to capture many of the best sites. The Norwegian oil industry is founded heavily in technology and has been very successful internationally even though the competence was built up over a short period of time.

For such a development to happen within offshore renewables, the industry might need to reconcile on some technical solutions and use their resources to work in the same direction. Industry emergence could also happen by chance, without a strong technical basis in the home market; the airline company Norwegian is for instance about to become a major international airline even though Norway does not have the slightest competence in aircraft construction. However, it is important to have something to base the industry creation on, some form of history around it. Norway has a background in R&D projects concerning wave energy that could provide such a fundament. Marintek at NTNU is in addition a well-established research centre within offshore technology that has built up competence within groundwork of offshore wind turbines. However, it is a challenge that the offshore renewable technology is dependent on subsidies. It is thus important that the development do not get too technically driven; it has to be commercially attractive. SN Power does not wish to focus on technologies with prominent technological leaps ahead in order to reach profitability. SN Power believes it is beneficial to become proficient at home before exporting the competence to other countries.

5.5.2.2 Expansion of SN Power?

At the ENOVA conference January 2012, speaker Tollef Thorleifsson proposed a possible future scenario of Norway's focus on renewable energy where SN Power played a central role as an international actor within a broad range of renewables, as well as taking in some of the large renewable projects that now belong to Statoil and Statkraft. SN power considers this view as interesting, but it is quite different from what SN Power is doing today. They wish to be a strategic partner, not just a financial one. There are many opportunities SN Power has turned down because they are only asked to contribute financially. However, the realization of such an

idea is primarily a political question where the Norwegian government should decide if it should be more involved in the renewable energy sector. If so, they should decide whether the involvement should be restricted to commercial projects or not, if they are willing to go for investments abroad, if there should be a required rate of return etc. Anyhow, the political will needs to be in place for such commitment to happen. Few actors are as global as SN Power and their experience is that the second investment in a new market is better than the first one; it is thus an interesting thought that SN Power with its extensive market experience all over the world could expand its business to contain a broader range of renewable energy. *"Give us capital and we will find good projects"*. Quality of projects is still an underlying necessity, not growth. If SN Power was to expand in the direction of Thorleifsson's idea, it would be important to develop a strict strategy for how to do it. Looking at the Norwegian hydropower industry, foreign companies are not allowed to control hydropower plants. This regulation is part of the licensing policy in order to protect Norwegian assets. Thus, it is not unlikely that other countries want the same protection of resources. SN Power's belief is that they help other countries to produce power they would not have managed to do themselves, or would not have managed to do as efficiently alone.

5.6 Northzone Ventures

Name: Tellef Thorleifsson

Position: Co-founder and the partner who has worked most with renewable energy.

Place, date: Oslo, 1. March 2012.

5.6.1 Organization Background

Northzone Ventures (NV) was founded in 1996 and is a venture company investing in areas such as renewable energy, IT and telecom. NV has offices in Oslo, Copenhagen, Stockholm and London and raises funds from large institutions internationally, mainly in Europe. NV gets involved in companies in the early phases and have some seed initiatives and some initiatives in later phases. When entering a project, NV becomes active owners, as board members or as the chairman of the board. Companies NV invests in are not required to have governmental support as the decision depends on the industry area and capital intensity. Governmental support is considered positive and a sign of approval, but NV is aware of the time consuming process of writing applications. NV's funds have duration of 10- 12 years and their time horizon for each project is 5 -10 years, similar to most of their competitors. There are not many companies like NV in Norway, some within seed and some venture funds. However, there should be more of companies like NV.

NV does not explicitly have green values, but base decisions on obtaining profit for their funds. Personally, Mr. Thorleifsson is motivated by returns, but also by contributing to something that matters. To Mr. Thorleifsson, renewable energy is more rewarding than oil. However, NV does not try to affect policy makers on a general basis. Mr. Thorleifsson tried to influence policies when he was the leader of a venture capital association and to some extent through individual companies.

NV's main markets are the Nordic Countries, partly due to network and partly to personal motivation of starting something in the home country. NV is well known in the market and gets a lot of inquiries. A great deal of these inquiries is good projects, but not all is suitable for external capital and rapid growth. Lately, NV has been skeptical to involve in large capital demanding projects within renewable energy generation. Due to a tough market NV is more

focused on energy saving projects, but this can change. A lot of renewable energy companies such as REC have experienced decrease at the stock exchange.

5.6.2 Outlook for Renewable Energy in Norway

5.6.2.1 Political Will and Support Regime

The largest market for Norwegian offshore renewable energy is the UK. Japan is also a large developer, but the market is to large extent controlled by large Japanese companies like Mitsubishi. Other markets like Canada will grow in offshore wind power. Norway could have been in the same situation, but Mr. Thorleifsson predicts that nothing is going to happen in Norway, as there exists a total refusal of decision-making in the so-called red-green government. The government has every possibility for accomplishing renewable initiatives, but only prioritizes oil. *“For reasons unknown, they call themselves a Red-Green government”*. The current government’s rule during the past six years has led to minimal action in renewable energy. The lack of action is peculiar as relatively simple actions, such as car taxes could have been initiated. The Socialist Left Party (SV) would have done more, but the minister of petroleum and energy does not seem concerned about the environment. The oil industry is the largest lobbyist in Norway and has strong influence on The Norwegian Confederation of Trade Unions (LO). The hydropower industry is also considered strong, but strangely no additional hydropower is built in Norway, the government would rather import coal power from Denmark.

The new oil findings restrain the development of offshore renewable energy for two reasons. (1) It creates growth and business development and reduces the pressure on renewable energy development. (2) It creates changes in attitude. In 2007 all agreed on the importance of reducing global warming, but in 2008 job creation were more important, which led to an attitude towards oil as being OK and access to energy as more important. However, Mr. Thorleifsson believes that the current focus will turn due to sky-high oil prices, and is personally very worried about global warming and wants to do something about it.

The green certificates agreement is a good system and should have been set a long time ago. More can be done in the early phases of technology development, especially in terms of commercialization of research and companies in selected areas. Norway should recognize that it is a small country and prioritize certain areas. Other counties actively give more support in the early phases of technology development and a company in NV’s portfolio, Revolt technology, moved to the USA due to access to more capital.

The governmental strategy of not deciding industry structure and priority areas is wise. A wide approach in terms of support is favourable considering tax payers’ interest of what is most profitable. Nevertheless, the government has to make some choices. Innovation Norway’s objectives are for instance mixed and too diverse. Innovation Norway is indifferent to whether a new toy store is opened in Bergen or if new technology is developed. The objectives should be to bring forward businesses that are scalable and have a great potential, preferably within renewable energy. Norway has chosen oil and gas, and maritime industry to be prioritized areas. Norway should add development of renewable energy as a priority, and not be satisfied with using money on saving rainforest in Brazil. Priority projects should be based on research communities and their results, not by the government deciding on a specific area. If one area is prioritized from the government, there is no guarantee that Norway will develop the best solution, thus a wide approach is favourable.

Norway has a strong focus on offshore, but is one of the countries in the world with much available land, in contrast to Japan who has to move off shore. Norway enhancing competence from the offshore industry is a good thing, but Norway does not need to only prioritize oil with a wider approach. Personally Mr. Thorleifsson believes the solar power industry will take large steps towards grid parity, whereas the wind industry will experience incremental improvements.

5.6.2.2 Home Market and Test Facilities

It is important for wave and tidal companies to have access to test facilities since many years of learning will pass before commercialization. It is possible for the government to rely on companies testing devices in the UK, but it imposes a risk of losing development and knowledge creation in Norway. From a company perspective, Mr. Thorleifsson sees the need for a test market, but it is not possible to have a test market for all sorts of devices. It would have been beneficial if large companies had an attitude towards testing small companies' solutions. Large American companies have a culture of helping entrepreneurs and buying their solutions, while Norwegian companies choose the safer and more familiar solutions. *"The government is often blamed for difficulties of testing pilot projects, but it might be equally applicable to attitudes in large companies"* This makes Norwegian startups go abroad to get pilot testing partners.

NV was involved in a wave power project in the UK, called Orecon. Several venture actors participated in the project. UK was chosen because they offered the best support, while Norway was out of the question. NV could have invested in a Norwegian company located in the UK, but Orecon had a good team. The technology worked, but tank tests showed that the cables were undersized. Experiences from Norwegian offshore industry showed that the energy produced was less than estimated and that the project would not be cost effective.

5.6.2.3 Norwegian Renewable Energy Opportunities

Mr. Thorleifsson believes it is possible to build industry with a limited home market, but it is more difficult. REC managed to do this as well as Opera software that was boycotted by Telenor. The advantage of a small home market is that one is forced to have an international perspective. It is possible for Norwegian offshore wind developers to participate in the development of Sheringham Shoal, and it does not really matter if the project is located on the British or Norwegian side. Subsidy regimes are vital for the wave power industry, and Mr. Thorleifsson finds it thought provoking that the technology development of wave power has been going on for so long, without having verified success in large scale. It should not really matter to an entrepreneur what technology to pursue as long as it is clean and cost efficient. People should be careful about being too emotionally attached to their perception of the best solution.

Utility for Renewable Energy

Norway has many actors involved in renewable energy and Mr. Thorleifsson believes that Norway could have done more within renewable energy by merging several of these actors, and created one large entity. SN Power is one such actor that works internationally with pure hydropower, mainly in new economies in Asia and South America. Statoil and Statkraft are also engaged in renewable energy, but have reduced their activities the last years. Thus, the renewable energy projects in Statoil and Statkraft could be transferred to this new entity. Norway could use its capital resources and competence to build the new entity that could work internationally at a broad basis as a global utility company. A small amount of the Norwegian Oil Fund investments could be invested in renewable energy through this company. Statoil invests

in oil and gas around the world when buying oil fields; this new utility company could do the same within renewable energy by for instance investing in wind farms in Canada or solar power projects in Italy. The entity's activity can act as a motor for the Norwegian industry by attracting partners and technology. The investments should have a pragmatic approach to whether it is wave, solar or other renewable technologies that are chosen as investments projects. This company should engage in the technologies that are most cost efficient, has the lowest CO₂ emissions and perform at highest efficiency; basically the most profitable renewable energy projects that give best return on invested capital. If such a utility company was to be created, several actors could take the initiative, but ultimately the Ministry of Economics, which own Statkraft and SN Power must decide. The government is very passive owners. The strange thing about the Norwegian Labour Party (PA) is their current attitude towards governmental ownership. The government does not privatize, close down or create anything new. They are afraid to make mistakes, and end up doing nothing. However, the government is the largest capitalist we have in Norway and capitalist are allowed to think big. The government thought big when creating Statoil, and they are still allowed to think big within renewable energy.

Export of energy

Mr. Torleifsson has little understanding of the government's local thinking. Norway has access to a large market in need of renewable energy. The closing of German nuclear power equals more than the Norwegian hydropower industry, and Germany would rather import clean energy from Norway than gas from Russia. Borders are quite random, and Norway's great potential for building renewable energy induces a responsibility to become an exporter of oil and gas. Since we have the opportunity to export renewable energy, we should use it.

5.7 Innovation Norway

Name: Bergny Irene Dahl

Position: Head of the Environment Technology Arrangement (MTO)

Date, place: 05.03.2012, Trondheim

5.7.1 Organization Background

Innovation Norway's (IN) purpose is to create economic growth for Norwegian companies. IN is owned by, and reports to, the ministry of trade and industry and cooperates with several ministries such as the ministry of the environment. IN covers different sectors, one of them being energy and environment. Mrs. Dahl is in charge of "Miljøteknologiordningen" (MTO), which is quite narrowly directed towards companies that are in the full-scale demonstration and pilot phase who need to prove their technology to the market. *"Norway still has to demonstrate technology, especially when we don't have a home market. It is hard to sell abroad without having demonstrated your product in a home market"*. Environmental technology is considered as all types of technologies and solutions that are better for the environment than existing ones. Thus, the MTO takes on a broad approach from a technological viewpoint. In 2011 the majority of the 257 MNOK in available support went to renewable energy. A criterion for receiving support is international potential, if the scope of the project is restricted to e.g. Trøndelag, one does not receive support from the MTO. The goal of the MTO is to bring forward technology that makes Norwegian products more competitive. This is done to reduce the risk of full scale testing projects. The decision for entrepreneurs of whether to move to Scotland due to demand-side subsidies comes at a later stage and Enova supports building of parks.

IN stimulates learning in companies, and has a network consisting of four to five offices that are responsible for energy from wind and ocean that arrange meetings with companies. The network concerning wave and tidal power started in 2005 and invited ten companies within the industry to participate at six meetings where investors and experts were invited. The companies pay to participate in addition to support from IN. IN provides 100 hours of counselling from external experts in-between the six meetings. At least one of the meetings must be in a country the company wants to enter, as Norway constitutes a small market and companies should aim at reaching out to foreign countries. IN's offices in foreign countries helps entrepreneurs in their respective markets. IN also participates in other ways. At a renewable conference in Amsterdam, they rented a large stand and asked if Norwegian companies wanted to participate and represent Norway together. The companies had to pay, and IN provided a field trip with matchmaking and company visits. These offers are very popular and often result in waiting lists.

IN offers an arrangement called "Connect", where they teach companies to present themselves to investors. IN does not directly match large and big companies but invites them to the same arrangements. Most often small companies contact larger ones. Statoil have invested in many, but have reduced this activity lately. IN also offers an arrangement where they support technology developers who have gotten a first demanding customer who is willing to cover 20% of their project costs. Statoil and SN Power have functioned as such customers. *"An industrial partner is very important; they know foreign markets and provide a reputation for future customers"*.

5.7.2 Outlook of Renewable Energy in Norway

5.7.2.1 Home Market and Test Centre

Offshore renewable energy is currently not cost competitive, and the early development support is better in Norway than in the UK. A tidal power company supported by IN, Flumill, has tested in Scotland but is planning to do the next test at its Norwegian partner, Sørcomp's facilities. If Flumill was to operate abroad, the competence and R&D would still be located in Norway. Testing in Scotland does not necessarily mean that all Norwegian companies move their business there; it is where they get contracts that decide the location. Mrs. Dahl has heard several opinions concerning location of companies. Even though the development support is better or similar other places in Europe, companies find it easier to stay in Norway due to familiar networks and institutions. The decision to stay in Norway or not also depends on the industrial partner; companies are most likely willing to move for the cause of getting an industrial partner. A home market with feed-in tariffs and a test centre would without doubt make it easier for Norwegian offshore renewable companies, but the costs have not been analyzed and proved too high. Norwegian test facilities might have demanded a higher price, which would have made companies test in Scotland either way. IN does not want the companies to move abroad too early and sees no advantages of them pushing the companies out before they are ready. A lot of offshore renewable energy companies have tested in Scotland. It is not only the testing that is expensive; moving the business abroad also bears considerable costs.

A Norwegian test centre has been under much discussion. There have been tested onshore wind turbines at Valsneset for several years. Statoil has built its own test centre at Karmøy in relation to the Hywind project and also carried the cost of a sea cable. A test centre in Norway could have been an advantage, but the cost of testing, whether in Norway or Scotland, would have

been high either way. MTO does not have the money to build a test centre, but supports the companies that are testing. Mrs. Dahl emphasizes that the ministry of petroleum and energy ordered Enova to examine possibilities for a test centre and if it would be able to operate without losing money, and it has not been a test centre yet. If a test centre is to be built in Norway, large companies have to get heavily involved.

Mrs. Dahl believes it is possible to develop an industry with a limited home market, and that some companies might make it with the existing conditions, even though it would be easier with more funding and test facilities. She considers the support mechanisms to be good enough today. There is quite a lot of money available, but there are bottlenecks in the market, which are immature and dependant on political actions. The private capital also needs to be directed partly over to this industry, and not mainly to the oil and gas development. Many companies that are ready to test lack the necessary capital, and investors need proof that the technology is profitable before they invest.

5.7.2.2 Investor Situation

Few investors are interested in wave and tidal companies and it is hard to get the big investors, harder than before 2009. The marine energy industry is dependent on subsidies and implies more risk than other areas. The venture funds are also fully subscribed and have locked their money. It is harder for small companies than large ones to get support from innovation Norway, not due to size, but the fact that large companies often have the required capital or equity to get support, while smaller companies have to search for investors. IN demands the finance to be in place to avoid locking up money in projects that might not happen. A lot of investors have perceived the Norwegian politics unpredictable. Many actors in the industry are sceptical due to incidents like the shift in biofuel-focus, where the government opened a new biofuel factory and added a fee the next year, causing factories to close down.

5.7.2.3 The Norwegian Support Regime

Feedback revealed that the division of responsibilities between the support institutions is too difficult for companies to understand. IN, RCN and Enova therefore had to figure out their roles to reveal gaps and overlapping functions, which led to more cooperation. During their work, it became evident that employees in IN, RCN and Enova did not know each other's fields either. In Mrs. Dahl's opinion, the different organisations in the Norwegian support framework could be better coordinated. IN has improved the collaboration with RCN and Enova, but improvements in cooperation can be done with several other organisations as well, such as SIVA, Export Finance and especially the EU. Currently, they are not familiar enough with each other's range of actions.

Mrs. Dahl believes the offshore renewable industry has a need for more collaboration "*Research shows that companies that cooperate reach further, grow faster and earn more money*". IN has a department for clusters in collaboration with SIVA and the RCN, called Arena, and Norwegian Centre of Expertise (NCE). Clusters can apply for this scheme to support of development and operation, and cooperation between companies is emphasized. Within offshore wind, two clusters have received support, but there is none for marine energy. Wave and tidal companies are often overlooked, operate alone and do not have their own arena. As Norwegian wave and tidal companies are few, small and without industrial partners, IN arranges meetings and other events. The wave power company, Langlee, made contact with IN because they felt alone and

found many arrangements unsuitable for wave and tidal companies, and many companies feel the same way.

Energi 21 has stated Norwegian priority areas. Energi 21 has a wide approach, but has narrowed the scope in the latest round, focusing on, among others, offshore wind and smart grids. Which areas that will break through are, in Mrs. Dahl's opinion, not for the government to decide; who would believe that solar power could become a major industry in Norway? *"It is dangerous to narrow the renewable energy strategy to an extent that excludes some technologies"*. The challenge is that Norway has a large industry in oil and gas that attracts capital and labour, and Norway already has a renewable hydropower industry. Hydropower is the reason Norway does not engage more in renewable energy such as other European countries, such as Germany, do. Germany can state that they have an environmental focus, but it is a matter of self-sufficiency. They are connected to the Russian gas cable and risk losing their electricity.

5.7.2.4 Export of Electricity

There is a great debate concerning the possibilities for Norway to export offshore renewable energy to Europe as a part of a Green Battery approach. Mrs. Dahl believes a green battery approach is possible. The challenge would be the physical impact in the Norwegian natural scenery, but Norway has prominent resources. A green battery approach is both a political and economical question - should Norway subsidize power that is sold to Europe? Considering the resources in the North Sea and the possibility of reaching grid parity in marine energy, Norway will have energy forever. Lately, companies as Statkraft and Statoil have presented trends that move towards grid parity within renewable energy. *"It is very important that large companies participate. They are and drive the engine in the development of the industry"*.

5.8 Enova

Name: Øyvind Leistad

Position: Director of the Department of Energy Production

Date, place: 09.03.2012, Trondheim

5.8.1 Organization Background

Enova administers the energy fund, which amounts to two billion NOK yearly. Enova supports environmentally friendly solutions that have commercial potential. Enova has budgeted with 10 % of the fund to support their program called New Technology, technologies that must show innovation in cost reduction, energy efficiency or completely new solutions. Enova has not managed to grant the full amount available last year, as grants are dependent of the private capital and investor's willingness to invest. However, Enova would like to have more applications. Enova provides support at a late stage on the process toward commercialization and aims at lowering the risk for the first demanding customer. Enova does not provide guidance concerning technology, but advises companies on how to succeed with their business. It is important to develop the company alongside the technology to be able to attract private capital and professional management. Enova cooperates closely with RCN and IN.

To receive support, Enova demands innovation, a positive cash flow and certain amounts of operation time. Enova also demands external third party verification and evaluates profitability. Companies often have difficulties providing expensive documentations like lab testing and prototypes. In the development phase Enova supports, the first users or industrial actors are supposed to drive the technology development. Enova perceives this to be the problem. IN and

RCN experience more applications than they can support, but in the later phases, where Enova operates, the market test is tough and influences the number of projects available. The potential applicants of Enova support naturally decrease in numbers and the amount of companies in need of full scale testing has shown to be highly variable.

Enova is internationally active and gather information about activities in other countries. They are a member of international forums like IEA and the EU programme, “intelligent energy”. Experiences from other countries give valuable knowledge, but are not directly transferable to Norway as support schemes are affected by the way each society is built in terms of politics, labour market, tax systems etc. Enova consults the government in terms of statements on regulations and provides the ministry of petroleum and energy with input on own initiatives and on specific assignments.

5.8.1.1 Support Area

Enova is technology neutral and has a policy to support different technologies in the field of energy efficiency and renewable energy. Enova continuously performs feasibility studies on different technologies and sectors to map their potential. The government should never support more than 50% of the project, as the private sector has to carry most of the risk. Projects must survive the market test to get private investors. Enova cannot point out single sectors for support, but if someone else has brought the sector forward, Enova can introduce more targeted support programmes. *“You have to bet on several horses when you don’t know who is going to win”*. Bureaucrats cannot choose the market direction, but can adjust the policy according to what the market choose. Enova has not registered any signals towards certain technologies or sectors. Since the wave and tidal industry is at a stage where no leading technology is agreed upon by the market, all technologies must be supported. Marine energy technologies have to compete until it distinguishes from the rest.

5.8.2 Outlook of Renewable Energy in Norway

5.8.2.1 Home market

If there is going to be production in Norway, resources have to be invested gradually and increase in scale. This way, a learning arena can be developed, which is a part of other Norwegian clusters. Governmental control is necessary for something like this to happen. Moreover, Mr. Leistad states that technologies that are in early stages of development and far from commercialization generally will have difficulties obtaining a home market. When the learning curve levels out, the costs have to correspond to market competitiveness. Norway’s low electricity prices make the Norwegian power market very hard to compete in compared to other countries with higher electricity prices and feed-in tariffs. Enova’s challenge is that one can support a full-scale test project and innovation activities in Norway, but the next market is nevertheless outside Norway and value creation will be obtained in other markets. Mr. Leistad thinks it is an advantage to have foreign markets that can contribute in the next phase and share the development costs. He argues that the development support has to do with cluster building and an option for the future. One has to build and develop the competence among actors related to the technology, not only the technology itself. With an existing industry and related activity, the development will most likely continue in Norway. The technology developer does not have to be Norwegian, but we need to be able to utilize the new technology. Norway has good resource potential and competence in the offshore industry and operates at a somewhat high level in the development of several technologies. In addition, Norway has a lot of renewable

energy and would benefit from keeping this position. If Norway chooses to not do anything, the situation can move in another direction and Norway may lose learning effects. There is thus a risk that Norway does not secure its option for benefit of future technologies. The little R&D and development activity that some actors get involved in, can be viewed as an option on future value creation.

Enova finds it difficult to get power companies to host demonstrations. Unless the Norwegian power companies plan activities within offshore renewables abroad, there are few reasons to get involved at this stage. If companies cooperate and each invests a small amount, it is possible to keep the opportunity and benefit from learning. Companies can start with demonstration in Norway and hope that the green certificates agreement is enough to obtain profitable production, if not the companies have to go abroad. Foreign developers could also be interested in testing in Norway since the natural resources provide real operating conditions.

Mr. Leistad believes that it is possible for Norway to participate in certain areas in the development of offshore renewable industry, despite a limited home market. Companies are already engaged in deliveries to the offshore wind industry. The engagement will develop, as companies within shipping, marine constructions, and technical subcontractors become interested in diversification. It will happen with or without Enova's engagement.

UK has provided favourable subsidy schemes within offshore renewable and relied on the market to handle the rest. This has not happened yet and the UK may not have the development at learning they hoped for. Companies have to carry the cost and get the support when starting to produce, but they do not know what to produce since they have not tested their technology. At the critical stage of testing in larger scale, the Norwegian support can be as good as other countries', but not for the second market compared to Scotland.

Mr. Leistad does not believe that Norway has a special responsibility within renewable energy due to the oil and gas industry, as the drivers behind renewable industry are greenhouse emissions and power need. To solve the climate problem, the world needs new renewable energy sources, which demand investments in new technologies. The countries with the most resources are the ones with an option to invest in new technology development. From this perspective Norway has a responsibility due to its capital resources.

5.8.2.2 Test Centre

Mr. Leistad argues that it is problematic to establish test centres since different developers have different needs in operational conditions, which makes it hard to choose one specific site. Scotland has several test centres, but has poor activity at some sites. Norway has some test centres for onshore wind like Valsneset where several developers have tested, and Karmøy are trying to attract actors with need for deep water testing. Test centres are often local initiatives in order to create business activity. Concessions with long duration are important for creating an attractive test centre. Mr. Leistad states that no Norwegian company have tested technology in Scotland. However, the second application is often abroad. That the second application is in foreign markets is not necessarily a bad thing as one has to be in the market that provides most income. It makes no sense for Norway to implement the UK policy as Norway does not need the power and would have to export subsidized power. Norway has to choose another path and accept that the second market lies outside the country. Norway does not have the resources to pay for a market that serve the phase between demonstration projects and the green certificate

market. If Norway is wise, it uses the surrounding markets in that phase. The support system has to scale down as much as possible and still make sure that investments continue.

5.8.2.3 Support Regimes and Future Thoughts

Mr. Leistad believes that there is an unused potential in making the support system in Norway more visible. The companies do not know what the different organisations support or the difference between them. They also have to be educated in what support scheme that can offer support in the next phase. The green certificates are supposed to pull the technologies towards commercialization, but Mr. Leistad is uncertain about the effects. Mr. Leistad understands that the companies that have invested a lot of resources in research experience problems when reaching the stage of full scale testing. Enova has in the past given money to full scale testing of wave and tidal energy projects that should have spent more time in earlier phases with lab and pilot testing at a smaller scale. Only Hammerfest Strøm is still running and the rest of the projects Enova has supported have been expensive experiences that could have been avoided with more support in earlier phases. Nevertheless, Mr. Leistad argues that Norway has one of the most stable and long-term support systems for the early phases. IN and Enova have offered the same support for ten years and he can't think of any country that has offered this kind of support. In addition, RCN, IN and Enova have now developed good collaboration. They collaborate in evaluating applications and have developed common promotion material to appear more united. Mr. Leistad is not sure if they can do more improvement in the support system, but they could do more to develop a more diversified capital market to attract more capital in the early phases. *"To attract more capital in early phases we have to realize that we are few in Norway. We might have an industry that we can develop further by seeking collaboration abroad."*

Norway as a net exporter of energy

It is possible for Norway to become a net exporter of power to Europe. Sweden is doing something like this in their offshore strategy. Sweden is clearer in expressing the Swedish opportunities in Poland and Germany. Norway found out that there was no use for new cables due to small capacity on the grid. The discussion regarding offshore electricity development could create a home market despite conclusions showing that it is more economical to lay cables from shore. It might be possible with a combination. Someone has to calculate if it is cheaper to have unregulated power near the consumption, or to connect to the central grid and risk using power from coal. This could be an early market, but will require political determination.

5.8.2.4 Investor Interest

Enova is worried about the involvement of the private sector and the uneven distribution in the capital market. Little capital is invested in experimental and seed operations like marine energy. If one presents a promising project within the oil industry, one would have it financed within a day, but this is far from the case in renewable energy. Norway has a small renewable energy industry with few actors and there is not enough liquidity in the market. Mr. Leistad argues that more internationalization would give a better financial situation with diversified risk and more available capital in early phases. He states that there is more available venture capital in USA and Asia than in Norway and the rest of Europe. There is a huge market within offshore renewables, Norway is a small country and some foreign investors are involved in Norwegian companies. *"There may be thousand Chinese investors that are interested in investing in a Norwegian technology company. Norway is far from China, but some manage to do it".*

The wave and tidal industry is characterized by entrepreneurs and small companies. Few large industrial companies exist in Norway and these have chosen the role as a demanding customer, with a certain degree of R&D, and want to have competition among several developers in order to choose the best solution. To succeed the entrepreneurs have no option other than to get an industrial partner, but it does not have to be a large multinational company. *“The government cannot compensate for private initiative and trade, only make things happen faster and generate more ideas that the market can choose from. The desire, belief and capability have to be there. If the market is not interested, the government should not invest either”.*

5.8.2.5 Cooperation within the Industry

The wind industry would not have the same development curve unless actors agreed on the technology. Companies cannot collaborate on the activities that generate revenue, but on knowledge creation. Enova experiences odd behaviour on this field by the Norwegian companies they have supported. Enova does not require companies to make their operational data public, but they have to report them to Enova. Compared to Sweden where companies share operational data with each other, Norwegian companies would prefer not to share, even if collaboration can help to reduce the costs. Mr. Leistad does not know the reason for this attitude, but it might have to do with previous projects that have damaged their reputation by miscalculating data.

5.9 Renewable UK

Name: David Krohn

Position: Wave and Tidal Energy Development Manager

Date/place: 14.13.2012, Edinburgh, Scotland

5.9.1 Organization Background

Renewable UK is a trade association for wind, wave and tidal power in the UK. They have about 700 corporate members representing the spectrum of consultants, contractors, developers and other important players in the field. Renewable UK's main roles are to make sure that the policy framework is fortunate for the industry and eliminate barriers by engaging the government. They work a lot with the Department of Energy and Climate Change (DECC) and the Scottish government to make sure that they are talking to each other and that the funding regimes are coordinated and complimentary. In addition, they work towards increased knowledge about the environmental factors, consenting regimes etc., thus trying to improve the clarity around issues that people have doubts about in order to provide a more coherent framework. Not all of Renewable UK's members are British, but all of them have an interest in the UK market. Renewable UK work closely with the European Union Energy Association and are developing stronger ties to Europe.

5.9.2 Policy Framework

The support system in the UK is complex with many players. The Technology Strategy Board (TSB) is fundamentally driving a lot of the R&D. The TSB works across a whole spectrum of fields, such as construction and other renewables, and thus drives many different agendas. However, the TSB is an important player in the area of marine energy as they fund some of the most important R&D projects. The Energy Technology Institute (ETI) and the Carbon Thrust are other developing R&D institutions that fund early stage projects. The Carbon trust could be considered technical experts aiding commercialization of marine energy technology. These

organizations, along with DECC and the Scottish Government, are really important in driving the R&D agenda. DECC has created the Marine Energy Array Demonstrator (MEAD) and the Scottish government the Marine Renewable Commercialization Fund, which are providing upfront capital support of £20 million and £18 million respectively to the leading projects. These funds are more suited for companies on the other side of the innovation gap that have reached the full scale stage, whereas the TSB, ETI and the Carbon Thrust are created for the earlier stages of development. The funds can provide up to 25% of the project costs and getting hold of the remaining 75% can be difficult. Thus, getting private investors interested in marine energy projects is one of the biggest challenges of the industry right now.

On the demand side, the policy framework has improved a lot over the past year or so. The reason for the improvement is basically the harmonization of the financial support through the Renewable Obligation Certificate (ROC) in the UK. The number of ROCs per MWh generated increases from two to five in England, Wales and Northern Ireland in the period of 2013-2017, while Scotland already has the five ROCs regime in place. The introduction of ROCs is an important step for rewarding successful projects as well as catalyzing cost reduction. Another important player is the national grid as the industry is dependent on development of offshore grid work to distribute the generated power.

In David Krohn's opinion, UK is a front running country. Britain has some of the best maritime engineering capabilities due to the large resources on the coast, and is a clear leader in offshore renewables. The UK government just came out and said that they want to maintain this position and DECC's roadmap indicates that they want 300 MW of marine energy by 2020. The 2020-goals in the European Union are important parts of the commitment to offshore renewable energy, but the socio-economic benefit should not be overlooked. There is a massive global opportunity in marine energy and it is important that Britain develop their ability to produce components and devices to export to the rest of the world. The domestic demand is an important enabling factor that makes them secure the industry in the UK, but marine energy is probably not going to make a significant contribution to the carbon reduction by 2020. Compared to for instance offshore wind with 32GW by 2020, marine energy will contribute with 300MW in the same time period, but the potential from 2020 and into the future is immense.

The climate change commitment committee, which is a panel of Members of Parliament (MPs), has produced a report to get an idea on how the industry is doing and what its needs are. The committee interviewed leading companies, pan-industry organizations like Renewable UK, leading academic institutions, as well as the TSB and the ETI. Their conclusion was that that UK wants to use its first mover advantage in a better manner than in the case of onshore wind power in the 80's. Their strategy accomplishing sustained competitive advantage is through enabling the policy framework, which they have succeeded on in many areas already, but there is still progress to be made on the financial constraints. Renewable UK has had a couple of main areas they want to improve in the policy framework. Renewable UK has identified a £120m funding gap that needs to be filled by upfront capital support, debt financing and other government initiatives. The English and Scottish government provided £ 38 million, which was very welcome, but probably not sufficient to further capitalize and enable existing deployment. In addition, Renewable UK wants the green investment bank to put out more proactive support in the early stage marine energy technology and take on a slightly higher risk profile. The last and very crucial area is need for clarity and an appropriate support system through the electricity market reform, which will replace the Renewable Obligation Regime post 2017.

5.9.3 Industry

The UK marine energy industry contains about a hundred companies at the moment. It is a large variety of companies in terms of size and background. Utilities are becoming increasingly involved in the sector and take the role as project developers, supporting technology developers and providers of project finance. The companies are cooperating a lot with each other and the marine energy industry is viewed as a whole. Companies realize the need for all of them to work together which is really pleasing for Renewable UK. The trade organizations also work together to consolidate the industry and move forward. Within offshore wind, companies are competing to a much larger extent, while the wave and tidal industry feel much more like a community where they are dealing with issues together, trying to bring down the cost of energy.

The British government wants to do what it can to help UK companies and secure the skills and capacity, but large international companies such as Siemens and ABB are welcome because they add a lot of credibility to the industry. UK government probably wishes that UK industrial companies take a bigger lead, but they do not have any protectionist laws or similar, other than regulations that decide that projects need to be performed in UK territories. As long as the projects are in Britain, it will develop jobs and skills that will be valuable in the UK. However, certain components and skills are not available in the UK, in which companies in other countries are better to provide. It is therefore very unlikely that hundred percent of the value chain will be within the UK. Thus, there is definitely potential for other countries to get involved, also Norway with its strong maritime background and strong engineering base.

5.10 SAE Wind

Name: Anders Gaudestad

Position: Managing Director

Date, Place: 19.03.2012. Telephone interview (Kristiansand and Trondheim)

5.10.1 Organization Background

Statkraft and Agder Energi created the joint venture Statkraft Agder Energi Vind (SAE Vind) in 2008. The company was given the responsibility of developing land-based wind power in Norway. Statkraft owns 62% and Agder Energi owns 38% of SAE Vind. As Statkraft is a 45,5% owner of Agder Energy as well, Statkraft has directly and indirectly 80% of the total ownership. The owners are to a large extent involved in SAE Vind's activities. Statkraft does things like procurement, operations of parks, infrastructure, HR, computer systems etc., while Agder Energi does wind measurements and analyzes. SAE Vind's goal is to be the leading actor within land-based wind power in Norway, with a production of 1500 MW in 2020, which equals about 50% market share. SAE Vind has a superior position compared to other wind power companies in their financial situation; Statkraft is governmentally owned and can invest for 80 billion NOK until 2017, while most other companies have to be project financed.

