Background document

Policy Workshop

Development of Offshore Wind Energy in Europe

Egmond aan Zee, 30 September and 1 October 2004,
Netherlands

Organised by:
The Netherlands Ministry of Economic Affairs
In co-operation with
Concerted Action for Offshore Wind Energy Deployment

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Acknowledgement:
Policy Workshop Committee
the Concerted Action for Offshore Wind Energy Deployment
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Table of contents

1 Introduction

At the global renewables conference, Renewables 2004, held in Bonn, Germany in June 2004, delegations from 154 countries reaffirmed their commitment to “substantially increase with a sense of urgency the global share of renewable energy in the total energy supply”. The European Union and its Member States have been leading driving forces in putting renewables and their multitude of benefits on the international agenda.

Security of energy supply is a global issue with political priority. Within the European Union, the European Commission has initiated a broad discussion on the Union's future security of energy supply with the publication of the Green Paper 'Towards a European strategy for the security of energy supply' (2001). In the Green Paper, the EC foresees an increasing dependence on imports of fossil fuels from the current level of 50% to 70 % in 2020. A high level of dependency on foreign energy can have enormous economic effects on the overall economies of the EU member states. It is thus crucial that Member States continue to focus attention on securing the energy supply and initiate actions to increase energy supply from indigenous energy sources. This can be realised by international cooperation and by the deployment of the European Union's internal energy resources, both fossil and renewable.

Already in 1997, the European Commission expected that 68% of the growth in electricity from renewable energy sources between 1997 and 2010 would be from biomass and 24% could come from wind power. In its recent Communication on the share of renewable energy in the European Union[1], the Commission increased wind power’s expected share of the increase to 50%. The offshore wind energy potential is enormous - it can contribute both to the battle against climate change and to achieving the European Union Kyoto targets, and there are enough exploitable resources in European waters to meet the entire EU electricity demand.

Two thirds of Europe’s offshore wind energy potential is in the North Sea, which is characterised by large areas of shallow waters and a large wind resource. National governments of the countries surrounding the North Sea have already acknowledged the vast potential of the North Sea to supply clean, reliable, indigenous electricity to meet future demand. In March 2002, Environment Ministers of the countries bordering the North Sea[2] met in Bergen, Norway to jointly consider and pronounce on the major environmental issues facing the North Sea. This resulted in the Fifth Ministerial Declaration on the Protection of the North Sea, it included a commitment to take action to exploit the large renewable energy potential in the North Sea. In the declaration it is stated:

> *»The Ministers welcome the development of renewable energy, inter alia, offshore wind energy, that has the potential to make a significant contribution to tackling the problems of climate change. They agree to take action in order to exploit this potential fully and safely, taking into account the global and European commitments linked to the Kyoto Protocol. (...)*
>
> *The Ministers invite the oil and gas industries to consider the market potential for renewable energy, in particular offshore wind, within the North Sea and to further the*

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[1] European Commission (COM(2004)366), 2004.

[2] Ministerial Declaration of the Fifth International Conference on the protection of the North Sea, Bergen, Norway, 20-21 March 2000.

> *existing co-operation with the offshore renewable energy industry with respect to the sharing of information, technology and infrastructure.«*

In order to assess the actual state of play, the Netherlands Ministry of Economic Affairs, in cooperation with the informal Concerted Action for Offshore Wind Energy Deployment network, will organize a Policy Workshop "Development of Offshore Wind Energy" on 30 September-1 october, 2004.

It is the aim of the Policy Workshop to make recommendations for policy measures to deploy the offshore wind energy potential. The Chairman of the Workshop, Director General G.J. Lankhorst of the Netherlands Ministry of Economic Affairs, will report the outcome of the discussions to the Council of Ministers in the form of a Policy Declaration with recommendations for concrete measures to be implemented by European institutions, Member State authorities and the wind industry. The draft of this Declaration will be amended during the workshop.

The background document sets out the current state of play regarding the development of offshore wind energy and identifies actions that need to be undertaken to fulfil its potential. The background document is divided into the following sections:

- Chapter 1: Status and outlook;
- Chapter 2: Current status and prospects of offshore wind energy in the European Union;
- Chapter 3: What needs to be done to deploy the offshore wind energy potential;
- Chapter 4: sets the priorities for this workshop.

In Chapter 4 of this Background Document there is a summary of the actions Member States will have to pursue for the deployment of offshore wind energy. In general it concerns measures to:

1. stimulate the industry to develop innovative technologies and products which reduce the production costs of offshore wind energy;
2. assess the environmental impact of offshore wind energy;
3. provide prerequisites to integrate offshore windfarms into the electrical infrastructure.
4. provide a legal framework to allow market parties to develop offshore windfarms;
5. provide a financial framework which allows market parties to develop offshore windfarms;

Please note that whilst this background document represents a general consensus of opinion of the Policy Workshop Committee members, it should be borne in mind that they do not necessarily agree on every detail described.

2 Offshore wind energy: status, outlook

2.1 Energy and environment

2.1.1 Energy

The market for wind energy has been growing by an average 28% over the past 7 years. The average annual increase in installed capacity in the same period has been more than 35%[3]. The total renewable electricity production increased in the EU_{25} from 346 TWh in 1997 to 380 TWh[4] in 2002. Wind energy is the fastest growing resource, 30 from the 34 TWh/a increase comes from wind energy. By the end of 2003 there were 28,020 MW[5] onshore wind power capacity installed. In an average wind year this can produce 60 TWh.

Figure 1: Overview existing offshore windfarms

Windfarm	In operation (year)	Country	Power (MW)
Sheltered waters and / or small projects			
Vindeby	1992	Denmark	5
Lely	1994	Netherlands	2
Tunø Knob	1995	Denmark	5
Dronten	1996	Netherlands	11
Gotland	1997	Sweden	3
Utgrunden	2000	Sweden	11
Blyth Harbour	2000	United Kingdom	4
Yttre Stengrund	2001	Sweden	10
Middelgrunden	2001	Denmark	40
Rønland	2003	Denmark	17
Samsø	2003	Denmark	23
Frederikshavn	2003	Denmark	9
First near shore wind farms, shallow waters			
Horns Rev	2002	Denmark	160
Nysted	2003	Denmark	158
North Hoyle	2003	United Kingdom	60
Arklow Bank I	2004	Ireland	25
Scroby Sands	2004	United Kingdom	60

Offshore wind is making an impressive start. 100% of the offshore developments so far has been in the European Union, going from a negligible amount, to the installation of 500 MW in 2002 – 2004. This is a faster rate of growth than for onshore, reflecting the even greater economies of scale offshore, and industry's vision for a mainstream electricity supply. However, experience with offshore wind energy is still very small. Only five projects (Horns Rev, Nysted, North Hoyle, Arklow Bank I, and Scroby Sands) can be seen as representative for future offshore windfarms. Horns Rev is the 'oldest', commissioning took place 18 months ago.

Currently the offshore wind energy deployment is mainly taking place in Northwest Europe:

- The UK: 7,200 MW of exploration licences have recently been awarded in the government's second offshore wind round. About 1,000 MW of installed capacity is expected to be realised in time from the first round;
- France has a target of 500 MW by 2007;
- Denmark envisaged in 1997 some 4,000-5,000 MW by 2030;
- Germany is planning for approximately 25,000 MW by 2030;
- Ireland has issued site exploration licences for sites that could accommodate at least 2 GW;
- The Netherlands has a goal of 6,000 MW by 2020;
- The Swedish Energy Agency has suggested a planning for 2,700 MW of offshore wind power to be developed by 2015;
- Belgium planned 2,000 MW by 2012 (200 km^2 zone) and a licence has recently been awarded for a first project (60 x 3.6 MW or 216 MW).

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[3] European Wind Energy Association, Wind Energy - The Facts, an analysis of wind energy in the EU_{25}; Brussels, december 2003.

[4] Commission staff working document; The share of renewable energy in the EU; Overview of renewable energy resources in the enlarged European Union. {COM(2004)366 final}, Brussels May 2004

[5] European Wind Energy Association, European Installed Wind Capacity - End 2003, Brussels, 2004.

In the medium and longer term, developments in the Atlantic and Mediterranean area will also provide possibilities for offshore windfarms.
There are enough resources to fulfil these ambitions: an EC-funded study in 1995[6] estimated a depth and distance from shore-constrained potential of more than 3,000 TWh/a, which is equal to the EU_{25} electricity consumption. Hence, offshore wind energy is potentially a strong force in the climate change combat and the security of energy supply in the European Union.

Various studies have been conducted to estimate the size of exploitable wind resources in Europe. In 1994, a study from Utrecht University estimated the exploitable onshore wind resources in Western Europe to be 4,800 TWh after reducing the total potential by 90% to take into account constraints on the use of land. An even more conservative study from 1993, published by the University of Utrecht, taking into account Europe's high population density, and infrastructure elements such as roads, airports, railways etc., estimated the potential of onshore wind power to be 630 TWh.

Similarly, various studies have estimated the offshore wind power potential in Europe. The figure below uses findings from a Garrad Hassan and Germanisher Lloyd study from 1995.

