WP 2.5

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Social Acceptance, Environmental Impact and Politics

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1 Introduction

The objective of task 2.5 has been to bring together existing knowledge concerning offshore wind farms in relation to the following subjects:

- environmental impacts
- conflicts of interest
- social acceptance
- policies

This draft report has been prepared based on answers to questionnaires received from 13 European Countries, evaluating the different topics, as seen from within each of these countries. The answers given to the individual questionnaires can be found in Annex 1, arranged in order of subjects.

Where appropriate, each member of the concerted action has indicated the importance of specific subjects by giving them numbers from 1-3, “1” indicating high importance and “3” low importance.

On basis of this ranking and the responses from the members of the Concerted Action, and on the basis of interviews with key players within offshore wind energy, selected references have been reviewed in order to achieve the most up-to-date knowledge of the relevant issues of this cluster.

The focus, in particular for the section on environmental impact, has been to point to issues, which may become potential barriers for the large-scale development of offshore wind industry. Therefore the well-known environmental beneficial effects of wind turbine produced power are not specifically mentioned here (but in the report from Cluster 2.4). It must however be noted that these benefits, the avoidance of pollutant gasses and the preservations of raw materials like gas and coal, should be clearly stated in the Environmental Impact Assessment and that the emphasizing of these *positive* environmental impacts is crucial in relation to the public and political acceptance of wind energy. A study on the positive impacts may be necessary as these may differ in detail from the onshore situation, e.g. different pollutant levels per kWh; job creation rate per kW different. Some work exists on this but may need final definition (see Draft Report on WP 2.4.).

2 Environmental Impact.

2.1 Environmental Impact Assessment

Within the EU, an Environmental Impact Assessment[1] (EIA) must be carried out before public approval for larger projects can be granted. The minimum requirements of the EIA are specified in the EC Council Directive 85/337/EEC [i] amended in Directive 97/11/EC [ii].

The directives require that private and public projects, which are likely to have significant effects on the environment, must be subject to an assessment of their potential effects on the environment before they can be allowed to proceed.

An EIA shall identify, describe and assess the direct and indirect effects of a project on the following factors:

- human beings, fauna and flora
- soil, water, air, climate and the landscape
- material assets and the cultural heritage
- the interaction between these factors mentioned

The directives lay down rules for the EIA procedure, which includes a requirement for public participation: the results are to be made public, and the views of the public taken into consideration in the consenting procedure.

Wind energy projects are specifically mentioned in Annex 2 of the Directive 97/11/EC, indicating that the individual member states shall determine, either through a case-by-case examination or through thresholds or criterions set by the member state, whether wind power projects shall be made subject to an assessment.

In this way member states may exempt a specific project from the provisions in the directives, but it is unlikely that any offshore wind farm may be publicly approved without an EIA because of its size and the public attention regarding its environmental effects.

General conclusions:
Developers of offshore wind farms must carry out an EIA on the specific project, with the purpose of providing information about the possible impacts on the environment from the time of installation till the dismantling of the turbines and foundation.

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[1] The term "Environmental Impact Assessment" (EIA) covers the procedure that fulfils the assessment requirements of Directive 97/11/EC. In many countries, e.g. in the UK, the environmental information provided by the developer is presented in the form of an Environmental Impact Statement (EIS), which may then be described as the final product of an EIA. In this report only the term EIA will be used.

The EIAs from individual offshore wind energy projects will contain much valuable information regarding the effects from wind energy on the environment, but due to the fact that the experiences with offshore wind power are still relatively limited, the literature on environmental impacts appears sparse. In some cases the first pilot studies are only now underway. Currently only Denmark, Sweden and UK have put a few relatively small offshore farms into operation, and in Holland a semi-offshore farm is in operation.

2.2 Biological impacts.

The lack of experience with offshore farms and the impacts from here is clearly reflected in the responses to the questionnaires.

Only a few case studies on the impact on fish, birds, sea mammals and flora have been carried out in connection with the offshore plans already established, either as part of the Environmental Impact Assessments or as individual studies. Nevertheless, the response on the questionnaires clearly indicates that this knowledge has not yet been compiled in any systematic manner, resulting in the fact that the biological impacts and mechanisms involved are still being covered by uncertainty.

Biological issues considered potentially problematic were indicated as:

- Collision of birds with turbines
- Ousting birds off their traditional feeding/roosting grounds
- Unknown effect of low frequency noise emissions on fish life and sea mammals
- Impacts on fish larvae
- Disturbances of seabed and fauna during construction and operation.

2.2.1 Birds

2.2.1.1 Terminology

In the EU, different terms for bird-protected areas exist, the most important regarding offshore conditions being: Important Bird Areas (IBAs), Special Protected Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar areas.

- "IBA" – Important Bird Area **-** is a BirdLife term [iii] and covers a conservable site identified on the basis of its international significance for the conservation of birds at the global, regional or sub-regional level for: threatened bird species, congregatory bird species, assemblages of restricted-range species and assemblages of biome-restricted bird species. IBAs are identified by the private organisation BirdLife using standardised, internationally agreed criteria, but the term IBA in itself does not imply any legal protection of the area. IBAs have borders described, but these borders may not all have been precisely defined. Furthermore, the selection of IBAs in Europe has not been finalised – national BirdLife partners may add more areas to the list, as indicated by e.g. the Swedish Ornithologist Organisation [iv].
- "SPA" – Special Protection Area **-** is the official EU term regarding protection of birds, and SPAs are designated in the EU under the EC Birds Directive 79/409/EEC. The protections requirement regarding SPAs are given in Article 4(4) of the directive, where it is stated that for SPAs "*…Member States shall take appropriate steps to avoid pollution or deterioration of habitats or any disturbance affecting the birds, in so far as these would be significant having regard to the objectives of this Article…*"
  Member states shall furthermore, according to the directive, "assess any plan or project that either by itself or in combination with other plans or projects is likely to have a significant effect on an SPA, and ensure that any such plan or project is not approved if it would adversely affect the integrity of the site, unless there are 'imperative reasons of overriding public interest'" [v]
  There are currently 1,375 SPAs in Europe
- "SAC" – Special Area of Conservation – is an EU term covering areas designated in relation to the EC Habitats Directive 92/43/EEC. The aim of the directive is to contribute to the maintenance of biological diversity through the conservation of natural habitats and of wild fauna and flora in the Europeans territory of the member states. According to the directive, member states are committed to protect wild species and the habitats of plants, mammals, reptiles, amphibians, fish and invertebrates and to conserve threatened types of habitats. The designation of a SAC is only possible after a site has been adopted as a Site of Community Importance (SCI). An aim of the

directive has been to establish the "Natura 2000" network in order to ensure that selected habitats and species are maintained at or restored to a favourable conservation status.

- Ramsar areas are designated on basis of the international Ramsar Convention on Conservation of Wetlands of International Importance, especially for birds. Sites included in the Ramsar List are subject to conservation measures, including the establishment of nature reserves. If a site is de-listed, states having ratified the convention are obliged to compensate for the loss by creating additional nature reserves or by protecting an adequate portion of the original habitat [v].

  Other international conventions of relevance are the Bonn Convention on Conservation of Migratory Species of Wild Animals ("CMS"), aiming at conserving species of wild animals that migrate across or outside national boundaries, and the Berne Convention on the Conservation of Europeans Wildlife and Natural Habitats, aiming at the conservation of wild European flora and fauna in their natural habitats. The convention also covers non-European countries, e.g. in the case of migratory species moving to Asia and Africa.

Only the term IBA will be used in this report, for the following reasons:

- Ramsar areas, SACs and SPAs are in many cases the same
- the 1,357 SPAs overlap partly or wholly with 54% of all (3,619) European IBAs identified by the BirdLife European Partnership[2]
- the IBA approach is scientifically rigorous and BirdLife organisations advocates the importance of these sites
- according to the European Court of Justice[3] unclassified sites that deserve EU classification, should be treated as classified sites, in other words: IBAs, which have not been officially declared as SPAs, must be treated as an SPA until a decision has been made. BirdLife's official goal is to have 75% of the IBAs declared as SPAs.

[2] Personal communication with Alison Stattersfield, BirdLife (June 2001).

[3] The Santoña Marshes case from 1993 (Case C-335/90, Commission v Spain ECR I-4221)

2.2.1.2 Impact on Birds

The answers to the questionnaires and the ranking of the subject show that the impacts on birds from offshore wind turbines are considered to be of very high importance in Europe – in Holland, for instance, the impact on birds is the most important environmental factor according to the government, and when ranking the different issues in the questionnaire, the importance is also reflected in the fact that the impact on birds (and the visual impact) received the highest importance score of all environmental subjects from the members of the Concerted Action.

It is difficult to pose any general conclusions about the possible impacts for the following reasons:

- the impacts are site dependent (e.g. distance to shore, presence of fish, migrations routes).
- the impacts are relative to various bird species.
- only a few studies have been carried out for offshore wind turbines:
  In Denmark, at Tunø Knob offshore wind farm, Before-After-Control-Impact and After-Impact studies were conducted from 1994-97, but the results – that no effect of the ten 500 kW wind turbines could be detected on the abundance and the distribution of Eider ducks – were only valid for wintering Eiders [vi].
  In Sweden, two studies on migrating birds at Utgrunden and Yttre Stengrund are being carried out, but with no definite conclusions available yet.[4]
- the studies carried out for onshore wind farms in some cases present conclusions that contradict each other, some studies showing that birds avoid the vicinity of wind turbines (The Greenpeace Study [vii]), other studies concluding that onshore wind turbines have only little or no impact at all on bird life (e.g. [viii] and [ix]).

Expected impacts:
Impacts on birds may be expected, such as:

- collisions of migrating or feeding birds with turbines (rotor)
- turbines acting as barriers between feeding and roosting grounds or in migrations routes
- ousting birds off their traditional feeding/roosting grounds due to physical changes of habitat

The expected impacts will depend on the following parameters (for a detailed discussion, also see [vii]):

- construction work: the impacts on birds during the construction phase are only expected to be temporary and limited. However, the choice of foundation type may be of importance, as it is expected that the ramming of a monopile could cause noise levels up to 150 dB and potentially disturb both breeding and staging birds. If a caisson type of foundation is chosen, the noise level during the construction phase will be lower [x].

