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1 Introduction

Acknowledging the pressures on the use of the seashore and also of the fact that the coastal space offers a large potential for development, due to the possibility that innovative synergies can be created between socio-technical and ecological uses, a new vision for multi-use green infrastructure is foreseen as shown in the following figure (Lacroix and Pioch, 2011).

Figure 1: Example of multi-use management of a wind farm. The wind turbine density is artificially high to facilitate the presentation of the concept. From left to right: diving, scientific studies, aquaculture, fishing, tourism. © Denis Lacroix, Ifremer and Malo Lacroix (Source: Lacroix and Pioch, 2011, p.133).

MERMAID aims at integrating and improving today's technology in an optimal way in order to enhance economic feasibility, reduce environmental impact and increase the use of ocean space at specific sites. In this framework, a socio-economic analysis aims to identify the impact on human welfare of such an activity. This includes social and economic aspects, including consideration of the distribution of these impacts across stakeholders. In addition, specific social analysis can help give consideration to social/cultural values within ecosystem services frameworks deviating therefore from the narrowly-based financial analysis and including as well a comprehensive ecological economic analysis.

The Socio-Economic Impact Assessment (SEIA) is a useful tool to help understand not only the potential range of impacts of a proposed investment such as the construction of novel Multi-Use Offshore Platforms, but also the likely responses of those impacted by the investment project. Since it is anticipated that these novel designs of platforms will be associated with considerable socio-economic and environmental impacts, an SEIA provides an understanding that can help in order to design appropriate mitigation strategies which will aim to minimize negative and maximize positive impacts of such an activity. It should be made clear, that the suggested methodology adopted here will not only integrate socio-economic and environmental impacts but it will also consider the issues of equity and environmental sustainability focusing therefore on both the spatial and temporal dimensions of the interventions. In this context, the suggested methodology with a focus on sustainability extends the standard process of financial analysis into a fuller assessment that incorporates societal and environmental parameters.

The sections to follow will present a Methodology for Integrated Socio-Economic Assessment (MISEA) which is deemed necessary in order to assess the viability/sustainability of the different proposed designs of Multi-Use Offshore Platforms. In particular, the methodology will allow a step-wise approach of integrating all information produced in the previous WPs of the project towards the comparative assessment of the socio-economic viability of different designs (to be built by the engineers of MERMAID in previous WPs) of offshore multiuse platforms. In this framework, economic, social and environmental effects of the proposed (multi-use platforms) structures will be identified, quantified and combined. Sustainability should satisfy economic efficiency, social equity and environmental/ecological sustainability. In particular, in the framework of analysis that will be developed, sustainability is achieved when the following conditions are simultaneously satisfied:

a. Dynamic and Spatial Economic Efficiency and Sustainability: Economic efficiency satisfies the condition that the marginal (social) cost of each production activity under consideration equals the respective marginal (social) benefit. Hence, in this framework both private and social components of costs and benefits are considered in order to provide a holistic economic assessment in terms of efficiency. When the economic efficiency condition is satisfied over time and over space the economic sustainability of the considered production activities is achieved.

b. Dynamic and Spatial Social Equity and Sustainability: Social equity requires that the social effects of the production activities under consideration are acceptable and affordable by the different social groups identified in the region under investigation. These affordability and acceptability conditions should be relevant spatially (intra-generational effects) but also dynamically (inter-generational effects).

c. Dynamic and Spatial Environmental and Ecological Sustainability: Environmental and Ecological Sustainability means that the environmental and ecological effects of the activities under consideration are sustainable over space (in the region under consideration) but also over time.

Figure 2 presents diagrammatically the definition of sustainability using the social, the environmental and the economic spheres which are all related to each other so as in order for a development to be defined as sustainable, it needs to be bearable (social and environmental spheres), viable (environmental and economic spheres), as well as equitable (social and economic spheres).

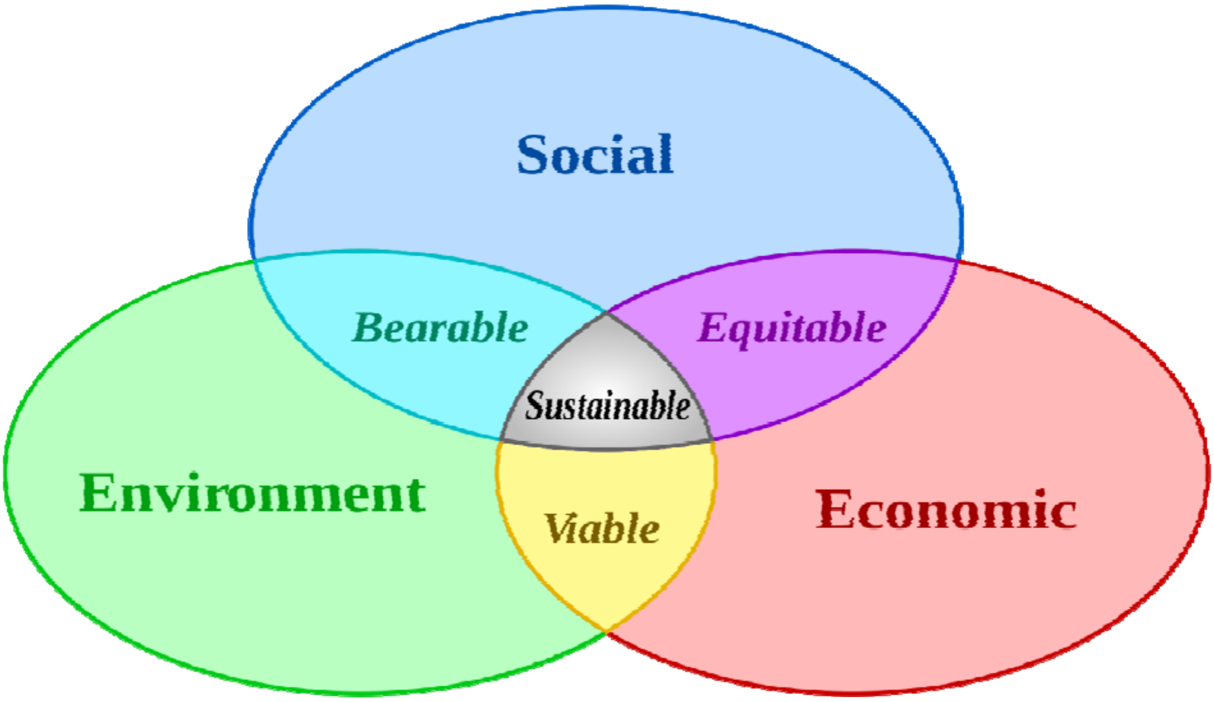

Figure 2: Spheres of sustainable development (Source: Wced, W.C.O.E.A.D./Brundtland Commission, (1987); Söderqvist et al. (2004))

In addition, it should be emphasized that efficiency is a necessary but NOT sufficient condition for sustainability since for example, it does not consider issues of equity (who gains and who lose).

As it will be presented in the next sections the development of MISEA entails the following general steps. First, WP8 will perform the socio-economic characterization of each of the four selected MERMAID sites with regard to the wind power production, aquaculture and transport maritime services. In the case of the Spanish site, wave energy will also be considered. Then the production and demand structures of the proposed multi-functional platforms will be investigated. This will be enabled by (a) identification and quantification of marketed (mostly private) costs and benefits of suggested multi-use offshore platforms, i.e. financial analysis of marketed costs and benefits, (b) identification and quantification of non-marketed cost and benefits. In the absence of existing non-market valuation studies, new ones might be performed with the help of case-study champions and stakeholders in WP2. The use of the results from non-market valuation studies is deemed important as social/environmental effects, especially of new structures, such as increase in food and energy security, coastal or marine environmental/ecosystem effects etc can be valued in monetary terms only by these methods.

As a result, consumption and production costs and benefits of proposed multi-use constructions will be evaluated with the use of both market and non-market methods so as to capture both private and social/public effects. In order to employ this methodology input of previous WPs is important in (i) providing market data on the cost of investment, operation and maintenance, and administrative costs of proposed structures; (ii) providing data on estimating/simulating private consumption and production (profit) parameters of proposed structures; (iii) identifying, through environmental impact assessment, the effects of the suggested structures on the environment; (iv) provide stakeholder and other information relevant for the construction of the non-market valuation questionnaires for the estimation of non-marketed cost and benefits of proposed multi-use structures. Hence, the suggested methodology adopts a holistic approach that encompasses tools of analysis not only from the mainstream economics but also from the field of environmental and resource economics. At a final stage, policy recommendations will be based on economic tools such as Cost-Effectiveness Analysis (CEA), Cost-Benefit Analysis (CBA) or other approaches/frameworks of socio-economic analysis such as Multi-Criteria Analysis (MCDA).

Summarizing the main steps, the adopted methodology for socio-economic analysis on the selected study site will consist of the following steps:

- Description/baseline profiling of case studies and socio-economic characterization with regard to future economic activities (wind/wave production, aquaculture, maritime services) integrating results from WP2 (inventory of stakeholders’ views)
- Identification of production and demand functions of the multi-use platforms
- List of data to be collected
- Decision on whether full or limited data impact assessment will be carried out (See section 4.4)
- Site-specific data collection and quantification of costs and benefits

- Assessment of impacts and evaluation of the assessment based on CBA/CEA/MCDA or limited data approach (explained in 4.4), integrating results from WP7 on Impact Assessment Analysis
- Policy recommendations based on impact assessment results and sensitivity analysis

At this point there is no doubt that the development of a MISEA of the viability/sustainability of Multi-Use Offshore Platforms is crucial for the project and depends on the derived results of the selected case studies (WP 7) together with the policy recommendations and identification of limiting procedures and legislation carried out in WP 2. The information generated during WP 2 & WP 7 feeds back into the other WPs and leads the way into WP 8.

Finally, it should be stressed out that although the objective of this report is to present the rational and internal consistency of the overall methodological framework, the actual implementation will be defined by data availability.

The next sections present the different steps that are involved in the development of a MISEA in more detail. Starting from scoping the assessment (Section 2), baseline profiling and characterization of production and demand of Multi-Use Offshore Platforms is presented (Section 3) in order to proceed to the importance of data needs and availability which is going to dictate the method of analysis to be followed (Section 4). The different tools that can be used to assess the socio-economic impact of Multi-Use Offshore Platforms are presented in that section, while implementation of risk analysis approaches is commented in Section 5. Section 6 presents a life cycle assessment of Multi-Use Offshore Platforms before policy implications of the investment projects are offered in the last section.

2 Scoping the assessment

The ‘scoping’ phase of the ISEIA establishes the goals and boundaries of the assessment and focuses the SEIA on key impacts. In this context, it is important to focus on the significant impacts in order of priority and identify all significant impacts for all impacted groups by using stakeholder consultation along with partners’ expertise. Therefore, it is essential that public involvement will occur throughout the life of the SEIA along with additional means (e.g., surveys, secondary data, literature review and professional expertise).

2.1 Key impacts of Multi-Use Offshore Platforms

In this sub-section an attempt will be made to identify the potential key impacts of Multi-Use Offshore platforms. However, as stated before it is important to note that ongoing consultation is expected to fine tune the key impacts while these are dependent on the very nature of the designs (floating, offshore, large size, combined activities).

Considering that the suggested methodology extends financial analysis to consider also social and ecological parameters it is foreseen that impacts will be related not only to private organizations, firms and individuals but also to the society as a whole and to the environment. The following list presents potential socio-economic and environmental impacts of Multi-Use Offshore Platforms without being exclusive.