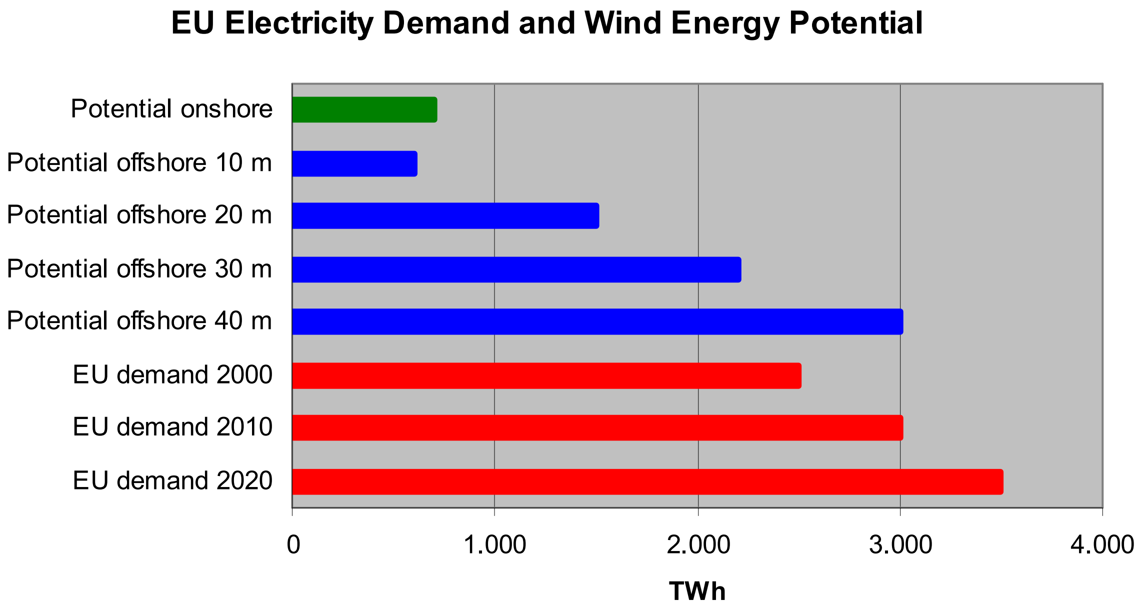

Figure 2, Source: EWEA

It shows that the exploitable European offshore wind energy resource alone is sufficient to meet more than the current total EU electricity needs of 2,500 TWh / year. Adding the exploitable onshore potential, wind energy could meet the future expected electricity needs of the EU.

There is an enormously rich wind resource in the North Atlantic. At least two thirds of Europe's offshore wind potential is in the North Sea. All conditions are present, including large areas of shallow water.

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[6] Offshore wind energy - ready to power a sustainable Europe, Concerted Action Offshore Wind Energy in Europe, TU-Delft, December 2001

The climate of the globe is such that there are very high wind speeds in both Northern and Southern latitudes between 40 and 60 degrees. The North Sea, positioned adjacent to the densely populated countries of the United Kingdom, the Netherlands, Belgium, and Germany, resides in this windy area of the Northern hemisphere. Average wind speeds are as high as 12 meters / sec, providing capacity factors up to, and, in some cases, in excess of 50%. The average capacity factor of offshore wind turbines in the North Sea is estimated at 40%. This should be compared with average European onshore capacity factors of 23%. In electricity terms, an average North Sea 2 MW wind turbine will produce 7 million kWh of electricity annually while a similar sized land based 2 MW wind turbine will produce 4 million kWh of electricity.

There is not yet a clear picture of the planning of the realisation of offshore wind farms in the European Union. A rough comparison of existing information (see also figure 3):

- Targets and planned projects in the different member states (40,000 MW, see overview in paragraph 2.1.1);
- Estimation of the European Renewable Energy Council (EREC) and the European Wind Energy Association (EWEA), which promotes 70,000 MW by 2020[7];
- BTM-consult estimates 10,000 MW in the period 2004 - 2008[8].

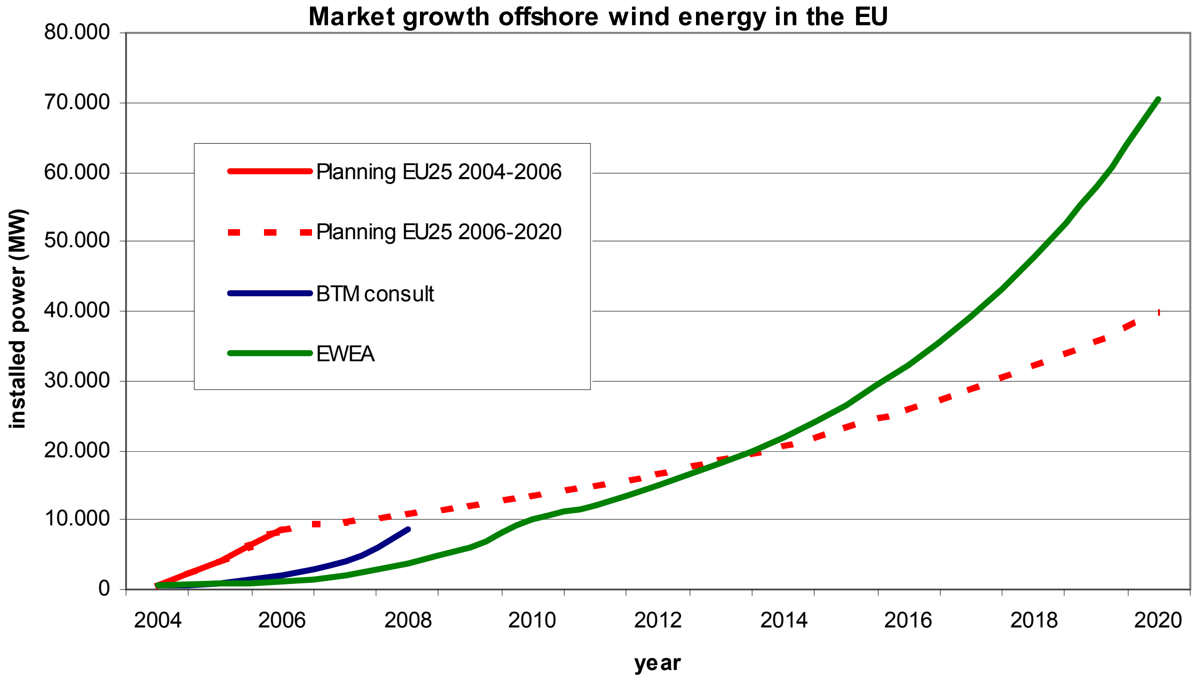

Figure 3

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[7] Renewable energy target for Europe, EREC, January 2004

[8] BTM consult, world market update 2004

2.1.2 Environment

Offshore wind is a relatively new activity. By the end of 2003, only 2% of wind power capacity installed in EU_{25} was offshore. Therefore, many knowledge gaps on potential impacts and the scales of such impacts on the environment still exist. Offshore wind has environmental effects on two levels, global and local. Offshore windfarms produce clean electricity emitting zero greenhouse gasses. There is thus clearly no doubt that the global environmental effect of offshore wind farms is positive. The environmental effects on a local level are much more diverse. They include possible impacts on birds, fish, benthos, marine mammals and humans in the surrounding areas of offshore wind farms (Collision of birds? Impairment/habitat loss of marine mammals due to noise and vibrations? Refuge function/alteration of habitats for fish and benthos? Prospects for mussel farming? Bigger risks to shipping/collisions? Etc.). There is only limited experience with offshore wind farms to date, therefore the local impacts on the environment (negative as well as positive) are not yet certain. In order to map the significant impacts, offshore wind project developers are obliged by national authorities to carry out Environmental Impact Assessments (EIA) in accordance with the EC EIA Directive[9] and monitoring studies before and during construction, operation and decommissioning.

Environmental assessment is a procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made. The process normally involves an analysis of the likely effects on the environment, recording those effects in a report, undertaking a public consultation exercise on the report, taking into account the comments and the report when making the final decision and informing the public about that decision afterwards.

In principle, environmental assessment can be undertaken for individual projects – Environmental Impact Assessment (EIA) - or for plans, programmes, and policies - Strategic Environmental Assessment (SEA)[10]. Both Environmental Impact Assessment and Strategic Environmental Impact Assessment are relevant for offshore wind. Responsibility for a SEA is normally for the public authority, whereas with Environmental Impact Assessment the lead role is for the project developer. It is good practice to undertake them even if not required, particularly given there may be some public sensitivity to projects, and that knowledge about some of the environmental impacts is subject to uncertainty.

EU Member States are currently preparing the implementation of the Strategic Environmental Impact Assessment Directive. The deadline for implementation wasexpired on 21 July 2004.

In areas protected by the EU Habitat[11]- and Bird Directive[12], developers must clarify if the project is not in conflict with these directives. Also the African European Migratory Water Bird Agreement (AEWA)[13] and the OSPAR convention[14] may have to be applied. This is usually carried out as part of the Strategic Environmental Impact Assessment or Environmental Impact Assessment.

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[9] Council Directive of 97 / 11 / EC of 3 March 1997 amending Directive 85 / 337 / EEC on the assessment of the effects of certain public and private projects on the environment (official journal No. L 073, 14/03/1997 p. 0005)

[10] Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment

[11] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

[12] Council Directive of 2 April 1979 on the conservation of wild birds (79/409/EEC)

[13] AEWA, under the Convention of Migratory Species (CMS), 1 November 1999, Cape Town, South Africa.

[14] The Convention for the Protection of the Marine Environment of the North-East Atlantic; Oslo and Paris Commissions, Paris, 21-22 September 1992.

The lack of knowledge concerns the occurrence of species as well as their reaction to offshore wind effects and their interrelationship (cumulative effects). Additionally, standards for evaluation are to some extent incomplete and are from time to time inconsistently applied in different countries. Hence, offshore wind developers face extensive requirements for impact assessments, which are both costly and time consuming. Other economic sectors which, in most cases, make an even greater impact on the marine environment (fishery; oil and gas industry; sand exploration; tourism; shipping) are sometimes faced with fewer requirements. Furthermore, it should be taken into account that the accumulated environmental impacts of offshore wind energy are expected to be substantially lower than the impacts from other power generation technologies.

