Documentary summary of the environmental impact of renewable marine energy

MERiFIC
Marine Energy in Far Peripheral and Island Communities

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CONTEXT

Because of their physical

Figure 4: Bathymetric map of the Celtic Sea and the Gulf of Gascogne
Source: wikipedia.org

This report is prepared in line with the project requirements of work package 3 (WP3) MERiFIC project ('technology support'). Through a study of existing literature, this paper summarizes and compares different conclusions from observation campaigns and monitoring reports, scientific articles and internet websites and aims to provide a key to understanding environmental impacts, proven or suspected, generated by marine energy extraction devices.

The set of matrices for each stressor and receptor is presented in Appendix 5.

The impacts can be classified according to several criteria. The nature and magnitude of an impact on the ecosystem depend on the extent of the duration and the intensity of the changes caused by the development (Carlier & Delpech, 2011). There are hundreds of concepts of energy exploitation of the seas that exist. Impacts are therefore to nature and variables of intensity. Hence it is difficult to define a standard of protocol for assessment.

However, tools do exist to establish the extent of the effects that project implementation could have as an impact on the environment. These tools allow common protocols to be defined, the limits of environmental acceptability and require the state to be accountable for the level of conservation of natural areas. These tools help to ensure a level of respect for the environment, in line with the concept of "sustainable development".

2. IMPACT STUDIES AND LEGAL FRAMEWORKS

The challenge for scientists is to develop information, from both the qualitative and the quantitative approach, integrating all elements of an ecosystem, for the assessment of impacts on the environment. Decision making tools should be in place to help guide developers, both for optimisation of project conception as for strict control requirements (Linely et al., 2009).

Regulatory Tools

EIE

The "EIE", "Evaluation of Environmental Impact" determines the authorisation of certain projects, public or private, that have or might have a physical effect on the environment, is assessed by a 'national authority'. This assessment should determine the direct and indirect effects of these projects on human beings, fauna, flora, soil, water, air, climate, landscape, material assets and cultural heritage, as well as the interaction between these elements (europa.eu).

The EIE facilitates the integration of environmental issues in the design of projects and thus save on budgetary resources, both public and private, because the cost of an EIE are considered "negligible" compared to the high costs that could be caused by unanticipated environmental problems that arise at an advanced stage.

In addition, the EIE formalises public participation by allowing it to contribute to the design concept of the project. This generally promotes acceptability of projects.

The problem is that the EIE currently lacks baseline ecological data (initial state of the environment), which limits their implementation. As emphasised by Gill (2005), the major problem with the integration of ecology in planning and decision making is the lack of adequate information. On the other hand, it is rare that the EIE address the cumulative effect of existing activities or other locations provided. The ESIE (Strategic Study of Environmental Impact) on the other hand, takes into account cumulative effects and synergies at larger scales than the project (Wilhelmsson, 2010).

ESIE

The "ESIE" ("Strategic Assessment of Environmental Impact") Directive is intended to supplement the EIE (europa.eu).

The Member State responsible for the development of a project is required to send a copy of the project, together with a copy of the report on environmental incidences to neighbouring States where it considers that the project is likely to have environmental incidences on their territory, or at the request of the other member State/s. These can initiate consultations on cross-border impacts of the projects with the responsible member State, as well as the measures envisaged to reduce or eliminate these incidences.

When a project is approved, the Member State responsible shall inform all stakeholders and provide them with the following:

- Planning or programme adopted;
- Statement summarizing how environmental considerations have been integrated and their relationship to the environmental incidences;
- Opinions and the results of consultations;
- Reasons for the choice of the project as adopted;
- Statutory requirements/measures for monitoring.

This assessment takes into account the likely significant effects of the implementation of the project, including the short, medium and long term effects, permanent and temporary, positive and negative effects, side effects, cumulative and synergistic and correlations with:

- Biodiversity, habitats, fauna and flora;
- Geology, substratum and coastal geomorphology;
- Landscape or seascape;
- Aquatic environment;
- Air quality;
- Climate and weather;
- Population and health;
- Other users, physical assets (infrastructure, other natural resources);
- Cultural heritage;
- Protection of sites and species.