- Commercial fishing
- Recreational fishing
- Commercial shipping
- Yachting and recreational boating
- Other water-based activities
- Land-based activities
- Regional tourism
- Processing transport
- Regional employment (direct and indirect) and training opportunities
- Cultural and heritage significance
- Access to local seafood and energy
- Sustainable food and energy production
- Risk potentially affecting the seabed
- Risk associated with the characteristics of the water column

- Risk to fish, mammals and birds
- Risks related to spread of invasive species and/or disease
- Non-existent visual impacts (compared to onshore/near shore activities)

As a result, key impacts are expected to be financial and social related both to the business/industry under consideration but also to the wider local or regional community.

Socio-economic impacts (excluding environmental) can be categorized as ‘direct’ and ‘flow-on’ (‘indirect’ and ‘induced’ economic effects) (Social Sciences Program et al., 2005). Direct impacts are defined as those which impact directly on those who are involved for example in aquaculture, their families and businesses and firms operating in the particular sector. Flow-on impacts refer to the ‘flow-on’ impacts resulting from the actions taken by affected parties (e.g., associated families, firms and businesses) in response to direct impacts.

In this context different designs of Multi-Use Offshore Platforms will impact on wind power production, aquaculture, transport maritime services and wave energy, with resultant possible changes in:

<u>Direct impacts:</u>

Earning capacity & costs of aquaculture/energy/maritime businesses

- levels of income for business owners & employees;
- overall profits;
- value of assets;
- management costs;
- operating costs;
- business value;
- service provision;

Employees and their families

- type and level of employment;
- family income;
- quality of life;

Adjustment costs

- relocation costs;
- training- retraining costs;

Impacts on suppliers of aquaculture/energy/maritime businesses

Flow-on/indirect impacts:

Impacts on local/regional communities

- income and employment of other in the region and associated social impacts;
- viability of the town/region;
- amenity value & community identity;
- tourism activity;
- community well-being;
- community perceptions of the sustainability of aquaculture/energy/maritime;

Impacts on consumers and the broader economy

- costs for consumers (e.g. different prices for some seafood);
- community perceptions of the sustainability of aquaculture/energy/maritime;
- changes in export earnings;

Another important category of impacts as noted before, in the content of the economic analysis that is expected to be related to the multi-use platforms concerns environmental/biological impacts.

Impacts on environment and ecosystem services

In order to perform the socio-economic analysis and integrate environmental impacts so as to ensure that the true value of ecosystems and the services provided are taken into account in policy decision-making, the ecosystem services approach can be employed. Ecosystem services are defined as services provided by the natural environment that benefit people. As defined in the Guidance document of the Marine Strategy Framework Directive (MSFD - Directive 2008/56/EC) the ecosystem services approach starts by identifying the ecosystem service of the marine area, link them with human welfare and elicit their value. In the context of the project we can make use of analyses made by Member States in their Economic and Social Analysis of the Initial Assessment in the MSFD implementation such as United Kingdom[1].The following figure presents an overview of the impact pathway approach of valuing ecosystem services.

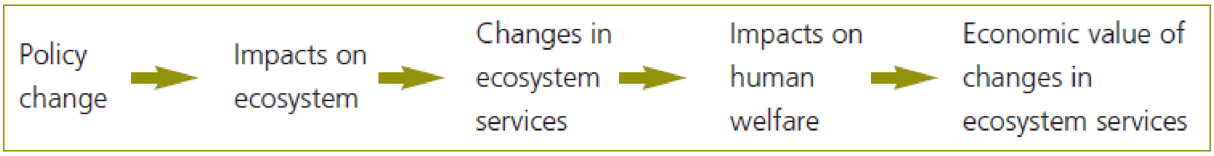

Figure 3: Overview of the impact pathway of policy change (Source: DEFRA, 2007, p.4)

The following steps can illustrate the ecosystem services approach:

1. Identify ecosystem services of the marine areas in cooperation with the analysis of status (Art. 8.1 (a) MSFD) and the analysis of pressures and impacts (Art. 8.1(b) MSFD).
2. Identify and if possible quantify and valuate the welfare derived from the ecosystem services using different methods of estimating the use and non-use values of these services described in section 2.2 below.
3. Identify the drivers and pressures affecting the ecosystem services.

The ecosystem services approach takes the ecosystem services obtained from the marine waters as a starting point. While there is no single, agreed method of categorizing all ecosystem services, the

[1] It should be noted that Prof. Koundouri is currently the representative of Greece in the Work Task of EC that supervises the implementation of MSFD from the Member States.

Millennium Ecosystem Assessment[2] framework is widely accepted. A checklist for marine ecosystem services (such as the one in DEFRA 2007, p.24) can be used to provide a preliminary qualitative assessment of the use of marine waters which services are likely to be affected by the MSFD and the likely importance of these. It is important to attempt to assess as many aspects of the ecosystem services as possible, aiming at a full consideration of the use of the marine ecosystem.

Ecosystem services can be divided into final and intermediate services. Final services, (e.g. food provisioning, raw materials and energy) are usually easiest to identify since they link directly to human welfare, while intermediate services capture the underlying services that affects the final services (e.g., habitat, climate regulation, eutrophication mitigation and resilience) and will therefore require a deeper understanding of the dynamics and interactions of the marine ecosystems in order to be identified. As a final step, a quantification of the environmental pressures the different uses have on ecosystem services and thereby human welfare is done.

At an early stage in the analysis, it is also important to take into consideration how different services may interact. This is important since the benefits derived from one ecosystem service may depend on its relationship with other services, and any impact on the latter service might reduce the benefit derived from the former. There may be complementarities as well as conflicts between services. After identifying ecosystem services, these should be linked to the relevant descriptors of Art. 8.1 (a) MSFD. The monitoring of these descriptors can capture changes of ecosystem services over time. This work should be done in cooperation with natural scientists.

When the ecosystem services of concern have been identified the impact that these have on people's well-being can be addressed. Likewise the effect of different multi-use platforms' structures on marine environment can be assessed and compared with traditional use of coastal and marine resources. When assessing the impact of ecosystem services on human welfare, it is critical to focus on the benefits generated by these services, as this is what affects human welfare directly. It is, therefore, the benefits rather than the services *per se* that is to be valued. These benefits can be described by identifying use and non-use values derived from final ecosystem services. Thereafter,

[2] http://millenniumassessment.org/en/Index-2.html

stakeholders can be identified by connecting benefits with different actors (e.g. tourism, fishing, households, governments, public etc.).

At this point it is important to introduce the concepts of use and non-use values. Hence, use value is the value derived from using or having the potential to use a resource, while non-use is the value that is derived from the knowledge that the natural environment is maintained. The value of natural resources is often considered within the framework of Total Economic Value (TEV) which comprises of the use and nonuse values as shown in Figure 4 and which can be used to value ecosystem services.

In this framework use value includes direct use, indirect use and option value, while non-use value has three components those of altruism, bequest and existence values. These concepts are explained as follows (DEFRA, 2007, pp.30-31):

Direct use value is derived where individuals make actual or planned use of an ecosystem service. This can be in the form of consumptive use which refers to the use of resources extracted from the ecosystem (e.g. food) and non-consumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity). These activities can be traded on a market (e.g. food) or can be non-marketable i.e. there is no formal market on which they are traded (e.g. recreation).

Indirect use values are derived where individuals benefit from ecosystem services supported by a resource rather than directly using it. These services include key global life-support functions, such as the regulation of the chemical composition of the atmosphere and oceans, and climate regulation; water regulation; pollution filtering; soil retention and provision; nutrient cycling; waste decomposition; and pollination.

Option value is related to the value that people place on having the option to use a resource in the future even if they are not current users (e.g., a national park where people who have no specific intention to visit it may still be willing to pay something in order to keep that option open in the future). In addition, option value can also be thought of as a form of insurance, e.g. a wide species mix in a particular habitat can provide an insurance function: as conditions change, different species may fulfill key ecological roles.

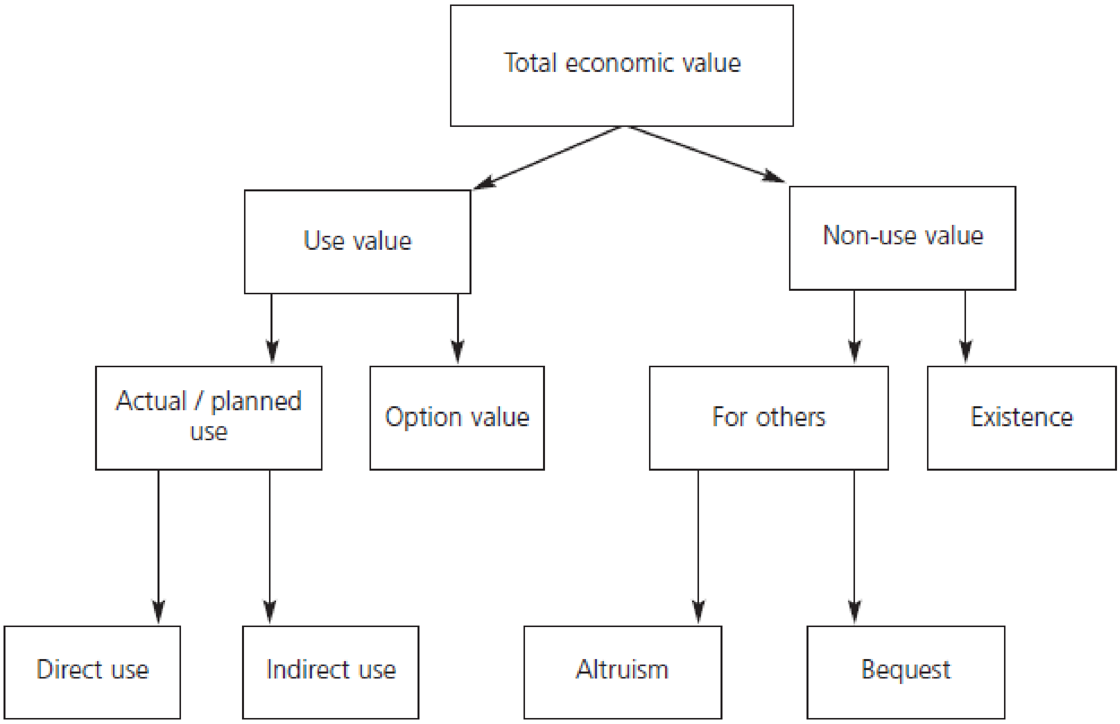

Figure 4: Total Economic Value (Source: DEFRA, 2007, p.30)

In the context of non-use values bequest value arises where individuals attach value to the fact that the ecosystem resource will be passed on to future generations; altruistic value where individuals attach values to the availability of the ecosystem resource to others in the current generation and existence value is derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it (e.g., pay for the preservation of whales, through donations, even if may never actually see a whale).

An additional element of value which is not presented in the above figure is that of quasi-option value. As quasi-option value refers to the value of information secured by delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delay, this element may be worthwhile investigating since the suggested novel designs are subject to some degree of uncertainty.

Finally, the pressures and drivers affecting the ecosystem services of concern should be identified, providing guidance and information when developing the scenarios used in the cost of degradation analysis.

In summary, the key steps of ecosystem services approach are (DEFRA, 2007, p.4):

1 Establish the environmental baseline.
2 Identify and provide qualitative assessment of the potential impacts of policy options on ecosystem services.
3 Quantify the impacts of policy options on specific ecosystem services.
4 Assess the effects on human welfare.
5 Value the changes in ecosystem services.

