Blue Growth

Scenarios and Drivers for Sustainable Growth from the Oceans, Seas and Coasts

Maritime Sub-Function Profile Report
Offshore Wind Energy (3.2)

Call for tenders No. MARE/2010/01

Client: European Commission, DG MARE

Rotterdam/Brussels, 13th August 2012

The research for this profile report was carried out in the period April – August 2011. This report has served as an input to the main study findings and these have been validated by an Expert meeting held on 9/10th November 2011 in Brussels. The current report serves as a background to the Final Report on Blue Growth.

Contents

1 State of Play

1.1 Description and value chain

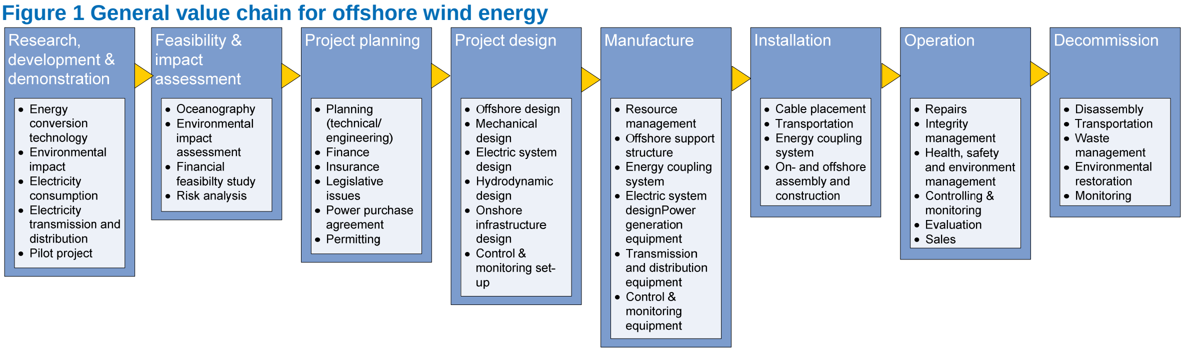
Offshore wind energy refers to the development and construction of wind farms in marine waters, and the conversion of wind energy into electricity. The advantage of constructing wind farms offshore is that the wind speeds are higher, and that there is less competition for space with other user functions than on land (though competition is far from absent). Additionally, the more uniform wind speeds mean less wear and tear for the turbines. On the other hand, the offshore environment and climate is harsher than on land, due to the high wind speeds, waves and the salty environment. This increases the relative risks for set-up, as well as the costs of exploring and developing the necessary technology.

So far, offshore wind is the cheapest, and most mature of the offshore renewable energy technologies.[1] It has been the front-runner since the 1990s. Various types of efforts have been undertaken to cope with the different water depths and seabed conditions in which these offshore wind farms are operating (see chapter 2).

Compared to offshore wind energy, being the most developed of the offshore renewable technologies, it is still an industry in its infancy. There is ample room for improvement both in terms of technology, public acceptance and market environment, making it an intriguing and potentially profitable area for new ventures.

In the value chain, all relevant elements and activities in the whole sector of offshore wind energy are depicted. The value chain as portrayed here, coincides to a great extent with the stages that the installation of an offshore wind energy project follows. However, a value chain is aiming at creating insight in all activities and types of employment that is associated – both directly and indirectly – with all elements in an industry or sector. A common value chain for offshore wind energy can be visualised as follows:

Figure 1 General value chain for offshore wind energy



1.2 Description of the current structures

The technical background information

The fundamental working principle of a wind turbine is that it converts the kinetic energy stemming from wind power into electrical energy. In this principle, the offshore turbines are comparable to

[1] Please compare also categorisation in final report as growth stage maritime economic activity and compared to Ocean Renewable Energy, for instance.

onshore models. Despite the fact that a number of designs have been used, only one system has been commercially successfully implemented onshore and offshore to date, i.e. the three bladed upwind horizontal axis wind turbine. In view of other designs currently being developed such as vertical axis and two bladed upwind horizontal axis wind turbines, the horizontal design is expected to dominate the market for at least the next 10 years.

The turbine captures the wind energy with three blades, which in principle work like a propeller in reverse. The rotational energy is transferred via a shaft to a gearbox to increase the relatively slow rotation of the blades. The gearbox is connected to an electrical generator which converts the kinetic energy into electrical energy which is then transformed to a higher voltage to be suitable for grid injection. Research aims, a.o., at reducing the number of moving parts in the gearbox, extending the lifespan of equipment.[2] Some wind turbine developers (like Siemens) even intend to remove the gear box and use a permanent magnet instead. This principle is called direct drive. In 2011, Siemens installed the first prototype of its 6 MW offshore wind turbine with direct drive technology.[3]

Another development is related to the flexibility of the blades. Due to the large surface of the blades, the rotor blade will “feel” different wind speeds at different heights Therefore, to make them operate optimally, the blades should be able to bend and move like the wing of a bird according to the wind speed and turbulence.

The corrosive environment offshore and the high levels of moisture in the air would lead to electrical and mechanical problems and places some impediments to use onshore designs for offshore without further technical modifications. Therefore modern offshore turbines use air conditioning systems to protect the sensitive electronics inside the unit and protective paint to protect the steel structures.

Currently, there are a number of offshore wind turbines available to the market with Siemens being the current market leader with its 2 and 3 MW class units. Vestas has introduced a new 3MW design which is highly attractive to the offshore market. Currently, first-of-its-kind large scale projects (up to 400 MW offshore wind parks) with turbines in the 5-6 MW class are being installed in .e.g. Belgium and Germany. Research on up-scaling the wind turbines themselves is ongoing and focussing also on the increase of the capacity of each turbine, e.g. towards wind turbines with a capacity of up to 10 MW.

Foundations can be divided into to six types: 1) monopile, 2) ‘multipile’ (tripile and tripod), 3) gravity base, 4) jacket, 5) suction cup and 6) floating foundations.

While each of the aforementioned designs is valid in their own right, only three are expected to be suitable for deeper water (typically more than 20m for wind farms currently under construction). Other foundations are for non-homogeneous soil conditions – these are ‘multipile’, jacket and floating foundation designs. Current first large scale deployment projects in deeper waters (40m) indeed use tripod, tripile and jacket foundations while gravity foundations for these depths still have to be demonstrated as a valid alternative. Research aims at enhanced installation and construction techniques, enabling installation in deeper parts of the sea so that more parts of the marine environment can be exploited[4], and floating wind turbine systems[5]. Alternative solutions could be

[2] E.g.: http://www.northernpower.com/community-wind/community-wind-theme-gearbox-problem.php

[3] From the demand side, Siemens products are perceived to be currently stronger for higher-wind-speed sites, whereas Vestas will be preferred supplier for development sites with lower average speeds. Further reading: “Swedish eyeing Malta for world’s largest floating wind farm”. Available at: http://www.independent.com.mt/news.asp?newsitemid=141855 Last accessed on 9th July 2012.

[4] Stancich, R, 29 November 2010. GeoSea: New technology drives down turbine foundation installation costs. *Wind EnergyUupdate*

the development of multi-use offshore platforms[6]. The latter could provide important synergies with other maritime economic activities, .e.g. offshore oil & gas but also short-sea shipping and coastline tourism using the platforms to recharge fuel or electric energy.

In terms of installation of offshore turbines, three types can be distinguished, for which particular technological solutions apply:[7]

- Near shore installations requiring more traditional onshore turbines with a maximum capacity of 2-3 MW
- Deep-sea installations in bigger distance to the shore lines for which offshore turbines with a capacity of 5 MW are best suited and
- Larger distances to the coastline which favour floating wind foundations, as currently developed in Malta, for instance

One challenge in the further roll-out of offshore wind is the grid connection. In a typical set-up of an offshore wind farm connection to shore, each turbine is connected to each other (via interarray cables) and then to the offshore substation before it is connected to an onshore substation via an export cable. The installation process requires specialised marine equipment for the installation of the substations itself as well as the interarray cables and export cable. Recent technical developments are – amongst others - pointing towards the installation of a “Super grid”[8] in combination with a smart grid system. First projects demonstrating building blocks for the modular development of an offshore grid (HVDC technology; offshore multi connector platforms; combined interconnector and wind electricity generation) are in the design phase and will be implemented by 2015-2016.

Performance of the maritime economic activity to date

The cost curve within the sector of offshore wind displays a comparable sound cost-reduction effect. Within the past 20 years, the sector experienced a 70% reduction in the procurement costs of offshore wind turbines. Even taking into account that future offshore wind farms will be located further offshore and in deeper waters, the evidence appears to be positive.

The sector itself has been estimated to have the potential to contribute around € 70 bn to the construction and operation sectors linked to the wind energy industry within the next 30 years, according to a study carried out in 2006.[9]

Despite the predicted scenario, the evidence of the past few years has not entirely justified the optimism. According to an investigation by EWEA in 2011, costs in the onshore wind power sector were on a decreasing trend until 2004. Subsequently, due to factors such as the increasing cost of materials and a strong demand for wind capacity, prices stopped their decreasing trend. This was largely due to the under-capacity of manufacturers and sub-suppliers. Although the offshore wind energy sector is similar to the onshore sector in terms of demand for materials, market etc, there is insufficient data available to draw similar conclusions for the offshore sector. This is due to the fact that the number of completed projects is limited, and that there is a large spread of investment costs which makes the proportion of returns difficult to assess. Based on existing evidence, however, EWEA anticipates that the manufacturing capacity constraints will be addressed by 2011,

---

[5] Lee, K.H. (2005) Floating wind turbines, special report for the 20th Workshop on Water Waves and Floating Bodies – Spitsbergen, Norway

[6] http://cordis.europa.eu/fp7/energy/home_en.html

[7] Schiff & Hafen, 2012: Report: “Interdisziplinaeres Networking fuer effiziente und nachhaltige Offshore-Operationen. January 2012. Page 63.