[4] Observations from Utgrunden indicate that Eider ducks have no problems avoiding collisions with the turbines, as the ducks discover the turbines already 3-4 km before they reach the farm, and then subsequently pass the farm at safe distance (1 km).

- bird species: different bird species react differently and individually to man-made obstacles such as wind turbines. The EIAs for each offshore wind farm must therefore address the avian issues in detail.
- flying heights and migratory paths, depending on the following parameters:
    - number of birds: migrating birds in larger amount often fly at higher altitude, thereby encountering less disadvantages of the wind farm. Migrating birds offshore, however, tend to fly at lower altitude than over land.
    - weather conditions: during conditions of poor visibility, e.g. in foggy weather, the risk of collisions for birds increases.
      Furthermore, air pressure, temperature and wind directions influence flying height and direction.
    - time of day: birds usually migrate at higher altitudes at night than at daytime, resulting in a decreased collision risk if the flying height then becomes higher than the zone of risk (the rotor height). But in general, as the collision risk increases in situations of poor visibility, the risk of collision will be larger at nigh time than at daytime.
- distance to shore: migrating birds often have their flight path near the coastline, therefore the effects of a near shore wind farm might be larger. In general the number of birds declines with distance to shore, but there is insufficient information available on bird migration away from the coastline
- water depth: as birds prefer shallow water to deep water, due to better feeding possibilities, the risk of collision and ousting should diminish if the farm is placed in deep water.
- feeding conditions: as the foundations prove a good living environment for small fish, mussels etc, this tends to attract bird colonies, feeding from this new fauna. If fishery, as expected, is to be forbidden within the offshore farms, the farm area may serve as feeding ground for birds, thereby improving feeding conditions and minimizing the ousting of birds off their traditional feeding/roosting grounds, but at the same time increasing collision risks.
- dimensions of the wind farm: it is believed that larger turbines, being more visible, will reduce the risk of collision. The negative effects of large-scale offshore wind farms on migrating birds might also be reduced, if a sparse layout arrangement is used.[5]
- operating strategies: the possibility of stopping all turbines at low visibility conditions would reduce collision risks e.g. during times of heavy migrations.
- color/illumination of turbine: the risk of collision may diminish if the turbines are as visible as possible (which on the other hand may influence the public acceptance negatively, depending on the visibility, i.e. distance to shore). The towers can be painted in bright colors and illuminated appropriately, but concerning illumination this is to be handled with great cautiousness as lights may also attract bird, thereby increasing the risk of collision. Especially the mounting of light on

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[5] Tulp et al., 1999 [xi] suggest that the negative effects of large scale offshore wind farms on migrating birds might be reduced, if certain aspects are considered: as birds tend to avoid flying between turbines, the farm should not be long and line-shaped like a long row, lying perpendicular to migration paths. A corridor, with a distance between turbines of several kilometers, may be recommendable in order to minimize the risk of huge wind farms acting as barriers. Finally it is suggested that a small distance between the individual turbines, minimizing the total surface area of the farm, may reduce impacts on migrating birds.

the turbines for ship navigation or repair works may attract nocturnal migrants during conditions of poor visibility, leading to an increased risk of collision[6] [xii].

- noise/movements during operation: as it is expected that offshore wind turbines will produce more noise than onshore models, e.g. due to increased blade tip speed (see report from CA-OWEE Work Package 2.1), this may influence the impact on birds both negatively (ousting) and positively (fewer collisions).

  The noise from maintenance vessels – or helicopters - may cause more disturbances to birds than the noise from the turbines themselves – maintenance should therefore also due to environmental concerns be minimised, using low-noise vessels if the farm is in the vicinity of areas with birds (or other fauna).

Another unsolved question, beside the ones mentioned above, is how close a wind farm can be situated to a bird protection area. In Denmark, the Rødsand offshore wind farm will be situated 3 km away from a Special Protected Area, making this farm a very important object in relation to impact studies in relation to birds.

It is obvious that an IBA in general cannot be recommended as a suitable area for a wind farm, as collision and ousting risk will be unacceptably high. More information about these areas is therefore necessary, also because the borders of IBAs are not always well defined (unless they are already defined as official EU Special Protection Areas). These investigations may result in more SPAs or altered borders of existing SPAs areas, thereby making the planning process of offshore wind farms more difficult.

General conclusions:

As studies regarding the impact of offshore wind farms on birds and general studies on migration patterns are sparse, and as the effects depend on many different parameters, more knowledge is needed, both as general studies concerning bird migration and as site-specific studies: Ecological monitoring programmes/ Before-After-Impact-Studies are highly desirable in order to judge the effect on birds. The public dissemination of such studies is vital to promote good practice through the industry.

Furthermore it will be very important to collect information from different studies in order to cover the whole area, as different "narrow" site specific studies are carried out at the different projects.

It is important not to cause public concern regarding the effect of offshore wind farms on bird life: careful siting of turbines, away from important migratory paths (where these are clearly defined) and bird

[6] A case from the Oresund Bridge between Denmark and Sweden demonstrates how difficult this issue is to investigate. Despite of several studies being performed prior to the construction, concluding that the risk of bird collision was minimal, some 600 birds were killed at day one in October. Apparently the birds were attracted by the illumination lights on a very foggy day, and collided with the bridge in great numbers, falling to the road below. This situation had not been accounted for in any of the studies performed, and the situation may be expected to occur relatively infrequent. The story generated quite some debate in local media and illustrates the point that the "law of great numbers" apply. Even though the total impact is very small, isolated events as the one described, may cause significant decrease in public acceptance.

habitats, on the basis of serious investigations of populations and behavioural patterns in the specific area, as part of the specific EIA, is necessary to minimize the effect of offshore wind turbines on birds.

If an offshore farm is placed in the vicinity of bird areas, effects on birds should be minimized by considering e.g. type of vessel (low-noise) and time of day and year for construction, maintenance and dismantling work: the collision risk will be lower when carrying out work at daytime and at a time of the year when the number of birds is low, and at a non-sensitive period: when birds are moulting or breeding, planned operations at the farm should be avoided.

2.2.2 Sea mammals

The effect from offshore wind farms on sea mammals is generally not considered to be very important, as can be seen from the responses to the questionnaires (App. 1).

An assessment of the local mammal population, e.g. seals, whales and dolphins, is however needed in the EIA, and if the specific site is situated in the vicinity of e.g. grey-seal colonies this question may become crucial in relation to the approval of the project This was the case for the Swedish Bockstigen project, where a Before-After-Impact-Study was carried out before construction, during construction and two years after start of operation, showing that wind turbines did not affect the seals in any respect. [xiii]

The same experience can be drawn from the Tunø Knob Wind Farm, where the seals seem unaffected by the turbines.

At the moment a Danish project is underway by SEAS, where the movements of radio-tagged seals are followed as part of a larger seal surveillance program in relation to the construction of the Rødsand wind farm where the population of seals is significant.

Although the impact on mammals seems marginal, further investigation is needed in relation to the following subjects, as emphasized by the CA members:

Expected impacts:

- loss of habitat due to disturbance through noise emission from turbines and from construction and maintenance vessels (or helicopters) and equipment. The disturbance during the construction phase is expected to be only temporary, whereas disturbance from turbines and maintenance vessels might have permanent effects.
  With regard to noise emission, for the Rødsand Offshore Wind Farm it has been estimated based on measurements from the Vindeby and Bockstigen offshore farms that the submarine noise will at most be audible to marine mammals at a distance of up to 20 metres from the foundations. [xiv]

- vibrations in the infra sound area could affect the animals' sonar system, making it more difficult to retrieve food[7].
- potential influence from low frequency sound emission and electric and magnetic fields in cables. However, calculations of magnetic fields from submarine cables dug down one metre under the seabed show that the magnetic field on the seabed above the cable will be smaller than the geomagnetic field.[8] Therefore no impacts are expected if the cables are properly buried. [xiv]
- effect on mammals may increase due to visual impact from large-scale offshore wind farms (moving blades, especially).

General conclusions:

- More studies are needed to evaluate the effect from noise and magnetic fields, and the visual impact on mammals.
- Before-After-Impact-Studies, including seismic surveys and monitoring of underwater noise levels, and studies on noise reception of sea mammals must be carried out.
- When planning offshore wind farms, specific protections areas for sea mammals should be avoided, and duration and quantity of noise minimised during construction (especially at sensitive time periods) and operation. Submarine cables should be properly buried or shielded.

2.2.3 Fish

Only a few studies deal with the subject of the impact from offshore wind farms on fish, as the existing wind farms are erected in areas with no or very few fish.

A Swedish study of the first offshore wind power project in the world outside Nogersund, Blekinge (Sweden), showed that there was no negative impact on fish from the 220 kW turbine [xv] – the fish population within 400 m from the turbine increased, however the fishermen caught less fish when the turbine was in operation (leading to a conflict of interest).

Expected impacts:

- Preliminary observations seem to indicate that the foundations tend to resemble a natural reef, giving good living conditions for fish, benthic communities[9] and fauna [xvi]. Also the fact that fishing with trawling equipment will not be allowed within and in the vicinity of farms, will affect the fish population in a positive way by improving habitat as breeding and resting grounds for fishery species. The exclusion of fishery will in many cases lead to conflicts with the fishing industry, see Section 3.3.
- Potentially negative effects are

[7] On the other hand, when fishery (with trawling equipment) is prohibited in the vicinity of the wind farm, feeding possibilities might improve

[8] The geomagnetic field is the constant magnetic field surrounding the earth

[9] benthic communities: communities living on the sea bed, also known as "Benthos". ("Benthos" originally means "seabed" in Greek)

- effects of noise emission and vibrations on fish life both in the construction phase and after installation, which may lead to loss of habitat. Maintenance vessel may also have a negative impact, but compared to the "usual" impact from fishing boats this must be considered as a minor impact
- especially during construction, sedimentation and turbidity[10] of water may impact on fish larvae, however this is regarded as a temporary impact. Construction during sensible periods should be avoided, as this may lead to a high fish mortality rate.
- the fact that foundations will serve as natural reefs, but consist of hard material compared to the sea bed, may lead to changed biotope,[11] and thereby to a change in fish population. If the sea bed is rocky, as for instance at many Swedish offshore locations, the potential alteration of biotope will be limited
- electric and magnetic fields around the cables may influence fish and fish breeding, but no research results have yet been found published on these issues

General conclusions

As the effect of noise, vibrations and magnetic fields on fish is relatively unknown, studies and surveys are needed before, during and after construction. Projects should seek to minimise the effect of structures and cabling on existing stocks, their food sources and spawning activity, e.g. by shielding and burying cables appropriately in order to minimise electromagnetic impacts on fish. Construction works should be avoided during sensible periods.