To identify the groups of people in the society who will be affected by changes in ecosystem services is vital as this will determine how these impacts will be valued and over what population the values are to be aggregated. The spatial scale to identify the affected population will, therefore, differ according to the water use of concern and could be on a local, regional or international scale. Combining biophysical and economic information will require agreement on common spatial scale of analysis. Changes in policies will also affect stakeholders, such as businesses and households, directly in that it might put restrictions on their use of the marine waters or indirectly in that they are to finance (through e.g. taxes) certain measures aimed at protecting the marine waters.

As a result, the above changes can/may impact on suppliers (owner and employees) and receivers of energy, food and maritime services but also on external stakeholders related to the natural environment.

2.2 Extent of appropriate information for undertaking the assessment

From the previous section it must have been clear that due to the multidimensional character of the impacts (socio-economic and environmental of direct and indirect outcomes (i.e., at stakeholder, industry and community scale) leading to welfare gains and sometimes losses (benefits) a range of different information will be needed in order to assess them. As a result, market data, secondary data for the performance of simulations, survey based primary data, data provided from literature review, consultation with experts and stakeholders and information coming from environmental impact assessments are deemed as very important in the framework of integrated environmental and socio-economic assessment.

Of particular importance in this task of identifying impacts of interest is the input from other WPs such as WP2 which is expected to supplement the current impacts. In particular, useful input of WP2 will be derived from the following objectives of WP2:

- An inventory on policy and legislation imposed challenges on planning and management strategies
- Compile an inventory of stakeholder views, expectations and possible conflicts

As a result, the legal and policy analysis of WP2 will provide the policy and legal background against which socio-economic viability of offshore platforms will be assessed. Moreover WP2 stakeholders' analysis and more specifically the stakeholders' roundtables will provide inputs to the construction of non-market valuation questionnaires to be developed in WP8, in order to elicit socio-economic costs/benefits of non-marketed effects of multi-use platforms. For that reason the participation of WP8 partners in these consultation meetings as emphasized in the inception report is important.

In addition, there is more potential for the roundtable discussions in WP2 to contribute to achieve WP8 objectives. For example, these discussions could provide input in the MCDA framework of analysis with regard to the criteria set as well as the scoring.

The output of WP7 that identifies innovative platform plans and designs and incorporates previous WPs' outputs will form a solid background for the analysis to be applied in WP8. The case-study specific environmental impact assessment analyses and case-study specific financial feasibility analyses of WP7 are also an important input to WP8. With regard to the environmental impact assessment analyses it is foreseen that the adoption of an ecosystem service perspective will be beneficial in terms of WP8, since it will allow environmental impacts to be measured in a way that is as helpful as possible for economic analysis. It should be also noted that the cooperation with WP7 should start at an early stage in order to get a clear picture of which economic activities might be implemented on the different sites. This in turn should aid in gathering the relevant data, and possible avoid developments that would have serious negative socio-economic consequences.

Table 1: Extent of appropriate information and source of information

Policy and legislation	WP2
Inventory of stakeholder views, expectations and possible conflicts	WP2
Identify the criteria set and the scoring for a MCDA	WP2
Environmental impact assessment	WP4&7
Socio-economic characterization of the sites/profiling baseline conditions	WP8
Characterization of production and demand of Multi-Use Offshore Platforms in each site	WP8 in cooperation with WP7
Case-study specific financial feasibility analyses	WP7
Valuation of non-market environmental and social impacts	WP8
Apply economic tools (e.g., CBA within MCDA framework) for assessment	WP8

There is no doubt that the availability of suitable existing data is an important prerequisite for undertaking the assessment of the different designs. The MISEA of the viability/sustainability of Multi-Use Offshore Platforms will be developed following the next steps:

- Development of General Framework of Analysis and Method of Analysis when data is available
- Method of Analysis under Sufficient Data Availability
- Method of Analysis under Insufficient Data Availability

The method of analysis under sufficient/insufficient data availability or maximum/limited data approach is described in Section 4. Under sufficient data availability all steps of MISEA will be fully applied. Under insufficient data availability a parsimonious, generic approach to multi-dimensional impact assessment will be employed. To be useful, impact assessment methods must be feasible within the time and financial constraints of technology-related projects. In WP8, if data availability proves to be insufficient, a model will be developed that will achieve parsimony in data and in model design, by providing a generic model structure that can be used for virtually any type of system, and that can be parameterized with low-order moments of outcome distributions. In other words, an integrated assessment of economic, environmental and social impacts at lower data requirement level will be developed and implemented, relative to methods that rely on case-specific, complex bio-economic simulation models. This will be achieved by identifying in advance the indicators that need to be quantified. Any subsequent data collection activities can be focused on the relevant information, thus eliminating the cost and respondent burden caused by the “kitchen sink” approach to survey design.

Potential challenges related to data availability and impact assessment that could arise and further considerations:

-Measuring indirect impacts of socio-economic and environmental character is often significantly more challenging than measuring direct impacts. For example, changes in the quality or quantity of an environmental service being provided are often difficult to measure or are poorly understood.
-Very site specific data are needed and hence transferring values may be problematic. Importantly, ecosystem services are context dependent in terms of their provision and their associated benefits and costs.
- Some impacts cannot be certain beforehand and hence data needs cannot be predicted. For example, capturing a relevant quota of energy from the environment will change the situation downwards and it is uncertain what the effect will be. As a result, a challenge within this WP will be not only putting an economic value on specific impacts but also identifying them.
- The economic assessment of a marine intervention such the one proposed must be underpinned by biophysical research and data relating to the various ecosystem processes, structures, stocks, flows and dose response relationships. Since, ecosystems provide a range of service outcomes, many of which are deemed valuable goods (‘benefits’) by human society and result from complex interactions that occur at multiple spatial and temporal scales, yielding often multiple services (joint products), a systems approach is necessary, in understanding all of the links.
- The policy issues that are relevant and could pose constraints (existing laws, standards and targets, etc.) as well as the general institutional framework should be identified in each study site as these could interact with the whole process of economic assessment and therefore the data needs.

-Scaling issues: the spatial scale of data will depend, as noted in the previous section, on the affected population which could be on a local, regional or international scale. Both environmental and socio-economic impacts apart from local or regional can also have in cases a transboundary character. As a result, the need arises for more or less aggregated data, while combining biophysical and economic information will require agreement on common spatial scale of analysis.

- Another widely recognized issue concerns the potential problem of double-counting which is a feature of the complexity of ecosystem services and the difficulty in understanding their multiple interactions. A case of double-counting may occur in which competing ecosystem services are valued separately and the values aggregated. A clear definition of final and intermediate services is usually helpful for avoiding double-counting.

3 Profiling baseline conditions and characterisation of production and demand of Multi-Use Offshore Platforms

This section focuses on gathering information about the socio-economic environment and context of the proposed development with regard to energy production, aquaculture and maritime services. Hence, before achieving the evaluation of the socio-economic impact it is necessary to start with the baseline profiling of the case study areas in order to identify who is going to be impacted. This approach is expected to enable then the identification of the production and demand functions of the Off-shore Multi-Functional Platforms.

3.1 Description of case studies and socio-economic characterization

In this context, the following subsections are expected to gather information on baseline conditions (i.e., current impacts, historical context and current status) of the selected activities of wind power production, aquaculture, transport maritime services and wave energy. This description is to provide a basis to understand the conditions affecting the region’s economic and social environment in which the effects of the novel structures can be anticipated. However, it is emphasized that this description of the current situation at study sites does not represent the conditions to which impacts of Multi-Use Platforms are to be compared and it is made clear that within the framework of this assessment different designs of Multi-Use Platforms will be compared.

In addition, in order to assess indirect and induced impacts a regional profiling is deemed necessary which will help identifying the geographic communities likely to be impacted by the proposed change. This will be possible by gathering secondary social and economic data about those communities. Then the profile of relevant characteristics of the region/communities defined as potentially affected will be built up.

Information typically gathered as part of a regional profile includes the following (Social Sciences Program et al., p.15).

- Population
- Labor force
- Education, skills and training
- Industry structure and firm performance
- Measures of social capital and social well-being.

Or more analytically:

- Population characteristics (e.g., the demo-graphics of relevant groups, major economic activities etc)
- Political and social resources (e.g., distributions of socio-demo-graphic characteristics, presence of distinctive or potentially vulnerable groups, regulatory factors, institutional framework etc)
- Historical factors (e.g., past or ongoing community controversies, particularly those involving technology or the environment)
- Relationships with the biophysical environment (e.g. ecological setting; patterns of resource use, areas having economic, recreational, aesthetic or symbolic significance to specific people etc)
- Culture, attitudes and social-psychological conditions (e.g., attitudes toward the proposed action; trust in political and social institutions, perceptions or risks)
- Indentifying who will be impacted (e.g., types of activities which may be affected, who undertakes these activities, when and where; extent/scale of activity potentially affected and the range of values associated with these activities; geographic location of members of groups who

may potentially be impacted by the proposed change; proportion of the group, or of their activity, likely to be affected)

Especially with regard to relationships to the biophysical environment and an initial assessment of the current environmental status of the marine waters the MFSD can provide useful guidance. In particular, the Directive dictates that the initial assessment must include economic and social analysis of the use of those waters and of the cost of degradation of the marine environment. Hence, in this context it is required an analysis of the human activities that use the marine environment covering both market and non-market costs and benefits while the social analysis is assumed to supplement the economic analysis by putting more emphasis on (Eftec and Enveco, 2010, p.18):

- Employment impacts, including at local and regional as well as national level; and
- The distribution of economic impacts amongst different groups in society.

Importantly, this phase will gather information on:

- Current status of operations (aquaculture, energy production, maritime services)
- Current impacts of the relevant activity (aquaculture, energy production, maritime services) (e.g, which other activities may be affected, who undertakes these activities, when and where, what is the extent/scale of activity potentially affected and the range of values associated with these activities, which are the relationships of current operations with the biophysical environment)
- Historical, regulatory and other factors impacting on these activities (current management arrangements, policies, institutional framework)
- Geographic location of involved stakeholders who may potentially be impacted by the proposed change
- Proportion of the group, or of their activity, likely to be affected by the future economic activities

It is noted that analysis of mainly available secondary data from a variety of government, industry and community sources (e.g., Census) will contribute to identify the broad level and/or nature of potential impacts of a proposed change and will play a key role in providing the necessary baseline information. Furthermore, it should be reminded that of particular importance in this task is the contribution of WP2 by providing focus groups output.

3.1.1 Wind power production

The scope is the profiling of the current wind power production operations and identifying businesses, households and individuals that may be impacted by the future economic activity (multi-purpose platforms). Broader social and environmental issues related to current and future operations should be also highlighted.

3.1.2 Aquaculture

The scope is the profiling of the current aquaculture production operations (i.e., current impacts, historical context and current status) and identifying businesses, households and individuals that may be impacted by the future economic activity (multi-purpose platforms). Broader social and environmental issues related to current and future operations should be also highlighted.

3.1.3 Transport maritime services

The scope is the profiling of the current transport maritime operations (i.e., current impacts, historical context and current status) and identifying related businesses, households and individuals that may be impacted by the future economic activity (multi-purpose platforms). Broader social and environmental issues related to current and future operations should be also highlighted.

3.1.4 Wave energy

The scope is the profiling of the current wave power production operations (i.e., current impacts, historical context and current status) and identifying businesses, households and individuals that may be impacted by the future economic activity (multi-purpose platforms). Broader social and environmental issues related to current and future operations should be also highlighted.

