European Offshore Wind and Marine Renewable Energy and Electricity Grid Development - Reconciling Climate Adaptation and Mitigation in Coastal and Marine Regions

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1. Introduction

Coastal and marine areas contribute to the quality of life, social well-being and economic prosperity of Europe. Coastal and marine ecosystems provide a wide range of essential goods and services, including absorbing carbon and mitigating climate change. Climate change is affecting Europe's marine and coastal ecosystems, necessitating urgent efforts for climate mitigation.[2] Economic activities in these coastal and marine areas, such as tourism, fishing and agriculture, are vulnerable to these changes.

Coast and marine areas will contribute significantly to the development of renewable energy, and to a sustainable, secure and competitive energy policy for Europe. So an important issue is how sustainable energy development can be implemented in coastal and marine areas, while also reconciling adaptation and mitigation measures for climate change, and preserving the biodiversity and ecosystem goods and services.

This article begins to look at this complex topic of offshore wind farms and marine renewable energy and related electricity grid requirements in the context of European directives and policies, and recent offshore wind farm, tidal and wave leases issued in the United Kingdom. The article concludes with some preliminary recommendations.

2. European coastal and marine policy

The *Integrated Maritime Policy* was adopted in 2009 and aims to achieve healthy marine waters by 2020. It applies an integrated approach to ecosystems and strives to contain the collective

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[2] For example, the increase in the amount of carbon absorbed by the oceans causes ocean acidification, decreasing the ability of many marine organisms to build shells and form skeletons. Coastal zones are also exposed to the risks of climate change. Rising sea levels increase the likelihood of storm surges, coastal erosion and flooding, lead to the contamination of fresh water supplies with salt water, and endangering natural buffers such as wetlands.

pressure of human activities within sustainable levels, including the development of renewable energy. The Policy establishes a regulatory framework for adaptation to climate change and allows for the regular update of environmental measures to incorporate climatic changes.[3]

The *Marine Strategy Framework Directive* requires the development of a marine strategy by each member state by 2012. Countries will have to provide a comprehensive assessment of the state of the environment, identifying the main pressures on their respective marine regions, and defining targets and monitoring indicators. By 2015, they have to develop coherent and coordinated measures.[4]

The *Recommendation on Integrated Coastal Zone Management* (ICZM) was adopted in 2002, and is intended to integrate policies, sectors and interests into the planning and management of human activities to achieve sustainable coastal development under the *Integrated Maritime Policy.* Within a recent paper, the Commission indicated that it may be planning a further proposal to strengthen the recommendation for ICZM in 2011 to support comprehensive and effective climate strategies in coastal zones. [5]

The 2009 *White Paper on Adapting to Climate Change* provides for European guidelines on adaptation in coastal and marine areas.[6] The OURCOAST initiative initiated in 2009 is intended to build a database of coastal planning and management practices, including adaptation to risks and climate change.[7]

The *Water Framework Directive* (WFD) adopted in 2000 establishes a European framework for the protection of all waters in the European Union (rivers, lakes, coastal waters and groundwater) in order to achieve good quality water resources by 2015. The Directive contains clear deadlines for steps required to move toward sustainable, integrated water management. Most countries made good progress towards the delivery of the river basin plans for March 22, 2010, and these plans are necessary to achieve good quality status for European waters by 2015. The Commission's analysis of these plans will contribute to the 2012 *Blueprint to Safeguard EU Waters,* together with a review of the *Strategy for Water Scarcity and Droughts* and the vulnerability of water, biodiversity and soil to climate impacts and human pressures.[8]

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[3] http://ec.europa.eu/maritimeaffairs/

[4] http://ec.europa.eu/environment/water/marine/index_en.htm

[5] http://ec.europa.eu/environment/iczm/home.htm. The possible role of ICZM is explored in ICZM and the Integrated Maritime Policy in a document by the European Commission: *Marine ecosystems under the weather: The European Commission's committment to cleaner seas and oceans by 2020*. In this document, the Commission states: "In addition, the Commission is planning a further proposal to strengthen the Recommendation in 2011, to further support comprehensive and effective climate strategies for coastal zones." This document and further information is located at the following website: http://ec.europa.eu/environment/water/marine/index_en.htm

[6] http://ec.europa.eu/environment/climat/adaptation/index_en.htm

[7] http://ec.europa.eu/environment/iczm/ourcoast.htm

[8] http://ec.europa.eu/environment/water/water-framework/index_en.html

Regional initiatives for Europe's coast and marine areas are briefly discussed below.

