MERMAID

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Socio-economic Analysis of the Baltic Site

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Produced by:	**AUEB:** Amerissa Giannouli
Contributors:	**AUEB-RC**: Phoebe Koundouri, Amerissa Giannouli, Tasos Xepapadeas, Petros Xepapadeas, Evita Mailli, Osiel Gonzalez Davila, Eleftherios Levantis, Nikolaos Kourogenis **DHI:** Flemming Møhlenberg, Ole Svenstrup Petersen, Nick Aarup Ahrensberg **EEWRC**: Elias Giannakis **ITU:** Nilay Elginoz, Bilge Baş **Stichting DLO**: Christine Röckmann (IMARES), Marian Stuiver, Sander van den Burg
Work Package Leader Responsible:	Phoebe Koundouri AUEB-RC
Reviewed by:	All task partners

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1 Introduction and scope of the deliverable

1.1 Goals and objectives of the deliverable

MERMAID aims at integrating and improving today's technology in an optimal way in order to enhance economic feasibility, reduce environmental impact and to increase the use of ocean space at specific sites, by means of Multi-Use Offshore Platforms (MUOPs). In MERMAID, business opportunities associated with MUOPs are investigated in four different locations in Europe through a financial assessment. In addition, MERMAID aims at identifying the impact on human welfare of MUOPs through a framework for socio-economic assessment. This framework takes into account the fact that human welfare is dependent on a wide range of social and economic aspects, including ecosystem services.

The overarching aim of this deliverable is to assess the sustainable development of the final conceptual designs of MUOPs. Sustainable development is described by a three-dimensional sustainability condition. In particular, in the framework of analysis, sustainable development is achieved when the following conditions are simultaneously satisfied:

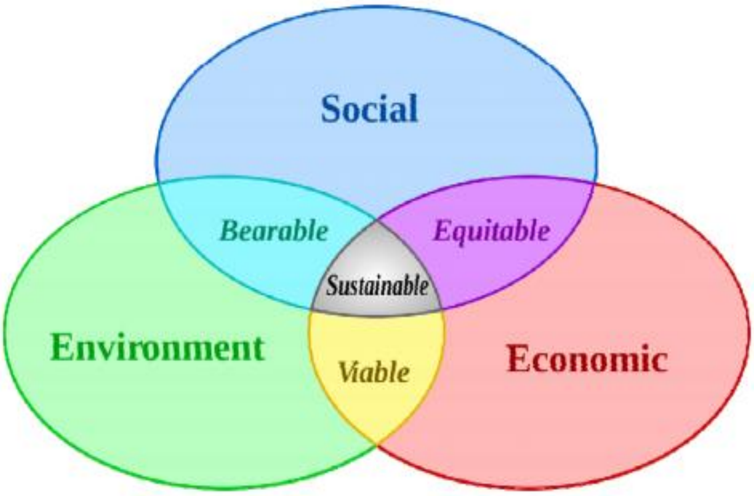

Figure 1 Spheres of Sustainable Development (W.C.O.E.A.D./Brundtland Commission, (1987); UN (2015)

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 an integrated economic assessment in terms of efficiency. When the economic efficiency condition is satisfied over time (inter-generationally) and over space (intra-generationally) the economic sustainability of the considered production activities is achieved.

b. <u>Dynamic and Spatial Social Equity and Sustainability</u>: Social equity requires that the social effects of the production activities under consideration are bearable and equitable 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. <u>Dynamic and Spatial Environmental and Ecological Sustainability</u>: 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.

In this deliverable, we examine the possibility of sustainable development of the developed conceptual MUOP design by socio-economically assess the envisioned MUOP to be placed in the **Baltic.**

The specific location is called **Kriegers Flak**, which is a shallow ground within the Danish Exclusive Economic Zone (EEZ) in the estuary of the Baltic Sea. The Baltic Sea is the world's largest estuary, comprising salty North Sea water mixed with freshwater from rivers from Russia, Scandinavia, the Baltic countries, and a large part of Northern Europe. Kriegers Flak is a shallow (25m) ground situated at the confluence of the Danish, Swedish and German economic interest zone, approximately 15 km from Danish and Swedish coasts. Studies within MERMAID have indicated that the site is very well suited for MUOP development, the site being characterized by medium, but high quality, wind resource, moderate exposure to waves, and currents and salinities and temperature being close to optimal for salmon aquaculture It is an excellent site for harvesting of MUOP synergies, combining a 600 MW offshore wind power plant, 10,000 tons salmon aquaculture and possibly biomass production from seaweed.

The wind farm is estimated to consist of two areas with a total of 8 MW turbines. The seabed conditions are good, thus foundations may be of gravity-base type or driven monopiles. In addition to the turbines, two 220 kV substations and necessary submarine cables to onshore connections are planned.

The fish farming is planned as two separate facilities located between the two groups of turbines to gain some physical protection from the foundations and the wind turbines. Each fish farm section will consist of 12-14 round cages with a diameter of 45 m and a feeding barge delivering feed by means of compressed air through tubes to each cage. The depth of the net cages will be 12-15 m and the cages may be either floating or submersible. The conditions at the site are favourable in terms of dilution of waste from the farm and optimal conditions for fish growth and quality. More detailed information about the decisions of the MUOP design can be found in the rest of MERMAID Deliverables (e.g. MERMAID 2.4, MERMAID D7.2, MERMAID D7.3).

In the Baltic Sea an important shared resource is ocean space. Therefore, more efficient utilization of the space by co-locating aquaculture and wind energy plants is an important feature of a MUOP here.

Table 1 Baltic Site Factsheet

Geographical location	Kriegers Flak, Western Baltic Sea
Offshore distance	15 km east of the Danish coast
Depth	18-40 m
Substrate	Sandy layer (thickness of up to 8 m)
Surface water temperature	0-20^{o}C
Salinity	7-9 psu (upper 15-18m)
Currents density	Variable currents driven by wind, gradients & differences in sea level
Mean tidal range	No tides present
Wave height	Mostly moderate (1-1.5m)

1.2 Relationship to overall project objectives

This deliverable presents the results of the application of the Methodology for Integrated Socio-Economic Assessment (MISEA) which was developed in MERMAID (MERMAID D8.1) to socio-economically assess the different proposed designs of novel Multi-Use Offshore Platforms (MUOPs). MISEA assists on identifying, not only the potential range of impacts of a proposed investment such as the construction of MUOPs, but also the likely responses of those impacted by the investment project. Since it is anticipated that these novel designs of platforms will have considerable socioeconomic and environmental impacts, MISEA provides an analytical framework that lies in agreement with the sustainability conditions. MISEA assists on designing appropriate mitigation strategies to minimize negative and maximize positive socio-economic and environmental impacts. In this context, this methodology extends the standard process of financial analysis into an assessment that incorporates socio-economic, legal, technological environmental parameters.

In particular, the methodology allows a stepwise approach of integrating information produced in the previous work packages (WPs) of the project towards the socio-economic assessment of different designs (being built by the engineers of MERMAID in previous WPs) of MUOPs. The multi-disciplinary information, allows a direct comparison between different MUOP designs, including comparison between multi-use and single-use alternatives. Under MERMAID, the information produced by the different WPs was used for the socio-economic assessment in each selected site and platform design.

- Legal and policy analysis provided the policy and legal background required for the development of the particular platform designs. Stakeholders' analysis and more specifically the stakeholders' roundtables provided inputs to for the final design and the socio-economic assessment of the selected MUOPs with regards to social acceptance and potential conflicts between stakeholders (MERMAID D2.1, MERMAID D2.4 and MERMAID Repository[1]: Regional Profiling Datasets).

- The identification of innovative platform designs formed the background required for the collection of the financial data, as well as the socio-economic analysis and monetization of environmental externalities. (MERMAID D7.1, MERMAID D7.2, MERMAID D7.3, and MERMAID Repository[2]: Regional Profiling Datasets).

- The case-study specific environmental assessments (MERMAID Repository[3]: Regional Profiling Datasets) identified the environmental effects in relation to the suggested designs. MUOPs are related to a stream of new social/environmental goods and services (e.g., increase of employment, increase food and energy security, potential interactions with marine environment etc.) with no values readily observed in existing markets. Hence, it was required to follow non-market economic valuation methods to estimate these values (Economic Valuation Methods are explained in D8.1). Although the information was limited and based on experts' opinions and stakeholder's views, the economic values of the main environmental externalities were estimated successfully.

- The case-study specific financial feasibility assessment was crucial for the comparison between different offshore platforms. The data used in the financial assessment were the investment costs with regards to equipment, construction, labor and other costs, as well as operation data for the costs and revenues according to different functions used in the final design of each study site (e.g. energy/aquaculture production output, price, raw materials, energy used, maintenance costs, operating costs).

This methodology provided useful information on which economic activities should be implemented on the different sites, with the scope to avoid developments that would have negative socio-economic and environmental consequences, considering legal and technical aspects. This load of information assists on identifying challenges and opportunities towards the implementation of suggested MUOPs. A representation of the connections between the WPs' outputs used as inputs is given below.

[1] http://mermaid.madgik.di.uoa.gr/
[2] http://mermaid.madgik.di.uoa.gr/
[3] http://mermaid.madgik.di.uoa.gr/

