Waveplam

D3.1 Methodology for Site Selection

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PREFACE

As energy demand and awareness of the need of renewable energy sources increase, the interest in new forms of renewable energies, like marine energies, is growing too. This may be translated in the investment into and the implementation of wave energy projects. Global estimates talk about a 10% of the current energy demand being satisfied by wave energy, and so does the European estimate. At the moment, experience is mainly limited to test sites and demonstration projects. As engineering experience overcomes the major technical problems that are holding it back, the wave energy industry will need other non technical issues to be tackled as well. Identifying and addressing these is the main objective of the *Waveplam* project, and thus speeding up the introduction of wave energy into the market.

One of the specific objectives of this project is to generate recommendations for promoters to guide them through the process of implementing wave energy projects. This deliverable will deal with the first task within this objective, which is the development of a methodology for the selection of suitable sites for wave energy projects.

1. SCOPE

The scope of this methodology is the description of all the activities in the process of site selection, from the first actions related to the selection of an interest area, through the compilation of all the data about that area and the information that can affect the project, to the identification of one or more suitable sites in the interest area.

The selection of the most appropriate technology for a given site is a decision that some project developers will have to take after assessing the resource and evaluating other characteristics of the site. The methodology mentions this step but does not contain any guidelines on how to select the most suitable technology depending on the site. Those cases where the project is designed for a specific technology will have to adapt the site selection to their chosen device requirements, being all the recommendations in this document general enough to be applicable to them.

The methodology for site selection has been written oriented to commercial state offshore wave energy projects and it does not cover the planning and site selection phases of onshore devices nor breakwater or near shore coastal structure-mounted devices for a number of reasons, explained next. First of all, real onshore projects (meaning devices built on natural coastal elements) are not likely to transcend the demonstration project status and reach commercial development. Secondly, near shore projects mounted on artificial structures, like breakwaters, are extremely dependent on the construction of the structures; the planning process is necessarily triggered by the construction of the breakwater, and the factors that affect the site selection are limited to the location of the port facility.

This deliverable contains a description of the tasks to accomplish for the identification of suitable areas for wave energy projects and contains a checklist of information that needs to be known for the higher guarantee of success and grant of permissions. Also, it tries to expose the different situation in each country by informing on what factors are more relevant or likely to be show-stoppers, what information is available and where it is available.

This report should be regarded as a document full of useful recommendations and an up-to-date checklist of information items, rather than as step by step guideline.

2. INTRODUCTION

When wave energy reaches commercial development, it is likely that wave energy parks are installed along coasts with a good potential for harvesting this kind of energy.

One of the issues that the promoters of a wave energy park will have to face at an early stage is the selection of a suitable site for the project. The selection of an appropriate location for a wave energy project is not a simple task. There are many factors to consider that constitute advantages and disadvantages. The key for a successful choice lies in selecting a site located in an area with the most advantages, such as good energy resource and proximity to technical facilities and least disadvantages, which are usually negative interactions with the environment, the local economic activities or technical impediments that make the installation process more difficult or unviable.

From the extensive information that needs to be gathered, an accurate assessment of the available resource is the most important factor, which will allow calculating the extractable power with a given device. This in itself demands considerable effort. Up-to-date mathematical models can provide elements of the extensive database required, but still it will be necessary to carry out specific physical monitoring at the site. Accurate establishment of the resource is closely followed in significance by a through analysis of all the possible interactions, negative or positive, of the project with previously existing infrastructures and the baseline environment.

2.1. Objective

This document aims at offering guidance on the categories of information that is useful to have at the planning stage and giving some advice on where to find this information. As a general advice, the authors of the methodology want to point out the fact that not all this information will be freely available or even accessible. Apart from this, the situation will differ between countries, or even regions in the same country. Differences in legislation can cause the significance of the information to change as well; a factor that is no-go in one country may mean no major constraint in another country, or data that is crucial in one region may be irrelevant in another one.

Waveplam Deliverable 3.1 pursues two objectives within the project:

- To develop recommendations on how to select a suitable site for marine energy projects, taking into account the available information, the energy resource and all the environmental, technical and socioeconomic constraints
- To produce a document that is easily readable and aids project developers and investors, guiding them through the process of selecting a site with optimal

conditions for the implementation of a marine energy project: maximum resource and least constraints

2.2. Target groups

In the current state of development of the industry, test and demonstration sites are the most common type of wave energy project, while only one pilot commercial zone has been installed in Portugal. These test sites are being developed in those countries that have decided to invest in wave energy, they form part of a government's strategy for the development of this kind of renewable energy, and thus, they count on different degrees of public support, at least in the funding aspect.

This situation will change when wave energy is one more contributor to the renewable energy mix and commercial parks start being commonly installed. In that moment, there can be different scenarios where different actors may be in charge of selecting the most suitable site for the project: from a device developer who wishes to install a full commercial park after test and demonstration to a public regional development agency, utilities, private investors or administrations may act as project developers.

The aim of this document is that any of those groups of people who find themselves in the situation of having to choose the best possible location or give advice on the most suitable sites within an interest area, can benefit from this methodology.

In fact, the process of gathering information can be very different depending on who the promoter is; much of the information about spatial planning required in this geographic evaluation is produced by the public administrations. These bodies sometimes will make this information available for the public, and some other times they will not. Therefore, the involvement of public bodies in a project can be a big advantage.

Hopefully, local administrations will translate their commitment with marine renewable energies in the cooperation with promoters and marine park developers, by offering data and administrative support.

2.3. A matter of Spatial Planning

The need for a space and the exploitation of a certain service in the sea relates the site selection with MSP (Marine Spatial Planning). As new stakeholders and industries, such as the offshore renewables industries, put their eyes on the sea as an area of interest to develop their activities, conflicts among them and with the previous users will arise. Countries are very aware of this and because of that, many governments are already developing Marine Spatial Planning. It is expectable that in the future, the criteria in Europe and maybe in other parts of the world will be homogeneous, so that the type of area granted to each kind of use and the procedures to solve the conflicts will follow a standard methodology. In that scenario, the selection of a site for wave energy parks will be decided in advance by the administrations and the process will be more straightforward.

Tools as SEA (Strategic Environmental Assessment) and EBM (Ecosystem Based Management) provide a way of introducing environmental criteria in the planning process of any new industrial activity or programme adopted by the governments. Both SEA and MSP rely on concepts such as stakeholder involvement and adaptive management. The former means that wave energy, as an industry and as a stakeholder in MSP, should participate actively in the planning processes whenever they have the chance, explaining their requirements to the authorities so that these are taken into account in the plans since an early stage. Participation is beneficial to the industry, but also for the planning authorities, in terms of the information and knowledge that experts from the sector can transfer to the administration. The latter refers to the changeable nature of both industrial activities and the environment, calling for a "learning by doing" mentality when granting spaces to the different users.

Several aspects dealt with in the methodology below are closely linked to Marine Spatial Planning and implementation of SEA, namely, sections 3.4.1.6. "Environmental and Planning issues", and 3.4.1.7. "Interference with other uses". Marine Spatial Planning has the vocation of becoming the regulating tool for any kind of conflicts for the use of the marine space. Since nowadays the regulations are not homogenously implemented, these sections are explained in a general manner.

3. METHODOLOGY

3.1. General

Ideal sites for wave energy parks will be those with a good resource that can be optimally harnessed by the existing technology or technologies, but that also present ease of installation, logistic advantages and the minimum negative interactions with the environment and the local socioeconomic activity.

This ideal scenario needs also to be economically viable; therefore, in may cases a trade off will exist between the variables. For instance, when it comes to the depth of installation, bigger depths mean more energetic waves, but also further distance to the coast, longer cable and higher cost.

The definition of suitable areas for wave energy projects is a Maritime Spatial Planning affair, and will need to be addressed by the administrations. In this sense, Strategic Environmental Assessment will be closely linked to the final decisions about particular sites. In those regions where an SEA has been carried out, this will establish the requirements for areas to be excluded and those that can be considered.