5.10.2 Outlook of Renewable Energy in Norway

5.10.2.1 Political Will

To realize land-based wind power in Norway, six issues has to be addressed: The goal, the tool, the concession process, grid, cables, as well as local accept. The goal is the EU's renewable energy directive that Norway is obliged to reach and the tool is the Green Certificates. Green Certificates are favourable because it is a market based incentive system. Prior to the Green Certificate market in Norway, the incentive scheme for wind power resulted in a very

unpredictable development of the industry. One could get investment support from Enova that depended on the government budget, which varied from one year to the next. Currently, there is a surplus of certificates in Sweden and the Green Certificate system is not functioning optimally. This will probably be adjusted by the market itself or by the control station in 2015. Experiences from Norway show that initiatives decided by politics can result in the industry working for several years and use hundreds of millions, only to experience another political decision that close the initiative down and prioritize something else. The green certificates are obliged to last until 2020 and involve considerable less risk, which make more companies engage in wind power development. The concession process is very expensive and tedious. Over the last six months SAE Wind has met with the minister of petroleum and energy, Ola Borten Moe, the ministry of environment and the Norwegian Water Resources and Energy Directorate (NVE) to express their opinions concerning the concession process. While Sweden is developing wind power parks, Norway is using 5-8 years to get a concession. The politicians must recognize that they have made a economic commitment to the EU, agreed to a certificate market with Sweden, the Norwegian tax payers are paying the bill, and developers are ready to build, but cannot do anything without concessions.

"We need grids and cables to avoid locking the power within Norway". Renewable energy needs grids and cables, which implies interventions in nature. Developers will not build wind parks if the supply exceeds the demand. If the power does not reach foreign customers, the excess supply will drive the prices down in Norway. Norway has the opportunity of being a small battery for Germany, Denmark and the Netherlands, but Norway does not have the resources or grid in place to cover Europe. However, it is an important opportunity and German grid politics are stating that Norway can contribute. Norway has close to 50% of the water reservoir in Europe, and could thus import wind power from abroad and keep the water in the reservoirs until its stops blowing.

The local accept for windmills in people's surrounding area has increased by 15% in one year. This increase could be caused by news of the nuclear power disaster in Japan, Germany's closing of nuclear, and pollution from coal as well as oil and gas. People may also be more aware of global warming after more extreme weather in Norway. Studies done by SAE Vind has shown that people have a more positive attitude towards windmills in their local area, as it makes the mountain available due to increased infrastructure, creates jobs and income to the local community, and is by some perceived as a symbol of a clean environment.

5.10.2.2 The Oil Industry

A question can be raised of whether Norway is renewable or not, as Norway produces 125 TWh renewable energy and exports 2500 TWh oil and gas yearly. There is a large demand for oil and gas worldwide, and replacing gas with coal is an environmental gain. The environmental activists who proclaim that Norway has to end their focus on oil and gas are lacking historical insight. If Norway continues the effort in renewable energy, the Nordic market can have up to 50 TWh in excess production by 2020. Unless Norway export this power to foreign markets, it will cannibalize the own hydropower production and make local municipalities lose income. If Norway reaches the 2020 goal, renewable energy will constitute about 2% of Norway's GDP, while oil and gas will account for about 25% - 30%. Norwegians need to remember that the oil and gas industry has created the prosperity we have today. SAE Vind and Statkraft do not experience large competition with the oil industry in relation to attracting a competent work

force. The reason for this is probably that Statkraft is profiled as the largest European actor within renewable energy.

5.10.2.3 Offshore Renewable Energy

Mr. Gaudestad has talked to several politicians that previously were very positive to offshore wind, but have reduced their enthusiasm lately. The production is greater offshore, but cost and complexity are also higher. The costs and complexity in offshore operations are at least twice as high as land-based wind. Statkraft had to depreciate NOK 300 million due to exceeding expenditures in the Sheringham Shoal offshore wind project with Statoil. There are many areas available on shore before one has to move offshore.

Some years ago, several Norwegian politicians proclaimed future world leadership in offshore wind, and emphasized the fabulous opportunity in offshore competence from the oil and gas industry. The politicians do not have to answer to details of high costs and risk since the development of large scale offshore wind in Norway may be 15 years from now and thereby another government's responsibility. In contrast, land-based wind has a short-term perspective and has to be answered to within a short period of time. Land based wind is much more realistic and may cause local resistance in which the politicians risk getting negative media attention.

5.10.2.4 Participation in Industry Development

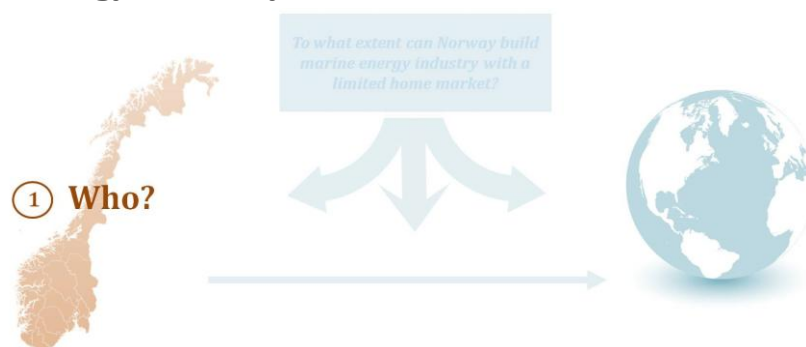
Several local companies within the oil and gas industry have approached Mr. Gaudestad for advice on how to participate in the development of the offshore renewable industry. His advice is to go abroad to a commercial market where one gets paid as well as enhances increased competence, instead of doing R&D in Norway. In order to participate in the offshore renewable industry, companies have to seek markets with another energy mix than Norway. UK has a different need as they have to phase out coal and nuclear power, and are providing incentives to facilitate development.

Norway still needs some R&D projects like wave and tidal power energy. R&D projects are supposed to make money in the long run, which makes it necessary to take a wide approach. Very few companies have the resources to carry out a test project like Hywind.

6 Discussion

The following chapter will discuss the four research questions identified on the basis of literature review and mini cases. The first two research questions are concerned with the Norwegian system and conditions. Perceptions of the different system actors' contribution to the industry are presented in question one, while question two examines whether Norway has advantageous conditions that could compensate for the limited home market. After the two first research questions, a joint discussion is presented evaluating the Norwegian system. Question three and four assess the Norwegian marine energy in a global context. Question three evaluates markets Norway may utilize to compensate for lack of domestic demand while question four assesses the importance of timing in the marine energy industry development. Tables summarizing the case study companies opinions related to each research question are enclosed in appendix A5.

6.1 How Do the Industry Actors Contribute to the Development of Marine Energy Industry?



Both cluster and innovation systems theories suggest that actors in the home market are decisive for competitive advantage and innovation. To be able to answer the question of whether the Norwegian marine energy industry can participate in industry development with a limited home market, the home market conditions need to be addressed. A central thought in the innovation system approaches is that innovation is an interactive process among different actors and that innovation is a collective process among these actors (Malerba 2005). This research question will assess the Norwegian system and how the different actors affect development of marine energy industry. First, the case companies' perceptions of different system actors will be presented, namely; the political system and support scheme organizations, entrepreneurs, large companies, investors and the public. Thereafter, all system actors and their collective contribution for industry development will be assessed, based on Bergek and Jacobsson (2003) theory of functions in innovation systems.

6.1.1 How Is the Norwegian Political System Perceived to Participate to Industry Development?

The following section will discuss the different case companies' perception of how the Norwegian government and support organisations affect the development of the marine energy industry.

6.1.1.1 Limited Governmental Will

"There exists a total refusal of decision making in the so-called red-green government. They have every possibility for accomplishing renewable initiatives, but they only prioritize oil."

Tellef Thorleifsson, Northzone Ventures

Several of the case study companies expressed opinions about the political will to prioritize renewable energy in general as these opinions also hold for marine energy. The investors are the most unambiguous in their opinions of Norwegian political will. Both NV and Scatec emphasize the current government's lack of interest in renewable energy in contrast to the heavily commitment to oil. Scatec states that Norway resists renewable initiative pressure from abroad as long as possible. Furthermore, Scatec argues that the considerable

support to the oil and gas industry causes inflation effects because of the extreme ability to pay wages. Scatec thus argues that government should regulate the development pace in the petroleum sector.

Large companies are also quite clear about their perception of little political will towards new renewable energy. Rambøll argues that the government prioritizes oil and states that there is a lack of long-term goals for renewable energy, while SAE Vind mentions that politicians are afraid to commit to uncertain technologies in their election period. Even though land-based wind has demand-side policies in place, the industry still experience lack of governmental will as tedious concession processes prevent the industry to evolve. Cicero also states that the governmental focus on oil and carbon capture and storage is at the expense of other initiatives.

The general political will in Norway is perceived as negative toward commitment in renewable energy by most industry actors, as it is a widespread view that the government's main priority is the oil industry.

6.1.1.2 A Wide Approach for Support Can Be Insufficient for Full Scale Testing

In contrast to most of the mini case evidence, where strong governmental commitment to a certain technology or sector encouraged industry development, all case study companies favoured a wide approach for support of technology and industry areas in Norway. A wide approach implies distributing the granted support between a large spectre of innovative technologies, letting market forces decide areas for success and adjust policies accordingly. Several companies referred to the Norwegian solar power industry and the importance of letting market mechanisms decide areas of success, as concepts that may seem impossible could prove to be the next big industry.

"The government cannot compensate for private initiative and trade. If the market is not interested, the government should not invest either".

Øyvind Leistad, Enova

Nevertheless, several case companies emphasize that the current wide approach provides good support for early phase R&D and encouragement of new technologies, but is inadequate for capital demanding, larger scale testing. There is a gap between RCN and IN, who support early phases, and Enova who support the commercialization phase after full scale testing. "Miljøteknologiordningen" were introduced in 2011 and is directed at the full-scale pilot phase, but many entrepreneurs still have a hard time getting through full-scale testing, which is reflected in the applications received by support scheme organisations; RCN only has funding for 20% of their applications and has to turn down several good projects. In contrast, Enova does not manage to grant all the available support due to lack of adequate applications. Furthermore, several marine energy projects that have been granted support by Enova should

have spent more time in earlier phases with testing at a smaller scale. Consequently, limited conditions for full scale testing and a poor home market for production, make the entrepreneurs plan to move abroad, either for full scale testing or for later production. Figure 15 illustrates that the marine energy developers operate in either Norway or abroad depending on development phase. The grey line represents the Norwegian companies and what locations they usually choose in different phases. The grey line is placed between foreign markets and Norway in the pilot full-scale phase because several of the entrepreneurs are operating in both places depending on where they receive support.

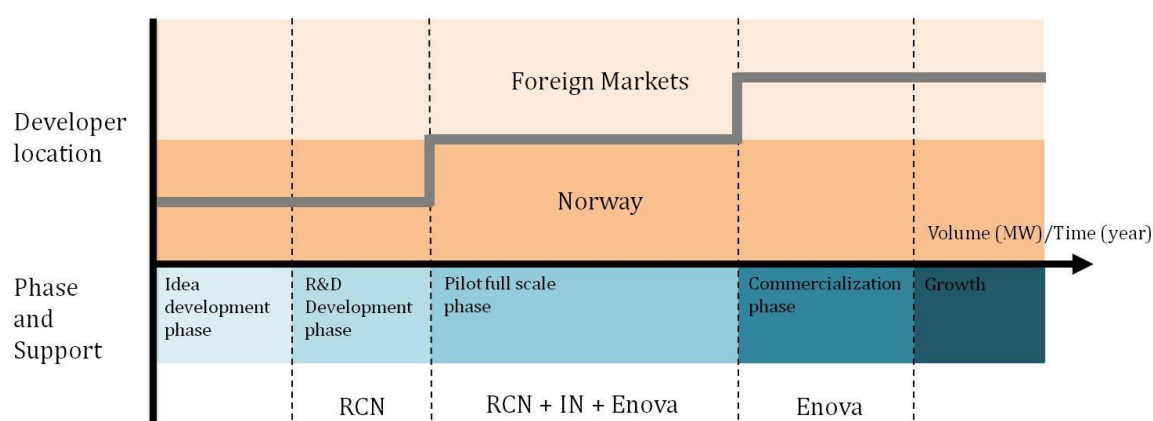


Figure 15: Location of Norwegian Marine Energy Developers

Most of the case study companies agree with a wide approach in the support of renewable energy. The policy framework provides good conditions in the early phases, but many find it inadequate for larger scale pilot testing.

6.1.1.3 Confusing Support Scheme Organisations

Entrepreneurs find the policy regime confusing due to insecurity related to where to apply and to whether funding is granted, and also due to a demanding application processes. Scatec confirms the complexity of the application process by having developed skills in applying for support. The support scheme organizations confirm these impressions and argue that they are in the process of strengthening their collaboration and understanding of each other's business areas. As the support organizations did not even know each other's activities, it is difficult for applicants to understand where and if they can apply for support.

6.1.2 How Do Entrepreneurs Participate in the Development of Marine Energy Industry?

The project assignment conducted during the fall 2011 revealed that all Norwegian marine energy device entrepreneurs had an international strategy from inception due to a limited home market. For instance, Hammerfest Strøm is one of the world's leading developers of tidal devices and has both developed and tested in Norway before moving to Scotland.

All the entrepreneurs had received support from the Norwegian support organisations, as the marine energy devices are very cost demanding to develop. Nevertheless, Rambøll reflects on the attitudes towards support in the renewable energy industry. Many developers expect and demand that all energy projects receive support, which hinder stimulation of innovative ways of cost reductions and investor attraction. When people are in great need or experience pressure they tend to create and innovate more, and expectations of support can remove such

stimulations. Furthermore, some of the entrepreneurs have turned down interested potential partners due to high demands of ownership. Thus, expectations of ownership can also be biased and prevent industry development.

“Research shows that companies that cooperate reach further, grow faster and earn more money”.

Bergny Dahl, IN

The majority of entrepreneurs interviewed do not see the need for collaboration with other entrepreneurs, even though they face many of the same challenges related to technology and business development. Enova observes the same trends in the offshore wind industry, where companies are reluctant to share their results. Enova finds this odd as Swedish companies in the same situation share results to drive the industry forward. Innovation Norway argues that the marine energy entrepreneurs often are alone and overlooked and would benefit from more collaboration.

The entrepreneurs do not see advantages of more collaboration, while all support scheme organisations stress that entrepreneurs need to collaborate more in order to break technology barriers and prevent being overlooked by other industry actors.

6.1.3 How Do Investors Participate in the Development of Marine Energy Industry?

The majority of entrepreneurs state that raising capital is their greatest barrier for further development and the support scheme organisations are all concerned about the involvement of the private sector. Venture capital investors are perceived to have little interest in the technological and political risk, as well as the long time period for commercialization associated with marine energy.

Marine energy investors are often private persons with a special interest and devotion toward marine energy, known as angel investors (See appendix A6 for explanation of terminology). Investors managing large funds, such as venture capital firms, are required to get highest possible return on investments and thereby have stricter demands. The case company investors, Scatec and Northzone Ventures, are both involved in renewable energy. Scatec is labelled an incubator and has renewable energy as its main purpose, while Northzone Ventures is a venture capital firm that engages in renewable projects given estimated profitability. Today's tough market for renewable energy has made Northzone Ventures reluctant to invest in demanding projects. Neither Northzone Ventures nor Scatec are planning to invest in marine energy and both are sceptical toward wave power. NV has previously invested in a wave company that had too promising cost estimations, and Mr. Dahle in Scatec has previously worked with wave power and has little faith in the technology. However, both investors have more confidence in tidal power. Entrepreneurs that have obtained an angel investors or industrial partner, argue that small entrepreneurs searching for capital partners tend to overestimate time to commercialization and thus damage the industry reputation.

Based on the case companies' perceptions, Norwegian investors do not participate in marine energy industry development to a large extent. Several of the case study companies mention more funding opportunities abroad and few relevant investors in Norway.

6.1.4 How Do Large Companies Participate in the Development of Marine Energy Industry?

"Large companies are the engines for marine industry development"

*Bergny Irene Dahl.
Innovation Norway*

For the entrepreneurs to develop their technology, an industrial partner who can assist with knowledge, network and capital is needed. Most industry actors view participation of large companies as a necessity as they provide competence, capital and legitimacy to the industry. The Norwegian entrepreneurs have difficulties finding industrial partners in Norway, and Enova is concerned about the difficulties in getting utilities to host demonstrations. Statkraft and Statoil have both invested in renewable energy abroad, and both SAE wind and NLI encourage entrepreneurs to look abroad for strategic partners. NV argues that entrepreneurs' difficulties financing pilot testing might be equally applicable to attitudes in large companies as to governmental decisions. Norwegian companies often choose safe and well known partners, as opposed to the US where large companies have a culture of helping entrepreneurs by testing and using their solutions. However, there are some entrepreneurs with industrial partners in Norway. Examples of industrial partners are NLI, a company within the oil industry that has three offshore energy projects, and Sørcom, which has made the tidal power company, Flumill stay in Norway after testing in Scotland.

Some entrepreneurs have entered partnerships with large companies, but large companies are generally perceived as unwilling to engage in marine energy. However, several actors perceive large companies as a necessity for industry evolvement.

6.1.5 How Do the Public Participate in the Development of Marine Energy Industry?

Several case companies mention the lack of pressure for renewable energy from the public. Norwegian hydropower makes Norway self-sufficient, as opposed to other countries whose energy mix consists of environmentally damaging energy sources, often imported from other countries such as Germany's import of Russian gas power. Rambøll stresses that lack of pressure is also a result of low unemployment rates. RCN states that most Norwegians do not see the bigger picture in relation to export of renewable energy, only the increase in electricity prices and interventions in nature. Furthermore, RCN argues that the government should educate the public in reasons for why Norway should invest more in renewable energy. Scatec has a similar opinion, and argues that Norwegians in general underestimate the size and importance of new renewable industries like solar and wind. According to NV, the financial crisis has led to a shift in attitudes. As employment rates and value creation are in focus, global warming and thus pollution from the oil industry are trivialized. However, SAE Vind reports increased local acceptance for windmills in Norway among local communities that have established land-based wind farms.

The Norwegian public does not provide the same pressure for renewable energy as in most other countries due to dominance of hydropower in the energy mix and high employment rate. The public is rather perceived as showing resistance for marine energy due to the possible increase in electricity prices and intervention in nature.

6.1.6 How is the Collective Contribution of the System Actors?

After going through the case companies opinions of different system actors several implications can be made. Bergek and Jacobsson (2003) present five functions to evaluate a system's contribution to industry development, which all have to be served for an industry to develop and perform well. The following section will discuss each of these functions and how the different actors affect industry development. Following the theory of Bergek and Jacobsson (2003), the marine energy industry is in the first phase of industry evolution due to lack of a dominant technology design and thus practises experimentation and legitimacy of technology.

6.1.6.1 Does the Norwegian System Guide the Direction of Search?

The majority of the case study companies perceive the government as unwilling to prioritize new renewable energy areas, creating an unfavourable base to guide the direction of search. Even though most system actors agree with the wide approach for governmental support and the industry is searching for dominant technology designs, the wide approach does not favour the search towards marine energy technologies, but rather innovation projects in general. Both investors have negative experiences with wave power. Wave power has a long history in Norway, dating back to the 1980s and is not yet commercial, which further provokes scepticism. Negative stories make the industry lose credibility and provoke a higher need of success stories. Most system actors view participation of large companies as a necessity as they provide competence, capital and legitimacy to the industry. Thus, increased involvement of large companies could also strengthen the legitimacy.

The perceived unwillingness by politicians, the wide approach and lack of legitimacy, imply a poor guidance of search for Norwegian marine energy industry.

6.1.6.2 Does the Norwegian System Supply Enough Resources?

Lack of investors and industrial partners make supply of resources such as capital and competence underserved. There is no relevant governmental support for production of electricity, but R&D support is perceived as good until the pilot-testing phase. However, the early phase R&D also has potential for improvements as the RCN only has funding available for 20% of their applications, while Enova does not grant all available support.

The Norwegian supply of resources is quite well served by support organisations for early R&D phases, but inadequate in large scale testing phases. In addition, resources are not well served by investors and large companies.

6.1.6.3 Does the Norwegian System Provide Positive External Economies?

One apparent implication from the case companies' opinions is the need for collaboration between entrepreneurs. Moreover, the three support organizations have also realized a need for more collaboration with each other, and large companies' low interest in marine energy entrepreneurs indicates little collaboration between entrepreneurs and larger companies.

Overall, the creation of positive external economies is limited as few actors collaborate and share knowledge.

6.1.6.4 Does the Norwegian System Facilitate Formation of Markets?

Theory and mini cases advocate the advantages of domestic demand and that governments may have to initiate measures to facilitate formation of markets. However, Norway does not have demand policies and incentives for creating a market for production of energy, and the public

might rather pressure for less new renewable energy initiatives. Even though there are some favourable policy schemes available, the Norwegian system does not facilitate an end-market formation.

6.1.6.5 Poor Contributions for Industry Development

A central thought in innovation system thinking is that actors as a collective act *create new knowledge* (Bergek and Jacobsson 2003; Malerba 2005). The Norwegian system actors do not serve any of the functions optimally and knowledge is only to a limited extent distributed between them. Thus, several factors other than the more obvious lack of domestic demand contribute to a limited Norwegian market. Figure 16 summarizes how the different functions are served in the Norwegian system and their collective effort to create new knowledge. Negro (2007) argues that functions influence each other and can induce virtuous or vicious cycles that enhance or reduce development. The poorly served functions indicate that the Norwegian system experiences vicious cycles such as: The lack of pressure for renewable energy does not create political will and demand-side incentives, which makes the industry less interesting for investors. In contrast, if some functions improve, it can create ripple effects to other functions. If for instance collaboration improves, the industry might obtain more legitimacy and attention among industrial partners, investor and government.

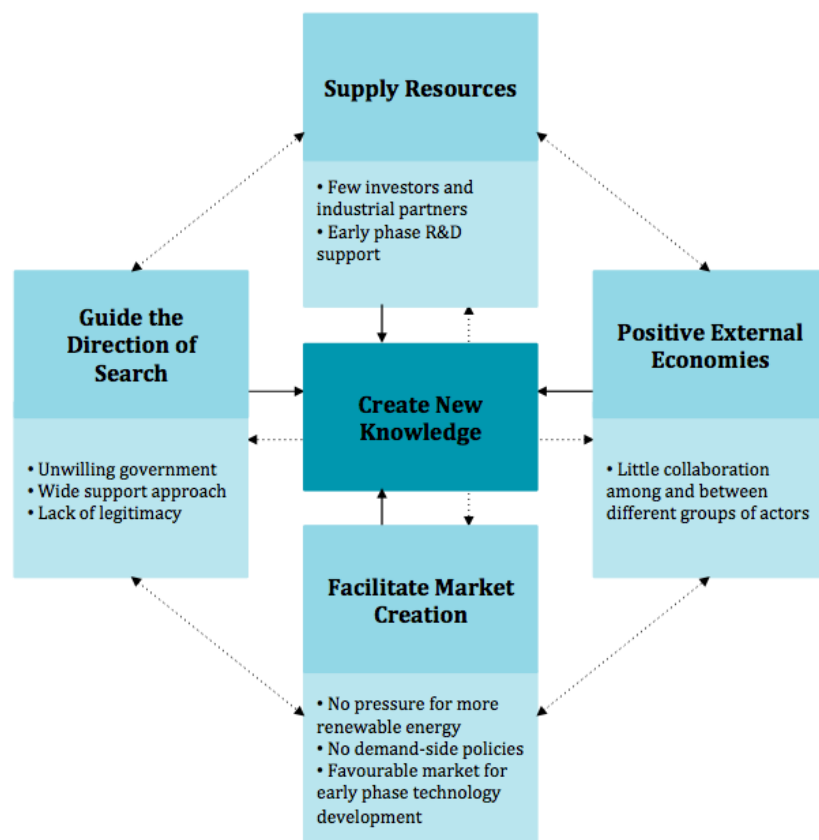


Figure 16: Functions Served in the Norwegian Innovation System

According to Bergek and Jacobsson (2003) the Norwegian industry will have a poor development, as all the functions are poorly served. As Porter's (2000) definition of a cluster is similar to an innovation system, the industry actors' perceptions confirm that there is no marine energy cluster Norway.

6.2 Are There Any Advantageous Conditions in Norway That Can Compensate for Limited of Home Market?



Theories of national competitive advantage and innovation systems both discuss the configuration of a country's underlying conditions for success in the international scene. Even though Porter's (1990) *demand conditions* are considered poor for wave and tidal power production in Norway, other factors may give a foundation for involvement in the industry, in line with the Norwegian development of solar power despite a limited home market. In this section we will discuss if there are advantageous conditions in Norway that can compensate for the lack of domestic demand for marine energy production, based on the opinions of the case study companies.

6.2.1 Competence, and Related and Supporting Industries

6.2.1.1 Oil and Gas and Maritime Industry

Norway is a leading country within offshore operations in oil and gas- and maritime industry, and has developed viable clusters within both of these industries on the west coast (Regjeringen.no#2 2012; Regjeringen.no#3 2012). The majority of the case study companies commented possible linkages between the petroleum – and maritime industry. Cicero and RCN believe that the established clusters within the petroleum and maritime industry could be expanded to contain other marine operations such as wave and tidal power development. In periods when there is a dip in the petroleum market, RCN notices an increase in activity within offshore renewables from supply companies in the petroleum sector. Offshore petroleum companies starting to diversify into renewables indicates that the companies themselves believe they have competence within the field and thus supports the argument that the petroleum industry could be an important factor in development of marine energy devices. Grünfeld and Espelien (2011) conclude that Norway should commit to segments and companies that are linked to the large existing clusters in Norway. An expansion of the existing clusters to include marine energy would thus be in line with their recommendation.

The entrepreneurs list the presence of related industries such as oil and gas as one of the favourable reasons to be located in Norway compared to other countries. Langlee for instance

"People are saying that you should take oil and gas solutions and think like shipping – little equipment, cheap and a lot of identical vessels".

(Anders Tørud, NLI)

finds it beneficial to have relations with Norwegian suppliers that can provide most of the equipment when they execute demonstration projects. Both NLI and RCN comment that petroleum operations have very strict demands and they emphasize the importance of

transferring the technical solutions from the oil and gas sector without bringing the high cost level.

According to Scatec, offshore wind, and the petroleum and maritime industry can be viewed in analogy to the history of REC and the metallurgical industry. However, Mr. Gulli from Fred Olsen argues that the solar power industry was a spin-off development of the traditional metallurgical industry rather than a new industry. In addition, Mr. Gulli believes that the differences between the marine energy industry and the oil and gas industry are much greater than the differences between solar and metallurgical industry. Cicero also emphasizes that the synergies with the petroleum industry not should be exaggerated; it is still challenging to construct marine energy devices. In addition, Scatec admits that offshore renewables have less standardized elements and thereby require more technology development than the solar industry did.

6.2.1.2 Other Competence Important for Development

Other industries in Norway such as the hydropower and the fishery industry are also believed to be interesting for the marine energy industry. SN Power argues that it is important to have groundwork in order to build an industry and internationalize. The groundwork does not have to be hundred years of hydropower experience, but it has to be some form of competence or underlying conditions. SN Power values their competence in business development, not only their technical background when initiating projects. Norway has groundwork in their history of developing wave power technology and in Marintek at NTNU, which has a well-established research centre within offshore energy technology. RCN emphasizes that there are few countries that have progressed further in the development of wave and tidal technology than Norway.

6.2.2 Favourable Physical Resources

As seen in the industry overview, Norway has one of the greatest wave power potentials in Europe and reasonable tidal resources. Several of the case study companies have mentioned the possibility of Norway becoming an exporter of energy and effect to Europe by developing offshore renewables, and Innovation Norway states that if one considers the resources in the North Sea when the technologies reach grid parity, Norway will have immense energy resources available. Germany's closing of nuclear power equals more than the Norwegian hydropower production, which creates a large potential market for Norwegian export of power. Several participants at the Renewable UK wave and tidal conference commented a possible connection between the north coast of Scotland and Norway, which could give massive benefits including later commercial development of marine energy. However, SEA Vind emphasizes that if Norway continues the effort in renewable energy, the Nordic market will have 50 TWh in excess production by 2020. Unless Norway exports the excess power to foreign markets it will cannibalize the hydropower production and make local municipalities lose income. Thus, it is not likely that the Norwegian government decides to develop the full marine energy potential within the next decades as there is little need for increased power supply, and inexpensive hydropower are accessible. A central question is whether Norway is interested in subsidizing electricity sold to Europe, thereby increasing the Norwegian electricity price. Nevertheless, the physical resources provide a realistic environment for testing of marine energy devices at the current point in time.

6.2.3 Considerable Capital Resources

Norway has a large amount of available capital due to petroleum earnings and the politicians, through the oil fund, have the responsibility to invest these assets in a profitable manner in order for coming generations to favour from the country's physical resources. As the petroleum

production and consumption constitute an environmental hazard, it could be discussed whether Norway has a greater responsibility to contribute to the development of green technology than other countries. Enova believes the countries with the most resources are the ones with an option to invest in new technology development. From this perspective, Norway has a responsibility due to its capital resources. However, the question of whether Norway should invest in new green technology due to moral reasons is more complex than the total CO₂ balance as there are many interests to consider. Nevertheless, Norway has considerable means to invest in green technology compared to other countries.

6.2.4 Possible Value Chain Roles Based on Underlying Competence

Based on the advantageous conditions in Norway, several of the case study companies believe Norway has the potential of taking part in certain areas of the industry even though the demand conditions are poor. RCN believes that Norway could supply ground work for floating and rock solid devices with the competence from the oil and gas industry, and also operational work based on competence from the maritime industry. Enova argues that marine and wind energy initiatives will develop as companies within shipping, marine constructions and technical subcontractors become more interested in diversification. Scatec believes Norway could take on several roles in the value chain of offshore renewable energy given that Norway wants to focus on this field. Norway could specialize in marine constructions and underwater operations, and advanced support vessels to the industry could probably be built in Norway. Engineering design and maintenance operations could also comply well with the present Norwegian competence base. The arrows with orange shading in Figure 17 below illustrate the suggested roles Norway can take in the value chain based on the underlying competences in Norway.

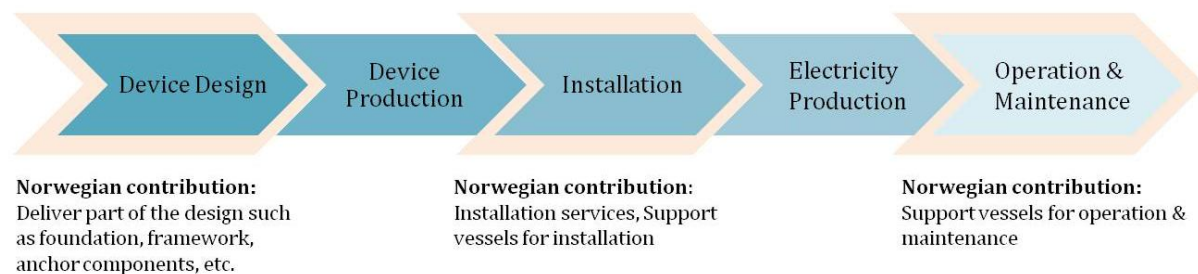


Figure 17: Possible Supply Chain Roles based on Underlying Competence

Whether the suggested roles are possible to obtain or not, will depend on the further development of the industry both in Norway and abroad. REC's closing and Demarks security in their home market argue that it might be difficult to keep industries in countries without domestic demand as the industry matures. However, in contrast to wafer production, offshore competence involves expertise and high tech solutions and are not likely to be outperformed by countries specializing in low cost production.

6.2.5 Can the Conditions Compensate?

There are certain advantageous conditions in Norway within marine energy: technical and business competence from related and supporting industries as well as favourable natural and capital resources which could be exploited in the future, and provide a realistic environment and means for testing devices. The advantageous conditions discussed are illustrated in Figure 18.

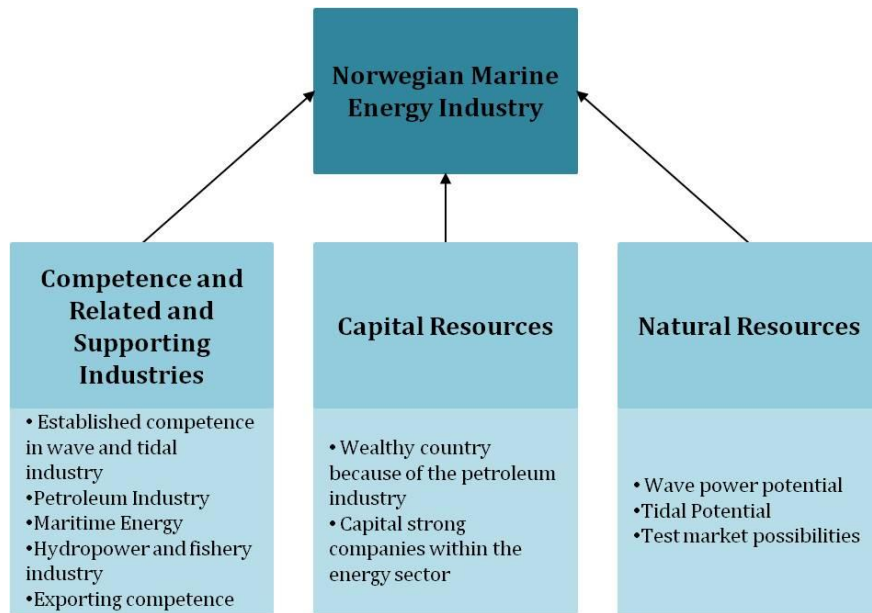


Figure 18: Advantageous Conditions in Norway for the Marine Energy Industry

Several of the case study companies commented that there might be a conflict of interest between the petroleum industry and the marine energy industry as they demand the same competence and there is a shortage of qualified engineers. The supporting and related industries might thus impose both a threat and an opportunity for the marine energy industry. However, the current advantageous conditions will increase the possibility for success if Norway decides to focus on marine energy.

6.3 Discussion of RQ1 and RQ2: Evaluating the Norwegian Marine Energy Industry Development through New Framework

The theory discussion in section 3.5 revealed that the reviewed literature does not have a framework for assessing home markets in early evolution phases that considers several aspects of industry development. Porter's (1990) framework considers a nations competitive advantage, Eliasson (2000) present a competence block needed for a viable industry to emerge and innovation system approaches consider industry actors and their collective effort toward innovation (Malerba 2005). However, no framework explicitly assesses factors needed for an industry to evolve in early phases. We have thus created a new framework that could be used to evaluate features needed for the marine energy industry to evolve in the phase before grid parity. Based on the two previous sections, six essential features are identified: *coordination, demand, supply-side policies, investor and partner access, competence for related industries* and *physical resources*. Following is a description of the different factors and an evaluation of Norway in light of the new framework. The blue lines in Figure 19 illustrate the evaluation of Norway on the each of the six features.

