Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Deliverable D7.2

Detailed description of demonstration scenarios

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Author(s)	Maria Inês Marques, Miguel Jorge Marques, Nuno Lopes Filipe, Paul Kessler, Tiago Lourenço (EDP CNET); Inès Tunga (ESC); Pablo Ruiz-Minguela, Vincenzo Nava (TECNALIA); Donald Noble (UEDIN); Jillian Henderson (WES); Neil Luxcey, Nicolas Germain (FEM)
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EXECUTIVE SUMMARY

DTOceanPlus aims at accelerating the commercialisation of the Ocean Energy sector by developing and validating an open source suite of design tools for the selection, development, deployment and assessment of ocean energy systems (including sub-systems, energy capture devices and arrays). The suite of tools will include a Structured Innovation tool, for the technology concept selection; a Stage Gate tool, for the technology development process, as well as a set of Deployment Design and Assessment tools for the design of the system and its validation.

The suite of tools will be validated by running a valuable set of demonstration scenarios, which will show the different uses of the tools under a wide set of conditions, e.g. for various deployment sites, tidal and wave technologies, and using all the tools developed in DTOceanPlus.

This report describes the methodology used to refine the validation scenarios and the compilation of required data inputs, accounting for the different potential use cases. Given the large number of permutations of tools, use cases, and the set of minimum validation requirements, the actual number of validation scenarios is reduced to a number that can be run during the life of the DTOceanPlus project but that are sufficient to fully validate the functionality of the DTOceanPlus suite of tools. The selection process, based on a successive approximation approach, which led to the identification of six validation scenarios is briefly described in Section 3.

In Section 4 of the document, the selected validation scenarios were refined, and the definition of these scenarios will be completed during the project to ensure that the most updated information is used. The deliverable: D7.3 "Scenarios input data", will address the data needs, as well as a more detailed and precise description of the Validation Scenario and the validation criteria.

The characterisation of the validation scenarios through a thorough representation and compilation of data were defined in Section 5 and will be again, defined with more detail and precision, at D7.3.

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ABBREVIATIONS AND ACRONYMS

Dx.x	Deliverable x.x from a task or work package
EC	Energy Capture
ED	Energy Delivery
ET	Energy Transformation
ESA	Environmental and Social Acceptance
KPI	Key Performance Indicators
LMO	Logistics and Marine Operations
PD	Project Developer
PF	Priority Factor
PSC	Project Steering Committee
PTO	Power Take-Off
RAMS	Reliability, Availability, Maintainability, Survivability
SLC	System Lifetime Costs
SPEY	System Performance and Energy Yield
TD	Technology Developer
Tx.x	Task x.x within a work package
UC	Use Case
VC	Validation Case
VS	Validation Scenario
WP	Work Package
WPL	Work Package Leader
LCOE	Levelized Cost of Energy
CAPEX	Capital Expenditure
IRR	Internal Rate of Return

1. INTRODUCTION

1.1 SCOPE OF THE REPORT

The objective of D7.2 “Detailed description of demonstration scenarios” is to document the outcome of the activities carried out within T7.2 “Scenario Refinement and Input Data Compilation” of the EU-funded DTOceanPlus project. The activities carried out during this task led to a better description of the demonstration scenarios (in the following also named Validation Scenarios VSs), previously defined in WP2, which will be run within the framework of the project to illustrate the different uses of the tools. The characterisation of the data required to run the validation scenarios as well as their characterisation have been accounted for and detailed.

Considering the results of T2.3 of the project, after briefly describing the selection process which led to the identification of the VSs that served to define the minimum requirements of the VSs, a description of the refinement of the VSs and characterisation as well as compilation of data requirements are updated and detailed in this document at sections 4 and 5 and will be again, defined with more detail and precision, at the future deliverable D7.3. With further detail, each scenario will be identified through a set of project data, inherent to the technology as well as metocean conditions and other location related data. Moreover, all the reference data information (components and their characteristics, such as failure rates, mechanical properties, costs, environmental impacts and all those needed by the tools developed in WP3-WP6 to run) is compiled in this deliverable at Section 5 and Annex I. Therefore, all the data and information gathered in this task will be implemented into the digital representation model of the ocean energy system as defined in T7.1 [5].

While the selected Validation Scenarios do not directly cover every permutation of use-case, technology type and technology aggregation level, they do deliver validation of all the tool functionalities necessary to support those permutations, meaning that the resulting validation of the suite of tools is complete.

Moreover, the choice of this selection of VSs was supported and advised by the different types of potential users of the tools present in the consortium of the DTOceanPlus project.

1.2 OUTLINE OF THE REPORT

The public deliverable D7.2 describes:

- the methodology to define the initial set of useful validation cases VCs of the DTOceanPlus toolset
- the refinement process which aims at updating the set of VCs
- objectives, scope and description of the scenarios.

The document is structured in five sections:

- **Section 1** is an introduction to the document: the context in which this document was prepared is explained, as well as the objectives which have been achieved.

- **Section 2** summarises the initial selection process carried out in Task 2.3 and documented in D2.3 Demonstration Methodology
- **Section 3** summarises the selection process of the VSs.
- **Section 4** is dedicated to the refinement of the validation cases and includes a detailed description of the validation scenarios that are used to validate the suite of design tools.
- **Section 5** describes the compilation of the input data required to characterise each of the validation scenarios in an appropriate manner. With further details, each scenario is identified through a set of project data, inherent to the technology as well as metocean conditions and other location related data.

1.3 SUMMARY OF THE DTOCEANPLUS PROJECT

DTOceanPlus aims at accelerating the commercialisation of the Ocean Energy sector by developing and validating an open source suite of design tools for the selection, development, deployment and assessment of ocean energy systems (including sub-systems, energy capture devices and arrays).

At a high level, the suite of tools developed in DTOceanPlus will include:

- **Structured Innovation tool**, for concept creation, selection, and design.
- **Stage Gate tool**, using metrics to measure, assess and guide technology development.
- **Deployment tools**, supporting optimal device and array deployment:
  - Site Characterisation (e.g. metocean, geotechnical, and environmental conditions);
  - Energy Capture (at an array level);
  - Energy Transformation (PTO and control);
  - Energy Delivery (electrical and grid issues);
  - Station Keeping (moorings and foundations);
  - Logistics and Marine Operations (installation, operation, maintenance, and decommissioning).
- **Assessment tools**, to quantify key parameters:
  - System Performance and Energy Yield;
  - System Lifetime Costs;
  - System Reliability, Availability, Maintainability, Survivability (RAMS);
  - Environmental and Social Acceptance.

These tools are supported by underlying common digital models and a global database, as shown graphically in Figure 1.1 REPRESENTATION OF DTOCEANPLUS TOOLS.. In fact, the so-called Digital Representation provides a standard framework for the description of sub-systems, devices and arrays, thus allow sharing of design information.

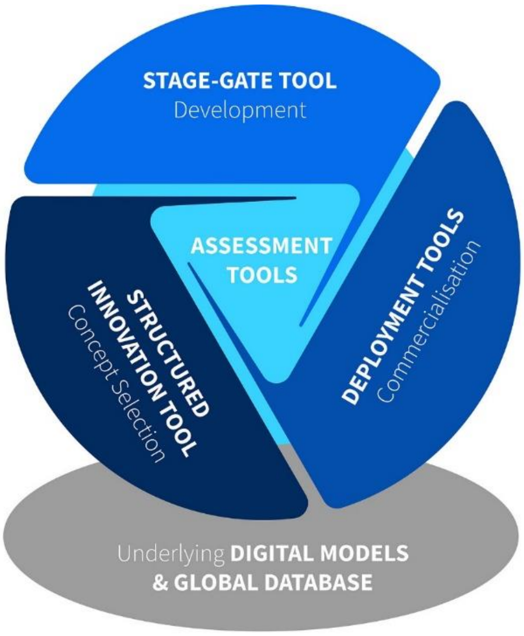

FIGURE 1.1 REPRESENTATION OF DTOCEANPLUS TOOLS.

2. SUMMARY OF INITIAL SCENARIO SELECTION PROCESS

This section summarises the initial selection process carried out in Task 2.3, which is documented in D2.3 Demonstration Methodology [1].

2.1 THE FUNNEL APPROACH FOR IDENTICATION OF VALIDATION SCENARIOS

The minimum requirements for the validation scenarios are those defined in the Description of Action [1] document:

- At least two sites should be considered, one for wave and one for tidal technology;
- At least four technologies should be validated, i.e. the ones developed by the four Technology Developers part of the DTOceanPlus consortium. Two of them are Wave Energy technologies and two of them are Tidal Energy technologies.
- All the toolsets should be validated: the Structured Innovation tool, the Stage Gate tool and the Deployment design tools. The Assessment tools are transversal and used by all the other tools.

Given the complexity of the tools being developed in the DTOceanPlus project, there are many potential validation scenarios. With three design tools (Structured Innovation, Stage Gate, and Deployment, all using the Assessment tools), three levels of complexity (Array, Device, and Subsystem), and two technology types (wave and tidal) there could be at least 3×3×2=18 cases. There are also four main categories of users (Technology Developers, Project Developers, Public and Private Investors and Policy Makers), so it is therefore not practicable to validate all permutations.