[8] See also: http://www.friendsofthesupergrid.eu/

[9] National Renewable Energy Laboratory: Musial, B, Butterfield S, Ram B, 2006: Energy from Offshore Wind. Conference Paper. NREL/CP-500-39450. February 2006: Accessible at: http://www.nrel.gov/wind/pdfs/39450.pdf

allowing for competition between manufacturers, as well as the accompanying unit reductions in costs.

For PWC (2011), the main question is whether or not offshore wind energy will eventually be cost-effective enough to compete with fossil fuel energy sources without government subsidies. The main measures of this can be divided into three categories; capital expenditure, operating expenditure, and final cost of energy. According to the ADORET report by IEA-RETD (2011), from a combination of sources, it appears that offshore wind energy is at present (at least) twice as expensive as onshore wind energy, in terms of all three measures. Nevertheless, it is approximately three times less expensive than wave or tidal energy, which can be related back to its Technology Readiness Level (TRL). Offshore wind energy is measured at 9, which indicates that it has been launched in terms of operational projects, even if currently at a small scale. This is particular significant in comparison with wave and tidal energy, both of which are not currently operational, but are at the systems testing or pilot stage. Offshore wind energy does not only appear to be the most financially lucrative offshore energy technology to date, it also entails R&D activities that are placed further up the value chain for energy creation.

Total wind power capacity in 2010 was 84 GW, of which 3 GW was installed offshore[10] [11]; by the end of 2011, almost 4 GW was installed[12]. For wind energy overall (offshore and onshore), wind turbine and component manufacturing provides most employment (43,000 in 2007), followed by wind farm development, installation, operations and maintenance (29,000 employed in 2007), while there were found to be another 15,000 jobs elsewhere in the value chain.[13] Out of these some 7,000 were related to offshore wind activities (figure 2007). [14] In 2011 alone, 866 MW offshore capacity was added, 9% of all new wind capacity – a volume comparable to 2010. However the investments related to the installation of offshore wind were comparably high: € 2.4 bn in 2011 alone, or 19% of all investments in the wind sector. [15]

In the period 2007-2010, overall employment in the wind energy sector has been growing by nearly 30% a year and the overall number of fte's directly working in the wind energy sector has been claimed to be as high as 135.000 jobs in 2010. [16] Measuring the employment in offshore-related employment is more difficult, as many companies provide services both onshore and offshore, but the same sources estimate this number to be around 35,000.

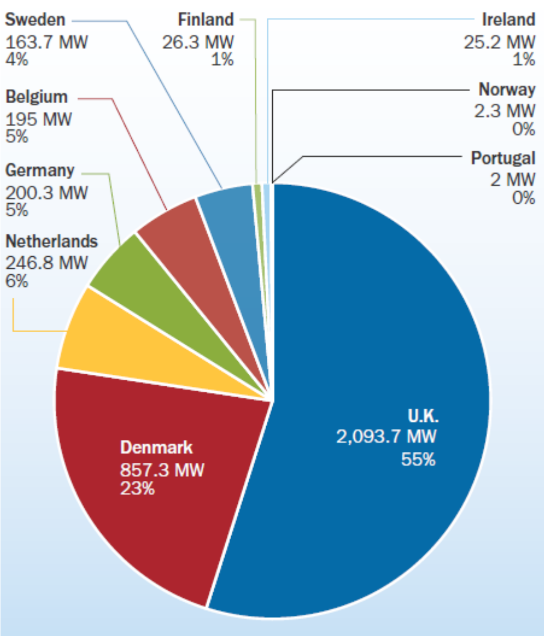
A total of 1,136 offshore turbines were installed and grid connected in European waters by mid 2011, bringing total installed capacity in Europe to 2,946 MW spread across 45 wind farms in nine countries. The offshore wind capacity installed by the end of 2010 will in a normal year produce 11.5 TWh of electricity. In 2010 Thanet in the UK became the biggest offshore wind farm in the world with a capacity of 300 MW installed.[17] Thanet follows the Horns Rev 2 in Denmark which was the biggest offshore wind farm with a capacity of 209 MW in 2009. The third biggest offshore wind farm is also in Danish waters, and was connected to the grid in 2010 - Rødsand 2 with a capacity of 207 MW.

Other sources indicate that the costs for offshore wind could be reduced by further investments into floating wind foundations. The latter can deliver wind power much more frequently, due to the fact

[10] EWEA, 2012. Green Growth The impact of wind energy on jobs and the economy
[11] EWEA, 2010. Wind in power
[12] EWEA, 2011, Wind in our sails
[13] EWEA, 2009, Wind at work, p.8.
[14] EWEA (2009), Wind at Work, p.9
[15] EWEA (2011), Wind in Power, 2011 European statistics, p. 5.
[16] EWEA (2012) Green Growth, p. 36.
[17] http://www.guardian.co.uk/environment/2010/sep/23/thanet-windfarm-bright-future-green-industry

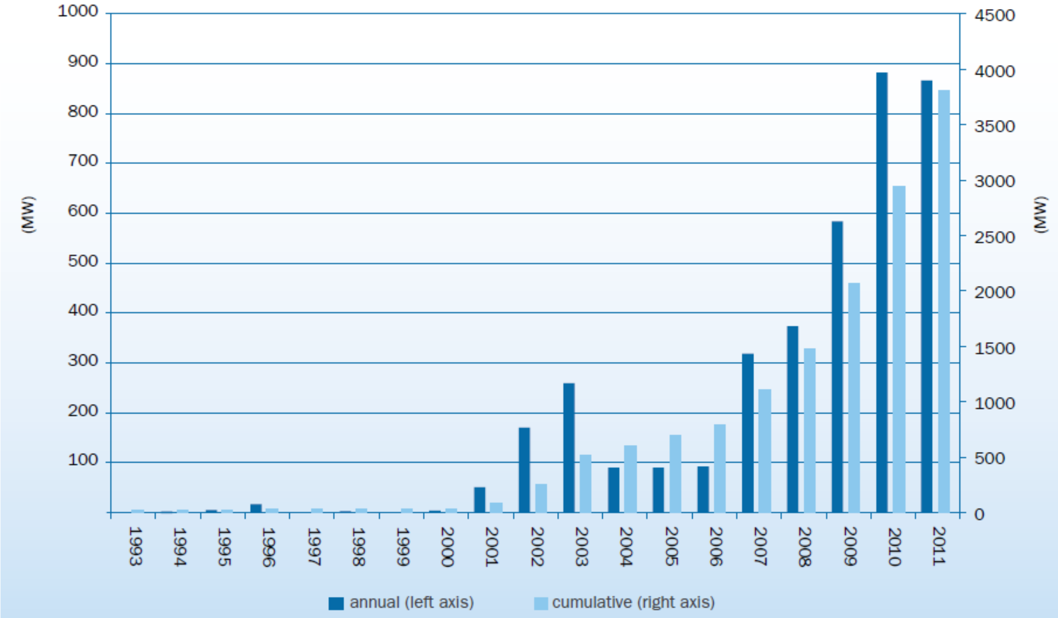
that they can be anchored within 30 minutes and rotate 360 degrees. Hence, they're less dependent and fixed towards a certain wind environment.[18]

Figure 2. Installed capacity: cumulative share by country in MW (2011)



Source: EWEA, 2012: The European offshore wind industry key 2011 trends and statistics. Page 10

Figure 3. Cumulative and annual offshore wind installations in MW (2011)



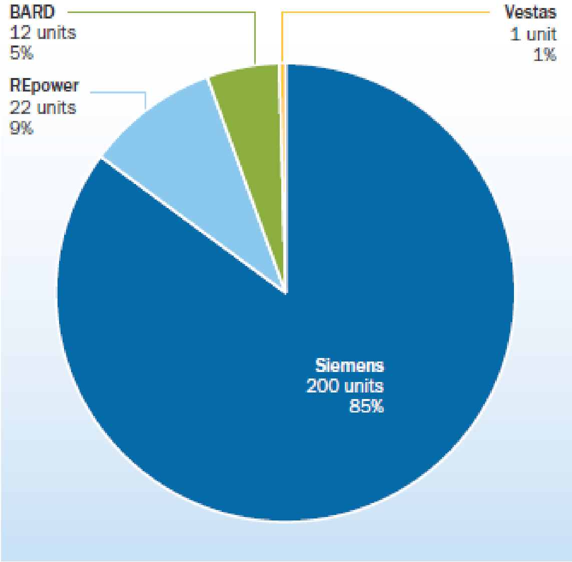
Source: EWEA, 2012: The European offshore wind industry key 2011 trends and statistics. Page 9

Offshore wind business clusters in Europe can be found in Denmark and Germany. Because the national governments of those Member States included (offshore) wind energy in their national renewable energy strategies, vast amounts of wind energy capacity were installed. This created a niche market for companies headquartered in Denmark and Germany (e.g. Vestas, Siemens Wind Power, Enercon and many smaller companies working in other parts of the value chain). Today, such clusters can be found, amongst others, in Esbjerg and Nakskov in Denmark, and

[18] As confirmed by a recent article in the Malta Independent News. Further reading: "Swedish eyeing Malta for world's largest floating wind farm". Available at: http://www.independent.com.mt/news.asp?newsitemid=141855 last accessed on 9th July 2012.