3.2 Production and demand structures of the proposed multi-functional platforms

At this stage focuses on the production and demand structures of the different suggested multi-functional platforms in each study site. As it will become apparent apart from the private costs and benefits of the structures, analysis is going to include the social and environmental impacts which are related to externalities which are perceived by the particular society but are not valued in the market place, such as environmental impacts.

The next subsections will aim to identify economic issues, environmental issues (both in terms of national effects such as global warming and local environmental effects such as noise and visual intrusion) and social issues concerning level of employment, regional development and overall attitude of the population towards the technologies and specific options proposed. However, it should be noted that the novel character of the constructions and especially their off-shore location are expected to reveal significant differences compared to conventional related activities. For example, it is regarded that operation and maintenance of offshore facilities are more difficult and expensive than equivalent onshore facilities. A general rule of thumb is at least twice what it costs to keep equivalent offshore plant and machinery onshore working and in good repair. Offshore conditions cause more onerous installation and commissioning operations, and accessibility for routine servicing and maintenance is a major challenge, physical as well as economical. During harsh winter conditions, for instance a complete wind farm may be inaccessible for a number of days due to sea, swell, wind and visibility conditions. Even finding a small weather window may be a challenge. Even given favorable weather conditions, operation and maintenance tasks are more expensive than onshore, being influenced by the distance of the offshore wind farm from shore, the exposure of the site, the size of the turbines, the reliability of the turbines, and the maintenance strategy under which they are operated.

Both for offshore renewable energy and for aquaculture a substantial part of the costs is variable cost related to operations and maintenance of the plants. It is obvious that optimization of the use of ocean space for different purposes might benefit from shared resources such as staff allocation, transportation of staff and material from and to the platforms, use of forecasting systems, ships etc., and perhaps also sharing offshore housing of personnel on a more permanent basis. Furthermore application of Integrated Multi-Trophic Aquaculture can lead to reduced impact on the marine environment.

The production and demand analysis will be based on economic data (market costs and prices), environmental valuation surveys (if deemed necessary) and Benefit Transfer (BT) techniques. The suggested methods are presented in more detail in the relevant section.

3.2.1 Production-Side Analysis of Proposed Multi-Functional Structures

This analysis will be based on proposed financial costs of offshore structures as identified in WP7 as well as social and environmental costs as identified in WP2 and WP4/7.

3.2.1.1 Identification of private/financial costs of suggested Multi-Use Offshore Platforms

The identification of the private costs of the suggested offshore structures with regard to aquaculture, energy and maritime services is the first step of the production-side analysis and it is expected to consider the following broad elements:

- Capital costs which are the upfront costs to construct, install the project hardware and major maintenance work that needs to be carried out during the lifetime of the platform beyond typical operating expenses.

- Platform development costs which may include: Technical, legal and planning consultants' fees, and the developer's own time, in negotiations with legal and statutory bodies (for example in obtaining planning permission and consulting the Environment Agency), financing and legal costs, including the costs of arranging finance, electrical connection costs, costs of licenses.

- Running and operation and maintenance costs per year which may include: fuel costs, if applicable, it can include direct costs, or collection, staff costs, insurance fees, transport costs, annual fees for licenses and pollution control measures, general maintenance and operating costs, of plant, equipment, site, etc.

- Training costs are expected to cover the training of people who will run the platforms with regard to the safety, financial and environmental implications of the project. These skills will need to be updated as technology and knowledge develops.

3.2.1.2 Identification of social and environmental costs of suggested Multi-Use Offshore Platforms

As the scope of the developed methodology is to integrate private and social/environmental costs of the suggested multi-use platforms it is equally important to consider the latter in the suggested framework of analysis. For example, it is regarded that offshore renewable energy installations (e.g., wind farms, energy wave devices) all have local environmental impacts (e.g., to local submarine habitats and seabird populations). Especially in the case of wind farms a regional scale ‘displacement’ impact e.g., displacement of fishing by marine protected areas around wind turbine sites and consequent increase fishing pressure in ‘unprotected’ areas (Turner et al., 2010) or a boost in jelly fish populations may be expected. Aquaculture is associated with local environmental consequences and potential impacts on the marine food web via fish food provision and accidental releases of fish with a low genetic diversity (Langmead et al., 2007: cited in Turner et al., 2010).

3.2.2 Demand-side analysis of potential production of goods and services of proposed multi-functional structures

Analysis here will be focused on proposed financial and social/environment benefits of offshore structures.

3.2.2.1 Identification of private/financial benefits of suggested Multi-Use Offshore Platforms

Suggested financial benefits are highlighted as follows:

- Sale of energy, aquaculture products and maritime services
- Saving of fuel consumption and reduction of energy expenditure
- By product sales (or displaced costs)
- Greater productivity (macro scale)
- Higher real disposable income (macro scale)

3.2.2.2 Identification of social and environmental benefits of suggested Multi-Use Offshore Platforms

- Direct and indirect employment
- Energy security and enhancement in power and food quality
- Health benefits (associated with reduced pollution)
- Environmental benefits (e.g., mitigate global warming, avoided emissions-compared to non-existent wind farms of current status, improved water quality near coast or seabed life through less use of pharmaceuticals)
- Technology transfer
- Community welfare
- Household welfare

At this point it is reminded that the ecosystem services approach will be employed as described in the previous section linking impacts on ecosystem to human welfare.

Furthermore, as it has been noted (Turner et al., 2011) the marine and coastal zone interventions and their benefits (use and nonuse values) can be linked to four environmental impacts/effects categories (relevant for human welfare) (p.20-21):

• Direct and indirect productivity effects;
• Human health effects;
• Amenity effects (congestion); and
• Existence effects such as loss of marine biodiversity and/or cultural assets.

4 Data availability and approaches for socio-economic impact assessment of Multi-Use Offshore Platforms

At this stage in order to proceed to the socio-economic impact of Multi-Use Offshore Platforms it is important to construct a list of the economic, environmental and social indicators based on the previous section. It is noted again that while the economic figures can be more easily identified, the social and environmental indicators are generally hidden impacts and may be viewed either as external costs/negative impacts (i.e., to the environment – local and/or global) or as external benefits/positive impacts (i.e., job creation).

4.1 List of data to be collected

Table 2: Impact indicators

Economic	Social	Environmental
Capital costs	*Employment*	*Emissions- climate change*
Project development costs	*Education*	*Noise (compared to on shore constructions)*
Running and operation and maintenance costs	*"Green" tourism*	*Visual (compared to on shore constructions)*
Training costs *Income*	*Self-reliance (energy and food security)* *Community benefits* - financial return – this can be for the individual but also for the community for community based	*Effect on the marine ecosystem, erosion, local hydrology* *Recreation* *Risk abatement*

	schemes - diversification of rural incomes - an increase in local employment - a contribution towards environmental sustainability and potential for combining with Green Tourism - some degree of control over the scheme for the community, for community based schemes - a sense of satisfaction for those involved, and building capacity and strength of community *Health* - Health hazards related to the operation of the platform and associated equipment - All interrelated factors – such as air quality	*Transport of primary fuel, equipment etc – local and global issues* *Navigational routes* *De-commissioning* *Product/by product disposal*

4.2 Methods for quantification of costs and benefits

Considering the complex nature of impacts, socio-economic and environmental, it is evident that different approaches will be needed in order to quantify them since there are impacts which are easier to value and other which are not.

As a result, private costs and benefits identified under the economic impact indicator in the table above will be estimated through financial analysis, consultation with experts within MERMAID combined with available secondary data from related industries and literature review.

The needs regarding valuation of social and especially environmental impacts are somewhat different. One theoretical approach of capturing and describing the benefits derived from the different ecosystem services is the TEV framework presented in Section 2. The framework provides a systematic tool for considering the full range of impacts the marine environment has on human welfare. This includes both "economic" and "social" considerations. In addition, the TEV framework and the framework for categorizing ecosystem services can be seen as complementary as shown in the following figure.

MA framework		TEV framework			
MA Group	Service	Direct Use	Indirect use	Option value	Non-use value
Provisioning	Includes: food; fibre and fuel; biochemicals, natural medicines, pharmaceuticals; fresh water supply	*		*	
Regulating	Includes: air-quality regulation; climate regulation; water regulation; natural hazard regulation etc.		*	*	
Cultural	Includes: cultural heritage; recreation and tourism; aesthetic values	*		*	*
Supporting	Includes: Primary production; nutrient cycling; soil formation	*Supporting services are valued through the other categories of ecosystem services*			

Figure 5: Valuing ecosystem services through the TEV framework[3] (Source: DEFRA, 2007, p.32)

As it is anticipated that multi-use platforms will interact with the physical environment the impact on marine ecosystems is foreseen. As also mentioned in Section 2, coastal ecosystems provide a wide range of final services and goods of significant value to society - fisheries, transport medium, flood alleviation, recreation and aesthetic services etc. As it has been emphasized in valuing such assets, it is important to capture how society values these services and goods.

The various elements of TEV are assessed using economic valuation methods. While some of these elements are more easily valued than others, for example the use type values, non-use values are

[3] Millennium Ecosystem Assessment (MA) framework

usually more difficult to assess. The way to derive TEV is from preferences of individuals. These preferences may be observed when goods and services are exchanged in actual markets and the price they pay in the market reflects how much, at the very least, they are willing to pay for the benefits they derive from consuming that good or service. However, for environmental goods and services which are not traded in actual markets such behavioral and market price data are missing and purchasing behavior is observed within the context of a hypothetical market.

In this context two broad categories of economic valuation methods with regard to ecosystem services can be distinguished as shown in Figure 6. Stated preference methods and revealed preference methods. Revealed preference methods rely on data regarding individuals' preferences for a marketable good which includes environmental attributes and could be divided in market-based and surrogate markets related. As also shown in Table 3, market-based include the market prices method, production function, replacement cost, cost of illness while we could also add defensive expenditures. Surrogate market related includes travel cost method and hedonic pricing. On the other hand, stated preference methods use carefully structured questionnaires to elicit individuals' preferences for a given change in a natural resource or environmental attribute and are the only methods that can estimate non-use values which can be a significant component of overall TEV for some natural resources. In this category, the contingent valuation method and choice experiment are included while we could also add the laboratory economic experiments.

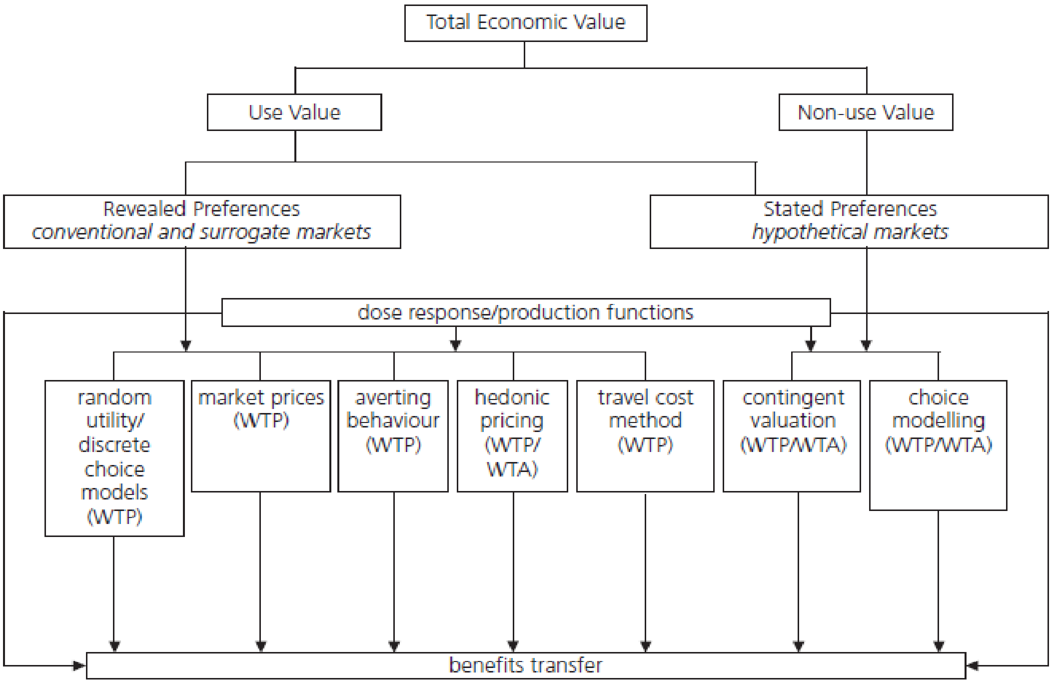

Figure 6: Techniques for monetary valuation (Source: Eftec, 1999).