To identify the most relevant Validation Scenarios, a "funnel" approach has been used during the activities carried out, as shown in Figure 2.1 FUNNEL APPROACH FOR THE IDENTIFICATION OF VALIDATION SCENARIOS..

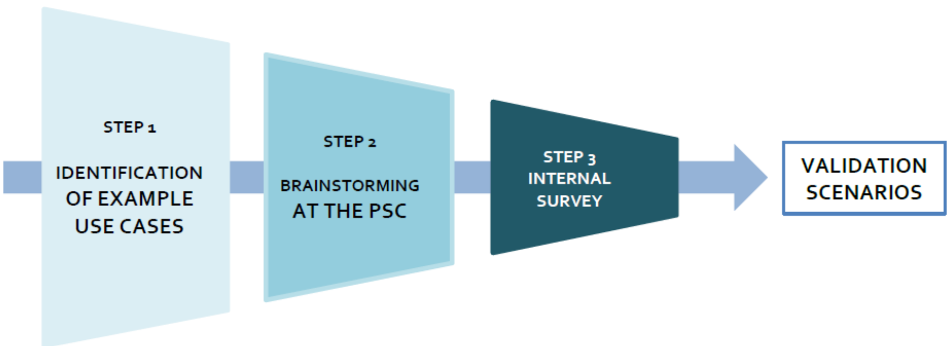

FIGURE 2.1 FUNNEL APPROACH FOR THE IDENTIFICATION OF VALIDATION SCENARIOS.

This methodology is based on a three-step procedure:

- Step 1: Identification of example Use Cases. This step is important to define the most relevant Use Cases that involve the use of the tools.
- Step 2: Brainstorming at the Project Steering Committee (PSC). During this face-to-face meeting, a brainstorming was held to identify the most relevant areas, among the whole Example Use Case space, for validating the tools.
- Step 3: Internal Survey. The involvement of the Technology Developers, participating in the DTOceanPlus project, served to further reduce the real needs of the sector and then select the most relevant Validation Scenario.

The involvement of different actors at each step helped also to identify possible gaps and situations which were not identified at the previous step and that could have biased the final outcome.

2.1.1 BRAINSTORMING AT THE PROJECT STEERING COMMITTEE MEETING

The second step in the funnel approach was the Brainstorming activity that took place in Paris on October 16th, during the PSC meeting. All the Work Package Leaders (WPLs) took part in the meeting, as well as the software developers.

The postprocess of the outcome of the brainstorming activity served to define potential Areas of Interests, which was contrasted against the Technology developers in the following step.

2.1.2 INTERNAL SURVEY

While performing the brainstorming exercise during the Project Steering Committee Meeting in Paris, it was pointed out that none of the technology developers in the consortium were present. It was, therefore, decided to carry out a survey among the participants of DTOceanPlus in order to involve the Consortium Partners

The third and final step in the funnel process involved the Technology developers that are part of the consortium of the DTOceanPlus project.

The postprocess of the outcome of the internal survey served to define the Validation Scenarios.

2.1.3 CONCLUSIONS AFTER THE BRAINSTORMING AND THE SURVEY

By comparing the outcome of the brainstorming and the survey within the consortium members, some general conclusions could be inferred:

- **Deployment Design Tools:** The use of these tools is highly envisaged at Array Level. This is aligned with the outcome of the brainstorming and it is consistent with the expectations of the project, in which the Deployment tools are tools for the global validation of coupled and more complex systems.

- **Stage Gate design tool:** There is not an agreement between the Brainstorming at the PSC meeting and the survey. The Stage Gate Tool, indeed, seemed to be a valuable tool while assessing the performance of an ocean energy system especially at the device level of aggregation during the PSC meeting. However, the technology developers in the consortium, as well other key users such as ESC and project developers as EGP, consider that a scenario involving the Stage Gate Tool is more relevant at Subsystem Level.
- **Structured Innovation design tool:** Again, when considering validation scenarios involving this tool, during the PSC meeting a consensus was achieved that the Structured Innovation tool was useful to investigate scenario at Subsystem Level. However, during the survey it emerged that the Technology developers, as well as other key users such as ESC and project developers as EGP, consider more important scenarios involving the Structured Innovation tool at Device Level.

The procedure of refinement of priorities has been useful to further focus on the real needs of the sector, as well as to identify gaps and differences in the views that have not emerged during the PSC meeting. Accounting for all the above, Section 4 presents a refined proposal of Validation Scenarios, aimed at representing and covering the most relevant and important use cases.

2.2 PROPOSED VALIDATION SCENARIOS

The validation scenarios that the full sample of respondents considered of interest were the following:

- At array level, the use of Deployment tools represents by far the most preferred option.
- Similarly, at Device level, the use of Structured Innovation tools seems to be more relevant than other scenarios;
- Finally, at Subsystem level, the use of Stage Gate tools represents the most preferred scenario.

It is worth considering that, even if some spreading is identified, the groups of participants in the survey have achieved similar conclusions.

While analyzing the results and given the wide spectrum of example use cases and objectives, it seemed appropriate to limit the number of representative Validation Scenarios to a number equal to 6. Indeed, each validation case would require a significant amount of data collection. For this reason, some validation scenarios were paired such that they could use a common framework of technology, intended site and catalogue of components and services.

All the tools will be validated both for wave and tidal technology, with different level of aggregation. The choice of the aggregation level was proposed accounting for the outcome at the brainstorm in Paris and the internal survey.

2.2.1 OVERALL CLASSIFICATION

After this approach, the following six validation scenarios have been identified, three of them involving at least two wave technologies, and three of them involving at least two tidal technologies. Similarly, various alternatives for deployment sites have been proposed, at least one for tidal and one for wave scenarios. All the tools will be validated: Structured Innovation Tool, Stage Gate Tool and Deployment Design Tools, while the Assessment Tools will be used by all the other tools.

- VS1 is representative for a Wave Technology using the Structured Innovation tool at Device Level
- VS2 is representative for a Wave Technology using the Stage Gate tool at Subsystem Level
- VS3 is representative for a Wave Technology using the Deployment Design tools at Array Level
- VS4 is representative of a Tidal Energy technology using the Structured Innovation tool at Subsystem Level
- VS5 is representative for a Tidal Technology using the Stage Gate tool at Device level
- VS6 is representative for a Tidal Technology using the Deployment design tools at Array Level

TABLE 2.1 PROPOSED VALIDATION CASES.

Ref	Technology	DTOceanPlus tools	Complexity
VS1	Wave	Structured Innovation	Device
VS2	Wave	Stage Gate	Subsystem
VS3	Wave	Deployment	Array
VS4	Tidal	Structured Innovation	Subsystem
VS5	Tidal	Stage Gate	Device
VS6	Tidal	Deployment	Array

The matrix in Table 2.1 PROPOSED VALIDATION CASES. can be visualized in Figure 2.2Figure 2.2 PROPOSED VALIDATION SCENARIO MATRIX.. It is evident that all the tools will be validated both for wave and tidal technology, with different level of aggregation. The choice of the aggregation level was proposed accounting for the outcome at the brainstorm in Paris and the internal survey.

		Tools to be Tested					
		Structured Innovation Tools		Stage Gate Tools		Deployment Design Tools	
		Wave	Tidal	Wave	Tidal	Wave	Tidal
Level of Aggregation	Array Level					VS3	VS6
	Device Level	VS1			VS5		
	Sub-system Level		VS4	VS2			

FIGURE 2.2 PROPOSED VALIDATION SCENARIO MATRIX.

In the following Table 2.2, a more detailed description of the scenarios is presented.

TABLE 2.2 DETAILED DESCRIPTION OF THE VALIDATION SCENARIOS.

	VALIDATION SCENARIO 1	VALIDATION SCENARIO 2	VALIDATION SCENARIO 3	VALIDATION SCENARIO 4	VALIDATION SCENARIO 5	VALIDATION SCENARIO 6
Technology Type	Wave	Wave	Wave	Tidal	Tidal	Tidal
Tools to be Validated	Structured Innovation	Stage Gate	Deployment Design	Structured Innovation	Stage Gate	Deployment Design
Aggregation Level	Device Level	Subsystem Level	Array Level	Subsystem Level	Device Level	Array Level
Lead Partner	Corpower	Corpower	IDOM	Orbital	Orbital	NOVA
Other Partners Interested	EGP, WES	EGP, WES	EGP, WES	ESC	-	-
Technology	Corpower Ocean - C4	Corpower Ocean - C4	MARMOK - A14	Orbital O2; 2 MW	Orbital O2; 2 MW	Nova M100DD - 100 kW
Total Power/Number of Devices	300 kW - 1 device	300 kW - 1 device	2 MW / 8 devices	1 device	1 device	10-50 devices
Subsystem/Component	n/a	PTO	n/a	Connectors	drivetrain scaling	n/a
Intended Site	Billia Croo, Agucadora, Chile	Billia Croo, Agucadora, Chile	BiMEP	EMEC Berth 5; Raz-Blanchard	EMEC Berth 5; Raz-Blanchard	Bluemull Sound; Bardsey; Raz-Blanchard

3. DEMONSTRATION METHODOLOGY

3.1 INITIAL CONSIDERATIONS

As previously discussed, an important task within the DTOceanPlus project is to validate the novel toolset using real data. This requires a set of validation scenarios (VSs), also known as demonstration scenarios. The activities developed in Task 2.3 of the project were devoted to the definition of a proper methodology leading to the selection of Validation Scenarios with a certain impact and value for the sector of ocean renewable energy. Task 7.2 is dedicated to the refinement of the selected Validation Scenarios and provides a detailed description for each of the Validation Scenarios. This description includes the overall characterisation of the scenario, the definition of the project that will be validated and the set of project data inherent to the technology as well as metocean conditions and other location related data.