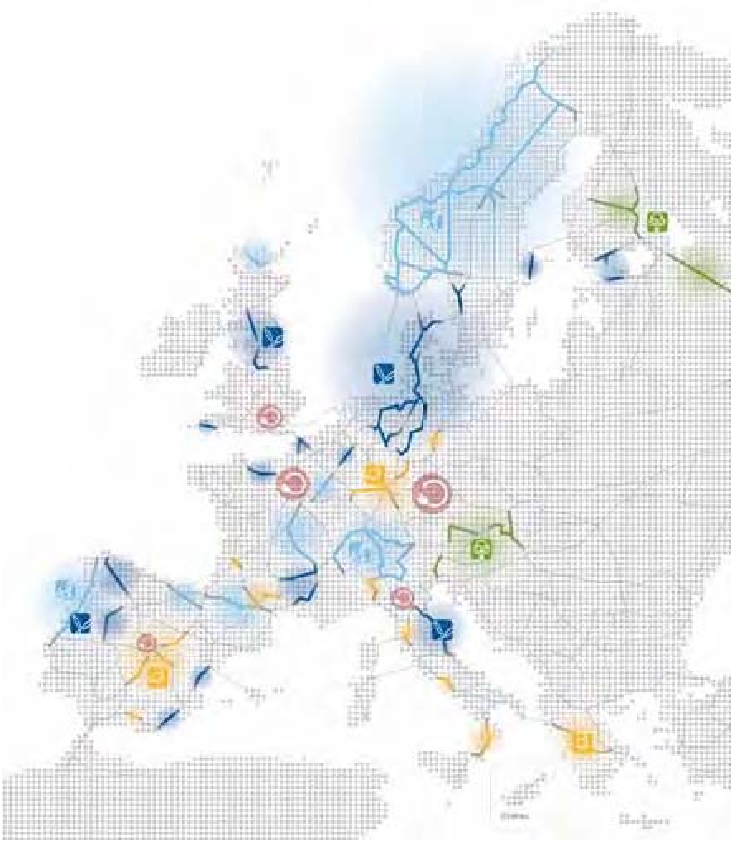
Bremerhaven and Schleswig-Holstein in Germany. These clusters have a strong positive effect for the local economy. [19]

Figure 4: Wind turbine manufacturers: share of 2010 grid connected turbines (units)



Source: EWEA, 2012: The European offshore wind industry key 2011 trends and statistics. Page 7

The map beneath illustrates the current role of renewable energy sources in a fragmented power system. After hydro, wind is the largest renewable power generation source, accountable for around 4.8% of EU electricity demand. Wind energy already has a considerable share in the Northern German, Danish power systems as well as in Portugal and Spain notably.



Source: EWEA Nov 2010

[19] EWEA, 2009. Wind at Work.

The only non-European installations in 2010 have been in China and Japan. China now has an installed capacity of 102 MW and Japan 15.32 MW. Substantial future developments outside of Europe can be expected in China, Japan, the US, Canada, South Korea and Taiwan

1.3 Regulatory environment

1.3.1 European legislation

The most important European regulations regarding offshore wind energy are listed below:

- Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment
- Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.
- Council Regulation (EU, Euratom) No 617/20101 of 24 June 2010 concerning the notification to the Commission of investment projects in energy infrastructure within the European Union and repealing Regulation (EC) No 736/96
- Regulation (EC) No 663/2009 of the European Parliament and of the Council of 13 July 2009 establishing a programme to aid economic recovery by granting Community financial assistance to projects in the field of energy
- Commission Regulation (EU) No 838/2010 of 23 September 2010 on laying down guidelines relating to the inter-transmission system operator compensation mechanism and a common regulatory approach to transmission charging
- Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC
- Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity repealing Regulation (EC) 1228/2003
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
- Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 concerning greenhouse gas emission trading systems. This Directive states that at least 50% of the proceeds from the auctioning of allowances should be used amongst others, to develop renewable energies (to achieve the 20% renewable energies target by 2020). In addition, it states that: *"to accelerate the demonstration of the first commercial facilities and of innovative renewable energy technologies, allowances should be set aside from the new entrants reserve to provide a guaranteed reward for the first such facilities in the Union for tonnes of CO2 stored or avoided on a sufficient scale, provided an agreement on knowledge-sharing is in place."*
- In November 2010, the European Commission published its communication "Energy infrastructure priorities for 2020 and beyond – A blueprint for an integrated European energy network" (EC, 2010). The communication outlines four priority corridors for electricity including "offshore grid in the Northern Seas and connection to Northern as well as Central Europe". The European Commission aims to publish in 2011 a legislative proposal for a revised Trans-European Network (Energy) Instrument in the form of a new "EU Energy Security and Infrastructure Instrument" and guidelines for an improved cost allocation for crossborder transmission including the facilitation of permitting procedures.

The Strategic Energy Technology Plan (SET-Plan) published by the European Commission in November 2007, aims at increasing, coordinating and focusing EU support on key low-carbon energy technologies, such as wind power. The implementation of the SET-Plan started with the establishment of the European Industrial Initiatives (EIIs)[2] which bring together industry, the research community, the Member States and the Commission in risk-sharing, public-private Partnerships aimed at the rapid development of key energy technologies at European level. In parallel, the European Energy Research Alliance (EERA) has been working since 2008 to align individual R&D activities to the needs of the SET-Plan priorities, and to establish a joint programming framework at the EU level. The envisaged budget for the SET-Plan has been estimated at up to €71.5 billion, of which just €6 billion are earmarked for the wind energy sector.

Table 1: European funding related to Offshore Wind

Source of funding	Programme	Finance instruments	Geographical scope	Type of projects
EBRD	Technical Cooperation Funds Programme (TCFP)	Grant co-financing	EBRD countries	Pre-development phase
EC	Intelligent Energy Europe (IEE)	Grant support	Member States, Norway, Iceland, Liechtenstein and Croatia	Capacity building
EC	European Regional Development Fund and Cohesion Fund	NA	Member States	Installation investments
EIB	NA	(Framework) loans	Member States	Installation investments
EC	European Local Energy Assistance (ELENA; part of IEE)	Grant support	Member States, Norway, Iceland, Liechtenstein and Croatia	Technical assistance and project development
EC	Seventh Framework Programme Energy (FP7)	Grant support	Member States	RD&D
EC	EU Recovery Programme	Grant support	Member States	Investments in installations
EBRD	Sustainable Energy Initiative (SEI)	Credit lines, long-term debt financing and equity investments	EBRD countries	Installation investments
EC	Entrepreneurship and Innovation Programme (EIP)	Venture capital and guarantees	Member States, Norway, Iceland, Liechtenstein and candidate countries for EU enlargement	Early and expansion stage companies

1.4 Strengths and weaknesses of the maritime economic activity

- Strengths of this maritime economic activity in a global perspective:
  - High theoretical energy potential
  - Many opportunities for synergy with the experienced offshore value chain

- Lack of dominant players on the offshore wind energy market, providing niche market opportunities
- Savings on fuel costs: according to EWEA (April 2012), in 2010 wind power avoided €5.71 billion in fuel costs to produce electricity.
- Recent developments in 2010 point to an increased capacity of the sector to attract new investors, both from the banking sector and from pension funds (EWEA 2011b)
- An ambitious sector, supported (though in a variable degree) by politics

- Weaknesses of this maritime economic activity in a global perspective:
  - The energy sources of this maritime economic activity are less predictable than many conventional sources
  - Technological development still required to overcome the problems that come with the harsh marine environment and the depth of the sea
  - Offshore wind generally has a higher proportion of jobs classified as "high-skilled" than the economy at large. Companies are finding these positions difficult to fill
  - Difficult regulatory framework and permitting processes (red tape). The EU average for the administrative lead time of an offshore wind energy project is 18 months. Mentioned here as a weakness, because this is a long time, it is much shorter compared to onshore wind energy (42 months), according to the surveys submitted to the WindBarriers project. A possible explanation for the shorter building consent time is that the six countries in the survey seem to have developed efficient and streamlined decision-making processes, including Maritime Spatial Planning (MSP) (EWEA July 2010)
  - Lack of public awareness on the benefits of offshore wind turbines
  - High unit price (in terms of EUR/kWh as compared with traditional electricity sources) at present state of development. [20]

Besides the weaknesses, some constraints likely place some obstacles to the further development of the sector:

- Constraints for economic growth
  - Other uses of the sea area may limit the potential for offshore wind developments, e.g. shipping routes, military use of offshore areas, oil and gas exploration, and tourist zones (EEA 2009) as well as fisheries.[21]
  - For the sea space with a maximum of 10 km from the coastline, the visual impact of wind turbines on local residents and tourists is significant, as the wind farms can be seen from the coast. Based on that, it is assumed that in practice only 4 % of the offshore area in the 0–10 km class might be available for developing wind farms. In the sea areas between 10km to 30 and 30km to 50km respectively from the coast, it is assumed that spatial planning and social limitations will be relatively smaller, hence 10 % of the areas are assumed to be used for wind farms (EEA, 2009). Even with these restrictions, this amount of electricity from wind would be sufficient to fulfill about 78% of the projected electricity demand in Europe in 2030 (5100 TWh).