The Arctic

The Arctic is severely affected by climate change. Sea ice cover is decreasing, and a decrease in permafrost cover is foreseen by 2050. Methane hydrates are located in this permafrost and on the seafloor, and are both an abundant energy resource and a climate risk. With less sea ice, more shipping and hydrocarbon and mineral development is likely to occur. The EU's main policy goal is supporting adaptation to climate change, in cooperation with the eight circum-arctic countries and OSPAR, the Barents Euro-Arctic Council, the European Environment Agency and the Arctic Council. The EU is funding environmental projects through the Northern Dimension, a policy shared with Iceland, Norway and the Russian Federation.

The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean

The European Community and the countries surrounding the Mediterranean are parties to the Barcelona Convention,[9] which implemented through the Mediterranean Action Plan. This formulates policies and strategies to protect biodiversity and the marine and coastal environment. In 2008, the parties to the Barcelona Convention signed a Protocol on Integrated Coastal Zone Management in the Mediterranean, identifying adaptation to climate change as a priority. The Marrakesh Declaration, adopted by the Barcelona Convention in November 2009, highlights the need for urgent action to counter the serious impacts of climate change on ecosystems and resources, as the Mediterranean region is a hot spot for climate change.[10]

The Bucharest Convention on the Protection of the Black Sea against Pollution

The Bucharest Convention[11] of 1992 initiated environmental cooperation in the Black Sea. The Strategic Action Plan for Environmental Protection and Sustainable Management of the Black Sea supports regional cooperation. While the European Community is not yet party to this Convention, an amendment allowing it to participate was proposed in April 2009. Biannual scientific conferences assess the impacts of climate change on the Black Sea ecosystem and on the sustainable development of coastal areas. The Black Sea waters are warming and there is well as to a slow constant rise in sea levels, more frequent floods and structural changes in ecosystems.

[9] http://www.unep.ch/regionalseas/regions/med/t_barcel.htm

[10] http://ec.europa.eu/environment/enlarg/med/index.htm and http://www.unep.ch/regionalseas/regions/med/medint.htm.

[11] http://www.blacksea-commission.org/main.asp

The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea
The European Community and all the states bordering the Baltic Sea are parties to the 1992 Helsinki Convention.[12] It strives to balance biological components in a healthy Baltic Sea environment, supporting a wide range of sustainable economic and social activities. The Thematic Assessment on Climate Change in the Baltic Sea Area (2007) projects that sea surface temperature could increase by 2ºC to 4ºC and the length of the ice season be reduced by two to three months, preventing the achievement of the goals of the HELCOM Baltic Sea Action Plan.

The OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic
The OSPAR Convention[13] consists of15 countries and the European Community, and conserve marine ecosystems and safeguard human health in the North-East Atlantic by preventing pollution. Its key objective is to protect the marine environment from the adverse effects of human activities and to contribute to the sustainable use of the seas. The OSPAR Quality Status Report reflects the overarching impact of climate change and the further obstacles it creates to achieving environmental objectives in the marine region. OSPAR has also adopted environmental measures to ensure the safe storage of carbon dioxide in geological formations under the seabed.