Table 3: Components of TEV of natural resources and appropriate economic valuation methods

TEV component	**Economic valuation methods**
Direct use values	
	Production Function (PF)
	Net Factor Income (NFI)
	Replacement Cost (RC)
	Market Prices (MP)
	Hedonic Pricing Method (HP)
	Travel Cost Method (TCM)
	Contingent Valuation Method (CVM)
	Choice Experiment Method (CEM)
Indirect use values	
	Replacement Cost (RC)
	Cost-of-Illness (COI)
	Market Prices (MP)

	Production Function (PF)
Option values	Contingent Valuation Method (CVM) Choice Experiment Method (CEM)
Non-use values	Contingent Valuation Method (CVM) Choice Experiment Method (CEM)

Source: Adapted from Birol et al. (2006) on TEV of water resources

In order to value non-market benefits/costs the use of stated preference methods such as CVM and CEM is deemed important. In the group of stated preference methods CVM has a predominant place. The method was originally proposed by Davis (1963) and its direct approach is based on the development of a hypothetical market or scenario in which the respondents to a survey are given the opportunity to buy the good in question stating their Willingness-to-Pay (WTP). Different elicitation methods/questions (open-ended, iterative bidding, payment card, close-ended, close-ended double-bounded) are used to derive the WTP amounts and because these values are contingent on the hypothetical market the method is called CVM.

CEM (Bennett and Adamowicz, 2001; Birol and Koundouri, 2008) is another stated preference method that has gained popularity among environmental economists. In a CE framework, the good in question is broken down into its component attributes, which are presented to respondents normally as set combination of the attributes. Respondents are then presented with a sequence of these choice sets, each containing alternative descriptions of the good under question, differentiated by its attributes and levels. By observing and modelling how respondents change their preferred option in response to the changes in the levels of the attributes, it is possible to determine how people trade-off between the good's attributes.

With regards to renewable energy sources there is extensive literature on the public's preferences. Several studies have been conducted over recent years using different valuation techniques to explore individual preferences for renewable power generation and “green” electricity reporting positive WTP for green energy premia (Westerberg et al., 2012; Bollino, 2009; Koundouri et al., 2009; Hansla et al., 2008; Borchers et al., 2007; Kotchen and Moore, 2007; Bergmann et al., 2006;

Wiser, 2006; Menges et al., 2005; Nomura and Akai, 2004; Liljestam and Söderqvist, 2004; Zarnikau, 2003; Álvarez-Farizo and Hanley, 2002; Batley et al., 2001; Roe et al., 2001). Furthermore, Turner et al. (2010) provides an extensive literature review of marine and coastal ecosystem benefits valuation studies.

Regarding the above studies it is observed that the majority is realized in Northern Europe. One exception is that of Westerberg et al. (2012) who explore the tourist demand for sustainability and recreation of high density beach tourism of the Mediterranean Sea. The authors find that everything else being equal, wind farms should be located no closer than 12 km from the shore while, a wind farm can be located from 5 km and outwards without a loss in tourism revenues if accompanied by a coherent environmental policy and wind farm associated recreational activities. In addition, the authors offer a literature review of studies that provide evidence on the impact of wind turbines on tourism.

Furthermore, the application of experimental methods in laboratory settings (Davis and Holt, 1993; Kagel and Roth, 1995) to study issues of economic nature such as decision or game theoretic models, policy problems, institutional procedures is also getting more and more popular among economists. Following Levitt and List (2007) lab experiments offer the possibility to the investigator to influence the set of prices, budget sets, information sets, and actions available to actors. Hence, within the context of the laboratory the investigator can measure the impact of these factors, *ceteris paribus*, on behaviour of individual economic agents. Examples of experimental games used to measure for instance social preferences are the ultimatum game, dictator game, trust game, gift exchange game, and public goods game. Other topics of experimental economics applications are in the area of market games, coordination games, finance etc. In the typical lab experiment, subjects enter an environment, in which they are aware that their behaviour is being monitored, are provided with instructions and real monetary payoffs.

Furthermore, the fact that gathering primary site-specific data is costly and time-consuming has made BT a more and more popular alternative for the valuation of ecosystem goods and services. BT method uses existing economic value estimates from one location to another similar site in another location. In particular, it concerns an “application of values and other information from a ‘study’ site where data are collected to a ‘policy’ site with little or no data” (Rosenberger and

Loomis, 2000, p.1097). In simple words according to this technique the results of previous environmental valuation studies are applied to new policy or decision-making contexts.

However, there are a number of criteria that have been identified in the literature for benefits transfer to result in reliable estimates as summarised in Brouwer (2000):

- sufficient good quality data
- similar populations of beneficiaries
- similar environmental goods and services
- similar sites where these goods and services are found
- similar market constructs
- similar market size (number of beneficiaries)
- similar number and quality of substitute sites where the environmental goods and services are found

Bergland *et al.* (1995) discussed three main approaches to BT: (i) the transfer of the mean household WTP (ii) the transfer of an adjusted mean household WTP and, (iii) the transfer of the demand function. Hence, while the first approach assumes similarity in good and socio-economic characteristics between the study and target site, the other two approaches attempt to adjust the mean WTP and re-calculate it respectively, in order to account for differences between the two sites in terms of environmental characteristics and/or socio-economic characteristics. See also recent BT reviews such as Navrud (2010) and Johnston and Rosenberger (2010). Finally, it is noted the Environmental Valuation Reference Inventory (EVRI)[4] is a comprehensive benefits transfer database that consists of over 1900 valuation studies and could be used for BT applications.

The following figure (Figure 7) from Turner et al. (2010, pp.22-23) presents examples of economic valuation techniques that could be employed to assess specific effects categories and ecosystem services.

[4] http://www.evri.ca

Type of Effects Categories and Ecosystem Services

- Use values relate to productivity, human health and amenity effects
- Non-use values relate to existence and bequest
- Productivity effects directly related to, for example:
  - fisheries, agriculture, recreation/tourism, water resources, industrial production, navigation and indirectly to ecosystem processes yielding storm protection, flood alleviation, erosion reduction, sedimentation and waste assimilation, nutrient cycling etc
- Human health effects related to habitats, landscapes and cultural assets
- Existence value effects related to ecosystems and cultural assets.

Types of Economic Valuation Techniques

Effects	Valuation Approach
Productivity	**market orientated** benefit valuation, using market prices of goods and services, based on changes in the value of output, or loss of earnings • For example, loss of fisheries output due to pollution, or recreational benefit loss through increase illness caused by polluted coastal waters
	surrogate markets benefits valuation including marketed goods, property values (hedonic pricing) and other land values, travel costs of recreation, wage differentials, compensation payments, damage costs avoided.
	cost terms in a cost-effectiveness analysis by using actual market prices of environmental protection inputs; known as preventative expenditures, replacement costs, shadow projects; defensive expenditure
Health	cost of illness measures, preventative and defensive expenditures, or survey-based valuation (see below)
Amenity	travel costs of recreation, properties/land values, or survey oriented methods such as contingent valuation, contingent ranking and choice experiments, using questionnaires to elicit individual willingness to pay or to be compensated valuations
Existence/ Bequest	only derived from survey-based methods

Figure 7: Economic valuation techniques for ecosystem services assessment (Source: Turner et al. (2010, pp.22-23))

The methods mentioned above could be potentially used to assess the social and environmental impacts of the multi-use platforms. However, it is important to remind that impacts will be extremely site dependent, making for example BT a challenging task, while it should not be underestimated the fact that at present there are impacts that are unknown and will be explored through the project (e.g., hydrodynamic effects). Additionally, the use of stated preference methods such as CE pose questions such as: should one standard questionnaire be developed for all case studies with minor case study adaptations? Or should the questionnaire development in the different case studies be more or less independent of each other? Or should one valuation study be carried out for one of the sites and then the other sites rely on BT from this site?

It is regarded that related decisions will be taken on the grounds of applicability of BT in terms of extremely site dependent impacts, while the number of original studies to be carried out, if deemed necessary, will be constrained by the specific budget and time limitations. Hence, options such as run one valuation study and use it for BT purposes for the other sites or in some settings employ a more cost-effective field implementation, e.g., the use of web panel questionnaires will be seriously taken under consideration.

Turner et al. (2010) argue that although several approaches can be used to estimate the value of ecosystem goods and services these approaches fall into two groups (p.54):

- techniques that estimate economic values – valuation approaches (stated and revealed preference methods), and;
- those that produce estimates that are equivalent to prices – pricing approaches or costs based (market prices, opportunity cost/damage costs avoided, replacement costs)

Whilst valuation approaches may be theoretically correct (elicited WTP consists of both the price paid to purchase a particular good, as well as consumer surplus) pricing approaches are often used to value various aspects of ecosystem value since the former are often very expensive and time consuming to undertake. Finally, economic valuation of ecosystem goods and services is supplemented by the BT technique as well methods for eliciting non-economic values such as focus groups, in-depth groups, delphi surveys, systematic reviews etc.

4.3 A maximum data approach for socio-economic impact assessment

An important goal of the ISEA is to identify the socio-economic impact of Multi-Use Offshore Platforms by adopting an integrated approach. In the framework of a maximum data approach important means to achieve that are economic tools such as the CBA, CEA as well as MCDA.

While CBA evaluates programs in monetary terms CEA evaluates programs against specified objectives. However, both methods allow for a ranking of programs in terms of resource use and outcomes through the expression of a ratio which is calculated after collecting detailed information on costs and outcomes.

In addition, a different relative to CBA appraisal methodology which allows taking account of project impacts that are not easily given monetary values is that of MCDA. In simple terms MCDA involves a structured approach to differentiating between a range of options, based on a set of objectives or criteria (economic, ecological and socio-cultural), against which each option is assessed.

As argued in Turner et al. (2010, p.33): “The choice between CBA and CEA is determined by the nature of the policy problem under scrutiny. If the problem is one of meeting some environmental standard, complying with a law or achieving a target then finding the least cost way of achieving this by completing a CEA is the appropriate action. If the problem is one of choosing between a number of different possible policy or project options which do not involve compliance with standards or targets then CBA is the most appropriate assessment tool. If the situation is one where monetary valuation is not possible or appropriate then CEA and CBA should be replaced with a multi-criteria assessment process.” Alternatively, an even broader option is to monetize as much as possible and to combine it with an MCDA without replacing CBA completely.