2.2.4 Seabed and benthos

In general the disturbance of seabed, and thereby of benthic communities, will primarily take place during the construction (and dismantling) phase. During operation the effects from gravity foundations will be higher than the effects of e.g. monopile foundations, both due to the simple fact that gravity foundations will cover an area of the seabed larger than is the case for monopile foundations and due to the risk of scouring of the seabed.

Even though a gravity foundation is chosen, the total seabed area covered by foundations will still be very small compared to the total area of the wind farm.

Expected impacts:

- loss of habitat and individuals due to construction activities. However, the disturbance of the seabed from sedimentation during the construction phase so far only seems to be temporary, as experience from the Swedish Bockstigen project shows
- changes in sediment structure may in some cases rise from changed water flow around the foundations

[10] Turbidity is the degree of cloudiness or opacity of the seawater due to disturbed sediment.

[11] Biotope is a small area with its own environmental conditions that is home to a particular ecological community of plant and animal life

- footprint of turbine foundations and cables, maintenance vessels, electromagnetic radiation and noise may reduce abundance and diversity of seabed life
- the foundations act as natural reef and introduce fauna, however these artificial hard substrates may cause changes to the biotope structure with unknown consequences regarding benthos and subsequently food chain
- the absence of fishery and shipping (except for maintenance vessels) will have a positive local effect on fauna and seabed

General conclusions:
The quality and quantity of possible impacts on seabed and benthos are not well known, calling for surveys of specific project sites, both as part of the EIA and as generic studies. When designing wind farms, maintaining or improving habitat for local species of importance should be considered.
In general the subject of cables need to be further investigated in relation to impacts due to physical size and electromagnetism; the area around the cables may be included in the fishery exclusion zone.

2.2.5 Hydrography, sea currents and water quality

Expected impacts:
- These topics are only considered important at a very few special locations, due to the typical low ratio between foundation diameter to inter turbine spacing.
- However, detailed modelling may be necessary depending on size of project, proximity to shore, shallowness of water and general sensitivity of local hydrography or sea currents.

General conclusions:
In order to avoid impacts on hydrography, sea currents and water quality, foundations should be designed to minimise scouring, erosions, sediment redistribution and alteration to current flow. Projects must minimise risk of contamination during construction, operation and decommissioning and avoid use of pollutant chemicals when foundation, tower and turbines are protected against marine environment.

2.3 Effects from accidents

The effects on the environment due to accidents are to be taken seriously, as for instance a collision with an oil tanker may in worst-case cause severe damage regarding fauna and flora, water quality, coastline etc. It should however also be noted that especially the first generations of offshore farms may prevent accidents from happening, as the turbines will often be placed in shallow water, where the collision risk may already be high. Properly marked turbines will more clearly warn ships against the risk of collision, than was the case before the turbines were installed.

Collision risk analyses are carried out as part of the EIA, but so far it seems to be quite difficult to develop reliable risk models – as can be expected, taking the lack of experience with collisions of this kind into consideration.[12] Moreover, the effects of potential oil pollution for e.g. birds have not been estimated in e.g. the Danish EIAs.

Expected impacts:

Accidental impacts on the environment may origin from collision between ship (e.g. maintenance vessel) or aircraft (e.g. helicopter) and turbine/foundation or substation, or from damage to submarine cable caused by anchoring, colliding or sinking ship, by trawling equipment or during construction.[13]

The effect of such accidents may be a pollution of the environment caused by substances from the offshore farm (turbine/substation/cable) or substances from the colliding ship or aircraft. The exact consequences of a collision are dependent on many parameters, such as type of ship/helicopter, collision angle, speed of colliding vehicle.
If larger ships, such as oil tankers, collide with a turbine, in many cases it is to be expected that only the turbine and foundation will be seriously damaged. In other words, a ship collision does not necessarily mean leakage of huge amounts of harmful substances.
Moreover, if a leakage of polluting substance is actually the result of the collision, the degree of impact on the environment will vary in relation to weather (temperature, wind speed) and of course the nature of the polluting substances.

The most possible polluting substance in these cases is regarded to be oil:

- oil spillage deriving from the turbine is not an issue of major concern, as the turbines contain only small amounts of oil.
- the diesel oil inside the substation is neither regarded as being a major source of risk, as the oil amount is limited and the diesel oil will relatively easy evaporate. However, to minimise risks of leakage, substations should be constructed with double walls.
- damage on submarine cables may cause release of mineral oil isolating the cable, is this type of cable is chosen. In a worst-case-scenario at Horns Rev [xvii], the maximum oil leakage amount would be 4,200 l. Although this is a relatively small amount, and although the risk of such accidents has been calculated to be very low (one every 32,000 years), mitigation measures such as protection of the cable (by trenching if possible) and prohibition against fishing within the area of the farm and around the cable are therefore highly recommendable. Moreover, the pressure inside the cable is to be monitored continuously in order to take immediate action in case of leakage.
- the most critical impact on environment regarding oil pollution would be caused by oil from ships. Diesel oil from fishing boats and maintenance vessels is not regarded as seriously as oil from larger ships, because diesel oil will evaporate to a relatively high degree compared to bunker oil. According

[12] For instance, the risk analyses regarding the Rødsand and Horns Rev projects were not immediately accepted by the developers, as the figures were based on the assumption that a ship entering the farm area would unavoidably cause a collision. A revised risk analysis has therefore been carried out for the Horns Rev project, and a similar revised analysis is currently being carried out for the Rødsand project.

[13] During the construction of the Middelgrunden Offshore Wind Farm, the submarine cables were damaged three times, however without environmental impacts, as the cables did not contain oil as isolating material.

to [xvii] the most critical event would be the pollution resulting from a collision with an oil tanker, as this collision would result in the leakage of considerable amounts of jet fuel (2,500 t), and bunker oil, (500 t). The bunker oil is the more destructive due to its low evaporation rate. The consequences of such a collision calls for development of special emergency procedures with a short reaction time for each large offshore farm.

General conclusions:
As the consequences of collisions may be very serious, mitigating measures are called for in order to minimise collision risks, such as: proper marking of farm/turbines and protection of cables. However it should be noted that the collision frequency is relatively low and that a collision would not necessarily result in severe environmental damage.[14]
For further discussions, please refer to Section 3.1; for a detailed discussion, see for instance [xviii]

2.4 Visual effect.

The environmental impact, which is considered the most important along with the impact on birds, is the visual impact. This reflects the growing public concern in Europe on the visual effects of wind power on the landscape in general. The public concern is illustrated by e.g. the Danish case, where the future development of wind power politically has been bound to offshore locations. However, offshore farms raise new concerns regarding visual effects as wind turbines here represent man-made development in an otherwise structureless landscape.

Obviously the visual impact diminishes with the distance to shore, and in general it is assumed that the visual impact to viewers at sea level is negligible when the farms are located more than 8 km from shore. With distances larger than 45 km, the visibility will be almost zero due to the curvature of the earth’s surface. These distances will be greater where there are elevated viewpoints, but may also be severely reduced depending on the atmospheric clarity.

The visibility from shore will also depend on the requirements regarding marking lights and painting – as the development within wind energy results in turbines continuously increasing in size, marking lights will be mandatory in order to avoid collision with low flying aircrafts. As the marking requirements may depend on turbine size, and as the choice of turbine often has not been made at the time of carrying out the EIA, additional marking requirements can actually change the visual impacts of an entire farm, when the turbine type has finally been chosen. These alterations in visual impact will require additional investigations and visualisations, after the time of public hearings, and may result in increased public resistance. Therefore marking requirements and their effects regarding visual impacts should be known as early as possible in the planning phase (see Section 3.1.3 below).

[14] For Horns Rev, the revised calculations resulted in a ship collision risk of 1 collision every 641 years.

For the offshore farms already established at near shore locations, concerns on the visual impacts have played a major role in the public hearings. Also the visual impact is a determining factor for public acceptance at locations renown for their scenery or close to recreational areas.

A public opinion survey in the Netherlands concluded that visual intrusion was the most important impact factor, but would not necessarily result in fewer visit to the affected location – the wind farm may also have positive effects on the visiting public, becoming a tourist attraction with visitor centres onshore and boat trips to the farm.[15] The same results were found in Germany where it was concluded that offshore wind farms would have no negative impacts on tourism as long as the farms were not placed in near-shore waters. If the farms were placed 15 km from shore, it would not be regarded as a problem at all [xix].[16]

As the visual impact is a matter of the viewer’s taste, it must be expected that there will always be public resistance, especially for near-coast projects, but even the visual impact from offshore projects invisible from the shore may experience resistance when being seen from ships, boats and ferry lines.
Experience from Denmark (Middelgrunden Wind Farm) indicates that local involvement in the ownership of the wind farm may have an important role for the acceptance of the visual impact close to a city, see Section 3.

Furthermore, an open and careful planning process with detailed visualizations may result in less public resistance. In the case of the Middelgrunden project, as a result of visualizations and public hearings, the farm layout was changed from 3 rows with 9 turbines to the existing curved profile with 20 turbines. This change of farm layout and thereby of the visual impact gave rise to increased public acceptance.

Swedish investigations indicate that visualizations can cause problems with acceptance because pictures do not present the true visual impact of wind turbines on a landscape. Neither do they present their functional contribution. People construe the depicted wind turbines not as a source of renewable energy but as a new element in the landscape that will diminish its scenic value. On the other hand visualizations of turbines undeniably have some value in accelerating social adjustment by providing an idea of what planned developments will look like. Inevitably, however, these pictures never truly depict the experience of an active wind turbine, although they are a great aid.

The benefits of using visualizations are connected to a person's professional training and their previous experience with wind turbines. If people can understand the rationale behind certain designs or if they can recognize some benefits in relation to other wind power locations, visualizations can work well to create a positive dialogue. In this context it is important to understand that a 'picture' can both suppress the benefits

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[15] The fact that offshore farms may become tourist attractions is probably one on the reasons why the mayor of Nysted (the municipality closest to the Rødsand Offshore Wind Farm) has insisted on renaming the planned wind farm. As a consequence, the official name of the Rødsand project is now “Nysted Offshore Wind Farm” (in this report, however, the term “Rødsand” will still be used).