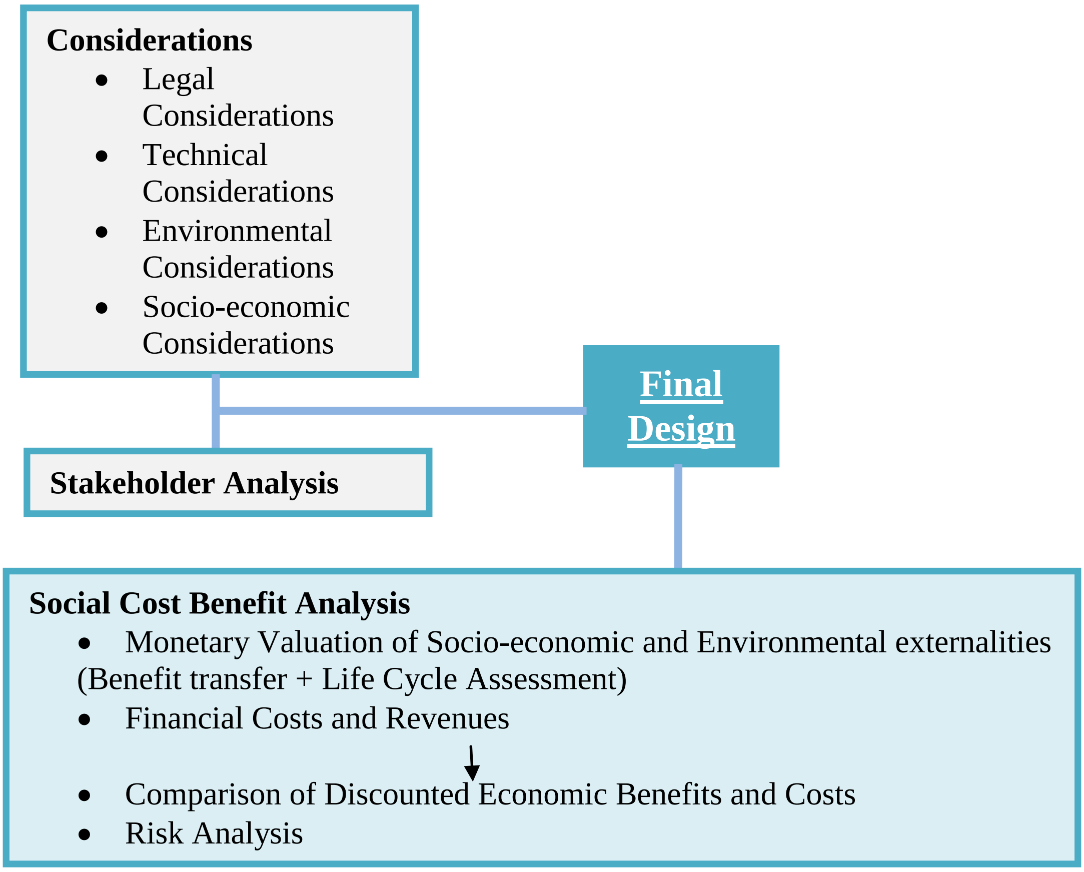

Figure 2 MERMAID Stepwise approach of integrating information

1.3 Outline for the reader

The document is divided into **6** different sections. **Section 2** describes the general methodology framework of the conducted assessment and introduces the online assessment tool as the application of this methodology. **Section 3** includes a regional description of the Baltic Sea site. **Section 4** describes the economic valuation of environmental changes. **Section 5** includes the financial assessment for the Baltic Sea site. **Section 6** includes the undertaken social cost benefit analysis and **Section 7** offers concluding remarks and recommendations.

2 General framework of the methodology and introduction to the Assessment Tool

2.1 The methodology for Socio-economic Assessment of MUOPs

In this section the Methodology for Integrated Socio-economic Assessment (MISEA) is described in detail. This methodology allows us to identify, valuate and assess the potential range of impacts of different feasible designs of MUOP investments, and the responses of those impacted by the investment project. This methodology aims to investigate the possible sustainable development of MUOP investments, by focusing on marine sustainable management, extending the standard process of financial analysis into an interdisciplinary assessment that incorporates socio-economic, technological, legal and environmental parameters, parameters, aiming at an estimation of the total impact on economic welfare in society.

Economic welfare includes the net benefit earned by a private company, as well as the total benefit /cost to the national economy. If we want to capture the total economic value of a project we need to consider the socio-economic and possible environmental impacts to the ecosystem.

Socio-economic impacts can be characterized as “direct” and “indirect”. This distinction is with regards to the level of effect on those who are involved in the MUOPs, meaning that particular economic sectors and people can be affected directly and/or indirectly by the use and operation on MUOPs. Direct impacts correspond to the earning capacity and costs of aquaculture, energy and maritime business, concerning for example the employees and their families, as well as the suppliers of aquaculture, energy and maritime businesses. Indirect impacts on the other hand are related to impacts on consumers and the broader economy.

Based on the analysis produced under each MUOP design for each site and the stakeholders’ views (MERMAID D2.4), MUOPs will create new employment opportunities and will have strong economic impact in the community. Enterprises will benefit by the development of new technologies and will improve the technical capacities for energy production and aquaculture. In addition, MUOPs have the potential to increase research and development regarding technological advances and to boost educational aspects.

Accordingly, implementing an MUOP would affect the environment and the ecosystem services. Ecosystem services are defined as services provided by the natural environment that benefit people (Defra, 2007). Individuals place values on the environmental resources and their ecosystem services for given changes in their quality and/or quantity, which are expressed in relative terms based on individuals’ preferences. Based on the MERMAID EIA manual, experts opinions of the MERMAID project and Life Cycle Assessment (LCA), environmental effects were identified. These were linked to human welfare and their value was elicited using economic theory.

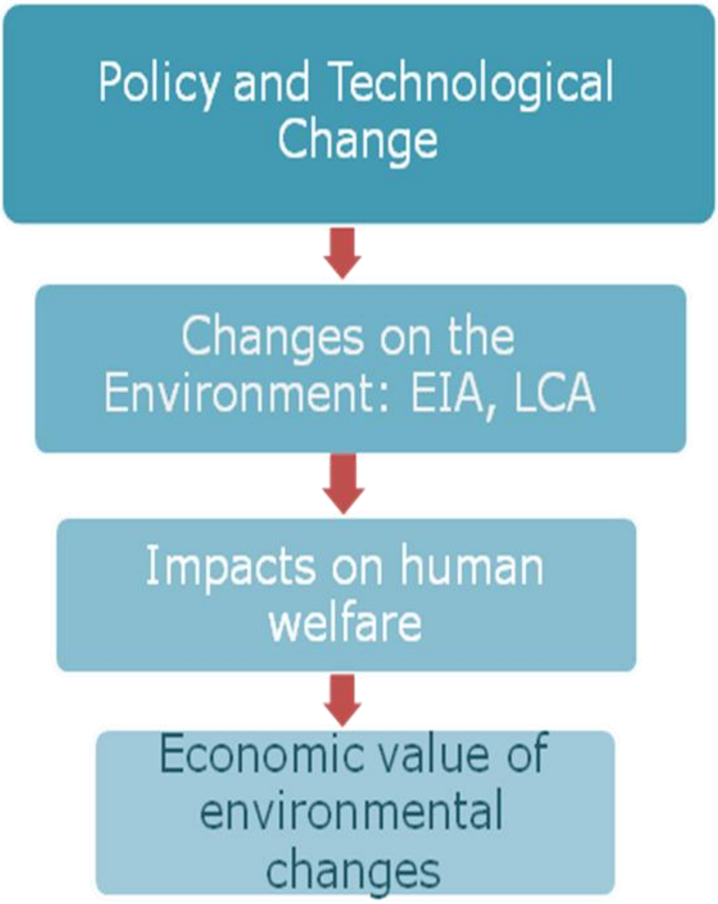

Figure 3 Overview of the impact pathway of policy and technological change

The Total Economic Value (TEV) for any given product or resource is the sum of use (direct, indirect, option value) and non-use values (altruistic, bequest, existence value). Natural resources and their ecosystem services are generally not traded in markets. As a result no market price is available to reflect the economic value of environmental changes. Hence, expressing these impacts in monetary terms using non-market methods is required (see Freeman et al., 2014). We present at the next figure the TEV framework and the economic techniques used in economic valuation of benefits derived from the ecosystem services (see D8.1 for more details).

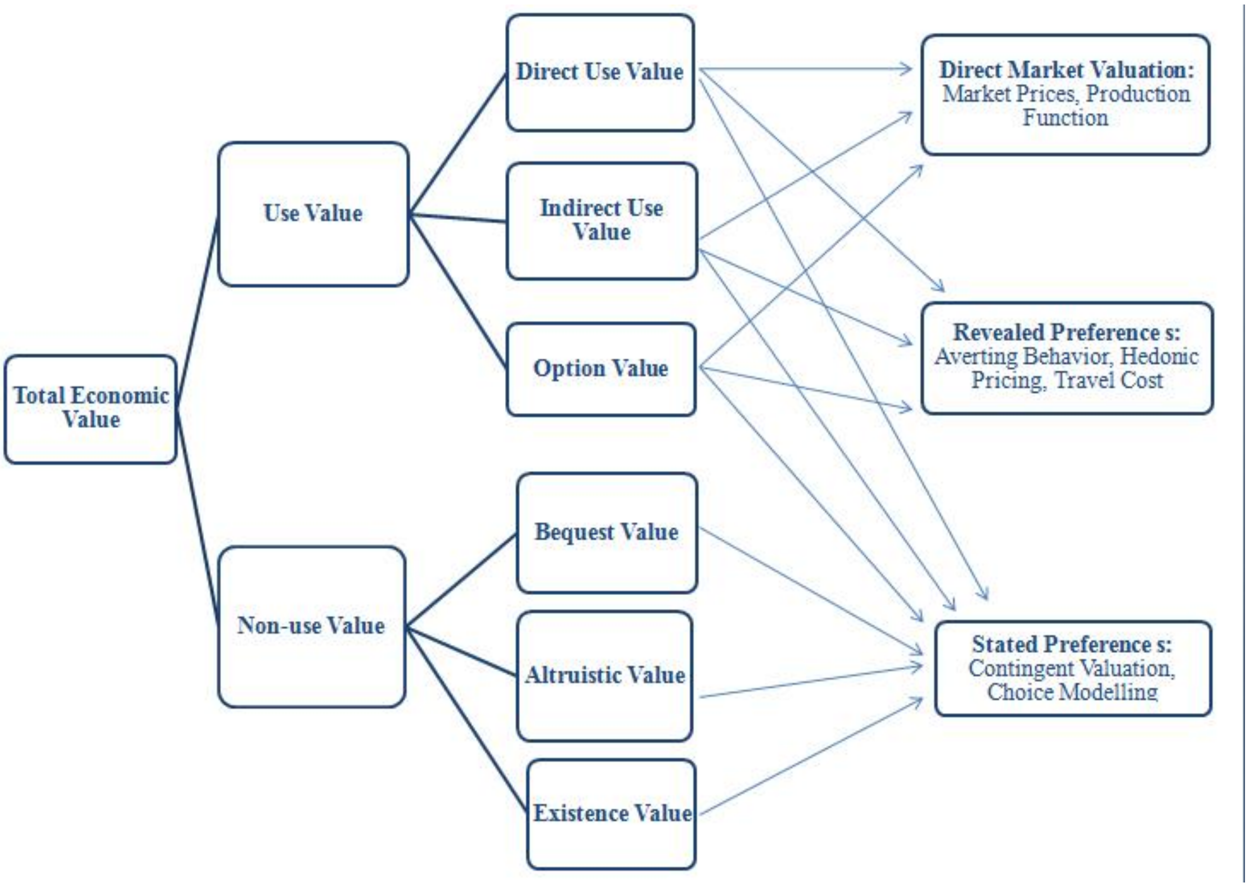

Figure 4 Techniques for monetary valuation of non-market services (Koundouri and Giannouli, 2015)

Primary valuation can be done either using stated preferences or revealed preferences techniques. However, in MERMAID, the benefit transfer method was applied for the socio-economic assessment, i.e. monetary estimates of the non-market value of impacts of MERMAID study sites were derived from earlier studies (Johnston et al., 2015). In addition, based on the Life Cycle Assessment (LCA), we compared each platform's CO_2 emissions to those that would have been produced via traditional (not renewable) energy sources as the result of producing same amount of electricity and aquaculture products. For this case, we used the social cost of carbon (SCC) to estimate the benefits produced from this comparison. After the identification and quantification of the environmental and socio-economic benefits, the financial costs and revenues from energy extraction and aquaculture production were included into the analysis.