---

[20] Potential cost reductions per unit price are expected from the further development of floating wind platforms due to the following advantages: First, the constraints imposed by coastline tourism actors and local residents are less manifest due to less visual aspects. Second, floating wind farms allow for repairs in the port, rather than out at the sea, which will considerably reduce the maintenance costs involved. Thirdly, the environmental impacts are perceived to be less than compared to closer to the shore installations. Further reading of Guardian Article 23rd April 2012: US and UK to collaborate on 'floating' wind turbines: http://www.guardian.co.uk/environment/2012/apr/23/us-uk-floating-wind-turbines (last accessed 9th July 2012)

[21] The latter being mentioned by a few interviewees on the cluster report on Ireland (see separate Annex and Chapter 6.2. of the Final Report).

- Technical and financial capacity to harness offshore wind in deep waters of 60 to 100 meters often located far off the coastline: a technological upgrade of wind turbines towards floating foundations will be needed to harness wind power in deep waters that are currently off-limits to conventional turbines. This requires huge investments also from public sources.[22] A recent example is provided by the UK, where the Energy Technologies Institute will commission £25m offshore for a wind floating system demonstrator, which will require the selected technology company to produce an offshore wind turbine that can generate 5MW to 7MW by 2016. The project is suggested to demonstrate off the Cornish coast at the WaveHub site.[23]
- Lack of infrastructure and transmission/distribution capacity. There are still technical and financial challenges in grid connection and integration. Considerable investments will be required in onshore and offshore grid infrastructure in order to accommodate for the large expected expansion in variable generation capacity from offshore renewable energy projects. There is a limited range of suppliers for high voltage subsea cables due to high investment costs and long lead times for new capacity. Without increased capacity in manufacturing, a shortage of high voltage (HV) subsea cables is likely[24]. Further to that, adequate ports facilities will need to be adapted to the needs of the sector. This in turn will require new types of supporting vessels.
- Dependency on public funding rather high in terms of market developments towards more floating wind foundations.[25]

---

[22] See also 2.2. of this report on the European Energy Programme for recovery and the "New Entrants Reserve" earmarked also for floating foundations

[23] http://www.guardian.co.uk/environment/2012/apr/23/us-uk-floating-wind-turbines

[24] EWEA (2011) Wind in our sails

[25] As illustrated in the case of Malta with its expected 460-metres diameter floating wind farm. Albeit the private nature of the project, the investor Hexicon makes further investments of the magnitude in other countries, e.g. Cyprus and Sweden dependent on co-funding from the EU. Further reading: "Swedish eyeing Malta for world's largest floating wind farm". Available at: http://www.independent.com.mt/news.asp?newsitemid=141855 last accessed on 9th July 2012.

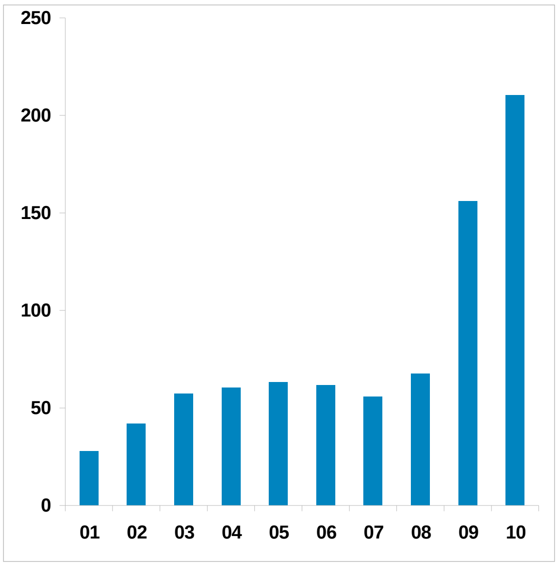
2 Research and technology

2.1 Research & technology mining patterns

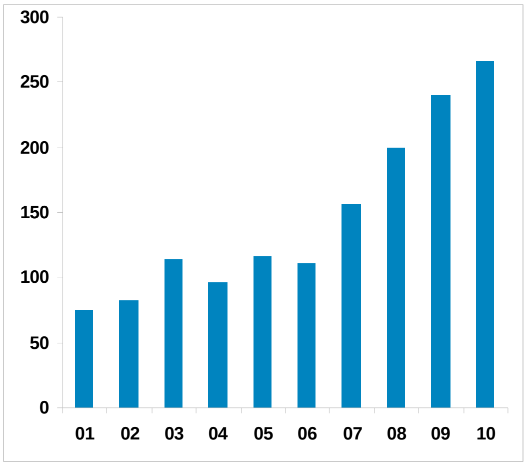
It is difficult to estimate the amount of Research & Technology carried out in the field of Offshore Wind, given the wide arrange of different activities it comprises and actors involved. Nevertheless, certain indicators such as the number of inventions, publications, inventions, citations, and patents can provide fair estimates of global trends in research and technology and EU's position.

Table 2: Below tables compare the total number of global inventions and publications related to Offshore Wind (2001 – 2010):

Inventions



Publications



Source: Thomson Reuters, 2011

The rising number of global inventions in the past two years and more so of the publications in the course of the last decade gives a clear outlook of the increasing importance of Research and Technology in this function.

The table below compares EU-27 countries in terms of patents filed on their grounds, with competing countries (2001–2010). Priority country means the place where the invention was invented and filed. [26]

Table 3: Country score in inventions related to Offshore Wind

Priority countries	Total inventions (2001 - 2011)	% of global
EU-27	479	38%
US	170	13%
China	156	12%
Japan	133	10%
South Korea	43	3%
Global	1276	

Source: Thomson Reuters

[26] Priority country is used in the absence of an inventor county within the patent data. The particular field is not present across a good amount of authorities

Figures above indicate that the EU-27 countries are strongly leading in terms of inventions, with 38 % of global inventions related to Offshore Wind on EU-27 territories, compared to the US and China both following with 13% and 12% of global inventions respectively.

Table 4: Country score in scientific citations related to Offshore Wind

Priority countries	Total citations (2001 - 2011)	% of global
EU-27	5499	46%
US	2453	21%
China	454	4%
Japan	190	2%
South Korea	42	0%
Global	11932	

Source: Thomson Reuters

Table 5: Country score in published papers related to Offshore Wind

Priority countries	Total published papers (2001 - 2011	% of global
EU-27	824	40%
US	508	25%
China	91	4%
Japan	65	3%
South Korea	18	1%
Global	2052	

Source: Thomson Reuters

The positive positioning of the EU-27 countries is also championed in terms of the number of scientific citations. Not less than 46% of all global scientific citations can be attributed to researchers in the EU. This is mirrored also by the percentage of published papers. Since published papers and scientific citations can be considered one of the indicators for future inventions, the table above can be also interpreted as a comparable sound basis for future growth.

With 8 companies (assignees) based in the EU ranking within the top-20, Offshore Wind can be considered a market where EU companies are currently well represented.

Table 6: Top 20 global patent assignees - organizations or individual owners of the patent's invention - are presented in the table below in Offshore Wind

Top assignees	Total number of patents filed (2001- 2011)
GENERAL ELECTRIC CO	16
VESTAS WIND SYSTEMS AS	16
MITSUBISHI GROUP OF COMPANIES	13
SIEMENS	12
ZUEBLIN AG ED	11
HITACHI	8
UNIV SHANGHAI JIAOTONG	8
REPOWER SYSTEMS AG	7
GOYO KENSETSU KK	6
SHIMIZU CONSTR CO LTD	6
ABB GROUP	5
GEOSEA NV	5
KAJIMA CORP	5
NORDEX ENERGY GMBH	5
WESERWIND GMBH	5
AERODYN ENG GMBH	4
BARD ENG GMBH	4
CLIPPER WINDPOWER INC	4
CLIPPER WINDPOWER TECHNOLOGY INC	4
ISHIKAWAJIMA HARIMA HEAVY IND	4

Source: Thomson Reuters

2.2 Assessment of Research activities and projects

At EU level, the European Energy Programme for Recovery provided €565m to innovative elements of offshore wind energy projects. In 2010, the New Entrants Reserve (NER300) call invited Member States to make proposals for 6, 8 and 10 MW turbines in farms with a nominal capacity of 40 MW, and a floating demonstration with a nominal capacity of 25 MW.

The HiPRWind project[27] (2010 – 2015), co-funded by the FP7, is focusing on the development of an integrated floating wind turbine installation. With the involvement of nineteen companies led by the Fraunhofer Research Institute, the project is expected to enrich the knowledge of the floating wind power sector.

Driven by the strong interest of several Member States in deep water applications, the European Commission launched a call for two demonstrators of floating systems, and the New Entrants' Reserve (NER300) funding scheme will provide support for the demonstration of a floating offshore wind farm with a 25 MW capacity to be up and running in 2015. This follows the thematic logic of the previous FP7 calls on "future emerging technologies" (DeepWind project), on "deep offshore multipurpose renewable energy conversion platforms for wind/ocean energy conversion" (Marina project), the "coordinated action on offshore renewable energy conversion platforms" (Orecca project), and the 2007 call on "wind mapping for offshore wind application" (Norse Wind project).

The WindSpeed project[28] suggests among others that to this the solution will be in total design, integrated plans for all functions combined.

[27] http://www.hyperwind.eu/
[28] http://www.windspeed.eu/partners.php

An overview of relevant FP6 and FP7 projects, including links to the above-mentioned projects, is provided in Annex 3.