It is clear that EIA's for offshore wind energy will be more expensive to conduct at the start of development than at later stages, when a useful framework may have been developed and further experience gained. Policy initiatives could take account of this and international co-operation in the field could be encouraged and formalised. The industry has more than a decade of experience of environmental impacts, predominantly from early studies in Sweden, the Netherlands and Denmark, but more studies are needed. A number of Member States already exchange information on environmental impacts - in the EU, Concerted Action for Offshore Wind Energy Deployment (COD). So far, COD has collated information in 161 reports/ publications and ongoing research projects accessible in a central database[15]. Until now, only Denmark has provided first results of impact research (Horns Rev). Existing information is mainly on (planned) research methodologies and baseline studies.

2.2 Industry

2.2.1 Make-up of the industry

From initial site finding through to installation and operation, today’s wind energy industry encompasses a range of disciplines and industrial sectors. This includes not just engineering and manufacturing sectors, but also meteorology, ecology, finance, brokerage and many others.

The extra challenges that offshore provides over the more common renewable energy applications are the size of the projects (€ 200 - 1.000 Million. for each project) and the construction and maintenance work at sea which requires specialised equipment and specialised employers.

The industry can be delineated into development, operating and manufacturing-related activities including component suppliers.

Developers find potential wind farm sites, draw up plans for development, and take these plans through the consenting process. There is no typical developer company – they range from small communities to large utility companies. As wind energy has become more commonplace, more and more conventional-sector companies have become involved in wind energy development and / or operation.

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[15] COD Environmental database; 2004; www.offshorewindenergy.org

Turbine manufacturers are responsible for producing the component parts of a wind turbine, namely the tower (usually made from rolled steel), the nacelle and blades (both of composite materials) and, housed inside the nacelle, the generator and gearbox.

European manufacturers collectively have always had a majority share of the worldwide market, in 2003 accounting for approximately three-quarters of worldwide installed capacity. Furthermore, in markets which offer homegrown turbines (the United States, India and Japan), European manufactures still rank amongst the top three suppliers to these markets.

Figure 4: Top 10 manufacturers

Manufacturer	Installed 2003 (MW)	Share	Accum. 2003 (MW)	Share
Vestas (DK)	1812	22%	8400	20%
GE Wind (US)	1503	19%	4428	11%
Enercon (GE)	1218	15%	5758	14%
Gamesa (ES)	956	12%	4965	12%
NEG Micon (DK)	855	11%	6398	15%
Bonus (DK)	552	7%	3367	8%
RePower (GE)	291	4%	893	2%
Nordex (GE)	242	3%	2219	5%
Mitsubishi (JP)	218	3%	806	2%
Suzlon (Ind)	178	2%	463	1%
Others	263	3%	4026	10%
Total	**8088**		**41723**	

The table (figure 4) shows data for the top 10 manufacturers in 2003, who together accounted for some 95% of installed capacity.
Historically, European dominance has been greater than the position for 2003. GE Wind, which entered the market in 2002 through purchase of the then fourth-ranked turbine manufacturer Enron, is singularly responsible for a drop in Europe's share from around 90% in 2002 to 75% in 2003. This trend is partly distorted by the buoyant market in the US in 2003 combined with the relatively weak dollar. The 2004 US market is expected to be considerably smaller. Nevertheless, GE Wind represents a major challenge to European dominance, with Danish manufacturers reacting in 2004 with a merger of its two largest manufacturers – Vestas and NEG Micon.

2.2.2 New entrants offshore

Installation of wind turbines offshore is naturally quite a different prospect to installation onshore, and therefore the industry has expanded to accommodate new (to the wind industry) players. Principal amongst these are offshore foundation manufacturers and operators of offshore installation vessels.

Offshore wind turbines are fixed to the seabed using a monopile (a single steel pile), or weighted down using a concrete gravity foundation. Use of the former employs thick walled, large diameter steel tubes, similar in structure to the steel tower but necessitating large rolling equipment. To supply this market, some specialist manufacturers of large piles, jackets and pressure vessels have entered the market. Gravity foundations employ the capabilities of large civil construction companies.

Offshore wind farms also create a demand for various offshore vessels for survey work, construction and installation, cable laying, piling and drilling. This demand has been supplied by a variety of existing and purpose-built vessels, in both instances drawing heavily from experience in the maritime and offshore oil and gas sectors.

The requirement to install foundations and turbines in particular has initiated the development of specialised vessels to be able to move rapidly between locations and establish a stable working platform more independent of weather conditions, either by traditional jacking mechanisms or by the use of suction anchors.

2.2.3 The industry: economics

The global market for wind energy is ~ 7,000 - 7,500 MW/a, and expecting to grow to 9,000 - 10,000 MW/a in the coming years[16].

Direct employment in wind turbine manufacturing, i.e. not including sub-suppliers, was 30,946 in 2002. Direct employment in installation is 14, 649 (2002). Direct employment in maintenance was 2,768. Total direct and indirect employment in wind turbine manufacturing, installation and maintenance (not including production of European wind turbines installed outside the union, or employment effects of imported sub-supplies to the Union) increased from 25,075 in 1998 to 72,275 in 2002 or 188%[17].

2.3 Project costs – experience and expectations

A comprehensive review of offshore wind farm costs was published as part of the UK government's Innovation Review in early 2004. The table below reproduces project capital costs presented therein. The current generation of near-commercial projects (Horns Rev, North Hoyle, Nysted and Scroby Sands) were built for around € 1.7-1.9 million/MW. O&M costs are estimated at approximately € 105,000 per turbine per year. It is stressed that the information on which both sets of costs are based is very sparse, and that further experience is required to produce truly representative cost estimates.

Windfarm	In operation (year)	Country	Power (MW)	Capital cost (€ mln.)	Specific capital cost (€ mln/MW)
Sheltered waters and / or small projects					
Vindeby	1992	Denmark	5	10,3	2,1
Lely	1994	Netherlands	2	4,5	2,3
Tuno Knob	1995	Denmark	5	10,4	2,1
Dronten	1996	Netherlands	11	20,5	1,2
Gotland	1997	Sweden	3	4,7	1,9
Utgrunden	2000	Sweden	11	13,9	1,4
Blyth Harbour	2000	United Kingdom	4	6,3	1,6
Middelgrunden	2001	Denmark	40	51,3	1,3
Samsø	2003	Denmark	23	35,0	1,5
First near shore wind farms, shallow waters					
Horns Rev	2002	Denmark	160	300,0	1,9
Nysted	2003	Denmark	158	268,8	1,7
North Hoyle	2003	United Kingdom	60	105,7	1,8
Scroby Sands	2004	United Kingdom	60	107,1	1,8

Figure 5: Published total technical capital costs for offshore wind farms

Cost reductions over time in onshore wind have been well documented. During an average annual growth rate of over 30%, in the last 20 years the cost of energy reduced by some 80%. This has largely been a function of bigger turbines, better more cost-effective design and the scale production made possible by volume markets, and R&D efforts. Future cost reductions in the coming years are expected to be in the range of 3-5% annually.

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[16] BTM consult, world market update 2004

[17] European Wind Energy Association, Wind Energy - The Facts, an analysis of wind energy in the EU$_{25}$; dec. 2003

Many commentators expect offshore wind to follow suit with cost reductions over the years as the technology evolves, markets expand, and experience is gained.

The same Innovation Review provides estimates of achievable cost reductions in the short and long-term. Over the next 5 years, it concludes that a 15% cost/MW reduction could be expected. In deriving this estimate, it considers the scope for cost reduction in separate elements of the capital cost. Development and project management costs are considered to have a highly favourable scope for cost reduction. Wind turbines, foundations, monitoring systems and installation activities are considered to have a favourable scope, with the offshore electrical supply considered to be too mature to hold much scope for cost reduction. However, the larger the project, the lower the cost/kWh of the grid connection, so in this respect there is room for essential cost reductions on a cost/kWh base. Onshore electrical works is the most uncertain cost element, and may even show an increase in future costs. In the longer-term, a 40% per MW capital cost reduction over 20 years is estimated, based on ISET Progress Ratios which assume cost reductions as a function of the volume of the market[18] [19]. A previous analysis of long-term energy costs, also for the UK government as part of its Energy Review, estimates that by 2020, offshore wind will be comparable in costs (on a unit energy basis) with CCGT and cheaper than nuclear power, IGCC and fossil generation with carbon sequestration. Energy efficiency measures are at present considered (and in 2020), as the single most cost-effective measure that can be taken.

There are of course many uncertainties inherent in these long-term estimates, and there are technical, administrative and political challenges to be overcome in achieving the volume of market, which is necessary for large-scale cost reductions.

In order to arrive at a proper comparison between the costs of renewable energy and fossil energy projects externalities should be taken into account in full. Without taking into account the external costs of fossil fuel produced electricity, the costs of electricity production with onshore windfarms is around € 0.04 - 0.08/kWh. The external costs of fossil fuel based electricity vary between € 0.01 and € 0.15/kWh[20].

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[18] Offshore wind; Economies of scale, engineering resource and load factors, Garrad Hassan 2004, Document: 3914/BR/01, for DTI.

[19] Technisch-economische parameters van duurzame elektriciteitsopties (Cost of renewable electricity resources and technologies), ECN, July 2004, ECN-C-04-75.

[20] External costs, research results on socio-environmental damages due to electricity and transport. European Commission, Directorate General for Research, ISBN 92-3353-1, EC 2003.