The description of T7.2 prescribes detailed requirements to be fulfilled for the selection of the demonstration scenarios for different uses of the tools. Indeed, it is required that the toolset is tested for at least four technologies (two for wave energy harvesting and two for tidal) in at least two deployment sites (one for wave and one for tidal). All the design tools should be tested: Structured Innovation design tool, Stage Gate design tool, Deployment design tools. The Assessment tools are used by all the other tools and will therefore be tested concurrently.

The toolset aims at covering a wide spectrum of potential users, with different needs and objectives; moreover, the toolset is designed to be capable of working at different levels of aggregation of the system: array, device, and subsystems or components.

Considering the number of permutations of technologies, deployment sites, tools to be tested, user needs, and levels of complexity of the project, it was identified in deliverable D2.3 that the validation scenarios should be extracted from a very wide sample space. The following section is dedicated to the process which is based upon the considerations of D2.3 and describes how the initial characterisation of the validation scenarios is refined towards a detailed description and compilation of data for each scenario.

3.2 THE APPROACH FOR THE REFINEMENT OF THE VALIDATION SCENARIOS

The scenario refinement process is tied to the "funnel" approach which was the base for the initial selection carried out in Task 2.3 and described in Deliverable 2.3 (Step1 – Step3 of Figure 2.1 FUNNEL APPROACH FOR THE IDENTIFICATION OF VALIDATION SCENARIOS.). The funnel approach led to the identification of different validation scenarios that were selected to validate the developed suite of tools. This first part of the overall identification of validation scenarios comprises three individual steps:

1. Step1: **Identification of example Use Cases**: This step is important to define the most relevant Use Cases that involve the use of the tools.

2. Step2: **Brainstorming at the Project Steering Committee (PSC)**: During this face-to-face meeting, a brainstorming was held to identify the most relevant areas, among the whole Example Use Case space, for validating the tools.
3. Step3: **Internal Surveys:** The involvement of the Technology Developers, participating in the DTOceanPlus project, served to further reduce the real needs of the sector and then select the most relevant Validation Scenario.

Hereby, the main objective of this funnel approach is the reduction of the sample size to focus on the most relevant validation scenarios involving different actors and stakeholders amid various partners of the DTOceanPlus project. The involvement of different actors at each step helped also to identify possible gaps and situations which were not identified at the previous step and that could have biased the outcome.

In order to refine the previously identified candidates to validate the DTOceanPlus suite of tools, the funnel approach is complemented by the scenario refinement process (see Step4 – Step7 of Figure 3.1 SCENARIO REFINEMENT PROCESS) which is designed as an overlying iterative process to achieve the appropriate depth in defining and describing the validation scenarios.

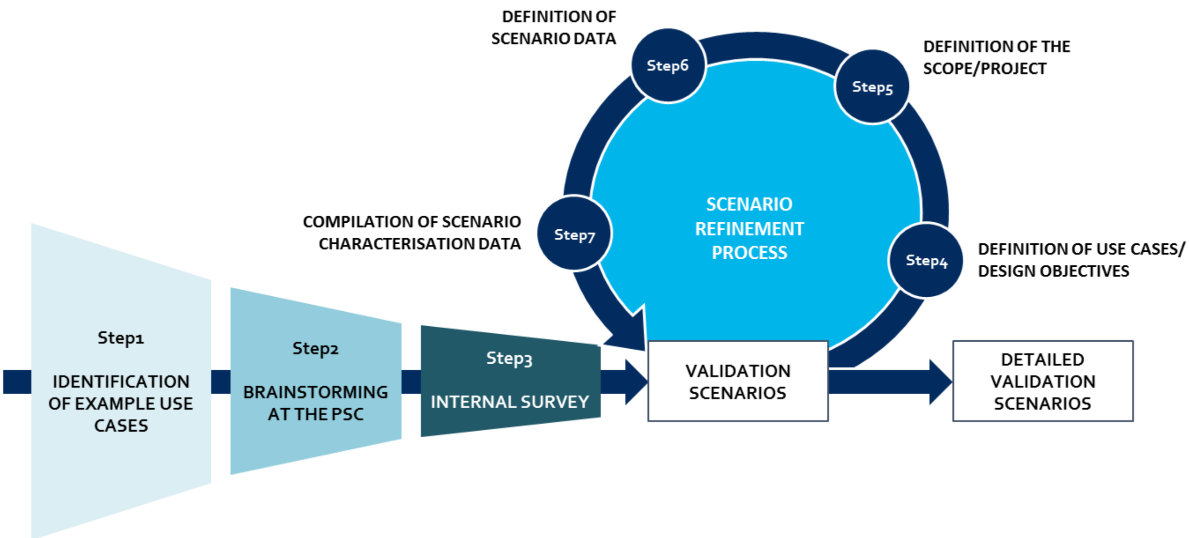

FIGURE 3.1 SCENARIO REFINEMENT PROCESS

The scenario refinement process is subdivided into four consecutive steps:

4. Step4: **Definition of Use Cases/ design objectives:** The definition of the Use Cases and objectives for each validation scenario is the first step of the scenario refinement process to adhere the overall purpose of the validation ("goal").
5. Step5: **Definition of the scope/ project:** This step enables the user to define the scope of the validation scenario and describe the project ("setting the scene").
6. Step6: **Definition of scenario data:** Within this step, the characterisation of the input data requirements for each validation scenario is concluded. This step is important to generate a

set of data that represents and describes the project and validation scenario in an appropriate manner according to the specifications produced in Task 7.1.

7. Step7: **Compilation of scenario characterisation data:** The compilation and collection of the required data to characterise the validation scenarios is completed to facilitate the validation of the DTOceanPlus suite of tools according to the pre-defined objectives in Step4.

The overarching goal of the scenario refinement process is a comprehensive description of scenarios which will be considered for the demonstration purposes, including data characterisation and classification. These steps are the foundation to integrate all the data and information gathered in this Task T7.2 into the digital representation model of the ocean energy system as defined in T7.1.

3.2.1 DEFINITION OF USE CASES/ DESIGN OBJECTIVES

The purpose of the initial step of the scenario refinement process is the definition of the design objectives and Use Cases that shall be validated. Based on the initially selected validation scenarios that are the output of the funnel approach, the validation objectives of the key stakeholders in each validation scenario are defined. The potential validation objectives may address economic, technical and/ or strategic questions regarding the implementation of ocean energy systems in different sectors, sites and settings.

The validation scenarios are selected in a way that enables validation of all four DTOceanPlus tools comprising the Structure Innovation Design Tool, the Stage Gate Design Tool as well as the Deployment Design Tools and the Assessment Design Tools. Correspondingly, the objectives can range from a wide range of different Use Cases which are to be defined in accordance to the scope and aggregation level of the pre-determined validation scenarios. The scope of each validation scenario comprises the defined set of tools that should be validated, the technology type and the aggregation level.

The definition of the corresponding design objectives for each scenario are performed through internal surveys within the DTOceanPlus consortium. This specifically includes the thorough feedback of the industrial partners for wave and tidal energy systems. Together, a set of real-world Use Cases is defined for each of the scenarios that will guarantee the practical significance of the validation process. The definition of such design objectives further includes a brief description of the different Use Cases.

3.2.2 DEFINITION OF THE SCOPE/ PROJECT

The second step of the scenario refinement process consists of the definition of the project. This comprises the identification of the lead partner of the specific validation scenario who is identical with the entity that defined the design objective in the previous step. The Lead Partner is in charge of the provision and/or organisation of the collection of data if provided by other partners/sources. This assigned partner is responsible for providing the input data to the Lead Partner for the validation scenario.

At this stage, this includes the level of aggregation, the total power or number of devices that are subject to the validation, the technology to be tested and the intended site to deploy the validation case. To define the data requirements and input information the user that will validate the scenario must provide for each validation scenario to validate the performance of each design tool. It is important to define the project's scope and objective that determines which tool modules are required to provide an answer to such design objectives. After identifying what range of tools from the DTOceanPlus suite of tools are used in each UC, the scenario refinement process will define the explicit scenario data and input information. The required specifications according to the definition of the design objectives and the scope of the project are illustrated in Table 3.1 SPECIFICATION OF SCENARIO CHARACTERISATION AND PROJECT DEFINITION.

TABLE 3.1 SPECIFICATION OF SCENARIO CHARACTERISATION AND PROJECT DEFINITION

	A. SCENARIO CHARACTERISATION
A.1	***Tools to be validated***
A.2	***Technology type***
A.3	***Aggregation level***
	B. PROJECT DEFINITION
B.1	***Lead partner*** *or partner with interest*
B1.1	*Example Use Cases (Design Objectives)*
B1.2	*Brief description of the specific Use Cases*
B.2	***Total power/ number of devices***
B.3	***Technology to be tested***
B.4	***If A.3 is subsystem/ component, need to specify***
B.5	***Intended site***

3.2.3 DEFINITION OF SCENARIO DATA

Following the consecutive refinement process, the next step serves as a link between the design objectives and the scenario data criteria. Hereby, the translation of the design objective to a set of data and input information which sufficiently characterises the demonstration scenario will be achieved. This inherent set of data and input information of the scenarios gathered in this task will be incorporated in the digital representation model of the ocean energy system as defined in T7.1.