The United Nations Economic Commission for Europe Guidance on Water and Adaptation to Climate Change
The UN ECE Guidance on Water and Adaptation to Climate Change [14] is implemented under the UN ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (the Water Convention). The Task Force on Water and Climate is responsible for activities related to adaptation to climate change, including flood and drought management., and works in close cooperation with the Task Force on Extreme Weather Events established under the Protocol on Water and Health. The Task Force prepared aGuidance on Water and Adaptation to Climate Change that was adopted in 2009. The next task is assisting in the implementation of pilot projects on adaptation to climate change, and developing exchanges of experience on adaptation to climate change in transboundary water basins through a pan-European platform.[15]

[12] http://www.helcom.fi/

[13] http://www.ospar.org/

[14] http://www.unece.org/env/water/meetings/transboundary_adaptation_workshop.html

[15] http://www.unece.org/env/water/meetings/transboundary_adaptation_workshop.html

3. European Climate and Renewable Energy Policy

EU DG Climate Action and future trends for climate and sustainable energy

On February 17, 2010, the Commission announced the creation of two new Directorates-General (DG) for Climate Action and Energy. The Climate Action DG will be created from activities in DG Environment, international negotiations on climate change activities in the External Relations DG, and climate activities in the Enterprise and Industry DG. Jos Delbeke, previously Deputy Director-General in the Environment DG, was appointed Director-General of the Climate Action DG. The details of and the links between the DGs of Climate Action, Energy and Environment have not yet been specified.[16]

Connie Hedegaard was appointed the Commissioner for Climate Action and issued a statement on February 10, 2010 including:

> .First, to implement the Climate and Energy package that was adopted last year, but which now requires follow-up**.** I want to ensure that as we invest in a sustainable future, we choose solutions that at the same time can benefit climate, energy security and job creation – in other words, improve the quality of life for everyone. I want to show that by investing in climate friendly and energy efficient technologies, we gain economically. The opportunities are huge…"[17]

The European focus on climate action and energy security is likely to strengthen policies and initiatives for offshore wind energy, and the establishment of European electricity grids.[18]

Role of Offshore Wind in European Renewable Energy Policy

In September 14, 2009, at an offshore wind conference in Stockholm, Andris Piebalgs, then EU Energy Commissioner, gave a speech on offshore wind energy.[19] Commissioner Piebalgs noted that the European Environment Agency published a study of the wind energy potentials in Europe, which estimated that the economic potential for energy production from offshore wind is more than 3000 TWh in 2030, or 80% of expected EU electricity consumption. The

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[16] http://www.europa-eu-un.org/articles/fr/article_9503_fr.htm

[17] http://ec.europa.eu/commission_2010-2014/hedegaard/index_en.htm

[18] Interestingly, Connie Hedegaard, European Commissioner for Climate Action, was awarded the "Wind turbine prize 2010" at the annual assembly of the Danish Wind Turbine Owners' Association on 27 March 27, 2010. The award was motivated by Connie Hedegaard's "strong personal engagement in both national and international climate policy and her energetic work to promote renewable energy sources, not least wind power" Commenting on the prize, Commisioner Hedegaard said: "I am very grateful for this recognition, which is a further encouragement for my work in the challenging new position of European Commissioner for Climate Action. I am determined to further strengthen the European Union's response to climate change, and continuing my support to renewable energy will be a significant part of that." See http://ec.europa.eu/commission_2010-2014/hedegaard/pdf/windturbine.pdf for further information.

[19] http://europa.eu/rapid/pressReleasesAction.do?reference=speech/09/387.

Communication on Offshore Wind Energy[20] recognized that wind energy will play an essential role in meeting the EU's target for 20% renewable energy by 2020 and achieving a secure, environmentally friendly and affordable supply of energy for European citizens and businesses.

The Communication identified the challenges to exploiting Europe's potential for offshore wind energy, and how action can help meet these challenges. Key themes include the need for more cross-border cooperation to share experiences and coordinate better in fields such as electricity grid and maritime spatial planning, regulatory practices regarding interconnector investments, and environmental impact assessments of wind farms. Generally the significant potential for using wind energy for electricity generation remains unused. Wind power is increasing, and more than 40% of all new electricity generation capacity added to the European grid in 2007 was wind, with wind energy expected to be more than one third of renewable energy production by 2020.