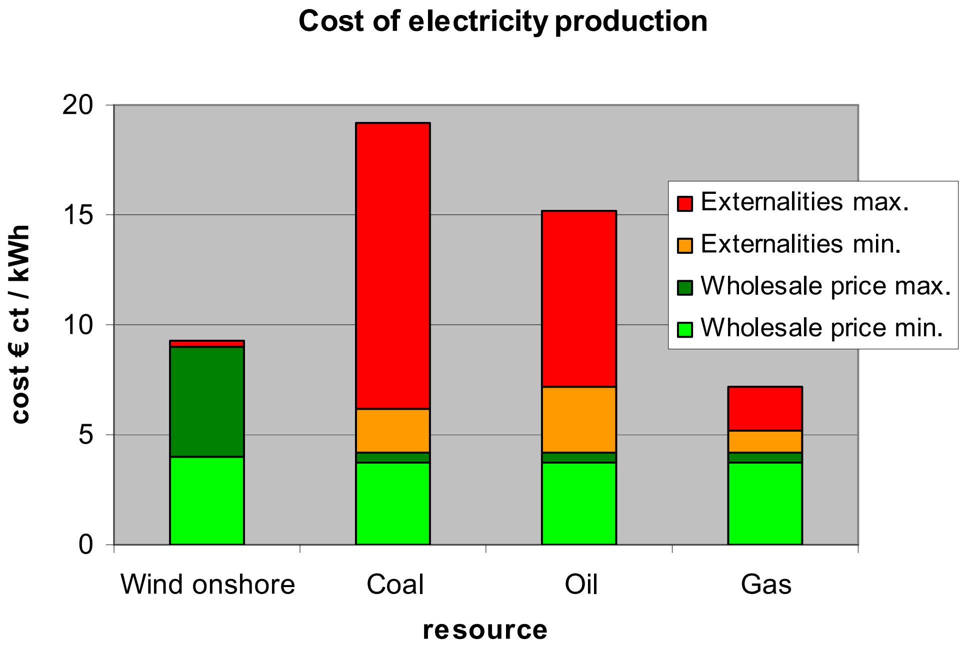

Figure 6: Cost comparison fossil - wind energy

2.4 Grid Connection

An electricity grid is integrated for the purpose of transmitting electricity from areas of net production to areas of net consumption, and for absorbing variations caused by demand fluctuations, power station outages and other events. It has developed under a culture of ‘predict and provide’ where, as a general rule, generation and grid capacity respond to the requirements of customer's demand. Limitations and needs of generating technologies have defined the parameters of the system, and sometimes even driven its development. The system has evolved to cope with very little storage capacity, necessitating real-time balancing of supply and demand. More recently, the drive for a liberalised European electricity market is starting to have a major impact on both the physical infrastructure, and its operation.

As a relatively new generating technology, wind energy makes new demands on the system. Where its location is remote from consumers and/or other power stations, it may necessitate system reinforcement. Its intermittence complicates the job of balancing the system. The industry’s ability to predict power supply has improved and further improvements will make a contribution to managing increasing penetration levels.

On a European system level, wind energy penetration today is still a small percentage of energy or installed capacity. Individual transmission areas do however have appreciable penetrations. For example as a percentage of yearly energy production, wind energy penetration is approximately 16% in the Eltra jurisdiction of Denmark, approximately 30% in the Schleswig Holstein region of Germany (3.5% for the E-On Netz transmission system of which Schleswig Holstein is a part) and 10% on the island of Crete. As a percentage of installed capacity, Eltra has a penetration level of 32%, Galicia region in Spain 25%. As a percentage of peak load, E-On Netz for example has a 30% penetration. The individual RES-

E Directive targets imply penetrations, which, if met principally by wind energy, will be nearly 30% annual energy penetration by 2010. While helpful in indicating what might be possible, each system is different and these kind of figures must be viewed in their own specific context, which includes the level of interconnection with other jurisdictions, the generation mix and so on.

It is only in the last few years (as wind energy's penetration has increased in a number of European countries, and as it becomes clear that the trend will continue), that there has been any widespread initiative to address the grid issues that wind energy poses. This is not to say that potential problems have not been highlighted at an early stage – on the contrary, there has been a longstanding debate about the potential problems of increasing penetration of wind energy. But it is only now that attention is starting to move on from the potential problems to the application of solutions.

2.4.1 The key challenges

Reinforcement
Increasing energy demand, new power stations and market liberalisation all contribute to demands for system reinforcement. A need for new power lines to export power from wind energy-rich areas is beginning to emerge across Europe. There is a time element to reinforcement, which many Member States are already experiencing. A strategic grid upgrade is often a major construction project, and protracted licensing timescales are a common occurrence. Grid bottlenecks in areas of high wind resource could therefore compromise the timely realisation of renewables targets.

Concerns have been raised that artificial congestion can sometimes arise due to the unintentional effects of different national electricity policies. This can happen where there is varying promotion of different sources of generation across member states, creating price differentials and inefficient cross-border trades.

System issues
Below a certain level of wind on a system, wind energy-induced variations are manageable in the context of the other demand/production and grid variations. Above this level, wind energy starts to introduce additional complications over and above those already managed by the system operator. The actual point at which system operators see wind energy in a significant way is dependent on the characteristics of any one system.

In order to ensure a balanced, stable system and acceptable power quality, grid operators need, among other things, wind energy to appear to them more like a conventional power plant, which means providing system services. At the same time there also needs to be adaptation of operation and planning of the grid and its users, and updating of technical connection criteria, to better fit the characteristics of wind energy.

System services are, basically, providing control responses for managing system parameters like voltage and reactive power, which help to balance the system and maintain power quality. This also includes the ability to constrain off wind power for system security reasons. This latter provision is sometimes seen as being in conflict with priority despatch for renewables. Because the fuel is free, it may often not make economic sense to reduce the wind's output when other options are available. But sometimes it is necessary, and indeed advantageous to wind energy where, for the sake of being constrained off for a very small percentage of the time, more wind can connect to the system without the need for major reinforcement. Such an arrangement requires defined market conditions for constraint, to allow plant owners to make an economic evaluation of the option.

There are costs associated with provision of these services – for instance in modifying wind turbines themselves, or provision of equipment which ensures reliable wind power plant shut-down for security reasons. Wind turbine manufacturers are already starting to offer so-called grid compliant turbines – the costs of making these and other changes are not thought to be prohibitive for the industry.

Capacity credit

Wind energy generally displaces energy generation from fossil fuel plant, but there is a debate around the extent to which it can displace capacity. The issue is the extent to which a system operator can rely on plant being available to meet system demand. There are many parameters which determine this, including the reliability of fuel supply and the diversity of technologies and plant size in a system. Capacity credit is a measure of the extent to which wind energy (or indeed any new technology) can substitute for conventional capacity (as opposed to energy). Because wind power is intermittent, it has a lower capacity credit than say biomass or storage technologies, and therefore a greater amount of back-up is required. Estimates for the capacity credit of wind power are quite varied and more research and experience is required to determine the exact level for any one system. It can be considered not only an absolute quantity, but also a reflection of operational experience – that is, system operators may become more comfortable with allocating a capacity credit to wind as they amass the operational data required to take a probabilistic approach to managing wind power on the system.

Studies and Experience to-date

System operators are already starting to show an interest in more actively managing the wind energy on their systems. For instance forecasting helps system operators by improving the predictability of wind energy, and operators like the Danish system operator Eltra, and the German operators E.ON Netz, RWE Netz and Vattenfall Transmission, all benefit from wind energy forecasting systems. These and other European system operators already hold a considerable body of valuable experience in incorporating wind energy on networks.

Eltra's experience, albeit is in the context of a relatively robust system, has been helpful in both demonstrating what is possible, and highlighting areas for further work. Eltra now takes an active part in finding solutions to the integration of wind energy, including an integral role in the Horns Rev offshore wind farm. On integration of large wind energy plants, Eltra says:

> *»due to the large and increasing share of wind energy power plants, it has been necessary to create new concepts for the incorporation of wind energy in the electricity grid. Not only the size and production opportunities make it interesting to operate the new large offshore wind farms as wind energy power plants. Also, new technology and innovation enable wind farms to considerably function as power plants meeting a major part of the control requirements made on traditional power plants.«*

Several recent technical studies[21,22] have concluded that technical issues raised by wind penetration are solveable. Rather than technical limits, it seems likely that economics will be

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[21] Garrad Hassan, ESBI, UCC, 2003. "The Impacts of Increased Levels of Wind Penetration on the Electricity Systems on the Republic of Ireland and Northern Ireland." Final Report.

the parameter which sets the optimum penetration level in many systems. Most commentators also agree that there needs to be a twin-track approach of grid compatibility of wind energy and wind energy compatibility of the grid.

Policy
Where costs are incurred, this will be subject to consideration of the expected benefits – both in monetary terms and otherwise. Allocation of costs is often a subject of debate, and can prove a barrier to deployment where costs act as a disincentive to positive action.

Also subject to debate is the nature of RES priority access provisions in European legislation. A legislative requirement for priority access can and is helpful in the realisation of offshore wind, and it is important that interpretation of this requirement can accommodate new and improved practices for maximising the energy contribution from RES.

So while we do not yet have all the answers to cost-effective integration of wind energy into the networks, it is clear that there is increasingly a willingness to apply expertise to finding solutions, and that practical experience is extremely valuable. More research and demonstration is required in a number of areas including forecasting and complementary technologies such as storage. Administrative barriers are progressively being removed, and this work needs to continue. It is noteworthy that Europe hosts world-leading expertise in wind energy integration, and the benefits of sharing this expertise both within and outside of the Union should not be underestimated.

2.5 Contribution to national & European Union policies

This chapter describes the contribution of offshore wind energy to the Member States and EU policies. First to the Directive 2001/77/EC[23] on the promotion of electricity produced from renewable energy sources in the internal electricity market. In addition, the contributions to more general policies are given.