The validation scenario data will be structured in three areas. Among these areas are a detailed technology description, a set of data for the site characterisation and information regarding different phases of the project. The detailed technology description further encompasses the prime mover, the PTO & control system, the power transmission and the station keeping system. The specifications of the validation scenario data are illustrated in Table 3.2 DATA SPECIFICATIONS OF THE VALIDATION SCENARIOS.

TABLE 3.2 DATA SPECIFICATIONS OF THE VALIDATION SCENARIOS

	C. DATA SPECIFICATIONS
C.1	**Technology Description**

	C. DATA SPECIFICATIONS
C1.1	*Hydrodynamic System*
C1.2	*PTO & Control System*
C1.3	*Electrical Dispatch*
C1.4	*Station Keeping System*
C.2	**Site Characterisation**
C2.1	*Resource*
C2.2	*Seabed Properties*
C2.3	*Marine Life*
C2.4	*Competing use of space*
C.3	**Catalogues**
C3.1	*Components*
C3.2	*Vessels*
C3.3	*Infrastructures/ Ports*
C.4	**Phases**
C4.1	*Planning & Development*
C4.2	*Installation & Commissioning*
C4.3	*Operation & Maintenance*
C4.4	*Decommissioning*

The data specifications defined in this subtask are in line with the digital representation of ocean energy systems as described in D7.1.

3.2.4 COMPILATION OF SCENARIO CHARACTERISATION DATA

The final step of the scenario refinement process is concluded by the compilation of scenario characterisation data, which is intended to provide a guideline for the compilation of the input data.

The compilation of the scenario input data requires the collection of information that is contained in Table 3.1 SPECIFICATION OF SCENARIO CHARACTERISATION AND PROJECT DEFINITION and Table 3.2 DATA SPECIFICATIONS OF THE VALIDATION SCENARIOS. Moreover, the user that will validate the scenario must assure that the collected data complies with the requirements of the DTOceanPlus suite of tools to validate the identified validation scenarios and selected Use Cases. This dependency is illustrated in Figure 3.2 DEPENDENCIES ON THE COMPILATION OF SCENARIO CHARACTERISATION DATA.

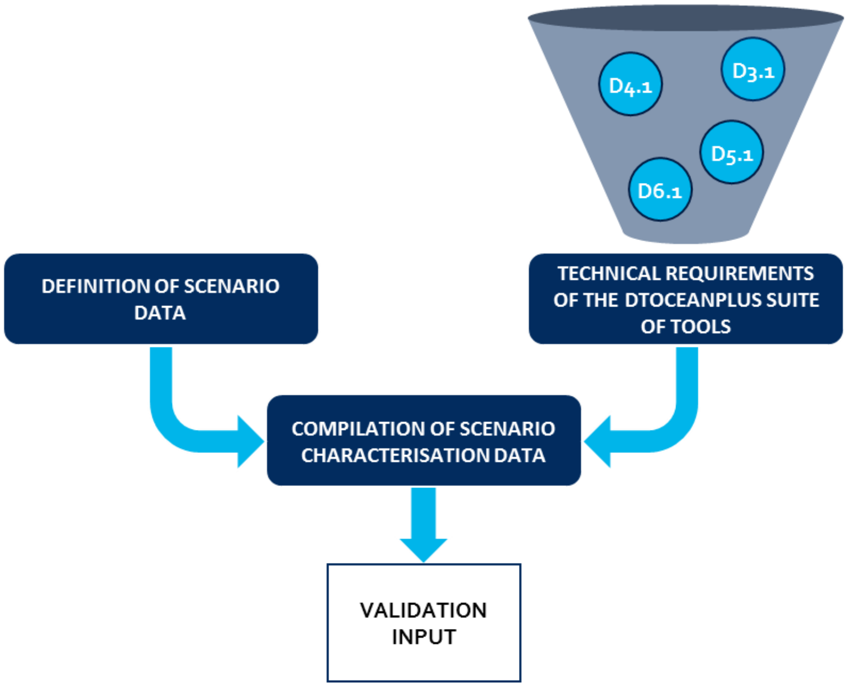

FIGURE 3.2 DEPENDENCIES ON THE COMPILATION OF SCENARIO CHARACTERISATION DATA

The compilation of the relevant data to conduct the validation of the DTOceanPlus suite of tools depends on the definitions of scenario data originating from Deliverable D2.3 and Task7.2 but likewise determined by the technical requirements of the different tools that are subject of the validation procedure. These requirements are described in Deliverable D3.1 [6], D4.1 [7], D5.1 [8] and D6.1 [9].

3.3 THE PROCEDURE FOR THE VALIDATION OF THE DTOCEANPLUS TOOLS USING THE VALIDATION SCENARIOS

To identify the appropriate approach to validate the performance of the DTOceanPlus suite of tools, a two-folded procedure has been developed enabling both the qualitative and quantitative assessment of the set of tools. A schematic view of this approach is shown in Figure 3.3 VALIDATION PROCEDURE OF THE DTOCEANPLUS SUITE OF TOOLS.

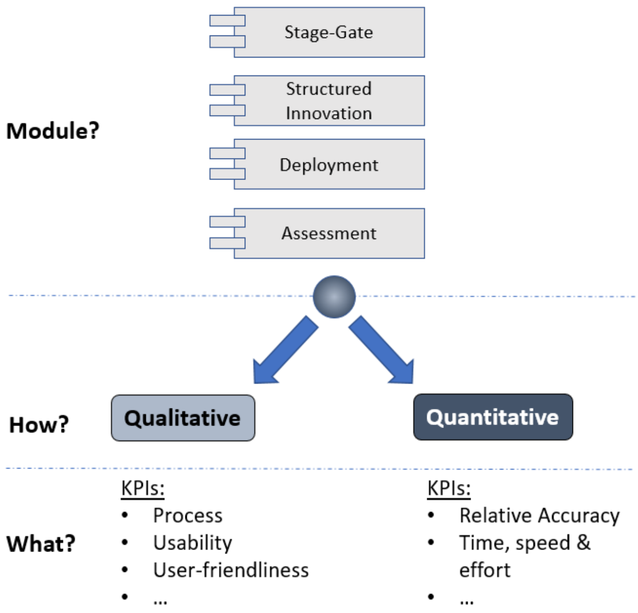

FIGURE 3.3 VALIDATION PROCEDURE OF THE DTOCEANPLUS SUITE OF TOOLS

As it is indicated in Figure 3.3 VALIDATION PROCEDURE OF THE DTOCEANPLUS SUITE OF TOOLS, the approach is based on three levels that aim at answering the following questions (which can be find at sections 5):

1. Step 1: **Which tool should be validated?** This question is important to define the scope of the validation process and identify what tools are used for the relevant validation scenario.
2. Step 2: **How is the validation performed?** Based on the modules that are subject to the validation scenario, the validation procedure is limited.
3. Step 3: **What Key Performance Indicators (KPIs) are used to validate the performance of the tools?** This step determines the output of the validation process.

4. REFINEMENT OF VALIDATION SCENARIOS

4.1 VALIDATION SCENARIO 1: WAVE / SI TOOL / DEVICE LEVEL

VS1 is representative of a **Wave Energy Technology**, using the **Structured Innovation Tool** at **Device Level**.

4.1.1 DEFINITION OF THE SCENARIO OBJECTIVE & USE CASES

Within the scenario refinement process of VS1, the corresponding validation partners **EGP**, **WES** and **CorPower** decided to refine the objectives. These refined design objectives therefore incorporate and conjoin the specific contents of the preliminary defined objectives of Deliverable D2.3. Moreover, the specific interests of the validation partners are seized in the Use Cases which will reflect how each of the different users of the tool may exploit the value of the DTOceanPlus suite of tools tailored to the design objective of VS1:

Design Objective 1: To rapidly evaluate different system-level concepts and to identify the most promising investment potential to reach innovation targets at the least possible cost.

Design Objective 2: To identify areas of innovation to improve within its technology and to create a new or improving device concept.

Design Objective 3: To carry out a gap analysis and identify enabling technologies.

TECHNOLOGY DEVELOPERS

The validation partners of VS1 representing *technology developers* are **CorPower** and **WES**.

- **UC1.1:** Creating new or improving a device concept
- **UC1.2:** Creating new or improving a component for an existing device
- **UC1.3:** Identifying enabling technologies required (gap analysis)
- **UC1.4:** Generating ideas for optimising device: topology, scale(s), location(s), market(s)
- **UC1.7:** Identifying potential areas of opportunity

Inputs: User requirements (e.g. budget, risk, location, KPI, etc...) or technology characteristics relating to existing technology

Output: New concepts/ideas

PROJECT DEVELOPERS

The validation partners of VS1 representing *project developers* is **EGP**.

- **UC4.2** Identifying areas of opportunity, in terms of topology/scale(s)/ location(s)/market(s) for array/device/subsystem
- **UC4.3** Identifying enabling technologies required (gap analysis)
- **UC4.5** Assessing current arrays/technology

Inputs: User requirements (e.g. budget, risk, location, etc...) and project characteristics (MW deployment, KPI, etc...)