More explicitly, MISEA consists of the following steps:

- **Scoping Phase** Defining boundaries, key impacts, key stakeholders, information availability

<u>Socio-economic characterization of the existing situation in the site with regards to wind power production, aquaculture and transport maritime services</u>: The collection of required data for the socio-economic

characterization was performed during the implementation of the regional baseline characterization questionnaire (MERMAID Repository[4]: Regional Profiling Datasets). See section 3.

- **STEP 1** Socio-economic characterization per case study: Wind power, wave power and aquaculture production

Production-Side Analysis of Multi-use Space: This analysis is based on estimated financial costs of offshore structures, and also on the costs of environmental and ecological changes due to the proposed multi-use structure, as identified by the environmental impact assessment.

Demand-Side Analysis of Multi-use Space: This analysis depends on the evaluation of socio-economic consumption benefits related to the proposed structures and also on the benefits of environmental and ecological changes due to the proposed multi-use structure, as identified by the environmental impact assessment/environmental analysis.

- **STEP 2** Translated Externalities into financial flows: Benefit transfer and Life Cycle Assessment (LCA)

Costs and benefits produced by environmental change related to wind power, wave power and aquaculture production were estimated using benefit transfer methods (transferring monetary values from earlier studies to the policy site) and relying on the Life Cycle Assessment with regards to CO_2 emissions quantity change. (See section 4)

- **STEP 3** Recommendations based on economic tools: Social Cost-Benefit Analysis (SCBA)

The last step for assessing viability is the use of Cost Benefit Analysis (i.e. Social Cost Benefit Analysis for MERMAID Project). See section 6.

It should be noted that, a sensitivity analysis was also performed in order to incorporate the socio-economic uncertainty of the environment under which each MUOP design could be developed and operate (See MERMAID D8.6). Particularly, it is assumed that uncertainty about each parameter value can be captured by a probability distribution that will be used to compute the social costs/benefits. A subsequent step in including uncertainty requires experts to provide their estimates of the most likely value of parameters of interest, together with upper and lower bounds, assessing the likelihood that actual values would lay above or below these upper and lower estimates.

Overall, the methodology is used to evaluate the trade-offs with regard to socio-economic welfare between different proposed multi-use structures. Case-study specific recommendations are offered after employing Social Cost Benefit Analysis. See section 7.

[4] http://mermaid.madgik.di.uoa.gr/

2.2 The Assessment Tool

For the purpose of MERMAID MUOPs' assessment, an online assessment tool was developed (See Annex II). This tool incorporates the information produced during the project, comparing the socio-economic aspects derived from the MUOP to the baseline of each case study under consideration. This tool has the potential to be used for future sustainability analysis of multi-use projects.

The importance of this tool lies on its outputs and its capacity to provide a guideline to support decision-making. The MUOP assessment tool was applied in all four case studies and attempts to help all the stages of the research by indicating the pathway of choosing the most appropriate MUOP design with regards to the different aspects involved (socio-economic characteristics, technological, legal, environmental, financial and economic constraints and considerations). The tool helps to identify costs and benefits emerging from the MUOP specific design and thus provides important information for the Social Cost Benefit Analysis (SCBA). The assessment tool collects and systematizes multidisciplinary information for each case study. The different sections of the tool are the following and they are closely related to the MISEA:

A) Technical and Legal Feasibility Assessment;
B) Environmental Impact Assessment;
C) Monetization of Environmental Externalities;
D) Financial and Economic Assessment;
E) Social Cost Benefit Analysis and Risk Analysis

The sections of the assessment tool related to the Baltic Site are presented in the Annex II.

A. Technical and Legal Feasibility Assessment

The Technical and Legal Feasibility Assessment (TLFA) section of the assessment tool requires from the users to identify if the MUOP design is feasible by considering legal and technical considerations. Users are also required to take into account financial costs and revenues of the installation and operation of the platform, consider the project's time horizon, any existing possibilities of combined use and finally any other options for technological upgrades. Simultaneously, a set of risks needs to be identified and taken into account. The set of risks include: technical uncertainty, financial uncertainty, impact diffusion (i.e. correlated risks between functions), political uncertainty and unclear definition of property rights.

The users select the appropriate answer which is then quantified accordingly as input into the tool. The first questions represent the main aspects that need to be taken into account for the legal and technical feasibility. The tool quantifies the answers and feeds them into an algorithm that displays a message of whether the user may continue with the rest of the process, or, a message could be shown based on the unmet technical or legal constraints, i.e. if the answers to the last questions are negative.

Table 2 Technical and Legal Feasibility Assessment and Significant Risks

A. Technical and Legal Feasibility Assessment (TLFA)	
a.	Approximations to production parameters (Costs: capital, Operation and Maintenance (O&M), administration costs and revenues)
b.	Definition of project's time horizon
c.	Possibilities of combined use
d	Possibility for technological upgrades
e.	Uncertainty about reliability of the techniques used
f.	Uncertainty about estimates of costs and revenues
g.	Impact diffusion (correlated risks between functions)
h.	Political uncertainty
i.	Unclear definition of property rights
j.	Is location feasible? (Take into account legal considerations)
k.	Is location feasible? (Take into account technical considerations)

B. Environmental Impact Assessment

Regarding the Environmental Impact Assessment (EIA), the users are asked to identify all significantly positive and/or negative environmental impacts (at local, regional and global levels). Also, they are asked if there is an EIA available for similar project(s) in the region. The set of risks identified for this section refer to the uncertainty about climate change and other environmental parameters, the possible non-linear environmental effects, as well as the irreversible environmental effects of the operation of the platforms. The table below presents the questions posed to experts and researchers, including the set of risks to be identified. The answers of the users, which should be based on an Environmental Impact Assessment or Environmental Analysis undertaken during the design phase of the MUOP, are quantified for the tool.

Table 3 Environmental Impacts Assessment and Significant Risks

B. Environmental Impacts Assessment (EIA)	
a.	Significant negative environmental impact (local, regional, global)
b.	Significant positive environmental impact (local, regional, global)
c.	EIA available for similar project in the region
d.	Uncertainty about climate change and other environmental parameters
e.	Non linear environmental effects & threshold identification
f.	Irreversible environmental effects
g.	Environmental considerations: is the location feasible?

C. Monetization of Environmental Externalities

The user is asked to choose the location of the MUOP. According to this choice, pre-estimated monetary values of the identified environmental change related to the specific location are incorporated into the final section of the assessment tool (see Section 4).

D. Financial and Economic Assessment

The Financial and Economic Assessment (FEA) section of the tool attempts to extract the estimated financial costs (capital, operations & management, administrative) of the MUOPs. This section also requires the estimation of potential financial revenues as well as the efficiency gains from combined use of the platform.

The user can upload a csv (comma separated value) formatted file, a format that can easily be exported from all common spreadsheet software such as Microsoft Excel. Alternatively, the user can input manually the requested values at the appropriate input boxes. It should be noted that, the user will be asked to include the number of kWh and kg related to yearly energy production and aquaculture production, respectively. By this way, the corresponding change in CO_2 emissions due to MUOP operation is monetized through the social cost of carbon as an input to the SCBA (see Section 4).

E. Social Cost Benefit Analysis and Risk Analysis

This final section of the tool uses the financial and economic data, including monetized externalities, produced by the previous sections and run a Social Cost Benefit Analysis (SCBA) by comparing discounted flows of costs and benefits. The results indicate if the proposed design is socio-economically sustainable or not. The risks that may influence the results of this assessment concerns the uncertainty and missing information in estimation of external effects and in perception formation as well.

The tool concludes with a risk analysis, simulating different scenarios to define sensitive values and the overall risk of the selected infrastructure.

- First scenario: Deterministic model

The tool uses a number of potentially sensitive variables according to user selection over a predefined list, and calculates net present value for the user specified time horizon. The user chooses the minimum and maximum values for each of the variables. The tool performs sensitivity analysis based on these inputs and produced visualizations so that the user is able to observe the behavior of these variables.

- Second scenario: Stochastic models with one variable fixed.

While one of the potentially sensitive variables of the model (e.g. interest or growth rate) is fixed at the user input value, the tool models the others as randomly distributed according to a predefined distribution. With these parameters the tool runs a Monte Carlo simulation so as to obtain a distribution for the total cost. The results are presented as a summary table with basic statistical values for the distribution of the total cost, and graphic visualizations.

3 The Baltic Site Regional Profiling

The proposed site for the multi-use platform in the Baltic Sea is the offshore ‘Kriegers Flak’ site. The Kriegers Flak is a large sandy shoal with a sand layer thickness of up to 8 m located in the Western Baltic Sea between Denmark, Sweden and Germany. The suggested MUOP in the Baltic Sea case study is designed to be applied within the Danish exclusive economic zone and covers an area of approximately 180 km^2. Denmark has designated the area of the Kriegers Flak to install an offshore wind farm of 600 MW, which is planned to be fully operational in 2022. Since Kriegers Flak has good conditions for fish farm activities, the ultimate objective is to combine wind turbines and offshore aquaculture. The description of the study site profile contributes to a better understanding of the effects of the selected activities of wind energy and aquaculture on the local socioeconomic environment. This section outlines the socioeconomic context of the study site, describes the institutional framework, and identifies actors, i.e. economic sectors, individuals that may be impacted by the multi-purpose platform.