2.5.1 RES-E directive

The Directive for the promotion of renewable electricity sets indicative national targets for renewables share of electricity consumption, and provides more specific objectives for the electricity sector in meeting the White Paper 12% target. The national targets in the Directive aggregate to 22.1% (EU_{15}) / 21% (EU_{25}) of electricity consumption supplied by renewables by 2010.
In the period 1997-2002 the contribution of renewables increased from 346 GWh/a to 380 GWh/a[24], this is too slow to meet the targets in time. The target is a production from RES of 675 TWh/a in the EU_{15}. Acceleration could come from biomass and wind energy.

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[22] Carbon Trust, 2004. Presentation on report by Mott McDonald on UK Network.
[23] 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
[24] Commission staff working document; The share of renewable energy in the EU; Overview of renewable energy resources in the enlarged European Union. {COM(2004)366 final}, Brussels May 2004

	RES% of total demand			RES-E production in GWh/a			
Country	1997/1999	2002	2010	1997 RES all	1997 wind	2002 RES all	2002 wind
Austria	70,0%	68,0%	78,0%	39.004	20	41.780	209
Belgium	1,1%	1,4%	6,0%	576	8	1.156	56
Cyprus	0,1%	0,1%	6,0%	0	0	0	0
Czech Republic	3,8%	3,8%	8,0%	2.195	15	2.757	16
Denmark	8,7%	19,6%	29,0%	2.822	1.934	7.035	4.877
Estonia	2,0%	2,0%	5,1%	11	0	20	0
Finland	24,7%	24,7%	31,5%	19.027	17	20.753	63
France	15,0%	14,4%	21,0%	65.408	25	65.012	265
Germany	4,5%	8,1%	12,5%	23.948	3.034	47.024	17.200
Greece	8,6%	10,4%	20,1%	3.942	37	3.338	540
Hungary	7,0%	7,0%	3,6%	219	0	213	2
Ireland	3,6%	5,1%	13,2%	844	50	1.323	330
Italy	16,0%	16,8%	25,0%	46.299	118	48.883	1.470
Latvia	42,4%	42,4%	49,3%	2.955	2	2.879	46
Lithuania	3,3%	3,3%	0,7%	418	0	454	0
Luxembourg	2,1%	2,2%	5,7%	108	3	158	27
Malta	0,0%	0,0%	0,5%	0	0	0	0
Netherlands	1,8%	3,3%	0,9%	1.734	475	3.586	910
Poland	1,6%	1,6%	7,5%	1.963	2	2.084	60
Portugal	38,5%	19,8%	39,0%	14.300	38	10.449	362
Slovakia	17,9%	17,9%	31,0%	4.137	0	5.261	0
Slovenia	29,9%	22,9%	33,6%	3.320	0	3.869	0
Spain	19,9%	16,2%	29,4%	36.158	717	29.626	9.564
Sweden	49,1%	46,8%	60,0%	70.183	205	71.804	600
United Kingdom	1,7%	2,9%	10,0%	6.842	665	10.951	1.256
Total	12,9%	12,9%	21,0%	346.413	7.365	380.415	37.853

Figure 7:RES-E Directive

The installed capacity offshore wind energy can be around 10,000-15,000 MW in 2010; this would produce 35-53 TWh/a; about 25% of the required increase. After 2010 offshore wind energy has the potential to contribute 140-245 GWh/a to the European Union electricity supply.

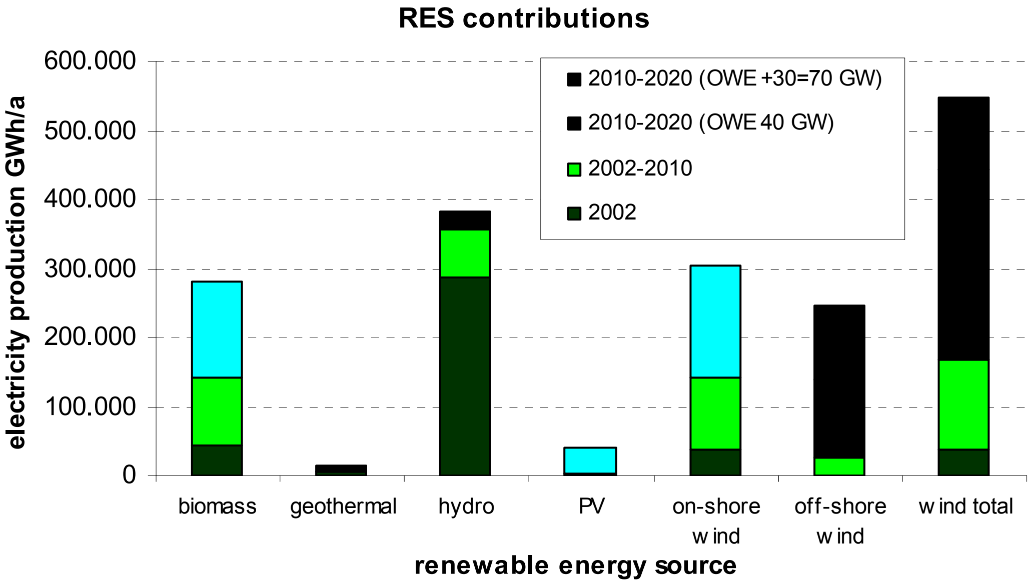

Figure 8:RES contributions to RES-E directive

Conclusion: If targets of the RES Directive are to be met, then there is a vast potential for the deployment of offshore wind projects.

2.5.2 Security of Supply

Security of supply is at the forefront of Europe's energy policy objectives, most recently reflected in the EC's Green Paper[25] on the subject. The paper foresees a crucial role to be played by renewable energy in Europe's response to increasingly insecure and price-volatile conventional fuels. It says,

> *» ...in the medium-term, renewables are the only source of energy in which the European Union has a certain amount of room for manoeuvre aimed at increasing supply in current circumstances. We can not afford to neglect this form of energy. «*

Offshore wind could give a significant substitution of fossil fuel imports. An installed capacity of 40,000 - 70,000 MW would produce 140 - 245 TWh/a.

Conclusion: Offshore wind energy could play an important role in securing indigenous European energy supply in the future and reduce import dependence.

2.5.3 Sustainability – Kyoto / Johannesburg / Bonn

Sustainability is at the heart of European Union energy policy, and the energy sector is expected to play an important part in meeting the European Union's Kyoto commitment. This was also stated and declared at the international conference for renewables, June 2004 in Bonn[26]. Wind energy is a cost-effective means of achieving future carbon reductions.

The European Union's binding CO_2 reduction target represents 355.8 Mt CO_2. The EC expects a shortfall of 161.6 Mt CO_2. 40,000 MW offshore wind energy would save 105 Mt CO_2 emissions, with 70 GW the saving is 184 Mt CO_2.

Conclusion: Offshore wind is an important opportunity to meet European Union's commitment to CO_2 reduction.

2.5.4 Lisbon convention

Offshore wind energy has a highly innovative character. Europe already has a globally strong position in the market sectors involved. World wide the European wind turbine industry has a market share of 78%[27], offshore contractors have a market share of 100%. Deploying offshore wind energy would increase the competitiveness of Europe, paving the way to ensure a strong export position in a market with enormous global potential. R&D institutes and industry already have a long history working together and established extensive networks. This is an important pre-condition for a fast development.

Conclusion: Offshore wind energy has the potential to strengthen Europe's export position with this innovation.

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[25] CEC, 2000. "Towards a European Strategy for the Security of Energy Supply." Green Paper. COM (2000). 769 Final.

[26] Conference report; outcomes & documentation - political declaration / international action programme / policy recommendations for Renewable Energies. Renewables 2004 - International Conference for renewable energies 1-4 June, Bonn, Germany

[27] BTM consult, world market update 2004

2.5.5 New jobs, regional development

The potential for wind energy to generate jobs is well documented. Offshore wind in particular, because of the heavy engineering skills and materials required, is already starting to promote regeneration of areas of low employment caused by a slump in manufacturing orders.

Conclusion: The deployment of offshore wind energy gives as a secondary effect a strong impulse to new jobs and regional development.

2.6 Conclusions

- Offshore wind energy is one of the European Union's most important renewable energy resources. Deployment of this potential is of great importance to both a sustainable energy supply and the economic development of the European Union.
- There are only little experiences with offshore wind energy deployment, hence the environmental impacts cannot yet be judged.
- The investment costs in monetary terms (exclusive of externalities) are relatively high, but a cost reductions of up to 40% in the coming decades is likely. Such cost reductions will be achieved through innovations and the installation of 40 - 70 GW offshore wind power in the period 2004 - 2020.
- Offshore wind energy could contribute significantly to national & EC energy policies such as the Lisbon Agenda, sustainable growth, environmental protection, employment, exports and security of supply.

3 Deployment offshore wind energy

This chapter gives an overview of what needs to be done to deploy the European Union's offshore wind energy potential, with emphasis on locations for windfarms and their legal bases (3.1); innovations (3.2); the financing of projects (3.3); how to integrate offshore wind energy into the electrical infrastructure (3.4) and the environmental impact (3.5). In each paragraph, both the actions needed and the question of who is responsible are addressed.

3.1 Consents and legislation

To develop an offshore windfarm, a developer needs the legal rights to use a part of the national or international waters. A number of active European Union Member States have already introduced a consents system to obtain these legal rights. These, and the legislation procedures, are described in this paragraph. The relevant environmental aspects in the decision-making procedures are separately described in 3.5.

Offshore wind energy policy is, in most countries, under development. A premature coherence between all implied policies areas has been reached, often resulting in a complicated network of procedures, acting as a disincentive for developers. The best practices[28] in offshore wind energy policy are:

- 'one stop shop'procedure;
- transparency in financial burden for project developers;
- anti-speculation clauses;
- enhanced communication and public involvement;
- burden sharing for grid connection;
- allowances for innovation in technology;
- securing pioneering risks;
- risk hedging systems;
- monitoring requirements;
- decommission and rehabilitation guarantees.