Not every country has undertaken the SEA for marine renewables, meaning that not every region has planned yet to allocate spaces for this activity. The first stage of this methodology describes a similar process to that one an administration would follow and allows the identification of broad favourable and unsuitable areas. The second stage goes further into detail in the suitability assessment of a particular site.

3.2. Methodology

The methodology is composed by two phases, similar to a high level and a detail level. The first stage is where information is gathered and a preliminary assessment of the suitability is undertaken and the second stage, where all the information is integrated into a relevant geographic analysis tool for the decision making.

In the process of selecting a suitable area two stages are defined; in the first one, a preliminary assessment of the suitability of the area is carried out. This stage consists of several steps, but the most important objective is gathering all the relevant and available information susceptible to affect the project and identifying in an early phase potential incompatibilities of the area with the implementation of a wave energy project.

If the gathered information shows that the selected area is a priori suitable for the project, an accurate resource assessment needs to be carried out, in order to find out about the real possibilities of harvesting energy in the area. For this, not only the available resource needs to be known and assessed. The final feasible resource is the part of the total existing resource that can actually be harnessed. Factors that limit this are the efficiency of the technology to be installed at the moment of the installation and spatial constraints due to conflicts with other activities and environmental protection figures.

In the second stage, a thorough geographic analysis is recommended, for which spatial analysis tools are recommended, being the most widely used the GIS packages. The objective of this phase is to identify one area or several areas where the project can actually be implemented and to have a solid base on which to make a decision. In an advanced state of planning of the project, the exact location of the site needs to be defined.

The methodology explained below is in fact a recommendation to promoters and planners so that they take into account all activities and regulations that can affect the project. The process may be very different depending on the specific project; factors like the country where it is implemented, the activities and type of habitats in the chosen region, the competent legislation, the size and aim of the wave energy park among others, can all condition the number of interactions and thus the planning and consents procedure.

- *Step 0: Defining characteristics of the project*
  Defining an interest area for further study

- *Stage 1: Preliminary Assessment*
  - *Step 1: Gathering Information on the relevant subjects*
  - *Step 2: Carrying out a detailed resource assessment*

- *Stage 2: Geographical Analysis. Integration of the data in a GIS tool. Suitability Analysis and identification of suitable site(s)*

Figure 1. Summary of the methodology

3.3. Step 0: Definition of project

A ground level action or step 0 has been defined as a step previous to the suitability assessment begins. This is not as such a part of the methodology, since it has to do with the scope and objectives of each individual project rather than with the selection of an appropriate location. It consists of:

- The definition of a general area of interest for the project; this will be a particular stretch of coastline off which the project be implemented, and which will be the subject of the proceeding detail studies.

- The definition of the characteristics and requirements of the project as a whole. Factors such as overall power, type of wave energy devices expected to be installed; orientation and size of the delimited area and operation depth range among others must be considered.

When a project is in an embryonic stage, is when its characteristics are defined, even if not definitively. Later on in the planning phase, when more information is collected, and there is better criteria to refine these characteristics, they can be changed, for example, to fit the suitable sites in the area.

First of all, an area of interest should already exist or otherwise be chosen. The geographical analysis and assessment proposed here is very detailed and thorough and it is not suitable for large areas; it would take too long to collect all the information for a whole country.

Factors as overall installed power, number of berths, depth of operation, dimensions of the marine zone that will be delimited will be drafted in this stage, so as to have an idea of what the project is going to be like. The technology to be used in the wave park can be selected in advance. This will be the case, for instance, when a technology developer is involved in the planning of a commercial park for their own technology. In other cases, the kind of converter to be deployed will only be decided once a site-specific study has been carried out to assess what the most suitable device to harness the available energy would be. In other cases, several technologies may be sharing a common space in the sea, with an array of devices each. Even if this is not the case now for other forms of renewable energy, it is not so straightforward to predict what the end solutions will be, and it is not thought as convenient to ignore certain options.

3.4. Stage 1: Preliminary Assessment

The first stage of the methodology aspires to list all the relevant items of information and to provide guidance on where to find this information. In most cases this should be publicly, but not necessarily freely available. As a result of this first stage, a preliminary assessment of the suitability of the area should be obtained. This will include identification of excluded and permitted zones inside the interest area, i.e., whether it is worth investing time and money planning a project in the area. Stage 1 is in turn divided into three steps, which constitute three separate actions within this preliminary assessment. Step 0 or ground level step is not a part of the methodology as such, but it means that when the promoters of a project are going to take step 1, they will need to have defined in advance the scope of their project, the technical characteristics of the wave park and a general area where they plan to install it. Nevertheless, as this will be an early point of the project, promoters should note that the characteristics of the wave park, such as area, hub number, minimum or maximum depth, may need to be modified to suit the site with best conditions.

The following diagram shows the main activities within each phase. In orange are step 0 and step 1, which consist mainly on desktop work. In green we can see the steps that resource assessment involves, from the measurements and calibration, to the assessment of the actually usable resource. Finally, in light blue the geographical analysis phase, with the digitalization of the data and their visualisation in a GIS format.

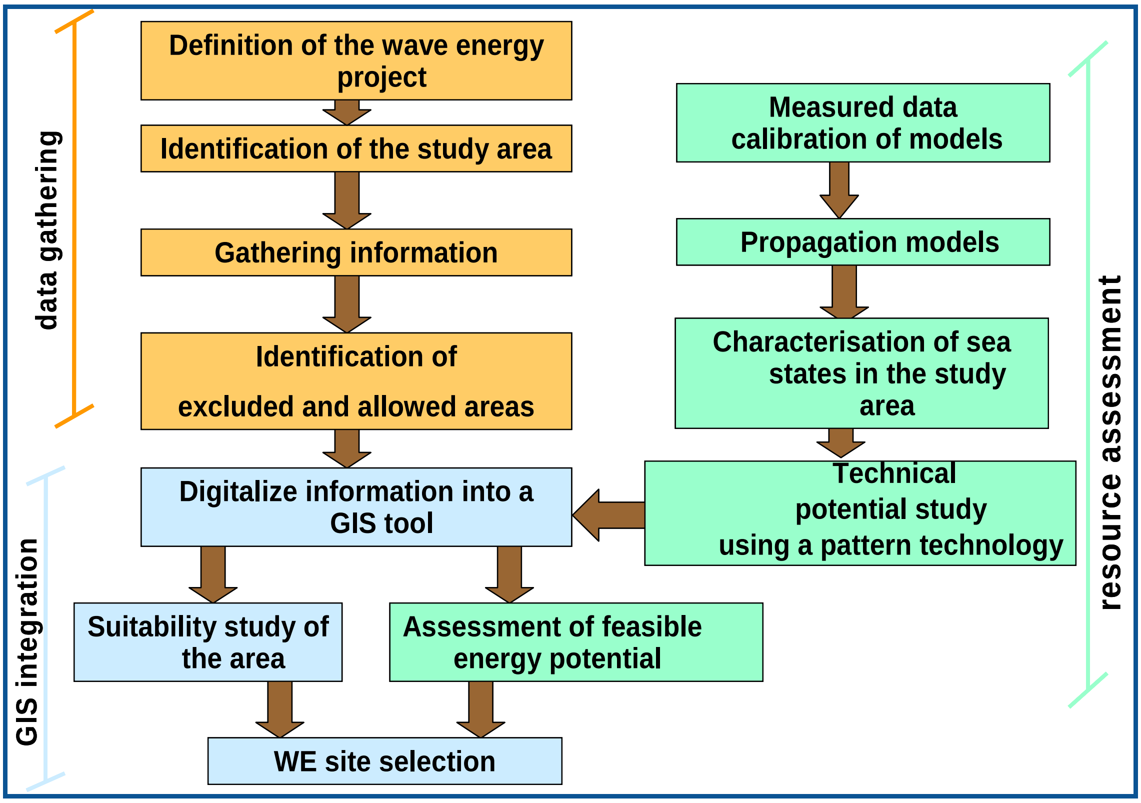

Figure 2. Diagram showing the main activities contained in the methodology

3.4.1. Step 1: Gathering Information

Once there is a clear picture of the project characteristics, there are numerous items of information for promoters to consider when planning a wave energy project. Most onshore wave energy projects will be associated with the construction of new breakwaters or similar infrastructures, so the steps to be taken may vary significantly.