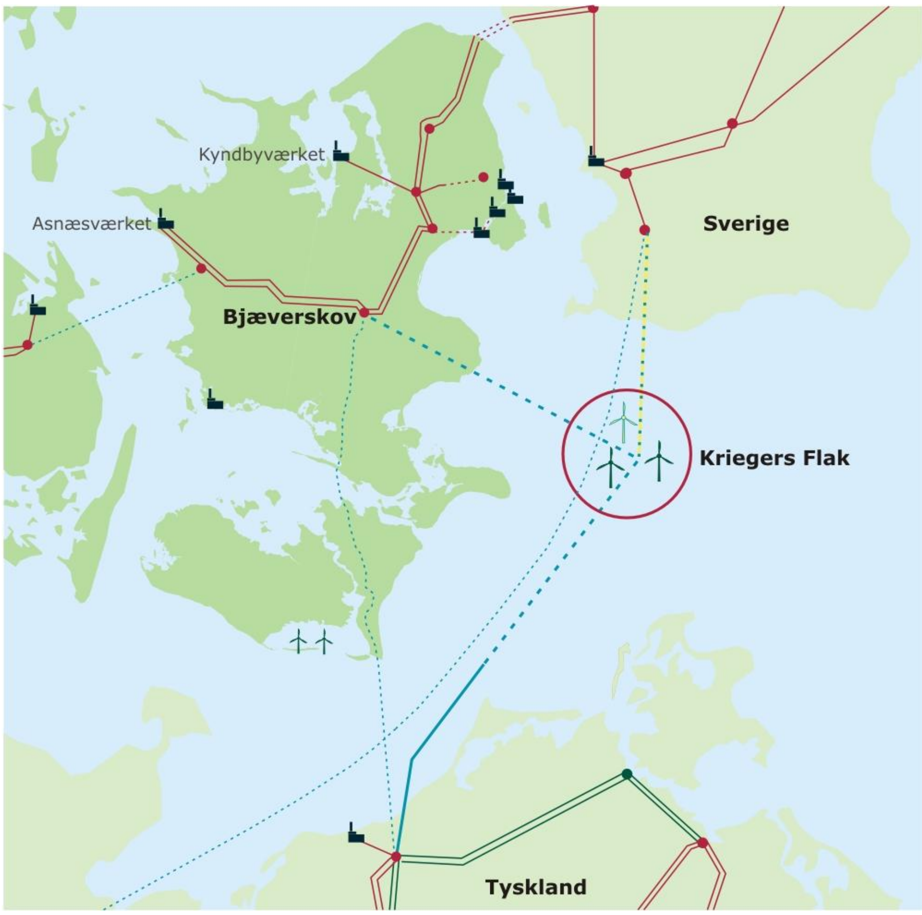

Figure 5 Location of the site

3.1 Demographics and Economic Activities

The land area of the study site amounts to 7,273km^2. The population accounted for 816,172 inhabitants in 2012 with density of 112 inhabitants per km^2. The population of the study site exhibits a rather balanced distribution between male (49.6%) and female (50.4%), while the average household size is around 1.8 persons per household. The qualitative aspects of human resources in the study site can be revealed through the educational level of the population. The educational attainment indicates a rather high share of population with elementary education (34%), and a low share of population with higher education (22%), while almost 44% of population has secondary education.

Total employment in the Baltic site amounts to 370,000 persons (2013). The employment synthesis is rather balanced since male employment amounts to 51% and female employment accounts for 49%. Unemployment rate in the region amounts to 7.4% (30,000 persons). The structure and organization of the regional economy can be studied through the analysis of the sectorial employment. The analysis of employment by branch of economic activity portrays that the major sectors offering employment in the region are the public administration, education and health sector (35%) and the trade and transport sector (21%). Overall, regional economy is highly services oriented since the tertiary sector accounts for 77% of total employment, while the secondary sector contributes by 21%. The contribution of the primary sector to total employment has been contracted to 2%.

The total value of regional production in the study site amounts to 432,125 million DKK (2011). In terms of the sectoral shares of regional production, the tertiary sector contributes about 62% to the regional product generation, the secondary sector contributes by 36%, and the primary sector by only 2%. In particular, the manufacturing industry contributes by 30% in the regional product formation, the wholesale trade sector by 27% and the transportation sector by 12%.

3.2 Socio-economic Impacts of MUOP

The most vulnerable groups to wind power production in the study site are: (a) energy suppliers; (b) persons involved in equipment and machinery sector; (c) energy consumers; (d) persons involved in transport constructing and letting activities. The most vulnerable groups to aquaculture in the study site are: (a) fishermen; (b) persons involved in transport constructing and letting activities; (c) persons involved in tourism activities; (d) persons involved in transport and storage activities. The most vulnerable groups to transport maritime services in the study site are: (a) fishermen; (b) persons involved in tourism activities; (c) persons involved in transport and storage activities. The most vulnerable groups to wind energy production in the study site are: (a) energy suppliers; (b) persons involved in equipment and machinery sector; (c) energy consumers; (d) persons involved in transport constructing and letting activities. In all four cases the geographic location of stakeholders who may be impacted by the proposed changes is within the Danish economic zone at the Kriegers Flak in the Baltic Sea.

Aquaculture has great opportunities in remote areas of Denmark in terms of growth and jobs. However, NGOs are opposed to aquaculture because of the emission of nutrients and the interaction with habitats and species. NGOs primarily focus on the discharge of nutrients and the use of antifouling to the nets. In general, fish farms and aquaculture at sea are less accepted by the public compared to wind farms. However, all these public images can change. There is currently a debate that argues that aquaculture is not polluting and produces healthy food in an environmentally efficient and correct way. Furthermore, it is likely that the pylons and foundations of turbines would provide a new habitat for sessile filter-feeders, and that they would be able to sequester part of the waste lost from the fish farms, thereby reducing the environmental impact of the fish production. Finally, the development of a MUOP can create opposition for developing more intensive economic activities at sea.

The planned windmill park is expected to create 10,000 jobs during the construction phase. The operational and maintenance needs of the MUOP will secure jobs and will act as an international window for Danish know-how. Both aquaculture and wind energy extraction will benefit from sharing seabed area in terms of sharing transportation costs, housing etc.

3.3 Institutional and Policy Framework

According to the Danish Aquaculture Organisation, the environmental legislation on aquaculture exists on two levels: (a) general legal acts that all types of economic activity have to comply with, and (b) legal acts for various forms of aquaculture. However, there is no specific law on aquaculture in Denmark. All Danish fish farms have to be officially approved in accordance with the Danish Environmental Protection Act Ord. n0. 122 of March 1st 1991. A fixed feed quota is assigned to each individual farm in addition to specific requirements including feed conversion ratios, water use and treatment, effluents, removal of waste, etc. In Denmark, aquaculture is being an integrated part of the Danish fisheries sector and as such it is mainly covered by the Fisheries Act under the Ministry of Food, Agriculture and Fisheries.

The overarching legal framework for marine farming is the environmental frame directive, implemented in Danish legislation as consolidated act. No.932. Marine farming is only partly covered by this directive. The ecological status applies for coastal waters up to 1 nautical mile whereas the chemical status applies for coastal waters up to 12 nautical miles. The most critical issue in this directive is the discharge of nitrogen. In the programme of measures for marine farming stands that there must be no overall reduction in the current discharge of nitrogen approved marine farms, but also that new permits must not lead to increased discharge. It is impossible for farms to increase the production without an increase of nitrogen load. On the longer term farms could possible compensate for such increase. If marine farms want to increase their production it can apply for a part of the total nitrogen quota. But the permit is only granted under the condition that the increase in the discharge of nitrogen is eliminated by compensatory farming.

The management, control and development of fisheries and aquatic resources, like aquaculture, in Denmark are regulated by the Fisheries act (2004). In particular, Chapter 13 of this act addresses offshore ocean farming and establishes licensing system governing mariculture facilities. Besides the fisheries act, the regulation on the establishment and operation of ocean farms contains more detailed rules on the licensing system of mariculture facilities. There is no general definition of aquaculture in the Fisheries Act (2004). The Regulation relative to the establishment and operation of ocean farms (1991), adopted under the Act, has, however, the following definition of ocean farming: "With ocean farming is understood fish farms consisting of cages and the like, placed in marine waters which requires the use of feed for its operation".

However, for aquaculture facilities that are placed on land taking in marine water and for farming of mussels, oysters etc. no regulations have been issued pursuant to the Fisheries act (2004). For fish farming that requires feed an approval according to the Environmental Act is required. All marine farms must have an environmental permit no later than 2014. The Environmental Protection act (no. 1757 issued December 22th 2006) sets the overall framework for issuing such permits. At this time most marine farms have obtained permits under this act. Marine farms also have to comply with the requirements for discharge of residues of medicines (Order no. 1022 issues August 25th 2010) and protected habitats (Protection of Nature Act no. 933 issued September 24th 2009).

An Environmental Impact Assessment (EIA) is necessary for developing aquaculture activities. This can be found in the Planning act (order number 1510 issued December 15th 2010). For marine farms situated up to one nautical mile for the coast will require a full EIA. This is a general rule. To some extent it is decided by the local government in the area and they can administer this rule in different ways. For existing farms outside the nautical mile zone only a screening is required. This has been done as a result of a political compromise between government, farmers and environmental organizations. The regulation on supplementary rules contains requirements regarding the contents of the EIA. The Regulation provide that when establishing a new marine water fish farm outside a zone designated for aquaculture in the Regional Plan, or when changing such a facility considerably, an EIA shall be worked out. If the aquaculture facility in question is designated for intensive fish farming or has an intake of fresh water, an EIA shall be worked out as far as the facility it is likely to have a considerable impact on the environment, even when it is to be established in an aquaculture zone. The Regulation lists the different criteria that shall be used when considering whether a facility is likely to have such an impact, i.e. the size of the facility, waste production, the vulnerability of the surrounding environment etc. When it comes to the contents of the EIA, the Regulation states that the EIA shall include a description of the planned facility, a summary of the most important alternative sites that has been examined, the reasons for the choice of alternatives, a description of the environment that can be considerably influenced by facility, as well as an account of the short term and long term influence on the environment. As to ocean farms outside the County Council planning area, the Coastal Directorate decides whether an EIA shall be carried out in relation with an application for the setting up of a facility.

The Danish Government provides the main conditions for offshore wind parks in the Promotion of Renewable Energy Act (Act no 1392 27th December 2008), and the Danish Electricity Act (Danish Energy Policy, 2012). Chapter 3 is mainly relevant for off-shore wind parks. This chapter regulates the access to exploiting energy from water and wind offshore. Most important condition is that the right to exploit energy from water and wind within the territorial waters and the exclusive economic zone (up to 200 nautical miles) around Denmark belongs to the Danish State. The act also lays down the procedures for the approval of electricity production from water and wind and pre-investigation.

Some of the most important sections of the Renewable Energy act (2008) are: (a) approval for preliminary investigations shall be granted either after an invitation for applications in a tendering procedure or after receipt of an application; (b) approval for preliminary investigations shall be granted for areas in which the Minister for Climate and Energy considers energy exploitation may be relevant; (c) the Minister for Climate and Energy may stipulate terms for the approval, including on the conditions to be investigated, on reporting, on the performance and results of the preliminary investigation, on the access of the Minister to utilise the results of the preliminary investigation, cf. and on compliance with environmental and safety requirements and similar.