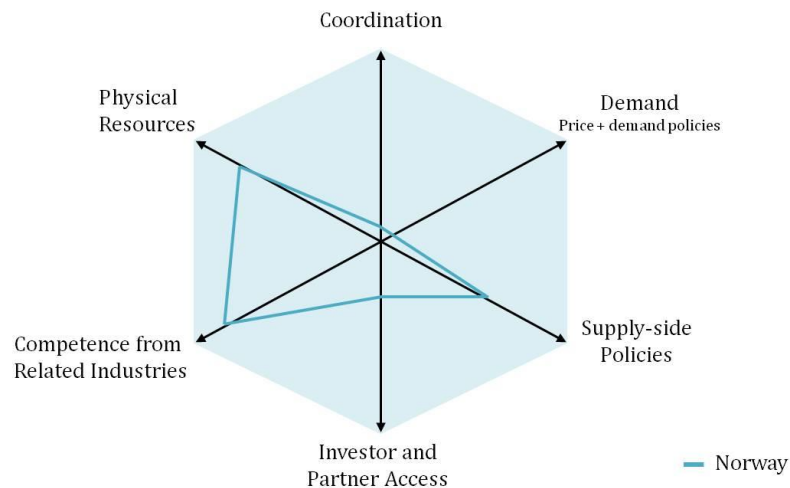


Figure 19: Norwegian Situation for Development of a Marine Energy Industry

Coordination: Porter (1990) presents industry structure and rivalry as an attribute in his cluster framework. However, in early phases of technology development the most important activity is to develop and improve technology. If entrepreneurs collaborate on common challenges they could help each other develop technology to faster arrive at a dominant design. The development also depends on activity and collaboration from all actors in the system. Thus, industry collaboration may be of more importance than rivalry in early phases. This feature is therefore labelled coordination in order to include the whole industry environment and activity among actors in the nation that contributes to industry development. The Norwegian marine energy industry scores low on coordination as the entrepreneurs do not see a need for cooperation, and few large companies get engaged in the marine energy industry.

Demand: Both the cluster and innovation systems approach emphasize demand as an important attribute. Countries in need for renewable energy in their energy mix can introduce demand-side policies in order to stimulate demand for renewable energy technology. Demand policies raise the profit to producers of renewable energy to a level that can compete with traditional energy production. Markets with high electricity price need less demand policies for renewable energy to be cost comparative. Thus, demand can be measured in price plus demand policies. Norway has low electricity prices and no demand policies as the electricity mix consists of 99% hydropower.

Supply-side policies are policies that stimulate innovation and technology development. Porter (1990) argues that the government is an additional factor that does not provide competitive advantage, but governmental subsidies are crucial for marine energy industry to evolve. The marine energy industry is at an early stage of technology development and in need of considerable improvements to be cost efficient. Thus, R&D currently characterizes the marine energy industry, and supply side policies are crucial for development to happen. As discussed, Norway has adequate supply side policies for the early phases of R&D, but the policies for larger scale testing are perceived as insufficient.

Investor- and partner access: Investors can be placed under supporting and related industries in Porter's cluster framework, and are essential actors in innovation systems. As the technology development demand major capital investments and competence, entrepreneurs are dependent on investors and industrial partners to develop their technology. Most entrepreneurs have a

hard time finding suitable partners and investors in Norway making the investor and partner access relatively low.

Competence from related industries: Porter (1990) considers related and supporting industries as a factor, but in relation to industry development, competence from related industries can contribute to develop new industries. The marine energy industry can utilize other industries' competences in the whole value chain. Norwegian offshore competence can constitute an advantage in areas such as installations, maintenance and advanced technology.

Physical Resources: As exploitable wave and tidal power potential are located in certain parts of the world, physical resources naturally decide locations for production. Nevertheless, the physical resources do not necessarily have to be world leading, as sophisticated demand provides incentives for developing more efficient solutions and technologies (Porter, 1990). Germany does not have a large amount of sun compares to other countries, but managed to build a solar industry with favourable policies. Thus, modest amount of physical resources could give a demanding home market as long as the demand and incentives are in place. Norway has a large potential for wave power and moderate for tidal power.

The six attributes imply that Norway have moderate conditions for development of a national industry on their own as there is low demand, coordination and investor interest, but good competence from related industries, physical resources and R&D policies. However advantageous the Norwegian conditions might be or not be, commercial companies are dependent on demand in order to survive in the long run. If there is no realistic outlook of accessible demand, the marine energy industry development will stagnate. There are thus no underlying conditions that can fully compensate for lack of domestic demand if the entrepreneurs cannot access demand in other markets. Norwegian wave and tidal power companies are therefore forced to look abroad in search of demand and we will elaborate further on what markets Norwegian marine energy companies can exploit in the next section.

6.4 What Markets Can Norwegian Companies Exploit to Succeed With a Limited Home Market?



The previous questions have elaborated on Norway's innovation system and advantageous conditions. According to the cluster approach a firm's capabilities to tap into the location advantages of other nations are limited (Chang Moon and Rugman 1998). However, Rugman and D'Cruz (1993) disagree with Porter and argue that firms can build on both domestic and foreign diamonds to be competitive. Several advocates of the innovation systems theory argue that different innovation systems function across national borders (Niosi and Bellon 1994; Hekkert, Suurs et al. 2007; Markard and Truffer 2008). Consequently, the Norwegian marine energy industry can exploit other markets to compensate unfavourable features of the Norwegian market.

6.4.1 Physical Potential and Policies Constitute Attractive Markets

Several of the system actors emphasize that marine energy companies should pursue foreign markets. Enova stresses that it is wise of Norway to utilize other markets as this could provide higher earnings in the long run. Innovation Norway helps Norwegian companies in foreign markets and argues that companies should aim at reaching out to foreign countries due to Norway's limited home market. Northzone Ventures believes that it is possible for developers to participate in the development of the British initiatives in the North Sea, and that it does not really matter if it is located on the Norwegian or British side.

The industry overview presents the worldwide market of marine energy. Wave and tidal resources naturally have geographically restricted markets due to different power potential at different locations. Globally, UK is one of the countries with largest potential for both wave and tidal energy. North-West Europe has a large potential for tidal stream power development in which countries like France and Portugal also hold favourable natural conditions. The number of countries with renewable energy targets has increased to a large extent the over the last years, and it has also been a renewed interest in marine energy, which create more potential markets. Demand subsidies in Portugal, UK and Ireland generate some of the most favourable electricity prices for marine energy. UK's price equals approximately 2.15 NOK/kWh, compared to Norway's approximately 0.50 NOK/kWh with green certificates.

Considering natural resource potential and policies, Norway is located near several of the promising markets such as UK, Ireland, France and Portugal. As UK has best physical resources as well as the most favourable subsidies, this market will be further elaborated.

6.4.1.1 What Conditions Is Present in the UK Market?

Russo (2003) argues that the determinants of how sustainable industries will evolve are related to costs of traditional alternatives negative externalities. In contrast to Norway's traditional hydropower, the energy mix in UK is dominated by natural gas, coal and nuclear energy, which generate negative externalities in terms of environmental damage and thus demand for renewable energy. The UK has a current installed capacity of 8 MW and a goal of 27 GW by 2050 (appendix A5). The industry actors attending the Renewable UK wave and tidal conference showed great optimism for marine energy power, and the speakers all praised the governmental initiatives that have helped the UK industry to grow over the recent years. Several argued that the Scottish government's clear communication of goals, future plans and the willingness to focus on the industry has been important for keeping the projects within the country. Maria McCaffery, CEO of renewable UK, believes that within the last year, the government have put in place some of the most progressive policies in the world. As mentioned, Scotland has the most favourable demand subsidies for marine energy, and by 2017 the rest of the UK will also have implemented the 5 ROCs subsidy. The UK is also to set up the world's first investment bank exclusively dedicated to renewable initiatives, and Renewable UK emphasizes the importance of channelling the support to marine energy. Figure 20 outlines the most important subsidy initiatives in relation to the different development steps and technology readiness. The Scottish government has initiated the New Marine Renewable Energy commercialization fund to provide upfront capital in order to manage later stages. There exist several additional initiatives such as the marine array demonstrator (MEAD) created by the department of energy and climate change (DECC).

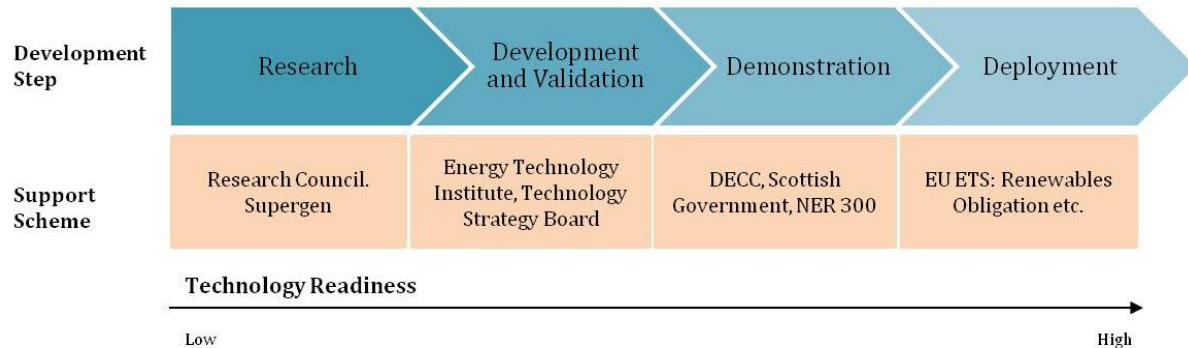


Figure 20: Overview of the British Support Policy Schemes

The number of companies with installed devices is increasing and the value chain in the UK has started to evolve. Utilities and other actors also show increased commitment to the marine energy industry and some utilities have developed own devices. The director of the Marine Estate of Crown Estate proclaims that the involvement of large industrial actors and equipment

"The wave and tidal industry feel much more like a community where they are dealing with issues together, trying to bring down the cost of energy."

David Krohn, Renewable UK

manufacturers are going to be of great importance for delivering of the first array scale projects, while Renewable UK emphasizes that large companies add a lot of credibility to the industry. The Energy, Enterprise and Tourism Minister in Scotland, Mr. Fergus Ewing also welcomes multinational companies, which is important to provide cost reduction and scale in the industry. ABB, Alstom, Andritz, Siemens, Rolls-Royce and Voith have all

entered as partners for marine energy projects. Mr. Fergus Ewing also points out the importance of the EMEC test centre and its attraction of worldwide actors. Renewable UK praises the collaboration between system actors in order to develop the industry toward commercialization; industry actors realize the need for collaboration and view the industry as a whole. Law firms have also gotten involved, as legal matters become more important as the industry move towards commercialization. Nevertheless, UK also stresses the need for more private investment.

6.4.1.2 What Conditions Can Norway Utilize in the UK Market

In accordance with theory on open innovation systems and double diamonds of competitive advantage (Niosi and Bellon 1994; Markard and Truffer 2008; Rugman and D'Cruz 1993), the framework introduced when evaluating the Norwegian marine energy development in section 6.3, can be used to compare national conditions and consequently reveal what features each market perform better.

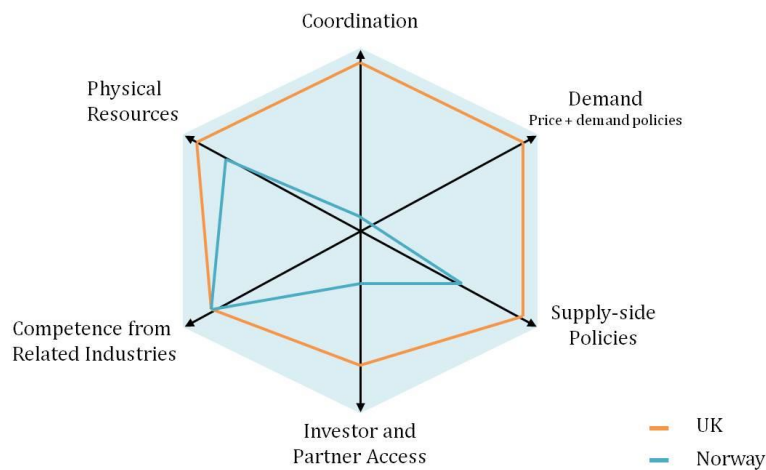


Figure 21: Norwegian and British System Mapped Together

The comparison of the UK and Norwegian market, illustrated in figure 21, implies that Norwegian companies could have possibilities for utilizing the UK market in several aspects. The previous discussion of favourable markets have revealed that the UK clearly outperforms Norway with its collective approach for industry development, aggressive demand-side policies, supply side policies for larger-scale testing and engagement from large companies. UK has similar offshore competence, but better physical resources than Norway mostly due to larger tidal power potential. Moreover, UK also experiences some challenges in getting investors interested.

6.4.2 Off-grid Markets

Several case study companies mention subsidies as a driving force for marine energy industry development. However, off-grid markets can also be attractive foreign markets for Norwegian marine energy actors. Off-grid markets have high electricity prices and need less subsidies to be profitable, thus there is less political risk associated with alterations in subsidy regimes. Scatec mentions Chile, Hawaii and Mali, as attractive off-grid markets. Hawaii has for instance an energy mix of 80% diesel and a goal of 80% renewable by 2020. Of the entrepreneurs, Langlee stands out by targeting off-grid markets in addition to the policy driven UK market. Langlee has already initiated projects such as a contract to develop at Stewart Island in New Zealand, and is

also in the process of making a contract with a developer at the Canary Islands. Langlee collaborates with local partners in all off-grid projects, and island communities contact Langlee for cooperation, which indicates that partners in off-grid markets view involvement in marine energy as profitable. However, coordination in off-grid markets will be limited, as industry activity has not yet been established.

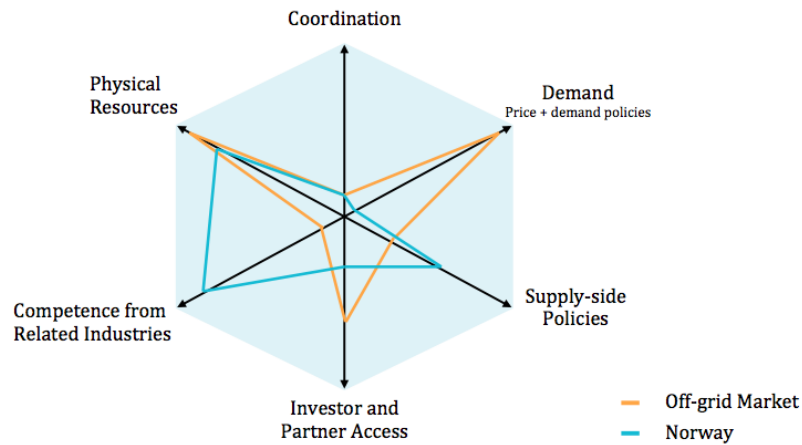


Figure 22: Norwegian and Typical Off-Grid System Mapped Together

Figure 22 illustrates Norway compared to a typical off grid market, which has physical resources and demand, but needs competence and technology to develop and implement new energy sources. Thus, off-grid markets may be an attractive market for Norwegian companies engaged in marine energy.

6.4.3 Protection and Partners

Countries might restrict subsidies to local content, making it harder for foreigners to enter. SN Power points out that the Norwegian hydropower industry does not allow foreign companies to control hydropower plants and other countries could very well claim the same protection. Scatec states that it was more focus on free trade during the development of solar industry, and that the financial crisis has made countries more protectionists. However, renewable UK proclaims that it is unlikely that the entire value chain will be located in the UK. Renewable UK further stresses that there is potential for other countries to get involved, such as Norway with its maritime competence. Compared to leading policy markets, off- grid markets are in high need of competence from abroad and are more likely to welcome, rather than prevent, foreign initiatives. Off-grid markets may however require use of local services.

"There is definitely potential for other countries to get involved, also Norway with its strong maritime background and strong engineering base."

David Krohn, Renewable UK

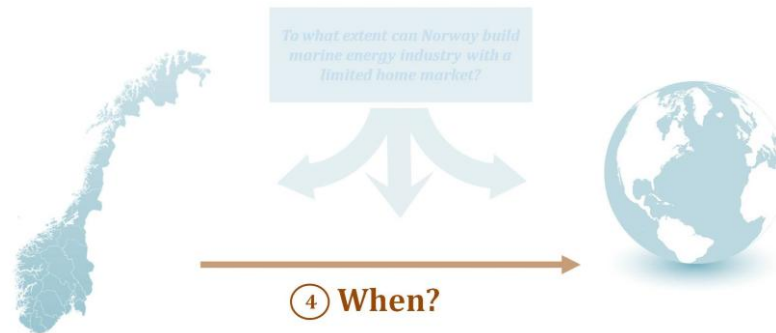
SN Power wants partners when entering new markets as local companies enhance valuable knowledge about the market and policy system. Thus, involving a local partner may be a way to avoid potential protectionist restrictions. SN power has also used Norwegian companies in international markets because they have great experience in hydropower and often offer the best services. RCN, Innovation Norway and SAE Vind argue that small entrepreneurs should utilize international companies and their business and international competence. Thus, finding a local partner in the foreign market, or a Norwegian industrial partner who is engaged in international operations, might act as an entry to protected markets.

6.4.4 Where?

Norwegian companies can exploit markets with favourable conditions missing in Norway. The UK stands out in terms of physical resource potential, demand policies and industry activity. Less popular, but highly relevant, are off-grid markets, which have a high demand independent on subsidies and a great need for renewable energy technology. Companies that have transferable competence from the offshore industry as well as entrepreneurs can exploit markets like the UK and off-grid markets.

As discussed in research question two, Norway has the possibility of exporting power to European markets, as well as considerable capital due to the oil industry that can be invested in marine energy projects in foreign countries. Mr. Thorleifsson from NV, believes that Norway should create a renewable energy entity that invests in renewable energy projects that give highest return on invested capital. Other actors involved in renewable energy should be merged into this entity, such as renewable energy projects within Statoil and Statkraft. SN Power finds the idea interesting as they have extensive market experience all over the world and could expand their business to contain a broader range of renewable energy. Thus, Norway can also make use of others' limited markets by letting other nations exploit its natural resources and capital.

6.5 How Important Is Timing for the Development of a Norwegian Marine Energy Industry?



In this section we will focus on the time horizon of the marine energy industry and discuss when and to what degree Norway should get involved in the marine energy industry.

6.5.1 Time Horizon in Development of the Marine Energy Industry

According to Klepper and Graddy (1990) there are two factors affecting the pace of the evolution process of an emerging industry, namely the characteristics of the product technology and the nature of the buyers' preferences. Limitedness of technological change and similar buyers' preferences induce faster maturity (Klepper and Graddy 1990). The marine energy industry is characterized by immense opportunity for technological change and the variety of buyers' preferences is high due to different operational environment at different sites. Presentations at the Renewable UK conference in Scotland (appendix A4), made it evident that the industry has yet to gather around some technical solutions and develop standards. Within tidal energy technology, the industry is starting to see a trend towards wind turbine-like seabed turbines, but there is still technological variety between the different concepts. Within wave power there are great differences in the devices both in scope and scale. The immense variety induces a slow maturity of the marine energy industry, in line with Klepper and Graddy (1990).

The time horizon on the development of marine energy industry is thus long due to both technical and market conditions. When the marine energy industry will reach commercialization is still uncertain, but Renewable UK does not believe marine energy will make considerable contribution to the carbon reduction before 2020, however the potential post 2020 is immense.

6.5.2 Creator, Anticipator or Follower?

The timing of industry entry could be crucial to the long-term survival of a firm. Agarwal and Bayus (2004) argue that firm survival rate is positively related to time of involvement in the industry creation. Creators that enter the industry before the firm take-off have higher survival rates than anticipators that enter after firm take-off and before sales take-off (Agarwal and Bayus 2004).

At the Renewable UK conference (appendix A4) the analogy between the on-shore wind power in the 1980s and the current development of marine energy industry was elaborated in several presentations. The British industry actors are clear that they are not willing to let their development lead slip as it did back in the 1980s, and timing is thus considered important. UK wants to utilize its first mover advantage within marine energy and not leave the development to other countries. The UK has thus taken on the creator role in the marine energy industry.

Norway has been present in marine energy R&D projects for a long time and could of that reason be considered a creator. However, as the government has taken on a strategy of letting the market forces decide what technologies to pursue, Norway should rather be considered an anticipator waiting for the market forces to stimulate further growth.

6.5.3 Extend Support to Retain Development in Norway

Figure 15 discussed in research question one, shows where in the development phases companies decide to move abroad. As the figure implies, all companies eventually need to move out because of the limited home market. A central question is how much of the operation and competence that will remain in Norway when the companies move. RCN and Innovation Norway do not see Norwegian companies moving abroad as a problem, as they believe parts of the company and competence still will be located in Norway. However, the interviews with the entrepreneurs in the fall 2011 indicated that several of the device companies were inclined to move their operations to the UK if necessary. When companies are forced to move early in the development phases, they are possibly less likely to keep valuable functions in Norway. Cicero emphasizes that it could be less expensive to get involved later when the technology is more mature and one can benefit from the experience of others. However, there are many benefits connected to enter in the early stages of the learning curve and possibly become a leader.

Whether Norwegian government should increase its involvement in order to keep up with the global development relies on what the goal is. Cicero emphasizes that if the government's primary target is to contribute to the global development of green technology, there is no problem in only supporting the R&D phase. However, if the government has a strategic interest in marine energy and wants to develop exporting industry, they may have to extend the support.

If the goal is to become an important industry actor in the marine energy industry the government should focus on keeping most of the competence within Norway. The entrepreneurs list proving their technology as one of the most vital factors in attracting investors, and Scatec argues that Norway has a handicap when it comes to proving technology as there are few facilities to test devices. Some test initiatives have already been conducted in Norway, but there are no centralized governmental initiatives to develop a shared test facility such as EMEC in the UK. According to Innovation Norway, a Norwegian test centre has been under much discussion and the development of such facilities seems favourable, but it might demand a higher price than Scottish ones, thereby making developers test in Scotland either way. Nevertheless, a way to make competence stay in the Norwegian industry could be to extend the period companies can operate in Norway by improving the support schemes to cover larger R&D projects and better prototype testing. This is in line with the recommendations of Gründfeld and Espelien (2011) to strengthen the commitment to business oriented R&D programs in segments that have potential for high international competitiveness. The possible consequence of the suggested changes to the support system is illustrated in Figure 23 below.

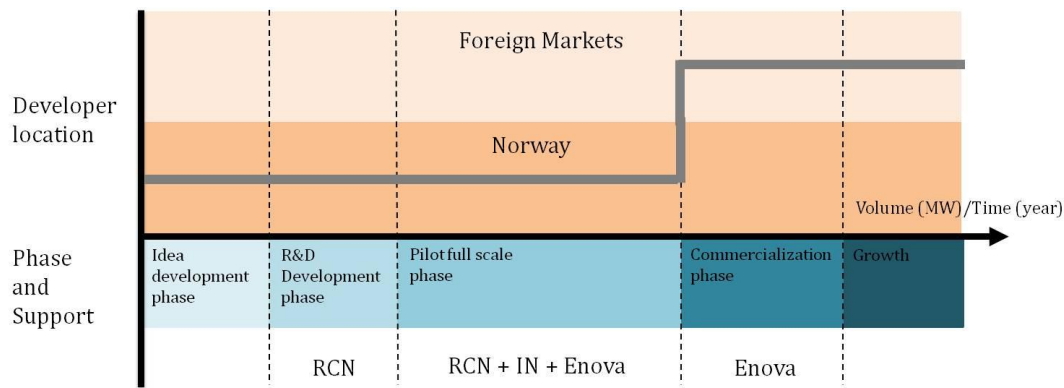


Figure 23: Location of Norwegian Companies Given an Increase of R&D and Testing Support

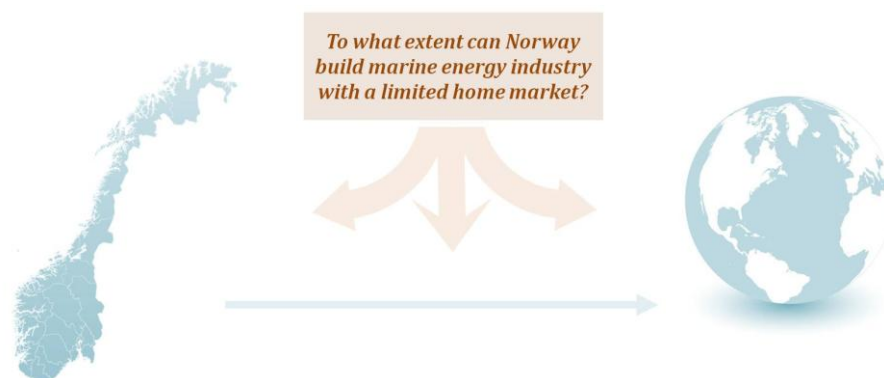
The grey line indicates the location of Norwegian companies, and the period Norwegian companies choose to stay in Norway will be prolonged to the commercialization phase due to better testing opportunities.

6.5.4 The Importance of Timing

Timing could be essential when regarding which countries will take the global industry lead. The *creators* may have an advantage as the development and learning process is slow in the marine energy sector. On the other side, the marine energy industry is still at an early phase and there are many steps left to fully commercialization. Technological breakthroughs could induce development leaps in the industry reducing the time to commercialization and thus making it crucial to be part of the front-running development at the current point in time. Likewise, technical challenges could increase the time to commercialization considerably and make room for new market players to enter and laggard countries to catch up before sales take-off. Nevertheless, Norway is one of the countries in the world that has conducted R&D within marine energy the longest and has thus every opportunity to make use of early entry advantages. The question is to what extent the major system actors chose to continue their involvement.

7 Conclusion

7.1 To What Extent Can Norway Develop a Marine Energy Industry with a Limited Home Market?



The last section discussed the contribution from different actors in the Norwegian marine energy industry system, Norway's opportunities for exploiting both advantageous conditions at home and favourable conditions in foreign markets, as well as the importance of timing. Our findings made it evident that there are four fundamental factors that need to be in place if a country is to build a viable industry with a limited home market: (1) Willingness among the system actors needs to be present. Considerable initiative and dedication among one or several system actors is needed in order to drive the development in the right direction. (2) The home market needs to possess favourable conditions to base the industry development on. (3) Access to other markets is needed, as there is limited demand at home. (4) Cooperation among the system actors is needed for the industry efforts to pull in the same direction. We will in the following discuss these four fundamental factors in the Norwegian system before we elaborate on future scenarios for the Norwegian marine energy industry development and discuss the implications for researchers, entrepreneurs, policy makers, investors and large companies.

7.1.1 Low Willingness Leading to Little Collective Progress in Marine Energy

The pollution from the petroleum industry in Norway, as well as emissions related to oil and gas consumption, constitute an environmental hazard, which in turn could statue as an incentive for Norway to develop green technology in order to improve the carbon balance. The Norwegian government has chosen to invest heavily in CCS technology, and invested 20-25 billion NOK in the Mognstad CCS test centre (Tekniskukeblad.no 2012). Beyond the focus on CCS, the government has taken on a portfolio approach where they grant support to a wide spectrum of innovative technologies. The diversification of support grants enables development within several green technologies, but the amount appointed to each sector is limited. The strategy for development of green technology is thus equivocal and the unbalanced focus on CCS could affect the development of other green technologies negatively as only moderate support is granted to each of the other sectors. The government has no explicit strategy for the development of wave and tidal technology in Norway. There are no long-term goals, only vague indications that wave and tidal could be an interesting industry in the future.

The low unemployment rate and low pressure from the public to develop new energy sources in Norway lower the incentives for the surrounding actors to get involved in marine energy. Thus,

large companies' and investors' will to develop the marine energy industry is also considered as low. Low involvement among public actors influences the involvement of private actors and vice versa. The result is a vicious cycle where little collective progress is made.

The collective progress is also reduced because the actors are not cooperating. The entrepreneurs comment that they want industrial partners, but are unwilling to give up ownership of the company and device concept. In addition, the Norwegian entrepreneurs are cooperating less with each other than entrepreneurial companies in other European countries. The cooperation between large companies and entrepreneurs is modest, making the competence of petroleum and oil and gas and maritime sector somewhat unreachable for device developers. Politicians are not taking on a coordinating role to lead the direction in the marine energy industry, and even though corrective efforts are in progress, collaboration among support scheme organizations is not functioning optimally. Most of the actors are thus striving to reach commercialization without the needed financial means or technical and strategic competence to succeed. Increased collaboration among all the system actors are thus needed in order to create a viable marine energy industry in Norway.

Entrepreneurs, large companies and investors should possibly take a larger responsibility in the development of Norwegian marine energy industry in addition to the government. However, several examples given in the mini cases indicate that greater governmental involvement is needed in the development of renewable energy because of the high risk and positive externalities involved. If all countries had practiced the same strategy as Norway on a general basis (excluding CCS), the development of renewable energy would have been much slower. Whether Norway should focus on marine energy at the expense of other renewable energy sectors is not apparent, as Norway has a lot of physical resources within other renewable sources such as onshore and offshore wind, hydro and osmotic. However, the likelihood of building a leading industry within one of these sectors is higher if the support is more focused than today.

7.1.2 Norway is not Exploiting its Advantageous Conditions

There are advantageous factors in Norway, which could be considered opportunities or options for future development of marine energy industry. Norway has viable oil, gas and maritime industries, which enhance competence within offshore operations. The clusters within the related industries could possibly be expanded to include wave and tidal technology development and are therefore considered an advantage to Norwegian marine energy companies. However, the petroleum industry could potentially be a competing industry in terms of human resources, which could lower the incentives for marine energy development at the current point in time. Norway has physical resources within marine energy and even though Norway does not exploit these resources due to limited home market, they provide a relevant testing environment for marine energy devices. Thus, the advantageous factors present in Norway is not exploited to their full potential, as there are few incentives and little will to develop marine energy in Norway.

7.1.3 Opportunities and Threats in Foreign Markets - Is Norway Falling Behind?

Norway has been part of the marine energy industry development since the 1970s and 1980s, but the development has been very slow and scattered. The involvement in the industry has lead to competence development within marine energy and some of the leading companies

globally are of Norwegian origination such as Hammerfest Strøm within tidal power and Fred Olsen within wave power. Both Hammerfest Strøm and Fred. Olsen have expanded their operation to the UK because of market opportunities. UK, Ireland, and Portugal have all increased their focus in marine energy and the growing markets constitute an opportunity for Norwegian companies, as they are dependent on foreign demand. At the current point in time, the leading markets do not have considerable protectionist regulations other than projects that are granted support need to be performed in the respective country. However, as the leading countries have higher industry activity and better support schemes on both supply- and demand side, the incentives for Norwegian companies to stay in Norway after the earliest development phases are weak. Furthermore, there is a lack of direction from Norwegian policy makers and little dedication among large Norwegian companies, leading to a greater gap between Norway and the UK. Thus, the Norwegian government's lack of a directed strategy within marine energy could lead to Norway falling behind the global development when countries such as the UK take on a greater stimulating and coordinating role.

7.1.4 What are the Possible Future Scenarios of Norwegian Marine Energy?

How the marine energy sector will evolve is still uncertain and dependent on the outcome of technological and financial challenges. Norway's role in the global industry is thus not settled at this point and will depend on both development of the international and national industry. We will in the following describe different "scenarios" in order to illustrate in a simplified manner the possible outcomes of certain strategies.

In general, there are two main outcomes of the global industry development: (1) The industry will reach commercialization and eventually grid parity, and become a major industry worldwide and (2) the industry will reach commercialization, but does not manage to drive the cost of energy down to the point where it can make a great contribution to the energy mix without considerable ROCs, feed-in-tariffs or other price increasing instruments. Thus, if the industry is to continue, the dependency on governmental support and accessible off-grid markets will increase, and the sales take-off current actors are hoping for will not happen. Scenario (1) is labelled "large international industry" and scenario (2) is labelled "small international industry" in figure 24. Further, the possible outcome of the Norwegian industry development is divided into the same two scenarios: (a) Norway will have a small marine energy industry and (b) Norway will have a major marine energy industry. Combining the possible outcomes of the international and Norwegian industry, we get four different scenarios illustrated in figure 24 below.

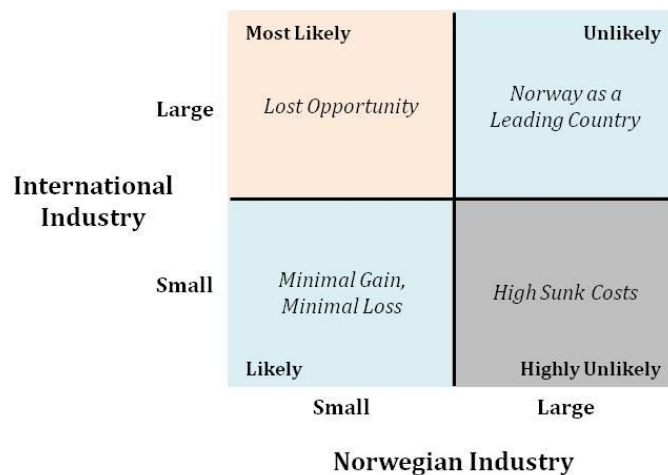


Figure 24: Future Scenarios of the Marine Energy Industry in Norway

The probability of the system actors in Norway deciding to increase the focus on marine energy and create a large industry is regarded unlikely at the current point in time. It is thus considered more likely that Norway will maintain the small industry contribution with a few present companies that operate both in Norway and foreign markets. The international industry on the other hand, is increasing in size and the UK investments are contributing to a higher probability of overcoming technical challenges. If the dedication of leading countries results in technical breakthroughs, the industry has the potential to grow extensively worldwide. Development of a large international industry is thus considered likely, especially in the long run, as a deterioration of the climate crisis possibly will create higher willingness to pay for renewable energy.

Large Industry in Norway, Small Industry Globally – High Sunk Costs:

The Scenario is shaded in grey in figure 24 because this outcome is considered unlikely to happen. If the marine energy industry does not evolve to be a major industry worldwide, it is highly unlikely that the Norwegian system actors will increase its efforts within the industry given the moderate interest in the industry from central actors today. If the scenario were to happen, it would involve large investments by Norwegian system actors resulting in minimal returns. The scenario thus implies high sunk costs and the Norwegian industry activity would probably stagnate and decline as the small international markets saturate.

Small Industry in Norway and Globally – Minimal Gain, Minimal Loss

With the government's current wide approach for supporting green technology and lack of direction and strategy within marine energy industry, Norway will most likely not develop a large industry. If the technological challenges within marine energy turn out to be insuperable and the industry development stagnates before grid parity, Norway will avoid great losses as it only constitutes a minor part of the global industry. However, the return on the few investments made will be minimal. A wise strategy would be to target off-grid markets, but as the current leading countries would have obtained a technological advantage, there is a greater probability of the industry leaders capturing the few existing market opportunities.

Small Industry in Norway, Large Industry Globally - Lost Opportunities

The scenario of the international industry growing large and the Norwegian industry remaining small, shaded in orange in figure 24, is the most likely outcome considering the present

situation in Norway and internationally. As both the industry and the demand are smaller in Norway compared to leading countries in this scenario, the benefits of moving to leading countries will increase further. Norway can possibly miss out on the opportunity of becoming a leading country within wave and tidal technology as other countries will have surpassed in terms of industry specific knowledge in all parts of the value chain. However, as the industry gets closer to grid parity, the possibility of private and public actors getting interested in building marine power production in Norway increases and a home market may develop. In this situation Norway is more likely to have to import technology from foreign actors, as the Norwegian industry is limited. Increased home market activity could nevertheless initiate growth in the Norwegian industry and thus result in a step from the current square to the scenario where the industry is considered large.