One stop shop
The pre-exploitation procedure necessitates input from up to seven different administrations, either direct authorisation or consultative - advisory capacity. At present, the United Kingdom and Denmark have adopted a one-stop shop procedure to ease the procedural difficulties for project developers.

EC Directive 2001/77
Member states are obliged to reduce the regulatory and legislative framework for authorisation procedures according to Directive 2001/77[29], which says:

> *»Member States or the competent bodies appointed by the Member States shall evaluate the existing legislative and regulatory framework with regard to authorisation procedures or the other procedures laid down in Article 4 of Directive 96/92/EC, which are applicable to production plants for electricity produced from renewable energy sources, with a view to:*

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[28] Enabling offshore wind energy developments; S.Shaw et all; 3E NV Belgium - EWEA; 2002

[29] Directive 2001/77/EC of the European Parliament and of the Councilof 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market

- *reducing the regulatory and non-regulatory barriers to the increase in electricity production from renewable energy sources,*
- *streamlining and expediting procedures at the appropriate administrative level, and*
- *ensuring that the rules are objective, transparent and nondiscriminatory, and take fully into account the particularities of the various renewable energy source technologies.«*

3.1.1 Zoning of Marine Area

By law, all countries involved have a territorial sea within which they can exercise their territorial jurisdiction. In all countries, the territorial sea has been set at the maximum allowed 12 nautical miles (22.2-km approx.). All countries have also established an EEZ or similar zone, in which they exercise functional jurisdiction, pertaining to wind farms, among other things. The zoning of the marine area is essentially the same in all countries. However, the size and nature of the area available for offshore wind energy may vary greatly for each country. Some countries concentrate offshore wind energy deployment nearshore (like Denmark), others focus the deployment in the EEZ (like Germany and the Netherlands). The extent to which the available area is used or taken up by other activities in these zones (such as shipping and mining) can vary as well.

3.1.2 The Pre-Phase

General

A pre-phase gives applicants certainty within a comparatively short period and at acceptable costs in the form of an exclusive right to develop a wind farm within a specific territory at sea. Existing pre-phases are based on a tender procedure. A pre-phase is applied under the procedures in Belgium and the United Kingdom.

The draft legislation as to offshore wind in the Netherlands is also based on a two stage licencing system. Following the appraisal by the Council of State body, it is generally expected that the licencing system as originally proposed will be revised in some parts.

Data to Be Supplied

In all countries concerned applicants should provide certain data. This generally includes:

- information on the applicant’s legal status;
- description of the project;
- data on the applicant’s technical, financial and any other qualities;
- technical data on the project;
- a work programme.

According to developers, it is not so much the quantity, but rather the nature of the information to be supplied that presents an obstacle. Market parties set store by an exact description of the information to be supplied. The extent to which the information supplied is deemed to be binding on the applicants may act as an impediment. In the development of their projects, market parties normally prefer a certain flexibility as to the technical and financial details.

Assessment of Applicants

In all the countries concerned applicants are assessed on certain criteria including their technical and financial qualities and expertise in (renewable) energy and/or offshore activities. See also figure 9.

Assessment of Applications

In all countries concerned, applications are assessed based on certain criteria. These may be technical, financial and economic aspects as well as the life cycle of the project and its relation to other activities in the overlapping or nearby marine area. See also figure 10.

overview consents procedure, assessment applicants		
Country	**Financial qualities**	**Technical qualities**
Netherlands	yes	yes, experience with energy & offshore
Belgium	yes	yes, expertise with electricity & marin civil
United Kingdom	yes	yes, experience with energy & offshore
Denmark	yes	yes, experience with e-production and offhore
Germany	no	yes, BSH requirements

Figure 9:Assessment of Applicants

Overview consents procedure, assessment application							
Country	**Project-development**	**Business plan**	**De-commis-sioning**	**Efficient use space**	**Technical quality project**	**Financial quality project**	**Grid Connection**
Netherlands		yes		yes	yes	yes	
Belgium	yes	yes	yes		yes	yes	
United Kingdom	yes	yes	yes		yes	yes	yes
Denmark					yes	yes	
Germany	yes		yes	yes	yes	no	no

Figure 10:Assessment of Applications

Preferred areas

Some countries (fig. 11 applies) have selected preferred areas; these have normally undergone a first screening in order to enhance the chances of successful applications for the development of wind farms within these areas.

Country	Preferred area's		Applications outside preferred area's
	Territorial waters	**EEZ**	
Netherlands	Excluded for windfarms, except 1 demo project	no	allowed
Belgium	yes	yes	
United Kingdom	no	3 SEIA's carried out	only under exceptional conditions (demo projects)
Denmark	yes, screening according to SEIA		not allowed, policy on applications outside preferred area's?
Germany	yes, underway for few projects	yes (SEIA ahead and spatial planning)	allowed, but no guaranteed price paid in Natura 2000 area's if licensed after 1-1-2005

Figure 11: Preffered area's

In the selection of a preferred area the following criteria are normally considered:

- wind conditions;
- water depth;
- availability of onshore electricity connections;
- shipping lanes;
- exclusion areas (defence areas, sand extraction, and mining);
- a (strategic) Environmental Impact Assessment that has already been carried out for the area.

Exclusivity

In general there are two types of exclusive rights:

- exclusive rights of potential developers with regard to other candidates to apply for the required licence(s) in a specific area to develop an offshore wind farm;
- exclusive rights of potential developers / licensees with regard to other (potential) users of the marine area (for instance, for shipping, fisheries, mining or sand or gravel extraction) in which the wind farm has been or will be installed.

The first type of exclusive rights plays a role in the pre-phase only, while the second type can play a part both in the pre-phase and after the licence has been awarded.

In countries with a pre-phase, a party successfully completing that phase is granted the first type of exclusive rights. In all countries these rights will lapse if certain activities, including the application for the required licences or the operating of a wind farm, are not fulfilled within a certain period. In Germany potential developers cannot rely on exclusivity and may therefore up to the grant of the license be confronted with applications of other candidates for the same site.

In all countries, the grant of the licence implies an exclusive right to operate an offshore wind farm in the awarded area.

If a security zone has been instituted, there may be no shipping or fisheries within this zone. In the Netherlands, under the Public Works Act (PWA) Policy Regulation it is explicitly stipulated that a security zone be instituted around the installations (wind turbines). Other countries, like Denmark, do not apply such security zones.

The wind farm operator's exclusive position towards other (potential) users of the marine area (for instance for mining, sand or gravel extraction) in which the wind farm is situated, is not so clear-cut. The lease used in the United Kingdom contains a provision stipulating that the lease can be withdrawn again for (part of) the area in favour of oil and gas extraction and without any compensation to the wind farm operator. In other countries the resolution of such (possible) conflicts of interest are left to the market parties.

3.1.3 The Licensing Phase

In most countries, assessment of the project (and not so much of the applicant) appears to be decisive under the awarding procedures.

The main licences are the construction and/or environmental permits. In all countries, with the exception of the United Kingdom, the required licences are granted under one act. In all countries an Environmental Impact Assessment is required.

The United Kingdom, Germany, Belgium, Denmark, and the Netherlands have already granted licences for offshore wind farms. Denmark, the United Kingdom, and Germany apply a one-stop shop system to the application procedure. In Germany the one-stop system is only for the EEZ, additionally licences from the different regions, "Lander" are required for the cable crossing through the Coastal Sea.

In Germany, unlike other countries like Denmark and the Netherlands, there are no provisions as to the possible transfer of obtained licences.

Cables

The permit to construct and operate the wind turbines usually extends to the cables that connect the individual wind turbines. All countries, however, require one or several licences for the installation and operation of cables that connect the wind farm to the onshore electricity grid. The situation may be complicated if additional licences are required for the installation of these cables within the territorial sea (see figure 12). Moreover, a cable permit does not necessarily imply the right to connect the cable to the national grid. Such a connection would require reinforcement of the network, which means additional expense.

The onshore connection might pose a problem in Germany because of the extensive protected coastal nature areas. Land Niedersachsen, has approved a cable corridor that offers room for four cables but the required exemption to traverse the Wadden Sea has not yet been granted.

		Cables		
Country	**Costs connection to grid**	**Costs reinforcement existing HV grid**	**Licenses in EEZ**	**Licences in territorial waters**
Belgium	Windfarm operators	TSO		Act on the Exploration and Exploitation of Non-Living Resources of the Territorial Sea and the Continental Shelf
Denmark	TSO (preferred area's only) or windfarm operator (other area's)	TSO		
Germany	Windfarm operators	TSO	Seeanlagen-verordnung	Länder
Netherlands	Windfarm operators	TSO	PWA license & Electricity act	PWA license
Sweden	Windfarm operators	TSO	Electricity act	Electricity act
United Kingdom	Windfarm operators	TSO	Electricity act	Electricity act

Figure 12: Cable costs & licensing

3.1.4 Conclusions

- Consents and legislation procedures are already introduced in some EU Member States. In other Member States with a deployable offshore potential, there are no such procedures yet;
- Existing procedures are based on national legal frameworks. Harmonisation may not be necessary;
- All Member States could improve their procedures by utilising facts, figures and experiences from other existing procedures. Such information may also be found in COD databases. Information may also be found member states' reports on what they have done in terms of reducing regulatory and non-regulatory barriers, streamlining and expediting procedures, whilst ensuring that the rules take into account the particularities for offshore wind energy. An EC Report on these administrative procedures is due by the end of 2005. Some Member countries have adopted 'one-stop shop' procedures in order to ease complicated decision making procedures.