The present section describes the most important of those conditioning factors:

- Energy Resource

- Bathymetry and seabed
- Electric grid
- Infrastructure and Supply
- Environmental & Planning issues
- Characterisation of the Environment
- Interference with other uses

3.4.1.1. Energy Resource: Wave Models

For assessing the wave power resource of a specific location, wave climate needs to be known. A site with a good wave climate in terms of resource is that one where ideal wave heights and periods occur in a significant likelihood. Wave climate is inferred from statistic data.

There are several ways to obtain statistic wave data. The main sources of wave data are: remotely sensed data (obtained from satellites), in-situ measurements, and data obtained from models.

There are numerous satellites measuring wave height and this source is becoming more and more available. The disadvantage is that the measurements are taken with a low frequency and therefore their statistics are useful only in a preliminary assessment.

In-situ measurements with buoys offer the most realistic results, but they are scarce, due to the maintenance difficulties and high cost of offshore buoys and equipment. Since there are not many long-term measurement data records for waves, statistic data are usually obtained from numerical models. Model data show a good level of accuracy and greater availability.

Numerical models usually do a hindcast, i.e., they simulate past wave conditions from past measured meteorological (wind) conditions, for which log-term records do exist. Nowadays, their accuracy allows producing realistic simulations. This kind of data entails several advantages over measurement data; given the shortage of experimental wave data, these are the best source for long term wave data, dating back around 40 years. Apart from this, they provide continuous data record and good information on extreme events.

Global models such as the WAM model, developed in the 80s by the WAMDI Group, or the American WAVEWATCH III are third generation models, which means that they integrate non-linear wave interactions in their calculations. Global models are general and suited to large areas in big ocean depths. To be able to describe in detail what happens in a particular area near the coast, these global models have regional or local nested models. There are also other local and regional models that are not nested in the global models.

There have been several initiatives at a national, European and international level to assess wave energy potential and generate useful databases. As a result, a number of documents containing this information have been produced. These use modelled data and measurements. Table 1 shows the sources of statistic data that have been used to produce these documents.

WERATLAS

WERATLAS, the European Wave Energy Resource Atlas, was partially funded under the JOULE II programme, and it contains annual and seasonal (yearly, winter and summer) wave-climate and wave-energy statistics for a set of offshore locations distributed along the European coastline. These are the North East Atlantic, the Northern Sea, the Barents and Norwegian Sea and the Mediterranean Sea. 10 years of data were used to make this atlas. It contains 6 hourly directional spectra data for the North-eastern Atlantic computed by the WAM model, directional buoy data and Plessey radar data for the Northern Sea. WERATLAS is user-friendly software for PC's running under WINDOWS. It enables the user to browse easily through the statistical information, and print and save it for future use. It consists of software to be used with windows and a technical report. Both are available on purchase. The application costs 200€ and the report 50€.

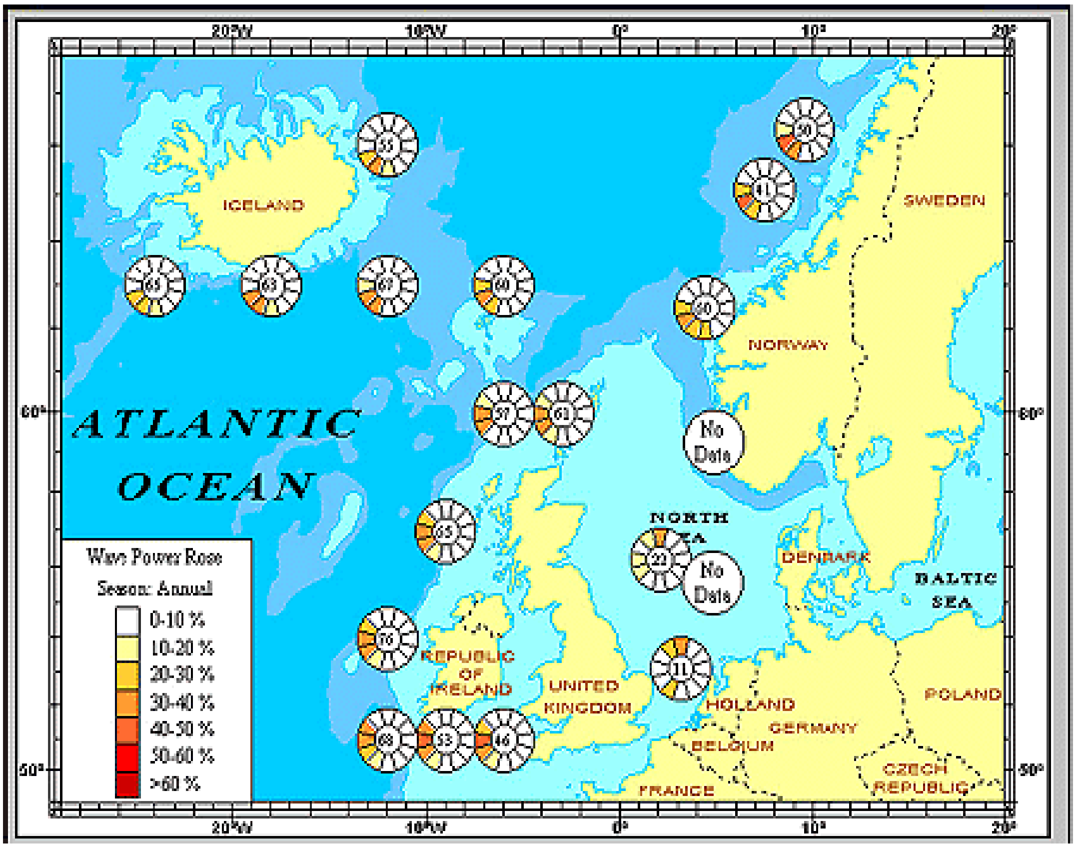

Figure 3. Wave power roses in the North East Atllantic

EUROWAVES

EUROWAVES, also funded by the EU, was a project that went on from 1997 to 2001. It combines in-situ measured data, satellite remote sensing records and WAM wave model simulations. It is a prototype tool to assess wave climate at any coastal or shallow water point in Europe with reliable accuracy and fine spatial resolution. It is a MatLab Toolbox containing long-term data (6-8 years) for H_s (H_{m0}), T_m (T_{01}) and mean wave direction at a large number of offshore points. The package transforms these values to an operator selected inshore location.

ONDATLAS

Ondatlas, the Wave Energy Atlas of Portugal, is an electronic Atlas compatible with Internet access that contains comprehensive wave climate and wave energy statistics. These comprise monthly and yearly values, variability and probability data for significant height, mean period, peak period and wave power and directional histograms for wave and power direction. A summary of this model is available from the article of Pontes, Aguiar and Pires. It was done using a regional model not nested in a global one.

IWERA

IWERA is a report that aims to study the total, feasible and practical nearshore wave energy resource off the Irish Atlantic coast. It is based on the WAM prediction model, so addresses issues such as the validation of computer models of wave climate with actual recorded data before conversion of the estimated annual average energy to electrical output. The accessible resource includes the expected efficiency of a pattern technology and all the data is graphically presented in the atlas. 3 years of data were used in it.