Large Industry in Norway and Globally - Norway as a Leading Country

If the marine energy industry becomes large globally, Norway would benefit from being part of it, as the marine energy potential worldwide is extensive. Norway can be a major contributor to the industry by having the whole value chain placed in Norway, or specializing in specific value chain segments and become leading within these segments.

An obvious way of becoming an industry leader within the whole supply chain is to benchmark the British innovation system within marine energy and provide an equivalent level of governmental support and coordination. Considering Norway's physical resources, there is a potential market in Norway if the political, private and public will come in place. Norway could decide to take on a role as a "green battery" for part of Europe in the future and develop marine energy industry in order for it to become a viable part of the energy mix in export. Given that the private market actors are more interested in wave and tidal in the UK than in Norway, it could be necessary to introduce incentives for larger companies and investors to increase involvement. The Norwegian government introducing pull policies such as ROCs and feed-in-tariffs is as we have discussed highly unlikely, but it is nevertheless a present alternative. Another alternative would be to introduce higher CO₂ emission prices, as CICERO argues is more effective than feed-in tariffs over time. However, a considerable increase in carbon prices would probably receive negative response from the public and large companies and is thus also unlikely to happen. A small home market can arise if stricter directions for electrification of oil platforms are introduced. Regulations on the oil platforms may create incentives for petroleum companies to take a greater part in the development of offshore renewable energy or at least provide development of sea based cable work to the mainland.

Another way Norway could profit greatly on the marine energy industry is by becoming a major contributor within certain areas of the supply chain. The idea of Norway specializing in floating groundwork and frame constructions has been suggested by many of the case study companies. For Norway to develop a viable industry within for instance marine ground work, it is important to make the present industry actors choose to continue operating in Norway in order to retain the knowledge within the country and attract actors from related industries. For the marine energy companies to continue Norwegian activity, they have to be able to test their devices in Norway to a greater extent than today. As discussed in relation to timing, an expansion of the R&D support to include full scale testing would make it more lucrative to stay in Norway until commercialization and possibly increase the activity in Norway.

If Norway manages to keep up with the development in the UK and other leading countries within marine energy, the Norwegian industry might in time expand to involve the whole value chain. As the technology develops closer to grid parity, it could become competitive with onshore wind and thus make use of the green certificate agreement between Norway and Sweden. For the expansion of energy production to be necessary, Norway needs to expand the transmission capacity to Europe. As Europe is in a more critical situation than Norway in terms of increasing the renewable share in the energy mix, major international grid projects could be initiated before grid expansions are considered necessary in Norway. Thus, in order to be ready for a possible technological breakthrough within marine energy, Norway should consider taking part in expanding transmission capacity even at a point where it is not yet profitable.

A strategic opportunity overlooked by many of the marine energy industry actors is the opportunity to target off-grid markets. A way to become a leading industry globally could be to seize the off-grid market opportunity early in the development phase and learn from the experiences in these markets. Marine energy is closer to grid parity in off-grid than in grid-connected markets, and there are thus greater possibilities for profits in the early commercialization phases

Looking at the example with REC in Norway, it is important to emphasize that Norway could potentially become an important contributor to the industry purely as a result of private initiatives. However, the likelihood of this happening in the marine energy industry is probably lower than in the case of REC as the oil industry is still flourishing as a result of new oil discoveries in the North Sea, and the marine energy technology is at an earlier stage of development. The suggested increases in governmental efforts will either way increase the likelihood of companies like REC succeeding.

7.1.5 Creating a Viable Industry with a Limited Home Market – Difficult, But Not Impossible

Norway has two of the three fundamental factors needed to create a viable industry with limited home market; (2) advantageous conditions in both a relevant natural environment and competence, and (3) accessible demand in close foreign markets. However, (1) the willingness and (4) cooperation among the system actors are not in place and the pace of development in Norway is slow compared to leading markets. The Scenarios illustrate that there are uncertainty connected to the future of marine energy in Norway and internationally. The Scenarios are not static and one can move between the identified squares depending on technological breakthroughs and national initiatives and focus. However, if the Norwegian system actors do not increase cooperation with each other and will to develop renewable energy, Norway will most likely fall behind the international development and not have a significant role in the global industry. If Norway is to create a viable marine energy industry, great collective effort from all the system actors is needed. Especially important is the involvement of government and large companies as these actors have the greatest power and means to stimulate development. Increased dedication from either the government or large companies could potentially ramp up the activity level among the other system actors and thus create positive ripple effects in the whole industry. In addition, the degree of involvement of large companies affects the governmental involvement and vice versa. As the activity level of large companies in Norway is relatively low in the marine energy industry, the government might need to increase the incentives for large companies to get involved. It is essential that the government develops and

communicates a stable and long-term strategy for wave and tidal industry and defines goals and means to reach these goals. Ultimately, we do believe that Norway can build a viable marine energy, but it demands great collective effort from all system actors and it will be more difficult than if Norway had a present home market.

7.2 Implications

7.2.1 Implications for Researchers

Niosi and Bellon (1994) present open innovation systems and argue that all systems relate to both international and national environments, while Rugman and D'Cruz (1993) argue that cluster theories should include multinational activities and that Porter's (1990) diamond of competitive advantage should be double. These theories argue that foreign market may be utilized, but they do not discuss implications for nations with limited home markets. If globalization leads to more integrated nations, home markets could be of less importance. The mini cases suggest that it is possible to utilize transferable competences together with other markets to compensate for lack of domestic demand and other insufficient conditions in a nation's home market. The Norwegian solar industry utilized the metallurgical competence, and the marine energy industry may exploit offshore competences. Nevertheless, the Norwegian solar industry has closed down production in Norway, indicating that a sustainable industry might be in need of certain factors in their home market, such as advanced competence that is hard to obtain. Thus, the researchers studying home markets should study implications of having a limited home market and issues related to sustainability of industries in nations with limited home markets.

Renewable energy industries are characterised by a long technology development period and extensive amounts of industry creation activities take place in this phase. Implications and issues regarding phases before commercialization are not directly discussed in literature. Some advocates of innovation systems consider evolution phases and industry actors' collective effort toward innovation (Berkek and Jacobson, 2003), the theory emerging industries assesses stages of industry development from a firm perspective, regardless of national borders, and cluster theory considers several aspects of home markets (Porter, 1990), but does not take evolution phases into account. Similar to most renewable energy industries, the marine energy industry development are characterised by a long technology development period and much of industry creation activities take place in this phase. Our study of the marine energy industry suggests six features that are relevant in assessing different nation's conditions for development of marine energy industry; *coordination, demand, supply-side policies, investor and partner access, competence for related industries and physical resources*. The features are likely to apply to other developing renewable industries as well, such as offshore wind and solar power. The framework can be used to assess a nation's conditions for renewable energy in early development phases, as well as opportunities of exploiting conditions in other markets, and should be a subject for further research.

The findings of this thesis imply a need for further research on industries with a limited home market and a long technology development phase before commercialization. The implications for researchers are summarized as:

- Researchers should assess the implications of a limited home market and related issues, such as decisive competence in the home market, significant factors for successful utilization of foreign markets, and what strategies to apply.
- There is a need for further development of the presented framework, which assess nation's conditions for renewable energy in early development phases, as well as opportunities of exploiting conditions in other markets. Other renewable industries need to be examined to investigate similarities and differences.
- More research related to emerging industries at industry level should be conducted, as most literature concerns the firm level. Theory on emerging industries often neglects the importance of national borders and foreign market, thus further studies investigating the industry creation process in a national context is needed.
- More research is needed on the emerging wave and tidal industry and its international development. Use of other case studies, quantitative research and other research methods are needed to validate the findings of this thesis.

7.2.2 Implications for Policy Makers

The government is perceived to have no long term-goals and a wide support approach following the market forces, resulting in lack of direction for the marine energy industry. The policy makers have great influence on the development of the marine energy industry and must understand the consequences of having a wide approach, as a more focused approach gives higher probability for success according to experiences from other renewable energy industries. A wide approach is beneficial if the international marine energy industry remains small, but if the international industry reaches grid parity and the current support regime continues, Norway will most likely be unable to follow the international industry.

If the policy makers want Norway to become a large actor in the potentially large marine energy market, they can either implement a policy regime similar to the UK and stimulate creation of a home market, or communicate dedication toward marine energy by implementing more support for full scale testing and R&D mechanisms that keep marine energy activity in Norway and thus involvement of related industries.

With regard to the presented framework for renewable energy industry development in early phases, policy makers should recognize type of technology and development phase when evaluating frameworks, as different challenges are present in different stages.

If Norway wants to have the possibility of exporting marine power in the future, grid expansion must be considered in advance.

7.2.3 Implications for Entrepreneurs

Increased collaboration could induce several benefits. First, success of one company would benefit other entrepreneurs, as the marine energy technology is in great need of success stories in order to gain legitimacy in the Norwegian market. Second, collaboration and knowledge sharing can provide data for more accurate cost efficiency estimations, which could restore the legitimacy lost by investors experiencing too promising estimations. Third, united, the entrepreneurs could also gain more influence on the government and become more visible to the rest of the industry. Fourth, as the UK market collaborates and progresses, the Norwegian entrepreneurs will continue to struggle with their current problems if they do not follow the UK example of collective effort and knowledge sharing.

The international industry will most likely progress before a Norwegian home market is present, making entrepreneurs dependent on targeting foreign markets. As the international industry increases and attracts new entrants, entrepreneurs will experience increased competition and benefit from establishing a position in attractive markets such as the UK, but also off-grid markets, which will reach grid parity first.

In order to obtain industrial partnership and investors, sceptical entrepreneurs must lower their demands for ownership and control and seek partners located in, or entering targeted markets. Entrepreneurs should seek innovative ways for cost reduction and funding, and not necessarily wait for development to be handled by the government.

7.2.4 Implications for Investors

As the industry coordination in Norway is poor, investors must understand their effect on the rest of the system. Investors must realize the entrepreneurs' capital needs related to full scale testing, which affects technology development and time to profitability. As entrepreneurs have a tendency to overestimate cost efficiency and time to commercialization, investors must be able to assess marine energy technology and the validity of estimations for cost efficiency, maturity level and expected return. As different marine energy technologies are difficult to compare, investors would benefit from common industry standards that do not exist in the industry today. Investors must educate the entrepreneurs in requirements for a profitable investment projects, making entrepreneurs more suited to develop their business, as well as technology and communicate valid estimations.

Investors must be aware of the high risk and costs related to immature technology in the marine energy industry, and the probability that the international industry will remain small and unprofitable. However, high risks are associated with potential for high return. If the increase in international initiatives results in marine energy technology reaching grid parity, there exists an extensive market. According to Agarwal and Bayus (2004) firms entering before firm take-off are most likely to have success. Increased investment from European governments will attract more entrants and thereby firm take-off, thus investments in current marine energy projects can give highest return on investment.

7.2.5 Implications for Large Companies

Large companies must be aware of their decisive role and responsibility in marine energy industry development. The Norwegian wide approach supports marine energy if the market is engaged in marine energy. Given the current policy regime, large companies' involvement in marine energy projects will focus the support towards development of marine energy industry. Engagement of large companies will also increase the industry legitimacy and attract potential investors.

Entrepreneurs are dependent on large companies for capital and testing of technology. Large companies could contribute a great deal to development as they provide entrepreneurs with a good reputation for future customers and knowledge about foreign markets. Large companies must consider projects provided by other than established and well-known companies, as partnership with entrepreneurial companies can provide innovative and effective projects as well as profit from ownership. Multinational companies have involved in UK marine energy, thus the Norwegian companies should investigate possible partnerships with Norwegian and

foreign entrepreneurs and their likelihood for success in foreign markets. For large companies related to the oil industry, marine energy projects can spread the risk in a portfolio of projects.

If the international marine energy industry becomes large, Norwegian companies within related industries can participate by adapting their services to this new market and strive to become a leading supplier. Companies within oil and gas can utilize their offshore competence in marine energy industry, providing a business area for the future when the oil reserves run out.

7.3 Concluding Remarks

This thesis has assessed whether Norway can develop a marine energy industry with a limited home market.

Our findings suggest that it could be possible to build a viable marine energy industry in Norway with a limited home market, but it is unlikely due to low level of cooperation and willingness to develop the marine energy industry among system actors. However, the development pace of the international industry is increasing as large companies and policy makers are getting more involved and invest in the industry. The UK industry is flourishing and development of the entire value chain is in focus. Norway may thus miss out on an opportunity of becoming an important actor of in the global industry with the current level of involvement.

For the Norwegian marine energy industry to become a major contributor to the global industry, the system actors must realize the need for collective effort and increase their involvement to ramp up development. Entrepreneurs must cooperate more with each other and other system actors, and share non-critical knowledge in order to collectively drive the technology towards cost-efficiency. Large companies must extend involvement in the marine energy industry in order to reduce technical and financial challenges as well as increasing industry legitimacy. Investors must increase knowledge about marine energy technology and estimations, and realize the capital need in critical stages. In order to stimulate development in the marine energy industry, the government needs to increase their dedication, develop a long – term strategy for further development, and communicate their commitment to the system actors. As large companies and policy makers are the actors with most power and means to increase the development of a viable marine energy industry, it is especially important that these actors extend their involvement.

The future of marine energy is still uncertain, but if the industry reaches grid parity, the power potential is immense worldwide. In addition, Norway has advantageous conditions at home that could potentially compete with the industry leaders. Norwegian actors must thus realize the potential in the marine energy industry and understand that a leading position is not necessarily obtained without increased efforts.

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A1 Technology Overview

A1.1 Wave Technology

The technology overview is mainly based on the project assignment conducted in the fall 2011; the next sections are thus taken from Sølvsødt and Sønning (2011).

A1.1.1 Physics

The atmosphere and the sun generate almost all dynamical processes in the ocean either directly or indirectly. Unbalances in heat exchange between ocean and atmosphere results in wind which in turn generates waves (Holmberg et al., 2011). The turbulence in the wind produces random pressure fluctuations in the sea surface, which produces waves with small wavelengths. The wind causes the small waves to become larger by producing pressure differences along the wave profile which make them grow. The process is unstable which in turn makes the waves grow exponentially (Falnes, 2011). Wave energy absorption can be considered a phenomenon of wave interference. Falnes (#2, 2011) hence describe absorption of wave power by the paradoxical statement: “To absorb a wave means to destroy a wave”. Figure A1.1 illustrates an incident wave; b shows a wave generated by the wave energy converter’s up and down movement; c shows a wave generated by the wave energy converter’s side by side movement, while d shows the resultant wave field after superposition of all three waves.

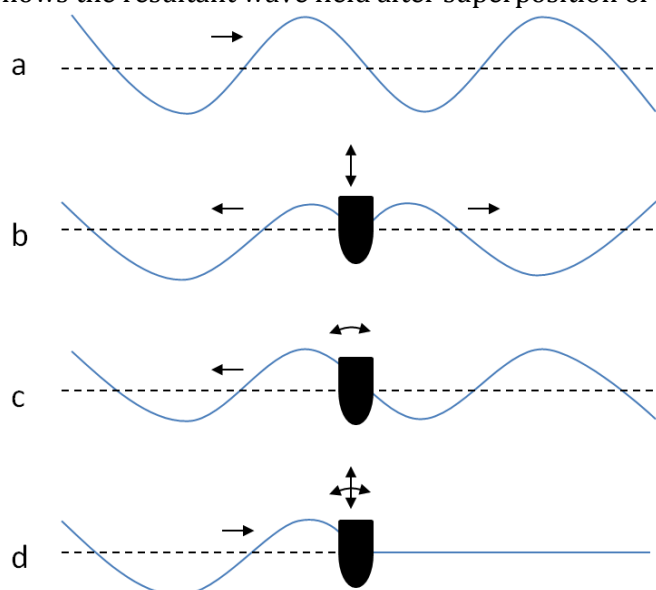


Figure A1.1 Wave absorption of a wave energy converter operating (Falnes et al., 1978)

A1.1.2 Natural resources

The level of wave resource varies with time and distance from shore. Waves travel with small energy loss until nearing the shore where energy is lost through friction against the sea floor and breaking. The *theoretical resource* is the power flux crossing a line sufficiently offshore to be unaffected by the bottom friction. The *wave power potential* is

how much of the theoretical resource that can be extracted from a technical point of view including wave power plant characteristics (Holmberg et al., 2011). Table A1.1 below shows the theoretical resource and wave power potential for a sample of countries.

| Country | Theoretical wave resource | Wave power potential |
|---------|---------------------------|----------------------|
| Norway | ~600 TWh | ~12-30 TWh |
| Ireland | ~500 TWh | ~28 TWh |
| UK | ~600-700 TWh | ~50 TWh |
| Denmark | ~35 TWh | ~5 TWh |

Table A1.1: Wave power theoretical resource and potential (Holmberg et al., 2011)

Of the theoretical wave resource in Norway, only 205 TWh/year is possible to develop within the cost frame of 3 NOK/year-KWh, and 119.7 TWh/year is already developed. The wave resource varies substantially throughout the year as well as the wave height. The difference between extreme wave height and the average significant wave height in Norway varies from 5.5-6.5 to 9-10. This makes it difficult to dimension the technology to handle both extreme and regular waves (Sandgren et al., 2007). Figure A1.2 below illustrates average yearly accessible output density of waves in Norwegian waters, while figure A1.2 shows the distribution of wave energy transport worldwide.

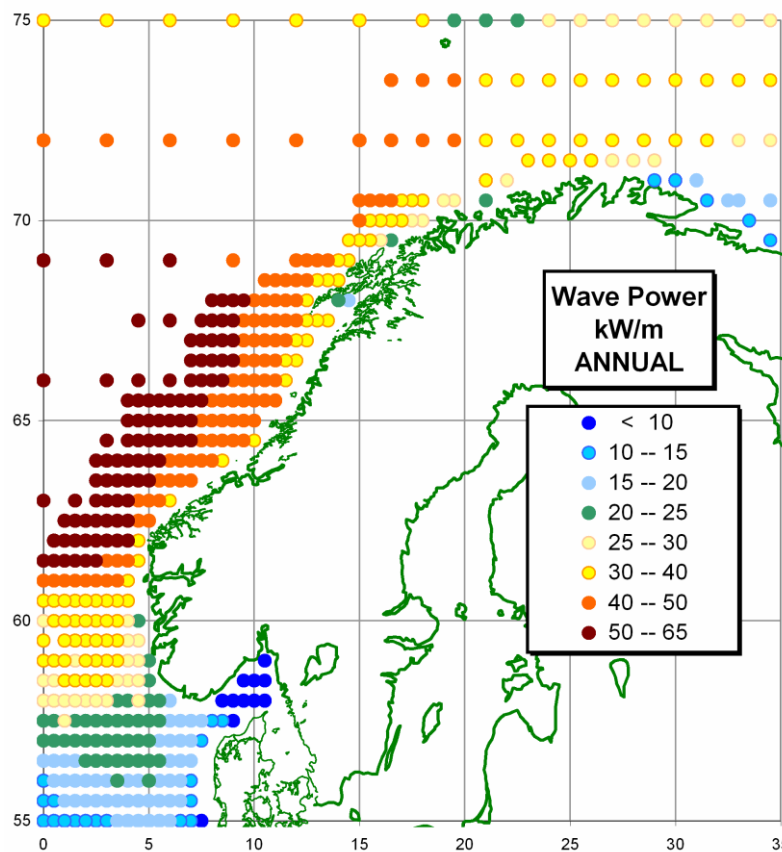


Figure A1.2 Average yearly accessible output density of waves in Norwegian waters (Sandgren et al., 2007)

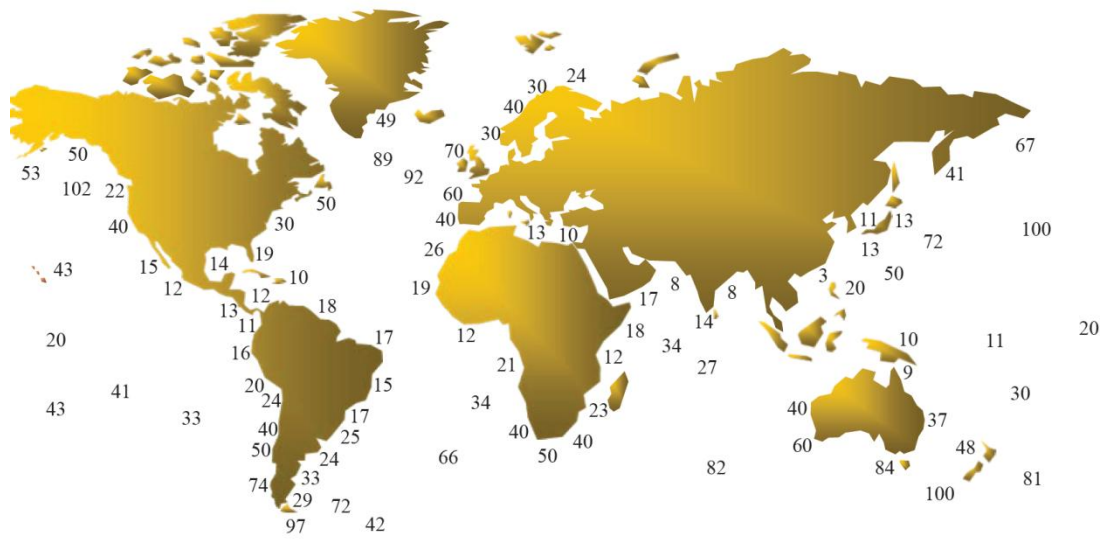


Figure A1.3: Average wave power in kW/m wave front (Falsnes, 2011)

A1.1.3 Technology development

The oil crisis in 1973, created an interest in alternative energy sources which lead to substantial wave energy development. Programs were launched by governments in several countries, in particular in the UK, Norway and Sweden. University research was initiated in 1973 at the Edinburgh University in Scotland and was followed up by research at other universities including NTNU in Trondheim by Johannes Falnes and Christian Budal. Two wave power plants were installed during the 1980's by Kværner and Norwave, but after accidents both plants were shut down. Johannes Falnes believes the reason none of the plants were repaired is because of lobbyism by wave power opponents that believed that wave power development would hurt their own business or industry (NRK 2, 2007). The commitment to the development and research faded as the oil market recovered and the funding were cut off at the end of the 1980's (Nielsen, 2011). Thus, Wave power technology has had a slow development phase in Norway since then.

The wave power industry is characterized by wide variety of technologies, more than 50 different concepts is recognized (Holmberg, 2011), we will further describe the most common and developed technologies.

A1.1.3.1 *Oscillating Water Column (OWC)*

The OWC technology is based on principle of expressing and expanding air and driving it through an air turbine (Holmberg, 2011). The ocean surface is trapped inside a chamber that is open to the sea below the water line as an oscillating water column. The chamber has an air turbine and generator on top which generate power as the internal water surface moves up and down in response to incident waves outside the chamber, pressing and sucking air out of and into the chamber (Nielsen, 2011). The OWC concept can be utilized at both off shore and shoreline sites.

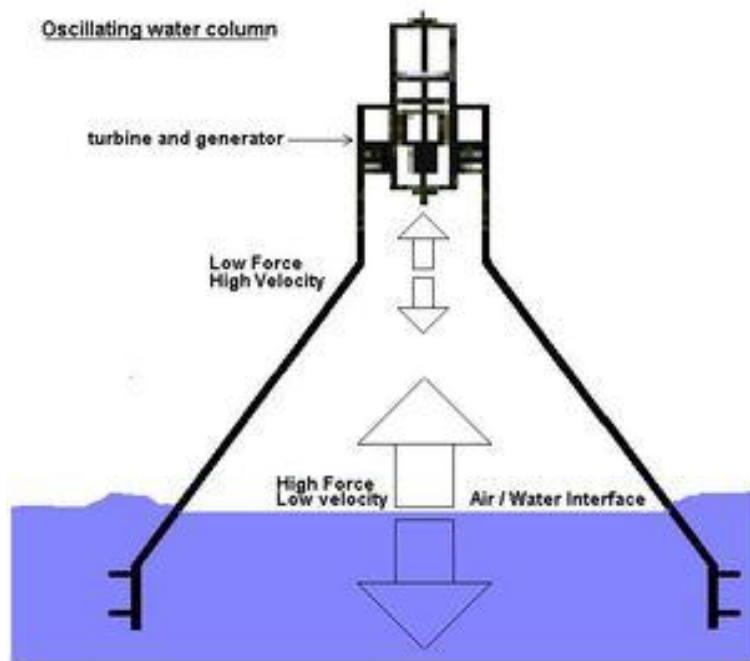


Figure A1.4: Oscillating Water Column

A1.1.3.2 Attenuator

In an attenuator energy is extracted as waves pass along the length of the floating device. The device is directed to incident waves and is usually long multi segment structures. Each segments functioning as pontoons are joined together by a joint. The relative motion between them is concentrated at the joint and used to pressurize a hydraulic piston that drives fluid through a motor that turns a generator (Holmberg, 2011)

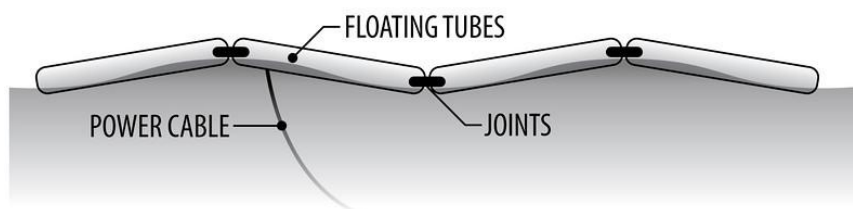


Figure A1.5: Attenuator (Need-media, 2011)

A1.1.3.3 Point absorber

The point absorber is a device that consist bodies that oscillating with one or more degrees of freedom floating on the water surface. The device is referenced to a fixed system either by large reactor of a damper by wires or by a stiff connection (Holmberg, 2011). Power is extracted through motion in the point absorber that creates relative heave motion between the two bodies. The device can be designed to work at both offshore and near shore sites.

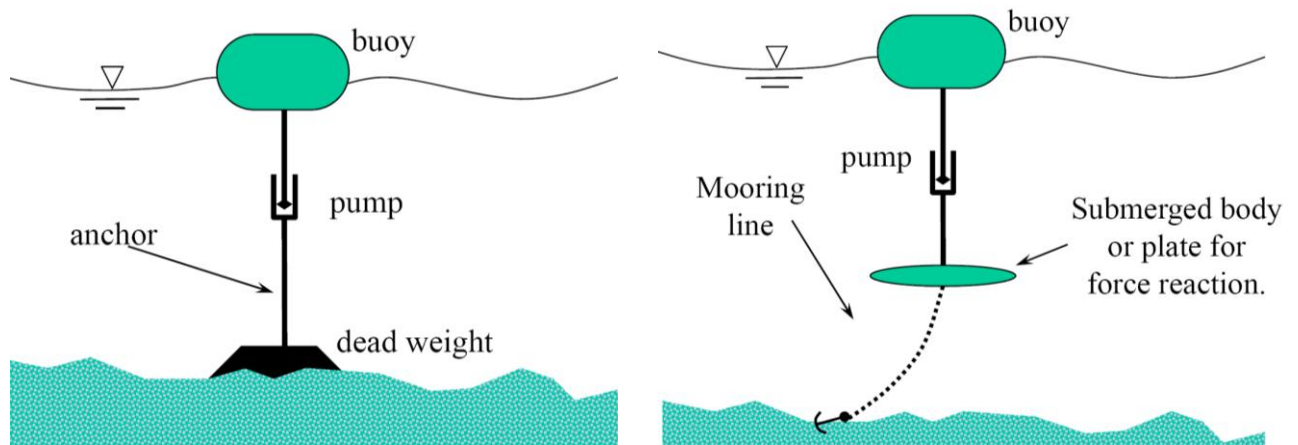


Figure A1.6: Point absorbers (Falnes, #2, 2011)

A1.1.3.4 Pressure differential

The device has an air filled body that change volume when water presses against a membrane. When the body is submerged the pressure differential of successive crests and troughs induces the body to rise and fall. The relative movement of the body to the reactor generates electricity, similar to the point absorber (Holmberg, 2011). The size of the body determines the suitable climate, but the devices need to have a body relatively close to the water surface.

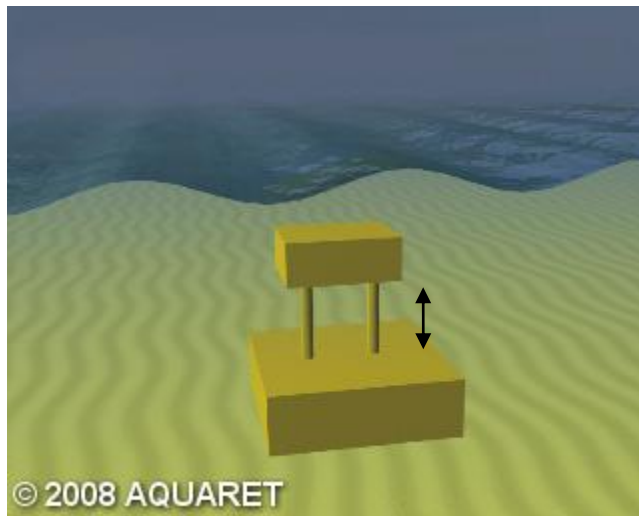


Figure A1.7: Pressure differential (Holmberg et al., 2011)

A1.1.3.5 Oscillating Surge Convertor

Oscillating surge convertors utilize the back and forth motions generated by elliptical movements in the water as the waves approach more shallow water. A displacer moves back and forth while hydraulic energy converters secured at the fixed component extract energy. The device could be floating offshore or fixed to the seabed in shallow waters, however the latter case is the most common.

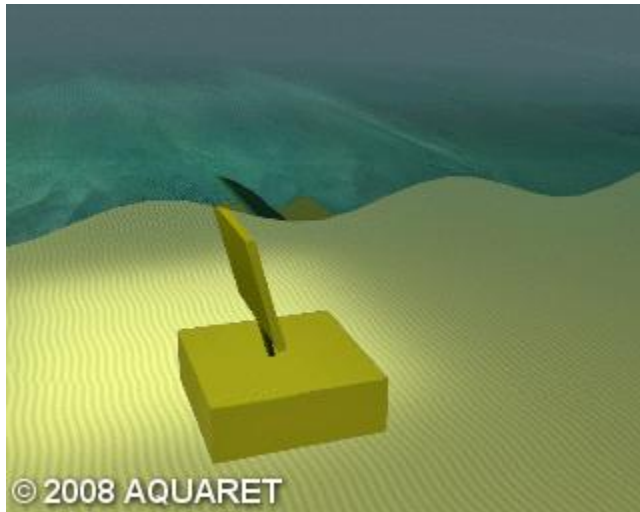


Figure A1.8: Oscillating differential

A1.1.3.6 Overtopping Devices

Overtopping devices is based on a principle of storing seawater in a reservoir and utilize the difference in water head to drive low head turbines. The device use sloped surfaces or reflector arms to drive waves to the reservoir and are often large installations. The device can be designed to operate on the shore line or offshore.

A1.2 Tidal Technology

A1.2.1 Physics

Tidal changes are the net result of multiple influences that act over varying periods. Tides are due to gravitational attraction of the moon and the sun on the Earth. The moon is closer to the earth than the sun, which makes the moon have more effect and causes the earth to bulge towards the moon. The earth's rotation also affects the increase and decrease of ocean level. The height difference depends on the placement of the sun, moon and earth.

The time between two high tides or two low tides is approximately 12 hours and 25 minutes, exactly half a tidal lunar day which is the time required for the earth to rotate once relative to the moon. The lunar day is slightly longer than an earth day because the moon orbits in the same direction as the earth rotates. The forces create waves that move west in the same direction as the earth's rotation. The wave is less than one meter, but several thousand meters long. Not until the waves meet the shore or obstacles you can see the large height differences that the tides can create.

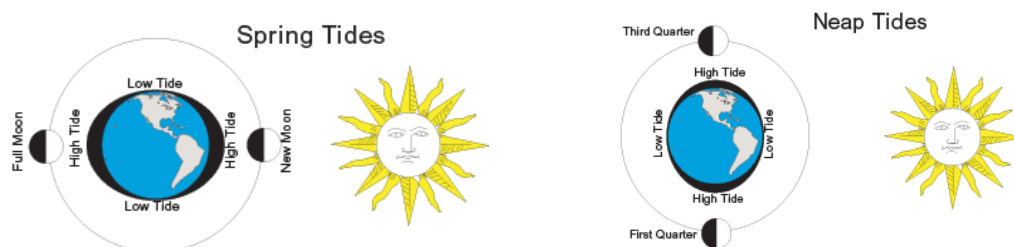


Figure A1.9: Tide illustration

Twice a month the sun, moon and earth are located on the same line and the tidal force from the sun reinforces the force from the moon. This situation, when the tide's range is at its maximum, is called spring tide. The gravitational force is the forces and is given by Newton's second law, where G is the gravitational constant, m_1 and m_2 are the mass of the two bodies and r is the distance between them.

$$F = G \frac{m_1 m_2}{r^2}$$

When the sun and the moon are 90 degrees relative to the earth, the tidal range is at its minimum, and is called neap time. The moon use 29,5 days to circle around the earth, which gives spring tides with 14.75 days intervals (Gjevik 2011).

A1.2.2 Natural resource

Costal characteristics and geometry of the earth makes individual location characteristics affect tide forecasting. However, for a given location the tide differences are relatively constant and predictable, as is the time of high and low tide relative to other points at the location. This makes tidal a very predictable source of renewable energy. It has a higher energy density compared to that of air. A 6-knot tidal current has higher energy density than an equivalent 100 kph wind and the kinetic energy corresponds to over 300 kph in air. The European ocean energy association estimates the global tidal range energy potential to be about 200 TWh/year, where approximately 1 TWh/year is available at comparable shallow waters and theoretical global resource is estimated to be 800 TWh/year (Soerensen and Weinstein, 2008). The Worlds Offshore Renewable report estimates available tidal energy to be 3000 GW and that less than 3 % is located in areas suitable for power generation (Renewable UK 2010).

The local bathymetry greatly influences the tides exact time and height of a particular costal point and creates great differences across the earth. The Bay of Fundy, on the east coast of Canada, has the earth's largest documented tidal ranges, which are above 16 meters. The table A1.2 below shows some tide ranges of the global ocean.

| Place | Country | Tidal range |
|---------------------|-----------|-------------|
| Vardø | Norway | 334 cm |
| Tromsø | Norway | 269 cm |
| Trondheim | Norway | 318 cm |
| Bay of Fundy | Canada | 16.2 m |
| Severn Estuary | England | 14.5 m |
| La Range | France | 13.5 m |
| Puerto Rio Gallegos | Argentina | 13.3 m |
| Penzhinkaya Guba | Russia | 13.4 m |
| Gnat Cove | USA | 9.4 m |
| Reykjavik | Island | 4.7 m |

Table A1.2: Tide ranges of the global ocean (Source: Dalhaug 2011)



Figure A1.10: The Bay of Fundy, Canada

When tides occur twice a day it is called semidiurnal tides, one tide per day is called diurnal tides and when there are two tides each day with different heights, mixed semidiurnal tides occur.