The Commissioner noted that terrestrial wind farms are important now, but installations at sea will become increasingly important. By generating electricity without fossil fuel, and creating jobs and growth, offshore wind can make a significant contribution to all three key objectives of the EU's new energy policy: reducing greenhouse gas emissions, ensuring security of supply and improving EU competitiveness. Offshore wind is more complex and costly to install and maintain but also has a number of key advantages. Winds are typically stronger and more prevalent and stable at sea than on land, resulting in significantly higher production per unit installed. At sea, wind turbines can be bigger than on land because of the logistical difficulties of transporting very large turbine components from the place of manufacturing by road to installation sites on land. Finally, offshore wind farms seem to cause less concern than terrestrial installations, unless they interfere with competing maritime activities or important marine environmental interests.

Integrated Marine Spatial Planning for Offshore Renewable Energy

Given the European focus on offshore wind development, coastal and marine conservation organizations and interests will need to focus on marine environmental interests, so they are adequately considered in the planning of the offshore wind developments and related electricity grid infrastructure. This role is increasingly important as many of the larger environmental organizations are prioritizing climate mitigation over preservation of marine biodiversity and conservation, particularly with respect to renewable energy. A consideration of climate adaptation and mitigation in tandem with a broad range of EU directives, policies and recommendations may be the most appropriate approach.

The European Wind Energy Association has discussed how increased activity in marine waters has led to more competition between shipping and maritime transport, the military, the oil and gas sector, offshore wind and ocean energies, port development, fisheries and aquaculture, and environmental concerns. These activities are regulated on a sectoral basis by different agencies, each with its own specific legislative approach to the allocation and use of maritime space, which has led to fragmented policy making and limited EU coordination. In contrast to spatial planning

[20] Memo 08/70: Communication on Offshore Wind Energy, issued in Brussels on November 13, 2008

on land, European countries generally have limited experience of integrated spatial planning in the marine environment, and governance structures and rules can be inadequate.

In addition to the wide range of sectoral approaches for the sea, countries have different planning regimes and instruments. For example, in Germany there are regional plans for the territorial seas and national Exclusive Economic Zones plans, whereas in France, sea "Enhancement Schemes" have been used in some areas as the main instrument. The UK, Germany and Denmark, have integrated the deployment of offshore wind energy into a global approach that encompasses industrial, research and policy aspects, and they are seen as the most promising markets.

The European Wind Energy Association noted that without an integrated approach, offshore wind energy deployment can be caught between conflicting uses, interest groups and rules from different sectors and jurisdictions within and between states. This can create project uncertainty, increases the risk of delays in, or failure of offshore wind projects, and impairs growth. These barriers are further aggravated by the absence of an integrated and coordinated approach to maritime spatial planning between the different member states and regions.[21]

Given the scope of proposed offshore renewable energy in the near future, the comments of the European Wind Energy Association emphasize the need for further discussion. These comments also highlight conservation concerns. Coastal and marine areas which assist in carbon mitigation activities through renewable energy production are also adapting to climate change and experiencing increased impacts from human activities.

4. **European Electricity Grids**

There are many future energy scenarios for Europe as renewable energy is increased and as the energy sector is "de-carbonized". One vital aspect is how these variable energy loads and systems of renewable energy such as wind, wave, tidal and solar will be managed, transmitted and distributed to different regions, countries and local communities within Europe. Different stages of the electrical supply chain have been identified, with two stages affecting marine renewable energy. Two de-carbonized stages of the electricity supply change are generation from renewable energy sources and low carbon fossil fuel alternatives, and transmission and distribution through future networks or smart grids.

One possible future scenario for electricity includes macro grids and micro grids where network operators control regional and local loads, storage and generation, which can be separated from the transmission system in the event of failure, and virtual power plants which electronically connect and aggregate the power from a geographically dispersed set of generation facilities. This scenario is particularly relevant if renewable energy provides 20 % of the energy needs and must be integrated at European, regional, national and local level. As the participation of renewable energy increases, this will require the rapid evolution in electricity generation, transmission and distribution systems from passive networks, focusing on the delivery of

[21] European Wind Energy Association, *Oceans of Energy,* September 2009 at pages 21 to 23.

electricity to end-users, to active networks that incorporate many of the functions, services and tools associated with transmission systems.