It is also reminded that the use of tools such as CBA or CEA should be broad in scope in the sense that social effects due to externalities of the platform alternatives to be also included. Such externalities valued by non-market methods, as presented in previous sections, will make possible their inclusion in a CBA or CEA framework in which traditionally market and financial benefits and costs were only considered.

Hence, adopting a maximum data approach will likely require the use of both primary and secondary data. However, the existence of many extremely site-specific effects will dictate whether there is imperial need for original questionnaire surveys or whether a BT originated from a literature survey would suffice to estimate socio-environmental related values in all sites.

Primary data collection through questionnaire surveys and environmental valuation methods such as CVM and CE and revealed preferences methods will allow questions to be more targeted on the nature and extent of specific types of social or economic impacts providing a wider and more detailed range of information to be examined compared to secondary data.

For example surveys could be targeted to elicit the value that specific stakeholders have for example recreational fishers fishing in a particular region. This approach enables both qualitative and quantitative information and data to be collected, while it makes also possible the derivation of associated non-use values which is deemed as a more challenging task. This data will enable descriptive and analytical statistics to provide general background context, describe a particular situation and elicit WTP values for different ecosystem services.

An alternative way of producing economic value estimates, through questionnaire surveys or secondary data, is that of production function. As an example, Luisetti et al., (2008) estimated the value of fish nurseries in the Blackwater (Essex – UK) with a production function method.

Important advantages of primary data coming from surveys are that they can draw out more meaning on complex issues and potential explanations about particular variables or outcomes of interest, allow stakeholders to raise their own issues, allow measurement of larger and possibly representative samples, simplifying comparison and aggregation of data. On the other hand they can be time consuming and expensive with the actual cost and expense to be dependent on the size of the sample population, the level of survey coverage and survey methods used (Social Sciences Program, 2005).

Limitations related to secondary data availability are that data may not contain information directly applicable or relevant to the impacts being assessed due to the type of information collected, may contain biases which would potentially misrepresent impacts if relied on while privacy considerations can also impact on data access. In addition, the time and cost involved in accessing and analyzing secondary data depends on factors such as the amount and type of data, and the extent of data manipulation (Social Sciences Program, 2005).

The following subsections present the different versions (CEA, CBA, MCDA) of the full data approach which depend on specific data availability, both in terms of quality and quantity.

4.3.1 **Cost-Effectiveness Analysis (CEA)**

CEA is a type of economic evaluation that compares the cost of the investment to its effectiveness. Hence, CEA is a form of economic analysis that enables comparison between different kinds of interventions with similar effects (outcomes) on the basis of the cost per unit achieved. CEA is distinct from CBA, which assigns a monetary value to the measure of effect. Hence, this approach may be deemed more practical for selecting between investment options when the budgets are fixed and/or benefits are hard to attribute monetary values to while it only requires marginal economic data on costs.

The steps involved in conducting a CEA are described below (Turner et al., 2010, pp. 47-48):

Step 1: Define the environmental objective involved
Step 2: Determine the extent to which the environmental objective is met
Step 3: Identify sources of pollution, pressures and impacts now and in the future over the appropriate time horizon
Step 4: Identify measures to bridge the gap between the reference (baseline) and target situation
Step 5: Assess the effectiveness of these measures in reaching the environmental objective

Step 6: Assess the costs of these measures

Step 7: Rank measures in terms of increasing unit costs

Step 8: Assess the least cost way to reach the environmental objective

4.3.2 **Cost-Benefit Analysis (CBA)**

Regarding CBA, it is a technique that assesses the monetary social costs and benefits of an investment project over a time period in comparison to a well-defined baseline (reference) alternative. In this way the costs and benefits of Multi-Use Offshore Platforms are evaluated and compared and the long-run economic efficiency of implementing the project of Multi-Use platforms is assessed. In particular, in a CBA framework the estimated economic values (benefits) accrued by the involved stakeholder groups are aggregated over their relevant populations and added to capture the total economic value (i.e. total economic benefits) generated by the investment project. The calculated total economic benefits are weighed against the total (fixed and variable) costs of implementing such a project. As a rule, a project is deemed to be socially profitable if total benefits exceed total costs.

Importantly, since this proposed project is expected to have long-run impacts on the local economy and ecology, the project's sustainability is to be tested using a long-run cost CBA, and the net present value (NPV) of the project is to be estimated using different discount rate schemes (Birol et al., 2010). The NPV results will then reveal whether the net benefit generated by the investment project of Multi-Use platforms is positive and significant well into the future, conditional on the utilized discount rate scheme. A general calculation of the NPV is the following:

$$NPV = -\sum_{t=0}^{N} \frac{K_t}{(1+r)^t} + \sum_{t=0}^{N} \frac{B_t - C_t}{(1+r)^t}$$

Where K_t is the construction cost, B_t is the stream of benefits, C_t is the stream of maintenance costs and r is the discount rate.

With regard to CBA application it is important to emphasize that the involved benefits and costs expressed in monetary terms should be adjusted for the time value of money so that all flows over time are expressed in terms of their present value. Therefore the importance of discount rate in assessing the desirability of suggested investments on a ‘sustainable development’ basis is evident, as well as the fact that CBA of long-term investments is enormously sensitive to the discount rate. Hence, special consideration should be given to the fact that actions taken in the light of the Marine Strategy Framework Directive involve economic flows that accrue in the distant future and in the presence of uncertainty due to climate change.

The realization that actions taken today can have long-term consequences, presents a new challenge to decision makers in assessing the desirability of policies and projects, a challenge summarized as the goal of ‘sustainable development’. The use of the classical NPV rule to assess the economic efficiency of policies with costs and benefits that accrue in the long term is problematic. The welfare of future generations barely influences the outcome of such a rule when constant socially efficient discount rates are used for all time. The deleterious effects of exponential discounting ensure that projects that benefit generations in the far distant future at the cost of those in the present are less likely to be seen as efficient, even if the benefits are substantial in future value terms. From the perspective of social choice, the present yields a dictatorship over the future and recent economic literature (Koundouri, 2009, Hepburn et al., 2009; Gollier et al., 2008; Hepburn and Koundouri, 2007) proposes the use of a Declining Discount Rate (DDR).

Therefore, within the project the use of DDR in long-run cost–benefit analysis will replace traditionally employed constant discount rates. Such a DDR increases the weight attached to the welfare of future generations. The policy implications, that we find aligned with the project’s nature and EU’s policy aspirations, are that it implies that the policy-maker will put relatively more effort to improve social welfare in the far distant future than in the shorter time. Furthermore, it has been noted that (Hepburn and Koundouri, 2007, p.177): “the fact that declining discount rates also emerge from specifications of intergenerational equity suggests that they help to reduce the tension between considerations of efficiency and intergenerational equity.”

Finally, it should be also emphasized that the suggested CBA analysis will not only be characterized by the fact that it will extent the financial analysis into a fuller economic cost-benefit format, but it will also provide further modifications which will allow to incorporate fairness and distribution equity concerns (i.e. who gains or losses from environmental change) through for example an equity weighted costs and benefits exercise. This approach will require marginal economic data on costs and benefits.

4.3.3 Multi-Criteria Decision Analysis (MCDA)

MCDA is a method for making decision processes transparent and structured, when there is a large amount of complex information. MCDA can be used for different purposes, e.g.: (1) to identify a most preferred alternative, (2) to rank alternatives against each other, (3) to short-list a set of alternatives or (4) to distinguish the acceptable alternative from the unacceptable (CLG, 2009). See e.g. Brinkhoff (2011) and Huang et al. (2011) for MCDA literature reviews. An MCDA is typically performed in eight steps, shown below[5]. A full MCDA includes, apart from identifying the decision alternatives and the relevant criteria to be assessed, scoring, weighting and finally the combination of these into an overall value for each alternative (CLG, 2009):

1. Establish the decision context. What are the aims of the MCDA, and who are the decision makers and other key players?
2. Identify the decision alternatives.
3. Identify the objectives and criteria that reflect the value associated with the consequences of each alternative.
4. Describe the expected performance of each alternative against the criteria, quantitatively by scores and/or other units.
5. Assign weights for each of the criteria to reflect their relative importance to the decision.
6. Combine the weights and scores for each of the alternatives to derive an overall value.
7. Examine the result.
8. Conduct a sensitivity analysis of the results to changes in scores or weights.

MCDA methods for an overall analysis of alternative preferences against a set of criteria can be divided into: (a) compensatory and, (b) non-compensatory methods.

[5] For less complicated decisions, it is possible to only use steps 1 – 4 and 7 for the analysis, which is then in this section referred to as an MCDA. An MCDA ends with a performance matrix.

In compensatory methods, compensation for weak performance on one criterion is accepted, thus resulting in an assessment of the trade-offs between positive and negative performances. Examples of compensatory methods are the Multi Attribute Value Theory (MAVT) developed by Keeney & Raiffa (1993) where the multi-attribute utilities of an alternative can be calculated using value functions. Another method is the linear additive model where the score of each criterion is multiplied by the weight of that criterion and then all weighted scores are added (Belton & Stewart, 2002). Yet another example is the Analytical Hierarchy Process (AHP) which is a linear additive model where both scoring and weighting are made by pair-wise comparison (Saaty, 1980).

Non-compensatory methods are used when trade-off is unacceptable. There are some different methods which can be used for different purposes, e.g. (CLG, 2009): (1) dominance, i.e. one alternative dominates another if it performs at least as well on all criteria and is definitely better on at least one criterion, (2) conjunctive where all options that don't reach up to some externally set threshold level of performance are excluded, (3) disjunctive selection procedures where an option will pass if it reaches a minimum threshold level of performance for at least one of a set of criteria, (4) lexicographic ordering where supplementary information is provided concerning the ranking of criteria in terms of experienced importance, or (5) elimination by aspect which combines the factors in both the conjunctive/disjunctive models and the lexicographic ordering.

In order to apply an MCDA for a sustainability evaluation of Multi-Use platforms it is necessary to define a set of economic, social and ecological criteria which focus on the nature of Multi-Use platforms, where these criteria are consistent with sustainability and the three spheres of sustainability as defined in Section 1. Consequently, these criteria could be evaluated for each alternative, weighted and integrated using a linear additive model. At this point it should be noted that suggesting a "compensatory method" it is important to restrict how compensations are allowed to be made. Based on a following sensitivity analysis it is possible to evaluate the sustainability of different alternative platforms.

In this context it should be noted that although CBA only provides an aid to decision making the most cost efficient option may not be the most appropriate on other grounds. As a result, an MCDA in these cases can provide an alternative as it permits the inclusion of measurable non-monetary criteria into the assessment and allows for stakeholder deliberation and dialogue.

However, it should be clear that as method for economic analysis, MCDA is considered inadequate to deliver information required by the MSFD as it “does not present comparisons of costs and benefits that provides a CBA of potential measures or informs whether their costs are disproportionate, and therefore would not comply with the minimum requirements of the Directive” (Eftec and Enveco, 2010, p.33). However, MCDA might still be adequate from a MSFD perspective if it explicitly includes economic efficiency as assessed by a CBA as one criterion and if it is possible to sort out the CBA results from the MCDA, see also the following section.

4.3.4 Multi-Criteria Decision Analysis (MCDA) with a Cost-Benefit Analysis (CBA) included

In principle, a MCDA might be carried out with or with the input from a CBA (CLG, 2009). However, considering MCDA as a framework of analysis rather than an alternative to CBA, there is the possibility that MCDA can integrate the results of a CBA with other aspects of a decision to allow decision-makers to choose the most appropriate course of action. That is, if economic efficiency is included as a criterion in a MCDA, CBA is needed as a tool for investigating to what extent this criterion is met. In a sustainability perspective, the CBA could in this way account for the economic dimension of the MCDA, whereas complementary criteria should be developed in the ecological and social dimensions.