UK MARINE RENEWABLE ATLAS

The Atlas of UK Marine Renewable Energy Resources is an update of the 2004 Atlas with the inclusion of new data and enhanced presentation. The atlas incorporates offshore wind, tidal and the total wave resources around the whole coastline of the British Isles. The original atlas comprised of only 3 years and 3 months worth of data. This was extended to 7 years, covering from June 2000 to June 2007, for the current version. The records are taken from both the regional UK Waters Wave Model which has a grid resolution of 12km, and the Global wave model which has a node spacing of 60km. The atlas is freely available on the WEB.

These documents constitute a reasonable first approach (Step 1) to the wave energy resource in the area. In general terms, they can aid in foreseeing whether the total potential energy resource is high or low in an overall area. When it comes to deciding the exact location of the wave energy park, the assessment needs to be narrowed down to a scale of tens of miles, where orientation of the coastline and the isobaths and the geomorphology can significantly alter the energy reaching the potential site.

Document	Data source	Coverage
WERATLAS	WAM model and buoy data	NE Atlantic, North Sea, Mediterranean and Barents Sea
EUROWAVES	Buoys, satellite, WAM model, propagation models	Europe, incluyes bathymetry
ONDATLAS	Regional model MAR3G	Mainland Portugal and Madeira
IWERA	WAM model and buoys	Irish coast
UK MARINE RENEWABLE ATLAS	Global and regional models	UK Continental Shelf

Table 1. Main Atlases in Europe and their scope

Wave models can also be used for another task; this is propagating the deep ocean wave conditions to the coast of interest. For this purpose, information on the bathymetry is needed, namely, depth and orientation of isobaths. Step 2 explains how models can be used for propagating the waves to the area of interest, apart from constituting a source of long-term data, as has been explained in this section. Ideally, apart from the assessment from models, in-situ measurements will be planned at the chosen site, to validate the results obtained with the models.

3.4.1.2. Bathymetry & Seabed Morphology

The characteristics of the seabed in the location area of the infrastructure can have significant influence on the methods used during installation, and therefore in the cost of the project. Furthermore, the performance of both buoyant devices and those directly positioned on the seabed is likely to be affected by the seabed morphology. Proximity of isobaths, slopes, presence of sandy flats, rocks, irregularity of the seabed and all other relevant aspects need to be known.

Bathymetry is the distribution of depths in a given area. For deciding the depth at which the installation will be done, pros and cons of being near the shore have to be considered. Advantages include ease of transportation of the produced electricity, ease of installation and maintenance and better sorted energy flux. On the other hand, disadvantages are a lesser energy flux due to influence of the seabed and environmental impact.

As an approximation, it is considered that when the waves travel on depths that are smaller that half of their wavelength, they are on shallow waters and their influence reaches the bottom. Because of this, the shapes of the seabed and the changes in depth have an effect on the wave field, transforming it as waves travel. Diffraction, refraction and reflection will then change the direction of the waves. Having an accurate knowledge of the bathymetry can yield a good understanding of the processes and the wave field in the area.

Bathymetry is important also for another reason; looking at the existing offshore wave energy devices, they are designed to perform optimally at a certain depth, usually between 50 and 100 m. The bathymetry off the selected coast will determine at what distance of the shore the desired or optimum operation depth is reached, therefore, the length of the submarine cables, influencing greatly the cost of the project.

Maps of isobaths exist for most coastal areas, since navigation authorities produce nautical charts and update them periodically. These maps typically contain low resolution bathymetric information, but they can provide a preliminary idea of whether the seabed is predominantly flat or it has steep slopes.

It will be necessary further on in the project to plan and budget a specific bathymetry study in the area of interest. High resolution acoustic tools offer very detailed images of the seabed surface, and allow the identification of any irregularity.

Apart from the bathymetry, the nature of the seabed and the morphology will also have influence on installation methods. Very irregular and rocky seabed will not be an advantage and may hinder the installation of elements such as the moorings of the buoyant devices and the submarine cable. Burying the cable can be a simple operation or become a more complex and costly process depending on the type of seabed. Usually, techniques such as ploughing and jetting are used on sandy or unconsolidated sediments, and for hard rocky bottoms, a trench needs to be opened for cable burial. As for the installation of moorings, this can also vary depending on the type of substrate and developers may have to design specific mooring systems to suit a particular site.

Table 2 shows information on where to obtain bathymetry and soil data.

Country	Bathymetry	Cartography
Belgium	Management Unit of the North Sea Mathematical Models (MUMM) – Kustatlas – V. Van Lancker et al.	Management Unit of the North Sea Mathematical Models (MUMM) – Kustatlas – V. Van Lancker et al. Management, research and budgeting of aggregates in shelf seas related to end-users (Marebasse), in Final Scientific Report, Belgian Science Policy, 2007.
Denmark	National Survey and Cadastre	National Survey and Cadastre
France	Service Hidrographique et Océanographique de la Marine (www.shom.fr)	Service Hidrographique et Océanographique de la Marine (www.shom.fr)
Greece	Nautical Charts from Hellenic Navy Hydrographic Service (HNHS)	Publication and Surveys of Research Centers, (Hellenic Centre for Marine Research, Institute of Geology and Mineral Exploration)
Ireland	*pending information*	*pending information*
Italy	Nautical charts from Instituto Idrografico della Marina	Regional public bodies, Universities and publications
Norway	Sjøkartverket / Norwegian Mapping Authority – Hydrographic Service www.sjokart.no	Sjøkartverket / Norwegian Mapping Authority – Hydrographic Service www.sjokart.no
Portugal	Nautical Charts from Instituto Hidrográfico	Instituto Hidrográfico, public bodies and Universities
Spain	Nautical charts from Instituto Hidrográfico de la Marina	Regional public bodies, Universities and publications
UK	Admiralty Charts	British Geological Survey

Table 2. Information on bathymetry and seabed

There is no periodic publication for the types of seabed, but many areas close to the coast have been mapped. Regional or local authorities may have this information and it may also be available in publications from Universities or the research institutions that undertake the studies.

3.4.1.3. Characterisation of the environment

Knowing the geographic characteristics and the atmospheric conditions in the region is important at the time of planning the installation works, to ensure viability of the engineering operations and selecting a site for works and access.

Coastal morphology can condition the works of cable lying in the transition zone between the sea and the land. Elements such as cliffs, beaches, rivers and deltas…

will require very different planning for the installation works. Some features may even make it non viable to install a submarine cable whilst some others will be more operation friendly. Cartographic information is usually available from regional public authorities, either in the shape of maps or as satellite images (even Google Earth contains useful data).

Climatic conditions: wind regimes (speed and predominant direction), tidal range and currents, temperature are conditions that will influence as well the installation. It should be noted that the useful life of this kind of projects is typically 25 years, so extreme event records and return period data should be gathered. Meteorological offices have long term data records and statistics for extreme events. Also building and engineering standards and norms set the design parameters for any kind of installation.

Seismicity, volcanology and other phenomena related to active tectonic margins. Since they pose a considerable risk for any kind of facilities, theses should be taken into account.

3.4.1.4. Grid connection and capacity

A wave energy park is not an isolated facility; it must be connected to the grid to fulfil its objective. Building and operating a wave energy park involves many specialist operations and works. Sizeable vessels are likely to be needed for some of the works, such as cable laying. In general, maritime traffic and activity will increase during installation and decommissioning phases, and the support of ports, harbours and other infrastructures will be desirable.

Connection to the grid is a major issue for all renewables, especially for the youngest ones, wave energy among them. The ultimate aim of an energy installation is to supply the produced power to the grid. So it is necessary to be in proximity to a grid with sufficient capacity to accept the power. Once the overall power of the installation has been defined, the promoters of the project will have to obtain technical information about the existence of distribution lines, substations, connection points, voltage and supply capacity in the region. The procedure for obtaining this information may differ between countries. In Spain, for example, an official application for connection must be made to the grid operator but does not guarantee that a grid connection will be secured.

Another aspect related with the proximity of the electric grid is the convenience of the fact that the production point is at a short distance from the consumption point. This reduces costs of transport and makes the infrastructure more viable and justifiable.