For developing and establishing offshore wind park projects in Denmark, three licenses are required. All licenses are granted by the Danish Energy Agency: (a) license to carry out preliminary investigations; (b) license to establish the offshore wind turbines; (c) license to exploit wind power for a given number of years, and – in the case of wind farms of more than 25 MW – an approval for electricity production.

When the project can be expected to have an environmental impact, an Environmental Impact Assessment (EIA) must be carried out. The specific procedure for the Environmental Impact Assessment (EIA) regarding offshore electricity producing installations is described in Executive Order No. 684 of 23 June 2011 on EIA. That also includes sections that implement the EU EIA directive (PM).

The rules governing EIA reports are described in Executive Order no. 684 of 23 June 2011. Any party applying to establish an offshore wind farm must prepare an environmental report in order to ensure: (a) that the environmental conditions within the defined installation are described; (b) that impact and reference areas are studied and described; (c) that all known environmental impacts in connection with the establishment and operation of the wind turbine installation have been previously considered and assessed; (d) that the authorities and the general public have a basis for assessing and making a decision regarding the project.

When, on the basis of preliminary investigations (license 1) an application (including an EIA report) has been submitted regarding an offshore wind power project, the Danish Energy Authority present this material for public consultation with a deadline of at least eight weeks. After that the final authorisation for the establishment (license 2) of the offshore wind farm is done according to detailed conditions that reflect both the conclusions of the EIA report and consultation responses from the general public and the authorities concerned. The authorisation, issued by the Danish Energy Authority, is made public. Any party with an interest in the decision has the right to register a complaint with the Energy Appeal Board regarding the decision's environmental aspects. The authorisation may not be acted upon before the appeal deadline has expired. Once authorised to carry out a project, the developer must provide the Danish Energy Authority with documentation proving how the conditions in the permit issued will be fulfilled. This must be done in the form of a detailed project description of the construction/installation works. The developer may not begin to construct the offshore wind farm until the Danish Energy Authority has determined that the documentation submitted is sufficient.

When an installation is ready to produce electricity for the grid, the holder of the authorisation for the establishment applies to the Danish Energy Authority for a permit to exploit the wind energy (license 3). Electricity production may not begin before such a permit has been issued. In addition, the developer must also obtain a licence to produce electricity if the overall project has a capacity of more than 25 MW and if the developer does not already hold such a licence.

In general, the establishment of offshore wind turbines can follow two different procedures: a government tender procedure run by the Danish Energy Agency; or an open-door procedure. For both procedures, the project developer requires all 3 licenses. In the open-door procedure, the project developer takes the initiative to establish an offshore wind farm of a chosen size in a specific area. In an open-door project, the developer pays for the transmission of the produced electricity to land. An open-door project cannot expect to obtain approval in the areas that are designated for offshore wind farms in the report Future Offshore Wind Power Sites - 2025 from April 2007 and the follow-up to this from September 2008. There are three examples of the open-door procedure. It was followed for the DONG Energy off-shore wind farm at Avedøre and Frederikshavn – and for the Sund & Bælt project at Sprogø.

4 Monetization of Environmental Externalities

From the previous section it is concluded 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), a range of different information was needed in order to assess them. As a result, market data, secondary data for the performance of simulations, surveybased primary data, data provided from literature review, consultation with experts and stakeholders and information coming from environmental impact assessments were important in the framework of integrated assessment.

Table 4 Ecosystem Services Probably Affected by the MUOP

Baltic Site				
Category of Ecosystem Services	Provisioning Services	Supporting/Regulating Services	Cultural Services	Habitat Services
Ecosystem Services	Food and Raw Materials	NutrientCycling	Cognitive Development	Diversity
Comments	Constrution and Operation Phase	Operation Phase	Not relevant	Construction and Operation Phase

Source: Communication with Site Managers and Biologists

4.1 Life Cycle Assessment

Main characteristic of an LCA study is its content that covers all of the life cycles of a product/service, in other words ‘cradle-to-grave’ approach. In this method, all of the used resources, material & energy flows, wastes and emissions through product/service life time with their quantities are considered by preparing a life cycle inventory (LCI) for the study. By using different calculation procedures, these inventory is evaluated as to elucidate the potential environmental impacts of the considered project in the form of various environmental impact categories such as climate change, eutrophication, ecotoxicity, etc. (Baumann & Tillman, 2004). ISO 14040 series standards are published to define procedures for LCA studies and standardize their application worldwide (ISO, 2006a, b). According to mentioned standards, an LCA study consists of ensuing steps of Goal & Scope Definition, Inventory Analysis, Impact Assessment and Interpretation steps. LCA is an iterative method which may be developed continuously as getting more precise data related to processes analysed. Thus, quality of an LCA study mainly depends on the used data in LCI.

In the context of the LCA study made for Baltic site, two LCA studies, separately for two functions of the MUOP design, in line with ISO 14040 and 14044 standards is carried out using Ecoinvent integrated GaBi software and the CML 2001 method is used to calculate the results. The design for Baltic Case includes a wind farm with installed capacity of 600 MW and a fish farm with a capacity of 10000 ton salmon production. There are several turbine and foundation types that are listed in the “Kriegers Flak Technical Project Description for the large-scale offshore wind farm at Kriegers Flak” report (Energinet.Dk, 2013). 8 MW turbines with monopile foundations were chosen among these turbine and foundation types for the LCA study. This choice considers a wind farm consisting of 75 wind turbines. An offshore salmon farm is designed for Baltic Sea Case by Musholm and DHI in the context of the project. Total capacity of the designed marine net-pen system fish farm is 10,000 tons harvested fish per year, and the fish cages are designed to resist offshore conditions. LCI tables are available on request.

The goal of the first LCA study is to analyse potential environmental impacts of electricity production function of MUOP through its lifetime. The systems studied included production and installation of structures (wind turbine components), electricity transmission system (offshore substation and submarine cables), operation and maintenance activities, disposal of MUOP farm as well as transportation of materials during the life cycles of the MUOPs. Electricity distribution that is located onshore was excluded from the system studied. Functional unit was selected as 1kWh electricity produced.

The main data for LCI inventory was provided from the report of Kriegers Flak Technical Project Description (Energinet.Dk, 2013) and personnel communications with Nick Ahrensberg from DHI. Data gaps were filled by using the literature by the LCA team. LCI tables are available on request.

CML 2001 method evaluates the potential environmental impacts in 11 different categories: Global warming potential (GWP), acidification, eutrophication, ozone layer depletion, abiotic depletion, abiotic depletion fossil, freshwater aquatic ecotoxicity, marine aquatic toxicity, human toxicity, terrestrial ecotoxicity and photochemical ozone creation.

In the context of this study, GWP was the only impact category that was focused on as an input for the estimation of the economic benefit of changes in CO_2 emissions.

Obtained Global Warming Potential (GWP) impact category result for energy production function of the MUOP is 9.32g CO_2-eq. This result was then compared with values for producing electricity based on coal. The results showed that producing 1 kWh energy in this farm cause a decrease from 820 to 9.32g CO_2 equivalents (CO_2eq) which corresponds to a difference of *810.68g* CO_2-eq based on average CO_2eq value for electricity production via coal burners (Schlömer et al., 2014). When the European electricity mix value (ENTSO-E network), which corresponds to 462 g CO_2-eq/kWh (Itten et al., 2014), was chosen as the comparison parameter, the difference is *452.68g* CO_2 equivalents.

The goal of the second LCA study is to analyse potential environmental impacts of salmon production function of MUOP through its lifetime. The systems studied included production and installation of aquaculture structures, operation and maintenance activities, disposal of structures as well as transportation of materials during the life cycles of the MUOPs. Functional unit was selected as one tonne of salmon harvested.

The main data for LCI inventory was provided from personnel communications with Thorbjørn Harkamp from Musholm and Mads Joakim Birkeland from DHI and it included production capacity and dimensions of aquaculture structures. Data gaps were filled by using the literature by the LCA team. LCI tables are available on request. The result of LCA study of Salmon fish farm in terms of GWP is 3.64tonnes CO_2-eq per ton of harvested fish.

Table 5 Unit amount of CO_2 emissions per function of MUOP and the compared production technologies

Function	Parameter	Amount	Unit
MUOP Electricity Production	Amount of CO_2-eq production per 1 kWh	**9.32**	g CO_2-eq
Coal Based Electricity Production	Amount of CO_2-eq saved through MUOP electricity production per 1 kWh	**810.68**	g CO_2-eq
ENTSO-E Electricity Production	Amount of CO_2-eq saved through MUOP electricity production per 1 kWh	**452.6**	g CO_2-eq
Fish Production	Total amount of CO_2-eq production per 1 t fish produced	**3.6**	t CO_2-eq

Table 6 Total amount of CO_2 emissions per function of MUOP and the compared production technologies

Function	Parameter	Amount
MUOP Electricity Production	Amount of CO_2-eq production (assuming 1317.6 GWh/year)	9.32gCO_2-eq/kWh *1317.6GWh/year*25years =307,000.8ton CO_2-eq
Coal Based Electricity Production	Amount of CO_2-eq saved (assuming 1317.6 GWh/year)	810.68gCO_2-eq /kWh *1317.6GWh/year *25years =26,703,799.2ton CO_2-eq
ENTSO-E Electricity Production	Amount of CO_2-eq saved (assuming 2196 GWh/year)	452.6gCO_2-eq /kWh *2196 GWh/year*25years =24,847,740 ton CO_2-eq
Salmon Production	Total amount of CO_2-eq production (assuming 6000 t/year)	3.6tCO_2-eq *6000 t/year*15years =324,000 ton CO_2-eq

Based on the Life Cycle Assessment the economic benefit of changes in CO_2 emissions due to MUOP construction and operation was estimated. For this purpose, the social cost of carbon was used, which refers to the monetary value, the shadow price of world-wide damage done by anthropogenic CO_2 emissions (Pearce 2003). According to Arrow et al. (2014) social cost of carbon is $19.50 per ton of carbon using the random walk model in Newell and Pizer (2003), $27.00 per ton using the state-space model in Groom et al. (2007), and $26.10 per ton using the preferred model in Freeman et al. (2013). The value used was the one produced using the state-space model **(22.5€ per ton[5], 2013)**.

[5] Exchange rate 0.83 $/ €

4.2 Benefit Transfer

Gathering primary site-specific data is costly and time-consuming, which has made Benefit Transfer (BT) a popular alternative for the valuation of ecosystem goods and services. BT 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). That is the result 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. The first approach assumes similarity in good and socio-economic characteristics between the study and target site and 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), Johnston and Rosenberger (2010), and Johnston et al. (2015).