A common difficulty in MCDA applications is to avoid overlapping criteria. Overlapping might result in that some aspects obtains a greater impact on the MCDA results than what was intended, i.e. a type of double-counting. Due consideration has to be taken to this difficulty when defining criteria for the ecological, economic and social dimensions of sustainability. For example, sometimes the same type of effect/service can be evaluated in both the economic and the social dimension. However, this does not necessarily imply a double-counting because economic and social criteria might be complementary. Also other goals than economic efficiency is typically seen as desirable in society, for example, an equitable distribution of ecosystem services, minimum health standards for all citizens, etc. Also, we may not be able to monetize all relevant values. For example, WTP is the value people place on some service based on what they think is appropriate for them as individuals, since the choice is directly connected to and constrained by personal income

(SAB, 2009). However, the same individuals, having a community well-being perspective, can place another kind of value, e.g. ethical value, on the same service denoting the degree of its importance for humanity, which is not necessarily reflected by their WTP. That is, there might be a fundamental difference between their roles as consumers and citizens (Sagoff, 2007). This relates to a distinction between “individual WTP” and “social WTP” as described by Fish et al. (2011).

4.4 A limited data approach for socio-economic impact assessment

One of the most challenging tasks in impact assessment methodology is the use of a “parsimonious” approach that moves the focus from site-specific, processes based models and data, to the use of simulation models parameterized with population data (Antle & Valvidia 2006, Antle & Valvidia 2011, Antle 2011). Highly noticeable advantages of the generic model structure is the assessment design and significantly lower data needs which enable researchers to identify essential data, avoid collection of excessive data, and integrate data collection into technology development projects. The generic structure and parameter parsimony also simplify the utilization of the various types of data that may be available, including survey, experimental, modeled, and aggregated secondary data, as well as expert knowledge. The parsimonious structure also provides a framework in which sensitivity analysis of model parameters can be easily conducted. In other words, “minimum-data Tradeoff Analysis” (TOA-MD) is also well-suited to address the uncertainty in impact assessments, by using sensitivity analysis to explore how results are affected by different assumptions. This approach relies on form of a generic TOA-MD model that can be employed to assess impacts in a wide array of applications including agricultural, social and economic data populations (Antle and Valdivia 2010).

Put it differently, parameter estimation through TOA-MD relies on the use of low-order moments of outcome distributions. These parameters can be estimated reliably with small samples using standard “method of moments” estimates of means, variances and correlations and their standard errors. This feature contradicts structural or reduced-form econometric models that commonly rely on large sample properties of estimators, and must comply with endogeneity and identification issues.

The TOA-MD model is a prominent simulation tool that employs a statistical description of a heterogeneous population of decision making units (DMUs) to simulate the proportion of DMUs that utilizes a baseline system and the proportion of DMUs that would adopt an alternative system within defined strata of the population. Based on the predicted adoption rate of the alternative system, the TOA-MD model simulates associated economic, environmental and social impacts on adopters, non-adopters and the entire population. It should be also noted that population under investigation must be divided into different strata.

A distinctive feature of the TOA-MD model is its qualification to exploit statistical relationships between technology adoption and the environmental, economic and social outcomes related to adoption. According to economic research findings accounting for inter-relationships between adoption and outcomes is of paramount importance to attain precise estimates of impact which has important implications for data collection.

The data requirements for TOA-MD model are the following:

•population means and variances of production, output price and cost of production, for each activity
•population means and variances of environmental and social outcomes associated with each system
•correlations between system returns and environmental and social outcomes
• population means and variances of DMUs characteristics such as size, income generated outside basic activity etc.

To sum up, by employing TOA-MD, it is feasible to carry out an integrated assessment of economic, environmental and social impacts at low cost relative to methods that rely on case-specific, complex socio-economic simulation models. Referring to an earlier point, the critical decision for adopting limiting data approach will be made in terms of acquiring the most robust and informative results under the constraint of available list of data for each case study.[6] Stated differently, the threshold point for deciding on the best approach will be determined after we finish gathering case study-specific datasets and completing initial data analysis. According to Antle &

[6] AUEB-RC Economists team has the expertise on limiting data approach and is willing to share it with the people of Mermaid project

Valvidia (2011) cost reduction through TOA-MD is twofold. First, by using a generic model that can be applied to virtually any system, the time and resources needed to design a new model for each case are significantly curtailed. Second, by pinpointing in advance the indicators that need to be quantified, any data collection activities can be focused on the relevant information, thus eliminating the cost and respondent burden caused by the “kitchen sink” approach to survey design. Moreover, the TOA-MD approach reveals that correlations between economic, environmental and social data are often necessary in order to obtain accurate estimates of impact. Acknowledging this need in advance, can significantly reduce the cost of collecting data and at the same time improve the quality of impact assessment.

5 Risk analysis approach

It should be clear that whatever methodology is used to conduct the assessment, all results should be subjected to a rigorous uncertainty/sensitivity analysis[7] since “uncertainty is present at all stages of the assessment process, whether it be uncertainty about the magnitude of physical impacts and their geographical and temporal distribution, or uncertainty over the value of changes in ecosystem final services and goods” (Turner et al., 2010, p.23).

In this context, a way to explore uncertainty in a constructive manner is through sensitivity analysis. Importantly, this approach can be used to identify the parameters of the system which are particularly subject to uncertainty and have a significant impact on the overall outcome of the assessment.

A sensitivity analysis can be included within a CBA, to assess the impact on the benefit cost ratio and/or net present value of changes in the values of central parameters, e.g., the value of costs and benefits or the discount rate (Turner et al., 2010). In this framework, by examining the impact that increasing costs (or reduced benefits) may have on the net present value, it is possible to determine the breakeven point whereby the scheme would be no longer justifiable. Furthermore, in a CBA framework it may be relevant to perform an uncertainty analysis rather than just sensitivity analysis,

[7] CUT partners have the expertise to give advice on relevant procedures, not least the Monte Carlo approach with respect to both CBA and MCA

e.g. by assigning parameter uncertainty in the CBA and performing Monte Carlo-simulations as described below. This will also include a sensitivity analysis, i.e. to what parameters is the outcome most sensitive, how certain are we that option X is the “best”.

The MCDA framework also allows sensitivity analysis and enables decision makers to compare un-weighted rankings of management options with weighted rankings to gauge the level of support for, and possible impact of, their decisions. In addition, it is possible to incorporate different preferences and priorities of a number of different users of a resource in the form of weighted rankings of different options.

Furthermore, uncertainty about each parameter value can be captured by a discrete or continuous (if the uncertainty in e.g. benefits and costs items are to be studied) probability distribution and then sampling from these distributions will be conducted to define the deterministic model that will be used to compute the social costs/benefits. A further step in including uncertainty will be to ask experts for their estimates of the most likely value of parameters of interest, together with high and low estimates and assessments of the likelihood that actual values would lay above or below these upper and lower estimates. This will enable to form Bayesian prior distribution for each parameter.

Risk analysis

Risk analysis or risk assessment in CBA is aiming at addressing uncertainty associated with the future cash flows of a project. In risk analysis the ‘stand alone’ risk for the project is analyzed. This type of risk represents measurable uncertainty which is the case where a known probability measure is associated with stochastic variables. Accounting for risk requires therefore an assessment of probability distributions indicating the likelihood of the realized value of a variable falling within stated limits.[8]

Risk assessment implies the estimation of the sensitivity of the project performance to stochastic effects and potentially the probability that a project will achieve a satisfactory performance, where performance is measured in terms of some threshold value of the NPV or the *Internal Rate of Return* (IRR). Probability should here be understood as an index that takes the value 1 under full

[8] In contrast in the case of pure uncertainty specific probabilities cannot be assigned to random events.

certainty that a prediction will be confirmed, a zero value for certainty that the prediction will not be confirmed, and intermediate values for anything in between the two extremes. In this context risk assessment can be used to make inference and test hypothesis in the statistical sense. Thus with an appropriate risk assessment an analyst can estimate the probability that the NPV or the IRR of a project will be between pre specified limits (confidence interval estimation), or that will be above some acceptable cut-off level.

Uncertainty of future cash flows is natural consequence of the fact that these cash flows represent forecasts based on current knowledge and future expectations. For example, the forecasts of unit sales and sales prices are normally made by a marketing group, based on their knowledge of price elasticity, advertising effects, the state of the economy, competitors' reactions, and trends in consumers' tastes. Similarly, the capital outlays associated with a new product are generally obtained from the engineering and product development staffs, while operating costs are estimated by cost accountants, production experts, personnel specialists, purchasing agents, and so forth.

For the specific project that analyzes the viability/sustainability of Multi-Use Offshore Platforms, costs and benefits associated with offshore wind farms and aquaculture are expected to embody considerable uncertainties. These uncertainties will affect not just the economic part of the project, that is prices and unit costs, but also the natural and the technological part that will affect quantities of inputs and outputs and environmental impacts. In particular variables associated with wind power production, aquaculture and transport maritime services, production and demand conditions under existing production structures and proposed multi-functional structures, which will determine the future cash flows of the Multi-Use Offshore Platforms, are affected by strong stochastic factors. Furthermore, the project will address different natural environments from deep water (north of Spain), to shallow water with high morphological activity (the Wadden sea), and further to inner waters like the inner Danish/Baltic areas and the Adriatic Sea. This spatial differentiation implies strong and spatially non homogeneous physical and environmental risks.

Summarizing risks associated with the project could be classified as (i) economic, (ii) natural – environmental, and (iii) technological. These risks will affect the cash flows of the project and consequently the NPV and the IRR.

Define the NPV of the project as:

$$NPV(r) = C_0 + \frac{C_1}{1+r} + ... + \frac{C_k}{(1+r)^{k-1}} + \sum_{t=k}^{T-1} \frac{p_t x Q_t - c_t x L_t}{(1+r)^t} \tag{1.1}$$

where $(C_0, ..., C_{k-1})$ is the flow of capital outlays that correspond to the construction period of the project assumed to last k years, and $p_t = (p_{1t}, ..., p_{nt}), Q_t = (Q_{1t}, ...Q_{nt}), c_t = (c_{1t}, ...c_{mt}), L_t = (L_{1t}, ..., L_{mt})$ are vectors of prices, project outputs, unit operating costs and project input respectively, and T is the duration of the project. Thus $p_t x Q_t$ denotes the flow of revenues at time *t* and $c_t x L_t$ denotes the flow of operating costs. The discount rate is assumed to be *r* and constant for the duration of the project, but variable with respect to time and in particular declining discount rates can be considered without any difficulty. Given the definition of the NPV the IRR of the project is defined as the discount rate *i* such that:

$$0 = C_0 + \frac{C_1}{1+i} + ... + \frac{C_k}{(1+i)^{k-1}} + \sum_{t=k}^{T-1} \frac{p_t x Q_t - c_t x L_t}{(1+i)^t} \quad or \; NPV(i) = 0 \tag{1.2}$$

Formulas (1.1) and (1.2) will be used as abstract objects for presenting, at this initial stage, the methods for risk assessment. Given the specific data from the project specific quantitative results will be derived.

Risk assessment can be carried at three different but interconnected levels. (i) Sensitivity analysis, (ii) Scenario Analysis and (iii) Monte Carlo Simulations.