(DECC, 2011)

Member States can provide coordinated or joint procedures in order to avoid duplication of environmental assessment when the project is covered by this Directive and other Community Acts.

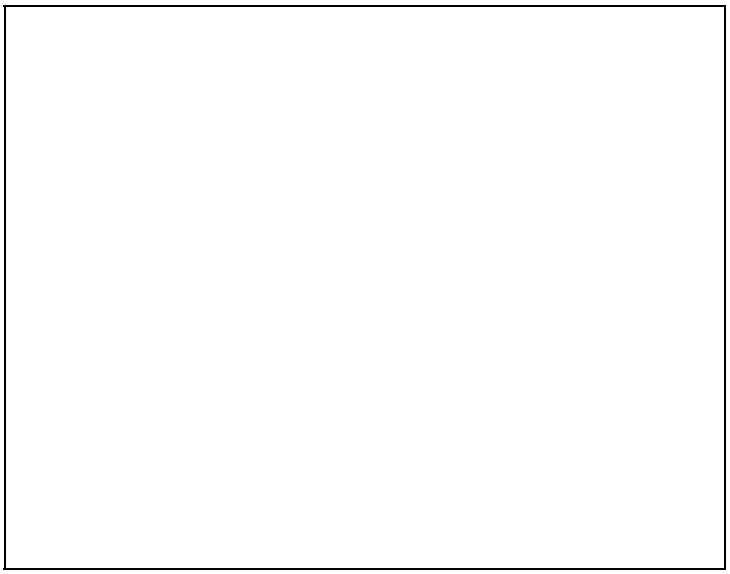

Figure 10: Main differences between the EIE and ESIE, adapted from Eales et al., 2003

Source: Wilhelmsson et al., (2010)

The Guidelines - Fauna Flora Habitats and Birds and the Natura 2000 network

The 'Birds Directive' (79/409/CEE, 1979) offers the long‐term conservation of wild birds in the European Union targeting 181 species and sub‐species, in particular migratory birds and those considered rare and vulnerable. More than 3000 sites have been classified by the member States of the European Union as Special Protection Zones (ZPS).

The directive "fauna flora habitats" (92/43/CEE, 1992) establishes a framework for community action conservation of fauna and flora and their habitats. This directive lists over 200 types of natural habitat, 200 animal species and 500 plant species of community interest in need of protection. Special Conservation Zones (ZSC), currently more than 2000 for 12% of European territory, aim to promote the maintenance of biodiversity, taking account economic, social, cultural, regional, and establish measures to maintain or restore a favourable conservation status, natural habitats and species of interest to the European Union.

The ZPS and ZSC form a network of conservation areas called "Natura 2000".

The Natura 2000 network is a collection/grouping of European zones of nature, land and marine, identified for rare or fragile wildlife, animals or plants and their habitats. Natura 2000 balances nature conservation and socio‐economic concerns (development‐durable.gouv.fr). Networking sites extend throughout Europe in order to make this initiative consistent with preservation of species and habitats. (Annex 3, Natura 2000 Iroise Sea)

According to the strategy for biodiversity in the European Union, the implementation of MRE (Marine Renewable Energy) devices must take account of Natura 2000 sites/zones in order to underpin the objectives of these guidelines. In France projects, plans, programmes or events that may significantly affect the natural habitats and species present on a Natura 2000 site must have the impacts assessed. A simplified evaluation form is provided by the departmental territories of the sea, and if it can demonstrate that the issues of conservation of habitats and species or sites/area are not threatened, there will be no need for further studies.

In France, the Natura 2000 network in the sea stretches to 39,848km2 of marine areas, nearly 40% of its territorial sea (in February 2010).

Figure 11: The location of candidate sites in the UK of Special Areas of Conservation
S ¶ Sandbanks slightly covered with water; E ¶ Estuaries; M ¶ not covered mudflats during low tide; I ¶ Large shallow inlets/coves/creeks and bays; L ¶ Lagoons; R ¶ Reefs; C ¶ Sea caves; HS ¶ Harbour seal (seals); GS ¶ Grey seal; CS ¶ Common Seal; BD ¶ Common Dolphins

Source: Hiscock et al., (2002)

The above document (Figure 11) shows the diversity of the Natura 2000 network sites (in the UK).