Supergrid

The concept of Supergrid was first launched a decade ago and it is defined as "An electricity transmission system, mainly based on direct current, designed to facilitate large-scale sustainable power generation in remote areas for transmission to centres of consumption, one of whose fundamental attributes will be the enhancement of the market in electricity".

Unlike point to point connections, Supergrid will involve the creation of "Supernodes" to collect, integrate and route the renewable energy to the best available markets, and can be is a trading tool to enhance the security of supply for all of Europe. There can be many forms of Supergrid, with an Offshore Supergrid is based on the seas around northwestern Europe. There can also be as a Solar Supergrid in the Mediterranean. These grids will ultimately be linked to supply electricity across the EU.[22]

Smart Grid

A smart grid is intended to generate and distribute electricity more effectively, economically, securely, and sustainably. It integrates tools and technologies, products and services, beginning with generation, transmission and distribution facilities and extending to customer appliances and equipment. Smart grids accomplish this with advanced sensing, communication, and control technologies, enabling bilateral exchanges with customers, providing greater information and choice, power export capability, demand participation and energy efficiency. Smart grids are useful for large scale and small scale renewable energy, and for balancing the variable loads that will occur with renewable energy. It also depends on eliminating the regulatory, legislative, transmission and economic barriers to free generation, movement and sale of electricity in Europe. There is an European SMARTGRID technology platform that provides further information.

European Offshore Electricity Grid Infrastructure

OffshoreGrid is a techno-economic study within the Intelligent Energy Europe programme that will develop a scientifically based offshore grid for northern Europe, along with regulatory framework that considers technical, economic, policy and regulatory aspects. The project will take place from 2009 to 2011, and targets European policy makers, industry, transmission system operators and regulators. The geographical scope is, first, the regions around the Baltic and North Sea, the English Channel and the Irish Sea. In a second phase, the results will be applied to the Mediterranean region. There will be selection of blueprints for an offshore grid in the Baltic and North Sea taking into account the costs of the various options, their socio-economic value, regional and national power market designs and the regulatory framework for the payment and operation of the grid.[23]

[22] See www.friendsofthesupergrid.eu for more information.

[23] www.offshoregrid.eu

The Mediterranean Interconnection Plan

The Mediterranean Interconnection Plan or Mediterranean Energy Ring[24] was one of five priorities identified in the 2nd EU Strategic Energy Review. The objective is energy interconnections, linking Europe with the southern Mediterranean through electricity and gas interconnections that will improve energy security, facilitate energy exchanges among southern countries, and help develop solar and wind energy potential. Interconnections are also considered for the Western Balkans and Turkey.

A more integrated Mediterranean energy market is necessary to cope with growing energy demand and to encourage low-carbon and renewable energy sources and energy efficiency. The Plan includes developing a regional electricity network and improving both south-south and south-north electricity corridors, with a focus on the integration of new generation capacities from renewable sources.

At the Paris summit meeting on July 13th 2008, the governments of the European and Mediterranean countries launched the Union for the Mediterranean. The Mediterranean Solar Plan[25] is an important energy project under that Union, and has two complementary targets: developing 20 GW of new renewable energy production capacities and achieving significant energy savings around the Mediterranean by 2020. A master plan for large investments is planned for the end of 2010.

5. UK Offshore Wind Farms and Marine Renewable Energy

The UK has extensive offshore wind farm developments underway as result of three rounds of leasing of offshore wind farms by the Crown Estate which holds the offshore rights. By 2020 at least 20 GigaWatts (GW) of offshore wind is expected to be installed and operating in waters. There are currently 228 offshore wind turbines in UK waters, with an installed capacity of 688MW, with a further 1,407 in construction and approved, totaling 4,598MW.[26] The first leases have also been issued for tidal and wave energy in Scottish waters.