Table 3 offers some information on the situation of the grid in the different European countries.

Country	Grid	Information
Belgium	Not the best grid along the coast.	The grid operator Elia has more information on the electricity grid in Belgium (www.elia.be)
Denmark	Good grid along the coast some times occupied by offshore wind	Energinet.dk
France	Only good in the north coast, where nuclear plants are. Bodie: Gestionnaire du Réseau de Transport d'Electicité (RTE ou ERDF)	Utilities have information about the capacity available
Greece	Varies along the cost.	The Hellenic Transmission System Operator holds information about grid connection. Official information obtanable after a project got the Production (feasibility) License.
Ireland	*pending information*	*pending information*
Italy	Varies along the coast	System operator in Italy is TERNA. Grid maps are not free and are not publicly available.
Norway	Grid will be updated	www.stattnet.no
Portugal	Very good grid along the coast	Connection points must be requested from DGEG (Directorate for Geology and XXXX), and are typically subjkect to calls; details for substations <60kV owned by utility (EDP) and hard to ge
Spain	Good grid along the coast.	Utilities have the information about connection points. An official application must be done before obtaining any info
UK	Not best along the west coast	System operator holds information on current and planned ability of the grid to accept connections

Table 3. Information on electric grid

3.4.1.5. Infrastructure and supply industry

The wave energy park or installation will need a series of services to be provided on a regular basis, such as maintenance operations and monitoring. Others will be less frequent, like the deployment or decommissioning of devices.

The proximity to a sizeable port will be necessary for the installation and a proper servicing of the park, due to this constant need for vessels that carry out deployment, maintenance and/or decommissioning works. Harbours for the vessels and even storage facilities for devices during maintenance and elements such as replacement cable and chains may be needed.

In general, not only harbours and facilities for vessels, but also the existence of an industry that is capable of giving various services and backing up the site will be beneficial. These would involve such facilities and skills as shipyards, monitoring equipment, ROVs, divers, maintenance boats for in-situ works, maintenance in harbour, installation-decommissioning activity, qualified staff for these operations. Close proximity of the services is indeed an advantage for the project.

Project developers may find it attractive to deploy in sites that are well supplied and offer the opportunity of contracting locally most of the works, with the reduction in costs that this fact can suppose.

3.4.1.6. Environmental and planning issues

The interest in harnessing the energy of the oceans, in our case, that transported by waves, has the same origin as the interest in other forms of renewable energies; lowering the dependence on finite and unreliable fossil fuels and fighting global warming by reducing CO2 emissions. This green origin leads to thinking that these new forms of energy are harmless for the environment. Even though that may be their aim, the introduction of artificial structures in the environment needs to be studied before concluding it is harmless.

There are numerous uncertainties regarding the environmental impacts that wave energy devices and parks will cause on the environment. Impacts will be different depending on the previous state of the receiving environment; many coastal areas are extensively degraded by industrial and port activities, while unpolluted or pristine areas are considered to be more sensitive and their protection and conservation remains a priority.

The most commonly considered effects are changes in currents and waves´ energy and patterns, and the consequent variation in sediment dynamics and beach morphology. This effect is usually expected to be negligible according to the existing bibliography on the topic. Another factor, where uncertainty is bigger, is the interference of marine parks and their structures with benthic habitats. Death of organisms by direct destruction of their habitat is bound to occur in construction and decommissioning phases, but the severity of this effect may not be enough to affect at an ecosystem level. Changes in species and their abundance due to change in the nature of the substrate (from soft sandy bottom to hard substrate) is another likely effect. Many authors have discussed the potential artificial reef and marine reserve effect of some elements such as moorings, allowing sessile organisms to settle and attracting fish and crustaceans to the area. Although this possibility opens the door to scenarios like marine sanctuaries or coordinated management with the fishermen community, the convenience and benefits are still to be proven.

These uncertainties are to be solved in the future with research and monitoring in ongoing and forthcoming test and demonstration projects.

From a planning point of view, environmental impact is not only a matter of sustainability. Most of the administrations in charge with granting permits for the installations will require Environmental Impact Assessment to be carried out, although the scope and detail of these studies will depend greatly on the country or region and the stringency of the competent legislation. This is ultimately a matter of spatial planning, and thus, local, regional, and national land use plans should be consulted to ensure there are no incompatibilities with those plans and the projected activity, in our case, a wave energy park. Also, and due to the fact that impacts on the environment will depend on the baseline state of the selected area, all environmental protection figures should be considered so as to check if any of them are being applied.

The **SEA** (**Strategic Environmental Assessment**) Directive 2001/42/EC was created with the objective introducing systematic assessment of the environmental effects of plans and programmes regulating activities related to land use. SEA has become in recent years a tool by which environmental criteria are incorporated into planning, policies and programmes. This assessment aims at establishing a high level Environmental Assessment that is common to all projects and previous to the implementation of the policies, it usually applies to local and regional development plans. Although all European countries have regulations to the implementation of this Directive in their territories, the programmes on which they are implemented vary, and few have currently established SEA for marine renewable energies.

Country	SEA	Information
Belgium	Concession area for offshore wind energy., but also wave and tidal are allowed in this zone according to the royal decree of December 2000	Masterplan North Sea Gauffre Project
Denmark	Planned for an area 20 km from the coast in relation to the offshore wind farm planning	Danish Energy Authority: "Future Offshore Wind Power Sites – 2025" English summary: 11 pp, August 2007. Danish report: April 2007, 105 pp. ISBN: 978-87-7844-643-5
France	Guideline planned for Bretagne by regional government.	
Greece	The 'Specific Framework Planning for Renewables' was published in 2008. Marine energy is not included, just offshore wind	Ministerial decree 49828 03.12.2008. Map with excluded, limited and suitable areas
Ireland	Planned	*pending information*
Italy	Completed for offshore wind	Maps of potential wind production (CESI Ricerca) with coverage of most of coastal areas. Maps for potential wave production are planned
Norway	-	www.dirnat.no
Portugal	Planned	
Spain	Completed for offshore wind. Applies to ME	Map with excluded, limited and suitable areas
UK	SEA for marine renewables completed for Scotland only Screening phase in the rest of UK	

Table 4. SEA for marine renewables

Table 4 shows the degree of development of specific SEA for wave energy or marine renewables in different European countries. Despite being a European Directive, each country can implement it in a different way, and as a result, the outcome and scope of the SEAs can be different. For example, in the UK, a SEA has been carried out off the Scottish coast, while for the rest of the country a screening will be undertaken to look for potential commercial scale farm sites and then the necessity of a full SEA will be assessed.

SEA can ease the planning process for a project developer; when a government decides to carry out a SEA, it already determines what areas are incompatible with the installation of the park, which ones may have limitations and which ones are suitable.

3.4.1.7. Interference with other uses

Due to the fact that coastal areas have typically been populated for many centuries, big expanses along the coast are already committed to other uses, corresponding to human commercial activities. These activities take place in a determined area of the sea, and therefore they may represent limitations to the installation of wave energy devices.

Limitations will depend on the severity of the conflicts; some of these activities may prevent the wave park from being installed, while others may be may be perfectly compatible. In occasions, they will be a source of public opposition due to conflict with the local socioeconomy. The last word on the issue of limitations and conflicts for space will be in the governments; since the development of wave energy parks may be part of policies and targets set by the governments, political and big scale economic interests will sometimes drive the decisions.

Activity	Conflict	Trend
Oil & Gas Extraction	Incompatible	Decrease
Aquaculture	Incompatible / research	Increase
Military Activities	Incompatible	-
Other marine renewables	Researchable	Increase
Sand & Gravel Extraction	Incompatible	Unpredictable
Dredging	Incompatible	Increase
Navigation routes	Incompatible	Increase
Submarine telecom/electric cables, pipelines, sewage pipes	Incompatible / small extent	Increase
Fisheries	Incompatible	Decrease
Submarine Archaeology	Compatible / damage to heritage	-
Sports and leisure use of the coast	Compatible	Increase
Landscape and seascape as public heritage	Compatible	Increase

Table 5. Conflicts of use

As this section explains, the situation will vary with the country and the moment; even if nowadays wave energy is not very developed, in the near future it may become an activity that has preference over others. ***Table 5*** shows the expected severity and trends for the main interfering activities.