The "Natural England"

Natural England is a British government agency that is in charge of issues for nature conservation throughout the United Kingdom. With regards to the marine environment, Natural England addresses issues for the coastal zone within the 12 miles limit from the coast.

"Sites of Special Scientific Interest" (SSSI) in the UK

SSSI's (Sites of Special Scientific Interest (SSSI) are designate as protected areas. This is a fundamental element in British legislation for the conservation of natural sites and on which many other notions of British law are based, such as the National Nature Reserve, sites under the Ramsar Convention, ZPS's and ZSC.

Governance Tools

The BACI

Wherever possible, data collection the BACI

Within marine parks, certain activities that may affect the environment, are submitted for authorisation in accordance with the procedure “notice of conformity” in the case of significant impacts or with the procedure “simple notice” in cases of minor impact (all fishing activities).

We still have very little leeway on the environmental impacts of MRE, due to the low number of sites. Scientific knowledge comes mainly from the existing/installed offshore wind farms. The diversity of the types and systems for the collection of data must be taken into account to adapt the devices for minimal impact on the environment.

2. MARINE ENERGY

The different types of marine energy

The sea is a fluid rich in energy flows that can be exploited in the following forms: offshore wind energy, wave energy (houlomotrice), tidal / currents energy. The harnessing of all these energies is possible and has already started in different locations around the world, at different stages of development.