On January 8, 2010, the Crown Estate announced the successful bidders for each of the nine Round 3 offshore wind zones which will deliver 32 GW of offshore wind capacity, or a quarter of the UK's total electricity needs by 2020. Earlier in Rounds 1 and 2, the Crown Estate awarded for 8 GW of offshore capacity. On March 16, 2010, the Crown Estate announced the the successful bidders for the world's first commercial wave and tidal leasing round, for ten sites in

[24] http://ec.europa.eu/energy/international/euromed_en.htm

[25] http://ec.europa.eu/energy/international/international_cooperation/doc/2010_02_10_mediterranean_solar_plan_strategy_paper.pdf and http://www.mediterraneansolarplan-conference.es/index.php/lang.en

[26] http://www.bwea.com

Scotland's Pentland Firth and Orkney waters. A total of 1.2 GW of capacity proposed by the wave and tidal energy developers for 2020, with 600 MW each from wave and tidal.[27]

A Strategic Environmental Assessment (SEA) scoping document is prepared as part of the Department of Energy and Climate Change's Offshore Energy SEA (OESEA) programme.[28] In 2010, the Energy and Climate Change Minister David Kidney announced the scoping for the next offshore Strategic Environmental Assessment, to update and extend the prior OESEA of January 2009 to include wave and tidal technologies, carbon capture and storage, and offshore hydrocarbon gas storage, and enable further licensing and leasing.

Given the magnitude of Round 3 offshore wind farm leases, there may be some interesting environmental issues. For example, a license was issued to develop a wind farm in Dogger Bank for up to 9 GW capacity, with construction scheduled to start on or after 2014. However, the Dogger Bank is also an important fishing areas, with cod and herring being caught in large numbers. Due to phytoplankton, it has high primary production throughout the year, and Dogger Bank has been suggested as an UK or an international protected areas.[29]

Though the limited nature of this article can not address this issue, how can UK and other countries' wind farms in Dogger Bank be reconciled with the significant biodiversity and ecosystem values of this area. If further studies find that the wind farm causes adverse impacts on seabird, fish or marine mammals or their habitat for Dogger Bank, how will these impacts be addressed, eliminated or compensated consistent with European and UK requirements?

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[27] http://www.thecrownestate.co.uk/offshore_wind_energy

[28] The OESEA will be conducted in accordance with The *Environmental Assessment of Plans and Programmes Regulations 2004*, which apply to any plan or programme which relates either solely to the whole or any part of England. The SEA process aims to help inform licensing and leasing decisions by considering the environmental implications of proposed plans and programmes, and the potential activities which could result from implementation. An environmental report was issued in January 2009, which considered the environmental implications of a draft plan and programme to enable further seaward rounds of oil and gas licensing. A Post Consultation Report on the UK OESEA was issued in June 2009. The O*ffshore Marine Conservation (Natural Habitats & c.) Regulations 2007* apply to the UK's offshore marine area which covers waters beyond 12 nautical miles, within British Fishery Limits and the seabed within the UK Continental Shelf Designated Area and form the legal basis for the implementation of the Directives in territorial waters out to 12 nautical miles. These regulations apply the *Birds* and *Habitats Directives* to UK coastal and marine waters.

[29] WWF Briefing, *Dogger Bank: A Potential MPA: Justification for the Potential Selection of the Dogger Bank as an Offshore Marine Protected Area,* found *at* www.wwf.de/fileadmin/fm-wwf/pdf.../Dogger_Bank_Sandbank.pdf. Interestingly, there have also been proposals by WWF to protect Dogger Bank as an international marine protected area for Denmark, Germany, Netherlands and UK, as it lies within the Exclusive Economic Zones (EEZs) of all these countries. See OSPAR Convention, MASH 04/5/E, WWF Presentation, *Managing across boundaries: The Dogger Bank – a future international MPA* (w*ww.ngo.grida.no/wwfneap/.../WWF_MASH04_transboundaryMPA.doc).*

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6. Recommendations for Reconciling Climate Adaptation and Mitigation in Coastal and Marine Regions for Offshore Renewable Energy and Electricity Grids

These recommendations consider the overall European framework for climate, energy and environmental measures for the offshore renewable energy developments. The recommendations are not specific to individual wind farms or sites.

