Offshore Wind Norway
Market and Supply Chain, 2012
Preface

The Norwegian offshore sector is characterized by a highly qualified workforce stemming from a proud history of shipping and offshore oil and gas activities. This competence is now being transferred into the offshore wind sector. Based on their offshore experience, Norwegian companies offer unique expertise that increases reliability and reduces the cost of electricity from offshore wind.

In order to update the international offshore wind community about the Norwegian offshore expertise, INTPOW – Norwegian Renewable Energy Partners – in cooperation with Innovation Norway has commissioned this market and supply chain study. The following report is an update of the 2011 edition published in April 2011.

The report provides an overview of Norway’s offshore wind capabilities and shows a wide range of offshore wind related activities among Norwegian companies. The report is not designed to give in-depth information on company level, but it will give the reader the opportunity to identify the various companies.

Innovation Norway
Innovation Norway promotes nationwide industrial development profitable to both the business economy and Norway’s national economy, helps to release the potential of different districts and regions by contributing towards innovation, internationalisation and promotion.

INTPOW
INTPOW is a networking organisation founded to promote cooperation between Norwegian and foreign players in the renewable energy industry. It is a non-profit joint venture between the Norwegian Renewable Industry and the Norwegian Government.

Created by Multiconsult/WSP
Multiconsult is a Norwegian leader in consulting, engineering and project management with 1400 employees with 40 years track record in offshore and 100 years in renewable energy. In 2010, Multiconsult entered a strategic alliance with the WSP group, a global consultancy of 10 000 staff and headquarters in London, towards the international offshore renewable energy market.

Norway April 2012
Executive Summary

The accelerating offshore wind market in Northern Europe represents a unique opportunity for Norwegian industry to transfer its offshore know-how and industrial capabilities from the maritime and Oil & Gas sector to the offshore renewable energy market. As offshore wind projects are developed further from shore and in deeper waters, the Norwegian experience is valuable.

The fulfilment of European national offshore wind energy ambitions are increasingly dependent on cost reductions and the long history as a world leading offshore nation with strong innovation capabilities, Norwegian companies deliver innovative cost reducing solutions.

This report maps out the Norwegian offshore wind supply chain and provides an updated and comprehensive overview of its key offshore wind companies. The report identifies more than 150 companies within the Norwegian offshore wind industry. A large share of the Norwegian companies active in offshore wind are technology developers, reflecting a high level of R&D activity and innovation. However, based on the maritime and oil & gas experience, also large offshore wind project developers and strong service and finance providers have emerged. In total, these companies have been involved in 64 different offshore wind farm projects in more than 9 countries, utilising more than 30 technology concepts. A full overview of all the companies can be found in Appendix A1.

In their efforts to reduce costs and increase delivery security, European projects and project developers might be well advised to make use of the Norwegian offshore knowledge base in environmental, materials, technology and design, project management, logistics, operations & maintenance, health & safety, financing and other areas.

Feel free to contact either INTPOW or Innovation Norway for introductions.
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1 Offshore wind trends

Offshore wind is expected to be a major contributor to the energy mix in Europe and elsewhere in the future. While Europe is still the major growth market and engine in this industry, both South Korea, Japan and China has set aggressive targets for offshore wind and are expected to follow quickly. In the US, regulation and public support limits expectation. Sustainable cost reductions through mass production and innovation is needed to deploy large scale offshore wind in most markets.

European development trends - After 20 years of relatively slow growth, the offshore wind industry is now facing a period of extraordinary growth. As of March 2012, the European Union is a global leader with about 4 GW of offshore wind installed. In 2011, a total of 140 GW of projects at various stages of development have been identified throughout Europe as presented in the graph below (EWEA, 2011).

A review of the European National Renewable Energy Action Plans (ECN, 2011) indicates that offshore wind is to play a significant role in Europe’s sustainable energy future: by 2020, 12% of the 1217 TWh EU27 renewable energy production is expected to come from about 44 GW of offshore wind. Furthermore, EU’s "Energy Roadmap 2050” (European Commission, 2011), published in late 2011, sets out pathways for an energy sector that is 85% carbon-free by 2050. This includes a wind power contribution ranging between 32% and 49% of the EU power production.

Ahead of the 2020 targets, the 2015-2020 period is expected to represent a massive wave of construction thanks to simultaneous market take-offs across Europe (including the UK round 3, Germany EEZ developments in North and Baltic Seas, France and the Netherlands among others).

Following long traditions in Norway, public authorities, R&D institutions and private companies have joined forces to establish a dynamic innovation system with a clear focus to deliver technology sound and cost effective solutions to the international offshore wind market. The Norwegian offshore wind industry has until now primarily targeted the European market, since the Norwegian home market has not matured as fast as the UK or German markets, mainly because of

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1 EWEA, 2011
abundant renewable hydropower energy supply. Still, there are several offshore wind projects under development in Norway.

**Outside Europe**, new markets are set to grow in Asia and North America. China alone aims at a cumulated offshore wind installed capacity of 5 GW by 2015 and 30 GW by 2020. Furthermore, a scenario study (Carbon Trust, 2011) forecasts a global cumulated installed capacity ranging between 440 and 1150 GW by 2050.