Outputs: New concepts/ideas

PUBLIC AND PRIVATE INVESTORS

The validation partners of VS1 potentially representing *public and private investors* is **EGP.**

- **UC7.1** Identify attractive areas of innovation for investment

Inputs: User requirements (e.g. budget, risk, location, etc…)

Outputs: Ideas for investment/funding

4.1.2 DEFINITION OF SCOPE AND PROJECT

Considering the refinement of this scenario some changes were defined. Initially, only one intended site was considered but due to the interest of other partners in testing the Structured Innovation Tool at Device Level, two additional sub scenarios were included. So, for these validation scenarios three sub scenarios (1.1, 1.2 and 1.3) were defined.

This scenario is representative of a Wave Technology, using the Structured Innovation Tool at Device Level. The Structured Innovation Tool will be tested considering the data of two sites: Billia Croo and Chile. Corpower and EGP will be the *Lead Partners* for these intended sites, respectively, and the *Technical Support Partner* will be ESC in all the sub scenarios.

In Table 4.1 SYNOPTICAL DESCRIPTION OF REFINED VS1 it is possible to observe the characterisation of each sub scenario.

TABLE 4.1 SYNOPTICAL DESCRIPTION OF REFINED VS1

	VALIDATION SCENARIO 1		
Sub Scenario	**1.1**	**1.2**	**1.3**
Technology Type	Wave		
Tools to be Validated	Structured Innovation		
Aggregation Level	Device Level		
Lead Partner	Corpower	EGP	WES
Other Partners Interested	WES		
Technical Support Partner	ESC	ESC	ESC
Technology	Corpower Ocean - C4	n/a	n/a
Total Power/Number of Devices	300 kW - 1 device	n/a	n/a
Subsystem/Component	n/a	n/a	n/a
Intended Site	Billia Croo	Chile	n/a

4.2 VALIDATION SCENARIO 2: WAVE / SG TOOL / SUBSYSTEM LEVEL

This Validation Scenario is related to the Validation Scenario 1, and therefore it is representative of a **Wave Energy technology**, using the **Stage Gate Tool** at **Subsystem Level**.

4.2.1 DEFINITION OF THE SCENARIO OBJECTIVE & USE CASES

Within the scenario refinement process of VS2, the corresponding validation partners **EGP**, **WES** and **CorPower** decided to reduce and refine the number of objectives to a single design objective. This refined design objectives therefore incorporates and conjoins the specific contents of the preliminary defined objectives of Deliverable D2.3. Moreover, the specific interests of the validation partners are seized in the Use Cases which will reflect how each of the different users of the tool may exploit the value of the DTOceanPlus suite of tools tailored to the design objective of VS2:

Design Objective 1: Perform a stage gate assessment for a PTO using embedded mode of the Stage Gate design tool and produce a report for the developer to validate their performance.

TECHNOLOGY DEVELOPERS

The validation partners of VS2 representing *technology developers* are **CorPower** and **WES**.

- **UC2.1:** Assesses what stage their technology is at (including sub-systems and devices)
- **UC2.4:** Identify what needs to be done to meet the next stage
- **UC2.6:** Identify where the next cost enhancements come from
- **UC2.7:** Validate the informative value of the stage gate process to perform the improvement in the structure innovation tool

Inputs: Technology characteristics

Outputs: Current stage; Steps to meet next stage; or an appropriate answer to the deployment and assessment design tools (energy yield etc.) depending on stage

PUBLIC AND PRIVATE INVESTORS

The validation partner of VS2 potentially representing *public and private investors* is **EGP**.

- **UC8.1:** Assess projects, devices, enabling technologies
- **UC8.2:** Assess if device/ technology is ready to go to the next stage?
- **UC8.3:** Identify R&D opportunities
- **UC8.4:** Assist in investment decisions

Inputs: Technology & project characteristics

Outputs: Outputs from assessment design tools

4.2.2 DEFINITION OF SCOPE AND PROJECT

In the first version of this validation scenario there were some location alternatives for the intended site that will be used to test the Stage Gate tool at Subsystem Level. Between Billia Croo, Aguçadoura and Chile the first one was selected. Also, for the definition of the Subsystem there were two possibilities: Mooring System or PTO. The PTO was chosen.

Validation Scenario 2 is related to the Validation Scenario 1, and therefore it is representative of a Wave Energy technology, using the Stage Gate tool at Subsystem Level. The tool will be tested according to the information of the site (Billia Croo), will have Corpower as *Lead Partner* and WES as *Technical Support Partner*. This information and other complementary can be viewed in Table 4.2 SYNOPTICAL DESCRIPTION OF REFINED VS2.

TABLE 4.2 SYNOPTICAL DESCRIPTION OF REFINED VS2

	VALIDATION SCENARIO 2
Sub Scenario	-
Technology Type	Wave
Tools to be Validated	Stage Gate
Aggregation Level	Subsystem Level
Lead Partner	Corpower
Other Partners Interested	EGP, WES
Technical Support Partner	WES
Technology	Corpower Ocean - C4
Total Power/Number of Devices	300 kW - 1 device
Subsystem/Component	PTO
Intended Site	Billia Croo

4.3 VALIDATION SCENARIO 3: WAVE / DEPLOYMENT TOOLS / ARRAY

VS3 is representative for a **Wave Technology**, using the **Deployment Design Tools** at **Array level**.

4.3.1 DEFINITION OF THE SCENARIO OBJECTIVE & USE CASES

Within the scenario refinement process of VS3, the corresponding validation partners **IDOM**, **EGP**, **WES**, **EDP** and **CorPower** decided to reduce and refine the number of objectives to a single design objective. This refined design objective therefore incorporates and conjoins the specific contents of the preliminary defined objectives of Deliverable D2.3. Moreover, the specific interests of the validation partners are seized in the Use Cases which will reflect how each of the different users of the tool may exploit the value of the DTOceanPlus suite of tools tailored to the design objective of VS3:

Design Objective 1: Validation of the techno-economic performance of how a device/ technology works in an array based on pre-defined metrics

TECHNOLOGY DEVELOPERS

The validation partners of VS3 representing *technology developers* are **CorPower** and **IDOM**.

- **UC 3.1:** Assess how their device/ technology works in an array cf. individual device
- **UC 3.4:** Assess evidence of marketing/ investment

Input: Site and technology characteristics

Output: Outputs from deployment and assessment design tools

PROJECT DEVELOPERS

The validation partners of VS3 representing *project developers* are **EDP** and **EGP**.

- **UC 6.3:** Planning Deployment and O&M
- **UC 6.4:** Assess evidence of marketing/ investment

Input: Site, Technology & project characteristics

Output: Suitability of device for site; outputs from deployment design tools

PUBLIC AND PRIVATE INVESTORS

The validation partners of VS3 representing *public and private investors* are **EGP**, **WES** and **EDP**.

- **UC 9.1:** Assist in Investment decisions
- **UC 9.2:** Due diligence
- **UC9.3:** Future potential for array expansion

Input: Technology & project characteristics

Output: Outputs from assessment design tools

4.3.2 DEFINITION OF SCOPE AND PROJECT

Relatively to this validation scenario no changes were defined and so, the initial characterisation was maintained.

VS3 is representative for a Wave Technology, using the Deployment design tools at Array Level. The intended site that will be used in this scenario is BiMEP [1]. The role of *Lead Partner* will be assumed by IDOM and the *Technical Supporter Partner* will be Tecnalia.

Information regarding the characterisation of this scenario can be consulted in Table 4.3 SYNOPTICAL DESCRIPTION OF REFINED VS3.

TABLE 4.3 SYNOPTICAL DESCRIPTION OF REFINED VS3

	VALIDATION SCENARIO 3
Sub Scenario	-
Technology Type	Wave
Tools to be Validated	Deployment Design
Aggregation Level	Array Level
Lead Partner	IDOM
Other Partners Interested	EGP, WES
Technical Support Partner	Tecnalia
Technology	MARMOK - A14 [1]
Total Power/Number of Devices	2 MW / 8 devices
Subsystem/Component	n/a
Intended Site	BiMEP

4.4 VALIDATION SCENARIO 4: TIDAL / SI TOOL / SUBSYSTEM LEVEL

This Validation Scenario is related to the Validation Scenario 5. It is representative of a **Tidal Energy technology** and the **Structured Innovation Tool** will be validated at a **Subsystem level**.

4.4.1 DEFINITION OF THE SCENARIO OBJECTIVE & USE CASES

Within the scenario refinement process of VS4, the corresponding validation partners **Orbital** and **ESC** decided to refine the objectives. This refined design objectives therefore incorporates and conjoins the specific contents of the preliminary defined objectives of Deliverable D2.3. Moreover, the specific interests of the validation partners are seized in the Use Cases which will reflect how each of the different users of the tool may exploit the value of the DTOceanPlus suite of tools tailored to the design objective of VS4:

Design Objective 1: To improve existing technologies e.g. reduced CAPEX, without changing the design features which are critical to success.

Design Objective 2: To structure decision making and discover options for potential design improvement with respect to engineering investment, LCoE improvement, timescales, societal acceptance issues, etc.

TECHNOLOGY DEVELOPERS

The validation partners of VS4 representing *technology developers* are **Orbital** and **ESC**.