Oil & Gas Extraction: even if these exploitations are located in deeper see areas than where wave energy parks will typically be installed, where a conflict exists, O&G is likely to be a no-go area for any other activity. This situation may change in the next decades, as renewable energies will expectedly substitute the use of fossil fuels.

Aquaculture: this activity presents different stages of development in different countries, but it is a relatively new and fast growing industry. It is expectable that the demand for sea space from aquaculture installations will grow in the near future, due to overexploitation of the seas. It is unclear how aquaculture will compete for space with marine renewable installations, since fish farms are typically placed in shallow and low energy areas. Still, the presence of a fish farm could prevent the installation of cables or other structures.

Military activities: the importance of this kind of interaction will greatly depend on the country; in some countries it may be automatically a no-go area, while in others negotiation will be possible or even that priority is given to energy harnessing. It is also a factor that can change with time.

Other renewable energy installations: In an equal way to wave energy, other forms of renewable energies at the sea are being developed, such as tidal currents and offshore wind. The former is unlikely to compete for space with wave energy, since the areas with a good tidal current do not present high wave energy, but offshore wind may be looking at the same locations as waves in the future, and will face the same problems of increasing cable length and costs when distancing the coast.

Sand & Gravel Extraction: normally the presence of moorings and elements on the seabed will be incompatible with this type of activity. The same applies for **Dredging material dumping Areas.**

Navigation routes: busy maritime traffic lines should be mapped and interference with them avoided. Normal functioning of ports and commercial marine routes should be guaranteed.

Fisheries: it is very likely that wave energy parks are going to be in conflict with local traditional craft fishermen, since vast coastal areas are exploited by them. There is uncertainty about what the solution to this conflict may be, which may depend on the extent of the safety zone.

Sports and leisure use of the coast: studies carried out by planned test and demonstration site WaveHub show that the decrease in wave height in the lee of a marine energy park is minor and is not expected to affect activities like surfing. Quality of the water is very unlikely to be negatively affected in the long term by the operation of this kind of installations, (except in the event of accidents of oil spillage). For this reason, bathers in the nearby beaches are compatible with the presence of a wave energy park, with a potential exception at the moment of installation works.

Communications, cables and pipelines: they should be carefully mapped and avoided. In fact, their extent and a buffer width of avoidance to both sides of it will be enough to dodge this interaction. The width of this prohibition band may be defined by law in some states, and it may differ from country to country.

3.4.2. Step 2: Resource Assessment

An accurate assessment of the resource in an area is still the most critical step in the evaluation of any site as a potential location for a wave energy installation. There is no international consensus on how to assess this potential. In Step 1: Information on resource, global models have been presented. As data obtained this way need to be validated with real in-situ measured data, specific physical monitoring should be planned at this stage of the project, deploying a directional wave buoy if possible.

3.4.2.1. Nature of waves

The waves arriving at a stretch of coast are formed by combination of swells and seas. When a local wind originates a sea state, there is a chaotic situation, with many different frequencies and directions. This situation changes as the waves travel long distances crossing the oceans, and approach the coast; long periods travel faster than short ones, which are more easily dispersed. Directions are also dispersed due to the limited width of fetch. For this reason, by the time waves reach the coast, the periods and directions have undergone a filtering process, and are more regular. These waves are known as swell.

When reaching the coast both swells and seas suffer further modifications by interaction with the bottom. Waves get compact and aligned, and there is a loss of energy by friction with the bottom.

With the use of wave time series data, a seaway occurrence matrix (scatter diagram) can be obtained. This is a table containing probabilities (monthly or yearly, etc) of occurrence for different significant heights and mean periods. Developers of WECs usually produce power matrixes for their devices, which show the performance of a device in every significant height and period condition. They therefore represent the power a device can extract at every given state of the sea, and are expressed in kW. By convoluting the two matrixes, the actual power that the device can harness in a period of time is calculated.

Since most WECs are resonant devices, knowledge of the wave frequency components, or spectral shape, of the encountered seaways is required to conduct this assessment accurately. Obtaining such information can be difficult without the specific deployment of wave measuring sensors. This procedure would be analogous to erecting an anemometer mast prior to wind turbine installations.

3.4.2.2. Data availability

Up-to-date wave generation models and the existence of digitalised meteorological information allow for wave data to be obtained by applying wave generation models on past meteorological conditions, as has been explained before. These numerical analysis data need to be verified by measurement data.

Country	Buoy data owner	Detail of the data	Comments
Belgium	Flemish Ministry of Transport and Public Works (Agency for Maritime and Coastal Services – Coastal Division) http://www.vlaamsehydrografie.be/welkom.asp	Wave measurements between 1984 and 2007	
Denmark	Oil companies and The Royal Danish Administration of Navigation and Hydrography and Danish Maritime Authority	Varies	Data difficult to get, sometimes to be paid for
France	Candhis and Anemoc databases from Centre dÉtudes Techniques Maritimes et Fluviales (CETMEF)	Candhis: Hs, Ts seasonal and annual tables. Anemoc: seasonal and annual Hm0, Tp or Te or H, dir.	Candhis: Free Anemoc: Levels 2 and 3 free Level 1 not available, see with CETMEF
Greece	Hellenic Centre for Marine Research	Varies. Usually data every three hours	Fees for comercial and research projects. Free for graduate (diploma) and post graduate (master, PhD) studies.
Ireland	Met Eireann	*pending information*	*pending information*
Italy	ISPRA (free from Idromare database)	Varies	Free on request and online consultation available
Norway			
Portugal	Instituto Hidrográfico	Not extensive	Differentiated cost levels
Spain	Puertos del Estado Instituto Español de Oceanografía LIM AZTI	Not extensive	Free on request
UK	British Oceanographic Data Centre Meteorological Office UK Hydrographical Office Proudman Oceanographic Laboratory	Varies	Fees and licence conditions may apply

Table 6 . Availability of buoy data

Most European countries have carried out wave measurements over the years and there is at least one organization in each country that owns and operates both scalar and directional wave buoys from which the information can be obtained. Nevertheless, the data may not be publicly available, unlike what happens in America, with NOAA and other agencies, there is no data gathering network or common inventory. This is the major difficulty that developers and interested parties have to face when wanting to undertake detailed assessment of the resource. Sometimes, the data these organisations offer are not detailed enough. ***Table 6*** summarises the availability of data in several European countries.

The situation varies between countries. In Spain, it is possible to apply for measurement data from the buoys belonging to ***Puertos del Estado***, which are freely accessible. However, they do not offer extensive coverage. Promoters should note that this is not possible in every country as in most of them such information is private or inaccessible.

After validation with real data, propagation models can predict the wave height and energy that will reach a particular stretch of coast, by extrapolating the data and characterising the loss of energy when approaching the coast by friction with the bottom and the change in module and direction due to reflection and refraction. The model accuracy is a function of the complexity of the topography.

3.5. Stage 2: Geographical Analysis

Once the information with the potential of conditioning or influencing the project has been gathered, a tool that allows geographical modelling is needed. This methodology suggests that in Stage 2, all this valuable information is integrated into a GIS package, a tool that allows easy visualisation of geographically referenced information. Every item of information that has been taken into account is now transformed into a GIS layer, and displayed over a map rendering a patchwork of excluded zones, and areas from least to most suitable. This second part of the procedure is very similar to that one used by government bodies for the Marine Spatial Planning processes.