**Project trends: deeper, farther, larger capacity, larger units.** After a decade of exploiting easy accessible sites in shallow water and close to shore, the average project size has been lifted from 60 MW up to typically 300-400 MW today. In 2010, Thanet (300 MW), the world’s largest offshore wind farm to date was commissioned in the UK, but larger projects such as London array (630 MW) and Greater Gabbard (504 MW) are already under construction. The Dogger Bank UK round 3 zone developed by the Forewind consortium is expected to reach a total capacity of 9-13 GW within 2020.

Most installed offshore wind farms have been installed in waters below 25 m but future projects are located further offshore, in deeper water depths. This implies new design and construction solutions in support structures, installation methods, HVDC transmission technology or remote manned platforms.

**Offshore wind challenges** – Various obstacles need to be overcome in the next five years if Europe is to meet its offshore wind targets:

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2 Multiconsult, 2012

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Overview of the key offshore wind obstacles ahead of 2020 ambitions²
**Cost reduction** is the most critical challenge, and one which is being tackled by all stakeholders. The offshore wind industry is reaching a critical transition point where significant investments must be triggered while costs need to come down. In the UK, for instance, the levelised cost of offshore wind energy is currently up to 1.6 NOK/kWh and is expected to decrease down to 1 NOK/kWh by 2020 (The Crown Estate, 2011-2012). Increased industry competition and innovation are expected to contribute significantly to lowering the cost of energy.

**Technical maturity and reliability.** Innovative solutions must be rapidly developed and demonstrated ahead of commercial deployment. Increased risks and uncertainties due to unproven solutions will require robust risk management.

**Supply and skills bottlenecks.** As the offshore wind market brings large volumes of activity and gradually moves into deeper waters, the demand for suitable supply chain, skills and staff capacity is increasing rapidly. Since the financial crisis of 2008-2009, these challenges have turned into opportunities, as employment and export potential became major drivers alongside climate change and security of energy supply. It is foreseen that the offshore wind sector will employ nearly 300 000 people out of 480 000 working for the broader wind power sector.

**Securing grid connection in a timely manner.** The development of grid connection and transmission is time consuming, especially onshore. Unclear planning processes, combined with unclear development and financing responsibilities have postponed offshore wind deployments in Germany and the UK.

**An uncertain policy environment.** The role of governments is decisive in setting and sustaining attractive and predictable policies (offshore wind specific targets, support schemes etc.) with the aim to provide financial players the long term confidence to invest.

**Securing necessary planning permission and consents in a timely manner.** As presented in a previous report prepared for the Nordic Council of Ministers (Multiconsult, 2010), many planning and consenting frameworks are not fit for the purpose of offshore wind and are currently under reform.

**Securing project equity and debt financing is likely to remain difficult** until the European Union finally recovers from the current economic crisis. According to Bloomberg New Energy Finance’s Central scenario, a cumulated investment of NOK 1015 billion of capital in offshore wind and associated grid connections could be required to build capacity before 2020.

The industry needs to demonstrate that:

- Cost reductions in the range of 30% can be achieved
- Technology challenges are met through the development and deployment of innovative designs and methods into commercial projects
- Sufficient upfront investments are made along the value chain to avoid bottlenecks and ensure that the supply chain is ready to deliver in time.

This report underlines Norwegian industry’s capabilities and potential to be a driving force within offshore wind energy. Norwegian companies provide reliable and innovative solutions based on centuries of experience from shipping and decades of experience from offshore oil and gas activities.
2 The industry structure & supply chain

To date, the Norwegian suppliers have to a large extent been driven by the transfer of offshore and maritime experience and capabilities related to design and installation of offshore structures. As projects move into deeper waters, the Norwegian experience is increasingly required at an early stage of the project lifecycle to contribute with offshore project planning experience and engineering solutions. Increasingly, the need for integrated solutions and cost reduction demand Norwegian suppliers’ expertise.

2.1 Methodology

This report is a desktop study with a systematic screening of active offshore wind players in Norway. Data from INTPOW, INNOVATION Norway and Multiconsult networks have been used, followed by interviews of selected key industry executives. In addition, publicly available information from websites, news, reports and other archive data has been exploited.

All identified companies are categorized according to their role and involvement in the project lifecycle and type of technology. A rough assessment of the maturity and track record of the various organisations was performed. The report has not been reviewed by the companies mentioned.

The companies referenced in this report only include those companies with existing activities or explicit strategies for the offshore wind market. Other companies with relevant capabilities transferable to offshore wind, but with no particular interest or clear offerings to the offshore wind market, have been excluded from this mapping.

The Norwegian offshore wind supply chain has gained competitive advantages from previous offshore and energy exposure, visualized in the figure below. Thus, this mapping only represents a small portion of the huge offshore oil & gas and maritime clusters present in Norway, and thus do not reflect the very wide potential for capability transfer.
2.2 Building the Norwegian supply chain database

In this study, more than 300 Norwegian companies that have offshore wind activities, or that target the offshore wind market with some or all of their products and services, have been identified. The study specifies each company’s place in the value chain, their main business focus as well as level of experience. Most of the Norwegian offshore wind companies are technology and concept developers. Utilities and Statoil have however also engaged in large offshore wind projects as have the financial and legal communities. A full overview of all the companies can be found in Appendix A1.