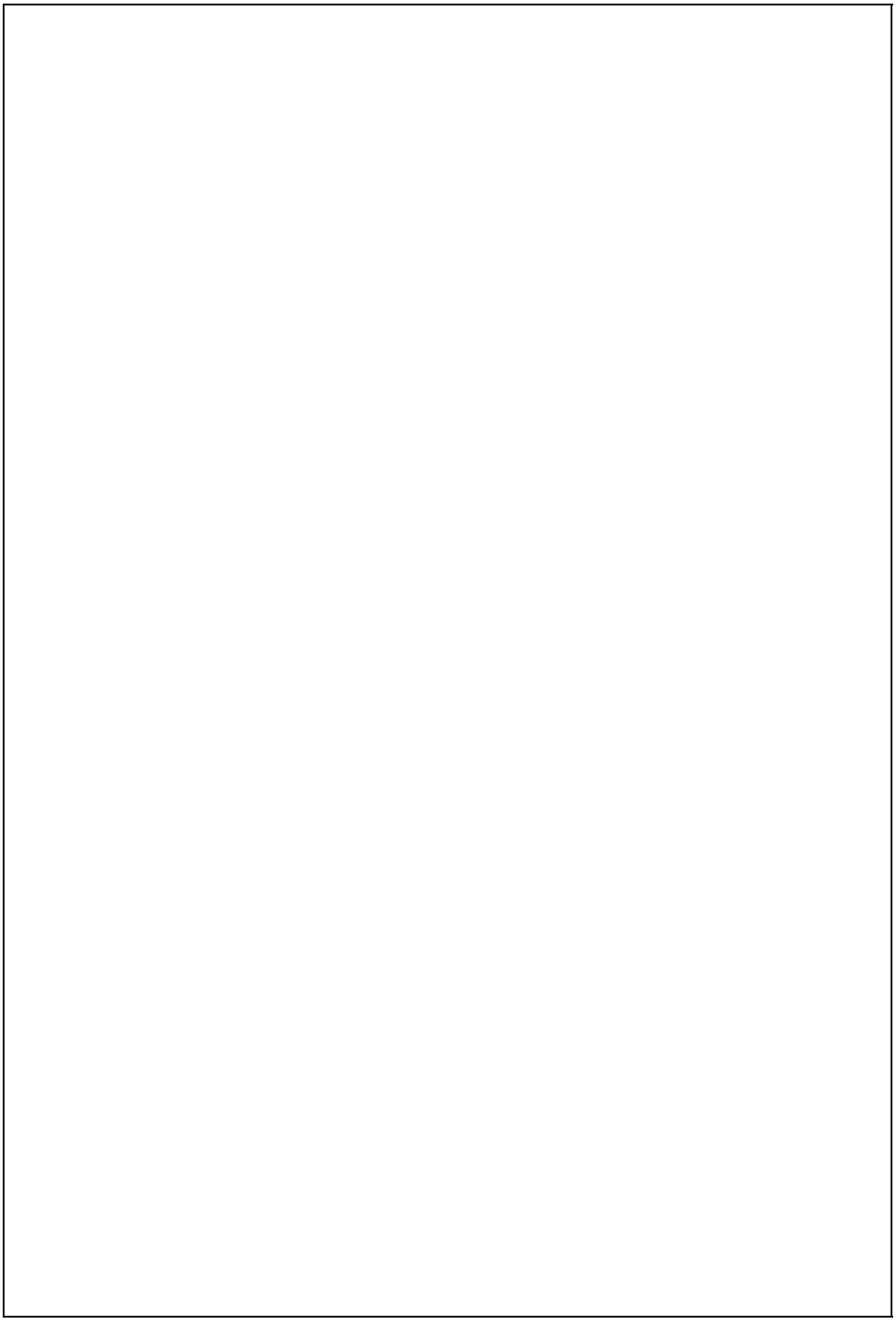

Figure 13: MRE projects in RTA regions

generally being lower, the recoverable power per unit area of helix is much greater than for a wind turbine.

Ocean currents are predictable, notably thanks to tidal currents**,** we can accurately estimate their production of electricity.

Figure 15: Image of a synthesis demonstrator Sabella D10 immersed in the passage of Fromveur to Ouessant
Source: connaissancedesenergies.org

Source: fr.dcnsgroup.com Source: letelegramme.com
Figure 16: The PaimpolBrehat Turbine

Marine Turbines are very expensive to maintain, which is frequent, and is difficult because of their immersion in water. For this reason, some turbines have a structure that can be raised above the water. Ballast systems can raise and lower the production units, as at SeaGen in Strangford Lough in the United Kingdom.

Source: bbc.co.uk

Figure 24: The Wave Hub
Source: energiesdelamer.blogspot.fr

Witt et al., (2012) published a study on the effects of biodiversity on the Wave Hub.

Offshore Windfarms

The wind is much stronger and more constant at sea than on land. It establishes over wide areas free of obstacles (ifremer.fr).

Source: infoniac.com Source: kkπelectronic.com
Figure 25: Wind Farms of Horns Rev and of Nysted Park Offshore in Denmark

Offshore wind farms differ in their anchoring system. Can be distinguished:

- Gravity based foundations, attached to the bottom by their own weight or dense materials. These devices are generally limited to shallow waters and require preparation of the seabed.
- Single pile foundation or Monopile foundation

Characteristics of environmental and social impacts can be acquired through experience from pilot plants of a significant size. Wave and tidal power technologies are in their infancy, but the lessons learned from the operation of offshore wind farms are applicable to the operation of hydrokinetic energy and wave energy, as they are independent of the type of devices for energy production.

In the future, wind farms and wave power could share the same foundation**s**, the same electricity transmission lines and maintenance costs; a sharing accompanied by a decrease in the overall disturbance of the marine environment (Wilhelmsson et al., 2010).

Each MRE project is characterized by its site and technology implementation that will affect a given space in a given period.

3 SUMMARY OF THE ENVIRONMENTAL IMPACT OF MARINE RENEWABLE ENERGY

Impacts on hydrodynamics and sediment dynamics

The physical presence of structures can disrupt coastal dynamic processes in the fields near to and far from MRE installations and change the landscape. The recovery of energy from waves and currents involves intercepting the kinetic energy which, in other circumstances, would be dispersed elsewhere in the marine environment. The interruption of the natural dynamics of marine energy will affect other physical processes (sedimentation, currents) and ecological (dispersal of food resources, larval recruitment, reproduction of species, etc), as well as human activities that are influenced by the functional dynamics environment or dependents.