[16] The tourists’ answers were based on visualizations where wind farms with different layout were presented from different angles and distances.

of wind turbines and camouflage some of the visual effects. Hence, visualizations must always be accompanied by detailed explanations. Furthermore, turbines are not only experienced by seeing them, but also through hearing and feeling their presence, and the use of "virtual reality" should be useful in this regard.

It is not possible to take everything into consideration when professionally designing a wind power site. It is, however, necessary to consider people's feelings and learn about the social network behind the sterile map when their backyard or beach idyll is entered. If a project has the confidence of the public there will be more space for artistic freedom and new solutions. The challenge is to use this trust in order to bring new meaning into a landscape. In the long run the choice of location and design cannot be explained and defended by saying that people's social and aesthetic preferences were merely anticipated, if the people affected most directly are not consulted with. Different individuals view wind turbines in accordance with their personal relation to a specific landscape, and the amount of time they spend in a particular place. Similar differences between occasional and permanent observers can be drawn from wind developments elsewhere, such as Palm Springs, California. Accordingly, the chances for constructive dialogue about landscape development can be improved if it can be clarified why some people view wind power as a practical solution to sustainable development while others see it as a threat to landscape preservation.
Time is an additional factor when it comes to recognizing the effects of different developments. People tend to react to immediate visual change in the landscape more vociferously than to widespread but long-term environmental effects of development. Hence, when summarizing some important factors concerning the concept of landscape and how the changes are perceived, it is found that time and space are the common denominators. People tend to view change according to custom of use, the pace of change and the visual evidence.[xx]

Most people cannot relate to the fundamental thought behind aesthetic solutions. In 1997 and 1998 Karin Hammarlund [xxi] tested several visualizations made by six different landscape architects based on their professional analysis of a particular landscape in relation to wind turbines. She asked representatives of the general public living in the areas concerned to grade the visualizations as good, acceptable or bad in relation to how they found them to harmonize with the surrounding landscape features. All at least made the grade of 'acceptable'. This result has to do with the relationship between form and function. Design that does not have an understanding of the function of the landscape to the people living in it, will not connect to the functional pattern of the landscape. It will show no concern of important recreational patterns or important viewpoints. It will not connect to the travel pattern of people, which is the way most people on a daily basis experience the landscape. Landscapes possess meaning for people and this meaning connects with how people make use of a place. This function strongly affects the conception of the landscape. So, what a particular landscape means to an individual depends on what this person is doing in that landscape. For this reason the function of each particular landscape must be specifically integrated with the aesthetics and design of a wind power site. Form that connects with function will mean something to the affected population, and not just to the designer, planner or landscape architect.

General conclusions:

The general conclusion is that visual impact of wind power has a very high profile in the public awareness. This is a barrier for future development of wind power throughout Europe, and although moving wind power offshore might prove a partial solution to this if the distance to shore is above 5-10 km, the visual impact will still act as a barrier to some extent. The experience with offshore wind power clearly indicates that there is strong public concern for this issue, even concerning offshore wind power farms, which are, from the shore, barely visible to the naked eye.

Experience from existing farms indicates that the following recommendations can lead to reduced public resistance related to the visual impact of offshore wind farms:

- the offshore wind farms should in general be placed as far away from the coast as possible, and in particular proximity to recreational areas and/or coastal settlements should be avoided
- the planning process must be very open and careful, and if the farm is visible from land, the effect on the environment and economy (e.g. tourism) of the coastal area must be assessed
- farm formation, number and size of turbines and cumulative effects should be thoroughly and openly analysed and discussed before decision is taken
- early local involvement in the planning phase is essential and community involvement in ownership of the wind farm will be beneficial

2.5 Noise and vibration effects

Noise from wind turbines arises from the movement of the blades through the air (aerodynamic noise) and the consequent transmission of power and momentum in the nacelle (mechanical noise). Furthermore, noise may arise from the control equipment within the tower (power electronics).

The degree of noise effects is primarily dependent upon the level and character of the noise emitted, the distance from the turbines to potential sensitive receivers, wind directions and background noise levels.

2.5.1 Airborne noise

It is expected that airborne noise may have the following impacts:

- ousting of birds
- loss of habitat for marine mammals
- decrease in public acceptance if turbine noise is audible to humans from the shore

Several participants have indicated that noise is an issue of public concern, although the noise from offshore wind farms will not generally be audible on shore. Nevertheless, it appears that wind power has received a reputation for being noisy, which, together with the fact that noise propagates much easier over the sea than over land, is reflected in the public attitude towards wind power, including offshore wind.

One participant stated worries that the turbine manufacturers and project owners may be tempted to place less emphasis on noise control, because the noise impact from offshore wind farms is not perceived as a significant problem with the turbines being placed far enough from shore to give what is believed to be inaudible levels of noise. Such an attitude, combined with increases in turbine size and the blade tip speed might, however, lead to the problem arising anew.

During construction of offshore farms, airborne noise from construction work (vessels, ramming etc.) is expected to effect birds and marine mammals (ousting), but as the effects are of limited duration, the effects are expected only to be temporary. However, sensitive time periods like breeding or nursery periods should be avoided if the construction site is placed near important biological areas – which may be in conflict with the intentions of the developers to establish offshore wind farms when stormy weather is least probable.

2.5.2 Underwater noise and vibrations

During construction, underwater noise from construction vessels and drilling or piling equipment may have a detrimental effect on marine mammals, fish and benthos. These effects are especially evident, when hammering down monopiles – experience from Sweden indicates that this construction method results in a chock reaction from fish, actually loosing conscience and drifting in the water surface as were they dead. However, the effect is temporary, but sensitive time periods should absolutely be avoided – in the case of fish larvae, construction work at sensitive periods may result in a very high fish mortality rate.

During operation, noise from offshore turbines can be transmitted into the water in two ways: the noise either enters the water via the air as airborne sound, or the noise is transmitted into the water from tower and foundation as structural noise. The frequency and level of underwater noise is thereby to a certain degree determined by the way the tower is constructed and by the choice of foundation type and material (monopile/steel - or caisson type/concrete - foundation).

Underwater noise from offshore wind turbines must of course exceed the level of underwater background noise (ambient noise, especially from ships) in order to have any impacts on marine fauna.

The following frequency areas were used for measurements during the EIA process at Horns Rev [xvii]:

Porpoises:	
Produce pulsed sounds:	2 kHz (perhaps communication)
Echo localization sounds:	13-130 kHz
Fair hearing:	1-150 kHz
Good hearing:	8-30 kHz
Speckled Seals:	
Produce sound:	0,1-40 kHz
Fair hearing:	0,1-60 kHz
Good hearing:	1-50 kHz
Fish:	0-130 kHz

Generally speaking, porpoises and seals are sensitive to high frequency noises, seals in the range from 100 Hz to 40 kHz, porpoises at 100kHz and higher. Fish are sensitive to low frequency noises, below 20 kHz. [xxii]

The effects on marine life from vibrations of the turbines are rather unknown, but as the developers seek to avoid resonance in the tower, the effects on especially fish and benthos may be limited.

Measurements from Vindeby (caisson foundation type) and Bockstigen (monopile) offshore farms indicate that underwater noise is primarily a result of the structural noise from tower and foundation [xxii]. When the results were scaled up, based on measurements from a 2MW onshore wind turbine, it was concluded that the underwater noise might be audible to marine mammals within a radius of 20 metres from the foundation. Generally it is believed that for frequencies above 1 kHz, the underwater noise from offshore turbines will not exceed the ambient noise, whereas it is expected that for frequencies below 1kHz, noise from turbines will have a higher level than the background noise.

Only measurements and impact studies after the construction will reveal if underwater noise will really affect marine mammals.

The impact on fish from low frequency sounds (infrasound, below 20 Hz) was not estimated, and in general this area is covered with much uncertainty. A planned study at Vindeby, carried out by SEAS, investigating the effects from noise and electromagnetic fields on fish communities living at the seabed, may yield valuable information regarding this subject.

General conclusions:

The general conclusion is that airborne noise impact has a high profile in the public awareness, but that this is related to previous generations of wind turbines and not to the technical realities of today. It therefore appears that a serious task for improving the public attitude towards offshore wind lies in demonstrating that noise from offshore wind power farms is not a significant problem. However, it is important to stress that noise impact may increase if the subject is neglected by the manufacturers - it must be remembered that noise may travel large distances over open water surfaces.

Regarding underwater noise and vibrations, the effects on marine animals, fish and benthos need assessment in generic studies and in a site-specific manner, because these effects are relatively unknown.

3 Conflicts of Interest

As most European countries have procedures for hearings of interest groups, potential conflicts of interest are well known. Apart from various lobbying organisations, primary conflicts of interest concern: ship traffic, air traffic, defence and fishing interests.

Some areas may definitively be excluded from consideration for use for offshore wind power at the pre-planning phase. These are major ship lanes, areas close to airports, oil & gas pipelines, cable routes, raw material deposits, military restricted areas and areas of importance in relation to fauna, e.g. IBAs. However, most other suitable sites will confront a number of potential conflicts of interests with other uses and users of the locations.

3.1 Traffic

3.1.1 Ships

The subject of ships is, according to the CA members[17], the most important subject in relation to conflicts of interest. The reasons for this seem to be the following:

- ship lanes represent a siting limitation factor, as certain areas will be prohibited for use as offshore wind farms where established shipping lanes demand it. Furthermore, locations where ships may lay anchor to enter harbours, must be avoided.
- even where careful planning is carried out, and the farm is not placed near major navigation routes, or routes have been altered in order to minimise collision risk, there will still exist a risk of severe environmental damage in case of ship collisions with wind turbines, e.g. an oil carrier collision, as previously described in Section 2.3. On the other hand, when wind farms are to be located on reefs, banks and other shallow waters, which in themselves constitute a risk for ship collisions, well-planned offshore wind farms can contribute to maritime safety. In Danish EIA risk analyses (Middelgrunden and Rødsand), a calculated risk in the order of 1 collision every 10 years has been accepted by the authorities, as the risk frequency was not higher than at baseline conditions.
- offshore wind farms must be marked properly and effectively, in accordance with national or international guidelines (IALA 1984, IALA 2000 [xxiii]), however painting and illumination /signal lights may have negative visual impact, which could lead to increased public resistance (see Section 3.1.3).