About 20% of the companies can claim to have extensive experience and a number of offshore wind references. Another 100 plus companies can claim references from earlier involvement in offshore wind related activities. In total these companies have been involved in 64 different offshore wind farm projects in more than 9 countries, utilising more than 30 technology concepts. The table below was used as a guideline to categorize the technology focused companies.

<table>
<thead>
<tr>
<th>Topside</th>
<th>Foundation</th>
<th>Electrical &amp; grid</th>
<th>Marine operations &amp; Logistics</th>
<th>Survey equipment &amp; methods</th>
<th>Test centre/Facility</th>
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<tr>
<td>Blades</td>
<td>Concrete support structure</td>
<td>Subsea cables (export)</td>
<td>Installation vessels</td>
<td>Survey equipment &amp; methods</td>
<td>Sea cable towing tank</td>
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<tr>
<td>Castings and forgings</td>
<td>Steel jacket structure</td>
<td>Subsea cables (array)</td>
<td>Support/crew vessels</td>
<td>Sensor</td>
<td>Turtles</td>
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<td>Towers</td>
<td>Substation</td>
<td>Substation</td>
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<td>Generator</td>
<td>electrical systems</td>
<td>Port</td>
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<tr>
<td>Rotor</td>
<td>Cable protection system</td>
<td>Access system</td>
<td>Installation cranes</td>
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<tr>
<td>Complete turbine</td>
<td>Subsea cables</td>
<td>Installation and crew vessels</td>
<td>Installation concept</td>
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<tr>
<td>Nuts and bolts</td>
<td>General electrical and grid</td>
<td>Transformer</td>
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<tr>
<td>Nacelle</td>
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</table>
2.3 Main reference projects

Both Nexans and Mika, offshore cable supply and installation companies, were engaged in early offshore wind projects as was Det Norske Veritas (DNV) with certification services.

The first Norwegian technology milestone was achieved in 2007 at the Beatrice demonstrator in Scotland, as OWEC Tower supplied the world’s first deep offshore wind bottom-fixed sub structure at 45m water depth. OWEC Tower became a jacket design reference and remains to date the only installed jacket design with offshore wind track record. Project references include Beatrice (UK), Alpha Ventus (DE), Ormonde (UK), Thornton Bank (Belgium) and several other project studies.

Fully commissioned in 2010, the Alpha Ventus offshore wind farm, Germany’s first, was built with Norwegian substructure design, manufacturing and marine installation contractor.

Norwegian Aker Solutions was awarded the manufacturing of the steel tripod foundations at its Aker Verdal facility. OWEC Tower delivered the design for six steel jackets as part of an EPC contract awarded to NorWind, another west coast based supplier. Various other Norwegian companies contributed to the project, including Tristein, a marine operations company.

In 2009, HyWind, the world’s first large scale floating offshore wind unit, was successfully deployed by Statoil on the west coast of Norway. The 2.3 MW demonstration project has opened up a completely new perspective of the potential for offshore wind. The main EPC contract was awarded to Technip, but the entire design and construction process involved more than 30 Norwegian suppliers.
Scira Offshore Energy, the joint venture between Statkraft and StatoilHydro, is now constructing the Sheringham Shoal project off the UK coast, with partly Norwegian content and expertise. Nexans (export cable supply and installation), Trelleborg Offshore (bearings for the monopile) and Storm Geo (met ocean services) are contributing to the project. For a full overview of Norwegian developers and utilities involved in offshore wind, see Appendix A3.

In 2010, Aker Solutions was awarded a contract for the design and fabrication of 49 offshore steel jackets for Nord See Ost, a 295 MW project in Germany developed by RWE. Aker Solutions is utilising its own steel jacket design developed in-house through Aker Jacket Technology AS.

2.4 Technology and service providers
Norwegian companies are recognised for their ability to turn general offshore competence into specialised new applications. So also for offshore wind; Norwegian companies are emerging as prime suppliers to the offshore wind turbine market. Several companies develop topside technology, including tower, electrical equipment, nacelle and rotor, especially suited for offshore conditions.

ChapDrive develops integrated hydraulic drivetrain solution. It has tested 225kW and 900kW. Started test on 5MW.

GE has acquired ScanWind, a Norwegian turbine technology, currently offering a 4MW unit.

SWAY 10MW is expected to be demonstrated onshore in near future.

Smart Motor offers fully integrated direct drive generators. Supplier to offshore wind, as well as tidal and wave energy devices.

Blaaster Wind Technologies is developing a direct-drive wind turbine. 3MW demo will be installed in 2012. Next step is planned to be 6MW.

Norsetek is developing a new light weight rotor concept for on- and offshore. The design reduces weight and makes logistics easier.

Anglewind is developing a new generation drivetrain technology for large wind turbines with an innovative system for locating the generator at ground or sea level.