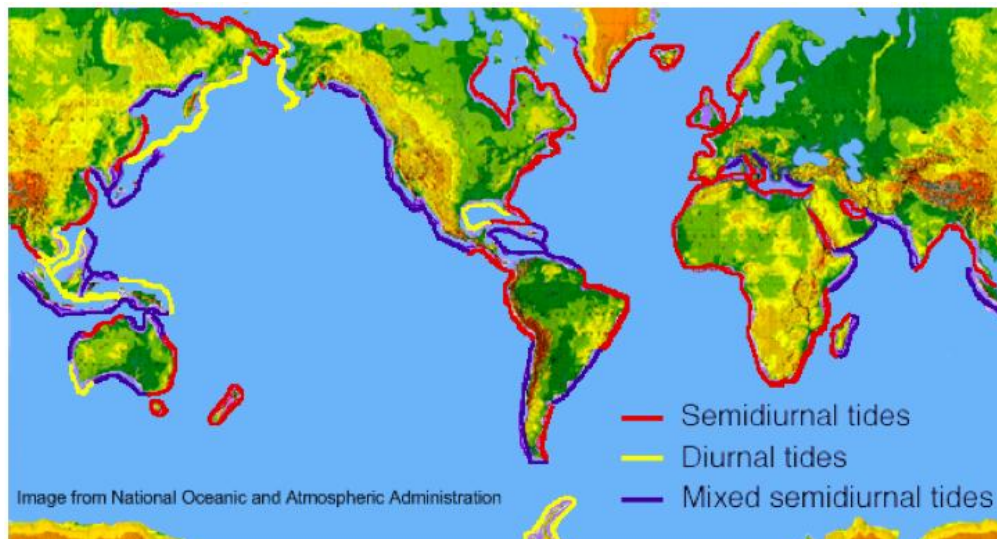


Figure A1.11 World tides

In terms of natural conditions, North- West Europe has a large potential for tidal stream power development, particularly around United Kingdom and north-west France. In the North Sea off the Norwegian coast, tidal currents are normally weak with mean peak spring currents ranging from 0.1 – 0.3 m/s. In coastal waters further north, however, tidal currents of 1m/s are common, with stronger currents at particular locations. The Maelstrom in the Lofoten Islands is one example. The location of Hammerfest Strøm's test turbine has a maximum current speed of 2.5 m/s. The tidal potential is small in the south of Norway, but increase north of Bergen as shown in figure A3.12. There exist few inlets with the right angle for powerful currents between Bodø and Trøndelag, which indicate limited energy potential south of Bodø. Sandgren et al. (2007) estimate the realistic exploitable potential of tidal power in Norway to be 1 TWh/year (Sandgren et al. 2007).

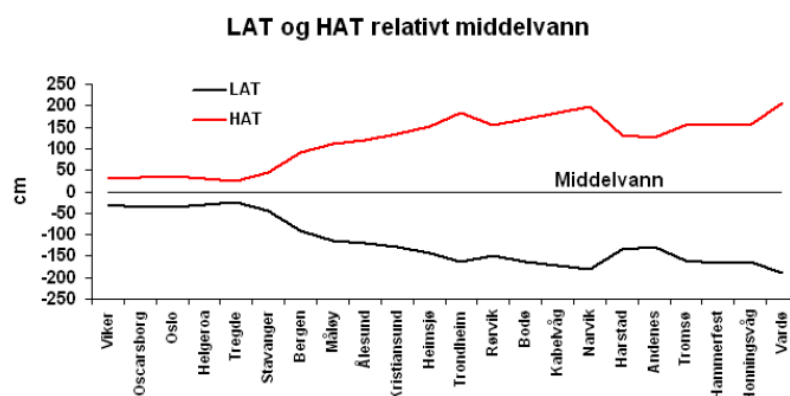


Figure A1.12 Relative middle water, Norway (Sandgren et al., 2007)

A1.2.3 Technologies

There are two options for getting energy from the tides: utilizing the potential energy in height difference with tidal barrage, or utilizing the kinetic energy in the tidal stream to power tidal stream generators

A1.2.3.1 Barrage/potential energy

Tidal power has been utilized since the Middle Ages, perhaps even in the Roman Period. Then in the form of tide mills, which are water mills driven by tidal rise and fall. A modern version of the tide mill is the electricity generating tidal barrage, which has been used for decades. The 240 La Rance was built in 1966, producing 600 GWh annually, thereby enough to cover the energy consumption to 300 000 people (Dahlaug, REN21 2011). Other tidal barrage projects commercialized in Canada, China and Russia by 2001, have estimated capacity of 262 MW in operation. Only tidal barrage systems have achieved commercial scale and count for most of the world's installed ocean energy capacity (REN 21 2011). Tidal barrages can cause damage to the marine environment. Tidal plants can alter the hydrology and salinity of the environments and alter the marine habitat. Changes caused by barrages include reduction in intertidal area, reduced range of salinities, changed bottom characteristics and slower currents (Pelc and Fujita 2002). During the construction phase of La Rance, the estuary was entirely closed off from the ocean for almost three years, and it required a long period of time before the marine equilibrium was restored. In addition it is above water and interferes with the visible environment as well as boat traffic. With Norway's history of protecting the nature it is highly unlikely that a barrage will be considered in Norway (Dalhaug 2011).



Figure A1.13 Tidal barrage, La Rance

A1.2.3.2 *Kinetic energy*

There are several pre-commercial projects, with a range of technologies that utilize kinetic energy. The energy conversion of a moving tidal stream has many similarities to the energy conversion of wind. However, there are two major differences; the density of water is approximately thousand times greater than the density of air, and the velocities in a tidal current are slower and more predictable than wind velocities (Bedrad 2005). Tidal turbines could be the most environmentally friendly option. In contrast with Barrages, they do not block channels or estuarine mouths, alter hydrology or fish migration. They can also turn slowly enough to prevent damaging fish life.

There are different structural variations that are used to transfer forces to the sea bottom. Some are floating and some are placed on the sea bottom. The different solutions can therefore have different profitability according to depth of placement. There are also different machine oriented variations such as counter rotation, and solutions for generators and gear solutions. The solutions affect installation and maintenance costs. The installations can also be exposed to large dynamic forces, which can damage the construction (Sandgren et al. 2007).

A1.2.3.3 *Horizontal Axis*

Horizontal axis turbines are the most common turbine configuration used today and often look similar to a windmill. It can be bottom-mounted with some distance to the surface, bottom-mounted and above the surface and floating. Floating structures and structures above the surface can more easily be maintained, but bottom-mounted that does not penetrate the surface cause less disturbance for ship traffic (Sandgren et al. 2007).

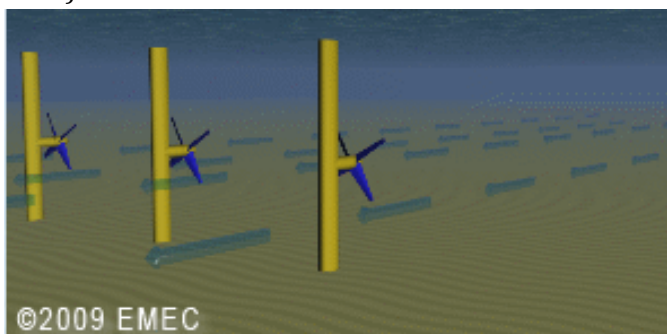


Figure A1.14 Horizontal Axis

A1.2.3.4 *Venturi effect*

By using the Venturi Effect, the turbines can also be housed within a duct, which create secondary flow effects by producing pressure difference and concentrating the flow past the turbine.

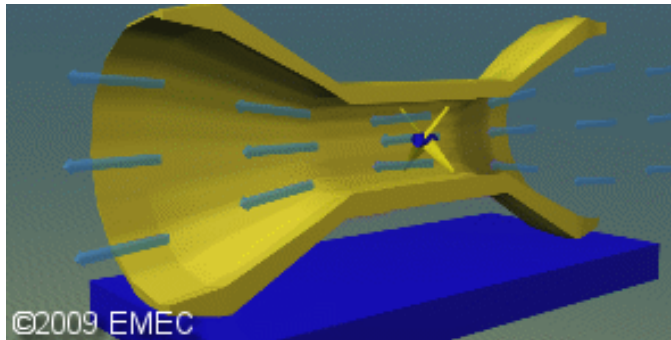


Figure A1.15 Venturi effect

A1.2.3.5 *Vertical axis*

A vertical axis turbine extracts energy from moving in a similar fashion as the horizontal axis turbine, but is mounted on a vertical axis. Georges Darreius invented the vertical and horizontal cross-flow turbine in 1923 to cope with centrifugal loads. There is less experience concerning their function over time, and they might be more sensitive to driftwood and similar objects. The structures can be floating or bottom mounted (Sandgren et al. 2007).

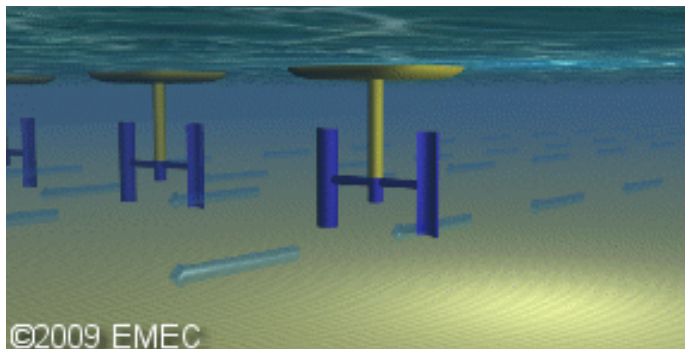


Figure A1.16 Vertical Axis

A1.2.3.6 *Oscillating Hydrofoil*

This technology is a hydrofoil attached to an oscillating arm. The tidal current flowing on either side of the wing causes the motion and results in a lift. This motion can convert fluid in a hydraulic system to electricity.

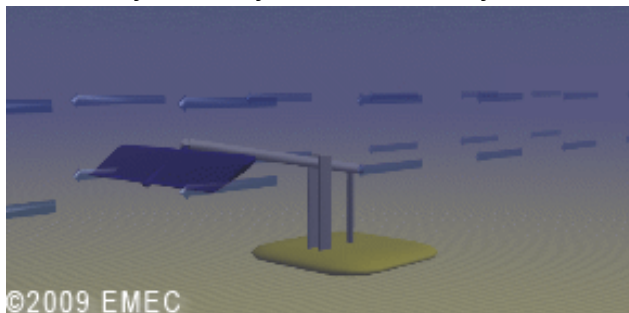


Figure A1.17 Oscillating Hydrofoil

A1.2.3.7 *Sails*

This technology utilizes the kinetic energy by attaching sails on wires. The tidal current pushes the sails, which pull the wires, turning a gearbox and producing electricity.

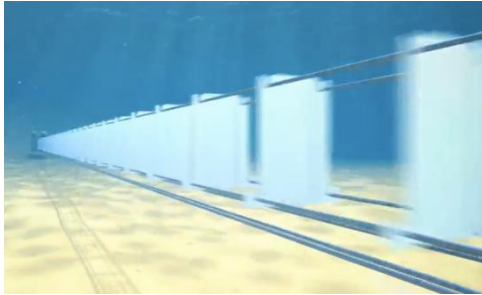


Figure A1.18 Sails

A2 Government Policies

A2.1 Research Council in Norway

The Research Council in Norway has a program called RENRGI, which grant support to research and development projects in an early phase. The projects can for instance be concerned with modeling and laboratory tests and the target groups are businesses and research environments. The cumulated support for 2011 is around 250 million NOKs (Enova.no, 2011). Businesses can gain tax deduction of 20% on costs related to research and development through SkatteFUNN in projects approved by the Research Council of Norway (Forskningsradet.no, 2011).

A2.2 Innovation Norway

Innovation Norway distributes 257 million NOKs of the Miljøteknologiordningen in 2011 and 2012. The program offers support to pilot projects and small to medium scaled demonstration plants within renewable energy and other environmental promoting technology (Enova.no, 2011). Innovation Norway can in addition offer innovation loans/ risk loans and support in matters concerning industrial research and development contracts (Enova.no, 2011).

A2.3 Enova

Enova support demonstration of new energy technologies through their “program for technology introduction”. The program’s cumulated support is about 150 million NOK per year. Enova also has a program that grants support to full scale demonstration projects of technologies within marine power production called “program for marine renewable energy power production” which is mainly meant for offshore wind, tidal and wave power. The yearly budget of this program is about 250 million NOKs (Enova.no, 2011).

A2.4 International Public Finance

Norwegian companies can apply for funding from international support scheme. The European Union offers several support schemes within renewable energy and research projects. EU’s seventh framework program (FP7) is a program to assure research and development within Europe. The program distributes 50 billion EURs over a seven years period from 2007-2013. The program covers research at different levels and also offers the possibilities of cooperation with countries within and outside the European Union (innovasjon Norge.no, 2011). Eurostar supports knowledge- and research driven SMEs with projects within research and innovation and is specifically targeted to development of new products, processes and services and the access to transnational and international markets. Eurostar covers 50 percent of the project cost of approved projects (Eurostar-eureka.eu, 2011).

A2.5 Regulation Policies

Norway has regulation policies concerned with renewable energy in terms of green certificates. Green certificates, or renewable energy certificates (RECs), require a fixed quota of electricity sold by operators in the market to be generated from renewable sources. Green certificates mostly concern distributors or producers, but consumers can also be directly involved in the trading system. Entities can generate the required amount themselves, purchase it through a long-term contract with an energy generator, or purchase certificates from other operators. The certificates are issued by renewable energy generators who sell them in the network at market price or/and sell them in the green certificates market (Lewis and Wiser 2006).

1st of January 2012, Norway entered an agreement with Sweden of a common certificate market. The target is a cumulated increase in renewable power production of 26.4 TWh within 2020, which corresponds to half of the electricity consumption of Norwegian households (Kolbeinstveit, 2009). The certificate fee is added to the regular electricity bill, thus the power companies are required to purchase certificates and demand payment by their customers. As of 2012, Norwegian consumers have to pay for certificates corresponding to three percent of the electricity consumption. The certificate price is determined by supply and demand, where the supply is related to the power production level and the demand is related to electricity consumption and the fixed certificate quota each year (Kolbeinstveit, 2009). The certificate price decreases as more actors invest in renewable energy production. In the opposite case, the amount of certificates decreases and hence the certificate price increases, which in turn will attract investors. Provided that the certificate price is 0.25 NOK/kWh, the cumulated support is estimated to be 560 million NOKs in 2012. However, the certificate price as of February 2012 was 0.15 NOK/KWh (Enova.no 2012). The certificate support will be independent of the location of the power plant and of what source of renewable energy utilized, and will thereby cause incentives to invest in the most profitable renewable energy production (Kolbeinstveit, 2009). The green certificates will hence not be of considerable importance to Norwegian wave and tidal power developers at this point, since the technology is in the development stage and cannot compete with the profitability of more developed renewable energy sources.

A3 Interviews from Introductory Project Fall 2011

This appendix includes the interviews conducted in the introductory project fall 2011 that examined the challenges in the Norwegian wave and tidal industry. Four wave companies, four tidal companies, and one special interest organization was interviewed. The interviews are presented as extensive summaries containing background, technology presentation and current information and strategy. At the end of the appendix, a table comparing the different companies summarizes the main topics.

A3.1 NORWEA

Interviewee: Carl Gustaf Rye-Florentz, MSc in Energy and Environmental Engineering, Production Consultant

Location: NORWEA's office in Wergelandsveien 23 B, Oslo

Date: 6. October 2011

A3.1.1 Background

NORWEA is an special interest organization for Norwegian wind, wave and tidal power. They have 130 members, mainly in wind power, which is a larger industry with more developed technology. NORWEA has members from the whole industry including banks, technology- and energy companies, lawyers, investors etc. They can initiate contact between different actors, give information about the market, but much of their work is political, pressuring the government for more beneficial policies for their members. Their current work is mostly related to lobbying for Green certificates.

A3.1.2 Technology

Tidal and wave power technologies are early in their development phase, and NORWEA does not expect them to be energy sources of high significance in the next ten years. No technology concept can deliver at low enough prices. This was the case for wind technology ten years ago. The wind industry has narrowed down to one concept – three blades. We have not yet experienced this in wave power, but waves have more natural variability than wind. In tidal there is an emerging trend towards turbines similar to wind turbines. Development in tidal power is slightly ahead of wave technology, but there is greater potential in waves. Connection to the grid is expensive for wave power and Mr. Rye-Florentz thinks that connections done by offshore wind can be utilized. Tidal power is closer to shore and do not experience the same grid challenges.

A3.1.3 Current situation and strategy

A3.1.3.1 *The Entrepreneur and Collaboration*

The entrepreneurs often invest in the company and many have a goal of attracting larger industrial partners that can contribute with competence, and investors that can contribute with cash. Some big actors buy ideas, but e.g. Statkraft has changed their

strategy to invest less in this type of energy. Small companies within wave and tidal cannot manage the entire value chain and are dependent on outside competence. It is more beneficial to collaborate with a large partner than to hire consultants. Their greatest problem is that they lack this collaboration with partners and the chance of getting one often depends on the team's network and whom they know. A barrier for tidal and wave entrepreneurs/small companies are collaboration and network making. Almost all wave and tidal companies are facing some of the same challenges with regards to technology and business development. In Mr. Rye-Florentz opinion tidal and wave companies should cooperate much more with each other than they do today. The most important collaboration partners for wave and tidal companies in Norway are industry- and energy companies, and government in terms of supporting policies.

A3.1.3.2 *Funding and Regulations*

In Norway there exists funding from Innovation Norway, the Norwegian Research Council and ENOVA. Norwegian tidal and wave developers can get hundreds of millions NOK/year for development. Many of the small wave and tidal companies lack money and use a lot of time to get financing. One of NORWEA's members thought they should use 20% of their time on getting funding and 80% on technology development, but it turned out the other way around. NORWEA, Enova, Innovation Norway and the Research Council has been on a tour in Norway where they informed actors about financing possibilities, and brought along 2-3 local investors in each region. The time horizon and the related uncertainty for return on investment on tidal and wave technology are too long for most venture funds. There is more likely that venture funds that are partly governmentally owned will invest. One or two of the funds on the tour were interested in wave and tidal power.

Scotland is one of the countries in the world with most policies for renewable energy. Here you get approximately 3 NOK per kWh. They also have some wave and tidal power plants that are delivering to the grid. The main reason for moving to Scotland is this financial incentive. Scotland also has better natural resources, grid and infrastructure. Most Norwegian companies are planning on international expansion eventually, but it is beneficial to be located in Norway during the development phase due to the support policies for technology development. Thus, the different national policies influence the strategies and internationalization of wave and tidal companies in Norway. They do the development in Norway, before moving to Scotland where they get more money for energy produced. Hammerfest Strøm is a Norwegian company that has moved operations to Scotland, and more Norwegian companies are implementing this as a part of their long-term strategy.

A3.1.4 Possibilities for Future Policies in Norway

Norway and Sweden will, most likely, have a common green-certificate system within 2012. Sweden has had certificates since 2003 and developed approximately 3000 MW of wind power. In the long run it can include even more countries to develop a common market and build where the best resources can be found, but this is ahead in time. The new el- certificates will almost certainly only have effects on wind, water and bio. Power production from wave- and tidal power is too expensive to benefit from the certificates.

The UK gives different technologies different certificates; one certificate for onshore wind, three for offshore wind and five for wave and tidal. This might be a path for Norway in the future.

The main funding organizations in Norway can be placed in three phases related to development; first the Norwegian Research Council, then Innovation Norway followed by Enova. To qualify for funding by Enova, you have to prove that your technology works, but many lack the funding to get this proof. This results in Enova not distributing all their money. A solution could be that some of the funding could be given out earlier in the technology development.

A3.2 Langlee Wave Power

Interviewee: Cathrine Bryøen, Business Development Manager Technology director

Location: Phone interview, Trondheim and France

Date: 11. November 2011

A3.2.1 Background

Julius Espedal had the idea behind Langlee in 2005 and founded the company in 2006. He has a M.Sc. in mechanical engineering from University of Trondheim, NTH/NTNU and has worked within electronics, offshore and product development. He founded another company called Frontec in 2001, which he exited after approximately five years. After one and a half years he managed to get two external investors from Sweden. One called Färna invest and a Swedish fund called Orevik in 2008. Färna invest consists of one man who sold his part of a company when it went IPO. He invests in interesting people and promising technology and has some other investment projects in Norway and Sweden. Today Färna Invest owns 49% and Mr. Espedal 43% of Langlee.

In addition to Mr. Espedal, Ms. Bryøen is the only full-time employee and started in 2009. They outsource a lot of resources such as lawyers and accountants. CEO, Mr. Espedal, has the main responsibility on the technical areas and financing, whereas Ms. Bryøen focuses on the business aspect, thus commercial, economy, marketing and also financing. In time periods where there is a large workload in one area they both concentrate on that manner. Right now they are working on the pilot project for the summer 2012. They are planning on hiring three people for that project during the spring 2012.

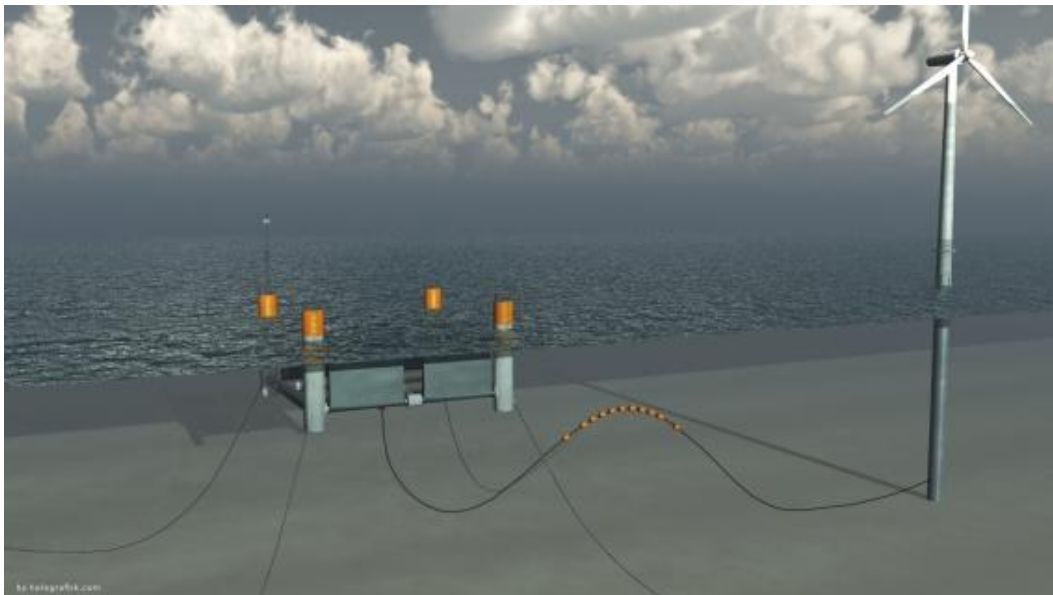
After concept studies and computer modelling Langlee went into a pilot period in 2008. They use data from the oil and gas industry as input to improve their models. They have performed three rounds of model testing. One small one early on, then two by Aalborg University in their wave pool in 2009 and 2010. These two were in the scale 1:20 of a larger plant they have designed for the North Sea. The University of Aalborg were chosen due to their knowledge of wave power. A pilot this summer will be built during the spring and placed in Egersund. All their research has been documented in different reports. Parallel to this there has been intensive work on marketing and financing. It takes considerable costs to put the technology forward.

A3.2.2 Technology

Older actors in their industry, such as Pelamis, Aqua Marine Power or Ocean Power Technologies (OPT), has existed for over 7 years and were lucky to be present in a period with a lot of investment capital. They have gotten something like 400 MNOK, which make Langlee wonder what they have used their money on since they still do not have a commercial product. Langlee are extremely good at planning and make tough prioritization. They only use resources to deliver quality in their work, use a lot of outsourcing and have no large minimal overhead. They have no plans of setting up production facilities and hiring a lot of people, but to outsource the structure and keep their core technology. During development of the company there has been a clear strategy of IPR. They would like to have local production.

The structure is 15X15 meter and the mooring concept is based on the same as fish farms. Langlee's core technology concerns transformation from mechanical movement to energy. They have developed a generator module and have the belonging patents. It is important for investors to invest in something of value. An advantage of Langlee's technology is flexibility of location, which can range from 40 – 150 meters. Offshore plants can be moored mostly everywhere, giving a possibility of not being visible from shore. The greatest advantage might be the fact that they deliver "plug and play"-plants. They have the energy production and are not dependent of any particular structure on land.

Since they have a lot of time, not being forced to push the product fast to market, they have had the opportunity to work a lot on cost reduction in during the development. They had an estimated price of 2,5 NOK per kWh in 2009 and estimate approximately 1,3 NOK per kWh in 2013. Their goal is to be competitive with land based wind energy.



A3.2.3 Current Situation and Strategy

Wave power is a new market, and the industry is not really an industry yet. But there exists a focus in Europe and the rest of the world, like the Klondike in the gold rush, where everyone searched, in this case for technology. Langlee finds inspiration in the

windmill developer, Vestas in terms of long term development, thus how the wind industry in Denmark developed in the late 70's. Vestas was originally a mechanical workshop that started to develop windmills. Their first turbine was 50 kW and delivered power to farmers. It took a period of 10 years to reach 500 kW. They needed a market for their product before they could earn income. Before you get income you are dependent on subsidies. Langlee has worked very hard to obtain funding for their most important projects and to document what they do. Langlee believes their technology can be huge and that wave and tidal can follow the same path as wind, exemplified through Vestas and their turnover of 15 billion Euros in 2004. The largest risk is not thinking big enough.

Langlee's main challenge right now is the long period of time before they get an answer on applications from organisations like Innovation Norway. They waited a year for their last application. Another large challenge is capital. They know what to do, but cannot work uninterrupted because they need capital. Thus, a barrier for growth is capital. There is also time to market, but the time might be their best friend after all.

They manage to extensive work through a very strategic market direction. Ms. Bryøen does research on who they should contact and what a possible role in the project might be. It has taken her a couple of years to develop this competence and to get familiar with the industry. Within the renewable marine sector you meet the same people across the world. They meet peers at the same events, in several international locations such as Santiago, Washington, China and the UK.

A3.2.3.1 Funding

Mr. Espedal started the search for investors when he founded the company by calling people he knew or people he knew worked with angel investment or start-up capital in Norway. There exist a lot of good forums in Norway such as venture lab, Connect Norway and Seed forum. All these forums collaborate and make it possible for small companies to present a pitch. Langlee has done this for 4-5 years now. They might need more capital than other companies in the same phase. There is less capital in Seed forum, maybe 5 MNOK, but when you want 40- 50 MNOK you have to work directly with venture companies and others in the network. Langlee has the Norwegian actors under control, but also considers foreign investors in other parts of the world. They are also aware of the possibility for "shooting in the dark".

Langlee considers themselves lucky to have an industrial investor in Färna Invest, which has a long term perspective. The investor has patience, and has invested nearly 22 MNOK. Before the summer 2011, Langlee got 6 MNOK in funding from their investors. Few other actors have managed the same. They thought they could raise it from others, but ended up with the same investor. Färna invest sees the importance of a large-scale demonstration, but is not willing to carry all the risk on its own. Thus, they are dependent on governmental support from Innovation Norway, Enova and the Research council. Langlee are currently working on getting venture capital. This is difficult and they might rather have a strategic partner or investor with a longer time perspective. The Norwegian actors participated in the sun power industry, and when it did not turn out the way people expected, it creates mistrust in new renewable industry. There are

also some technologies in the marine renewable industry that have failed, both in Norway and abroad. Venture capitalists do not want to take technical risk and want return on investment in a relatively short period of time. Langlee are currently applying Innovation Norway for 10 MNOK. With this and the capital they already have, they can carry out the pilot project summer 2012.

Langlee has planned a possible IPO initial public offering for the investors in 2015. This will correspond to several hundred millions. Hopefully, they have increased their sales and have a clear picture of how many plants to deliver by then, which makes a good case for the stock exchange. Neither Färna Invest nor Langlee have a pure environmental motive, but have a business motive and believe the technology have a great potential.

They have worked a lot on getting governmental support from the early phase of development. In research related activities they have got funding from Skattefunn and other arrangements from the research council. Companies in the renewable energy industry might have a hard time documenting a high degree of research, due to a focus on the product. Langlee has gotten 5 MNOK for a project that ends at the turn of the year 2011 and a smaller amount from Innovation Norway earlier, perhaps 300 000. They were given an establishment grant of 800 000 NOK quite late. SkatteFUNN constitutes a large amount by giving 20% of the costs back. Nevertheless, there is a displacement when you do not get the money until the October the following year. In their niche within marine energy, you cannot do development without governmental support.

A3.2.3.2 Customers

Langlee already sells plants by making agreements on size; the product does not necessarily have to be ready. The sales process in this line of business is very slow and takes two to three years. They currently have two contracts; six plants in Turkey and four in New Zealand. They also have four projects in their pipeline and are working on a contract with a project developer at the Canary Islands.

To get projects Ms. Bryøen talks to people in the market and assess the possibilities for a good match. Firms from all over the world make contact with Langlee after seeing them online, or in a presentation at fares like All Energy, which they have attended the last five years. People may contact them because they have an interesting technology, which is introduced after technologies that have been present for a long time without delivering expected results. When it comes to utility actors, Langlee has to contact them. In the case of island communities and other possible buyers, they contact Langlee.

Langlee has told their customers that they can deliver the first pilot plant in 2013. They wish to clarify their own pilot in Norway first, and are working on getting capital to carry out this project in 2012. They believe that they will have five to ten plants in the ocean in 2013, but not all with one customer. It is important that the local partner acquire knowledge about the plants performance in relation to placement in ocean etc. The plan is to deliver one plant in 2013 that will run for a year, before complementing it with more plants in 2014. They plan to use this stepwise approach with future customer as well. Before they can start anything the customer has to get a concession. In Turkey, they have waited for this in one and a half years. It takes years to project a wave power

park since one have to go through environmental impact reports etc. Since the technology is premature they do not get any payment in advance. The customer pays some kind of payment in advance to secure the contract when they get a concession. They have not figured out all the details, but have to adjust these procedures according to each case.

A3.2.3.3 *Market Decisions*

Langlee has a clear strategy for international growth as they do not have a home market in Norway. Norway has no renewable targets like several other countries in Europe. An important market for Langlee is countries that are oriented against marine energy, have expressed a clear strategy and supporting policies in place. Nevertheless, these countries also have a slow progress. Langlee's current market strategy is concerned with island communities that are dependent on diesel-generated power. These communities are more likely to move faster toward their technology. Such communities have a diesel cost of nearly 750 Euros per MWh, which gives about 4-5 NOK per kWh. Langlee is working with Island communities and had a meeting with actors from France yesterday, which have a lot of islands in their territory. The Norwegian renewable energy community does not focus on anything but Europe and Norway, with prices of approximately 39 NOK per kWh. Investment and analytic communities also relate only to the power prices in Europe. Langlee's model with local production can also improve the socioeconomic value of the islands by creating jobs.

Langlee's decision about whether to stay in Norway depends on the support from the government. They would like to produce the generator module in Norway, but not if it is more expensive than other countries. They find it favorable to be located in Norway due to the maritime cluster within oil, gas and also fish farming. It is beneficial to have relations with local suppliers, which can supply most of the equipment in Norway when they are performing demonstration projects. They have contacts abroad that are willing to do the testing, but it feels right doing it in Norway where Innovation Norway has faith in them. The Norwegian government does a good job, but it takes time. The pilot project this summer has to be tested in Norway (Egersund) because of rules set by innovation Norway in relation to Miljøteknologiordningen.

Langlee started taking international initiatives from inception. Already in 2005 Mr. Espedal went to Shanghai. "You have to contact the environment and show your technology". Langlee already have a virtual office in Aberdeen, Scotland. If they get a customer in Scotland they will definitely place a unit there. Norwegian companies have to prove to the Scottish government that they use local resources and infrastructure to get access to their support initiatives. Hammerfest Strøm has already done this by moving their operations to Scotland.

If the Norwegian government were to change their policies, Ms. Bryøen believes that they could introduce direct incentives to renewable energy and maybe specific to marine energy. -For instance 2 NOK per kWh the first five or ten years of production. This would create an investment case of interest. Without having an operating income you cannot calculate ROI. Investment costs are also higher for renewable energy than other power sources.

A3.2.3.4 Collaboration

Langlee does not collaborate with other similar companies in the industry, but they do have a dialog and share common factors such as membership in NORWEA, Scottish renewable forum and Oslo renewable energy and environment cluster (OREEC), where MS. Bryøen is among the board members. They are also joining the European ocean energy association, which works with lobbyism in Europe. They call some colleague every once in a while to check up on them and try to get an overview over the existing actors. Most of the Norwegian actors are at an earlier stage than Langlee. NORWEA are looking at possibilities to create a larger link between research communities and industry.

Aker solutions have done an internal study on wave power, which indicated that Langlee wave power had the most promising wave power technology. Aker solutions had a strategic interest in Langlee as a Company. This was in 2010 and Aker did not have time to make an assessment due to change of company structure, but they have shown interest in a partnership, acquiring ownership or something similar. Langlee would have liked if Aker had acquired ownership, but Aker is not ready yet. Large industrial companies like Aker have their main focus areas and many have strategically chosen wind. It takes a long time for them to decide whether they should focus on wave power as well. Langlee are in dialog with several strategic companies, but the problem arises when you do a Joint Venture with companies that are manufacturer or fabrication. These are end-customers and raise a question of who should make the sale and the commercial part: *"You have to decide collaboration form and what each part can contribute"*.

A3.3 Pontoon Power

Interviewee: Nils Myklebust, Technical Manager of Pontoon Power AS. MSc in Mechanical Engineering from the Norwegian School of Science and Technology.

Place: Trondheim, NTNU

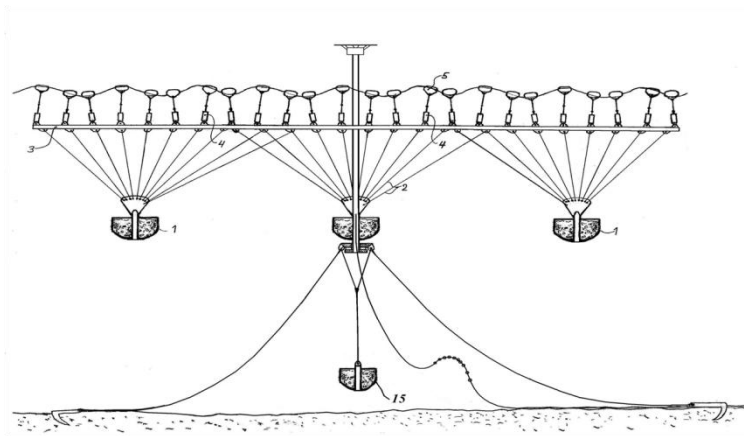
Date: 21. October 2011

A3.3.1 Background

One of the founders of Pontoon Power, Nils Myklebust, came up with an idea of a wave energy technology with hydraulic pumps in the early 1990's, but found that there already existed similar concepts and decided to not pursue the idea. However, in 2006 Nils Myklebust started to work on another part of the concept, namely the frame and structure of a pontoon/hydraulic pump plant. Nils presented the idea to his former work colleague, Jens Myklebust, in 2009 and they established Pontoon Power in February 2010. Since then they have performed different technical tests of the concepts as well as small scale prototype testing. The operation has been financed through financial support from Innovation Norway, a loan from Jens Myklebust's firm - JM Consult AS, and the founders' own capital. Pontoon Power consists of three people; Jens Myklebust and Nils Myklebust which own 50% of the company each, and Jens' son Eirik Myklebust. All three of them have a background as graduate engineers from NTNU. Jens works full time as General Manager, while Nils and Eirik work part time as technical manager and marketing manager respectively, alongside their regular jobs.