As collision risk analyses for all offshore wind projects is a mandatory part of the EIA, valuable information is and will be available from these studies, see for instance background reports to [xiv] and [xvii].[18]

[17] CA members: members of the Concerted Action on Offshore Wind Energy in Europe

[18] EIAs from the Dutch Near Shore (NSW) and the Q7 Wind Farm projects also include such risk analyses

Currently a large study and collision risk analysis is being carried out for the German Bight, and in general such risk studies and additional information on damage mechanisms are called for in order to investigate the issue of marine traffic safety and offshore wind farms more closely.

3.1.2 Air traffic

The main problem does not appear to be the civic air traffic, although certain areas will be prohibited by Civil Aviation Authorities, either national (CAA in the UK) or international (ICAO), for use as offshore wind farm sites where protection of air navigation demands this. Military issues incl. radar are dealt with in Section 3.2, below.

The requirements posed by helicopter teams seem to be the most important concern, e.g. rescue helicopter teams, who might have to access the offshore wind farms in heavy weather. As the sites are covered by quite heavy turbulence, helicopter manoeuvres within the area are difficult, making marking lights and ability to switching off all turbines immediately a serious safety issue.

3.1.3 Painting and illumination/marking lights

In order to minimise the risk of collision with naval or air traffic, authorities put different requirements on blade painting and marking lights for the different countries involved. In most cases some kind of nacelle lights are required as a minimum, following the standards for onshore turbines and other high buildings.
In Germany, for instance, buildings larger than 100 m must have marking lights, and colours on the blades are mandatory for wind turbines larger than this size.

The use of good navigation equipment like radar and GPS[19] should make it less important to paint turbines in bright and shining colours. This issue has been a subject of negotiation for some sites, and is standard in other European countries.

In Denmark research is going on in order to find the most appropriate colour for towers, seen from a visual point of view – the goal is to make the turbines appear as neutral as possible in relation to the surrounding nature.

The general conclusion is that turbines must be marked properly and effectively in accordance with national and/or international guidelines in order to minimise risk of collision with ships, low flying aircraft or helicopters. However, painting and illumination/marking lights may have negative consequences for the visual impact and increase the risk of collision with birds, both subjects resulting in the fact that the public acceptance of the farm may decrease.[20]

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[19] GPS: Global Positioning System – a satellite navigation system

[20] The subject of marking lights and visual impacts is illustrated in an example from Denmark, where the Danish Forest and Nature Agency has recommended that the turbines chosen for the Rødsand Offshore Wind Farm should

Therefore the safety issue should be well balanced with the environmental impacts, and the consequences of marking lights etc. on visual aspects and bird interests should be thoroughly investigated in the EIA.

3.2 Defence

Military area restrictions disqualify a number of feasible sites from being developed. Especially for Sweden and Finland this is considered problematic, as areas owned by the military cover a significant amount of the areas potentially used for offshore wind power. In both cases practical solutions for co-existence between military and wind power are called for, but a solution must come through the political system.

As an example of the importance of and need for political solutions, the British Ministry of Defence has objected to chosen sites on land and offshore as it is believed they would interfere with low flying aircraft, even though these sites were not in close vicinity to military airports or equipment, but apparently just due to the fact that the height of the turbines represents a danger in itself [xxiv].

3.2.1 Radar and radio signals

Also the issue of disturbance of radio and radar signals has been a subject of negotiation in some countries, and in general the issue of radar is approached with much concern, as the disturbance of radar signal from offshore wind farms may become a serious obstacle to future development.

Based on result from preliminary Swedish studies [xxv] the following conclusions can be drawn, as an illustration of the potential problems and mitigations:

- The effect of wind turbines vary with different radar systems – the radar defence systems of NATO countries are less affected by disturbance from wind turbines than for instance the Swedish radar system, because NATO's radar system is primarily based on satellites and airborne radar equipment, whereas some parts of the Swedish radar defence system consists of older units and hence less advanced equipment. With modern radar equipment, disturbances should be minimal.
- The disturbance of (Swedish) radar equipment from turbines is only related to moving blades:
    - the movements of the blades are registered by the radar as false echoes, giving rise to several dots on the operator's screen, which may be confused with the echoes from an aircraft.
    - For experienced radar operators this disturbance should be easily handled when the radar installation is not situated within the wind farm, and if the exact coordinates of the wind turbines are known, the radar system/operator should be able to compensate from the false signals.

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not exceed 100 m. (from sea level to upper blade tip), in order to avoid marking light requirements set by the Danish Civil Aviation Administration. The recommendation of the Agency was purely motivated by visual impact concerns.

  - If the turbines are stopped, there will be no disturbance of the radar system.
- The disturbance of *radio signals* is primarily caused by reflections from the tower and is depending of the frequency band of the radio links – influence from wind turbines may impair the performance for radio relay links for frequencies between 2 and 10 GHz.
- The potential disturbance effect of radar and radio signals increases with the number of turbines

As an example of measures to mitigate wind turbines' effect on radar systems and decrease the collision risk, it can be mentioned that in the UK, whenever relevant, wind farms will be equipped with radar reflectors/intensifiers and fog signalling devices, as specified by the Department of Environment, Transport and the Regions [xvi].

However, the subject of radar a radio signal disturbance is still a key area of concern, e.g. in the UK where a BWEA working group has recently been convened to address the concerns of defence and aviation authorities collectively.

General conclusions:

It can be concluded that although solutions seem to be available, it will be important for the development of large-scale offshore wind farms that the subject of interference with radar and radio systems is more closely investigated, as the potential effects are system- or country-specific.

The conclusions from the following studies may contribute with valuable information:

- A UK study carried out by Ministry of Defence, undertaking a number of trials to determine the extent of interference with radars from wind turbines, but these data have not been published yet. A BWEA working group has been convened to address this issue.
- The Swedish study concerning impacts on radar and radio systems will be finalised this year (2001).

3.3 Fish

Restrictions to fishing rights from offshore wind power are bound to be an area of conflicting interests as the fishermen will lose trawling ground and possibly areas for pot fisheries. Up to now this conflict has not excluded any projects from being carried through, but financial compensation must be given to the fishermen, often without much evidence that fishing is actually reduced. This conflict appears to be especially problematic for France, where the fishing lobby is very strong and do not hesitate to block harbours, if they feel their interests threatened, but such problems may also occur elsewhere since the fishermen are generally well organised all over Europe.

In order to minimise impacts on fish, and thereby reducing the risk of conflicts with fishermen, it is recommended to

- avoid construction of wind farm in sensitive spawning areas, areas with species of commercial or conservation importance and areas with a very high value for fisheries
- avoid construction during important breeding, nursery or feeding periods

- carry out site-specific and species-specific monitoring studies in order to investigate the effect of offshore wind farms on fish, e.g. investigate if foundations may indeed serve as natural reefs, as indicated from previous studies (Vindeby), thereby increasing fish life, and investigate the consequences on fish population/fishing possibilities when fishing is restricted within and in the vicinity of the wind farm.

3.4 Birds

Ornithological associations are also a very strong lobby in most European countries, and negotiations are often carried out to define whether or not an area can be used for wind power.

In order to minimise potential impacts on birds and the resulting conflicts with ornithologists, the general conclusions about avoiding designated areas (including IBAs) and major migration paths should be followed. The layout of the farm and of the individual turbines (painting, illumination, size etc.) should also focus on minimising impacts on birds. Case studies/monitoring programmes should be carried out with the aim to investigate the effects of offshore wind farms on birds and bird populations, and furthermore generic studies concerning mitigating measures should be carried out.

The fact that not all Important Bird Areas have yet been officially designated, makes large-scale planning more difficult, and it should be in the interests of both the offshore wind turbine industry, ornithologists and EU/national nature protection societies and institutions that the borders of such areas are well-defined and well-known. Furthermore, guidelines for the proximity of an offshore wind farm to an IBA would be useful.

3.5 Other conflicts of interest

3.5.1 Raw material deposits

The siting of offshore wind farms may interfere with existing raw material deposits. As these deposits are well known already, this should however not lead to any significant conflict of interests. It is furthermore believed that offshore farms do not exclude extraction of, for instance, oil in the same area – one CA member mentions that there may be possible synergies from simultaneous energy production in offshore wind farms and raw material extraction.

3.5.2 Marine archaeology

Seismic site surveys and historical records investigation during the planning phase prior to the decision of the exact location of the turbines should avoid possible conflicts of interest. Specific areas of archaeological interest should be avoided. If, however, for instance a wreck is found during installation, this may lead to a serious delay of the whole project. Measures must therefore be taken to avoid such incidents by carrying out the investigations necessary in the EIA.

3.6 Conflicts of interest - general conclusions

The general conclusion is that conflicts of interest are restricted to areas already known in the planning phase, thus severe conflicts of interest which could stop a project can theoretically be avoided through careful, open planning. However, regarding radar no final conclusions can be drawn yet, calling for additional national investigations, as the disturbance effect may vary from country to country.

4 Social Acceptance.

In general, opinion polls in countries like the Netherlands, Germany, Denmark and the UK show that more than 70 percent of the population is in favour of using more wind energy ([xxvi], [xxvii], [xxviii] and [xxix]). In the UK, a summary of opinion surveys indicates that 8 out of 10 support local wind projects [xxx], but no specific opinion surveys concerning offshore wind energy seem to be available.

In Germany, as mentioned in Section 2.4, a study on effects from on- and offshore wind farms on tourism (i.e. not the local population as such) indicated that offshore wind farms would generally be accepted by tourists as long as the farms were not situated too near the coastline.

The responses from the CA members received on social acceptance of offshore wind power at first sight indicate that there is no absolute clear conclusion as to the social acceptance of offshore wind power compared to onshore. Nevertheless, some hypotheses can be drawn from the responses received, and an analysis of the acceptance dilemma of onshore wind power applicable to offshore locations shows that:

- public acceptance in general is high but falls when it comes to our own living surroundings,
- coastal areas are more sensitive to change because of great recreational values,
- local acceptance seems to increase after the installation of turbines, provided that no disturbances are experienced,
- public acceptance increases with the level of information and economic involvement.