- **UC1.2:** Creating new or improving a component for an existing device
- **UC1.4:** Generating ideas for optimising device: topology, scale(s), location(s), market(s)

Inputs: User requirements (e.g. budget, risk, location, etc...) or technology characteristics relating to existing technology

Output: New concepts/ideas

4.4.2 DEFINITION OF SCOPE AND PROJECT

The initial characterisation of this validation scenario had some issues regarding the Intended Site and the Number of Devices. EMEC Berth 5 and Raz-Blanchard were two alternatives for the site and for the number of devices it can be 1 or 100, according to selected site. The chosen site was EMEC Berth 5 and the simulation will be performed considering the utilization of one device.

This Validation Scenario is related to the Validation Scenario 5. It is representative of a Tidal Energy technology and the Structured Innovation tool will be validated at a subsystem level. The Structured Innovation Tool will be tested based on the data of the selected site. The leadership of this will be taken by Orbital with the technical support of ESC.

The characterisation of this validation scenario can be observed on Table 4.4 SYNOPTICAL DESCRIPTION OF REFINED VS4.

TABLE 4.4 SYNOPTICAL DESCRIPTION OF REFINED VS4

	VALIDATION SCENARIO 4
Sub Scenario	-
Technology Type	Tidal
Tools to be Validated	Structured Innovation
Aggregation Level	Subsystem Level
Lead Partner	Orbital
Other Partners Interested	Catapult

Technical Support Partner	ESC
Technology	Orbital O2; 2 MW
Total Power/Number of Devices	1 device
Subsystem/Component	Connectors
Intended Site	EMEC Berth 5

4.5 VALIDATION SCENARIO 5: TIDAL / SG TOOLS / DEVICE LEVEL

VS5 is representative for a **Tidal Energy Technology**, using the **Stage Gate Tool** at **Device level**.

4.5.1 DEFINITION OF THE SCENARIO OBJECTIVE & USE CASES

Within the scenario refinement process of VS5, the corresponding validation partners **Orbital**, **WES** and **Sabella** decided to refine the objectives. This refined design objectives therefore incorporates and conjoins the specific contents of the preliminary defined objectives of Deliverable D2.3. Moreover, the specific interests of the validation partners are seized in the Use Cases which will reflect how each of the different users of the tool may exploit the value of the DTOceanPlus suite of tools tailored to the design objective of VS5:

Design Objective 1: Perform a stage gate assessment for a device using embedded and standalone mode of the Stage Gate design tool and produce a report for the developer to validate their performance.

TECHNOLOGY DEVELOPERS

The validation partners of VS5 representing *technology developers* are **Orbital**, **WES** and **Sabella**.

- **UC2.1:** Assesses what stage their technology is at (including sub-systems and devices)
- **UC2.4:** Identify what needs to be done to meet the next stage
- **UC2.6:** Identify where the next cost enhancements come from
- **UC2.7:** Validate the informative value of the stage gate process to perform the improvement in the structure innovation tool

Inputs: Technology characteristics

Outputs: Current stage; Steps to meet next stage; or an appropriate answer to the deployment and assessment design tools (energy yield etc.) depending on stage

PUBLIC AND PRIVATE INVESTORS

The validation partner of VS5 potentially representing *public and private investors* is **WES**.

- **UC8.1:** Assess projects, devices, enabling technologies
- **UC8.2:** Assess if device/ technology is ready to go to the next stage?
- **UC8.3:** Identify R&D opportunities
- **UC8.4:** Assist in investment decisions

Inputs: Technology & project characteristics

Outputs: Outputs from assessment design tools

4.5.2 DEFINITION OF SCOPE AND PROJECT

In an early stage, only one site of demonstration was foreseen but due to the interest of other partners in this demonstration two sites will be considered. These sites will constitute two sub scenarios: 5.1 and 5.2.

VS5 is representative for a Tidal Technology, using the Stage Gate Tool at Device level. This tool will be tested considering the information of EMEC Berth 5 (sub scenario 5.1) and Fromveur (sub scenario 5.2). The first sub scenario will be led by Orbital and the second one will be led by Sabella. WES will provide the technical support for both sub scenarios.

The Table 4.5 SYNOPTICAL DESCRIPTION OF REFINED VS5 present the characterisation of this Validation Scenario.

TABLE 4.5 SYNOPTICAL DESCRIPTION OF REFINED VS5

	VALIDATION SCENARIO 5	
Sub Scenario	**5.1**	**5.2**
Technology Type	Tidal	
Tools to be Validated	Stage Gate	
Aggregation Level	Device Level	
Lead Partner	Orbital	Sabella
Other Partners Interested	-	
Technical Support Partner	WES	WES
Technology	Orbital O2; 2 MW	SABELLA D12
Total Power/Number of Devices	1 device	1 device, 500 kW
Subsystem/Component	n/a	n/a
Intended Site	EMEC Berth 5	Fromveur

4.6 VALIDATION SCENARIO 6: TIDAL / DEPLOYMENT TOOLS / ARRAY

VS6 is representative for a **Tidal Energy Technology**, using the **Deployment Design Tools** at **Array Level**.

4.6.1 DEFINITION OF THE SCENARIO OBJECTIVE & USE CASES

Within the scenario refinement process of VS6, the corresponding validation partners **NOVA**, **Sabella**, **EDP** and **Orbital** decided to refine the objectives. This refined design objectives represents the specific contents of the preliminary defined objectives of Deliverable D2.3. Moreover, the specific interests of the validation partners are seized in the Use Cases which will reflect how each of the different users of the tool may exploit the value of the DTOceanPlus suite of tools tailored to the design objective of VS6:

Design Objective 1: To carry out a third party 'validation' of new array projects at various sites, but also to assess how their device/technology works in an array compared against an individual device and provide evidence for marketing/investment.

Design Objective 2: Ensuring functionality of floating tidal array projects and ensure that what's being validated is adjusted to floating.

TECHNOLOGY DEVELOPERS

The validation partners of VS6 representing *technology developers* are **Orbital**, **NOVA** and **Sabella**.

- **UC 3.1:** Assess how their device/ technology works in an array cf. individual device
- **UC3.3:** Optimising the size of array and balance of plant for their specific device
- **UC 3.4:** Assess evidence of marketing/ investment

Input: Site and technology characteristics

Output: Outputs from deployment and assessment design tools (energy yield etc.)

PROJECT DEVELOPERS

The validation partners of VS6 representing *project developers* is **EDP**.

- **UC 6.3:** Planning Deployment and O&M

Input: Site, Technology & project characteristics

Output: Suitability of device for site; outputs from deployment design tools

PUBLIC AND PRIVATE INVESTORS

The validation partners of VS6 representing *public and private investors* is **EDP**.

- **UC 9.1:** Assist in Investment decisions
- **UC9.3:** Future potential for array expansion

Input: Technology & project characteristics

Output: Outputs from assessment design tools

4.6.2 DEFINITION OF SCOPE AND PROJECT

In this validation scenario, due to the interest of several partners in the validation of this tool, three different location possibilities were considered, which are going to be performed according to the next three sub scenarios: Bluemull Sound (sub scenario 6.1), EMEC Berth 5 (sub scenario 6.2) and Fromveur (sub scenario 6.3).

VS6 is representative for a Tidal Technology, using the Deployment Design Tools at Array Level. The *Lead Partners* of sub scenarios 6.1, 6.2 and 6.3 will be NOVA, Orbital and Sabella, respectively. UEDIN will support them in technical matters. The characterisation of VS6 is provided in Table 4.6 SYNOPTICAL DESCRIPTION OF REFINED VS6.

TABLE 4.6 SYNOPTICAL DESCRIPTION OF REFINED VS6

	VALIDATION SCENARIO 6		
Sub Scenario	**6.1**	**6.2**	**6.3**
Technology Type	Tidal		
Tools to be Validated	Deployment Design		
Aggregation Level	Array Level		
Lead Partner	NOVA	Orbital	Sabella
Other Partners Interested	-		
Technical Support Partner	UEDIN	UEDIN	UEDIN
Technology	Nova M100DD - 100 kW	Orbital O2; 2 MW	1,5 MW SABELLA turbines
Total Power/Number of Devices	10-50 devices	5 devices	50 devices
Subsystem/Component	n/a	drivetrain scaling	n/a
Intended Site	Bluemull Sound	EMEC Berth 5	Fromveur

5. DATA CHARACTERISATION AND VALIDATION OF THE PERFORMANCE OF THE TOOLS

5.1 VALIDATION PROCEDURE AND INPUT DATA REQUIRED

5.1.1 VALIDATION PROCEDURE OF THE TOOLS

In order to ensure that the design tools are achieving the expected objectives, some KPIs were defined and will be used to validate the modules and to gauge if the proper outputs are being produced (metrics).

To this validation procedure, the KPIs were divided into quantitative and qualitative KPIs which were defined to assess the design tools in the several validation scenarios. A schematic view of the respective application of these KPIs is shown in Figure 3.3 VALIDATION PROCEDURE OF THE DTOCEANPLUS SUITE OF TOOLS and they are thoroughly listed at Annex I. Both qualitative and quantitative KPIs will be applied to the design tools (Stage gate, Structured Innovation, Deployment and Assessment), having the main goals of validate the interaction between the tools and the users and assess the performance of the tools.