It was decided under MERMAID to apply an adjusted BT to account for potential environmental and socio-economic impacts. In order to choose the relevant studies, common socio-economic and geographical characteristics are considered between the policy site and the study sites of each examined paper. Since it is hard to find studies related to offshore multi-use platforms, research has to be expanded on case studies that include similar environmental and social effects in the marine area without explicitly referred to offshore platforms. The aim is to estimate the effects produced - moving from the baseline to the final platform design - on the ecosystem services defined under the environmental assessment.

Based on the policy site characteristics and the information provided by the site manager and biologists, it was decided to estimate the economic value of the negative effects of the presence of Harmful Algal Blooms in Italian waters from the construction of MUOPs. Although such effects are currently rather small, they could be further enhanced by water quality issues related to aquaculture and by the introductions of additional artificial habitats. However, since these effects will not be crucial in the first 30 years of operation and the location of the MUOP was chosen with the scope to minimize such negative environmental effects, it was chosen not to consider this value to the social cost benefit analysis. Based on the policy site characteristics and the information provided by the site managers and biologists, habitat services with regards to increased diversity caused by the reef effect were given monetary values. However, economic values for all the possible effects on ecosystem services were not given due to lack of data. In order to do so, we approximated the positive effect on biodiversity and increase of marine biomass by the effect on algae and invertebrates **(31.44 € per person, onetime payment)**. Hence, based on the regional profiling[6], we estimated economic benefit due to environmental effect to be **25,750,259.247 euros** (2013). We were not able to estimate the economic values for all the possible effects on ecosystem services due to lack of data. Ressurreição, A. et al. (2012) paper was used for the purpose of benefit transfer. More details on the calculations are given in the Annex I.

[6] We estimated the average population growth rate between Sweden, Denmark, Germany and Poland to be 0.35%. These are the countries possibly affected by the platform.

Benefit Transfer Adjustments

- Income Changes: Assuming the demand for ecosystem services changes with income, we used the income elasticity (e) of willingness to pay (WTP) to adjust the value on the study site:

$$WTP_p = WTP_S \left(\frac{Y_p}{Y_s}\right)^e$$

WTP_p: the value from the policy site
WTP_s: the value from the study site
Y_p: income per capita from the policy site
Y_s: income per capita from the study site

The income elasticity of WTP is expressed as the % change in WTP for 1% point change in income and shows how much the WTP for an ecosystem service changes with income. According to Desaigues et al. (2007), the income elasticity for the European Union countries ranges from 0.2 to 0.5. For the study, the central value 0.3 for the elasticity and the GDP per capita as a proxy for income due to lack of data for the income per capita were used.

- Price Changes over time: Inflation causes the general price levels in a country to rise over time and any given amount of money is worth less. So, we adjusted the values to account for inflation in order to represent the general price level of the same year between the policy and study site by using the GDP deflators.

- Purchasing Power Differences: General prices for goods and services vary across different countries and within the countries, which reflects differences in the costs of production and demand. We used the purchasing power parity (PPP) adjusted exchange rates taken from the World Bank World Development indicators database. PPPs reflect how much 1$ costs in another country.

The process was based on UNEPs manual on valuing transferred values of ecosystem services (2013). Additionally, the Environmental Valuation Reference Inventory (EVRI), which is a comprehensive benefits transfer database that consists of over 1900 valuation studies and was used for the BT application. Values are expressed in 2013 prices, using data from the World Bank.

5 Financial and Economic assessment

For the Baltic site, the MUOP (wind-fish farm) efficiency gains for maintenance, salaries and mortality are expected to be 3%, 2% and 1%, respectively, from the combined use (i.e. 4% total efficiency gains).

The total price of the wind farm is expected to be between 2.0-2.7 billion euros, whereof the grid connection is budgeted at 0.47 billion euros. With regards to salmon farming, in existing 3000 tons farms, production costs are 2,85 euros per kg and it is expected to have slightly lower production costs in a larger farm, but also slightly higher cost of insurance. Salmon farming costs cover operation, maintenance and depreciation of freshwater and marine activities and the expected revenues for salmon farming are 36 million euros per year. Seaweed farming is a future option that requires future testing and market analysis.

However, since no explicit data for the fish farming were available the produced social cost benefit analysis was applied only for the wind energy function of the MUOP, as well as the environmental effects derived from this function.

6 Social Cost Benefit Analysis

The Social Cost Benefit Analysis (SCBA) 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 MUOPs are evaluated and compared to estimate the economic efficiency of implementing the project. As a rule, a project is deemed to be socially profitable if total discounted benefits exceed total discounted costs (positive net present value (NPV)). The NPV results 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 Kt is the construction cost, Bt is the stream of benefits, Ct is the stream of operation and maintenance costs and r is the discount rate. Monetized values of externalities are also included in the benefits or costs terms.

Furthermore, the Internal Rate of Return (IRR) has been estimated. IRR is the discount rate that makes the NPV equal to zero. The higher a projects IRR, the more desirable is to undertake the project. Any project with an IRR greater than the discount rate used for the project is a profitable one.

For the Baltic site the financial costs and revenues, together with the benefits derived by the CO_2 emissions reduction and artificial reefs effect due to wind energy production were included in the SCBA. Costs derived from the production of CO_2 emissions due to salmon harvesting were not included in the SCBA, since due to lack of information only the single-use scenario of energy production was examined. A 22-year time horizon was selected for the SCBA.

A triangular distribution was used in Energy Investment and Maintenance. Since there were no information regarding the stochastic factors affecting wind investment, the triangular distribution was considered reasonable, with central value the given investment cost and boundaries at $\pm$ 15% of the central value.

Furthermore, normal distribution was used in Energy output and artificial reefs. Again since there was no information about the specific distributions and only a central value for each of the items, a normal distribution was assumed with mean the given central value. The structure of the normal distribution was determined such that the mass included in the interval of ± two standard deviation from the mean has boundaries at a distance of $\pm\gamma$% of the mean the choice of γ was consistent with the data of the specific case. That is $\mu \pm 2\sigma = \mu \pm \gamma\mu$.

Two alternative values of 3% and 4% were used for the discount rate. These values are consistent with values obtained from the Ramsey formula for the long lived projects: $r = \rho + \eta \cdot g$

- where $\rho = L + \delta$ is the rate at which individuals discount future consumption over present consumption
- Catastrophe risk (L): catastrophe risk is the likelihood that there will be some event so devastating that all returns from policies, programs or projects are eliminated, or at least radically and unpredictably altered.
- Pure time preference (δ): pure time preference, reflects individuals' preference for consumption now, rather than later, with an unchanging level of consumption per capita over time.
- Annual growth in per capita consumption (g)
- Elasticity of marginal utility of consumption (η)

Finally, the Monte Carlo simulations involved 1000 repetitions. Risk analysis results are presented in deliverable 8.6. The results of the SCBA are summarized in the table below.

Table 7 Net Present Value and Internal Rate of Return estimations for energy production

	mean NPV(3%)	**st.dev NPV(3%)**	**mean NPV(4%)**	**st. de NPV(4%)**
Single-use: Wind function operation compared to coal energy production	1283.97	115.22	1018.85	110.61
Single-use: Wind function operation compared to ENTSO-E energy production	1062.20	112.29	823.60	107.31

All values in million euros.

The important issue in the Baltic site was that there was no information regarding operating cost. To obtain insights into the profitability of the project we worked as follows. The single-use scenario of wind energy production will be profitable if the NPV of the operating costs, NPV(OC), is less than the mean NPV under the corresponding alternative assumptions regarding the discount rate and savings related to the reduction of CO_2 emissions. This NPV(OC) can be transformed to annual equivalent operating costs (AOC) using the relationship:

$$NPV(OC) = \sum_{t=4}^{22} \frac{AOC}{(1+r)^t}$$

Table 8 Annual Equivalent Operating Cost

	AOC (3%)	AOC (4%)
Single-use: Wind function operation compared to coal energy production	102.01	90.53
Single-use: Wind function operation compared to ENTSO-E energy production	84.39	73.18

All values in million euros

Thus if annual operating costs are below the above values for each discount rate and savings related to the reduction of CO_2 emissions, the project will pass the SCBA test.

7 Discussion and Recommendations

Due to lack of data, we were not able to produce a SCBA for this MERMAID site. However, given our communications with the economists of the Baltic site, the multi-use platform scenario is expected to be economically viable in the future. Furthermore, longer time horizon in the SCBA than 25 years could change the outcomes based on the possible differences in energy prices and environmental effects, for example on the level of eutrophication.

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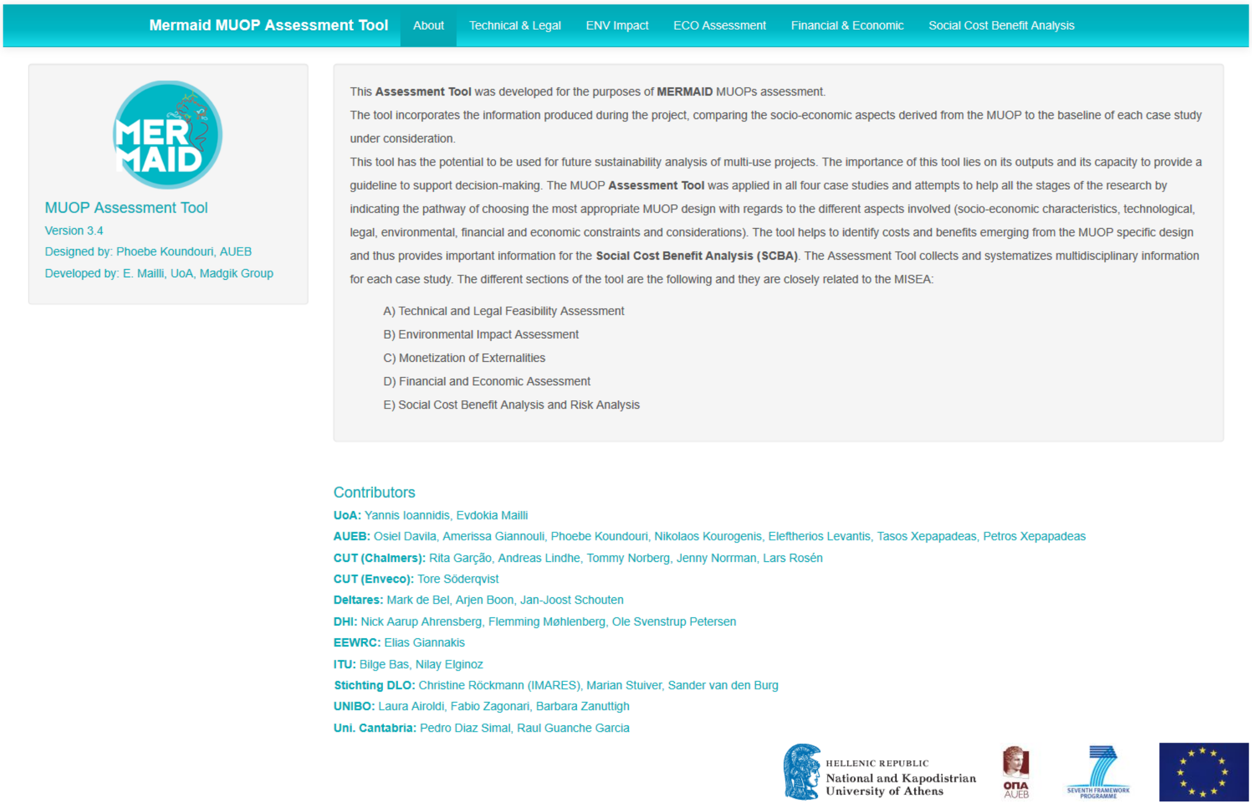
Annexes