Innowind’s concept is developing turbines that occupy less space and have a higher efficiency for every square meter.
Norwegian capabilities related to the Balance of Plant work package, such as offshore substations, inter-array and export cables, are solid. Offshore wind leaders in cable design, manufacturing and installation, such as Nexans, Draka and Parker are localised in Norway. Based on Norway’s track record in delivering subsea cables, interconnectors or electrification of offshore oil & gas facilities, experienced engineering companies are now building dedicated offshore wind teams.

<table>
<thead>
<tr>
<th>Nexans</th>
<th>Draka</th>
<th>Parker</th>
<th>Aibel</th>
<th>Troll Rosenberg (now Goodtech)</th>
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<tr>
<td>supplied, installed and commissioned submarine cables and accessories to both the Anholt and RIFFGAT offshore wind park.</td>
<td>supplied the subsea array cabling for the 576MW Gwynt y Môr offshore wind farm off the North Wales coast.</td>
<td>won the contract to produce and supply infield cables, accessories and offshore services to the DanTysk Offshore Wind farm.</td>
<td>won the EPC on 900MW offshore wind substation for the Dolwin cluster (DE), 2011-2014.</td>
<td>has developed an offshore wind substation based on Norwegian offshore oil and gas experience.</td>
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Based on decades of experience from harsh offshore environments, a set of new designs for bottom-fixed jackets, gravity based and floating concepts are under development – of which many can claim to be truly innovative. The experience from offshore marine operations and the need for efficient installation methods have induced concepts designed to be pre-assembled to reduce cost.

<table>
<thead>
<tr>
<th>OWEC Tower</th>
<th>Aker</th>
<th>Seatower</th>
<th>Vici Ventus</th>
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<tr>
<td>has delivered engineering design to Beatrice (UK), Alpha Ventus (DE), Ormonde (UK), Thornton Bank (Belgium) and several studies.</td>
<td>has designed, fabricated and delivered 49 steel jackets for RWE’s Nord See Ost offshore wind farm.</td>
<td>have agreed to offer their Cranfree gravity based technology to the European market in collaboration with MT Højgaard.</td>
<td>pre-assembled GBS concept is developed by the company Dr Olav Olsen who brings a unique track record from deep water jackets and concrete foundations in oil and gas.</td>
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</table>
Hywind, with its 2.3 MW, was the world’s first full scale fully operated floating turbine. It was installed in 2009.

SWAY is developing a downwind floating wind turbine concept. A 1:6 floating prototype was installed in 2011.

Force Technology and NLI develop Windsea - a floating concept with three turbines. Tank tests are done.

The University of Stavanger is developing a Floating Vertical Axis Wind Turbine. It is in early phase and seeks developing partners.

Norwegian companies have extensive experience of operating in distant offshore locations. Displaying a growing number of new concepts, marine operations and installation & logistics are two of the most dynamic offshore wind sectors in Norway. Most mature concepts include Fred Olsen Windcarrier and Master Marine. Several new concepts are developed, most of which build on proven technology. See illustrations of the various vessels below. Fred Olsen should be mentioned especially, as this company has invested heavily in a range of offshore wind engineering firms, technology and supply chain companies including Universal Foundation and Windcarrier.

Brave Tern is one of Fred Olsen Windcarrier’s two jack-up installation vessels.

Master Marine is the owner of an offshore vessel suited for offshore wind installation.

Inwind is an offshore wind installation vessel concept.

NorWind Installer is an offshore wind foundation installation vessel concept.

Aker Solutions is collaborating with Wärtsilä for the development of an offshore wind turbine installation vessel.

Eide Marine is actively involved in the development of an innovative installation concept.

Ulstein provides cutting edge marine vessels design both for installation and O&M.

Ingenium Ventus provides innovative installation concepts for foundations and pre-assembled units.
Vest Kran, a total supplier of lifting operations, provides a special purpose docking station (Sealock) for floating turbine installations.

National Oilwell develops innovative solutions for offshore wind installations and operations.

Windflip is developing a new concept for effective installation of floating wind turbines.

Offshore Kinetics is developing a complete maintenance system for offshore wind parks, consisting of mother ship, service vessels and personnel facilities.

The Fjellstrand WindServer innovative hull design is fuel-efficient and stable, even when it is stationary.

UMOE Mandal’s Offshore Service Vessel concept is able to dock with offshore windmills in higher sea states than possible today.

Brothers AS is developing a new gangway system for better access to floating wind turbines.

As investments in installation and support vessels increase, ship yards are expected to expand into this new sector. Aker Verdal is the only Norwegian yard with offshore wind experience to date while Bergen Group is positioned to serve this market through the development of a turnkey substation solution in collaboration with Goodtech. More shipbuilding facilities could be expected to follow suit. Motivated by a possible lack of ports with large storage areas and problem-free seaward approach, ports in Norway are ready to offer facilities dedicated to offshore wind. Lutelandet and Coast Center Base are both developing offshore wind offerings.