OffshoreGrid[29]

Offshore Electricity Infrastructure in Europe

Funding programme: Intelligent Energy Europe

OffshoreGrid is a techno-economic study. It has developed a scientific view on an offshore grid in northern Europe (North Sea and Baltic Sea) along with a suitable regulatory framework that takes technical, economic, policy and regulatory aspects into account.

The OffshoreGrid study confirms the anticipated advantages of an offshore inter-state grid: improved security of supply, improved competition and market and integration of renewable energy.

The General Recommendations of the OffshoreGrid study are:

- Where wind farm concession areas have already been defined, regulation should be designed to ensure that wind farm integration is favoured over traditional individual connections, wherever this is beneficial with regards to infrastructure costs. In particular the hub connection of wind farms is technically state of the art and can be beneficial.
- In countries where there is currently no strategic siting or granting of concessions, policy makers should aim for fewer areas with a larger number of concentrated wind farms, with projects within one area to be developed all at the same time, rather than for more and smaller concession areas.
- Integrated solutions such as tee-in (connecting a wind farm to an existing or planned transmission line) and hub-to-hub solutions (connecting different wind farms to one or more transmission lines to shore) can be very beneficial compared to conventional solutions (connecting wind farms to shore individually).
- Any new interconnector will have an economic impact on the interconnectors already in place, as it will reduce the price differences between the countries. Integrated solutions are less dependent on trade than a direct interconnector, and can therefore still be beneficial even with lower price differences. Where possible, opportunities for splitting wind farm connections should be carefully checked and pursued.
- The ongoing development of direct interconnectors should not be slowed down, as this concept can already be built today independently of the development of large wind farms far from shore, which could be beneficially teed-in. However it is advisable to anticipate tee-in connections for suitable wind farms in the future,
- The policy for merchant interconnectors which receive exemption from EU regulation should be reviewed. The concept of merchant interconnectors can incentivise investments that bear high risks. However, investors in, and owners of, merchant interconnectors could have an incentive to obstruct any new interconnector, as this would reduce their return on investment.

The options for connections that were studied have shown to be cost-efficient in many cases. Furthermore these grid designs can increase system security and reduce environmental impact. Policy makers and regulators should prepare measures to support such innovative solutions, which are not yet included in most current legal and political frameworks. In particular, the compatibility of support schemes and the allocation of benefits should be addressed as soon as possible, bilaterally or internationally.

[29] OffshoreGrid, 2011: Offshore Electricity Grid Infrastructure. Final Report, October 2011. Available at http://www.offshoregrid.eu/ (last accessed on 10th July 2012)

3 Future developments

3.1 External drivers and key factors affecting the performance of the cluster

3.1.1 External drivers

External drivers that might affect the growth (or reduction) of the offshore wind sector are:

- Development of supply, demand and price of fossil energy
- Geo-political considerations regarding self-reliance and security of energy supply
- Legislative framework and political landscape. Environmental and social concerns and government policies place many constraints on wind farm development. Examples of key judgements include the minimum distance to the shore and density of windmills on land and offshore, including 'no-go' areas designated for the protection of wildlife. Such constraints may change over time, in part due to evolving priorities and government policies (EEA 2009)
- Marine spatial planning and competition for space
- Technological development
- China's anticipated expansion of its wind industry, which is expected to be quite aggressive (Industry Primer of Wind Energy in 2010)
- Increasing demand beyond the industry's normal expansion of capacity may lead to increased prices for turbines[30] and therefore increased investment costs (EEA 2009).
- Increasing competition within the supply chains for offshore wind is expected[31]

3.1.2 Key factors

There are various barriers to the development of wind energy in Europe:

- Political stability with regard to support and financing policies
- Infrastructure and services: grid connections, interconnections, port and harbour facilities
- Funding and financial markets
- Physical influences
- Technological development
- Lack of skilled personnel within the region
- Laws and regulations on the process and/or criteria for obtaining development consents, permits and concessions are not clear or do not exist (EEA 2009)
- Lack of clarity on Environmental Impact Assessments (EIA) and the need for guidelines and information exchange at the international level to prevent regional and national obstacles. The variety of authorities involved in consent procedures is considered an inefficient, unnecessary bottleneck (EC, 2008d).

EWEA (July 2009) provides an inventory of administrative and grid connection barriers as encountered in a large number of EU countries, and provide recommendations to Member States on how to reduce these barriers.

Support services are limited and not very extensive, beyond the immediate sector. The impact of offshore wind on the environment is still largely unknown and cannot yet be stated definitely. Space at sea is also a source of competition between maritime economic activities; other users also have varying needs for the same space.

[30] Due to possible capacity bottlenecks in terms of production of wind turbines

[31] Schiff & Hafen, 2012: Report on "interdisziplinaeres Networking fuer effiziente und nachhaltige Offshore-Operationen. Seite 58

3.2 Assessment of response capacity and commercialisation potential

The European Wind Energy project has identified the following short-term priority activities (2010-2012) to help develop this maritime economic activity:

- New turbines and components;
- Offshore technology;
- Grid integration;
- Resource assessment and spatial planning

Globally, most offshore wind turbines are installed in Europe, primarily in Denmark, UK, the Netherlands, Sweden and Germany. Outside Europe, there are initiatives in the USA, Japan, China, India and Brazil. The largest offshore wind turbine manufacturers and developers are located in Europe, which represents a first mover advantage. It is expected that Europe will be the strongest player globally in the field of offshore wind energy exploitation for the coming years, but international competition is expected to increase.

Recommendations on how Europe can achieve and consolidate this strong global position is related to 5 main aspects; policy, the market, research and development, grid integration, and environment and planning. The main suggestion, however, is that Europe should use the advantage of its connectivity – that the various member states should combine their markets in order to maximise the competitive advantage of the region as a whole. This would also be effective for the supply chain, increasing the pool of available producers and suppliers of the various aspects of the chain. Furthermore, an increased exchange of information and existing expertise would be available to all the Member States and the benefits of the resulting power would be distributed throughout the region. Finally, the benefits of environmental research would be more widely available. That is, to focus on comparative advantage within the EU and leverage on it in view of attaining a competitive stance towards non-EU actors in that field.

In terms of research efforts related to offshore wind energy, the following primary areas of intervention include:

- Sensitivity analysis for key economic and technological assumptions;
- Detailed analysis of areas where model prediction and observed wind velocities differed most;
- Cross-country trend analysis of social constraints in EEA member countries, with emphasis on the countries with high economic wind energy potential;
- Inventory and analysis of policy-driven wind energy success stories in Europe and beyond;
- Further analysis of specific vulnerabilities of the environment and biodiversity, e.g. related to specific bird and other species and landscapes, and application of such vulnerabilities in mapping wind energy potential in Europe
- Increasing average size of turbines, increasing distance of wind farms to shore, increasing water depths, albeit more of a framework condition.

A current challenge is to make the knowledge institutes co-operate with the industry (addressed in the UPWIND project, see Annex 3).

There are additional challenges in considering the full life cycle of equipment. What will be done with discarded blades requires thinking about eco-design and application of principles such as Cradle-to-Cradle.

Further to the industry is changing rapidly in terms of further internationalisation. Some recent and non-exhaustive developments are listed beneath:

- the Chinese/Dutch company XEMC Darwind unveiled a 5 MW prototype and is seeking to set up factories in the UK and US;
- Mitsubishi Heavy Industry is partnering with SSE and locating in the UK with government support;
- the US company AMSC will export its 5 MW technology to Hyundai Heavy Industries;
- Sinovel and Daewoo bought the German manufacturer DeWind, and Daewoo may manufacture from its Romanian shipyard.
- GE is entering the offshore market with the acquisition of ScanWind, and its plans for manufacturing 4 MW turbines in UK, with R&D facilities in Norway, Sweden and Germany.
- South Korean manufacturers are entering the offshore market targeting the future 5 GW South Korean market, and have global ambitions: Hyunday Heavy Industries set up a partnership with Hyosung for 2 MW turbines (factory in Weihai, China); Samsung Heavy Industries is seeking a partnership in Europe (source: EWEA, 2011b).

3.3 Most likely future developments

Overall the growth potential of this subfunction is estimated as very high.

The European Wind Energy Association predicts a strongly growing home market of around 25% per year, contributing to an installed capacity of 40 GW in 2020[32, 33].This shows that here is an enormous potential to be exploited over the coming years[34].

EWEA (July 2011) sets out targets for the amount of wind power the industry expects to be able to deliver in 2020, 2030 and 2050. The report shows that by 2020 most EU countries will have at least tripled their wind power capacity reaching a total installed capacity of 230 GW by 2020 – providing 15.7% of EU electricity depending on demand. 190 GW would be onshore and 40GW offshore. By the end of 2010, 84 GW of wind energy capacity was operating in Europe, meeting 5.3% of EU power demand. By 2030 EWEA expects 400 GW of wind to be operating in the EU providing 28.5% of EU electricity depending on demand. 250 GW would be onshore and 150 GW offshore. The report also shows that wind power could provide 50% of the EU electricity supply by 2050.