Social acceptance of wind power has often been characterized by a NIMBY (not in my backyard) syndrome. The NIMBY-explanation is however a too simplistic way of explaining all variables involved when determining the general and local public acceptance of a specific wind power development. This means that the question of social acceptance really has many components: e.g. the general attitude towards offshore wind power in the population as a whole, the acceptance in the population who will experience the local impacts, the conflict management strategies and economic involvement.

One possible way of overcoming the dilemmas is presented by the Danish case for onshore wind power. Here most wind turbines are owned by locally established private cooperatives. This appears to improve the social acceptance, as it is, generally speaking, the same people who experience the impacts that receive the financial benefits.
For the Middelgrunden Wind Farm outside Copenhagen, it is very probable that the project could not have been carried out without involvement of the local public in this way.

In Denmark, most of the offshore projects will be owned by the utilities, but it is still a political priority to encourage the formation of cooperatively owned offshore wind power farms as well. It is probable that the next generation of offshore farms (Horns Rev, Rødsand, Læsø, Omø Stålgrunde and Gedser) will be partly publicly owned, giving the possibility to test different ownership models [xxxi]. The project will be managed by the Danish Association of Wind Turbine Owners, but has not been politically approved at the time of writing.

This "Danish model" is, however, rather unique, and for most other countries the offshore wind farms are either owned by utilities or private consortiums, thus only enabling indirect financial benefits and influence for the local citizens.

A broad-based participation in the implementation and decision process is used in a Swedish offshore project in Kalmarsund conducted by Vattenfall. This is a form of conflict management, which extends the group of actors involved in the decision process, increases transparency and promotes negotiations and discussions. An important factor is thus, who is involved in the decision process and in what form can different actors participate and represent their interest in the planning process. The result of this approach is so far that the project has conducted a management of dissent instead of putting trust in a fictitious consent. The importance of this type of conflict management seems to correlate with the amount of realised and planned projects in a demarcated and clearly defined geographical area suitable for offshore wind power.

One strategy concerning public involvement is to assume that the local public opposition can be overcome by rational decisions made by experts, and people will eventually get used to change. Another strategy is to directly involve the local public early in the planning phase, and incorporate the recommendations into the project at an early state. The purpose of this strategy is to give the local population a motivation to accept change by for example giving them a say in the planning of the project. The "risk" of this strategy is that the public debate generates so much awareness and thus delays the whole planning procedure. A delay, which on the other hand is unavoidable when permits are appealed against and projects face the threat of never being realised.

Presenting a wind power plan requires a sense of timing. In some cases, depending on the size of the project, it might be worthwhile to allow a certain period of adjustment. A large wind farm may in some cases be developed sequentially, which makes adjustments easier if people express misgivings. Such adjustments manifest the flexibility and reversible quality of wind power developments. Just because a wind farm can be erected quickly, does not necessarily mean it should be.[21]

Finally it should be mentioned that the social acceptance of offshore wind, as discussed in the introduction of this report, may expect to increase significantly, when people are aware of the positive impacts of offshore wind energy and when they realize the alternatives. The fact that oil and gas reserves are very limited, that other sources of energy are not only much more polluting but also more expensive when externalities are accounted for [xxxii], should be stressed in the public dialogue.

General conclusions:

According to experiences from the offshore farms already established it can be said that:

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[21] In Denmark, the pilot projects regarding five 150 MW offshore wind farms can be regarded as a sequential development of each wind farm – however, due to technical and environmental motives.

- the degree of involvement of the local population in the planning phase influences the public acceptance.
- the procedures on public involvement, hearings etc., vary considerably among countries and may even vary among regions within the same country.
- there is to day no clear overview on the results of different strategies for public involvement and conflict management.

The issue of public acceptance deserves to be studied in more details, e.g. through a monitoring programme focussing on public acceptance before and after the installation of an offshore wind farm in relation to the degree of public involvement and active conflict management.

5 National Policies.

5.1 General attitude.

On the political level the attitude towards offshore wind power seems to be very positive, which is reflected in the fact that several countries have established ambitious targets for the exploitation of offshore wind power (see draft report from cluster 4), with corresponding support mechanisms.

In the most ambitious plans several 1000 MW offshore wind power plants are planed for within 10-25 years. In most countries, however the energy policy targets do not distinguish between onshore and offshore wind.

5.2 Planning rules.

Planning rules and regulation only exist in some countries, but can be foreseen in the coming years.
The fact that the legal framework is still under construction and unclear in many countries is to be regarded as a major limiting factor to the development of offshore wind energy.
Moreover, national planning rules may vary significantly within the EU, and even on the national level, different and confusing legal frameworks exist within individual countries. Different regulations regarding the same subject exist in several countries, depending on whether a proposed farm is located inside the 12 nautical mile zone (often referred to as “territorial sea”) or outside (“exclusive economic zone”, extending from the 12 nm zone seawards to a maximum of 200 nm from the shoreline).
An example is Germany, where both federal and state law is applicable within territorial water, whereas only federal law is applicable further away from the cost.

For a detailed analysis of policies and regulations in Northern Europe (2000), please refer to the Dutch study carried out by Ecofys [xxxiii].

Table 5.2.1. below, presenting national planning rules and regulations in the member states of the Concerted Action, has been based on responses from CA-members.

Table 5.2.1. National Planning Rules and Regulations	
BE	Offshore wind energy legal framework is clearly defined, in: • Law on concessions for offshore wind and wave energy plants (as part of general electricity regulation law). • Law on (environmental) authorisations for all off-shore installations • Law on environmental impact reporting for all off-shore installations Some remaining uncertainties due to necessity of regional authorisations for grid connection.

Table 5.2.1. National Planning Rules and Regulations	
DK	The Danish Energy Agency is authorising offshore wind farms inside as well as outside territorial waters. Planned 4000 MW before 2030. A national committee has pointed at specific potential areas of which 750 MW will be utility developed and serve as pilot projects to be established before 2008. There are ongoing negotiations to have 150 MW of these 750 MW owned and developed by cooperatives. After 2008, the offshore wind energy sector will be subject to the same rules as for offshore gas and oil exploitations, i.e. open bidding procedures.
FI	EIA requested from >50 MW power plants. Suggested for > 10 MW wind farms. Regional planning authorities. Local planning permission needed. (Depending on regional land use plan) National "Waters Act" "Environmental Protection Act"
FR	No specific rules. The work of the CA is taken as a guide for future rules (like for onshore wind farms in the 80's)
GE	Within 12 to 200 miles zone the National Authority for Sea Traffic and Hydrography is the entity for permissions, legal basis is the international bill of sea rights together with a national regulation for building and operation of plants in the 12 to 200 miles zone. For developments near shore and grid connection through coastal sea, the regional governments of the German countries bordering the North Sea are the permitting authorities. Regional planning procedures are required in which all relevant national laws and regulations are to be applied – may be rather time consuming
GR	Legislation for renewable energy sources applies also to large-scale offshore wind energy
IR	Procedures for applying for foreshore licenses (to investigate site suitability) and foreshore leases (to develop wind farms) published. Applications made to Department of the Marine and Natural Resources Offshore wind farms will not, as a general rule, be allowed within 5 km of shore. Certain areas are identified as prohibited to ensure safety at sea, protection of established shipping lanes, air navigation, telecommunication needs and defence requirements Planning permission required from relevant local authority for onshore infrastructure associated with offshore wind farms.

Table 5.2.1. National Planning Rules and Regulations	
IT	Planned 2500 MW on- and offshore within 2010 according to the National White Paper of 1999. Only a small fraction of this target expected to be offshore. Total offshore potential is about 3000 MW. The Italian Navigation Code (INC) and the Application Guide of INC (AGINC) are the reference legislation for offshore wind farms installation in the Italian national waters; specifically art.36 and following of INC and art.5 and following of AGINC (for the type and format of application documents). Special permits should be considered for offshore Wind Farms, because of the long time limitation related to their presence for the activity of navigation, fishing, marine sport, and others. Many other Administrations are involved in processing the installation permits: Ministry of Transport, of Defence, of Environment, of Industry, of Civil Works, of Sea and Terrestrial Resources (General Direction of Maritime Fishing) and others. The Environmental Impact Evaluation should be considered necessary, even though no clear policy is applied today. At the end of the procedure the Permits are issued by the Compartment of Maritime Transport and shown to public office of interested Municipality and Province for public information and possible opposition. The installation of Offshore Wind Farm and Permit applications is under the control of the local Harbour Authorities by their presence Coastal Guard. Safety features for navigation and aviation are requested in the Permit. Information on the offshore plants is due to Marigrafico office for its inclusion on the nautical charts.

Table 5.2.1. National Planning Rules and Regulations	
NL	Within the 12-mile-zone, apart from a near shore wind farm pilot project (NSW), no wind farms will be allowed. There are practically no Dutch regulations and rules existing for large-scale offshore wind energy outside the 12-mile-zone. This could be positive or negative depending on political will. However, there are several laws and regulations that have to be considered when licenses in the Dutch Exclusive Economical Zone of the North Sea must be gained. These regulations are: • Sea Water Pollution Law (Wet Verontreiniging Zeewater) • Environmental Administration Law (Wet Milieubeheer) • Spatial Arrangement Law (Wet Ruimtelijke Ordening) • Environmental Protection Law (Natuurbeschermingswet) • Governmental Water Works Administration Law (Wet Beheer Rijkswaterstaatswerken) • Wreckage Law (Wrakkenwet) • Monuments Law (Monumentenwet) • Excavation Works Law (Ontgrondingenwet) • North Sea Installations Law (Wet Installaties Noordzee) • (Sea) Bottom Protection Law (Wet Bodembescherming) • Mining Laws 1810, 1903 & EEZ (Mijnwetten 1810, 1903 & NCP buiten 12 mijl – From recent studies, it seems that this law has no implications for offshore wind farms) • Route Law (Tracéwet – This law is important for the seaways to be chosen)
PL	Very broad planning rules of the Construction Law referring to constructions at sea, Energy Law pointing at the necessity of implementation of renewable resources.