From left to right: Aker Verdal, Bergen Group Rosenberg, Lutelandet
A few established EPC **contractors** present in Norway are already active in the offshore wind market. Those include Aker Solutions, Technip and Subsea 7 as well as several new entrants such as NorWind, Reinertsen, Odfjell Drilling and AF Gruppen. Specialised contractors such as Nexans, Technocean, Mika and Marinetrench are already present in the cable installation sector.

There are even more technology niches that are not as big as the ones defined above. These are not fully covered in this overview chapter, but all companies are listed in Appendix A1. **Communication** is an example of such a niche, in which Norwegian Norphonic is the leading provider of Heavy Duty VoIP Telephones, with over 40% of all wind turbines now relying on Norphonic to deliver essential communications and critical service continuity.

The Norwegian **consulting and engineering** sector is key to facilitate the transfer of know-how to new markets. Norwegian expertise from offshore structural design, marine geotechnics, marine operations, HSE and standardisation are employed in the global offshore wind industry. Some of the leading suppliers, including Kjeller Vindteknikk, Windsim, Multiconsult, Vissim, Tristein, NGI, Goodtech, DNV (initiated a joint industry project in 2011 to develop best practices on principles and technical requirements, as well as guidance for design, construction and in-service inspection work), SWECO, Norconsult, Storm Geo, Dr Olav Olsen and Inocean (recently formed a joint venture with ABB), have all taken position to serve the market.

### 2.5 Norwegian investors and finance providers

The Norwegian **financial community** has extensive experience from the maritime and energy industries and Norwegian banks are globally reputed within the industries. One example of this is DNB, with experience from offshore wind project financing (Lincs Windfarm in the UK and GlobalTech I in Germany) and through corporate debt (Sheringham Shoal in the UK). Both Nordea and Swedbank’s Norwegian units have also geared up to enter the market.

**Industrial and technology investors**, risk takers in the maritime and oil & gas industries, have entered the offshore wind market: Grieg, Tronderenergi Invest and Scatec have joined forces through the ownerships of Norwind Installer and OWEC Tower; Fred Olsen have invested in a large range of offshore wind companies, ranging from installation and maintenance vessels to consulting and engineering firms; newly established STRAUM is the owner of several offshore renewable energy companies, including the WindSea floater and a new jacket concept; and regional utility Lyse has a stake in the gravity based substructure developer Vici Ventus.

Also Norwegian venture capital funds have invested in the industry in companies such as AngleWind, Inwind, Chapdrive, SmartMotor and Havgul.

<table>
<thead>
<tr>
<th>Venture capital firm</th>
<th>Investee company</th>
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<tbody>
<tr>
<td>SåkornInvest Management</td>
<td>AngleWind</td>
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<tr>
<td>Northzone Ventures</td>
<td>ChapDrive</td>
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<tr>
<td>Viking Venture</td>
<td>ChapDrive</td>
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<tr>
<td>Energy Future Invest</td>
<td>ChapDrive</td>
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<tr>
<td>Statoil New Energy</td>
<td>ChapDrive and Danotek Motion Technologies</td>
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<tr>
<td>Investinor</td>
<td>ChapDrive and Havgul</td>
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<tr>
<td>Verdane Capital Advisors</td>
<td>Smart Motor</td>
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With Norway’s good financial rating, the state is able to provide very competitive long term financial backing to the export industry through the Norwegian export credit institution for export financing and GIEK, the guarantee institution. Renewable energy and offshore wind is a strategic focus area for these institutions.

2.6 Offshore wind clusters and interest groups
There are several emerging clusters and interest groups promoting offshore wind in Norway. Below is an overview of the most prominent of these groups.

Norwegian Renewable Energy Partners - INTPOW - is a public-private trade association, facilitating expansion opportunities for the Norwegian renewable energy industry. Offshore wind is a priority sector alongside hydropower and solar energy.

INNOVATION Norway is a public organisation that promotes nationwide industrial development profitable to both the business economy and Norway’s national economy, and which helps to release the potential of different districts and regions by contributing towards innovation, internationalisation and promotion.

NORWEA, the Norwegian wind energy association, is a lobby organisation actively involved in promoting onshore and offshore wind power as well as marine renewables in Norway’s domestic market.

The two leading regional industry clusters focusing on offshore wind are ARENA Now in Bergen and Windcluster Mid-Norway in Trondheim. Both are building clusters of regional offshore wind industry, Windcluster Mid-Norway also for the on-shore industry.
Many other organisations and clusters are interacting with the offshore wind supply chain, including Norsk Industri, Sogn og Fjordane Vindkraftforum, GreaterStavanger, Haugalandvekst, Agder vekst and Vindi Møre. Synergies with other industry clusters are being explored through Oslo Renewable Energy and Environment Cluster (OREEC), CleanTechMidt-Norge, NCE Maritime, Listerregionen Næringsråd and NCE NODE.

2.7 R&D - Norway emerges as an offshore wind technology platform

As part of Norway’s national R&D strategy, eleven Centres for Environment-friendly Energy Research (FME) have been established since 2008. The centres are funded by The Research Council of Norway (50%), universities (25%) and the industry (25%). Two of the FME’s, Nowitech and Norcowe, have offshore wind focus (see the figure below).