Table 7: Installed capacity, electricity production and share of EU demand

	Onshore wind (GW)	Offshore wind (GW)	Total wind energy capacity (GW)	TWh onshore	TWh offshore	TWh total	EU-27 gross electricity consumption	Wind power's share of electricity demand
2020	190	40	230	433	148	581	3,690	15.7%
2030	250	150	400	591	562	1,154	4,051	28.5%
2050	275	460	735	699	1,813	2,512	5,000	50%

Source: EWEA (2011b) 'Pure Power' - EWEA based on PRIMES

[32] The European offshore wind industry - Key trends and statistics: 1st half 2010. *EWEA*, August 2010
[33] A breath of fresh air - The European Wind Energy Association - Annual Report 2009. *EWEA*, April 2010
[34] EEA (2009), Europe's onshore and offshore wind energy potential. An assessment of environmental and economic constraints.

“The European Wind Energy Association expects that 194 billion Euros will be invested in European onshore and offshore wind farms in this decade, mainly driven by a strong EU regulatory framework to 2020” said Christian Kjaer, Chief Executive of EWEA. “Annual wind power investments in the EU will double from € 13 bn in 2010 to € 27 bn in 2020. This will make a very substantial contribution to meeting Europe’s commitment to reduce greenhouse gas emissions within the short timeframe provided by the scientific community.”

Other infrastructures and logistics are necessary to facilitate growth of offshore wind as well. These include specialised vessels, offshore construction equipment, harbour and other onshore facilities and skilled personnel.

Employment growth in offshore is expected to be particularly strong, due to several reasons. Firstly, the share of offshore wind power capacity as part of total wind power is gradually increasing, from just 2% in 2007 to almost 4% in 2010, while this ratio is expected to increase to 17% in 2020 and even 37% in 2030[35]. Secondly, the generation of wind energy offshore is relatively labour-intensive, not only at installation but also at operation and maintenance stages. One estimate is that employment in offshore wind is likely to grow sharply in the years to come: from 7,000 fte in 2007 and a stated 35,000 in 2010 to possibly up to 170,000 in 2020[36], The offshore wind sector is expected to grow in the coming decades, at rates which are higher than onshore. It is expected by some that offshore wind energy employment will exceed onshore employment by 2025.

3.4 Impacts, synergies and tensions

The growth of the sector will lead to the creation of 134,000 new direct jobs and 165,000 indirect jobs in the next decade.[37]

There is a link with the other renewable energy sources through sharing of the (offshore) power grid. This may have a positive impact if it leads to a quicker development of offshore super grids.[38] Until then, negative impacts as a result of competition for capacity may occur. In addition, there is a potential link with the production of oil, gas and methane production through the multiuse of platforms and other offshore constructions. The emergence of major contractors from the offshore oil and gas and traditional maritime sectors[39] may be seen as a powerful proof of these synergies. Finally, due to potential spatial competition and marine spatial planning, offshore wind is directly linked to all other sub-functions.

Annex 4 provides an indicative overview of the various types of impacts of the maritime economic activity in European's sea basins. Annex 5 provides an indicative overview of synergies and tensions between offshore wind energy and other maritime functions.

According to one interviewee, the most important ecological impact of wind farms is their visual impact. Floating wind farms can overcome this tension, albeit only to a limited extent.[40] Another impact is the noise impacts of offshore wind parks – both during construction and running stage with the latter stemming from the blades movements in the wind.[41]

---

[35] EWEA (2012) Green Growth, p. 15.
[36] EWEA (2009), Wind at Work, p.9
[37] According to an interviewee on that maritime economic activity
[38] Stancich, R., 19 March 2010. Vision for an offshore supergrid swims into focus. *Wind Energy Update*
[39] EWEA,(2011) Wind in our sails
[40] Which is mainly due to the fact that they are often equipped with night time lighting, which may also leads to unappreciated impacts for local residents and tourists.
[41] Schiff & Hafen, 2012: Report on “interdisziplinaeres Networking fuer effiziente und nachhaltige Offshore-Operationen. Seite 63

According to another interviewee the impact of the offshore wind industry on the environment is probably limited. The main impact is during construction and installation. The noise from pile driving can affect sea mammals, but there are more mammal friendly ways of pile driving. Another type of potential environmental impact is the electromagnetic field of the cable. However, this is probably limited, since the cable is buried deep down in the seabed. The impact on birds is probably very limited, since wind parks are normally located to avoid the main migration paths. There is also a positive impact due to substrate formed, on which benthic communities can flourish. Moreover, the offshore wind industry itself has a positive impact on climate change by reducing CO_2 emissions.

Potential synergies with desalination and fishery purposes are particularly strong for floating platforms compared to conventional and fixed offshore wind turbines and platforms.[42]

Further synergies are likely to occur for the shipbuilding industry, in particular special vessels for maintenance, repair and set-up of offshore wind turbines. Currently, though, the economic potential of this synergy for the EU shipbuilding industry is limited, due to the fact that special ships are either chartered or ordered with east-Asian shipbuilders, [43]

[42] Further reading: "Swedish eyeing Malta for world's largest floating wind farm". Available at: http://www.independent.com.mt/news.asp?newsitemid=141855 Last accessed on 9th July 2012.
[43] Ludwig, Thorsten, Seidel Holger, Tholen Jochen, 2012: Potenzialanalyse des deutschen Schiffbaus unter besonderer Berücksichtigung der Offshore-Windenergie. Zusammenfassung. S. 4

4 Role of policy

4.1 Policy and political relevance

An overview of relevant policies at the EU-level is provided in 1.2.

EWEA provided a number of policy recommendations for the short an medium term, reflecting the needs of the sector for EU involvement (EWEA, June 2010). In the short run improvements are required on the institutional framework and funding. Commitment is needed from EU member states and strong coordination is required to link the different stakeholders and (funding) programmes. For the medium term focus of policy recommendations is on the retention and increase of EU funding and adapting on the new EU policy direction. A high level of R&D funding is of importance.

4.2 Domains for EU policy

4.2.1 Regulatory framework

Establishing a European policy framework for offshore wind power: Clarifying roles for all players and regulations and policies

A stable political framework is needed to develop offshore wind farms on a sufficient and efficient scale and to maintain a good relation with investors. A framework can encourage Member States to develop national policies regarding sector targets and financial investments in offshore wind power. Four important pillars should be the basis for the European framework:

- legislation and policy measures (including specific payment mechanisms)
- grid reinforcement measures
- environmental measures
- R&D measures

Such recommendations include:

- The establishment and use of marine spatial planning instruments to reach optimal site selection
- The convenience of defining clear responsibilities of the different actors involved
- The need for long-term and strategic grid planning
- The importance of more efficient consenting procedures which build on past experience and are in proportion to the scale of the project
- The need to ensure good quality assessments
- The standardisation of design and certification procedures

Next to a framework, cooperation between public administration and the wind farms is important. Policy and technology are both important for the stable development of a cost-competitive wind industry. Investments in technology are an important factor to increase cost effectiveness. A cost effective industry is conducive to public acceptance, since it increases acceptance for use of public funds. However, the public also needs good information on potential risks and of new technology.

Stimulating cooperation between EU Member States and non-EU countries

In general, cooperation between countries can result in the sharing of knowledge and best practices. Offshore wind is a transnational issue. It therefore interacts with European policies regarding the sea. It deals with other uses of the sea and related policies, like the EU Common Fisheries Policy. Further to that and in cooperation with non-EU countries, it should encourage technology partnerships, as with the recent UK and US collaboration on the floating wind farms.[44]

Increasing regional cooperation

A more intensive regional cooperation has a two-fold meaning. On the one hand the inter-regional cooperation, since for individual regions it is impossible to develop the whole offshore wind supply chain. Therefore, cooperation between different European regions is important for developing a European supply chain. This transnational supply chain can connect European projects and developments elsewhere in the world and is a great change to create synergy and increase total market potential.. The EU should have a facilitating role, while the individual regions take a pro-active role. Regional funding is a possible facilitator in creating this transnational supply chain.
On the other hand, increased cooperation at a regional level means also cooperation of the various maritime stakeholders within the same regions to overcome obstacles to cooperation and the furthering of synergies at regional level.[45]

4.2.2 Market and value chain

Creating long term markets and an interconnected grid system

Cooperation between the European Commission and member states is needed for the continuity and growth of the offshore wind market. This should be coordinated by the EC. Policies of different countries should be coordinated, to improve overall system efficiency and cost-effectiveness, notably as concerns the development of an interconnected grid system. A grid system can lead to an optimal supply of power to the right market.

Cross boundary supply chain management

The wind energy sector is already a firmly grounded industry, covering a wide range of industrial sectors, disciplines and expertise. The offshore direction provides new challenges; new expertise is required for the construction, maintenance and other work at sea. The opportunities are interesting, because of the large size the projects can have. The wind energy sector has to invest in the offshore branch, because of these challenges and opportunities. Offshore wind energy should be integrated in the conventional wind energy supply chain.

Reap synergies between sector

The offshore sector covers, next to offshore wind energy sector, different sub-sectors that deal with the same challenges and problems as the wind energy sector. For example the oil and gas, offshore construction, shipping and ocean energy sector can work together with the wind energy sector. Knowledge can be shared and learning opportunities exist. Economies of scale, e.g. in terms of multi-purpose platforms, for instance, can present a further opportunity to create synergy within the offshore sector.