<table>
<tr><th colspan="2">Table 5.2.1. National Planning Rules and Regulations</th></tr>
<tr><td>SE</td><td>Legal framework under construction. In a recently published study carried out by the Swedish Energy Agency [xxxvi], and initiated by the government with aims to make standards for the future offshore wind power, it is proposed that 3,300 MW of offshore wind power is to be developed within the next 10 to 15 years. Seven offshore areas have been suggested as locations of special interest, first of all in the Southern part of Sweden.
For the moment a number of pilot projects are planned, and the intention is to follow these carefully during the whole planning and construction-process.
It is expected that the current regulations (2001) are soon to be revised and simplified:
• Building Permit required from local authorities' (municipality) building and planning committee, according to the Planning and Building Act.
• Permit required from local County Administrative Board concerning environmental issues (according to the Environmental Code). For projects larger than 10 MW, permits are issued by the Environmental Court concerned.
• Application for water operation permits shall be considered by the Environmental Court
• The government shall assess the permissibility of wind farms inside territorial waters if they are consisting of clusters of three or more wind turbines with a total output of not less than 10 MW.
• Construction of wind farms outside territorial waters requires permission from the government.
• The Swedish Energy Agency issues permits regarding cabling</td></tr>
<tr><td>SP</td><td>Legislation for wind energy onshore applies also to offshore</td></tr>
<tr><td>UK</td><td>• Defined procedure for obtaining site lease from Crown Estates (who is the "landowner" of most areas within the 12 nautical mile limit). First round of site allocations was made April 2001, where the location of 13 potential offshore wind farm sites was announced. Each site will consist of 30, 60 or 90 turbines.
Consents process still evolving but expected to include:
• Dept of Trade and Industry (DTI) provide "one-stop" consenting assistance but Dept for Transport Local Government and the Regions (DTLR) and Dept for the Environment Food and Rural Affairs (DEFRA) also involved.
• Undertake Environmental Assessment and consultation leading to EIS.
• Apply to DTI under the Electricity Act 1989.
• Apply to DEFRA under Food and Environmental Protection Act 1985.
• Apply to DTLR under the Coastal Protection Act 1949, or Transport and Works Act 1992.</td></tr>
</table>

5.3 Incentives.

In order to promote wind power (including offshore) most European countries have implemented support mechanisms, utilising a wide area of support mechanisms. The four main mechanisms applied are investment subsidies, tax exemptions, fixed tariffs and green certificates, often in some combination.

The responses to the questionnaires indicate that it is not only the amount of subsidies that determine the success of the schemes, but also the extent to which the income is safeguarded into the future. This is clearly indicated for e.g. the Swedish case, where the amount of subsidies obtainable appears promising, but where the schemes are modified too frequently for the schemes to make investors and creditors confident. Given the size of the investments and the relatively long payback times covering energy production facilities in general, risk evasive measures become of central importance.

To put it more directly: investors are generally willing to take risks, as long as the magnitude of risks is known. This requires that the support mechanisms are put into operation for periods long enough to cover at least the project planning period (so the initial feasibility study is also valid when it is put into operation). Two schemes that have obtained this are the former Danish and actual German feed-in tariff systems, which have secured significant investments in wind power, but other mechanisms might achieve the same goal if applied with care.

The ongoing liberalisation of the European energy sector has introduced significant uncertainties on subsidies, as the whole subsidy schemes have been revised, in order to comply with EU common market requirements. In some countries the procedure of exchanging old support mechanisms with new ones has been delayed, putting developers in a hard situation, not knowing which rules applied.

In general the liberalisation procedure seems to result in the subsidy schemes being harmonized towards the green certificate model, awarding wind power an extra bonus, determined by a certificate market. In the Netherlands such a scheme is already in operation. For other countries the schemes are not finally put in place, introducing significant uncertainties on future prices, as can be seen from the tables below.

March 2001, European Court of Justice made an important decision concerning the future of price support for the development of renewables, as it decided that The German Feed-in Law (the Stromeinspeisungs-gesetz) was not state aid. The court also stated that the German rules were in compliance with internal market rules, as they were intended to help achieve environmental objectives, which are a priority for the European Community.

This decision makes it possible for member states to implement similar schemes without challenging European state aid rules, as these rules are not considered to act as barriers for countries that set an obligation to purchase electricity from renewable sources [xxxiv].

Since the time of this decision, the future of the green certificate market is becoming increasingly insecure, as the feed-in tariffs in Spain and Germany can now continue. Furthermore, a law on renewables resembling the EEG in Germany has boosted the very promising market in France.

A review of national incentives (2001), based on [xxxv] results in the following survey relevant for offshore:

Table 5.3.1. The top 11 Offshore Markets

Country	Market support	Tariff, EUR/kWh
Denmark	Moving from fixed price to green certificates market	min. 0.057 over 10 years ?
France	Guaranteed access, fixed feed-in tariff	app. 0.07 over 15 years
Germany	Feed-in tariff	0,091
Greece	Guaranteed access, fixed feed-in tariff on mainland and interconnected islands	0.06
Ireland	Fifth round of Ireland’s Alternative Energy Requirement competitive bidding process has price cap of EUR 0.048/kWh over 15 years for projects larger than 3 MW.	0.048 for projects larger than 3 MW over 15 years (25% of which is linked to the Consumer Price Index)
Italy	Moving from relaxed fixed price system, with 2001 buy-back prices being EUR 0.124/kWh for the first eight years and EUR 0.069/kWh for the remaining lifetime, to green certificates market in 2002	0.124 for the first eight years, 0.069 for the remaining lifetime ?
Netherlands	Green certificates market introduced medio 2001	app. 0.077
Portugal	Interest-free loans, fixed tariff of EUR 0.06/kWh	0.06
Spain	Fixed payment EUR 0.0626/kWh or EUR 0.028/kWh on top of average market price	0.0626 +0.028
Sweden	Investment grants and payment of app. EUR 0,046 /kWh replaced by green certificate system in 2003	0.046 ?
UK	New system will link green certificates, worth app. EUR 0.047/kWh to obligation on power suppliers to buy renewables	0.047

For further details and an evaluation of the national incentives, where relevant, please see table 5.3.2. below.

Table 5.3.2. Description and evaluation of National incentives to promote offshore wind energy		
	Description	**Evaluation**
BE	Currently existing incentives are limited to Independent Power Producers and to projects smaller than 10 MW. A new system based on green certificate trading and a renewable energy quota with penalties for the 2 main Belgian regions (Flanders and Wallonia) is expected soon.	N/A
DK	1. Utilities have until now been obligated to buy the energy produced by wind turbines. 2. The feed-in tariff is currently DKK 0.33/kWh (EUR 0.044/kWh) plus green certificates varying from DKK 0,1/kWh to DKK 0,27/kWh (EUR 0.013-0.036/kWh) running for the first 42,000 hours of an offshore project with the rated power in typical places, app. 10 years. For the Horns Rev and Rødsand projects, a tariff of DKK 0,453/kWh (EUR 0,06/kWh) has been set. After 42,000 hours with the rated power the price will be based on the day-to-day market electricity prices plus green certificates. The green certificate system has been progressively delayed and following the outcome of a public hearing on the subject (September 2001), its introduction is postponed for minimum two more years starting up from 2005. 3. Public support for feasibility studies for cooperatives	The uncertainty not knowing the prices (due to the introduction of green certificates) makes people reluctant. As a consequence, no onshore turbines have been planned since the green certificates were introduced. The fixed feed-in tariff was securing continuous investments in wind energy, but had to be given up because of political resistance and liberalization requirements.
FI	Investment subsidy of 25-30 % given by the Ministry of Trade and Industry. A part of the energy tax is refunded (0.04 FIM/kWh).	N/A
FR	No specific incentive for offshore.	N/A

Table 5.3.2. Description and evaluation of National incentives to promote offshore wind energy		
	Description	**Evaluation**
GE	There is no firm governmental planning to develop offshore wind energy in Germany; Germany's Renewable Energy Sources Act (EEG – Erneuerbare Energien Gesetz) continues the reimbursement at a fixed feed-in tariff. In the reformed EEG a specially raised tariff is foreseen during the first nine years of operation of an offshore wind farm. This regulation is limited to projects coming online before the end of 2006.	The Development of wind energy in Germany under the umbrella of a fixed feed-in tariff system is seen as a major success and as an appropriate tool to develop a strong market. No evaluation as of yet – indication for attractiveness is the large number of projects applying for permissions in the German Bight.
GR	i) Subvention of up to 50% of the capital investment, ii) subsidization of loan interest, iii) tax-exemptions	N/A
IR	No specific incentive for offshore wind farms. The Alternative Energy Requirement (AER) competitive bidding process is open to offshore wind energy. The target in AER V for wind energy is 240 MW, 40 MW of which is reserved for small-scale (= 3 MW) wind farms. There are also plans for a Grid Upgrade Development Programme to accommodate additional renewable energy based generating capacity.	While AER V is open to offshore wind energy projects, planning permission must be evidenced in order to participate in the competition, which will effectively exclude offshore wind farms.
IT	Green certificates, region structural funds	N/A
NL	* System of Green Certificates. Spot market mechanism combined with a "Balancing Market" in the Amsterdam Power Exchange. * Fiscal incentives: Subsidies, REB (eco-tax), Vamil, Fiscal incentives do not yet apply outside the 12 nm zone.	Green certificates introduce more stability in the renewable energy market, which is a main requirement for potential investors. Spot market mechanism combined with the "Balancing Market" in the Amsterdam Power Exchange will positively affect the wind energy market. (Ref. Funtionele eisen van offshore winden, Kema, dec. 1998, pg. 15)
PL	None.	N/A

Table 5.3.2. Description and evaluation of National incentives to promote offshore wind energy

	Description	Evaluation
SE	There are currently no earmarked incentives focused on offshore wind power. The general support for introducing wind power in the power system is: 1. Investment aid, 15% of the total investment in a wind power plant is paid as a state subsidy. 2. Environmental bonus which is connected to the tax system for electric power , from 1 Jan 2001, 0,181 SEK (0,02 EUR) 3. Special support in order to make relief the consequences of fast decreasing power prices after deregulation 0,09 SEK (0,01 EUR) 4. Right to connect a small scale power station to the electric grid (small scale < 1,5 MW) 5. Special pay for decreasing losses in the electric grid up to 0,02 SEK (0,002 EUR).	The support system has been working the way it was intended – to develop an annual production of 0,5 TWh electric power from wind- but it has not given the long time security, which is needed, to interest investors and creditors. For example, today’s support system finishes 31 December 2002 with only promises of a new one, which nobody knows how it will be designed. A recent study initiated by government shall investigate how the support system can be replaced of a green certificate system 1 Jan 2003.
SP	No differences with onshore farms: The strategy of the Spanish government is summarized in the new "Program for Promotion of Renewable Energies" (Reference 1, see appendix) approved by the Parliament to maintain the situation of the Royal Law 2818/1998-23 December 1998, about the Electrical Special Regime for Renewable Energy Plants connected to the grid. That law fixed the price and the bonus of the electricity produced by renewable energy plants, price that will be up-dated every year by the Spanish Ministry of Energy and Industry according to the annual variation of the market price. All owners of installations using renewable energies as primary source, with an installed power equal to or lower than 50 MW, have two options, one is a fixed priced for the kWh generated, and a second option is a variable price, calculated from the average price of the market-pool, plus a bonus per kWh produced. In 2000 the bonus added to the base price was 0,0288 Euro/kWh and the fixed price was 0,0626 Euro/kWh.	N/A