Geographic Information Systems is suitable software for this task since they can integrate, process, represent and analyse geographically referenced data. It allows quick visualisation of conflicts of use and interactions, analysis of alternatives, and it makes it easy to change, if needed, position, shape, orientation, size and other parameters of the elements of the wave farm, to fit in better areas and enables observation of how the conflicts change with these modifications.

The method followed to carry out the GIS analysis is the definition of a parameter that can numerically represent the suitability of each particular area, a suitability index. This will depend on all the previous information, which is also assigned a numerical value, and a convolution of these values.

3.5.1. GIS integration

Each category of information that has been gathered needs to be represented in a suitable format for geographic analysis. For this purpose, it will have to be edited to suit a relevant GIS application.

These categories of information are now grouped in environmental, technical and socioeconomic factors, depending on their nature. These variables are carefully studied and divided into exclusive and limiting factors, which will depend on local legislation. Exclusive factors will be those which automatically rule out the installation, while limiting factors will, in different degrees, recommend against installing in the areas where they are present. Exclusive factors may be transformed in a layer in a way that the areas where they are present appear as blank, or given a null value so that their suitability index is 0. All the rest of the factors can be transformed into one layer each or grouped in the most convenient way, and given weighed values depending on the strength of the limitation. Like this, areas with best resource, least constraints and other advantages like grid and support industry can be highlighted.

Technical factors: technical factors are those that affect the installation from a technical point of view, conditions that can make the installation non viable because of technical impossibility or because of too high costs. Here is a list of technical factors:

- Wave energy flux: when this information is transformed into a GIS layer, it is likely that it is in the form of continuous grid. Values should be weighed, to give high resource a high value of suitability.

- Type of seabed: Type of seabed: installation methods can vary significantly depending on the nature of the bottom. For this reason, in the layer, sedimentary and rocky bottoms should be given different values. The rating will depend on the preferences of the technology or technologies that will be installed in the site.

- Access to ports and anchoring zones: these areas should be avoided so as to guarantee normal access and functioning of the ports and safety for navigation.

- Maritime routes: usual navigation traffic lines should be avoided

- Submarine cables: a buffer zone at each side of the cable line should be considered exclusive.

- Submarine pipelines: sewage pipes, communication cables, water pipes and others; the same principle can be applied, and take as exclusive the cable and surrounding meters.

- Marine military areas: in many countries, this will be considered a no go area. But as government policies change, a negotiation could be possible in some other countries or even priority may be given to energy extraction.

- Oil &Gas extraction: platforms and deposits are considered exclusion areas, and they will typically have safety areas around them that will vary in each country. Regulations on this should be consulted. This situation can radically change in the mid term future, as renewable energies progressively substitute the use of fossil fuels.

- Sand and gravel extraction and areas where dredging material is dumped

- Distance to a sizeable port: short distances are more convenient for operation reasons, so the layer containing this information should somehow give priority to locations situated near a port, in detriment of those less accessible..

Environmental factors: both coastal and maritime areas are usually subject to spatial planning regulations and plans by the competent authorities. All legislation affecting an area and the resources contained in it need to be consulted in order to find out which areas have restrictions upon them from an environmental point of view. Whether these are exclusion areas, not recommended or indifferent will depend on how demanding the national legislation is. As the impacts on the environment in the long term are still unknown, experience gathered from the test sites that are currently installed and planned will likely provide valuable recommendations on how to proceed.

The following are some points on the directives that should be taken into account.

- Spaces included in Natura 2000 network. This is the major Nature & Biodiversity policy of the EU. Its implementation is supported by the Birds Directive and the Habitats Directive
    - Special Protection Areas. (under Birds Directive)
    - Special Areas of Conservation (under Habitats Directive)

- Spaces included in the Emerald Network: Areas of Special Conservation Interest.

- RAMSAR: International Wetland Conservation treaty

- Habitats of endangered species

- Marine mammal breeding areas and migration routes: limiting factor

- Regional and national planning and zoning directives: sometimes certain coastal areas will be considered as exclusive.

- Beaches affected by the shadow of the wave farm: effects on sediment transport and beach morphology. A layer is created where stretches of sea from the beaches are drawn in the direction of the predominant wave regime, to visualise the limitation.

Socioeconomic factors: The following do not represent technical non-viabilities, but they are subject to particular conditions. The installation of a wave energy park in an area will likely interact with or transform the activities previously carried out in that area. Therefore, this is related to public perception and impact on local lifestyle, but will ultimately depend on government policies. .Strategic priorities from regional and/or national bodies will drive the decisions and will determine whether an activity should prevail over another one.

- Fishing activity: traditionally all coasts have been exploited by fisheries. Nevertheless, there are some particular areas where this activity has developed more intensely and represents a considerable source of income for the local population. These areas could limit the installation.

- Economic exploitation of other resources: shellfish, algae, and other marine resources are also commercially exploited; they may be considered limiting areas.

- Submarine archaeology: ship wrecks with a historical value are not found in every coast, but this may be a locally relevant factor.

- Swimming, surfing and beach leisure; the effect of a wave energy installation on tourism is unknown, but it is unlikely that leisure activities are incompatible with wave energy parks due to sufficient distance from the coast.

3.5.2. Suitability Assessment

The percentage of the total existing energy that can actually be harnessed, the feasible energy potential, is a function of the limitations imposed by bathymetry, coastal morphology and other technical factors, constraints like environmental protection areas, interference with other uses, and the efficiency of the current technologies.

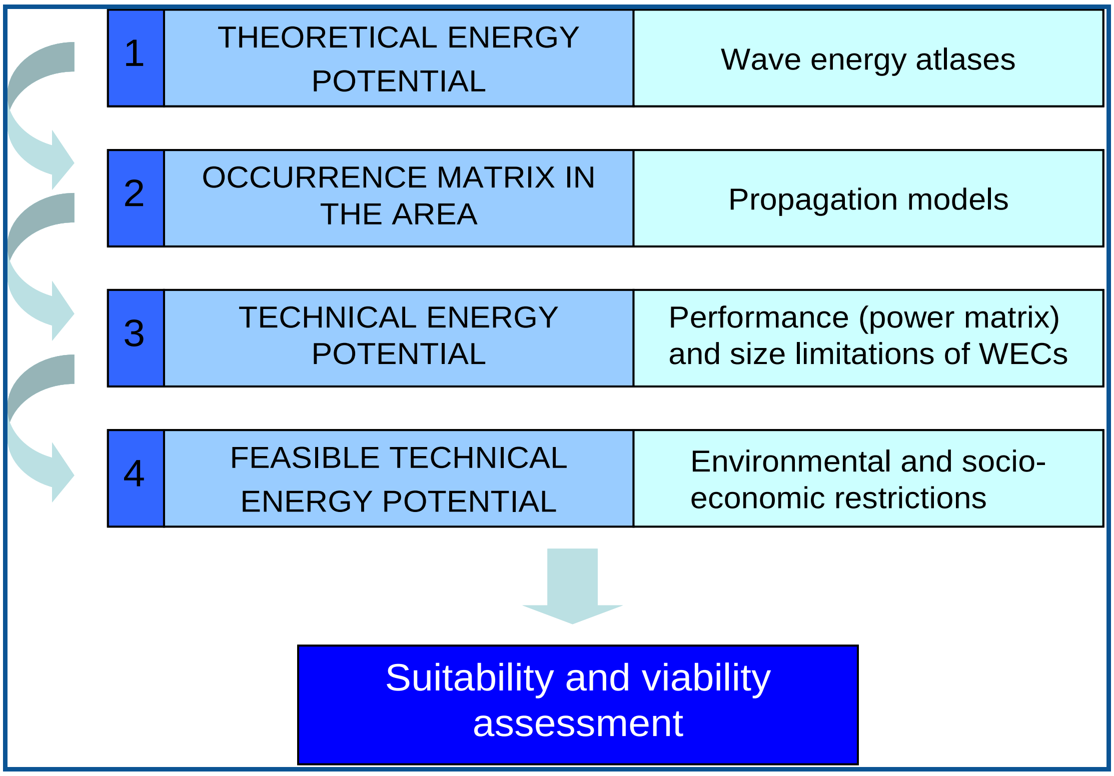

Figure 4. Diagram showing the derivation of total energy potential into feasible potential

Once all the layers with the geographically referenced information are overlapped, it is easy to visualize the interactions among the activities and the areas that each of them are actually using. It is also very straightforward to identify free spaces or areas where apparently there is no conflicting activity going on.