These two research centres and other important R&D organisations are presented below:

- **Nowitech** in Trondheim has an annual budget of about 40 MNOK and support research programs on wind turbine technology and equipment. The centre is currently working on six different research topics: integrated numerical design tools, new energy conversion systems, novel substructures (bottom-fixed and floaters), grid connection and system integration, operation and maintenance and novel concepts for offshore wind turbines.

- **Norcowe** in Bergen has an annual budget of about 30 MNOK that supports research on environment, wind and meteorology. The research and development is divided in the following five topics: wind and ocean conditions, offshore wind technology and innovative concepts, deployment and operation, and wind farm optimisation.
In 2010, the two FME’s have, together with Cedren (Centre for Environmental Design of Renewable Energy) and Christian Michelsen Research, joined forces to build a floating test turbine for measurements and testing offshore wind turbine components. The project is called Noweri and was granted 45 MNOK by The Research Council of Norway.

In 2008, Statkraft initiated an Ocean Energy Research Programme. The objective of the programme is to build a world leading competence network within ocean energy: offshore wind, tidal and wave energy. Statkraft funds the programme with 2.5 MEUR/year and the universities are matching the funding with own activities. The programme in total funds 30 scientific positions (PhDs, Post-Docs, and professors) at the universities.

Abroad, Statoil and Statkraft are co-founders of an Offshore Wind Accelerator initiative managed by Carbon Trust in the UK. The aim is to reduce the cost of energy by 10% by developing lower-cost solutions on access, foundations, wake effects and electrical systems.

SINTEF and MARINTEK co-operate with NTNU, IFE and several commercial players in various research projects. SINTEF is also engaged in applied research projects together with Norwegian industry with the aim to develop higher competence on serial production within offshore wind.

Technology development in Norway is financed or sponsored by the government from early stage R&D through prototyping to the development of export capabilities for the new technology.

The marine research community has excellent access to towing tanks for model testing and is deploying prototypes, either small or large scale, at various test sites.

From left to right: Hywind model testing at Marintek, Stadt Towing tank, CCB Kollsnes (simulation of 1:6 model SWAY floater), location of METCentre where Hywind is already connected (12km 15MW submarine cable laid at a depth of 200m)

http://www.carbontrust.co.uk/emerging-technologies/current-focus-areas/offshore-wind/pages/offshore-wind.aspx
3 The potential for offshore wind in Norway

3.1 Technical potential and specificities of Norway’s site conditions

The Norwegian offshore wind resource is among the best in Europe. The theoretical potential for offshore wind in Norwegian waters has been estimated to be nearly 14,000 TWh per year of which nearly 1.300 on depths between 60-300 meters.

The offshore wind resources in Norwegian waters was mapped in 2010 as part of a spatial planning and pre-selection of offshore wind areas carried out by Norwegian Water Resources and Energy Directorate (NVE)4. The review was based on a systematic assessment of environmental and human constraints (fisheries, shipping, aviation etc). The combined potential capacity of these areas range up to 12 GW.

The wind resources in Norwegian offshore areas are excellent, with the highest wind speeds north of Scotland and west of Stadt. The Norwegian maritime zone is largely characterized by a high degree of variation within water depths. Water depth tends to increase rapidly with the distance to the coast. Norway’s offshore wind potential is therefore located in deep waters compared to other European commercial prospects located at 35-40 meters water depth. Deep water close to shore provides many sites well suited for demonstrator projects. Sheltered deep water fjords provide a natural asset for inshore assembly of substructure, tower and rotor. Only a few attractive large scale sites are located near shore in shallow waters and suited for mature and economically viable technologies, such as bottom-fixed foundations5. A vast potential lies in the Southern North Sea, with water depths of 50-70 m in vicinity of existing oil and gas facilities. This area will be particularly relevant if a transnational offshore grid expands throughout the North Sea, and synergies with the electrification of offshore oil and gas infrastructure are triggered.

An illustration of both the wind resources and the water depths is shown below.

![Wind Resources](image1)
![Water Depths](image2)

3.2 Policy and planning framework in Norway

In December 2012, Norway formally agreed a binding 2020 target of 67.5 % renewable energy with the EU commission. This target is the highest in EU by far and a result of the role of the...
hydropower supply in the Norwegian power mix. New generating capacity will nevertheless be needed to reach the target and small hydropower and onshore wind are expected to be dominating sources for the added production under the common support scheme with Sweden (total 26.4 TWh).

In March 2010, The Norwegian Government approved a new act and a strategy for offshore renewable energy. It is intended to provide a regulatory framework for offshore wind plants, and to give direction for the support needed to make offshore wind power an important part of Norwegian energy industry. The Ministry of Petroleum and Energy (MPE) will pre-qualify and open specific areas for development of offshore wind power. Accompanying regulations have not yet been established.