Table 5.3.2. Description and evaluation of National incentives to promote offshore wind energy		
	Description	**Evaluation**
UK	Primary market is likely to be Licensed UK Electricity Suppliers to fulfil their Renewable Energy Obligation commitments. Revenue will consist of: • Energy sale to supplier on a "negative demand" contract or through amalgamation mechanism on NETA power exchanges. • Sale of Renewables Obligation Certificates (ROCs). • Sale of Climate Change Levy Exemption Certificates • Use of system charge or benefit Net value of the above expected to be around GBP 0.05/kWh (EUR 0.08/kWh). Internationally traded Green Certificates may also play a role. Capital grant budget recently announced of £39m from DTI plus £50m from National Lottery for offshore wind power (mainly) and biomass. Distribution method under discussion.	N/A

5.4 Conclusions

Regarding national planning rules and regulations it can be concluded that in many countries the legal framework has not been fully clarified yet, which is a barrier for future development of large-scale offshore wind energy. As suggested in [xxxiii], a one-desk policy for all necessary licenses would be beneficial in this regard.

Regarding national incentives, such as market support, history shows that feed-in tariffs have been used onshore in Denmark, Germany and Spain, Europe's top-three on-shore markets. After the feed-in-tariff in Denmark was announced to be replaced by a still not functioning green certificate market, the development of onshore projects has virtually stopped.

The conclusions, based on this example, is not necessarily that only feed-in-tariffs can secure future development of wind energy, including offshore, but it can be concluded that the countries within EU need to create *long-term* market support mechanisms that are sufficient and secure enough to attract investors and developers.

The EC Court of Justice decision regarding the feed-in-tariff system in Germany ("Stromeinspeisungs-gesetz") indicates that feed-in-tariffs are not in compliance with internal market rules, thereby securing this market support mechanism a future within the EU.

6 Ongoing Research Projects

Please refer to the appropriate sections in draft report regarding Activites and Prospects (Cluster 4)

It should however be noted that the five 150 MW offshore pilot projects in Denmark will all be subjects of environmental investigations, in fact the sites have in many cases been selected in order to thoroughly monitor and analyse environmental impacts. The project at Rødand, as an example, is situated in close vicinity to an important Special Protected Area (birds) and an equally important Special Area of Conservation (seals) and in the middle of an important bird migration path.

The studies will be closely followed by a group of international experts, under the secretary of a representative from the Danish Forest and Nature Agency. Furthermore, the Danish Energy Agency has compiled an advisory panel consisting of representatives from (national) environment organisations, such as WWF and the Danish partner of BirdLife, The Association of Danish Ornithologist.

Results will be published both in Danish and English.

7 General Conclusions

The following conclusions and recommendations concerning future RTD-activities in most cases imply the construction of offshore farms, as monitoring programs and Before-After-Impact-Studies carried out at specific sites often represent the only possible way to achieve exact knowledge or at least an improved understanding of the impacts from offshore wind energy, particularly on the environment.

Furthermore, the offshore wind farms already constructed or planned may yield important information concerning issues like social acceptance and conflicts of interest if research projects dealing with these issues are carried out.

Therefore the recommendations below (Section 7.2) should not be regarded as barriers for the future development of offshore wind energy – on the contrary, it is necessary that offshore construction projects are carried out, and in many cases it is necessary that some large-scale projects are carried out in order to achieve more information and knowledge regarding especially environmental issues.

These projects must however be subjects of intensive national and EU-funded research in order to reach conclusions about the impacts from offshore wind energy in relation to environmental questions, social acceptance and conflicts of interest: It is highly recommended that the present uncertainties and knowledge gaps are replaced by knowledge and certainty before real large-scale development of offshore wind energy is initiated.

7.1 Identification of problem areas

Potential negative environmental impacts:

<u>Birds:</u>

- collisions with turbine
- turbines acting as barriers for migrating birds
- ousting of feeding/breeding areas due to
    - noise emission from turbines in operation and vessels during construction, maintenance and dismantling
    - movements of blades
    - serious changes in food chain, e.g. due to new sediment structure and “unnatural” reef effect
    - accidents (collisions with e.g. oil tanker not only causing ousting of birds due to oil spill, but also killing birds)

<u>Mammals:</u>

- loss of habitat due to
    - noise emissions

    - movements of blades
    - food chain changes
    - electromagnetic fields and vibrations, e.g. affecting the sonar system
    - accidents

Fish:

- impacts on fish and fish larvae from sedimentation/turbidity, underwater noise, vibrations and electromagnetic fields
- effects from unnatural reef
- effects of accidents

Fauna and Seabed

- changes in sediment structure
- direct loss from foundation and cable footprints
- impact on biotope from foundations/hard substrates and electromagnetic fields
- disturbance/destruction of benthos due to accidents with ships/aircrafts

Coastline

- impact on coastline due to current/sediment changes arising from cables
- impact on coastline due to accidents

Visual impact

- man-made obstacles in an otherwise structureless landscape

Noise impact

- increased blade tip speed and the ability of sound to propagate more efficiently on sea surface may lead to noise impacts
- impact on birds, sea mammals and fish from underwater noise

Conflicts of interest:

- collision risk with ships (including maintenance vessels), helicopters and low-flying aircrafts
- disturbance of radar and radio signals

Social Acceptance

- reduced acceptance due to unsolved environmental impact questions, lack of public influence on project (e.g. farm layout) and lack of public financial involvement in/ownership of offshore farms

Policies

- insecure/insufficient support mechanisms will block future large-scale development of offshore wind energy

7.2 Recommendations for RTD programmes

In general:

- It will be very important to collect information from different studies in order to cover the whole area, as different "narrow" site specific studies are carried out at the different projects: Baseline and impact studies from individual projects are to be disseminated and jointly appraised (also suggested in [xxxvii]). Conclusions from local projects should be translated and all relevant existing material placed on a publicly accessible web site.
- The impacts from electromagnetic fields from cables on fish, marine mammals and benthos – and on pipelines (corrosion) and naval safety (disturbance of steering equipment) must be investigated – but this is not only to be regarded as the job for offshore wind developers, as it is a general issue of uncertainty.
- The impacts from above-sea and underwater noise emission and the impacts from vibrations during construction and operation must be investigated in relation to effects on birds and sea life
- Mitigation measures in general should be developed in order to reduce the environmental impact of offshore wind farms

Environmental impacts:

Birds:

- As studies regarding the impact of offshore wind farms on birds and general studies on migration patterns are sparse, and as the effects depend on many different parameters, more knowledge is needed, both as general studies concerning bird migration and as site-specific studies: Ecological monitoring programmes/ Before-After-Impact-Studies are highly desirable in order to judge the effect on birds
- Define IBA/SPA borders and proximity to offshore farms
- Define flight paths
- Investigate how to minimize impacts from different farm and turbine layout (incl. marking requirements)

Mammals:

- More studies are needed to evaluate the effect from noise and magnetic fields, and the visual impact on mammals. Before-After-Impact-Studies, including seismic surveys and monitoring of underwater noise levels, and generic studies on noise reception of sea mammals are called for.

Fish:

- As the effect of noise, vibrations (e.g. from placement of monopiles) and magnetic fields on fish is relatively unknown, studies and surveys must be carried out before, during and after construction: Site-specific and species-specific monitoring studies are necessary in order to investigate the effect of offshore wind farms on fish, e.g. investigate if foundations may indeed serve as natural reefs, as indicated from previous studies (e.g. Vindeby), the consequences hereof, and investigate the consequences on fish population/fishing possibilities when fishing (with net) is restricted within and in the vicinity of the wind farm

Seabed

- The quality and quantity of possible impacts on seabed and benthos is not well known, calling for surveys of specific project sites, both as part of the EIA and as generic studies. How will the foundations/hard substrates and cable footprints/electromagnetic fields influence base-line biotope? Investigations should seek to enhance habitat, e.g. by use of appropriate foundation design.

Visual impact

- Research of computer simulation possibilities to test different farm layout seen from different angels, levels and at different weather conditions in order to make visualisations comparable to real-life conditions.
- Clearer definitions of marking requirements.

Conflicts of interest:

- Risk collision studies and additional information on damage mechanisms are called for in order to investigate the issue of marine and air traffic safety and offshore wind farms more closely.
- Radar and radio disturbance: for the development of large scale offshore wind farms it will be important that this subject is more closely investigated – the conclusions from ongoing UK and Swedish studies may contribute with valuable information

Social Acceptance

- Studies of the effects of different ownership models and local ownership of offshore wind farms in relation to social acceptance

7.3 General recommendations for offshore wind projects

Fish, birds and other groups:

Identification and avoidance of sensitive areas
Avoidance of site works during sensitive time periods

Birds:

Layout design to accommodate flight paths, where these are defined.

Sea mammals:

Minimisation of noise levels during construction, operation and dismantling

Fish:

Minimise effect of structures and cabling on stocks

Seabed, Benthos:

Minimize sedimentations and turbidity

Hydrography, currents and water quality:

Use of appropriate foundation design
Avoid use of pollutant chemicals when foundation, tower and turbine are protected against marine environment

Visual:

Early assessment taking account of distance from shore, marking lights and nature of viewpoints
Well-balanced marking lights taking into account safety issues (most important) and visual impact on man and animal

Noise:

Ongoing PR work to counter poor publicity
Maintain good standards of noise emission despite increases in turbine size and tip speed

Social conflicts:

Promotion of openness and local involvement

Risk management:

Develop risk management methods and emergency procedures in order to reduce risks of ship collision and to minimize consequences of collisions

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