3.2 Innovations

There is a great deal of interest in offshore wind as a relatively benign energy source. Promotion of offshore wind by governments is premised on expectations that offshore wind will follow onshore wind in improving its performance, moving into more challenging conditions and achieving cost reductions. Predictions for 2020 by both the IEA and the UK government expect offshore wind to become competitive with conventional technologies, but only on the assumption that the technology develops from its present status.

For offshore technology, technological development is more of a necessity than a market benefit, if it is to be deployed in large volume. Offshore wind turbines installed to date have been marinised onshore turbines, meaning they are basic onshore turbines with an offshore support structure, corrosion protection, and internalised handling equipment. They have also been deployed in reasonably shallow waters.

The European Wind Energy Association (EWEA) is in the process of writing a future R&D strategy for wind energy, under an industry collaborative project which is itself supported by EC R&D funds. It promotes the view that the need for wind energy R&D will continue into the future, and is imperative in order to maintain Europe’s competitive market position. Priority R&D areas are given as follows:

- Economic, policy and market issues;
- Environmental and social impacts;
- Wind turbine and component design issues;
- Testing, standardisation and certification;
- Grid integration, energy systems and resource prediction;
- Operation and maintenance;
- New potentials (for instance the use of satellite data for resource assessments);
- Offshore wind technology;
- Megawatt and multi-mega watt turbines.

Both industry and academia undertake wind energy R, D & D, which have the capacity to gauge and respond to industry's needs. Governments and the EC have a role in providing R&D support, promoting institutional investment in demonstration and guiding research towards national and European priorities. Co-operation takes already place in the IEA Implementing Agreement on R&D for wind power[30] which was established in 1977. This Agreement started a task Offshore Wind Energy and deployment in May 2004, on the subjects Ecological issues and Regulations; Electric Systems integration, Operating and Maintenance; External Conditions; Wind Facilities Technology and Design; Technical Research for Deeper Water.

3.3 Financing

There is a vast amount of finance needed for the establishment of large-scale introduction of wind energy as targeted by the various Member States. Offshore wind energy is not yet a proven technology. The question is whether market parties (industry and financiers) will eventually come up with marketable solutions for inherent project risks?

The development of an offshore wind farm can take 2 to 5 years, during which the developer/investor has to spend ~ € 2 - 5 million on feasibility studies, environmental impact assessments and engineering.

The investment in the offshore windfarm costs ~ € 2,000/kW (see also paragraph 2.2). The windfarm produces ~3,500 kWh/kW/a. The energy production costs of offshore wind energy are now in the range of € 0,08 to > 0,10/kWh[31,32]. This price is likely to go down to € 0.04 - 0.06/kWh.

It is generally considered that offshore wind energy is not yet a commercial viable activity. Consequently, in all EU Member States, governments have introduced support schemes for wind and other renewable energy.

The argument behind governments' decisions to pay a premium price for renewables electricity is essentially twofold. On the one hand, renewable energy technologies must be developed to secure cheap and clean energy solutions in the future. On the other hand, it is

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[30] Currently member countries of the agreement are: Australia, Austria, Canada, Denmark, European Commission, Finland, Germany, Greece, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Spain, Sweden, the United Kingdom, and the United States.

[31] Offshore wind; Economies of scale, engineering resource and load factors, GarradHassan 2004, Document: 3914/BR/01, for DTI.

[32]

necessary to make up for current electricity market distortions, where the full external costs of electricity production are not reflected in market prices.

To bridge the gap when offshore wind energy can not yet compete with fossil fuels financial support is the first key to deploy the market.

Policy instruments used in the EU memberstates

Country	Investment subsidies	Fiscal incentives	Feed-in tariffs	Quota obligations / green certificates	Bidding systems
AU	X	X	X	X (hydro)	
BE	X	X	X	X	
DK	X	X	X		X
FI	X		X		
FR	X		X		X (wind)
GE		X (cheap loans)	X		
GR	X		X		
IR		X			X
IT	X		X	X	
LU	X	X	X		
NL	X	X	X		
PO	X	X	X		
ES	X		X		
SE	X	X		X	
UK	X	X		X	

Figure 13: Overview support mechanisms

Countries have different support schemes in place for renewable energy, see also figure 13.

Governments have supported the build up of other energy resources, just as they are now supporting renewable energy, and, indeed, continue to subsidise other energy resources, see figure 14.

Indicative estimates of total energy subsidies, EU15. (€ bn.)

	Solid fuel	Oil and gas	Nuclear	Renewables	Total
2001 On-budget	>6.4	>0.2	>1.0	>0.6	>8.2
2001 Off-budget	>6.6	>8.5	>1.2	>4.7	>21.0
Total	>13.0	>8.7	>2.2	>5.3	>29.2

Figure 14: Overview energy subsidies

The most important consideration for an investor is that he can accurately determine what and how big the risks are for an investment in an offshore wind farm. As in other projects, the financing of offshore wind farm projects requires an assessment and allocation of project risks. In case of non-commercially viable operations, the security provided by certain availability of government support schemes during 10-15 years is, from the sponsor/financier's point of view, of utmost importance. (It appears from the German experience, however, that a steady (but guaranteed) decline may also be considered acceptable by market parties). The following risks are normally considered in financing offshore wind energy projects:

- viability risk(technical/economic);
- technical risk (construction and in time delivery);
- market risk;
- operational risks (wind, weather, maintenance);
- revenue risk (price, volume, government subsidies);
- structural risk (financial structure);
- sponsor risk (quality of the sponsor);
- political risks (reinforcement, budgets, balancing solutions etc.);
- anti speculation requirements in the authorisations (use it or lose it clauses).

EC financial support
The Commission provides support for the development of offshore wind energy through the RTD-programmes, Intelligent Energy for Europe (EIE-programme), Trans European Networks for Electricity (TEN-E) and the structural funds of EBRD/EIB.

3.3.1 Conclusions

- Public support mechanisms are needed to bridge the period in which offshore wind energy is not yet competitive with energy from fossil fuels.

3.4 Grid integration

Future offshore wind farms will tend to be larger than their onshore counterparts, and are likely to require connection to the transmission system. There are a number of implications, not least of which is the fact that the onshore grid cannot physically accommodate some of the more ambitious plans for offshore wind. The magnitude of intermittent power being fed into the grid in relatively large step increases means that “system” issues will come to the fore in a short timescale.

While solutions exist and new options like short-term forecasting offer promise, finding the least-cost way of dealing with these challenges remains the subject of much debate. Furthermore, the future pattern and rate of offshore wind development is not certain. Because of this, the total costs of integrating large volumes of offshore wind into the grid are subject to some uncertainty.

Clearly there is a need for further work in this area.Grid issues should be linked to the broader question of the need for a greater level of investment in electricity generation and transmission infrastructure.

3.4.1 Recommendations

Clearly wind energy is a new challenge for planning and management of electricity networks. Work is progressing in addressing this challenge, and there are some promising developments, but further research and experience will be required. Wind energy proponents envisage it making a significant contribution to energy supplies, in the context of an overall energy mix with a range of complementary technologies.

Future actions required can be considered as either physical or institutional.

3.4.2 Physical

A need for grid reinforcement can arise from the advent of new technologies, like offshore wind, from increases and changes in consumption, and from the demands of market liberalisation.

Conclusion: Offshore wind would be better accommodated if it were to be considered as part of strategic plans for future grid development. This would mean that system planners should receive, and take into account, future plans for offshore wind.

In accommodating large penetrations of wind energy, Denmark has benefited from a robust, interconnected network, and from access to other European energy markets for trading out of country imbalances. Other alternative strategies could be possible, for instance a greater emphasis on demand management, forecasting and the use of storage technologies.

A key means for integrating wind energy is through updating technical connection conditions (often specified in grid code documents), and planning and security criteria. Often, these documents pre-date the advent of wind energy, or assume that wind energy will not make a contribution large enough to warrant consideration. Inappropriate technical criteria act as both a barrier to connection, and prevent development of new innovations which allow more cost-effective grid integration. At the same time, turbine technology itself needs to incorporate grid-friendly features, which allow it to perform more like a conventional power plant. In order to make wholesale investments in these changes, manufacturers need assurances on the generic capabilities required.

Conclusion: investigate and progress technical solutions which will aid the job of accommodating wind energy on the network.

3.4.3 Institutional

There are many industry actors involved in planning, co-ordinating and developing the grid at a European level. These include European Transmission System Operators (ETSO), Union for the Co-ordination of Transmission of Electricity (UCTE) and International Council on large Electric Systems (CIGRE). These organisations are beginning to devote time to addressing wind integration issues, and it is essential that information exchange between these and wind energy stakeholders – policy and industry – is enhanced, to the benefit of all involved.

Conclusion: information sharing will accelerate adoption of the best solutions.

It is recognised by governments and industry that grid integration of large volumes of offshore wind energy will incur monetary costs, and there are debates at national and European levels on the issue of to whom these costs should be allocated. Ultimately, as with development of the energy sector to-date, costs will be borne by the consumer (through energy bills) and/or the general consumer (through taxes and subsidies). But there is a question as to whether costs should initially be borne by the wind energy industry through project costs (thus making a project more expensive and possibly uneconomic in the context of its competitors), or socialised in some way. The arguments for and against each option centre on whether offshore wind energy offers long-term benefits to society, over and above its alternatives.

Where it is not clear how costs will be allocated, this issue often becomes a source of delay for realising projects.

Conclusion: define allocation of costs and ensure all actors are properly incentivised.

3.5 Environmental Impact

3.5.1 Blessing or risk to the environment?

There is not much knowledge on the intensity and scale of potential impacts on the local environment. First results of built offshore wind farms are already available, but Multi-annual impact studies (monitoring studies) are ongoing. Generic research of the cumulative effects, caused by the already existing activities (initial level of strains for the environment) and future strains caused by OWE, are still missing.