4.2.3 Skills and certification

The offshore wind energy sector is a relatively new user of the sea. Existing regulatory frameworks, used for other marine branches, were used to permit proposed offshore wind projects. Existing frameworks do not fully cover the needs and restrictions of the offshore wind industry. The industry

---

[44] Further reading of Guardian Article 23th April 2012: US and UK to collaborate on 'floating' wind turbines: http://www.guardian.co.uk/environment/2012/apr/23/us-uk-floating-wind-turbines (last accessed 9th July 2012)

[45] This statement is confirmed by an interviewee for the case studies on the Irish cluster. Also mirrored in SeaEnergy2020: Final Project Report, May 2012: Page 36.

has specific requirements that need to be integrated in custom made strategic plans. In development and installation of offshore wind turbines, the sector could partially use the existing skills in the offshore oil & gas market.[46] Further to that, synergies in terms of skill level also exist between shipyard employees and those in the offshore wind sector.[47]

Cross border cooperation

The offshore wind industry is still developing, but for a solid development timely involvement of environmental authorities, transmission system operations and health and safety bodies is important.

Skills of other sea users, link the vessel industry, are of added value for the effective and safe development of the offshore wind sector. With their key experience and expertise they can help the wind sector and synergy can be created. Other industries can profit from the wind energy sector by the power they provide. Next, good cooperation is of importance in minimizing conflicts.

4.2.4 Technological development

Establish a roadmap

Important for R&D efforts for the development and improvement of the offshore wind energy sector is to reduce costs, albeit without reducing safety. Benchmarks for the operation and maintenance phase should be set as a lead for companies investing in R&D. R&D efforts can be dedicated to the reduction of costs. Benchmarks can give policy makers an idea of the total costs in the sector and show that investing in the offshore wind sector is cost effective.

Increase research, technological development and demonstration pilots by EU funding schemes.

Funding is of crucial importance in further development of the offshore wind energy sector. A diverse set of funding programmes already exist for nearly every stage in the value chain (see figure *European funding* on page 6 for an overview). For further technological development significant effort and resources should be put in R&D and innovation. This should be done on EU as well as on Member State level. The EU has an important role in coordinating research programmes. On a lower level, stakeholders like research institutes, universities, the onshore wind industry and consultancy firms have to cooperate. Some important leaps forward are already made in the direction of coordination and cooperation between different stakeholders. For example, the EC's Strategic Energy Technology (SET) Plan provides guidance for R&D investments and the European Wind Energy Technology Platform (TP Wind) defines key R&D priorities and enhances cooperation between different stakeholders. TP Wind has planned to coordinate national initiatives regarding research programmes.

4.2.5 Infrastructure

Need for developing an optimised offshore grid

At the moment the electricity grids lack access sufficient points to connect offshore wind energy and the construction of such connections will require significant investments. However, in the absence of a continued long-term approach at an EU political level, building on the initiatives funded within the European Energy Programme for Recovery[48] grid investments risk being sub-optimal. Hence they will be viewed from an individual project perspective rather than from a system perspective. On

[46] Schiff & Hafen, 2012: Report on "interdisziplinaeres Networking fuer effiziente und nachhaltige Offshore-Operationen. Seite 58.

[47] Due to the expertise of the first with large installations and welding work. See also: Ludwig, Thorsten, Seidel Holger, Tholen Jochen, 2012: Potenzialanalyse des deutschen Schiffbaus unter besonderer Berücksichtigung der Offshore-Windenergie. Zusammenfassung. S. 4

[48] In which, for instance, a € 20m EU-funding is earmarked for the electricity interconnection Malta – Italy. See also: Regulation (EC) No. 663/2009 of the European Parliament and of the Council of 13th July 2009. Annex A.

the other hand, a coordinated approach to planning offshore connections can lead to significant cost savings – e.g. if wind parks are connected to the onshore grid via hubs or T-connections. For such a coordinated approach to materialise it is important that TSOs, wind farm operators and national authorities cooperate closely with the Commission having a facilitating role. A framework for such a cooperative approach has been established in the form of the North Sea Countries' Offshore Grid Initiative.

National and regional authorities can also play a vital role in upgrading the onshore transmission and distribution system to accommodate better the high throughput being transmitted from bigger offshore wind farms through interconnector cables.[49]

Moreover, the technological and economic feasibility of developing an optimised offshore grid in Northern Europe (Baltic and North Sea, English Channel, Irish Sea) is investigated under the Intelligent Energy Europe (IEE) programme of the European Commission, with a possibility of expansion towards the Mediterranean Sea.[50]

While such an approach will lead to an overall improvement of the cost-benefit-ratio, it might make the allocation of costs somewhat more complex. Since the costs of investment in grids will usually be recovered by network operators from customers via higher tariffs, cooperation between regulatory authorities will also be required in order to determine the distribution of the resulting burden between Member States. Lastly, a limited degree of direct EU funding might also be necessary to the extent that the projects concerned aren't fully viable from an investor’s perspective.

Other infrastructure, such as ports and specialised vessels

For the installation of offshore wind mills specific onshore port infrastructure is required. Harbours have to be capable to store, handle and deploy large wind farm components. In general offshore components are larger than their onshore counterparts.

Specific vessels have to transport those components to the planned wind farm location.[51] Some port facilities should be upgraded or expanded. The EU and national governments should support these developments. The European Maritime policy should give room to the development of this extensive infrastructure.[52]

4.2.6 Planning

Marine spatial planning

Marine spatial planning concerns the problem of bringing together the multiple users of the ocean, like shipping, fishery, recreation and offshore wind energy. The planning process has to lead to a rational and sustainable use of the sea. Marine spatial planning is executed on a global scale. In 2020 the European commission adopted the Communication 'Maritime Spatial Planning in the EU - Achievements and future development'. Goal of this policy is to make a common policy framework for all stakeholders. Marine Spatial Planning is important to prevent conflicts; increase synergy and ensure an efficient and sustainable use of the ocean.

---

[49] In Malta, for instance, the National Electricity Company Enemalta is currently upgrading its onshore grid to prepare for the interconnector Malta – Sicily and the likely investments in the 460-metre diameter wind farm of the Maltese coast with high capacity expected of 54 MW of electricity. European Commission, SWD (2012) 321 final: Assessment of the 2012 national reform programme and stability programme for Malta: Page.

[50] http://offshoregrid.eu

[51] The need for specialised vessels is expected to increase which poses further impacts on the port infrastructure and make-up of the industry as such. Further reading: Schiff & Hafen, 2012: Report on “interdisziplinaeres Networking fuer effiziente und nachhaltige Offshore-Operationen. Seite 62

[52] www.masscec.com/index.cfm/pk/download/id/11693/pid/11151

4.2.7 Environmental impact

Understanding the positive and negative impacts better.

The knowledge on the effect of offshore wind farms on the marine ecosystem is limited, although some recent research shows positive results for sustainability on the longer term. More environmental impact assessments are encouraged and the results should be published publicly. It may be helpful to perform an environmental impact assessment before licences are provided.

In terms of environment and particular relating to smaller Members States with a large coastline, offshore wind parks, notably the more efficient floating wind foundations can be a driver for contributing to the renewable energy targets by 2020 set by the EU.

Annex 1 Bibliography

- Ecorys (2010) Assessment of non-cost barriers to renewable energy growth in EU Member States – AEON.
- EEA (2009), Europe’s onshore and offshore wind energy potential. An assessment of environmental and economic constraints.
- EurObserver, 2010. The state of renewable energies in Europe, 9th EurObserver Report.
- EWEA (2007) Delivering Offshore Wind Power in Europe. Policy recommendations for large-scale deployment of offshore wind power in Europe by 2020.
- EWEA (2010a) A breath of fresh air - The European Wind Energy Association - Annual Report 2009. EWEA, April 2010
- EWEA (2010b). Wind in power, EWEA report
- EWEA (2010c) European Wind Initiative June 2010
- EWEA (2010d) Wind Barriers July 2010
- EWEA (2010e) The European offshore wind industry – Key trends and statistics: 1st half 2010, EWEA, August 2010
- EWEA (2011a) Operational offshore wind farms in Europe, end 2010.
- EWEA (2011b) Pure Power - Wind energy targets for 2020 and 2030
- EWEA (2011c) Wind in our sails; the coming of Europe’s offshore wind energy industry. November 2011
- EWEA (2012) Green Growth; The impact of wind energy on jobs and the economy April 2012
- EWEA (2012b): The European offshore wind industry key 2011 trends and statistics
- EWEA, ECN, 3E, CORPI, CRES, LNEG, SOW, UOB, 2012: Delivering offshore electricity to the EU – Spatial planning of offshore renewable energies and electricity grid infrastructures in an integrated EU maritime policy. SeaEnergy 2020 Final project report
- Lee, K.H., 2005: Floating wind turbines, special report for the 20th workshop on Water Waves and Floating Bodies – Spitsbergen, Norway
- Ludwig, Thorsten, Seidel Holger, Tholen Jochen, 2012: Potenzialanalyse des deutschen Schiffbaus unter besonderer Berücksichtigung der Offshore-Windenergie. Zusammenfassung. S. 4
- National Renewable Energy Laboratory: Musial, B, Butterfield S, Ram B, 2006: Energy from Offshore Wind. Conference Paper. NREL/CP-500-39450. February 2006: Accessible at: http://www.nrel.gov/wind/pdfs/39450.pdf
- OffshoreGrid (2011) Offshore Electricity Grid Infrastructure in Europe. Final Report of the IEE OffshoreGrid project, October 2011.
- Schiff & Hafen, 2012: Report on “interdisziplinaeres Networking fuer effiziente und nachhaltige Offshore-Operationen.
- Stancich, R. 2010: GeoSea: New Technology drives down turbine foundation installation costs. Wind Energy Update

Annex 2 Stakeholders interviewed

List of stakeholders interviewed for the report on offshore wind.