Annex I Benefit Transfer Application for the Baltic Site

Authors	**Description**	**Algae and Marine Invertebrates (Biomass)**							
			Value of Algae **(€) (2007)**		*Value of Inverts* **(€) (2007)**				
		Country	*Visitors*	*Residents*	*Visitors*	*Residents*	*Average*	Weights	**Benefit Transfer Value (€) (2013)**
Ressurreição, A. et al. (2012)	This study uses a contingent valuation method to estimate the public's willingness to pay (WTP) to avoid loss in the number of marine species. Onetime payment.	Gulf of Gdansk, Poland	14	20	14	21	17.25	0.75	17.36
		Isles of Scilly, UK	66	75	52	59	63	0.25	14.08
Weighted Average Value to avoid Algae and Marine Invertebrates Loss (€)									**31.44**

Notes: *Mean WTP is more appropriate for cost benefit analysis (Loomis and White, 1996).*
Values were expressed as onetime payment per individual.

Annex II The Assessment Tool



Mermaid MUOP Assessment Tool | About | Technical & Legal | ENV Impact | ECO Assessment | Financial & Economic | Social Cost Benefit Analysis

MUOP Assessment Tool
Version 3.4
Designed by: Phoebe Koundouri, AUEB
Developed by: E. Mailli, UoA, Madgik Group

This **Assessment Tool** was developed for the purposes of **MERMAID** MUOPs assessment.

The tool incorporates the information produced during the project, comparing the socio-economic aspects derived from the MUOP to the baseline of each case study under consideration.

This tool has the potential to be used for future sustainability analysis of multi-use projects. The importance of this tool lies on its outputs and its capacity to provide a guideline to support decision-making. The MUOP **Assessment Tool** was applied in all four case studies and attempts to help all the stages of the research by indicating the pathway of choosing the most appropriate MUOP design with regards to the different aspects involved (socio-economic characteristics, technological, legal, environmental, financial and economic constraints and considerations). The tool helps to identify costs and benefits emerging from the MUOP specific design and thus provides important information for the **Social Cost Benefit Analysis (SCBA)**. The Assessment Tool collects and systematizes multidisciplinary information for each case study. The different sections of the tool are the following and they are closely related to the MISEA:

A) Technical and Legal Feasibility Assessment
B) Environmental Impact Assessment
C) Monetization of Externalities
D) Financial and Economic Assessment
E) Social Cost Benefit Analysis and Risk Analysis

Contributors

UoA: Yannis Ioannidis, Evdokia Mailli
AUEB: Osiel Davila, Amerissa Giannouli, Phoebe Koundouri, Nikolaos Kourogenis, Eleftherios Levantis, Tasos Xepapadeas, Petros Xepapadeas
CUT (Chalmers): Rita Garção, Andreas Lindhe, Tommy Norberg, Jenny Norman, Lars Rosén
CUT (Enveco): Tore Söderqvist
Deltares: Mark de Bel, Arjen Boon, Jan-Joost Schouten
DHI: Nick Aarup Ahrensberg, Flemming Møhlenberg, Ole Svenstrup Petersen
EEWRC: Elias Giannakis
ITU: Bilge Bas, Nilay Elginoz
Stichting DLO: Christine Röckmann (IMARES), Marian Stuiver, Sander van den Burg
UNIBO: Laura Airoldi, Fabio Zagonari, Barbara Zanuttigh
Uni. Cantabria: Pedro Diaz Simal, Raul Guanche Garcia

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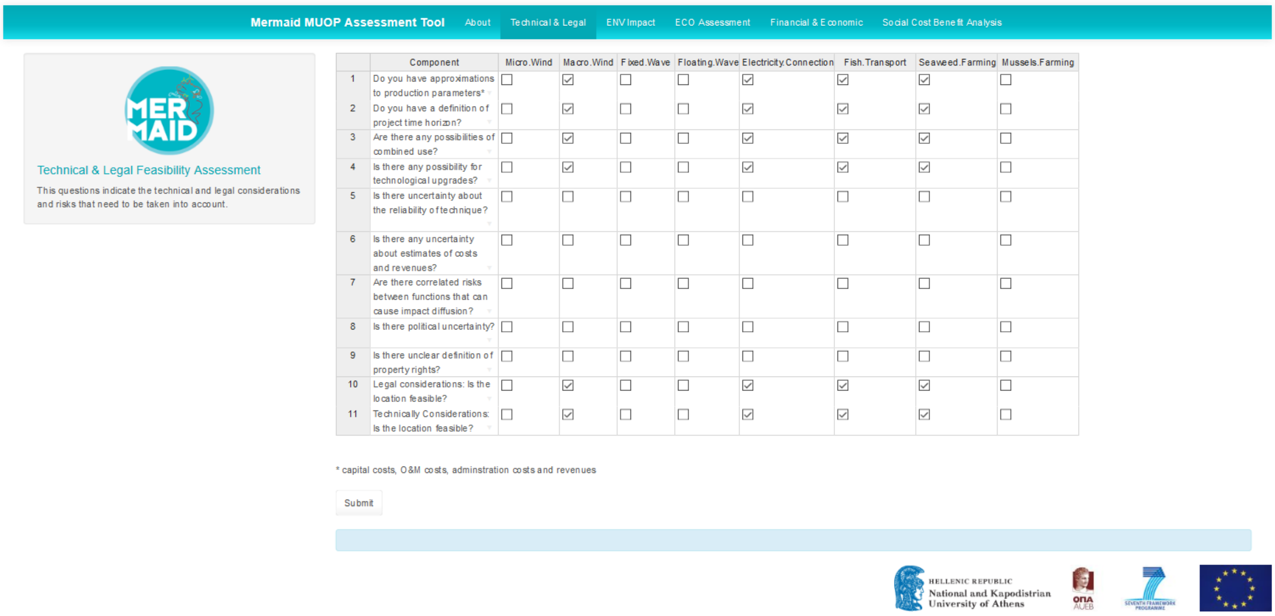
Techinal and Legal Feasibility Assessment



Mermaid MUOP Assessment Tool | About | Technical & Legal | ENV Impact | ECO Assessment | Financial & Economic | Social Cost Benefit Analysis

Technical & Legal Feasibility Assessment
This questions indicate the technical and legal considerations and risks that need to be taken into account.

	Component	Micro.Wind	Macro.Wind	Fixed.Wave	Floating.Wave	Electricity.Connection	Fish.Transport	Seaweed.Farming	Mussels.Farming
1	Do you have approximations to production parameters*	☐	☑	☐	☐	☑	☑	☑	☐
2	Do you have a definition of project time horizon?	☐	☑	☐	☐	☑	☑	☑	☐
3	Are there any possibilities of combined use?	☐	☑	☐	☐	☑	☑	☑	☐
4	Is there any possibility for technological upgrades?	☐	☑	☐	☐	☑	☑	☑	☐
5	Is there uncertainty about the reliability of technique?	☐	☐	☐	☐	☐	☐	☐	☐
6	Is there any uncertainty about estimates of costs and revenues?	☐	☐	☐	☐	☐	☐	☐	☐
7	Are there correlated risks between functions that can cause impact diffusion?	☐	☐	☐	☐	☐	☐	☐	☐
8	Is there political uncertainty?	☐	☐	☐	☐	☐	☐	☐	☐
9	Is there unclear definition of property rights?	☐	☐	☐	☐	☐	☐	☐	☐
10	Legal considerations: Is the location feasible?	☐	☑	☐	☐	☑	☑	☑	☐
11	Technically Considerations: Is the location feasible?	☐	☑	☐	☐	☑	☑	☑	☐