In many cases, there will be no such areas without conflicting uses, the whole region showing as a patchwork of areas committed to certain uses. Even if the severity of the interactions is difficult to quantify from a project developers point of view, the importance of the conflicts can be assessed. The information is now contained in layers and these layers show different areas.

At this point, a picture of the feasible resource should exist. This will be the resource left in those areas where the project is more likely to be implemented.

A way of assessing the suitability of each patch of sea is done by giving numerical values to the information contained in the layers. This way, features such as “sandy bottom” or “50 miles from nearest port” can be quantified, given a value. The weight of each advantage/ disadvantage will have to be decided by the project developers or decision makers, since as it has been pointed out throughout the document, the relevance of each piece of information varies with the country and the moment.

The result of combining the values of all the layers in each point, will give a final value for the Suitability of that particular point.

The decision making will greatly rely on the Suitability hereby calculated by objective means, but also on other factors that the political moment or economic interests will favour.

3.5.3. Detailed characterisation of the environment

When an area is identified in the Suitability Analysis as being suitable for the project, and has the potential to be the definitive location, field work will have to be planned to characterise the area in detail. This information needs to be known before any installation project is drawn and the exact location of elements such as cables and connection units is determined.

To determine the morphology and composition of the sub seabed, studies like high resolution bathymetry, seismic survey, magnetometry and sediment sampling will be necessary.

High resolution bathymetry can show the distribution of slopes in the area and detects the presence of any irregularities such as underwater mounts, ship wrecks, rocky outcrops and sand flats. This information is crucial for deciding the exact area of the installation, the zone where the cable is going to be installed, and where the moorings of WECs and connection units will best be settled.

Geophysics, on the other hand can help clear uncertainties on what lies under the seabed. To install any moorings or foundations, the depth of the sediment layer needs to be known, as well as the type of sediment.

These kinds of studies are costly and need to be carefully planned because they depend on the meteorological conditions. Works at sea which mean handling delicate equipment requires usually excellent weather conditions for a determined span of time. For this reason, it will always be more convenient to carry out these works in the summer or when benign climatic conditions can be met.

The cost and the time needed for the surveys will depend on the extent of the area to be studied. Big investments in environmental characterisation may discourage small companies whose aim is to install small parks formed by a few devices.

It would be highly convenient for the offshore renewables industry that there was a database with relevant information available from public authorities. Therefore, it would be recommendable that the commitment of the governments with the development of sustainable forms of energy extraction is translated into offering advantages such as the availability of information at all levels.

4. CONCLUSIONS

Choosing an appropriate location for a wave energy can a time consuming activity, for which as much support from public authorities as possible should be granted. The methodology suggests a way of evaluating the suitability of different areas within an interest region and making an informed decision. This does not mean that following the steps and gathering all the information will grant all permits for the project and/or prevent it from having to face opposition from the general public and the competent bodies. The aim is just to minimize negative surprises by being aware at all times and making an effort to block inconveniences before they occur.

When writing this report, much heterogeneity in the legislation, availability of information and government support has been identified among the EU countries, some of which are represented by partners of the Waveplam project.

At the current moment, the authors judge not possible to produce a document which is a step by step guideline throughout the complete process and which is fitting the situation in every country. Therefore, this methodology should be looked at as a checklist

At the moment in which this methodology is being written, it is virtually impossible to define a step-by-step procedure that can be followed in the same way and with the same results in every European country. For this reason, the intention of the authors is that the document is considered as a checklist of issues to take into account, rather than as a protocol whose steps they will have to follow for a successful project.

This methodology will be used later on for D3.3 case studies. The application of the steps to the different case studies in different countries can give plenty of useful information about the fitness of this methodology to the reality.

5. REFERENCES

- Atlas of UK Marine Renewable Energy Resource. Available from: http://www.renewables-atlas.info/
- Cavaleri, L.; Athanassoulis, G.A. and Barstow, S.: Eurowaves, a User-Friendly Approach to the Evaluation of Nearshore Wave Conditions. Proceedings of the Ninth International Offshore and Polar Engineering Conference, Brest, France, May 30-June 4, 1999.
- Clark, B.D. (1997) Alcance y Objetivos de la Evaluación Ambiental Estratégica
- Cornett, A.M. (2008): A Global Wave Energy Resource Assessment
- Dalton, G; Rousseau, N.; Neumann, F.; Holmes, B. (2009) : Non-technical barriers to wave energy development, comparing progress in Ireland and Europe
- Ehler, C; Douvere, F. (2009): Webinar on the book “Marine Spatial Planning: A Step-by-Step Approach toward Ecosystem-Based Management" organised by Marine Ecosystems and Management and the EBM Tools Network. Tuesday, 17 November 2009.
- EMEC-Assessment of wave energy resource
- EMEC-Guidelines for project development
- ESB (2005): Accessible Wave Energy Resource Atlas
- Galparsoro I., P. Liria, I. Legorburu, P. Ruiz-Minguela, G. Pérez, J. Marqués, Y. Torre-Enciso, M. González (2008): Atlas de energía del oleaje. La planificación espacial marina como herramienta en la selección de zonas adecuadas para la instalación de captadores. *‘Revista de Investigación Marina’* . 1: 9 pp.
- Huertas-Olivares, C.: Soerensen, H.C.; Rousseau, N.: Villate, J.L.; López, J.R.; Sarmento, A.; Russell, I.; Neumann, F.: First outcome of the WAVEPLAM project: Assessment of non-technical barriers and Best practices
- IEA – Implementing Agreement on Ocean Energy Systems. Pontes, T. (2009): Wave Data Catalogue for Resource Assessment in IEA-OES Member Countries.
- Institution for Mechanical Engineers (2009): Marine Energy Report
- Jongbloed, R.; van der Wal, J.T.: (2009): Other sea use functions and Interactions with offshore Wind Energy“, WP3 Windspeed project

- Marine Renewables Industry Association (2009): White Paper- Foreshore Licensing and Leasing for Marine Renewables Projects
- Mera, F.L. (2005): Análisis del oleaje como recurso energético en la costa vasca. Informe nº 1: análisis del recurso energético. Grupo de Ingeniería Oceanográfica y de Costas (GIOC).
- Nobre, A.; Pachecho, M.; Jorge, R.; Lopes, M.F.P.; Gato, L.M.C. (2008): Geo-spatial multi-criteria analysis for wave energy conversion system deployment
- Panicker, N.N. (1976): Power Resource Potential of Ocean Surface Waves. Pp J1-J48. Proceedings of Wave and Salinity Gradient Workshop. Newark, Delaware, USA, 1976.
- Pontes, M.T.; R. Aguiar and H. Oliveira Pires. A Nearshore Wave Energy Atlas for Portugal. Journal of Offshore Mechanics and Arctic Engineering; 127: 249-55, 2005.
- Prest, R.; Daniell, T.; Ostendorf, B. (2007): Using GIS to evaluate the impact of exclusion zones on the connection cost of wave energy to the electricity grid
- Simas, T.C.; Moura, A.C.; Patrício, S.; Batty, R. (2009): Review and discussion of common environmental legislation for ocean energy schemes
- Soerensen, H.C. (2009): “Key Stakeholders” Windspeed Project, D5.1 report
- Wave Energy Centre: Potential and Strategy for the Development of Wave Energy in Portugal
- WERATLAS, European Wave Energy Atlas, available from: www.ineti.pt/download.aspx?id=23D554A7272EB9BC553C12D3D78B845D