Relating to the quantitative KPIs, some of them, like Time, speed and effort could be applied to all tools and others, like Accuracy/Relative accuracy can be applied to Deployment and Assessment tools only.

With the intention to turn the qualitative KPIs more objective, ESC carried out an analysis about the "quantification" of the qualitative KPIs associated with the user interface performance. The SI Tool was reviewed in its current state and drawn out some key areas of focus for qualitative assessments:

- Installation process (application & database)
- Minimising lib (Dependencies)
- Technology Limitations (resource & design choices)

This then allowed to realise some additional / new requirements for improvements and additional features required to be a more effective tool.

Some of the Top level **Usability** Requirements proposed (ESC tried it for the FMEA v1.0 review) are:

- Easy to navigate (step by step, tree view, Hub & Spoke)
- Easy to interact
- Present information clearly
- Export easily
- Display results (legends, conditions, expectations, etc.)
- Provide trust in the output
- Reduce number of steps/ clicks
- Reduce number of errors
- Show system status

- Provide Consistency
- Align to Authentic/ minimal Design
- Provide help and Docs
- Help users diagnose & recover from errors
- Provide recognition than recall

Stage Gate and Structured Innovation tools

As processes, the Stage Gate and Structured Innovation design tools can be validated by considering how the outputs compare to the users' expectations before using the tool.

Aim & Vision of the tool (rating test of the Usability requirements using different persons representing the various users)**:**

- Expectation of user before using the tool
- Outcomes after using the tool

This should be supported by considering **Other Assessments** or questions to consider

- Do(es) the tool(s) aim to capture findings from other similar tools?
- Does the tool aim to provide a way to compare solutions?
- Do you have a copy of the current system/ software requirements?

Deployment and Assessment tools

Metrics are parameters that DTO+ calculates e.g. LCOE, Annual Energy Production. These are the outputs of the deployment and assessment tools and cannot be used on their own to validate the tools. These will be used to calculate the KPI 'accuracy'; by comparing the DTOceanPlus outputs to a developers own calculations, however it is important to note that this will be highly subjective - as the DTO+ outputs are very much dependent on the design choices in the set-up of the tools and there is no objective truth to the developer's own calculations as the sector has not yet delivered wave energy arrays (for example) or years of experience required for high-confidence data.

The intended outputs for the design tools are directly related with the conception of those. So, the defined metrics can also contribute to assess the KPI "Accuracy of the tool" by comparing the previous results of each developer in each technology with the outputs of DTOceanPlus tools for the various validation scenarios.

Eight main areas were created to divide the conceived metrics according to its type. The areas are the following ones: 1) System Lifetime Costs; 2) Reliability, Availability, Maintainability, Survivability; 3) System Performance and Energy Yield; 4) Environmental and Social Acceptance; 5) Energy Capture; 6) Energy Transformation; 7) Energy Delivery; 8) Logistics and Marine Operations.

In detail, some sub-areas were also defined to accommodate the metrics:

1) System Lifetime Costs

- Affordability: LCOE €/kWh), CAPEX (€), IRR (%).

2) Reliability, Availability, Maintainability, Survivability
    - Reliability: Mean Time to Failure (hours), Probability of failure (%).
    - Availability: Availability (%) or Downtime.
    - Maintainability: Mean Time to Repair (hours), Probability that a maintenance action can be carried out (%).
    - Survivability: Probability of structural irreparable failure (%).
3) System Performance and Energy Yield
    - Energy Capture: Efficiencies: captured, transformed, delivered (%); Total lost energy of the device or array during project lifetime (kWh).
4) Environmental and Social Acceptance
    - Acceptability: Global Environmental Impact Assessment score (Global positive); Global Environmental Impact Assessment score (Global negative); Number of jobs; Cost of consenting (€/MW); GWP - Phase (gCO2/kWh); CED - Phase (kJ/kWh).
5) Energy Capture
    - Energy Capture: Device or Array Annual captured energy (kWh).
6) Energy Transformation
    - Energy Transformation: Energy output from PTO (kWh/year).
7) Energy Delivery
    - Energy Delivery: Device or Array Annual delivered energy (kWh/year).
8) Logistics and Marine Operations
    - Installability: Installation duration (hours); Cost of Installation (€).
    - Maintainability: Cost of Maintenance i.e. OPEX (€).

In Annex II, two tables are provided with the listed KPIs and Metrics.

5.1.2 INPUT DATA REQUIRED

During the works on WP4, WES leaded a process in which each developer was contacted, one at a time to fill in an Inputs/Outputs spreadsheet, with the different inputs: User input value/ Module dropdown/ Catalogue dropdown.

This process resulted in an extensive list of inputs required to calculate metrics, which was then summarized in order to be presented in the next tables.

The type of inputs required vary and can be summarised into the four types that are listed in the next table:

TABLE 5.1 TYPE OF INPUTS REQUIRED

Type of input required	Description
User input value	Free-field box for user to input any value
Module dropdown	List of discrete values that the user can choose from (stored locally from module)
Catalogue dropdown	List of discrete values that the user can choose from (stored globally in catalogue)

Output from another module	Output from Deployment or Assessment tools

The amount of data available to input into the DTOceanPlus suite of tools varies depending on the TRL or maturity of a technology, so different versions of the Deployment and Assessment tools can be run. These are summarised in Table 5.2 , that presents the expected quantity of different types of inputs required to calculate metrics, which is still a work in progress, to be detailed in future deliverables.

TABLE 5.2 USER INPUTS REQUIRED

Module	User inputs required		
	Complexity level 1	Complexity level 2	Complexity level 3
ESA	0	1	4
RAMS	0	0	0
SPEY	1	1	1
LMO	3	11	14
SK	0	3	6
ED	2	5	5
SLC	4	11	7
ET	12	9	42
EC	2	2	5
SC	1	3	3

These inputs were based on the Inputs/ Outputs spreadsheet which is still being iterated.[4]

5.2 DEFINITION OF SCENARIO DATA

This subchapter refers to the data specification according to the intended sites for each validation scenario. This characterisation is divided in Technology Description, Site Characterisation, Catalogues and Phases.

Technology Description has four subheadings: Hydrodynamic System, PTO & Control, Electrical Dispatch and Station Keeping System. Site Characterisation includes Resource, Seabed Properties and Marine Life. Catalogues area is divided in Components, Vessels and Infrastructures/Ports and Phases area is composed by Installation, Operation & Maintenance and Decommissioning.

To describe the level of detail of each information above stated there is an evaluation scale. The scale has three levels: Basic, Intermediate and Detailed [1]. If there is no available data, its classification is “Reference System”. Also, some reference data will be provided by DTOceanPlus

5.2.1 DATA SPECIFICATIONS OF THE VALIDATION SCENARIO 1

This validation scenario will consider 3 different sub-scenarios and will be performed considering the information of two different sites. Billia Croo and Chile are the two sites chosen. In Table 5.3 is possible to observe the data characterisation and classification for this sub scenarios.

TABLE 5.3 DATA SPECIFICATIONS OF THE VS1

	Data Availability		
Sub Scenario	**1.1**	**1.2**	**1.3**
Technology Description	Detailed	Intermediate	n/a
Hydrodynamic System	Detailed	Intermediate	n/a
PTO&Control	Detailed	Intermediate	n/a
Electrical Dispatch	Detailed	Intermediate	n/a
Station Keeping System	Detailed	Intermediate	n/a
Site Characterisation	Intermediate	Intermediate	n/a
Resource	Detailed	Detailed	n/a
Seabed properties	Intermediate	Detailed	n/a
Marine Life	Reference System	Detailed	n/a
Competing use of space	Reference System	Reference System	n/a
Catalogues	Basic	Intermediate	n/a
Components	Intermediate	Intermediate	n/a
Vessels	Basic	Basic	n/a
Infrastructures/Ports	Basic	Basic	n/a
Phases	Intermediate	Basic	n/a
Planning & Development	Reference System	Reference System	n/a
Installation	Intermediate	Intermediate	n/a
Operation and Maintenance	Intermediate	Basic	n/a
Decomissioning	Intermediate	Basic	n/a

5.2.2 DATA SPECIFICATIONS OF THE VALIDATION SCENARIO 2

In order to accomplish the validation scenario 2 information of one site will be provided. The chosen site is Billia Croo. The data characterisation and classification for this validation scenario is presented in Table 5.4.

TABLE 5.4 DATA SPECIFICATIONS OF THE VS2

	Data Availability
Sub Scenario	-
Technology Description	Detailed
Hydrodynamic System	Detailed
PTO&Control	Detailed
Electrical Dispatch	Detailed
Station Keeping System	Detailed
Site Characterisation	Intermediate
Resource	Detailed
Seabed properties	Intermediate
Marine Life	Reference System

	Data Availability
Competing use of space	Reference System
Catalogues	Basic
Components	Intermediate
Vessels	Basic
Infrastructures/Ports	Basic
Phases	Intermediate
Planning & Development	Reference System
Installation	Intermediate
Operation and Maintenance	Intermediate
Decomissioning	Intermediate

5.2.3 DATA SPECIFICATIONS OF THE VALIDATION SCENARIO 3

Validation scenario 3 will be realized taking into account to the data with respect of one site: BiMEP. The information regarding this site is showed in Table 5.5, where is referred its characterization and classification.