* capital costs, O&M costs, adminstration costs and revenues

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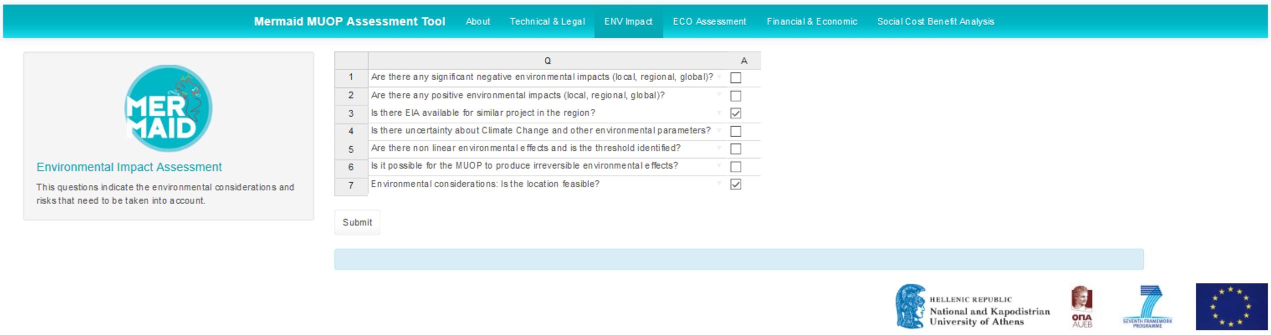
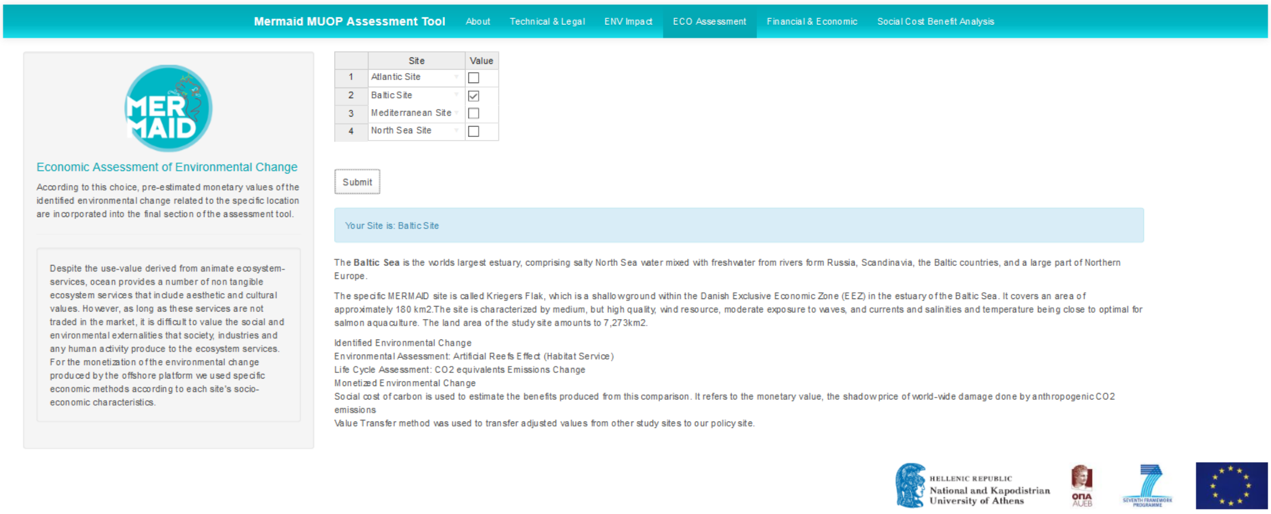
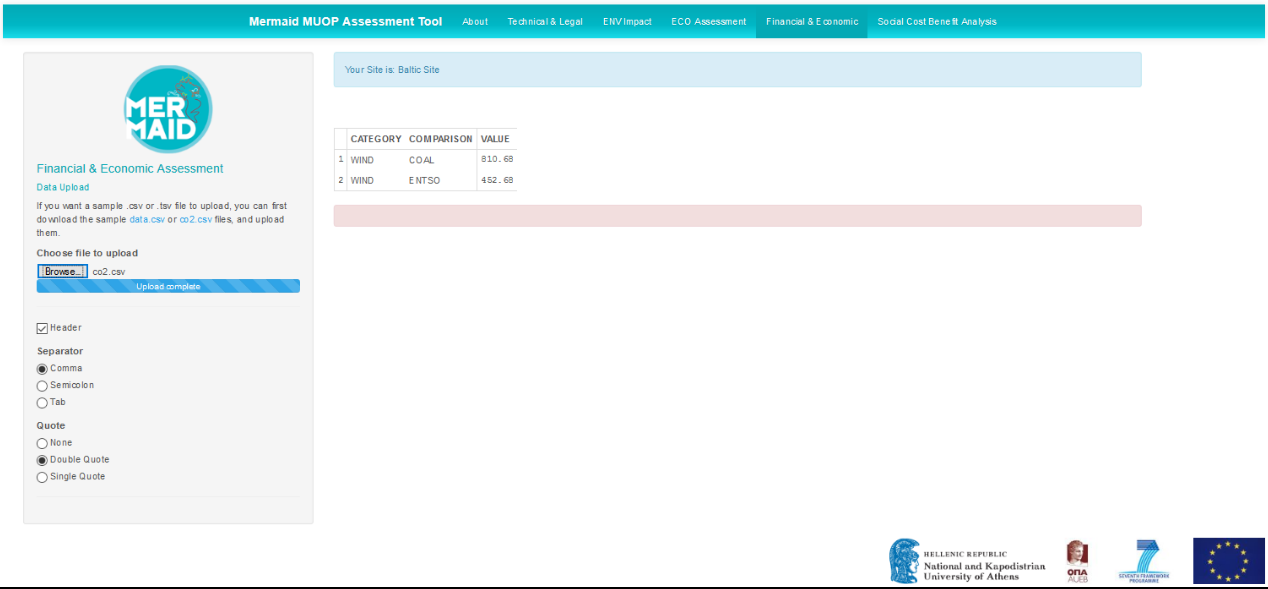
Environmental Impact Assessment

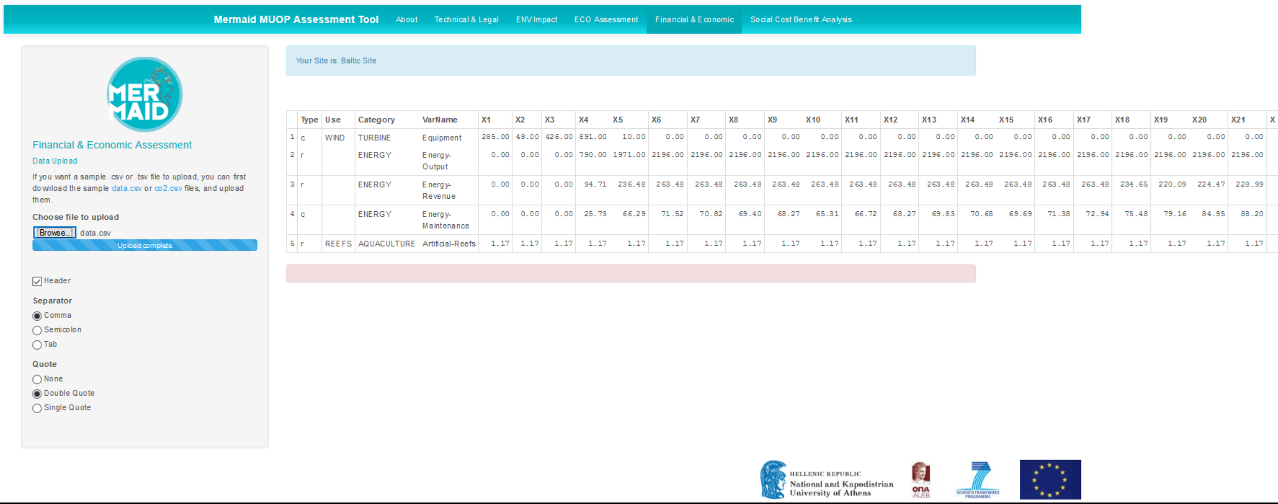


Monetization of Environmental Externalities



Financial and Economic Assessment





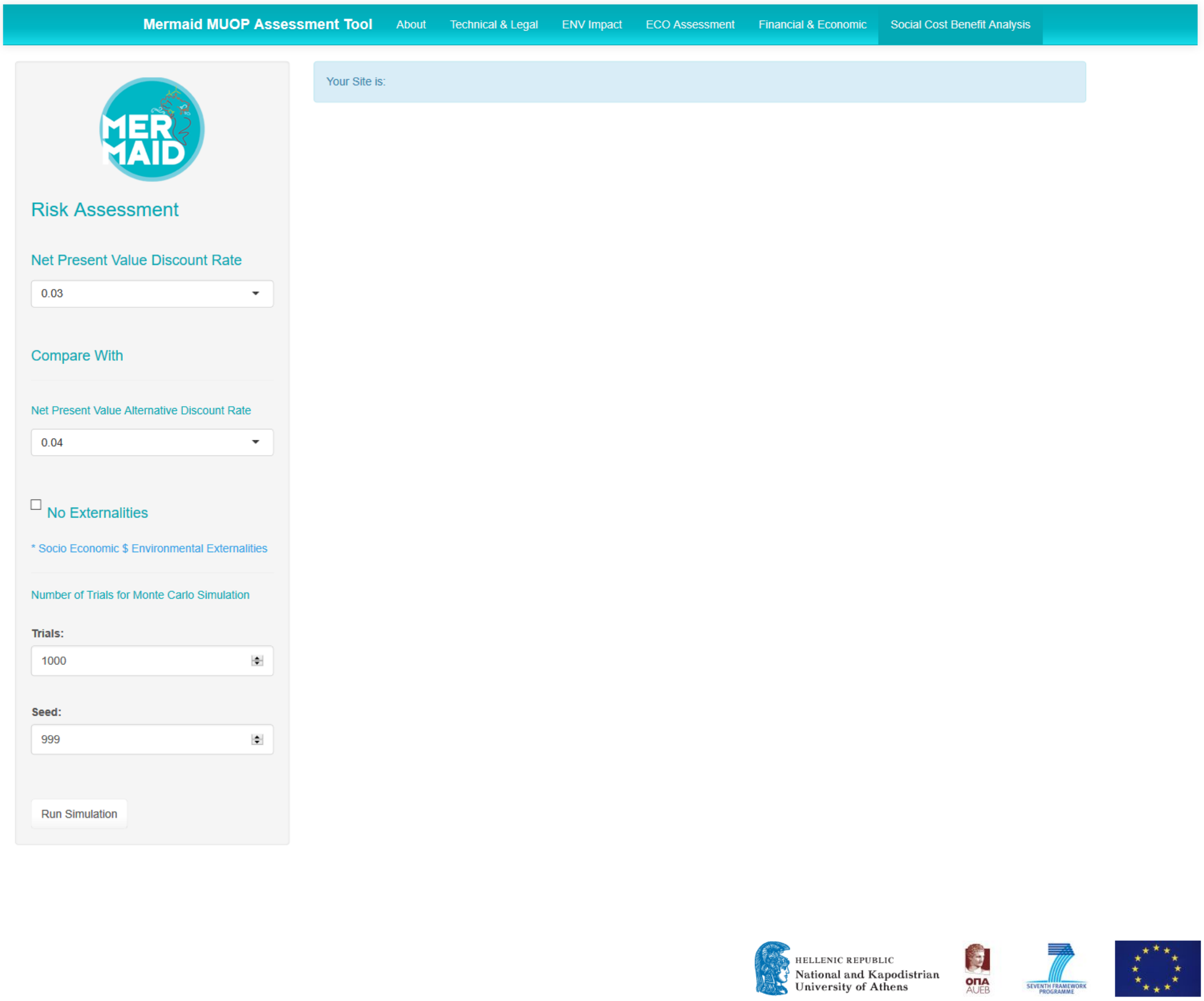
The user inserts specific requested data for the estimation of economic and financial benefits and costs.

Social Cost Benefit Analysis and Risk Analysis

It should be noted that the tool is able to compare at the same time the estimated net present value under different discount rates.

Furthermore, the tool calculates and compares the net present value for the case of including the monetized externalities and for the case where these are not included.

The detailed description of the tool and the user guide will be published in future publications.



Due to lack of data, the social cost benefit analysis for the MUOP could not be applied. However, we provide the layout for this particular section of the tool