A3.3.2 Technology

Pontoon Power's concept is called Pontoon Power Converter (PPC). It is a floating energy converter based on hydraulic pumping cylinders, pontoons, hydroelectric turbine and generator mounted on a submerged bridge structure. The machine room containing the turbine and the generator is placed well above sea level on a column, allowing a more spacious and less expensive arrangement than that of a submerged machine room. A helicopter deck on top of the machine room makes it easy to perform maintenance and service. In order to survive extreme weather, the PPC is developed with a hurricane protection, where vulnerable parts are submerged before an approaching storm. A single unit plant will be about 600 meters long, with 70 pontoons and produce approximately 15 MW and about 40 GWh a year. The uniqueness of the concept is the submerged, suspended bridge structure that makes it well suited for a wide range of water depths. As the PPC is a floating system it can function as a supplement to other offshore energy sources and could potentially provide electricity to oil platforms. The bridge structure hence renders more possibilities than systems that are fixed to the seabed. The structure-technology is patented in Norway and is in the process of being patented in Europe and the U.S. The pontoon/hydraulic pump technology however, is a well-known concept and is therefore not a subject of patenting. Pontoon Power describes one of the main success criteria in the wave power industry as being production cost per installed power. The focus in the production development of the PPC is therefore to keep the production cost as low as possible as well as create a system that can produce at high volumes. The PPC should be competitive with offshore wind power plants. According to a study Pontoon Power has done, comparing a five unit PPC plant to the Sheringham Shoal wind farm in the UK, they found that the PPC plant had approximately 10 to 20% lower cost per installed MW.



A3.3.3 Current situation and Strategy

NTNU has recently finished a theoretical study for Statkraft where Pontoon Power's technology was one of eight wave concepts that were studied with regard to energy conversion capacity. The results are not published at present, but indications are that the PPC is competitive compared with the other concepts. In March and July 2011, Pontoon Power performed model tests in the water tank at MARINTEK. The first model tested was a single pontoon in scale 1:10, while the second model was a 1:50 scaled plant with 31 pontoons. The tests verified that the concept works and provided helpful data for further development of the power converter. They are currently working on

getting support to a larger scale model they plan to have ready by March 2012 as well as an engineering study. In order to finance these projects, they have filed an application to the Research Council of Norway, but they are uncertain of the outcome, as they got no funding the last time they applied. Their goal is to have a full-scale prototype in the sea by 2016, but Nils admits that they might have to expand the timeframe, as it is hard to raise capital. He denotes the market outlook as one of the highest barriers to overcome in order to commercialize the concept; there is no will to develop renewable energy, especially in Norway. Offshore wind has received some support, but wave power has not received systematically funding since the beginning of the 1980's. Pontoon Power considers three possible commercialization strategies: Selling PPCs, running and operating PPCs or licensing the technology. They have not yet decided on which strategy to pursue, but recognize that they are dependent on being bought by or collaborate with a larger and financially stronger market actor as production within wave industry is very resource demanding. Nils mentions possible strategic partners as large utility companies, companies with engineering capacity and developers of renewable energy, but they have not initiated such a partnership yet.

A3.3.3.1 *Internationalization*

Pontoon Power is currently based in Norway, but experiences that international actors show interests in their concept. Those are mainly suppliers from the western part of the world, but they also get a lot of requests from Chinese companies that learn about Pontoon Power through the Internet. Up until now, they have not entered any partnerships, but Nils denotes China as a potential production location in the future because of the low production costs. At the time of the interview, Jens Myklebust was in China on a conference called Low Carbon Energy Summit to speak about Pontoon Power's technology. UK is also considered an interesting country as the governmental support systems are lucrative and the market potential is bigger. However, they have not planned when and how they will develop international initiatives as they are in a very early stage of the project.

A3.4 Fred Olsen

Interviewee: Tore Gulli, Wave Project manager, MSc Industrial Economics and Production development

Place: Telephone

Date: 15. November 2011

A3.4.1 Background

The initiative to start a wave power project started in the late 1990s when Fred Olsen was on a trip to Scotland. With his maritime experience and eagerness to develop renewable energy technology, he realized that wave power had to be the obvious power source to develop further. The company had already engaged in other renewable energy projects; traditional hydropower since 1983 and wind power since 1995. Fred Olsen got in touch with an inventor that had worked for Fred Olsen on different projects earlier. He was originally a naval architect and had many different ideas on how one could extract energy from waves. Tore Gulli was shortly after, in 2003, employed to be responsible for the development of the wave power technology and eventually

commercialization. Their goal was clear; they were not only going to develop wave power technology, but deliver a total solution. Mr. Gulli had little experience with wave power before he was hired by Fred Olsen, but he had extensive experience within international management, business development processes and engineering from his former jobs a.o. within the oil and gas sector. The project was established as a privately funded activity. There are 10 employees working on the project; the majority have a graduate engineer degree from NTNU, and some are engineers. The team members have from 15 years to 6 months of experience, but they all share the passion of developing renewable energy.

Fred Olsen has tested 8 sea-based prototypes as a part of the technology development. In addition, a number of laboratory and workshop test has been conducted. They have financed the operation by the Olsen family's private capital, resources from cooperation with key suppliers, as well as governmental support from tax funds (SkatteFUNN), The Norwegian Research Council and ENOVA in Norway. Internationally there has been support from and EU's FP6 R&D program and the British Technology Strategy Board.

A3.4.2 Technology

The device development has always been based on the principle of point absorption. Initially a platform with multiple point absorbers was developed and a scale model (BULDRA) was built; however during testing it became apparent that the overall economics not was feasible. Later several single point absorbers were developed and tested, culminating in the development of BOLT, which have operated in the sea for more than two and a half years. The wave energy devices are based at sea level, either close to shore or to other installations, in order to perform efficient maintenance and power distribution. Fred Olsen' focus when developing the concept has been to create a device that has a good functionality as well as being cost efficient. They hence concentrate on keeping a high level of operational stability and reliability, and low invested cost per unit instead of only capacity measures. They do not want to give a specific price per kWh, but they realize that they need to be competitive in the actual market, and their long term goal is to be competitive with offshore wind. The device can be scaled to produce at different capacities, but the units they are currently developing are relatively small with an operative capacity of 100 kW and an installed capacity of 250 kW. Most of the technology is patented, but Mr. Gulli emphasize that success is a combination of patents and competence, never patents alone.



A3.4.3 Current Situation and Strategy

Fred Olsen is at step seven of NASA's technology readiness level scale (TRL), and is working to reach step eight. They are currently testing their eight sea-based prototype (BOLT) at a test facility in Risør. This prototype is producing electricity and has been operating for about two and a half years. The next step is to test a full scale prototype in England. They have an established strategy in the commercialization process, but they chose to keep this information among their trusted partners. Their general strategy however, is to have a long-term perspective on development and they acknowledge that the concept will take time to finish as the industry demands extensive industrial processes that are very capital-demanding. The company has not tried to raise external capital during the last project, but has been fortunate to have the capital strong Olsen family as an investor throughout the development. The Olsen family believes in the concept enough to invest capital from their private assets and have the long-term perspective on the investment. Mr. Gulli argues that it is utopia to believe that there are any "quick-fix" solutions to succeed within the wave and tidal industry, and believes that there are too many Norwegian and international players/technology developers that lack a long-term perspective. Many have promised faster development and commercialization than they have been able to deliver, which in turn has weakened the credibility of the entire industry. He understands that the smaller firms need to be more open and bold in terms of their strategy as they are in a greater need of external capital, but it is not fortunate for the industry as a whole. This is one of the reasons why Fred Olsen decides to limit the external communication until data and results are properly verified.

A3.4.3.1 Barriers and Governmental Support

It has been a barrier that the Norwegian government has not been willing to create a realistic home market. The government has focused too much on traditional hydropower and failed to discover the connection between industrial development, electricity production and competence development within the wave and tidal power segment. There are great opportunities in Norway within this segment because of the natural resources, engineering competence, supplier industry, a coast with potential to

install wave power plants close to shore and a well-developed grid network along the coast. The Norwegian government should be able to exploit this opportunity. It is extremely important that the government develop a home market where companies can test their innovations in order to create competence and industrial supply resources. The British government has done the complete opposite of Norway; they have invested in building a home market with a long-term perspective. In Norway a company can receive support one year, and be rejected the next. It is difficult to create a long-term industry development on this basis. The Norwegian government should establish a test market and communicate that they find the market interesting in terms of competence development, and accept the risk involved. This would give Norway acceptance by other countries, but without the important home market the Norwegian suppliers have less credibility.

Currently, Fred Olsen's biggest challenge is the practical operational issues in order to make the technology functional. Product development within wave power is especially demanding as for instance the difference between extreme weather forces and average forces are large; in the range of 1:20. Tackling these challenges, however, results in competence development that could be of great value in similar industries and hence give spin-off effects. The innovative nature of this emerging industry also makes large industrial organizations eager to cooperate with companies such as Fred Olsen as they learn a lot from the collaboration process.

A3.4.3.2 *Internationalization and Cooperation*

Fred Olsen has had an international focus from the inception. This has been an intentional strategy since there is no home market in Norway. As the Fred Olsen is an international group of companies, they have naturally a large business network within the mother firm and Mr. Gulli has a network from his former work experiences. In addition, they had to develop an industry specific network by contacting different market actors in order to figure out the market essentials. They are now a member NORWEA, and was contributing to the establishment of NORWEA's forerunner within wave and tidal power (FFMFE) that later merged into NORWEA. They are also a member of the organization Renewable UK, which pleads their case in political matters in the UK. Fred Olsen has close cooperation with key suppliers as ABB, Siemens and medium sized companies in Norway. These suppliers have invested time and resources into the wave project which have enforced the competence level of both parties. Fred Olsen has taken the old shipping mentality of mutual trust and long-term perspective into the wave power industry. They try to avoid "shopping around" on a case by case basis, but rather find partners that share their vision and have a genuine interest of develop competence within wave energy technology.

Fred Olsen considers cooperation among competitors to be helpful. They cooperate with the Swedish company Ocean Harvesting Technologies (OHT) that has a technology that is not directly competing with Fred Olsen's concept, but related. They cooperate in non-critical areas of the development; operative matters, practical experience and exchange of supplier experience. Fred Olsen has provided OHT with the use of their test site as it would be extremely costly for OHT to build a similar site at the Swedish coast. Fred Olsen also cooperates with some other Norwegian and international companies, but not

to the same extent as with OHT. Mr. Gulli believes it should be more cooperation between the existing market actors. He argues there is good reason to share competence within the industry as there is no superior actor in terms of capital or technological dominance, and market actors hence need to develop the industry together. Many small Norwegian actors do not realize that cooperation and sharing of competence is essential in order reach commercialization. Mr. Gulli believes that many of these actors should be less protective of the technology ownership; "it is better to own a small share of a success than a large share of a failure."

In research and development issues is Fred Olsen is cooperating with Norwegian research environments at MARINTEK/SINTEF at NTNU, the University in Oslo as well some Master assignments projects at the UMB. Internationally they cooperate with universities in the UK, Belgium, Portugal as well as R&D departments in partner organizations.

Fred Olsen is monitoring many markets, but their target market is currently the UK because of the market size and governmental support schemes. The next prototype will hence be tested in England. Even though the green certificate market is under development in Norway, there is still uncertainty concerning the financial level of support and the market price. Anyhow, it will not likely to be competitive to the British, Irish or Scottish market. Mr. Gulli thinks it is unfortunate that they feel the need to move part of the project out of the country as there in reality is a great potential in Norway to develop the industry further.

A3.5 NLI

Interviewee: Anders Tørud, Master of Science UMB, Business Development Manager at NLI

Location: Kjeller

Date: 24. October 2011

A3.5.1 Background

NLI is an engineering and fabrication company that supply services and products to the offshore oil and gas industry. 80% of their activity is within oil and gas, thus their main activity is not offshore renewables, but renewables are getting bigger and bigger. NLI is a Norwegian owned company, has approximately 800 employees and a turnover of one billion NOK. NLI figured out that they could use their competence from oil and gas in the offshore renewable sector, and has three offshore renewable projects: OWC, Windsea and Hydra tidal. These projects are currently development companies that have not made any sales.

A3.5.1.1 OWC

OWC is a joint venture between Rainpower and NLI, where they each own 50%. Parts of Rainpower was formerly a part of Kværner hydro power in the 1980's, thereafter bought by GE, and when Norwegian owners bought the company back they named it Rainpower. In the 1980's, Kverner worked on a wave power project that followed the company as it changed owners. The oil crisis in the 1970's made it very attractive to

investigate alternative energy sources, but then the energy prices fell dramatically, to 10 USD a barrel, making renewable energy uninteresting. Due to this and other issues in Kværner, the project was shut down even though it showed good results. In 2010 Rainpower and NLI started a new project looking at OWC wave power devices. The Rainpower/NLI owc solution is not directly based on the Kværner technology or data from that project, but they started development of a new concept for an oscillating water column (OWC) wave power solution based on the fact that they had personnel with experience from OWC wave power in their organisation. They are now in the phase of early technology development with lab testing and calculations, and are planning to build a full scale, commercial prototype in 2015.

When Kværner first decided to pursue wave energy they used a thorough, systematic approach to figure out the best technology. They searched and analysed all possible concepts that was known from research, and worked with NTNU and others that were leading in wave power research. OWC was found to be the general working principle with the most potential. Since then several companies has developed different versions of wave power devices that is based on the owc general principle, among them OWC power AS. Mr. Tørud explains that this development is somewhat untypical; often one person/ entrepreneur has a good idea get a large industrial company to take part, like the cases of Hydra tidal and somewhat Windsea, but here a company decided to take a systematic approach to find the best concept.

There are about ten people working in the project organisation in total, but no one works full time. Two or three people are working almost 50%, which makes 1.5 – 2 yearlong assignments in total. They are outsourcing competence from e.g. NTNU and Sintef on wave physics. By not having fixed costs in salaries they reduce risk.

A3.5.1.2 *Windsea*

Force Technology and NLI own Windsea (50% each). Force asked NLI if they wanted to join in 2008. There was one employee in Force Technology that came up with the idea. Windsea also use workforce from the owners and has one or two employees.

A3.5.1.3 *Hydra tidal*

Hydra tidal is a small entrepreneur Tidal Company in Harstad, which has built a prototype ready for testing. NLI just bought majority ownership in the company, before this the entrepreneurs did all the development. Small energy companies and the founders own the rest. NLI is already heavily involved in the project. Hydra Tidal already had 2-3 employees when NLI got involved, which are still working on the project.

A3.5.2 Technology

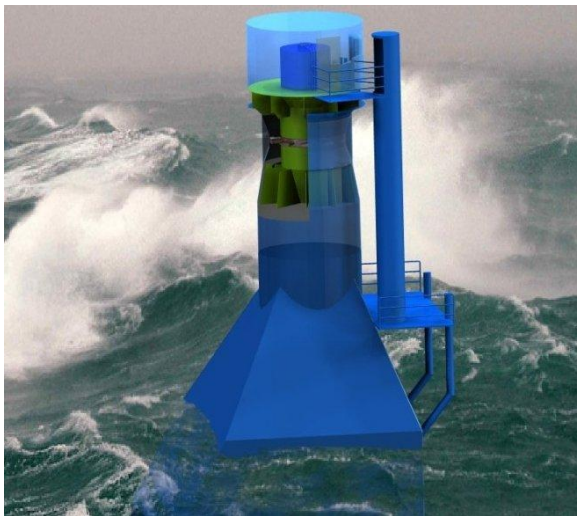
NLI wish to be a part of the renewable energy projects from an early phase and contribute to technology development. Their criterion is that the technology is close enough to their core competences for them to contribute.

Norwegian competences from oil and gas, shipping and hydropower can be utilized. The main challenges are not to make the technology work, but to lower the costs. They can

get the technology to work, but it is not cost efficient. The focus of founders has been the technology and to optimize the energy production. This creates efficient solutions, but is incredibly expensive. NLI tries to develop a robust, uncomplicated technology that demands little maintenance, which can last for approximately ten years. This may not be that efficient, but a lot cheaper. NLI is a large company and might have less focus on concepts than the small entrepreneurial companies and more on how to make business.

A3.5.2.1 OWC

The wave technology in OWC can be used near shore or in the ocean. The turbine is small and compact and has few movable components. NLI has reduced some of the problems that were reported from the 80's, e.g. a different design to avoid noise that is going to be tested in Rainpower's workshop. It is developed many different concepts in wave power, but few that are cost effective and durable.



A3.5.2.2 Windsea

Windsea delivers the foundation, which is complicated compared to wind on land. Windsea has developed two technologies, one at the ocean bottom and one floating. The designs are designed for different depths, which makes them complementary. The floating one has the same floating concept as a drilling rig and has three turbines. This gives higher energy efficiency and reduced investment costs per MW installed.

A3.5.3 Current Situation and Strategy

A3.5.3.1 Collaboration

The reason NLI is involved in these three particular projects is part coincidences, but also because of a good match between the competences of the partner and NLI. Rainpower is good at turbine technologies that match NLI's competence within structure. NLI also got strong relations to Rainpower. Force technology was more arbitrary, but their competence lies in high level engineering that match NLI's detail engineering. NLI is a large company, but not too large, which might makes it easier to relate to. Personal relations also play a part, people in the different companies talk and figure out that a partnership might be interesting. Hydra tidal was also partly arbitrary, but there was a dialogue for several years. As a small company Hydra tidal needed an industrial partner that could make the components.

Many small companies contact NLI for industrial partnership, and NLI wants to be in this position. Traditionally they delivered engineering and mechanical hours with margins and competition on hour price. NLI have traditionally owned few products themselves, but this is something they wish to do more of. In addition to coming up with smart ideas themselves, they talk with technology communities like universities and entrepreneurs. This is for example TTO, which is responsible for the commercialisation of technologies at NTNU. It has gradually become known in the industry that NLI are looking for good ideas. Mr. Tørud explains that it is most likely other actors than NLI that has the best ideas, and by making others come to them; they do not have to search for companies with great ideas. NLI are not looking for more wave and tidal projects, but want to develop the projects they already have.

They might be able to utilize their network within offshore wind in relation to the tidal and wave projects. This would most likely be in the research departments where the same people often work with wind, tidal and wave technology.

NLI have to get external financing for their projects to minimize risk. OWC got subsidies that covered 30-40% from the Research Council. They are also applying Innovation Norway's "Miljøteknologiordningen" for financing in the next phase, which is demonstration of the technology.

Windsea are planning on a prototype project in scale 1:3. They have applied Innovation Norway for funding and are working closely with other financing partners. An offshore wind project is too large for Windsea to do alone. They will not build the prototype themselves, but cooperate with low-cost countries like China. Windsea will still own the technology and deliver a turnkey project.

All projects exchange some experiences with competitors and NLI are familiar with most all other actors. They talk mainly about the industry development, not about technology. Mr. Tørud does not see a need for more collaboration with others.

A3.5.3.2 *Growth and Barriers*

OWC has a defined strategy for the next years. From 2014 the plans are characterized by guessing, but their first commercial sale is expected to be in 2016.

Mr. Tørud believes there are synergy effects between offshore wind and wave- and tidal energy; there are similar challenges in installation, general principles to guide the work, fabrication in low cost countries and mainly the same customers. There are also synergies with oil and gas operations, which have very strict demands – if you get something approved within oil and gas you manage in renewables. A challenge is to transfer technical solutions from oil and gas without bringing the high cost level. The consequences from mistakes in oil and gas could be catastrophically, like large oil spills, but in renewables it is mainly loss in energy. An oil platform is a one-unit project, but renewables obtain economics of scale. People are saying that you should take oil and gas solutions and think like shipping – little equipment, cheap and a lot of identical ships

OWC has not made contact with any energy companies yet because they want to verify their technology first, but this will be done shortly. NLI has not decided whether to do the testing in Norway or UK. UK has dedicated test sites and the most attractive market, but if they get financing from Innovation Norway they are obligated to stay in Norway. They are participating at international wave and tidal fairs to get market knowledge and an overview of other actors.

Windsea is in contact with several energy companies outside Norway, mainly UK, the Netherlands, Germany, France, USA, China and Korea. There was one offshore wind project in Norway; Havsul1 by Vestavind on the west coast, but Windsea did not manage to sell their technology to the project.

The largest barriers depend on which phase the technology is in. OWC and Hydra Tidal are in early research phases, which give technical and research barriers. They are fully financed by the research council and by the owners. For Windsea, finding partners to get funding for development and selling the technology to projects are the main barriers. OWC and Hydra Tidal will eventually come to this phase. A prototype project for OWC will most likely cost 20-30 million NOK. If they have to build a small park on their own before they get any buyers it will cost a lot more.

NLI is not planning on selling any of their projects, but wants to get returns on investments by delivering renewable power plants. The renewable market moves differently than oil and gas, thus renewables are long-term investments. NLI wants to spread risk and believes that this will be a profitable technology in the future.

Norway does not have subsidies that are funding the building of test sites, but for technology development. Green certificates would have minimal effect on offshore renewables. Mr. Tørud explains that it would be beneficial for NLI with a large home market. The situation in Norway is the opposite of the rest of Europe; Norway has 99% renewable energy from hydropower and do not have the same problems with energy supply. There is more reasonable that Norwegian companies develop technology and sell to international markets. What the government should consider is arrangements where it is possible to test full-scale prototypes to prove the technology, before going international.

A3.5.3.3 *Internationalization Strategy*

All three projects have international markets. Tidal energy is more limited due to the existence of tidal in certain places in the world such as Scotland and Canada. Windsea's strategy is to start in countries with the most potential and then expand to other countries. There is most activity in the UK, then Germany. Secondary markets are USA, China, Japan and Korea. They have an international strategy for wave and tidal as well. When they enter a new market they try to establish a position by meeting a lot of industry partners, investors and customers and also attend conferences. They are currently managing all activities by being located in Norway and travel, but are planning on establishing project and/or sales offices in the markets they enter. They do not have the capacity to build at their own workshops and will build their constructions in low cost countries in Asia. They might have maintenance at their own sites.

A3.5.3.4 Market

The wave- and tidal energy market is nascent. No energy companies have ordered fully commercial plants, but many have ambitions and participate in technology development that they can buy later. Offshore renewable has a limited home market at the moment in Norway. Norway has too much energy to make it profitable. E.g. Statkraft has invested in large offshore wind parks in the UK, but not in Norway. There is immature technology, a moving value chain and a lot of good infrastructure in the international market. UK has a goal of 20 % renewable energy by 2020, often has poor energy supply, need more energy and has great political frameworks to develop their technology.

UK has performed the first round of leasing for both tidal and wave power in the Pentlands Firth area. Crown Estate owns the areas and gives the applications that demonstrate the best projects permission to plan and evaluate whether the area is suitable for energy production. After this, companies can apply for concession to the energy government in the UK. If they are granted concession they make the decision of whether to invest. There are a lot of costs related to this process, which takes several years. NLI are delivering technology to the companies that are getting concessions.

UK has a developed system for allocating concessions and subsidies, and need more energy. This makes the energy companies interested. Calculations done on the market indicates approximately 0.5 billion USD in the period 2011 to 2015 invested in wave power in UK. UK has a very beneficial subsidy system. Scotland has added even more on top of this, thereby giving 3 NOK/kWh more than the market price for electricity. NLI believes that they can reach this limit if they manage to develop a cost efficient solution. Electricity is generally more expensive in Europe than in Norway and households in the UK also use gas, which makes the gas price influence the electricity price.

UK has an arrangement that is similar to Norwegian and Swedish green certificates in which all energy companies has to buy a certain percentage of green energy. This is a market-based arrangement where the end user pays. In Germany and Portugal they use feed-in-tariff where the government pays.

Several large companies are looking for renewable energy technology, but not many of these are Norwegian because the market in Norway are small due to a lot of renewable energy from hydro power. Countries like UK and Germany are more relevant when looking for an industrial partner.

There exist few energy companies that are involved in wave or tidal and not in wind, but a lot of companies within wind have not gotten involved in wave and tidal power yet. There is not much differentiation between energy companies involved in wave or tidal energy, but more on which countries they enter. Some energy companies only invest in mature technology and wait for further development in wave and tidal energy.

Norway has a lot of activity in technology development. There is a limited market for offshore renewables in Norway for the moment, and actors believe that they shall develop the technology and sell it in international markets. This is probably a result of competence in offshore and hydropower. Mr. Tørud believes that tidal energy might be

the exception due to good tidal resources in Norway, but this is after the technology has matured in UK.

A3.6 Tidal Sails

Interviewees: Are Børghesen, pilot and founder of Tidal Sails, and Jan Otto Reimers, MSc in mechanical engineering from NTNU, CEO in Tidal Sails.

Place: Haugesund

Date: 2. November 2011

A3.6.1 Background

Are Børghesen came up with the tidal energy idea while he was competing in a regatta in Ryfylket in 2003. Mr. Børghesen's boat was leading, but when they were to sail underneath a bridge, the boat stopped as a result of the strong tidal currents. As he tried to trim the sails, he started to think of what would happen if he turned the boat upside down and let the current-force carry it, and the idea of a tidal sail power plant was born. Mr. Børghesen is originally an airline pilot in Widerøe and he managed to raise the start-up costs with the help of capital from his colleagues, which believed in the project and in Mr. Børghesen's competence. The company was established in 2004, and the start-up capital was used on patents, technical tests and engineering services. Mr. Børghesen got in touch with people he needed to develop the project further through friends and people he met during the process. The next step was to ask if they were interested in engagement Tidal Sails in addition to their regular job. The size of the company has varied in terms of people; with only Mr. Børghesen at the very start to 25 people at the most in 2008. Now, they are about ten people that contribute to the company, but CEO, Jan Otto Reimers, is the only actual employee. The other contributors are paid after how much they work, either in payment receivables or in company shares.

Tidal Sails has had 13 sea based prototypes in the range of five to 25 meters in size. They have raised money to fund these projects with the help from governmental support systems. Tidal Sails has received support from ENOVA, EU-support through two projects; FP7 and a Eurostar-project, and funding from the research council in Norway to establishment of the EU-projects. Since the start-up Mr. Børghesen has been doing a lot of traveling in order to meet industry actors and raise money. Before Mr. Reimers became a part of Tidal Sails, Mr. Børghesen reckons that he used about 90% of his time traveling around meeting people and representing the company. Mr. Reimers has introduced a strict focus on core activities, namely product development. Now nearly 90% of the time is used on product development as oppose to representation.

A3.6.2 Technology

Tidal Sails concept is based on an optimized triangle profile with sails connected to a wire. The tidal current pull the sails and hence the wire, which is connected to a power generator. The sails are movable and adjust automatically to the optimal angle of attack. The tidal sail plant is installed under water so that ships can pass above it without problems. The technology diversifies itself from its competitors by the large area exposed to the current. Mr. Børghesen believes this is the most important element to

consider when developing tidal power. Another important factor is the efficiency of the plant. Tidal Sails earlier thought that their technology was a subject to Betz's law¹ that limits the degree of efficiency to 59.3%. After observing efficiency levels close to the supposed upper limit, they enquired professors at NTNU about these results and found that the law did not apply for Tidal Sails as it is considered a linear, not rotating system. This means that they potentially have higher maximum efficiency than competitors with rotating systems such as classical turbines. Tidal Sails has patented the technology in Norway and internationally.

A full scale plant can be as large as 500 meters long and can produce 1.5-2 kW for every square meter covered, giving a current of 2 m per second. In the fastest flowing currents a plant can produce up to 10 MW. They expect the price to be about 0.40-0.50 NOK per KWh for a regular plant.



A3.6.3 Current situation and strategy

Tidal Sails is currently testing a 7 meter long prototype at the marine test centre in Haugesund. The prototype was put into the sea in September and will be taken out when the required tests are performed. The cost of such a prototype is approximately two to three million NOK. Their plan is to have the first commercial plant ready within 2013. They want to function as a hardware supplier of tidal energy plants and consider power companies and license site owners as their main costumers. They do not rule out that it could be interesting to move into the power production industry eventually, but

¹ The Betz law means that wind turbines can never be better than 59.3% efficient. The law can be simply explained by considering that if all of the energy coming from wind movement into the turbine were converted into useful energy then the wind speed afterwards would be zero. But, if the wind stopped moving at the exit of the turbine, then no more fresh wind could get in - it would be blocked. In order to keep the wind moving through the turbine, to keep getting energy, there has to be some wind movement on the outside with energy left in it. There must be a 'sweet spot' somewhere - and there is, the Betz limit at 59.3% (Burton et al., 2001).

this is not a goal at this point. They want to outsource the production, be the owner of the technology and their core competence will be product development and sales. They have not any deliberate plans for how and when the organization will grow in terms of employees, it depends too much on future development which is difficult to predict. To start with, they will primarily hire people with an understanding of sales and aftermarket services.

A3.6.3.1 *Barriers*

Tidal Sais considers the biggest barrier to overcome at this point to be raising capital to fund product development. It has been particularly difficult to raise capital after the financial crisis in 2008. They did at one point engaged DnB Nor to help them raise capital, but they were told that the market was literally laughing of their proposals as the financial climate was too hostile. The investors are still interested in meeting companies like Tidal Sails and learn about their concepts, but they demand that all technical solutions are thought through and tested in order to consider further involvement. However, Chinese government is showing interest in renewable energy and it appears to be easier to get a Chinese investor than a western investor. Nevertheless, Mr. Børghesen and Mr. Reimers experience that offshore renewable energy is somewhat out of fashion, and describes it as difficult to find investors compared to ten years ago. When Tidal Sails was founded, there were only a few actors present in the market, now there are about a hundred globally. Mr. Børghesen believes that it has become difficult for investors to determine which companies to invest in as there has been an inflation of wave and tidal technology over the recent years. –The companies that should die out do not because of governmental policies, in addition to large organization that have acquired companies and want them keep operating even though the project is unlikely to succeed. Mr. Børghesen has no plans sell Tidal Sails to a large organization as the company is managing on EU support policies and some capital from Danova.

A3.6.3.2 *Cooperation and Internationalization*

Tidal Sails has an international perspective in their strategy and consider their market to be global, on both supply- and demand-side. They are collaborating with the Austrian ski lift manufacturer Doppelmayr as they have extensive competence within wire systems. It was not easy to get Doppelmayr enter into the partnership as the project is not within their primary target industry. Mr. Børghesen has visited the company many times and had almost managed to close the deal before the financial crisis in 2008. When the financial crisis hit however, Doppelmayr wanted to withdraw their engagement, but thanks to a Norwegian contact at the board of directors they managed to reach an agreement. Doppelmayr now has the second largest share in Tidal Sails, after Mr. Børghesen and his family, of 3.5 %. Tidal Sails also cooperate with other international industrial companies and considers it important to engage in these partnerships because the large clients will demand financial stability and backbone as such companies can provide. –Although they will demand something in return, either shares or production contracts.

Tidal Sails work closely with the most competent academic environments in Norway, at NTNU in Trondheim and the University in Bergen, to be certain that their calculations

and tests are computed correctly. They have also performed tank and wind tunnel test at the University of Hertfordshire in England.

Tidal Sails is not engaged in any cooperation with competitors. Most of the other actors in the industry are developing concepts with rotating systems, while Tidal Sails' concept is linear, and hence they do not necessarily have the same challenges. However, they pay attention to what is happening in the market. They are not a part of any special interest organizations, even though they often get enquiries from such organizations, but have decided to focus on the activities that generate value to the company.

Tidal Sails has no plan of moving the operation from Norway at this point, and argues that there is no reason to believe that Norway is not a well suited location for a company as Tidal Sails. Their customers are global organizations; especially Canada, the UK, the U.S. and China excel as interesting countries. However, it is favourable to perform a pilot study in Norway because of governmental support from for instance Innovation Norway, as well as it is impractical to travel back and forth between Norway and a foreign location.

A3.6.3.3 *Governmental Support*

Tidal Sails has generated capital from many different support scheme funds such as Innovation Norway, The Research council of Norway and European Union projects, and thinks that it is well developed financial support schemes in Norway. They believe that the newly established fund "Miljøteknologiordning" is an improvement as it makes it possible to apply for support to build and test larger scale prototypes. Nevertheless, they believe that some of the support funds could distribute more support instead of use money on expensive seminars to educate the employees. The competition of getting the support is fairly hard as it is many applicants and among them some large firms that have employees that are specialised to write such applications. Tidal Sails also experience that the support funds have more confidence in the large organizations and hence award them resources. In their opinion Norwegian support focus should more on small development firms as they believe it is in these firms that good ideas arise, not in the large bureaucratic organizations.

A3.7 Hammerfest Strøm

Interviewee: Harald Johansen, Technology director

Location: Phone interview, Trondheim and Hammerfest

Date: 10. October 2011

A3.7.1 Background

Hammerfest Strøm started as a project in 1996 by Hammerfest Energy. Norwegian energy supply decided to investigate new areas of activity and triggered the project. The project was driven by the introduction of the new law of energy and degree of own coverage – how much you can supply your own local energy area compared to how much you import, and because they wanted to find new areas of activities in relation to the capital they owned. Hammerfest Energy contacted Sintef to see if it was possible to utilize ocean energy. To reduce the risk they created an own company with other actors

in 1997 that worked with conceptual solutions until 2001 when they decided to go for one of the concepts. A prototype was built and installed in 2003 and connected to the grid after a test period in 2004. This was the first of this kind that was connected to the power grid. The prototype was designed for a lifetime of three years. They kept it in operation for four years to investigate the condition of the different parts, results of solutions they had chosen and if they had to change some of the components. After these four years the prototype was in a good condition, was reinstalled in 2007 and has delivered power to the grid since. Hammerfest Strøm currently employs 25 – 30 employees, who they have employed through their network and by advertisement.

A3.7.2 Technology

Hammerfest Strøm has patented their technology. The turbines are located at the ocean bottom and out of the way of boat traffic. Their low rotational speed makes sure that the life in the ocean does not get damaged. They have done environmental studies before they got the licence/ concession in 2002, after they brought it up for investigation, and after they put it down again. This documentation indicates minimal impact on life in the ocean.

Hammerfest Strøm wants to be a technology developer and a turnkey supplier of tidal arrays to the global market. They see themselves as being an EPCI contractor (Engineering, Procurement, Construction and Installation) and manage the whole project from design to testing. They are cooperating with subcontractors and everything they design and develop shall maintain the company's interests. They have a lot of competitors abroad, more than in Norway, but Hammerfest Strøm is one of the world's leading companies within tidal power. They have a clear schedule of when they can achieve certain power prices. Mr. Johansen does not wish to give the exact numbers, but is convinced that they will be able to compete with other marine renewable energies on prices in 2015.



A3.7.3 Current Situation and Strategy

Hammerfest Strøm has used their experience and knowledge from the prototype to plan their next project, a 1 MW model, three times the size of the prototype, at the Orkney

Islands in December. They are working with a project of 10 MW together with Scottish Renewables that will be installed on the west coast of Scotland. They are also mapping the global markets, regimes and the willingness to establish tidal energy production.