Interviewee	*Organisation*	*City/country*	*Interviewer*	*Face to face, or telephone*	*Comments*
Robert Pollock Audrey Martin Lisa Hardie	Argyll and Bute Council	Argyll and Bute, Scotland, UK	Sil Boeve	T	14/6/2011
Chris Westra		Delft, the Netherlands	Lija van Vliet	F2F	11/7/2011
Anne-Benedicte Genachte, Remi Gruet	European Wind Energy Association (EWEA)	Brussels, Belgium	Sil Boeve	T	12/7/2011
Jerome Guillet			Lija van Vliet	T	12/7/2011
Feargal Brennan	Cranfield University	Cranfield, UK	Lija van Vliet	T	26/7/2011
Trine Ulla	Statoil	Norway	Lija van Vliet	T	3/8/2011

Annex 3 Overview of FP6 and FP7 research projects

acronym	start date	funding programme	website	research area / short description
AEOLUS	2008-05	FP7 - ICT	http://www.ict-aeolus.eu/about.html	Distributed control of large-scale offshore wind farms
DEEPWIND	2010-10	FP7 - ENERGY	http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=144&CAT=PROJ&QUERY=01273fd0cb46:c8f4:78e029ff&RCN=96069	Future Deep Sea Wind Turbine Technologies
DEROGUE WAVES	2010-08	FP7 - PEOPLE	http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=1&CAT=PROJ&RCN=96039	Deterministic Forecasting of Rogue Waves in the Ocean
HEMOW	2011-04	FP7 - PEOPLE	http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=38&CAT=PROJ&QUERY=012dabfe6211:adf9:758f5878&RCN=98451	Health Monitoring of Offshore Wind Farms
HIPRWIND	2010-11	FP7 - ENERGY	http://www.hyperwind.eu/	Cross-sectoral approach to the development of very large offshore wind turbines
MARINA PLATFORM	2010-01	FP7 - ENERGY	http://www.marina-platform.info/	Marine renewable integrated application platform
MARINET	2011-04	FP7 - INFRA	http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=1&CAT=PROJ&QUERY=012ed25875f0:9eaf:79fa65b5&RCN=98372	Marine Renewable Infrastructure Network for Emerging Energy Technologies
NORSEWIND	2008-08	FP7 - ENERGY	http://www.norsewind.eu/public/index.html	Wind mapping for offshore applications
OFFSHORE	2008-08	FP7 - PEOPLE	http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=1&CAT=PROJ&QUERY=0130d0b3078b:d3e8:288a566c&RCN=87624	Fluid-structure interactions in offshore engineering
ORECCA	2010-03	FP7 - ENERGY	http://www.orecca.eu/web/guest;jsessionid=CE2AFA31BB3CE5FA3E638108AB97E9A2	Off-shore Renewable Energy Conversion platforms - Coordination Action
POWWOW	2005-10	FP6 - SUSTDEV	http://powwow.risoe.dk/	New and advanced concepts in renewable energy technologies
PREWIND	2004-07	FP6 - SME	http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_LANG=EN&PJ_RCN=7920953	Development of a Methodology for Preventive Maintenance of Wind turbines trough the use of Thermographs
RELIAWIND	2008-03	FP7 - ENERGY	http://www.reliawind.eu/	Development of components and systems for turbines and wind farms
RENEWITT	2004-09	FP6 - SME	http://cordis.europa.eu/fetch?CALLER=MSS_BG_PROJ_E	Development of new and novel automated inspection

acronym	start date	funding programme	website	research area / short description
			N&ACTION=D&DOC=1&CAT=PROJ&QUERY=0130d0bb1d6a:66e1:29398e13&RCN=75632	technology for glass reinforced plastic wind turbine blades
SEEWIND	2007-05	FP6 - SUSTDEV	http://www.seewind.org/	South-East Europe wind energy exploitation - research and demonstration of wind energy utilisation in complex terrain and under specific local wind systems
SYSWIND	2009-12	FP7 - PEOPLE	http://www.syswind.eu/	Training future mechanical, civil, electronic engineers and computer scientists in System Identification, Condition & Health Monitoring for a New Generation of WIND Turbines
UPWIND	2006-03	FP6 - SUSTDEV	http://www.upwind.eu/	New and advanced concepts in renewable energy technologies
WINGY-PRO	2009-11	FP7 - ENERGY	http://www.wingypro.com/Links.html	Demonstration of large scale systems for on-and off-shore wind farms
WINTUR	2009-07	FP7 - SME	http://www.wintur-project.com/	In-situ wireless monitoring of on- and offshore WINd TURbine blades using energy harvesting technology

Annex 4 Overview of impacts of the subfunction

Function	Indicators	Baltic	North Sea	Mediterr.	Black Sea	Atlantic	Arctic	Outer most
1. Economic impacts	market size	+	++	0	0	++	0	0
	export potential	0	++	0	0	++	0	0
2. Employment impacts	fte direct employment	+	++	+	0	++	0	0
	fte value chain	+	++	0	0	++	0	0
3. Environmental impacts	reduction CO2	+	++	0	0	++	0	0
	geomorphology	0	0	0	0	0	0	0
	fish	+	+	0	0	0	0	0
	birds	0	-	0	0	-	0	0
	mammals	0	-	0	0	0	0	0
	soil disturbance	-	-	0	0	-	0	0
4. Other impacts	competing claims on near-shore space	-	--	0	0	-	0	0
	competing claims on off-shore space	0	-	0	0	0	0	0

++ = Strong positive impact expected

+ = Considerable positive impact expected

0 = Negligible impact expected

- = Considerable negative impact expected

-- = Strong negative impact expected

Annex 5 Synergies and tensions between offshore wind energy and other functions

Function affected	Sub-function	General	Baltic	North Sea	Mediterranean	Black Sea	Atlantic	Arctic	Outer most	Remarks
	Affected									
1. Maritime transport and shipbuilding	1.1 Deepsea shipping	0								
	1.2 Shortsea shipping (incl. RoRo)	-		--						wind farms form obstructions to shipping
	1.3 Passenger ferry services	0								
	1.4 Inland waterway transport.	0								
2. Food, nutrition, health and eco-system services	2.1 Catching fish for human consumption	+ / -	+ / -	+ / -	0	0	+ / -	0	0	Interactions go in two ways. Wind farms exclude areas for fishing. On the other hand, they may provide safe havens for

Function affected	Sub-function	General	Baltic	North Sea	Mediterranean	Black Sea	Atlantic	Arctic	Outer most	Remarks
	Affected									
										species
	2.2 Catching fish for animal feeding									
	2.3 Growing aquatic products	+	+	+	0	0	+	0	0	wind farms may provide platforms and substrates for aquaculture
	2.4 High value use of marine resources (health, cosmetics, well-being, etc.)	+	+	+	0	0	+	0	0	wind farms may provide platforms and substrates for algae farms
	2.5 Agriculture on saline soils	0								
3. Energy and raw materials	3.1 Oil, gas and methane hydrates	++	+	++	0	0	++	0	0	there is a strong synergy between the two functions in their use of offshore know-how
	3.2 Offshore wind energy									
	3.3 Marine renewables (wave,	+ / -	+/-	+/-	0	0	+ /	0	0	synergies and tensions both

Function affected	Sub-function	General	Baltic	North Sea	Mediterranean	Black Sea	Atlantic	Arctic	Outer most	Remarks
	Affected									
	tidal, OTEC, thermal, bio fuels, etc.)									exist; synergies in use of similar know how, shared need for infrastructure and facilities; competition for those, competition for funding
	3.4 Carbon capture and storage	+								some synergy in use of offshore know-how
	3.5 Aggregates mining (sand, gravel, etc.)	0								
	3.6 Mineral raw materials	0								
	3.7 Securing fresh water supply (desalination)	0								
4. Leisure, working and living	4.1 Coastline tourism	-	-	-	0	0	-	0	0	tension with tourism as a result of visual pollution

Function affected	Sub-function	General	Baltic	North Sea	Mediterranean	Black Sea	Atlantic	Arctic	Outer most	Remarks
	Affected									
	4.2 Yachting and marinas	-	-	-	0	0	-	0	0	tension with yachting in competition for near-shore areas and visual pollution
	4.3 Cruise including port cities	0								
	4.4 Working	0								
	4.5 Living	0								
5. Coastal protection	5.1 Protection against flooding and erosion	0								
	5.2 Preventing salt water intrusion and water quality protection	0								
	5.3 Protection of habitats	-	-	-	0	0	-	0	0	Building wind farms may have adverse effects. Once in operation, adverse effects may result
6. Maritime	6.1 Traceability and	0								

Function affected	Sub-function	General	Baltic	North Sea	Mediterranean	Black Sea	Atlantic	Arctic	Outer most	Remarks
	Affected									
monitoring and surveillance	security of goods supply chains									
	6.2 Prevent and protect against illegal movement of people and goods	0								
	6.3 Environmental monitoring	+	+	+	0	0	+	0	0	Building wind farms will call for extra efforts in envy. monitoring, before, during and after construction

Explanation:

++ = Strong positive impact on other sub functions/sea basins expected

+ = Considerable positive impact on other sub functions expected

0 = Negligible impact on other sub functions/sea basins expected

- = Considerable negative impact on other sub functions expected

-- = Strong negative impact on other sub functions expected

P.O. Box 4175
3006 AD Rotterdam
The Netherlands

Watermanweg 44
3067 GG Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com

W www.ecorys.nl