The scale of the impact felt will depend essentially on the amount of energy extracted rather than the extraction method (Ian Walkington), although it is clear that different types of facilities cause different types of impacts (Bell & Side, 2011).

The consequences of such disturbance can have a direct impact on many environmental receptors: flora and fauna, navigation channels, coastal terrain, coastal defenses, etc. (Huddleston et al., 2010).

Physical presence; flow disturbances

Obstacles to flow tend to affect transportation of sediment, the order of a meter or kilometer and erosion around the installations (Walkington & Burrows, 2009).

Disturbance to flows induced by the mere physical presence of underwater elements, generate an increase in the water velocity around the foundations and therefore causes a winnowing (erosion) at the foot of the foundations creating a "scour pit" which can range from 0 to 100 meters.

Figure 34: Leveling around a monopile
Source: Rees, 2006

It is recognised that the size of this type of sedimentary winnowing is limited to 10 times the diameter of the obstacle (OSPAR,2006).

Technically this effect can be reduced by the introduction of anti‐scouring materials around the obstacle.

Energy Extraction

The removal of sufficient kinetic energy causes an aerodynamic change in the wake of the obstacle (hence the hydrodynamics in the wake of a Wind Turbine support).

Figure 35: Hydrodynamics changes in the wake of a wind turbine monopile

Source: Christiansen (2005)

Risk Avoidance

When encountering offshore Wind Farms, marine birds and / or migrators tend to bypass the Farm rather than pass between the wind turbines. This behaviour causes a change in the length of the migration route (Masden et al., 2009) and therefore a greater effort associated with the longer distance (Tulip.et al., 1999; Petterson & Stalin, 2003; Drewitt & Langston, 2006; Laresen & Guillemette, 2007). It changes the way birds use the habitat (Langton, 2011). These obstacles could be on travel routes preferred by certain species of birds, the route connecting areas / locations for feeding, resting**,** nesting, etc. (Drewitt & Langston, 2006). This effect of avoidance was observed from 100 to 3000m from offshore installations (Winkelman, 1992; Christensen et al., 2004, Kahlert et al., 2004), during the day or at night (Winkelman, 1992; Dirksen et al., 1998).

A detailed study of the cumulative effects of several wind farms in the same area is required. An assessment of the impact of several offshore wind farms in the coastal region of Germany. Indicate that, depending on the species, 2 ת 6% of the seabird population in the country could be affected (Dierschke et al., 2006). Modeling tools are available for different scenarios and different types of

Figure 43: Flight paths of birds during the commissioning of the wind turbines at Nysted Offshore Wind Park in Denmark
Detection by radar. The black lines indicate the flights of migratory birds, the red dots represent the wind turbines.
Graphic scale bar: 1000m
Source: Desholm & Kahlert (2005)

The severity of the effects on local bird population largely depends on the ability of the birds to find replacement habitats (Whilelmsson, 2010).

The "barrier" effect on marine fauna is very poorly documented. Globally it results from two distinct effects: electromagnetism and noise. Both stress factors will be addressed in specific chapters.

Loss/ degradation of habitats

Avoidance of wind turbines results in a loss of effective habitat, not only in the area of the wind farm but also in the buffer zone around the park. The effects of collision or avoidance could cause a loss / degradation of habitats. The inappropriate implementation of MRE in sensitive zones or of interest such as spawning grounds, resting areas, feeding, strategic routes or regions with rich biodiversity is susceptible to having a negative impact on certain taxons (Inger et al., 2009). Especially when these habitats are limited in terms of availability, size and that the dependent species have a low number of recruits or develop slowly (as with the elasmobranchs). If the substitute habitats are limited in terms of quality and caliber they are already occupied (that is to say they have achieved or are approaching their capacity), then the increase in density would result in strong competition for the available resources and so, there would be an increase in the mortality rate and lead to a decline in the size of the local population (Linley et al., 2009).

Stressor matrix: Energy removal - commercial-scale deployments.
Source: Polagye et al., 2010.

Receptor matrix: Physical environment: Far-field pilot-scale deployments.
Source: Polagye et al., 2010.

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