Hammerfest Strøm started in Hammerfest because it was founded by Hammerfest Energy, there existed good conditions the prototype in Kvalsund, infrastructure was well organized and the conditions in the ocean was suitable, with right current velocity and little influence by turbulence caused by waves. The prototype was not ready for rougher conditions, but now they are installing in Scotland, in the roughest weather conditions, to prove their technology to the market.

Hammerfest Strøm has formulated explicit internationalization strategies, both short term and long term. They are constantly mapping the global market to better understand willingness to use the technology as well as mapping natural current conditions.

They are currently not making any money and are financed through equity and subsidies. Getting capital has not been easy and they have gotten most of their finance from their owners. You have to prove your technology, and Mr. Johansen states that having a prototype that is delivering energy has been very important. They have a goal of delivering tidal plants without subsidies, but until then they rely on this support. Their ambition is to deliver turnkey tidal arrays and have a certain percentage of the global market. Mr. Johansen thinks that they have had advantages from the wind industry because they use a lot of the same concepts.

Their biggest challenge is optimization of technology, to lower costs and increase energy production. Cost of energy is the control parameter. They have to develop the technology to show their competitiveness. They are planning to commercialize through their 10 MW plant in 2013.

When answering the question of how he would improve Norwegian policy, Johansen says that the government have to decide, but the one thing he can say is: that the framework conditions that have existed in Norway are not good enough to further develop technology in Norway. The most important in this matter is the regulations and frameworks for further technology development. Tidal is not yet commercialized and there are a lot of new areas to be explored before being competitive.

A3.7.3.1 Collaboration

Hammerfest Strøm early got recommendations for collaborating with large companies, because it was difficult to make things happen locally in Hammerfest. One of the biggest challenges was tidal as a research subject. They had to convince Innovation Norway and the Norwegian Research Council of the opportunities in tidal power and the importance of being forefront in the industry. A lot of the work early on was political and trying to establish a position with large companies with international experience. Early on they got Statoil and ABB to join the team, who has been their most important collaboration partners in addition to local actors such as Hammerfest energy (founder), Alta kraftlag and Hammerfest næringsinvest. Hammerfest Strøm has strong relations with Enova (and NVE until Enova took over), the Research Council and Innovation Norway and has

on-going contact in their daily operations. They do not have cooperation with other tidal companies in Norway, but they know of each other and talk together at fares. Hammerfest Strøm is not a member of NORWEA.

When internationalizing they initiate contact on their own and not through their large industrial partners like Statoil or ABB. International cooperation started in 2007 and was an assessment in the process of figuring out where it was reasonable to move forward. Hammerfest Strøm initiated the collaboration with Scottish Power Renewables. Scottish Power Renewables further developed the technology, but the ownership and patents are Norwegian. If you want to take the project forward you have to have partners and capital. If you want to be a leading actor you have to find a market where the framework conditions are robust enough to further develop the technology. This market exists in the UK. The UK government offers robust frameworks and invited technology companies, end users and capital, thereby providing attractive local conditions. Scotland have both investment and production subsidies. This also creates willingness to invest in ocean energy among energy companies due to possibilities of return on investment. If Hammerfest Strøm had stayed in Norway and waited, they would have been far behind their competitors.

A3.8 Aqua Energy Solutions

Interviewee: Cathrine Torvestad, Managing Director of AES. MSc Finance from Norwegian School of Economics and Business administration.

Place: Wergelandsveien 23B, Oslo

Date: 6. October 2011

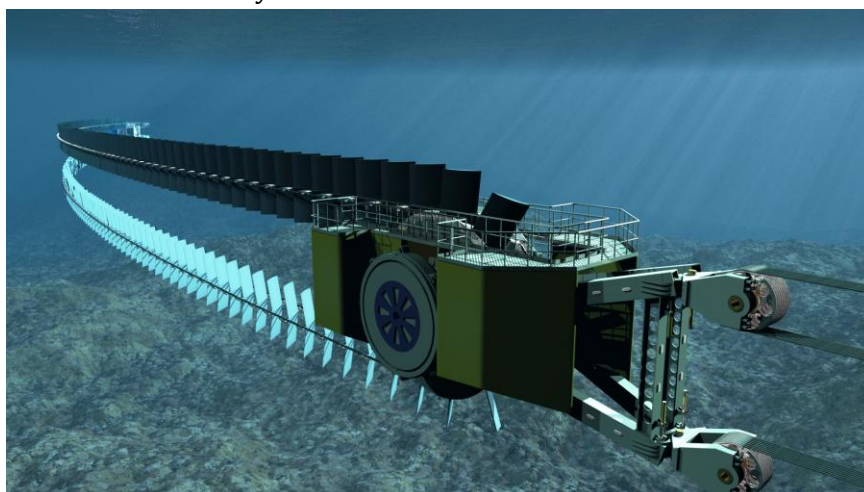
A3.8.1 Background

Aqua Energy Solution (AES) started as a back of the envelope idea in December 2008. The inventor, Jan Christian Torvestad and his companion Tor-Allan Jahr created the private company called Aqua Energy Solution AS, and used the capital invested in the firm to execute a proof of concept test for the AES tidal technology to verify that the concept worked. The technology was patented in Norway in 2009 and they filed a PCT application in 2010, which is still under evaluation. Since then, AES has been raising capital in order to develop the technology further. They have received financial support from the Research council of Norway, Innovation Norway, as well as some local support funds at Karmøy that have been used to fund the operation up until now. AES consists of six employees and approximately two man labor years. The managing director, Cathrine Torvestad, works full-time with the marketing and capital raising aspects of the business, while the other employees work full time in other companies and uses their spare time on product development in AES. Miss Torvestad has an economical background and started in AES right after she finished her studies, while most of the others employees have technical backgrounds.

A3.8.2 Technology

The AES concept obtains a large swept area by securing a high number of low cost, hydro dynamically optimized sails on moving wires. By using this approach it is possible

to tap considerable amounts of kinetic energy from tidal currents in a very cost efficient manner. The sails are permanently attached to two rotating wire loops and thus form an endless chain of optimized energy collectors. The tidal current engages the sails, which in turn pull the wires. This action, via a gearbox, drives a generator that produces electricity. The wires are controlled and kept in tension between two pulleys anchored securely in the seabed. This design provides the ability to produce large amounts of energy at a low unit cost per kWh. The power plants can be installed at the inlets of straits or in the open sea. The power plant can be installed at inlets or in the open sea closer to the surface than single tidal turbines. This is an advantage as the tidal current is stronger closer to the surface. The power plant can be raised to the surface and can thus be repaired without expensive support vessels. A full size power plant is expected to exceed 6 MW in nominal currents. AES has calculated that they possibly can deliver an electricity price of approximately 0.60 NOK per kWh in the long run. However, the operational costs are very uncertain at this early stage of development, and the levelized cost of energy is expected to be higher in the short term; NOK 0,88/kWh using discount rate of 15% over 20years.



A3.8.3 Current situation and Strategy

AES has the last couple of years worked on further development of the concept and executed different technical simulations with the help of Polytec in Haugesund. The next step in the commercialization process is to raise capital in order to fund a second prototype scaled down to 120 kW within 2013, and their goal is to complete a full scale prototype within 2016. AES denotes the phase they are in currently as the potential "Valley of Death", meaning that they are at a point where it is difficult to raise capital and many companies fail to do so. The governmental support organizations demand that AES finds a private investor in order to provide the same amount of public funding. As it is very challenging to find a private investor, AES struggles to develop their concept further. This is mainly because there is a lot of risk involved with investing in the immature tidal industry, as it is an emerging market with an emerging technology. Hence, the financial investors, such as private equity- and venture capital funds, primarily invest at a stage closer to commercialization and growth. The future strategy is to continue to overcome the financial barrier by looking for industrial partners and strategic investors. AES has therefore developed a system for strategic investors that open for multiple "decision gates" with low sunk cost. This makes it possible for an

investor to make new investment decisions later in the development process when the technical and market-based risks have decreased.

A3.8.3.1 *Cooperation and Barriers*

AES' business goal is "to become" a leading company within the renewable energy sector by exploiting the tidal resource with its patented current and tidal stream technology". In the process of becoming a leading company, AES recognize that they do not have the resources needed to commercialize the product on their own. They need to spend time on growing their network further. As of today, they are a part of NORWEA, use Innovation Norway actively and use Polytech in technical matters, but they have yet to establish an official strategic partnership.

A3.8.3.2 *Internationalization and Public Policies*

AES considers international involvement an important step in succeeding and observes what is happening outside the Norwegian borders. They are entering a European Union research-project with the help from TidalSense in Brussels. AES will provide the project with its technology for research purposes. Apart from the research project, AES has not had any international initiatives. AES considers Norway as an adequate country to perform product development in this early stage because of the lucrative public support schemes. However, they are observing the global market in terms of governmental policies, especially concerning the EU 2020-goals. Some countries are likely to invest in offshore renewable energy, such as wave and tidal energy, in order to meet these goals. The United Kingdom (UK) developed for instance a carbon trust fund to accelerate the process, but it was later cut off because of the financial instability. The internationalization process is hence dependent on the opportunities that arise and is somewhat unpredictable. AES still considers UK as an attractive market as there is high demand, a greater focus on renewable energy and specialized support systems. Later in the technology development stages AES will also perform testing and verification in the UK, as this could be essential for finding future partners in this market.

A3.9 Norwegian Ocean Power

Interviewee: Kent Thoresen, electrician, worked within business development

Place: Trondheim, NTNU

Date: 20. October 2011

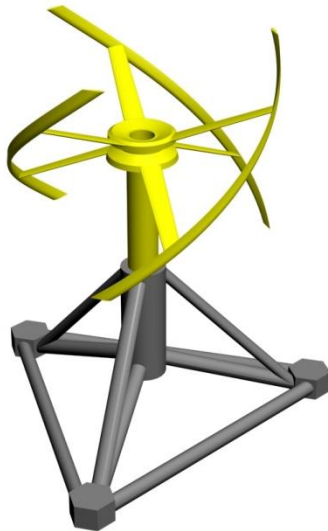
A3.9.1 Background

Kent Thoresen got the idea of a tidal turbine concept in 2002, but it was not before UK started to concentrate on offshore renewable energy and created support systems tailored to this industry that he started to develop the idea further. –It was finally a market for his concept. Kent Thoresen used a lot of resources on proof of concept testing to be sure that the turbine system was worth investing in before he finally founded Norwegian Ocean Power (NOP) in 2009. Mr. Thoresen, being an entrepreneurial and creative type, searched for a partner that could fulfill a different role in the company than himself. He used his professional network and contacted Ståle Mortensson who has an academic background and an MBA apart from being an officer in the military. Mr. Mortensson is hence responsible for the organizational part of the firm while Mr. Thoresen is in charge of the technology development. Since the start up, NOP has

performed extensive simulations and tests. NOP has received funding from various organisations companies, but most of the financial resources have the owners provided through their full time work in other projects. The company is operated by the two owners and is organized in a way such that there are no formal employees and hence no labor costs. They purchase all the services they need and raise capital to each particular task and project they perform, in that way they avoid working with a time limit in terms of funding the daily operation.

A3.9.2 Technology

The NOP tidal turbine, called Pulsus, is based on the well-known Darrieus design. NOP has had a strict focus on cost reduction when designing the turbine. Their approach has been to be competitive with onshore wind and has therefore tried to keep the system simple with a minimum number of components. The structure is robust and will be able to stand on the seabed for decades without comprehensive maintenance. The turbine will be available in three different sizes; their price target is between 0.10-0.20 NOK per KWh, which they believe they will reach. NOP considers the uniqueness of the concept to be that it can operate at lower currents than its competitors. On a large license area it is only a certain percentage that contains fast flowing currents; hence the license owners need multiple systems that can utilize the varying flow regime in the area. There are few competitors in the low speed segment of the industry, NOP has not patented all of the technical solutions, but they are kept a secret to a certain extent.



A3.9.3 Current Situation and Strategy

NOP is currently testing a prototype for dynamic measures of deflection and load during operational movement. This is planned as the last prototype before a pilot project will be connected to the electric network and is planned to be fabricated within 2012. This pilot will be in service for about a year before they start commercialized sale and production. NOP's strategy is to function as a hardware owner; they finance the production by debt with hedge in future production, then they lease the product to license owners, which in turn take up a loan to lease the technology. The repayment

ratio will after three years be low enough for everyone to earn a profit, and then there is still seven years left to next maintenance interval; hence they plan to start making money in 2015/2016. They plan to keep the organizational structure lean as it enables them to have an uncomplicated financial statement

A3.9.3.1 *Support Schemes*

Mr. Thoresen and Mr. Mortensson have worked day and night to be able to finance their tidal project up until now and think the Norwegian support system could be improved. The government lacks a clearly defined goals and a long term perspective. Supports and incentives are not well structured to meet the needs of innovation and industrial technological development. The government supports biodiesel one day and wind energy the next, then they stop these initiatives and key players look elsewhere for their ventures. The indecisiveness and lack of clearly defined and financially backed goals makes it difficult to predict the future, and to commit to investing in projects in Norway.

Mr. Thoresen believes that Norway has the natural resources needed to become a major electricity and technology exporter, but there seems to be little will and capital to develop other energy sources than oil and traditional hydropower. The governmental institutions are not really geared to support high risk technology innovation such as tidal technology. The application procedure also has improvement potential in Mr. Thoresen's opinion; it is not suitable for small entrepreneurial companies and often the questions asked are not relevant for early-stage renewable energy projects. In order to get more funding, the support systems demand that the company has a certain percentage in equity, but this equity is often difficult to obtain. Hence, the government believes that best initiatives are the ones that result from capital strong projects, while in practice it is often the small entrepreneurs that manage to create something new and innovative. The result is that most of the entrepreneurial companies die before they reach the commercialization stage if they do not receive EU-funding or similar support. NOP is currently receiving support from Miljøteknologifondet and Innovation Norway in order to fund the current prototype.

A3.9.3.2 *Internationalization and Entry Mode*

Right from the establishment, there has been a discussion whether the operation should be situated in Norway or elsewhere. The reason they did not move, was primarily because of familial considerations. Mr. Thoresen admits that he regrets not moving the company to the UK at the very beginning and he believes this has slowed the development by two years. They will re-evaluate the decision on whether to move or not within the next six months. There are many incentives to move the company to the UK apart from the fact that the natural resources and market size is greater in the UK, Mr. Thoresen is especially positive to the extent of the British support schemes. They have specialists evaluating funding applications and they do not demand private equity capital to the same degree as in Norway. There are more support schemes in terms of professional and technical help as well, and reports and tests that is requested by other market actors is made public to prevent rework of the same research material.

NOP has had an international focus from the very beginning; they have been working with leading experts within specific fields to develop the concept further. They do not

feel the need to construct everything in-house. When developing the turbine for example, they searched globally for the leading expertise on hydro turbines and got in touch with a Canadian turbine specialist who they acquired services from. A similar approach is used to develop other aspects of the concept.

NOP is already in touch with possible international customers that find the Pulsus turbine very interesting and are waiting for NOP to be able to deliver their product. It is not an issue that they deliver the same product to competitors as they all have the same problem and there are few companies that can exploit slow flowing currents. NOP does not have a published formal strategy to when and which markets they want to enter, but they will enter new markets naturally as their costumers expand their activity to new countries.

NOP plans to outsource the production to one or more production companies. When starting producing, the localization of the production is not important. The components are easy to produce and standardized so that the selection of supplier rely more on the price and the location of the delivery rather than the localization of the company. NOP is in contact with some Norwegian production companies, but it is not difficult to find similar suppliers in the UK, China or other interesting locations.

A3.9.3.3 Cooperation

NOP has no formal partnerships, but is in contact with important market actors. Mr. Thoresen describes it as easy to get in touch with the industry contributors; it is a small industry with limited number of potential customers. After attending the international trade fares in a couple of years, one knows everyone.

NOP does not need a close relationship with an actor from the energy industry as their business model is flexible and their product is relatively easy to produce. There have been some large industrial companies that have shown interest in NOP, but they have not found it interesting to enter any partnerships yet as they have a different attitude to product development and innovation. NOP does not believe that it is the amount of engineering hours that decide the successfulness of the concept, as many of the industrial companies often do, rather the fundamental design of the idea.

NOP has considered becoming a member of NORWEA, but has decided to desist at this point. NOP has not formed any close relationships with competitors as most of them have different problems, and hence there is not much to gain from cooperation. Mr. Thoresen does not believe that further cooperation with other tidal or wave power companies will help them significantly.

Wave Power

| | Pontoon Power | Fred Olsen | OWC | Langlee Wave Power |
|--------------------------------------|--|--|---|---|
| Background | | | | |
| Establishment year | 2010 | 2000's | 2010 (1980) | 2006 |
| Number of employees | 3 | 10 in house, 15 included partners etc. | 10 part time, 1,5 – 2 year long assignments | 2 fulltime, outsource the rest |
| Idea developer | Nils Myklebust | An inventor that was hired by Fred Olsen | Systematic R&D Kverner in the 80's, now Rainpower and NLI | Julius Espedal |
| Technology | | | | |
| Type of technology concept | Wave energy concept with a robust bridge structure and hydraulic pumping cylinders | Wave concept with point absorption system at sea level | Oscillating Water Column | Floating power converter modules |
| Development stage | Small scale prototype | 7 in NASAs scale | Prototype 2013 | Performed 3 rounds of model testing. Pilot in summer 2012. |
| Commercialization goal | Approximately 2016, but this might be postponed | Yes, but do not wish to distribute the information | Commercial demo in 2015 | Deliver pilot plant to customers in 2013, add more in 2014. |
| Price | Want to be competitive with offshore wind | Want to be competitive with offshore wind | - | Goal: competitive with land based wind. |
| Current status and strategy | | | | |
| Partner situation | No strategic partners. Have worked with MARINTEK at NTNU. | Many established partners. Member of NORWEA and Renewable UK | Joint Venture between NLI and Rainpower | Färna invest, Orevik, customers in New Zealand, Turkey. |
| Cooperation with similar competitors | No cooperation, but are familiar with other actors | Yes, cooperate with a Swedish wave power company and is in touch with several Norwegian actors | No cooperation, but are familiar with other actors | No cooperation, but are familiar with other actors, talk at fares. |
| Greatest barrier | Poor market outlook, challenging to raise capital | Lack of long-term oriented policies, raise capital and product development | Technical and research | - Answering time from innovation Norway. - Capital |
| Funding | Owner, Innovasjon Norge, research project funded by Statkraft | Olsen family private capital, ENOVA, SkatteFUNN, EU support | 30-40% from research council, applying "miljø-teknologiordningen". | Investors: Färna invest, Orevik and subsidies. |
| International initiatives | | | | |
| Where, what | Contact with suppliers and research environments, attend fares | Cooperation with international suppliers and research environments, attend fares | Not yet. Have not decided whether to test in Norway or UK, attend fares | Attend fares, customers in NZ, Turkey and Canary Islands. Virtual office in Aberdeen. |
| When | International perspective since inception | International perspective since inception | International perspective since inception | International perspective since inception |
| Entry mode | License, sell the technology or develop and operate the platform themselves | Power supplier and technology developer | Planning on project and or sales offices | Virtual offices. Will place units in locations when they start building. |
| Subsidy opinions | Lack of systematically funding since the beginning of the 1980's | Should create a home market which could help with further development | Need full- scale prototypes test facility | Direct intensives to marine energy. E.g. 2 NOK/kWh first 5-10 yrs. |

Tidal Power

| | Aqua Energy Solutions | Tidal Sails | Hammerfest Strøm | Norwegian Ocean Power |
|--------------------------------------|---|---|--|--|
| Background | | | | |
| Establishment year | 2008 | 2004 | 1997 | 2009 |
| Number of employees | 6 persons, 1 full time | 1 full time, 10 all together | 25-30 | 2 |
| Idea developer | Jan Christian Torvestad | Are Børgesen | Hammerfest Energy | Kent Thorensen |
| Technology | | | | |
| Type of technology concept | Tidal power system with underwater sails | Tidal power system with underwater sails | Horizontal underwater turbine | Vertical underwater turbine, operate in low currents |
| Development stage | 1 small scale prototype , plan a 120 kW plant within 2013 | 13 sea-based small scale prototypes, last one | Last prototype of 1 MW in December 2011. Planned 10 MW project with Scottish Power | Many small and medium sized scale prototypes. |
| Commercialization goal | 2016 (full scale prototype) | 2013 (first commercial plant) | 2013 with the 10MW plant in Scotland | 2013-2014, pilot project launch |
| Price | Goal of become competitive with offshore wind | - | Compete with offshore wind prices in 2015 | - |
| Current status and strategy | | | | |
| Partner situation | No strategic partner yet. Cooperation with Onetech, Polytech Member of NORWEA | Strategic partnership with Doppelmayr, Cooperate with different universities in Norway and internationally | Statoil, ABB, Alta kraftlag. Hammerfest energy, Hammerfest næringsinvest, Scottish Power | No strategic partner, but in contact with potential customers and suppliers |
| Cooperation with similar competitors | Member of NORWEA and the wave and tidal power group | No cooperation, but are familiar with the other actors, talk at fares | No cooperation, but are familiar with other actors, talk at fares. | Some contact with Hydra Tidal |
| Greatest barrier | Raise capital to develop the technology | Raise capital to develop the technology | Optimization of technology- improve cost of energy | Raise capital |
| Funding | Innovasjon Norge, Research council of Norway, local Karmøy funds. | Small private investors, Danova, Innovasjon Norge, Research council of Norway, two EU projects, | Subsidies, most equity from owners | Own capital from other projects, some funding from Statkraft |
| International initiatives | | | | |
| Where, what | EU project, Visited different conventions | EU projects, testing, international partner, cooperation with international universities | UK, technology development and testing with Scottish power, visited conventions | Have outsourced and co-developed different parts of the concept to different international actors, visited different conventions |
| When | International perspective since inception, EU project in 2011 | International perspective since inception, cooperation with international partners early in the development process | International perspective since inception, international operation in 2007 | International perspective since inception, cooperation with international partners early in the development process |
| Entry mode | Together with partner | Hardware supplier of tidal energy plants | Partnership with Scottish power | Licensing to license area owners and power production companies |
| Subsidy opinions | Should be more help to get through "the valley of death". Maybe more public venture funds | Improvement with the Miljøteknologifondet, more of resources to small companies | Framework conditions not good enough to further develop technology | Think that the government lacks a clear goal and long-term perspective |

A4 Conferences

A4.1 The Enova Conference 2012 - The Green Gold.

The Enova conference “The Green Gold” was held January 24th -25th 2012 and concerned development of green technology in Norway as well as energy efficiency technologies.

A4.1.1 Programme

24 January

10.00: Registration

10.30- 12.00: **Part one:** *Overview and trend analysis, IEAs perspectives until 2050 and financial opportunities that are generated by the global transition to low-carbon economies.*

- Ola Borten Moe, Minister of Petroleum and Energy, opening keynote.
- Bo Diczfalusy, Director of the Directorate of Sustainable Energy Policy and Technology at the IEA “Energy technology – where are we heading?”
- Thomas Skovbjerg, Director of Climate Change Capital PE London. “Opportunities for investors in the energy markets of tomorrow”

13.00 – 14.10: **Part two:** *How to make money out of green investments? Representatives from international corporations share how they view investments in environmentally friendly and energy effective solutions as a competitive advantage.*

- Claudia Dankl, Scientific project manager ÖGUT “Building of tomorrow”. Research for and demonstration of highly energy efficient and plus energy buildings in Austria, and business models for energy efficient refurbishment.
- Per Otto Dyb, CEO of Siemens AS “Tomorrows winners think green”
- Helge Aasen, CEO Elkem AS “Power production from industry heating – effort for a cleaner climate”
- Martinus Brandal, managing director in Solør Bioenergi Holding AS. “How to obtain profitability in the Norwegian bio energy industry?”

15.15- 15.55: **Part three:** *Managers of international investment funds provide an overview of technologies that attract most investors. They will also present what they are looking for related to investments in technology applies to renewable energy and energy efficiency.*

- Nils Kristian Nakstad, CEO Enova SF. “How can Enova contribute to development of energy markets in the future?”
- Tellef Thorleifsson, Partner Northzone Venture, “Investors and the green gold, - what is happening?”

25 January

09.00-10.00: **Innovation in the energy market:** *Market change through innovation – markets, cash flow, technology development*

- Magnus Agerström, Managing Director CleanTech Scandinavia: “Increased interest for nordic environmental technology – can we match the expectations?”

- Anne Espelien, Menon: “Where does Norway have advantages for industry development within renewable energy and environmental technology?”
- Hans Jacob Bull-Berg, Director, Nordea: “ Foreign capital and risk in renewable energy – a bank perspective.”

10-30- 11.30: *Case: Offshore wind power*

- Robert Helms, Head of New Markets, DONG Energy: "DONG Energy - Offshore Wind Experiences and Future Trends".
- Tore Tomter, Division Director, Siemens: “increased profitability – the key to new opportunities”.
- Trine Ingebjørg Ulla, Head of Market and Regulatory Affairs Statoil Renewable Energy: "Statoils vinkraftsatsning"

11.30- 12.30: How to do Norway to an attractive innovation arena?

- Harald Østberg, CEO Straum: “Straum- how to succeed with development and commercialization of marine renewable energy technology”
- Tore Melland, Head Analyst, Technology and Markets, Statkraft.
- Bergny Irene Dal, senior advisor, Innovatoin Norway, Ane t brunvill, Special advisor RENERGi, The research council of Norway. Rune Holmen, new technology, Enova: “One billion from the support scheme organisations – is it enough?”

A4.2 Summary of Renewable UK Wave & Tidal Conference 2012

The Renewable UK Wave and Tidal Conference 2012 was held 15th of March 2012 in Edinburgh, Scotland. The conference aimed at exploring the primary challenges facing the industry as well as highlighting the opportunities that exist for involvement in the wave and tidal energy sectors. The major focus of the conference was on financing the industry and achieving the appropriate policy conditions to enable the highest possible level of deployment. The conference targeted anyone interested in the development of the sector's huge potential, not just in UK but worldwide. The conference had in total nearly 500 participants and 47 exhibitors. The conference is the ninth annual wave and tidal event and is considered the leading event within in the marine energy industry. The conference was sponsored by The Crown Estate (core sponsor), Scottish Development International and Wales Cymru – Welsh Government.

In relation to the conference, Pre-conference workshops were held March 14th where we attended workshop 1; *Marine Energy: Supporting Array Technologies Competition information session*. The main conference offered two parallel programs; *A: The commercialization Process* (main session) and *B: Framework and Technical*. We attended the main session (parallel A) as this parallel was more concerned with the framework for commercialize technology and industry creation rather than technical matters.

A4.2.1 Programme

March 14th

Workshop 1: Marine Energy: Supporting Array Technologies Competition information session

March 15th

Main Sessions — The Commercialisation

08.30–09.15 **Registration, coffee & exhibition**

09.15–10.10 **Opening Session**

- Chair and Welcome: Maria McCaffery, Chief Executive, RenewableUK
- Core Sponsor Address: Rob Hastings, Director of the Marine Estate, The Crown Estate
- Political Keynote Address: Mr Fergus Ewing MSP, Energy, Enterprise and Tourism Minister

10.15–11.30: **Fostering Political Will**

- Chair: Paul Jordan, Chair of the RenewableUK Marine Strategy Group
- Duarte Figueira, Head of Offshore Renewables, Department of Energy and Climate Change
- Ross Fairley, Partner, Burges Salmon LLP
- Joe Phillips, Strategy & Policy, GL Garrad Hassan
- Martin McAdam, Chief Executive Officer, Aquamarine Power

11.30–12.15 **Coffee, exhibition & networking**

12.15–13.15: **Understanding Risk — The Road to Commercialisation**

- Chair: Rob Stevenson, CEO, Tidal Generation Ltd (part of the Rolls-Royce Group)
- Andrew Tyler, Chief Executive Officer, Marine Current Turbines Ltd

- Timothy Cornelius, Chief Executive Officer, Atlantis Resources Corporation
- Richard Yemm, Commercial Director, Pelamis Wave Power Ltd
- 13.15–14.30 **Lunch, exhibition & networking**
- 14.30–15.45: **Panel Debate: Financing the Wave & Tidal Sector**
 - Chair: Stephen Sackur, Journalist and Broadcaster
 - Jan Love, Director, Renewable Energy Scotland, Barclays Corporate
 - Calum Davidson, Director of Energy and Low Carbon, Highlands and Islands Enterprise
 - Jerry Biggs, CEO, NAREC Capital
 - Alan Mortimer, Head of Policy, Scottish Power Renewables and Iberdrola
 - John Callaghan, Programme Manager (Wave & Tidal), The Crown Estate
- 15.45–16.15 **Coffee, exhibition & networking**
- 16.15–17.30: **Delivering Cost Reduction**
 - Chair: Stephen Wyatt, Head of Technology Acceleration Manager, The Carbon Trust
 - Neil Davidson, Public Affairs Manager, Aquamarine Power
 - Ken Street, Business Development Manager, Alstom Ocean Energy
 - Anne van Houten, New Energy Market Developer, Bluewater Energy Services B.V.
 - Howard Rudd, Principal Engineer, Xodus Group Limited
- 17.30 **Closing Address**

A4.2.2 Summary of Key Point from the Conference

March 14th

Workshop 1: Marine Energy: Supporting Array Technologies Competition information session

The workshop was dedicated to promoting the new support programme for large scale tidal devices and supporting equipment sponsored by the Technology Strategy Board (TSB). The aim of the programme is to support building of a supply chain. The support classes companies could apply for was; Tidal array, subsea electrical hub, vessels for tidal installation, operation and maintenance, navigation and collision avoidance, anti fouling and erosion, and open class.

March 15th

Main Sessions — The Commercialisation

Opening Session

Chair and Welcome by Maria McCaffery, CEO of RenewableUK:

Mrs. McCaffery gave an update on the most exciting policy developments of the last year in the UK; current installed capacity of 8 MW and a goal of 27 GW by 2050. She praises the governmental initiatives that have helped the UK industry to grow over the past years. She believes the government has put some of the most progressive policies in the world in place since the start of last year, giving the industry the chance of getting the

first arrays off the drawing board and into the ocean. She highlighted a few of the initiatives that have been of great importance to the industry: A stable revenue support stream of 5 ROCs for the foreseeable future announced in the renewable obligation banding review, capital support in the form of the collision's £ 20 million marine energy array demonstrator and the Shoreline Management Plan's (SMP) £ 18 million wave and tidal commercialization fund, the release of a £ 103 million from the Scottish fossil fuel levy for investment in the renewable sector, the consenting of the largest tidal array in the world, the sighting of the offshore renewable's catapulting in Glasgow which would will play a crucial coordinating role across academia and industry, and collaboration between the European marine energy center in Orkney and the Ocean University of China to accelerate technological development. She also emphasized that there is a long way to go, but that the industry should work together to not let the world wide lead slip away.

Mrs. McCaffery encouraged further work with coordination in the industry; there must be coordination between the two pots of capital funding which total almost £ 40 million to ensure that companies can access the resource at the right stage of project development. The innovation funding from the technology strategy board, the energy technology institute and Scottish enterprise also needs to be targeted and coordinated. Whilst the policy framework for the immediate future looks appropriate to bring forward development, if UK is to stimulate growth beyond 2017, the industry needs clarity from the electricity market reform's proposals. They need long term consistent and sustainable revenue support in order to secure the necessary private investment needed to move forward. Mrs. McCaffery thus encouraged everybody to do all they can to ensure a smooth transition to the new framework; th new regime must be defined in order to give developers, utilities and all investors the confidence they need to make the financial commitments now. Renewable UK welcomed the creation of the Green Investment Bank that will be placed in Edinburgh, but they emphasized that it is important that it channels support to where it is most needed, obviously offshore wind is a prime candidate for such funding, but surely, given were the marine energy industry is at the moment and the future potential in wave and tidal technology, this should also be considered for early development finance and a tool to plug any potential gap in the funding from now to 2015.

Political Keynote address by Mr Fergus Ewing MSP, Energy, Enterprise and Tourism Minister in Scotland:

Mr. Fergus Ewing had a very positive address as he reiterated the Scottish Government's commitment to developing the wave and tidal industries. He gave an update on several key initiatives and presented the intentions of the government to keep Scottish marine energy sector in the forefront of the global market. He sensed optimism among industry actors and a united purpose to harness the most from their shores. He also mentioned that he met with a Norwegian lady on a conference the day before the conference where they discussed the outcome of a possible North connector. The connection which he hopes will take place between Norway and the North coast of Scotland to potential massive benefits to all, including the later commercial development of wave and tidal.

Mr. Fergus Ewing spoke about the investments made in the Scottish test center EMEC of over £ 30 million over the last years, but also emphasized that the government realize that more support is needed and that is why they have introduced the £ 18 million to the marine renewable commercialization fund. This fund will complement DECC's £ 20 million MEAD fund. Their fund will be utilized to raise marine renewable energy to a whole new level through the acceleration of the development and deployment of commercial arrays. The government knows that confidence is critical and this crucial next step of government funding will unlock future investment which will allow the industry to achieve the potential of marine renewables. In addition, Scottish enterprise has worked closely with the TSB in developing the £ 10 million marine energy array technology supporting fund and they know that many of the future technical challenges are common to all organizations. This programme co-funded by the industry, will help to solve a number of these challenges and accelerate the commercial development of the industry. The recent call for the £ 6 million through the WATERS fund has received significant interest and the Scottish government announced further awards for full scale approving devices in the following week (after the conference).

The 5 ROCs that has been available in Scotland for some time, has underpinned many of the investment there, and Mr. Fergus Ewing therefore welcomed the proposal of equalizing the ROC regime level all over the UK. There is a united and common purpose between the Scottish and British government. Mr. Fergus Ewing believes that marine energy has the potential to become the "jewel in the crown". Mr. Fergus Ewing realizes that these are hard economic times, but he also notice that there are many in investors and utilities that are interested and the government regard it as very important to maintain this confidence in the industry. Mr. Fergus Ewing welcomed the large international companies such as ABB, Siemens, Alstom and Rolls Royce and believes they are important to provide cost reduction and scale in the industry. Mr. Fergus Ewing emphasized the importance of the test center EMEC which attracts interest from worldwide actors. Both China and Chile were interested in setting up equivalents to the EMEC center. The list of companies with installed devices at the EMEC sight is growing; Hammerfest Strøm, Aqua marine power, Tidal Generation, Voith Hydro, Open hydro, Scottish Renewables, Atlantis, E-On, Scottish Power Renewables and Pelamis wave power have all installed devices. Mr. Fergus Ewing also pronounced that one of Europe's leading energy companies Vattenfall has secured the final wave birth at EMEC. Vattenfall plans to purchase and install a Pelamis second generation machine and this will mark the first step of their 10 MW joint venture project known as Aegir Wave Power of the Shetland Islands.

Core Sponsor Address: Rob Hastings, Director of the Marine Estate, The Crown Estate:

Mr. Hastings outlined the enabling role that the Crown Estate plays in the industry. He argued that it had been a good year for the marine energy emerging industry. The Crown Estate manages the property rights of the UK; they are a commercial enterprise and have a duty to sustainably enhance their assets in a way that all the income they produce are going to benefit UK tax payers. The Crown Estate has been active in the offshore energy sector since the mid-1990s and they are highly active in offshore wind. It is also in their vision that UK vast wave and tidal resources can be deployed at the

scale of offshore wind. They are focused on helping the UK wave and tidal industry maintaining their worldwide leadership.