Sensitivity Analysis

Sensitivity analysis is a technique that indicates how much the NPV or the IRR will change in response to a given change in variables that affects the cash flow of the project, other things held constant.

Sensitivity analysis involves the following steps:

1. Define a **base-case or benchmark** estimation of the NPV and the IRR, which is developed using the ***expected values*** for each variable involved in the cash flow.
2. Identify **sensitive or critical variables**. These are cash flow variables (e.g., unit labor cost, average wind velocity, fish output, fish price) with the property that a small deviations of their values from the benchmark value will change the NPV or the IRR a lot.
3. Construct a **sensitivity diagram** (Figure 8) that relates proportional changes in the critical variable to proportional changes in the NPV or IRR. In the graph below critical variables are sales price and variable cost, while the weighted average cost of capital cannot be regarded as sensitive variable.

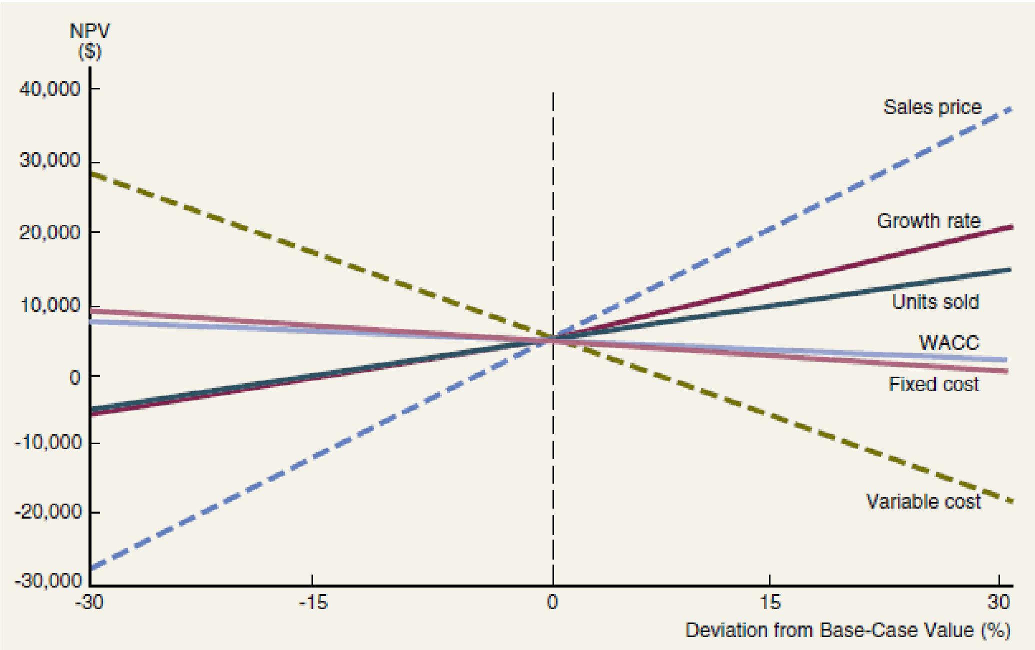

Figure 8: Sensitivity diagram (Source: Brigham and Houston (2003))

4. Identify **switching values** for important cash flow variables. A switching value is the value of the variable at which the NPV becomes zero or falls below a cut- off level.

Scenario Analysis

Sensitivity analysis provides descriptive result, but it does not allow for statistical inference and hypothesis testing with respect to the NPV or the IRR of the project. Scenario analysis introduces a **subjective probability distribution** that describes the probabilities of changes in the key variables, allowing thus to change more than one variable at a time. Scenario analysis involves the following steps:

1. Calculate the NPV and the IRR for a **base case or benchmark scenario**. A 50% probability is usually assigned to this scenario.
2. Calculate the NPV and the IRR for a **best case scenario**. A 25% probability is usually assigned to this scenario.
3. Calculate the NPV and the IRR for a **worst case scenario**. A 25% probability is usually assigned to this scenario

A scenario should be consistent regarding the assumptions about the evolution or trends of important cash flow variables and can be constructed using either a bottom-up or a top down approach. If an adequately large number of scenarios can be formulated so that a probability distribution for the NPV or the IRR can be approximated then the scenario method can be used for the construction of confidence intervals and hypothesis testing.

In practice the ability to generate a large number of scenarios is limited, and scenario analysis considers only a few discrete outcomes for NPVs and IRRs. Even however with a small number of scenarios the analyst may derive an adequate picture of the stand alone risk associated with the project, since probabilities can be directly assigned to NPV and IRR values.

Monte Carlo Method

The Monte Carlo method is a computational algorithm which is based on random sampling. To use the method the analyst need to assign specific subjective probability distributions (e.g. uniform, triangular, normal, lognormal) to important cash flow variables. The method proceeds in the following steps:

1. A value of a variable is selected from its distribution using a random number generator.
2. A vector of specific values is defined (e.g. unit labor cost , average wind velocity, fish output, fish price)
3. These value are used to calculate an NPV and an IRR which are stored for this replication

4. After a large number of replication (500-1000) a frequency distribution is estimated for the NPV and/or the IRR.
5. Making the normality assumption the estimated distribution can be used to construct confidence intervals and perform hypothesis testing.

Application

The purpose of risk analysis for the specific project is to apply sensitivity and scenario analysis - and potentially, depending on the availability of disaggregated data that will allow the meaningful approximation of probability distributions for important variables, Monte Carlo simulations – in order to assess the stand alone risk of the project.

The methodology will be applied to: Task 8.3, Task 8.4, Task 8.5. The target will be to provide a risk assessment of the economic viability/sustainability of multi-use platforms in the specific areas.

To perform an adequate risk analysis the cash flow of the project should be provided in a suitably **disaggregated form** so that critical variables and probability distributions can be determined.

6 Life Cycle Assessment of Multi-Use Offshore Platforms

Life Cycle Assessment aims to determine environmental effects of a product/ function of a product based on a “from cradle to grave” view. However, it is different from Environmental Impact Assessment (EIA) and Risk Analysis because of being product oriented. LCA can be used to make a strengths & weaknesses analysis, product improvement and product comparison. By this way, it supports decision making process by converting personal opinions to objective facts. It may contribute to remedies in design stage and provide environmental and economic benefits.

LCA has mainly three stages which is identifying and quantifying the environmental loads involved (energy and raw materials used, emissions, wastes), assessing and evaluating potential environmental impacts of the loads and assessing the opportunities available to bring about environmental improvements (UNEP, 1996). This stage continues to the end of the study because LCA is an iterative process which develops continuously.

Moreover, it should be noted that LCA can serve as valuable resource to other forms of analysis such as CBA. To this end, CBA can certainly integrate the results and the uncertainties derived from LCA and risk analysis respectively.

In the previous studies on LCA of wind power and wave energy devices, function of a product is defined as 1 kWh electricity (Sørensen and Naef, 2008; VESTAS, 2006). In this study a function of a product will be suggested to evaluate MUPs since, the only product of this complex system is not electricity.

There are several studies comparing separately wind and wave energy devices and other conventional energy generating methods (Sørensen et al., 2007). In the context of this study this comparison will be excluded due to the fact that this kind of comparisons has already been made. LCA will be used as a comparison tool between separate functions (wind power production, aquaculture, and transport and wave energy production) and MUPs. Additionally LCA is going to be executed for four sites even though LCA is not a site specific method, because of being product/function of a product based. The results for four sites are expected to be different from each other due to various resource usages, material transportation methods and distances and also construction methods.

In addition, it is intended to increase site-specific sensitivity of executed four LCA studies, by integrating the results with the results of risk analysis study which is only valid if the risk analysis study includes environmental risks.

Because LCA is an iterative process, firstly approximate results will be obtained and after in each step more detailed results will be reached repeating the steps in a more detailed manner. The results obtained at the end of the study will depend on amount and quality of the data gathered.

Data Requirement

A wide range of information is going to be required to conduct the LCA study for MUPs. Required data can be classified into phases of MUPs from cradle to grave. In this context, this timeline can briefly be divided into 4 phases as manufacturing process, transport and on-site erection, operation & maintenance and dismantling and recycling.

In the manufacturing phase, structure of the MUPs, the materials that will be used and their approximate masses, power and duty cycle during the manufacturing, transport distances and their methods and other energy requirements will be required (Guezuraga, 2012). For the transport and on-site erection phase, transport methods and distances, and construction methods are going to take place in the LCA inventory.

Operation and maintenance phase includes the actions through daily activities of the MUPs. So, maintenance operations, transfer of workers, replacement routine of some parts of the constructed structure will be needed (Guezuraga, 2012). In addition, for the aquaculture component of MUPs, daily activities for aquaculture and also the fish production should be known. Fish feeds, fish farming methods, fuel, heat energy and water need are some of the required data for this part (Papatryphon, et al., 2003).

The dismantling and recycling phase includes dismantling of the whole structure, its transportation and also recycling of the suitable components. In this part, methods and recycling opportunities of the materials are required knowledge for LCA database.

7 Policy recommendations

The followed methodology to this point is anticipated to provide decision makers with valuable insight regarding different aspects of the suggested novel constructions.

The results will suggest whether the project should be undertaken under alternative specifications regarding the discount rate and the stream of benefits if a CBA is to be followed or sensitivity analysis of selected criteria in a MCDA framework. This outcome will provide a rational to policy makers for the project appraisal and will provide evidence on whether Multi-Use platforms result in an increase of the overall social welfare.

In addition, the ISEA will provide insight on the determinants of public attitudes toward Multi-Use platforms (through consultation and surveys) that national and European policy makers should take into consideration when selecting the appropriate policy responses for efficient energy management. An implication for policy-makers could be that potential objection from local populations against such projects can be limited given that sufficient information is provided. Overall results will assess the viability of the novel constructions that optimize marine space allocation for different marine activities and provide evidence of their potential to provide us with environmentally-friendly and cost –efficient energy, food supply and maritime services.

In this framework and supported by the LCA approach, it will be possible to identify key impacts of interest related to different constructions and suggest potential mitigation options in order to minimize risk and non acceptable negative effects.

Importantly, this section is to provide policy recommendations harmonized with national and European policy frameworks.

In a European context results will directly contribute to the adopted EU Green Paper on Energy (COM, 2006) which develops a European strategy to ensure energy security, stable economic conditions and effective action against climate change. The Green Paper underlines the importance of Renewable Sources to ensure sustainable, competitive and secure energy. In this respect the EC announced a Renewable Energy Road Map which specifies policy action to be undertaken to meet the challenge of promoting Renewables to a degree that the share of electricity from renewable energy sources in the EU consumption reaches 21% by 2010.

Furthermore, it is important to note that the suggested novel plans will be in accordance with the recent Marine Strategy Framework Directive (MSFD - Directive 2008/56/EC) demonstrating in this way a sustainable use of the marine environment. The Directive provides a legal obligation to define a Good Environmental Status (GES) for all European regional seas by July 2012, and reach it by July 2020.

For that purpose, marine strategies shall be developed and implemented in order to protect and preserve the marine environment, prevent its deterioration or, where practicable, restore marine ecosystems in areas where they have been adversely affected. In addition, marine strategies shall prevent and reduce inputs in the marine environment, with a view to phasing out pollution (as defined in Art. 3(8) in the Directive), so as to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea.

The MSFD focuses on the protection of all marine waters, by preventing deterioration or, where practicable, restoration of marine ecosystems. Therefore, the Directive calls for a management that is aimed at achieving good environmental status and enables sustainable use. This means that the Directive does not prohibit the use of the marine environment, but requires the use to be sustainable.

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