In 2010, Norwegian Water and Energy Directorate (NVE) carried out a preliminary study identifying a preliminary selection of 15 potential offshore wind development areas. This work is now taken further with a Strategic Environmental Assessment with the aim to range the attractiveness of each area. An assessment of technology and economic trends was also performed to support a comparison and attractiveness ranking of the 15 areas. Roughly, the zones can be divided into three categories, two of which present challenging physical characteristics including deep waters and great distance to shore. The third category seems to align with current project trends. The figure below shows the proposed Norwegian zones categorized and mapped relative to the European project pipeline.


The proposed Norwegian zones categorized and mapped relative to the European project pipeline

3.3 Current and expected financial support for offshore wind

As of 1 January 2012, Norway and Sweden established a common market for green certificates, based on the Swedish system established May 2003. The market expansion is expected to increase competition and energy price stability. However, the green certificate system will not be sufficient to fund offshore wind projects. It is not clear if, how and when Norway will provide any tailor-made support scheme to finance electricity generation from offshore wind. The development of
commercial offshore wind projects is thus not part of the short-term focus in Norway, although various deep water demonstrators, both bottom-fixed and floating, are going ahead.

3.4 Offshore wind projects in Norway
To date, five 10 MW offshore demonstration projects have been granted license and several onshore test sites are under development in order to demonstrate new offshore turbine technology. Recently, consent was granted for SWAY’s 10 MW offshore turbine (see Appendix A2 for an overview).

As of March 2012 only Hywind, the 2,3 MW floating wind demonstrator developed and operated by Statoil since 2010 have been commissioned. Since Havsul 1, with 350 M W, received a licence in 2009 most early stage projects have been frozen and the permitting processes put on hold due to an ongoing review of the planning and regulatory framework. Briefly summarised, there is few large scale projects planned in Norwegian waters in the near future (see Appendix A2 for an overview).
APPENDIX

A1. Norwegian companies active in offshore wind
A2. Norwegian offshore wind projects
A3. Key Norwegian developers and utilities involved in offshore wind
A4. Key public bodies / institutions
## A1. Norwegian companies active in offshore wind

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A2. Norwegian offshore wind projects

Demonstrator projects
Enova give grants to offshore R&D projects that meets the eligibility criteria’s: Demonstration in real conditions and energy production (i.e. not laboratory tests or test of components), License and other public permissions granted, operation phase minimum one year. Onshore and offshore demonstration facilities will play a key role in developing the technology for offshore wind in Northern Europe. Hywind is the only Norwegian demonstrator under operation to date; six more have been consented while two additional projects are under development or consenting. The planned demonstration projects in Norway are shown below.

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</tbody>
</table>

Commercial projects
As of today, Norway has no commercial scale projects under operation and only one project has been fully consented. Several projects have been notified to NVE. Many of the projects already proposed by developers are located within the predefined areas from the Governmental group. The list below is compiled from NVE’s public available information.

<table>
<thead>
<tr>
<th>Project</th>
<th>Developer</th>
<th>Capacity (MW)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aegir</td>
<td>Fred Olsen Renewables</td>
<td>1200</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Fosen Offshore - Phase 2</td>
<td>Offshore Vindenergi</td>
<td>300</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Fosen Offshore - Phase 3</td>
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<td>Concept/Early planning</td>
</tr>
<tr>
<td>Gimsøy</td>
<td>Lofotkraft Vind</td>
<td>250</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Havsul I</td>
<td>Vestavind Offshore</td>
<td>350</td>
<td>Approved</td>
</tr>
<tr>
<td>Havsul III</td>
<td>Havgul Vindenergi</td>
<td>300</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Idunn</td>
<td>Fred Olsen Renewables</td>
<td>1200</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Lofoten</td>
<td>Lofotkraft Vind</td>
<td>750</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Mørevidn</td>
<td>TrønderEnergi Kraft</td>
<td>1200</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Selvær</td>
<td>Nord-Norsk Vindkraft</td>
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<td>Concept/Early planning</td>
</tr>
<tr>
<td>Siragrunnen</td>
<td>Sirragrunnen AS</td>
<td>200</td>
<td>Under consenting</td>
</tr>
<tr>
<td>Southern North Sea</td>
<td>Lyse Produksjon AS</td>
<td>1000</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Statvind</td>
<td>Vestavind Kraft AS</td>
<td>1080</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Steinsham</td>
<td>Offshore Vindenergi AS</td>
<td>105</td>
<td>Concept/Early planning</td>
</tr>
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<td>Utsira Phase 2</td>
<td>Lyse Produksjon AS</td>
<td>280</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Project</td>
<td>Developer</td>
<td>Capacity</td>
<td>Stage</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------</td>
<td>----------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Vannøya I</td>
<td>Troms Kraft Produksjon</td>
<td>75</td>
<td>Concept/Early planning</td>
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<tr>
<td>Vannøya III</td>
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<tr>
<td>Vannøya III</td>
<td>Troms Kraft Produksjon</td>
<td>600</td>
<td>Concept/Early planning</td>
</tr>
<tr>
<td>Ægir</td>
<td>Havgul Clean energy</td>
<td>1000</td>
<td>Concept/Early planning</td>
</tr>
</tbody>
</table>