Mr. Hastings gave a quick recap of the developments in the industry as well as the road ahead in terms of projects. Developers have quite rightly focused on continued technological development and testing by comparison with offshore wind. Wind turbine technologies had an established track record before wind farms were built offshore, such track records for wave and tidal energy are only just emerging and it is essential for them to be further developed, and for all parties to have confidence in delivery.

EMEC has played a strong supporting role enabling developers to put their machines in the ocean as soon as they were ready. EMEC has also played an important role in creating industry standards and support of the development process. This year, EMEC has seen five tidal stream turbines installed and being tested by Atlantis, Hammerfest Strøm, Open Hydro, the Rolls Royce team and Scottish renewables and more tidal turbine is to be tested later this year by Bluewater, Kawasaki and Voith. Two wave energy converters have also undergone tests; Aquamarine Power and Pelamis and two others are planned by Seatricity and Wello OY.

Utilities and other actors have shown serious corporate commitment to the sector by supplying significant support to utility scale arrays. This is an essential step in the industrialization of the sector providing a clear route to the market for the products. The involvement of large industrial companies and equipment manufacturers is undoubtedly going to be of key strategic importance to deliver the first array scale projects. The Crown Estate sees the construction and installation of industry's first arrays as the industry's next major milestone, and achieving this milestone will of course not be without challenges. Mr. Hastings comments on a report made on the reserves connected to the US coast line where they estimated a potential of 1400 TWh a year, roughly a third of the entire US energy consumption. Even though Mr. Hastings is confident not all of the potential will be developed in practice, it illustrates the scale of global resources potential and the huge economic value it represents. Mr. Hastings would like to think that the UK could have a global lead in this technology and thus benefit from the enormous export opportunities, but like so many other things, he would suggest that the main challenge for the industry lies in financing. He welcomed the Green Investment Bank and, like Mrs. McCaffery, emphasizes the importance of this bank supporting the marine industry now as it needs it the most; *"it is not about the Green Investment Bank being a lender of last resort, it is about them achieving a commercial return on relatively modest levels of investment while building a corner stone of government energy policy"*

A1: Fostering Political Will

Barbara Garnier-Schofield, Wave & Tidal Technology and Employment Assistant Head, Department of Energy and Climate Change (DECC): Enabling Marine Energy Policies:

Mrs. Garnier-Schofield spoke of DECC's renewable policies. The UK Renewables Roadmap was published in July 2011 and is basically an action plan to accelerate UK deployment and sets out a path to achieve their 2020 target while driving down the cost of renewable energy over time. She presents eight technologies with either the greatest

potential to help the UK meet the 2020 target in a cost-effective and sustainable way, or offer great potential for the decades to follow; Onshore wind, offshore wind, marine energy, biomass electricity, biomass heat, ground source, heat pumps and air source heat pumps. In order to assure that the UK meets the potential of the industry, DECC has developed the marine Energy Programme, which is meant to have a coherent approach taking the challenges that the sector is encountering. The programme is a cooperation between the government and the industry and it is addressing the barriers to development of the sector. The programme has three working groups considering; financial support for the marine energy sector, creation of a sector-wide knowledge sharing network, and planning and consenting issues. She further listed the funding in the different stages (taken from the presentation slides);

Early phase R&D:

- **Carbon Trust:** Published their Marine Energy Accelerator report in 2011, working with DECC and others on Technology Innovation Needs Assessments
- **SuperGen Marine:** new SuperGen 3 announced
- **Technology Strategy Board:** new £10.5m marine call for R&D supporting array deployment with Scottish Enterprise and NERC. Closes 17th April 2012

Energy Technologies Institutes:

- Partnership between Government and industry.
- Private sector partners to date: BP, Caterpillar, EDF Energy, E.ON UK, Rolls- Royce and Shell
- Several programmes: – ReDAPT (Rolls Royce tidal turbine), PerAWaT (wave and tidal array modelling), Wet-Mate Connector, Offshore Renewable Industrial Doctorate Centre, Tidal Energy Modelling Programme

Array demonstration support:

- £20m DECC **Marine Energy Array Demonstrator** (MEAD) announced June 2011
 - Developing MEAD with Finance Working Group
 - Planning to launch call Spring 2012
- £18m Scottish Government **Marine Renewables Commercialisation Fund** announced October 2011 (part of wider £35m programme).
- Additional £100m for Offshore Renewables from the Scottish Fossil Fuel Levy Fund
- EU NER 300 Competition

Marine energy parks:

- Driven in parallel by central Government and local/private sector interests
- Will create a network of parks across the UK Clustering activity and expertise to support sector development
- South West parks launched in January; Pentland Firth and Orkney Waters MEP to launch in summer

Renewable obligation:

- Renewables Obligation Banding Review – consultation announced October 2011 (closed 12th January 2011)
- Proposed bands:

- 5 ROCs Wave & Tidal Stream
- 30 MW project cap
- Devices deployed by end of RO accreditation in 2017
- Scotland & N Ireland consulting on similar basis
- DECC response to be published in spring
- New banding commences April 2013

Other market support:

- **Electricity Markets Reform** – developing a Feed-in-Tariff with Contracts for Difference
- White Papers published. Further consultations to come
- In operation from 2013/14 with transition period to 2017 – parallel operation with RO
- **Green Investment Bank** – Latest update envisages a role supporting marine project finance in longer term.

UK infrastructure:

- European Marine Energy Centre (EMEC) – wave & tidal testing sites, nursery site operating
- NaREC – “Nautilus” onshore drive train testing facility commissions this Spring
- Wave Hub array testing facility in Cornwall
- TSB developing Offshore Renewables “Catapult”

Other policy initiatives:

- Crown Estate considering leasing rounds and other leasing/facilitating activities
- Offshore Strategic Environmental Assessment for English and Welsh waters published 2011. Complements SEAs for Scottish and NI waters
- Work on marine spatial planning and marine conservation zones, implementation of EU Wild Birds and Habitats Directives
- Select Committee inquiry into “The Future of Marine Energy In The UK”

Ross Fairley, Partner, Burges Salmon LLP: Legal Blockages to Project Delivery - Pulling the Cork

Mr. Fairley speaks on the behalf of Burgers Salmon, a law firm that has been in the marine sector for quite some years and considers themselves a specialist within marine energy. Mr. Fairley gave a presentation on how legal institutions can be used to unlock projects. As industry move towards commercialization, legal matters will become more important. There has been a great focus on the technical development and now to a larger extent the economical issues, speaking of how to overcome the “valley of death”. However, Mr. Fairley emphasizes that legal can play a crucial role in bringing any large scale projects into realization. Mr. Fairley thus believes that it is important to have legal as part of your core competence along with technical and economical competence.

Joe Phillips, Strategy & Policy, GL Garrad Hassan: Back To The Eighties? Putting The Current Political Landscape For The UK Wave and Tidal Sector In Context

Mr. Phillips used the presentation to regard the analogy between the emergence of the marine energy industry and the creation of the onshore wind industry in UK in the 1980s. His hypothesis was “The current political landscape is leaving the fledgling UK

wave and tidal industry vulnerable to shifting policy objectives, in a similar manner to wind and wave power in the 1980s". Mr. Phillips looked at the political landscape in the 1980s compared to the current situation and found that there are some passing resemblances, but history is certainly not repeating itself. Mr. Phillips then examined the historical analogue and the impacts on recent policy developments. He concluded that the hypothesis is wrong with the rationale that there is consistent strong support from DECC and Scottish government, capital and market incentives are in place, the Crown Estate leasing rounds provide long-term confidence in market for investors and Original Equipment Manufacturers (OEMs) and utilities are now on board. Mr. Phillips also listed some qualifications for the hypothesis to be rejected; The Electricity Market Reform (EMR) is still a significant risk factor and has to be designed to fit its purpose, UK companies need to be protected through the a "adolescence-phase" in the development, and to make this happen, the public debate must be won and the short term views from HM Treasury must be resisted.

Martin McAdam, Chief Executive Officer, Aquamarine Power: Will EMR Accelerate or Delay Marine Energy?

Aquamarine Power is a wave power company developing a device called Oyster, it is a near shore, shallow water energy converter. They are fortunate in having many dedicated shareholders and investors on board; ABB, SSE, Scottish Enterprise and Sep – Environmental Energies Fund. Mr. McAdam presented how they have reduced the cost of power from the first model to the current, and third, one. Their goal is to compete with offshore wind. The single important challenge in the industry is financing, and it is important to get the private investors involved, no grant is going to finance the business completely. Mr. McAdam has one big request for the support organizations and that is to not give out a small amount to many projects, but rather to choose some projects that will receive enough to close the financing gap.

Mr. McAdam believes without a doubt that Scotland is the best place in the world to develop marine energy right now. The big question for the future is the design of the EMR (Energy Market Reform), when the 5 ROCs regime is over, is it going to help the industry? –Mr. McAdam does not know, but he urges the government to provide clarity and decide upon the design within 2013 instead of the 2014 as proposed to give the investors the information they need to commit to the industry. Mr. McAdam also called for the reasons for the EMR to be communicated; is EMR all about providing a tower for nuclear? If it is the case, this should be articulated and maybe nuclear should compete on the same basis as other low-carbon technologies, in which case all the externalities could be priced in. His conclusion was; the EMR could be a great thing for the industry, but it is very uncertain.

A2: Understanding Risk - The Road to Commercialisation

Andrew Tyler, Chief Executive Officer, Marine Current Turbines Ltd: Realities and Rewards in Commercialisation of Tidal Renewable Energy

Mr. Tyler presented what he believes are the five major success factors in order to reach commercialization:

- 1) Government support; in the short term, from his perspective, government has done everything they can to improve the condition for success.
- 2) Mature entry level technology; he believes that the level of technology will look very different in the ten, twenty or thirty years.
- 3) Economically viable technology
- 4) Economically viable operation and maintenance
- 5) Major industrial original equipment manufacturer, need the large OEMs to back up the development and assure legitimacy in the industry.

Tim Cornelius, Chief Executive Officer, Atlantis Resources Corporation: Delivering Ambitious Projects

Mr. Cornelius presented how Atlantis performs ambitious projects, recognizing that every project in this industry is ambitious. He gave a brief description of Atlantis methods in developing projects and stresses the importance of Front End Engineering Design (FEED) and Detailed Design Process.

Richard Yemm, Commercial Director, Pelamis Wave Power Ltd: Pelamis WEC - A Clear Track To Cost Convergence With Offshore Wind

Mr. Yemm presented how Pelamis Wave Power has developed through their 14 years of existence. There have been six full scale machines built to date. They have through the development learned a lot especially about the risks connected to these types of projects and are now better at foresee the risks. The key risks in the commercialization process which should be a part of every business plan in the marine energy are:

- Technology and cost of energy
- Site and Development
- Financing
- Execution
-

A3: Panel Debate: Financing the Wave & Tidal Sector

John Callaghan, Programme Manager (Wave & Tidal), The Crown Estate

Jan Love, Director, Renewable Energy Scotland, Barclays Corporate

Audrey MacIver, Joint Head of Energy, Highlands and Islands Enterprise

Jerry Biggs, CEO, NAREC Capital

Lindsay McQuade, Energy Policy Manager, ScottishPower Renewables

The panel debate with different financing organizations was concerned with what challenges that are yet to be addressed in the marine energy industry. The panel representatives agree that clarity in the policy framework is very important as well as having a long term perspective in policies. Scotland has been good at communicating their goals and future plans, and showing the willingness to focus on the industry; this is important for keeping the projects in the country and is why many of the projects are performed in Scotland rather than in the rest of UK. Some of the investors find that the developers are too focused on the technical parts of a project instead of the financing part. This is unfortunate as it is crucial for attracting investors and moving forward with the project. They underpin that the industry is in need of common standards to be able to measure successfulness of projects, and the EMEC test plant has been great help in this process.

A4: Delivering Cost Reduction

Neil Davidson, Public Affairs Manager, Aquamarine Power: The Road to Commercialisation - Getting Marine Energy Technologies Down the Cost Curve

Mr. Davidson presented how to get down the cost curve. He used the Oyster as a reference and looked at how this device has developed in terms of cost reduction as a result of learning; things become cheaper as one gathers competence. Aquamarine Power has learned a lot in terms of installation, operation and maintenance in relation to design. Mr. Davidson proposed three key elements to get down the learning cost curve:

- R&D –Research, design and development
- Learning by doing
- Economies of scale
-

Philippe Gilson, Director for Ocean Energy, Alstom Ocean Energy: Driving Out Cost and Risk

Based on experience from wind and hydropower, Alstom's approach to drive down cost of energy is through:

- Risk reduction
- Make use of relevant experience and products
- Demonstrate technology reliability and viability through a phased R&D
- Test benches before going to the sea
- Build a family of products to cover the wide range of site conditions

In addition, they argue that the following is required in order to succeed in creating a viable industry:

- Investment by supply chain
- National and European CAPEX funding for :
 - Pilot farms
 - Common infrastructure
- Visibility beyond ROCs Scheme

(Euro Focus) Anne van Houten, New Energy Market Developer, Bluewater Energy Services B.V.: Offshore Experience Can Bring Down Costs Significantly

Bluewater is originally an oil and gas related company, being a leading developer of Floating Production vessels (FPOs) and other floating offshore systems. They are a pioneer in floating production and offshore mooring technology. Mrs. Van Houten argued that there is a clear technological match between the oil and gas and the marine sector. They also see trends from wind to tidal; bottom founded tidal turbines and increasing turbine sizes leading to operation on deeper waters. The problem with this trend is that the devices get further out of reach and more expensive to inspect, maintain and repair. The challenges they face in the marine tidal industry is thus that they have new technology that is out of reach and difficult to access, which in turn induces high costs. Mrs. Van Houten discussed where to look for serious cost reductions; refining turbine efficiency will not drive down the costs significantly (power take-off only constitutes 10% of costs), the grid connection is only 9% of the total costs making it potentially limited to scale effects, foundation and installation is 61% of the total costs

and operation and maintenance 14%. From Bluewater's analysis of the costs, the most promising area of cost reduction is foundation and installation. Bluewater believes that a floating solution reduces costs significantly and there are potentially large reductions on the O&M side as well. Floating devices thus solves many issues as it provides easy access, makes installation less complex and costly, and the energy goes up as the most energy-rich area of water column is close to the surface. Mrs. van Houten argued that floating foundations provide a match with the offshore industry as it has a proven track record in mooring floating systems, has experience with operating systems at sea, and can provide cost-effective means of installation and optimize other aspects of the full offshore project.

Howard Rudd, Principal Engineer, Xodus Group Limited: Cost Reduction Through Integrated Thinking

Xodus Group is an engineering consulting group specialized in oil and gas, CCS, wind and wave and tidal power. Mr. Rudd's presentation concerned how to minimize the cost of energy of commercial arrays using available technology. Many of the estimates on the cost of marine energy always seems to go up, but converging on £250/MWh. They do not really know the cost of energy because of lack of extended operation and lack of array experience, but they do not know plant availability. There are huge uncertainty in OPEX and annual energy production, and too many things remains to be done for the first time. It has been a problem that early start-ups overestimate their numbers because they want to maximize their exit, which is not helping the industry in getting a clear picture of the real costs.

The industry is facing an integrated problem where everything depends on everything else; the key drivers are interrelated: push one down and another comes up! Xodus believes in an integrated solution through: thorough needs analysis and systematic options identification and appraisal, integrated cost of energy and risk model incorporated correct linkages, focus on values enhancements as much as cost reductions, setting a target, multidisciplinary teams avoiding 'silo' mentality and work with the supply chain. Mr. Rudd lastly emphasized that the biggest cost reductions could be achieved early in the project lifecycle.

A4.2.3 Exhibition

At the exhibition we spoke with Tore Gulli from Fred Olsen Renewables which has been in the industry both in Norway and the UK for a long time, and gained his thought on relevant matters:

Cooperation: In the beginning of the industry creation there was seven large actors including OPT, Oceanlinx, Orecon AWS, Pelamis, Wavegen and Fred Olsen, which formed a group and cooperated closely in the UK; particularly towards public bodies. However, one of the members of the group went bankruptcy, several members individually developed short-term strategies to survive and the group was dispersed. Now Renewable UK has taken the coordination role. In Norway there is still little culture for cooperation; but the formation of FFMFE and later NORWEA has helped in promoting collaboration.. It is not typically Norwegian-like to cooperate, and with absence of a

home market this is made worse. Most of the reason why the maritime cluster in Norway has a successful cooperation is because of the existing home market.

Political will and home market: There is much more political will in the UK; the Scottish firstminister has for instance visited Fred Olsen's test facility in Kragerø to inspect the progress in the sector. Mr. Gulli believes that Norway could have a home market if there only was political will; Norway has the competence and the resource potential. He does not believe it is possible to build up a whole industry in a country without a home market. He thus argues that a solution presented by Tellef Thorleifsson at the Enova conference in January 2012 where SN Power were to take a greater role in Norwegian Renewable energy focus, will not be possible without a viable home market. When discussing the development of the solar power industry in Norway that did develop without a home market, Mr. Gulli argues that the sun power industry was a spin-off development/application of the traditional metallurgical industry rather than a new industry. It is not the same for the offshore industries; wave and tidal power is far more different from oil and gas than solar from traditional metallurgical industry, and the technology is at an earlier stage.

Timing: Mr. Gulli does not believe it is too late for Norway to be a part of the industry if they act now. A Norwegian home market could eventually develop when the industry and technology get more mature, but then it will be too late to build an industry in Norway, again; now is the time to act.

Test market: Mr. Gulli does not believe that Norway needs to build up a test market as it is relatively easy to receive local licence for small projects, but if Norway is to install a grid it becomes more interesting and relevant. Mr. Gulli argues that EMEC has not been as successful as one might believe. It was established by academics before the industry was ready and the licence application process involves too much bureaucracy. It is thus cheaper for Fred Olsen to operate in Norway at this point, but they are performing tests in England as well. Fred Olsen has both British and Norwegian legal entities depending on where they operate.

A5 Industry Actor Opinions

A5.1 Opinions Related to Research Question One:

1. How is the contribution from Norwegian system actors in the development of marine energy industry perceived? - System actors being the political system, investors, large companies, entrepreneurs, and the public.

| Company | Political will |
|---------------|--|
| Cicero | - The governmental focus on CSS is at the expense of other development |
| RCN | - It is political will for R&D, but less regarding support test market. - Do not perceive a conflict of interest with the oil industry. |
| IN | - Challenge that the oil industry attracts capital and labour. |
| Enova | - The government cannot compensate for private initiative and trade |
| Rambøll | - The government has no long-term goals |
| SN power | - Has altered their portfolio to contain less new renewable technology. |
| SAE Vind | - Politicians have no long term goals. - Politicians are positive to initiatives that do not affect their reputation. |
| NV | - The government do not prioritize renewable energy, only oil. |
| Scatec | - The government do not prioritize renewable energy and have resisted pressure from the EU; they only have room for oil and health services. |
| Entrepreneurs | - The government should communicate long-term goals. |

Table 1: Perceptions of the Political will in Norway

| Company | Norwegian Support Framework |
|----------|--|
| Cicero | - Need long-term strategy that recognise climate challenges and introduce carbon price that will increase over time. - R&D phase well supported in Norway, if they have a strategic interest and wants to develop exporting industry, they may have to extend the support - Government should possibly assign more support to other green technologies such as offshore wind and marine power. |
| RCN | - Have received critique of having an unbalanced allocation between technologies. - Support should have a wide approach driven by market forces. - Unfortunate that only 20% receive support. |
| IN | - Support system is difficult to understand and could be better coordinated. - Support should have a wide approach driven by market forces. - Early development support is better in Norway than the UK. |
| Enova | - Support institutions could be more visible. - Support should have a wide approach driven by market forces. - Norwegian support for large scale testing is as good as other countries'. |
| Rambøll | - Should demand investor support from projects as early as RCN. - Market mechanisms should decide priority areas. |
| SN power | - SN power's extensive market experience could expand to a broader range of renewable energy. |
| SAE Vind | - R&D projects should take a wide approach. - Slow concession process. - Need grids and cables to avoid locking the power within Norway. - Land-based wind is more effective and should be developed first. |
| NLI | - Norway does not have subsidies that are funding building of test sites, but for |

| | |
|---------------|--|
| | technology development. - Government should consider arrangements for testing full-scale prototypes. |
| NV | - A wide approach of technology support is favourable, but must bring forward scalable businesses. |
| Scatec | - Should regulate the development of the oil sector due to inflation and give more favourable loans to renewable energy initiatives. - Pilot testing phase least successful since they are waiting for large industrial actors. - Demanding application process. |
| Entrepreneurs | - Not as beneficial conditions in Norway as abroad, - Demanding application processes |

Table 2: Perceptions of the Norwegian Support Framework

| Company | Opinions about Entrepreneurs |
|----------------|---|
| RCN | - Important that the companies that receive support cooperate with other actors |
| IN | - The marine industry entrepreneurs are often alone and overlooked. - The entrepreneurs would benefit from collaboration |
| Enova | - Developers reluctant to share information should collaborate more. - Need industrial partner to succeed, but it does not have to be huge company. |
| Rambøll | - Biased expectations of getting governmental support if they have investors - The entrepreneurs demand support if their idea is within renewable energy. - Competition among companies is crucial for industry development |
| NLI | - Most likely other actors than NLI, like small entrepreneurs, has the best idea |
| Scatec | - Developers need demonstrations projects to prove technology and Norway has few facilities for device testing. |
| Entrepreneurs | - International strategy from inception - See little need for collaboration - All receive support from support organisations - Need for capital for technology development. |

Table 3: Perceptions of the Entrepreneurs Contribution in the Marine Industry

| Company | Opinions about Investors |
|----------------|---|
| Cicero | - Extensive governmental funding will lead to less effective investors. - Inherent risk in green technology projects, as well as political risk by changing policies. |
| IN | - Harder to get investors after the financial crisis. - Few interested in marine energy due to subsidies and risk. - Private capital needs to be directed from the oil industry to renewables. |
| Enova | - Worried about involvement of private sector, which rather invests in oil projects. - Should use foreign investors. |
| Rambøll | - Perform more thorough analyses of technology than support organisations |
| SN Power | - Investments have to be commercial with given a rate of return, which makes marine energy irrelevant. |
| NV | - Tough market has made them more sceptical toward large demanding projects within renewable energy. - Unsuccessful project has made them sceptical towards wave power. - Thought provoking that wave energy has not progressed more. - Have no explicit green values. |

| | |
|---------------|---|
| Scatec | <ul style="list-style-type: none"> - Have no faith in wave power. - Currently fully booked portfolio. - Want to enter when technologies become commercial. |
| Entrepreneurs | - Dependent on more capital for larger scale testing, difficult to get investors. |

Table 4: Perceptions of the Investors Contribution in the Marine Industry

| Company | Opinions about Large Companies |
|----------------|--|
| Cicero | <ul style="list-style-type: none"> - Want the government to take most of the risk - Private actors within oil tend to exaggerate the costs connected to development to receive more financial support. |
| IN | - Large companies are the engines of industry development. |
| Enova | <ul style="list-style-type: none"> - Difficult to get power companies to host demonstrations. - Few large companies exist in Norway and they have taken the role as a demanding customer. |
| Rambøll | <ul style="list-style-type: none"> - Project areas depend on the customer, no customers have asked for marine energy. - Performs more thorough analyses of technology than support organisations |
| SN Power | <ul style="list-style-type: none"> - Wind has not had the success they anticipated. - SN Power wish to be a strategic partner, not just a financial one |
| SAE Wind | - Established to focus on wind power |
| NLI | <ul style="list-style-type: none"> - NLI use their competence from oil and gas in the offshore renewable sector - Wants to spread risk and believe marine energy to be profitable in the future. - There exist few energy companies that are involved in marine energy and not in wind, but a lot of companies within wind have not gotten involved in wave and tidal power yet - Norway not attractive market, E.g. Statkraft has invested in large offshore wind parks in the UK. - Countries like UK and Germany are more relevant when looking for an industrial partner. |
| NV | - Large companies should have culture of helping new companies. They may equally to blame as the government for difficulties in pilot testing. |
| Scatec | <ul style="list-style-type: none"> - With the current political will, a large company like Statoil or Statkraft has to take charge if the industry is to evolve. - Corporations are obliged to maximise profit, only laws engage them in renewable energy. |
| Entrepreneurs | - Some have managed to get an industrial partner, but this is generally perceived as being difficult. |

Table 5: Perceptions of the large Companies Contribution in the Marine Industry

| Company | Opinions about the Public |
|----------------|--|
| Cicero | - Natural resources should benefit the Norwegian people; should not pay for subsidies that result in dividends for investors. |
| RCN | <ul style="list-style-type: none"> - The public does not see the whole picture – government must communicate that Norway will benefit from export of energy. - People are used to low power prices and might be sceptical to have grids and devices in Norway for export to other countries. |
| Renewable UK | - Socio-economic benefits of marine energy |
| Rambøll | - There is no pressure for new development - The unemployment rate is too low. |

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| SN Power | - The public show great resistance toward expansion of the grid. |
| SAE Wind | - Increased local acceptance of renewable energy in local communities. |
| NV | - People are less concerned about effects of the oil industry. |
| Scatec | - General opinions is that new renewable energy are small and new industries, but these are large abroad. |

Table 6: Perceptions of the Publics Contribution in the Marine Industry

A5.2 Opinions Related to Research Question Two

2. Are there any advantageous conditions in Norway that can compensate for a limited home market?

| Company | Norwegian Advantageous Conditions |
|----------------|--|
| Cicero | <ul style="list-style-type: none"> -Norwegian conditions are favorable for strategic marine energy investments to be successful in competition with other countries -Norway has in many ways a cluster within petroleum and marine industries, which could be expanded. In that matter, Norway might be ahead of Scotland which could be an argument for building this type of industry in Norway - The synergy between oil and gas and offshore renewable energy should however not be exaggerated; it is still challenging to construct marine energy devices. |
| RCN | <ul style="list-style-type: none"> - The competence in the oil and gas sector could be a benefit when producing marine energy devices or components - The challenge however could be to have the right focus when transferring the competence of oil and gas to marine energy. There are very high standards and requirements connected to safety and operating time on oil platforms as well as profits are high. Within marine energy on the other hand, the focus is rather to drive down the costs -Hafstad believes that Norway can contribute to the offshore marine industry in certain areas: developing ground work for floating and rock solid devices with the competence from the oil and gas industry and also operational work based on competence from the maritime industry |
| IN | - If the technologies reach grid parity, Norway will have energy forever, considering the resources in the North Sea. |
| Enova | -Norwaycan participate in certain areas and Norway is engaged already in offshore wind.. This will develop as companies within shipping, marine constructions and technical subcontractors will be interested in diversification. It will happen with or without Enova's engagement |
| SN power | - It is important to have something to base the industry creation on. Norway has a background in R&D projects concerning wave energy that could provide such a fundament. Marintek at NTNU is in addition a well-established research centre within offshore technology that has built up competence within ground work of offshore wind turbines. |
| SAE Vind | If Norway continues the effort in renewable energy, the Nordic market can have up to 50 TWh in excess production by 2020. Unless we get this power out of Norway it will cannibalize our own hydropower production and make local municipalities lose income. |
| NLI | NLI believes there are synergy effects between offshore wind and wave- and tidal energy; there are similar challenges in installation, general principles to guide the work, fabrication in low cost countries and mainly the same customers. There are also synergies with oil and gas operations, which have |

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|---------------|---|
| | very strict demands – if one gets something approved within oil and gas one manages in renewables. |
| NV | - Norway has the opportunity to export renewable energy, we should use it |
| Scatec | - Norway has a knowledge cluster, a large service sector and world leading in building and designing advanced speciality ships. - Norway could specialize at marine constructions and under water operations. Maybe some of the advanced vessels could be built in Norway. Other value chain activities could be engineering design and maintenance. |
| Entrepreneurs | The competence within oil and gas is advantageous |

A5.3 Opinions Related to Research Question Three

3. What markets can Norwegian companies exploit to succeed with a limited a home market?

| Company | Foreign markets |
|--------------|--|
| Cicero | - Most likely growth in green energy demand will increase; Norway could function as a green battery and serve parts of Europe with higher electricity price. |
| IN | - Norway constitutes a small market and companies should aim at reaching out to foreign countries - Should Norway subsidise power that is sold to Europe? If one considers the resources in the North Sea and if the technologies reach grid parity, Norway will have energy forever. - Countries with more favourable policies are driven by self-sufficiency. |
| Enova | - One can support a full-scale test project and innovation activities in Norway, but the next market is outside Norway and value creation will be obtained in other markets. - It is an advantage to have foreign markets that can contribute in the next phase and share the development costs. - It is possible for Norway to become a net exporter of power to Europe. - Sweden has clearer internationalization strategies - UK may not have the learning effect they anticipated. |
| SN power | - They use Norwegian consultants, suppliers and academic environment in different projects abroad and their operations thus create considerable ripple effects in Norway. - Natural to use Norwegian companies because they have great experience and very often offer the best services. - Wants local partner with experience and knowledge about market, joint venture |
| Renewable UK | - Goal of UK as a market leader and to utilize first mover advantages. - Important to develop grids and the whole value chain. - Do not have any clear protectionist laws. - UK marine energy industry will need competence from abroad. - Industry actors cooperate like a community. - Large companies add a lot of credibility to the industry and are involved as industrial partners - Utilities are getting increasingly involved, someone developed own device. - Getting private investors interested is currently one of the biggest challenges in the industry. |
| Rambøll | - Most countries do not have as solid support arrangements as Norway. |

| | |
|---------------|--|
| SAE Vind | <ul style="list-style-type: none"> - Go abroad to a commercial market where you get paid and increase your competence level, instead of doing R&D in Norway. - If companies want to participate in the offshore renewable industry they has to seek markets with another energy mix than Norway. - UK has a different need as they have to phase out coal and nuclear power. - German grid politics are stating that Norway can contribute - More effective concession processes in Sweden. |
| NLI | <ul style="list-style-type: none"> - There is more reasonable that Norwegian companies develop technology and sell to international markets. - International strategy for their wave and tidal projects. The strategy is to start in countries with most potential, before expanding to other countries. |
| NV | <ul style="list-style-type: none"> - UK was chosen for the wave project, because they offered the best support, Norway was out of the question. - It is possible for Norwegian offshore wind developers to participate in the development of Sheringham Shoal, it does not really matter if it is located on the British or Norwegian side. - Norway has access to a large market in need of renewable energy. Borders are quite random, and Norway's great potential for building renewable energy gives us a responsibility as an exporter of oil and gas. Since we have the opportunity to export renewable energy, we should use it. - Other countries support more actively in early phases than in Norway. |
| Scatec | <ul style="list-style-type: none"> - When the Norwegian solar industry emerged, it was more focus on free trade than today since today's industry have experienced the financial crisis. - Today, countries like India, Brazil and Canada are restricting subsidies to local content. - When the world is experiencing recession, nations become more and more protectionist. - Hawaii and Mali do not have a grid. Hawaii's energy mix consists of 80% diesel and their goal is 80% by 2020. These markets do not need subsidies to be attractive. - Reasonable for Norway to have green battery thinking, but cables must be built in advance. - Governments abroad have developed projects on their own instead of waiting for the existing industry. |
| Entrepreneurs | <ul style="list-style-type: none"> - All target foreign markets for production - All target markets with the most favorable policy regimes; Langlee targets off-grid markets as well. - Some have foreign investors or partners. (Hammerfest Strøm, Langlee, Tidal sails) |

A5.4 Opinions Related to Research Question Four

4. How important is timing for the development of a Norwegian marine industry?

| Company | Opinions on Timing |
|--------------|---|
| Cicero | <ul style="list-style-type: none"> - If the innovation phase is not sufficiently supported, the risk is that the competence is lost to other countries. - To invest in a national industry that lacks a home market is expensive and involves great risk, but there are many benefits connected to enter in the early stages of the learning curve and possibly become a leader. It could be less expensive to enter later when the technology is more mature as one can benefit from the experience of others, but one run the risk of miss out on valuable learning and end up in a less desirable position |
| IN | <ul style="list-style-type: none"> -The decision to stay in Norway or not also depends on the industrial partner; companies are most likely willing to move for the cause of getting an industrial partner. - IN does not want the companies to move abroad too early and sees no advantages of them pushing the companies out before they are ready. - IN believes that some companies might make it with the existing conditions, even though it would be easier with more money and test facilities. |
| Enova | -Norway has good resource potential and competence in the offshore industry and operates at a somewhat high level in the development of several technologies. In addition, Norway has a lot of renewable energy and would benefit from keeping this position. If Norway chooses to not do anything, the situation can move in another direction and Norway may lose the learning effect. In this way, there is a risk that Norway does not secure its option for benefit of future technologies. The little R&D and development activity that some actors get involved in can be viewed as an option on future value creation. |
| RCN | <ul style="list-style-type: none"> -Mr. Hafstad does not believe it is too late for Norway to be a part of the marine energy industry -Development within wave power has been carried out for some time, but there is still no consensus of superior technology design. Thus, the wave industry is still very open. - Norway is probably too late to become a major contributor when it comes to development of close-to-shore wind power, while it is still possible within floating wind power. |
| Renewable UK | A report from a panel of Members of Parliament stated that UK wants to use its mover advantage within marine energy in a better manner than in the 80's in onshore wind power. |
| Rambøll | Mr. Christophersen does not believe it is too late to become an important player within offshore wind, but the investments hold up for too long, it will be. |
| SAE Vind | - <i>"We need grids and cables to avoid locking the power within Norway"</i> . |
| NV | -It is thought provoking that the technology development of wave power has been going on for so long, without having verified a wave power as a power source of large scale. |
| Scatec | - Adjustable power increases in value as the level of non-adjustable power rise. But this possibility only exists for a certain period of time. Each country is planning development of grids and if you don't participate in this planning, the possibility will be locked in because the other countries have made use of other solutions. Grid installations usually last for 100 years. <i>"You're either in now, or you wait 100 years until you get the same opportunity"</i> . |

A6 Investors

Investor can roughly be divided into six groups:

Incubators and Technology Transfer Organisations (TTOs): These are actors that help with technology transfer to commercial companies. They assist young companies or projects with some capital in the start-up phase and early commercialization phase, with activities such as verification of product or services.

Seed capital: Is normally invested in companies that have not reached first commercial sale. The age of these companies vary according to technology.

Angel investors: is a term for investors that enter projects in early phase and offer competence and experience through board membership, in addition to capital. Angels typically invest their own funds, unlike venture capitalists that manage pooled money for others. Angel capital fills the gap between friends and family and seed funding and venture capitalists.

Venture capital: is mostly invested in the early commercialisation phase, where the focus is to enter a market segment and to build an operative organisation.

Expansion and acquisition capital: focus on commercialized companies that are entering new markets on their own or through acquisitions.

Corporate venture investors: regard corporate ownership in companies that are not directly related to the company's core business. When Hydro invests in wind power their ownership can be termed as corporate venture. This kind of ownership encompasses all phases mentioned above and mainly emphasise the relation between the parent company and the smaller one.

Source: (Grünfeld and Espelien 2011)

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