3.5.2 How to speed up gaining knowledge?

By carrying out extensive environmental impact assessments for new offshore wind farms, experience can be gained where knowledge is lacking. On the other hand these extensive environmental impact assessments can cause a delay in the deployment of offshore wind (because they are both costly and time consuming) and thereby in the reduction of greenhouse gases. Therefore it is imperative to strike a balance between what is necessary for the (time consuming) assessment of (local) environmental impacts and the need for fast deployment of offshore windfarms to meeting renewable energy commitments in time (global environmental effect).

The following impacts are deemed to be important in the decision making process regarding offshore wind farms:

- Seabirds: Collision and/or habitat loss of seabirds;
- Migratory birds: Collision and/or barrier effects caused by construction and operating noise;
- Impairment and/or habitat loss of sea mammals by noise (construction and operation);
- Impairment and/or habitat loss of fish (turgidity; electromagnetic fields);
- Impairment and/or loss of benthos by smothering/burial;
- Accidental pollution of sea (caused by ship collisions);
- Turbulence of water layer structure (esp. in Baltic Sea);
- Visual intrusion;
- Interaction and cumulative effects.

To achieve a good balance between the wide range of demands for research and meeting renewable energy commitments in time, it is necessary to prioritise offshore wind Environmental Impact Assessment issues. A catalogue of relevant issues should differentiate between issues which score high on severity, likelihood and significance (need to know) and issues do not score so high on these (nice to know). Double work should be avoided and existing knowledge be made available for future development. Different preconditions in the EU-countries will probably not allow a high degree of standardisation. Ultimately it will depend on the chosen site, the national legal requirements and the sensitivity or protection status of affected subjects, whether issues require obligatory assessments. Other (so-called facultative) issues and their investigation (methods scale) would then require case by case decisions. Within the Concerted Action for Offshore Wind Energy Deployment (COD) framework there is a body of knowledge on the environmental impact of offshore wind energy. An overview is given in figure 15[33].

The establishment of a catalogue could help scoping on the extent of the research requirements for the different issues of the Environmental Impact Assessment. Only the need-to-know issues would require an obligatory assessment.

In order to gain the necessary knowledge on the specific environmental effects of offshore wind farms, a number of pilot projects may have to be deployed. This will ensure that environmental impact assessments and monitoring activities could provide the necessary knowledge and experience to speed up the development. Otherwise the deployment of offshore wind farms may only increase slowly.

Finally, there are opportunities to learn about impacts from existing offshore wind farms and the other marine industries. Making existing information accessible and the exchange of data will speed up the learning curve. International co-operation is desirable. With an active form of co-operation via international co-ordinated research projects, and by using available budgets collectively, research can become more efficient and more effective. These could also provide a description of Best Available Techniques (BAT) and Best Environmental Practises (BEP) for assessments of offshore windfarms. Examples of international cooperation are in OSPAR, the informal COD network and the intentions for German-Danish cooperation on ecological research concerning offshore wind energy (Letter of Intent was signed during the International Conference on Renewable Energies in Bonn). With this kind of international co-operation, there may be better opportunities for the appraisal of cumulative (transboundary) impacts.

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[33] Environmental Impacts of Offshore Wind energy, First Report, overview EI studies, COD 2004 (www.offshorewindenergy.org)

Figure 15: Overview expected impacts

Impact	Subject			
	Marine mammals	Birds	Fish	Benthos/seabed
Noise and vibrations	Dolphins, seals and porpoises are expected to habituate. Whales expected to be sensitive to noise, but effects unknownAreas regularly frequented by marine mammals should be avoided. Insufficient data to proof expectations. Monitoring needed.	Disturbance at small distance from turbines. Construction time avoiding the breeding season.	Risk estimated low. Expected to become accustomed to low-freq noise levels.	Unknown
Barrier effect	Maybe positive because of reduced disturbance (fishery) in wind park area.	Wind farms are flight barriers day and night. Higher losses to be expected in bad weather conditions.Loss of habitat limited, except for some species. Prediction of the effects of diminishing foraging and resting areas is difficult.	Colonisation of fish on support structures. Possible net increase in biodiversity and productivity, partly due to protection from fishery.	Unknown
Construction	Expected avoidance of construction area. In the singular case, repellents are necessary.	Avoid construction during breeding season.	Small loss of seabed area during construction. Redistribution of sediments minimal effect on fish and shellfish.	Localised effects on endangered species due to redistribution of (contaminated) sediments. Limited effect compared to background levels.
Collision risks	None expected	Depends on height and diameter, color, and pole placement. Estimates 10-100 to thousands collisions /year. Impact of large turbines unknown.	Unknown	Not applicable
Electromagnetism	Unknown	Unknown	Unknown, likely to be low. Effects of subsea cables limited, when insulated and buried. Risk of interruption of migratory routes low.	Unknown
Water movement	Unknown	Unknown	Redistribution and re-suspension of sediments expected with small effect on spawning fish (herring)	Very localised scour, which can be avoided using artificial fronds.

3.5.2 Conclusions

- There is a large need for improving the present body of knowledge on the environmental impacts of offshore wind farms. Prioritising between Environmental Impact Assessment issues for offshore wind issues will help that process.
- The establishment of pilot offshore wind farm projects may help in obtaining the necessary insight in nature and significance of specific environmental impacts. Member States, the EC and NGO's each have their own responsibilities in this.
- Co-operation between Member States (under internationally co-ordinated research projects and/or collective utilisation of existing budgets) will aid more efficient and effective environmental research..
- Offshore wind farms should be assessed both on their positive and adverse environmental impacts,and checked against the overall impacts of alternative means of generating electricity. These impacts should both be seen in isolation and as to their accumulative effects in case of a series of wind farms.

4 Governments' role in the deployment of offshore wind energy

The deployment of offshore wind energy is the responsibility of both governments and the private sector (the private sector should invest; the government should accommodate and facilitate). All parties have their own responsibilities in the development of offshore wind farms and meeting their targets. Co-operation between all involved parties will be of benefit to the deployment of offshore wind energy. This chapter focuses on what the governments can do / should do to deploy the market potential on a national scale or on EU level. Because of the scale of the issue and its extra-territorial nature, offshore wind should be addressed at European level as well as at national and local level.

4.1 Consents and legislation

Providing planning and the legal bases for offshore windfarms is typically the responsibility of governments. Consents and legislation procedures can be developed and implemented by the individual Member States. National consents and legislation procedures should of course include the implementation of EU directives. Those Member States who are bordering potential areas for offshore wind energy should all have consents and legislation procedures. For the development and optimisation of existing procedures Member States can make use of each other's experience. COD makes the experience of a number of Member States with existing consents and legislation procedures accessible.

4.2 Innovation

The energy production from offshore windfarms must become more competitive. Hence, innovations do have a high priority. The private sector is primarily responsible for this. Governments and the EC should support this, in order to create a competitive technology and a competitive industry.

4.3 Financing

Financing of projects is a combined responsibility of the private sector and governments. If governments want the private sector to deploy offshore wind energy, governments must provide financial support mechanisms to bridge the temporary gap between cost and economic value of wind energy. This is already the case in a number of Member States.

4.4 Grid integration

In the coming decade, the electrical infrastructure will undergo reinforcements and expansions, i.e. the interconnection capacity will be increased to improve the liberalised market. More interconnection capacity means a more liquid market. Governments have an important role in regulating this development. If governments were to regulate these reinforcements and expansions of the Trans European electricity grid, this could provide maximum access to the European Union's internal renewable energy resources. This would make integration of large amounts of offshore wind energy possible.

International and national research policies should aim to facilitate the grid integration of large wind parks. Research priorities for this aim are the improvement of power production forecasts (e.g. by means of artificial intelligence algorithms), demand side management strategies linked to renewable energy generation and short and medium-term storage. These developments can help to increase the capacity credit of wind energy and thus boost its value at the power markets. Moreover they can contribute to a better utilisation of the transmission system, as a consequence leading to extended deadlines for necessary reinforcements of the transmission grid.

4.5 Environmental impact

Governments have two roles. On the one hand they must protect the environment according to the EC Habitat and Birds Directive, and on the other hand they should promote the use of renewable energy.

To speed up the deployment of offshore wind energy, governments must get reliable information on the environmental impact of offshore windfarms. They get this information through assessments and impact studies by developers (usually as consents/licence requirement) and by their own research activities.

Results will be achieved faster if Member States co-operate in:

- Standardising research methodologies, to make results (more) comparable;
- Multinational research programmes which specify:
  - type of information on type of species is needed
  - which countries provide which part of the information

These research programmes can be carried out in a combination of:

- Requirements for Environmental Impact Assessment's and impact studies in consents and legislation procedures;
- Combined research activities.

Annex I, Workshop Committee

Name	Country	Representing
Michel Verhagen (chair)	Netherlands	Ministry of Economic Affairs
Imar Doornbos	Netherlands	Ministry of Economic Affairs
Cathy Plasman	Belgium	Ministry of Finance / Advisor North Sea
Artur Kawicki	Poland	Polish Ministry of Environment
Cornelia Viertl	Germany	Bundesministerium fur Umwelt, Naturschutz und Reaktorsicherheit
John Overton	United Kingdom	Department of Trade and Industry
Steffen Rønsholdt Nielsen	Denmark	Danish Energy Authority
Martin Finucane	Ireland	Department of Communications, Marine and Natural Resources
Claes Pile	Sweden	Ministry of Environment
Christian Kjaer	European Union	European Wind Energy Association
Stephan Singer	European Union	World Wildlife Fund
Urban Keussen	European Union	European Transmission System Operators
Paul Hodson	European Commission	European Commission
Ruud de Bruijne	SenterNovem; Secretariat Workshop	
Rebecca van Leeuwen-Jones		