### A3. Key Norwegian developers & utilities involved in Offshore wind

- **Agder energi**  - [http://www.ae.no](http://www.ae.no)
- **Fred Olsen Renewables**  - [http://www.fredolsen-renewables.no](http://www.fredolsen-renewables.no)
- **Havgul Clean Energy**  - [http://www.havgul.no](http://www.havgul.no)
- **Lofokraft Vind**  - [http://lofotkraft.no](http://lofotkraft.no)
- **Lyse Produksjon**  - [http://www.lyse.no](http://www.lyse.no)
- **Nordnorsk Havkraft**  - [http://www.nordnorskhavkraft.no](http://www.nordnorskhavkraft.no)
- **Nord-Norsk Vindkraft**  - [http://eng.nnvind.no](http://eng.nnvind.no)
- **OceanWind**  - [http://www.oceanwind.no](http://www.oceanwind.no)
- **Statkraft**  - [http://www.statkraft.no](http://www.statkraft.no)
- **Statnett**  - [http://www.statnett.no](http://www.statnett.no)
- **Statoil**  - [http://www.statoil.com](http://www.statoil.com)
- **Sunnfjord Energi**  - [http://www.sunnfjord-energi.no](http://www.sunnfjord-energi.no)
- **Troms Kraftproduksjon**  - [http://www.tromskraft.no](http://www.tromskraft.no)
- **TrønderEnergi**  - [http://www.tronderenergi.no](http://www.tronderenergi.no)
- **Vardar**  - [http://www.vardar.no](http://www.vardar.no)
- **Vestavind Offshore**  - [http://www.vestavindoffshore.no](http://www.vestavindoffshore.no)

### A4. Key public bodies / institutions


The principal responsibility of the Ministry of Petroleum and Energy is to achieve a coordinated and integrated energy policy. The MPE will pre-qualify and open specific areas for development of offshore wind power. It is expected that the MPE will open offshore wind farm tenders for these areas. Project owners will then apply for licence within the pre-defined areas for offshore wind power. The MPE will be authorized to issue fines if the project owner does not fulfil the requirements set in the license, or other provisions following from the Act described above.

**Norwegian Water Resources and Energy Directorate (NVE) - [http://www.nve.no](http://www.nve.no)**

NVE is a directorate under MPE, and manages the country’s water and energy resources. NVE is the licence and regulatory authority.

**Statnett - [http://www.statnett.no](http://www.statnett.no)**

Statnett is main onshore national grid owner, grid operator and grid regulator. Statnett competes with other private companies regarding the development, ownership and operation of offshore grid connection and transmission. Statnett’s roles related to connections of offshore wind farm to the National grid is not yet defined.

**Innovation Norway - [http://www.invanor.no](http://www.invanor.no)**

Promotes nationwide industrial development profitable to both the business economy and Norway’s national economy, and helps release the potential of different districts and regions by contributing towards innovation, internationalization and promotion. Offshore wind is one of the priority areas within the energy and environment field. This implies that small and medium companies offering innovative products and services related to offshore wind will be prioritized.

**The Research Council is Norway - [http://www.forskningsradet.no](http://www.forskningsradet.no)**

The Research Council is Norway’s official body for the development and implementation of national research strategy. The Research Council provides support for research and development activities. Funding is available to the private sector and research institutions alike. The objective of the
RENERGI programme is to develop knowledge and concepts within renewable energy. Focus areas are environmentally sound, economic and rational management of Norway’s energy resources, reliability of supply and competitive business development.

**Enova** - [http://www.enova.no](http://www.enova.no)
Enova SF was officially created on June 22, 2001 and became operational on January 1, 2002. Enova SF is a public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy. Enova SF’s main mission is to contribute to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals. Enova SF advises the Ministry in questions relating to energy efficiency and new renewable energy. Enova grant subsidies for renewable electricity generation such as technology development offshore.

**INTPOW** - [http://www.intpow.no](http://www.intpow.no)
INTPOW is a non-profit organisation and established in cooperation between the Norwegian Authorities and the Norwegian renewable industry business. Norway seeks to strengthen the long-term perspective on value creation and employment within its energy sector. This will be done through internationalisation of Norwegian technology in a competitive renewable energy market.

**Investinor** - [http://www.investinor.no](http://www.investinor.no)
Investinor is a government funded venture firm. Investinor invest in internationally oriented and competitive Norwegian companies in the early growth and expansion stages. Investinor has invested in Havgul Clean Energy, the wind power project developer behind Havsul 1 and Siragrunnen offshore wind projects.

**Eksport Finans** - [http://www.eksportfinans.no](http://www.eksportfinans.no)
Eksportfinans is the Norwegian export credit institution for Export Financing. Owned by banks and the Norwegian Ministry for Trade and Industry, it is the sole and exclusive operator of the government supported export financing in Norway. It offers competitive long term financing to the export industry. Renewable energy and offshore wind is a new strategic focus area.

**GIEK** - [http://www.giek.no](http://www.giek.no)
GIEK offers guarantees in connection with Norwegian export and investments abroad. Guarantees are issued on behalf of the Norwegian state. GIEK works hand in hand with Eksportfinans to offer competitive financing to the export industry. Renewable energy and offshore wind is a new strategic focus area.
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