Integrated Maritime Policy and Recommendation for Integrated Coastal Zone Management

- Spatial planning will be essential to meet the needs of climate adaptation and mitigation, and sustainable energy development in coastal and marine areas. Regional variations may be required for different areas in Europe in order to address different circumstances and impacts.

- For offshore renewable energy, it will be useful to consider how spatial planning and the EU *Integrated Coastal Zone Management Recommendation* can be utilized and in accordance with the EU's *Integrated Maritime Policy* and the EU *Marine Strategy Framework Directive, Birds Directive* and *Habitats Directive*.

Inclusion of Coastal and Marine Biodiversity Concerns in Authorization for Offshore Renewable Energy and Transmission Infrastructure

- Environmental assessment is one of the tools to understand, monitor and minimize the impacts of offshore wind farms, marine renewable energy and transmission infrastructure. *Strategic Environment Assessments* and *Environmental Impact Assessments* need to be rigorously and scientifically conducted for plans, programmes and project authorizations for offshore renewable energy and related transmission infrastructure.

- Ongoing monitoring and modification of offshore wind farms and wave and tidal projects may be required to address expected and unexpected impacts in construction, authorization, operation and maintenance, and the abandonment and reclamation of facilities. The impact of ship traffic for the operation and maintenance of these projects also needs to be considered.

- Environmental assessments process should include the possibility of decisions to not to issue leases or authorizations, due to adverse impacts on bird and marine species, ecosystems and habitats, and existing and potential conservation areas.

Consideration and Mitigation of Impact of Offshore Renewable Energy and Transmissions Lines and Hubs on Fish and Marine Mammals and Ecosystems

- While individual offshore renewable energy projects may have manageable impacts, large arrays of wind farms and wave and tidal projects could have additional and unforeseen impacts on birds, fish, marine mammals, and coastal and marine ecosystems, particularly for collisions and impacts, currents and circulatory pattern, noise, and species avoidance, gathering and migration. The electro-magnetic fields associated with the high voltage transmission lines and hubs of the proposed electricity grids may have significant impacts on certain species (sharks, skates and rays)[30] as well as benthic organisms.

- All impacts will have to be individually and cumulatively considered in the authorization, design and operation of offshore marine renewable energy and related transmission infrastructure.

Increased Marine Protected Areas and Compensation for Lost Ecosystems and Habitats

- It may not be advisable or consistent with the *Birds Directive* or *Habitats Directive* to have all coastal and marine areas suitable for wind farms designated multiple uses, or to assume that offshore wind farms will have minimal or no environmental impacts.

- Areas that are suitable for offshore wind farms and marine renewable energy may also be areas of biodiversity, or productive for fisheries. There may be the need to increase designations of marine protected and conservation areas to offset and compensate for the adverse impacts of offshore renewable energy and transmission infrastructure.

- The *Environmental Impact Assessment Directive* requires that unavoidable impacts be compensated for, while the *Habitats Directive* calls for compensatory measures for unavoidable impacts to *Natura 2000* sites. Given the necessity to facilitate permitting for offshore wind power, compensation methodologies and implementation should be based on a transparent economic and scientific methods and offset the loss of biodiversity, habitats and ecosystem services. [31]

[30] Dr A. B. Gill and H. Taylor, *The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon Elasmobranch Fishes*, Research Project for Countryside Council for Wales (September 2001).

[31] The *Habitats Directive* includes the precautionary principle for protected areas where projects can only be permitted if there is no adverse effect on the integrity of the site. Projects may still be permitted if there are no alternatives, and there are imperative reasons of overriding public interest. In such cases, compensation measures will be necessary to ensure the overall integrity of network of sites. Under the *Birds Directive*, these measures are to be applied to Special Protected Areas also. The *Environmental Impact Assessment Directive* requires that unavoidable impacts are compensated for. Similarly, the *Habitats Directive* calls for compensatory measures for unavoidable impacts to Natura 2000 sites.