TABLE 5.5 DATA SPECIFICATIONS OF THE VS3

	Data Availability
Sub Scenario	-
Technology Description	Detailed
Hydrodynamic System	Detailed
PTO&Control	Detailed
Electrical Dispatch	Detailed
Station Keeping System	Detailed
Site Characterisation	Detailed
Resource	Detailed
Seabed properties	Detailed
Marine Life	Reference System
Competing use of space	Intermediate
Catalogues	Intermediate
Components	Intermediate
Vessels	Basic
Infrastructures/Ports	Detailed
Phases	Intermediate
Planning & Development	Intermediate
Installation	Intermediate
Operation and Maintenance	Intermediate
Decomissioning	Intermediate

5.2.4 DATA SPECIFICATIONS OF THE VALIDATION SCENARIO 4

To perform validation scenario 4 data from one site is presented. The intended site is EMEC Berth 5 and its data can be observed in Table 5.6, according to characterisation and classification.

TABLE 5.6 DATA SPECIFICATIONS OF THE VS4

	Data Availability
Sub Scenario	-
Technology Description	Detailed
Hydrodynamic System	Detailed
PTO&Control	Detailed
Electrical Dispatch	Detailed
Station Keeping System	Detailed
Site Characterisation	Detailed
Resource	Detailed
Seabed properties	Detailed
Marine Life	Detailed
Competing use of space	Reference System
Catalogues	Detailed
Components	Detailed
Vessels	Detailed
Infrastructures/Ports	Detailed
Phases	Detailed
Planning & Development	Reference System
Installation	Detailed
Operation and Maintenance	Detailed
Decomissioning	Detailed

5.2.5 DATA SPECIFICATIONS OF THE VALIDATION SCENARIO 5

For this validation scenario information relative to two sites will be used. The sites are EMEC Berth 5 and Fromveur which corresponds to sub scenario 5.1 and 5.2, respectively. The characterisation and classification of the data relative to those sites are presented in Table 5.7.

TABLE 5.7 DATA SPECIFICATIONS OF THE VS5

	Data Availability	
Sub Scenario	**5.1**	**5.2**
Technology Description	Detailed	Detailed
Hydrodynamic System	Detailed	Detailed
PTO&Control	Detailed	Detailed
Electrical Dispatch	Detailed	Detailed
Station Keeping System	Detailed	Detailed
Site Characterisation	Detailed	Detailed
Resource	Detailed	Detailed
Seabed properties	Detailed	Intermediate
Marine Life	Detailed	Intermediate

	Data Availability	
Competing use of space	Reference System	Detailed
Catalogues	Detailed	Intermediate
Components	Detailed	Detailed
Vessels	Detailed	Basic
Infrastructures/Ports	Detailed	Detailed
Phases	Detailed	Detailed
Planning & Development	Reference System	Intermediate
Installation	Detailed	Detailed
Operation and Maintenance	Detailed	Detailed
Decomissioning	Detailed	Intermediate

5.2.6 DATA SPECIFICATIONS OF THE VALIDATION SCENARIO 6

Regarding validation scenario 6 a set of information will be provided according to three intended sites: Bluemull Sound, EMEC Berth 5 and Fromveur that correspond to sub scenarios 6.1, 6.2 and 6.3, respectively. The characterisation and classification of this data can be consulted in Table 5.8.

TABLE 5.8 DATA SPECIFICATIONS OF THE VS6

	Data Availability		
Sub Scenario	**6.1**	**6.2**	**6.3**
Technology Description	Intermediate	Detailed	Basic
Hydrodynamic System	Intermediate	Detailed	Intermediate
PTO&Control	Intermediate	Detailed	Intermediate
Electrical Dispatch	Intermediate	Detailed	Basic
Station Keeping System	Intermediate	Detailed	Basic
Site Characterisation	Intermediate	Intermediate	Detailed
Resource	Intermediate	Intermediate	Detailed
Seabed properties	Intermediate	Intermediate	Intermediate
Marine Life	Intermediate	Intermediate	Intermediate
Competing use of space	Reference System	Reference System	Detailed
Catalogues	Basic	Detailed	Basic
Components	Basic	Detailed	Intermediate
Vessels	Basic	Detailed	Basic
Infrastructures/Ports	Basic	Detailed	Detailed
Phases	Basic	Detailed	Intermediate
Planning & Development	Reference System	Reference System	Intermediate
Installation	Basic	Detailed Reference System	Intermediate
Operation and Maintenance	Basic	Detailed	Intermediate
Decomissioning	Basic	Detailed	Intermediate

5.3 DATA PRIVACY

Regarding data privacy issues raised by some of the partners, a data management methodology was developed to deal with this subject. In this methodology, there are three main areas: Role of Partners, Data Flow and Validation.

In the Role of Partners area was defined that there will be a *Lead Partner* for each Validation Scenario or Sub-Validation Scenario, which will be responsible for the data collection and validation of the tools with the support of a *Technical Support Partner* that will assist in the correct use of the data and tools. The Tool Developers will be the *Technical Support Partners* as they are most knowledgeable in concern to the data needs and functionality of the tools. The role of EDP will focus on the reporting and compilation of the validation results.

In concern to the Data Flow area, the *Lead Partner* will provide all data and information required to run the validation. In order to prevent any data privacy issues a set of dummy data will be generated by the *Lead Partner* and transmitted to the *Technical Support Partner*.

The *Technical Support Partner* latter will then check if the validation can be carried out with the level of data provided. Whether it can, the *Lead Partner* is able to perform the validation with internal data (not dummy data if wished) that is of similar format or granularity, among other aspects. If there are any problems of running the tools, the *Technical Support Partner* may guide the *Lead Partner* accordingly.

About the Validation area, was decided that the *Lead Partner* is responsible to provide a validation report based on qualitative and quantitative indicators. For **Deployment & Assessment Design Tools**, it is not required to provide absolute values of the results of the validation but rather relative indicators concerning the *accuracy* of the tools. For **Stage-Gate & Structure Innovation Design Tools**, it is required to provide a report on the qualitative validation and usability of the tool and the implemented process. In both cases, it is thus ensured that no sensible information will be disseminated among parties outside of their organization.

6. CONCLUSIONS

The objective of D7.2 "Detailed description of demonstration scenarios" is to document the outcome of the activities carried out within T7.2 "Scenario Refinement and Input Data Compilation" of the EU-funded DTOceanPlus project. The aim of the deliverable is to refine the definition of the demonstration scenarios (also named Validation Scenarios VSs) defined in WP2 which will be run within the framework of the project to illustrate the different uses of the tools. Moreover, comprehensive description of scenarios which will be considered for the validation purposes, including data characterisation and classification.

Initially, some scenarios were chosen trough a funnel approach process. This process was composed by three steps: Identification of example use cases, brainstorming at PSC and internal survey. Following this, a first version of the validation scenarios was defined and the conclusions of this process were:

- Deployment Design Tools: The use of these tools is highly envisaged at Array Level. The Deployment tools are tools for the global validation of coupled and more complex systems.
- Stage Gate design tool: This seemed to be a valuable tool while assessing the performance of an ocean energy system especially at the Device Level of aggregation and also for a Subsystem Level.
- Structured Innovation design tool: The Structured Innovation tool was useful to investigate scenario at Subsystem Level and also at Device Level.

The Table 2.1 summarize the six validation scenarios that were defined, presenting the technology to be tested, the tool to be used and the complexity level. In Table 2.2 is presented a more detailed description of each of the validation scenarios.

After the funnel approach four more steps were defined in order to refine the six validation scenarios predefined. These steps were:

- Definition of use cases/design objectives: The definition of the use cases and objectives for each validation scenario is the first step of the scenario refinement process to adhere the overall purpose of the validation ("goal").
- Definition of the scope/project: This step enables the user to define the scope of the validation scenario and describe the project ("setting the scene").
- Definition of scenario data: Within this step, the characterisation of the input data requirements for each validation scenario is concluded. This step is important to generate a set of data that represents and describes the project and validation scenario in an appropriate manner according to the specifications produced in Task 7.1.
- Compilation of scenario characterisation data: The compilation and collection of the required data to characterise the validation scenarios is completed to facilitate the validation of the DTOceanPlus suite of tools according to the pre-defined objectives in Step4.

With the application of this full process a refinement of the validation scenarios was achieved and final version for the VSs was presented. Due to the interest of several partners in some scenarios there was a need to create sub-scenarios on those. From Table 4.1 to Table 4.6 is presented the synoptical description of each validation scenario (VS1 to VS6).

In order to ensure that the design tools are achieving the expected objectives, some KPIs were defined by the partners and will be used to validate the modules. This validation procedure is divided between quantitative and qualitative KPIs which were defined to assess the design tools in several validation scenarios. Also, some input data requirements were developed to serve this purpose.

According to the intended sites for each validation scenario a characterisation regarding four main areas (Technology Description, Site Characterisation, Catalogues and Phases) was created. Following this and given the specificity of the validation scenarios, it was required to develop data specifications in each of these. An evaluation scale was used to describe the level of detail of the provided information (Basic, Intermediate and Detailed or Reference System if there were no data available). From Table 5.3 to Table 5.8 is provided the data specifications and its level of detail for all the validation scenarios. Regarding the data privacy, some clarifications were made to prevent some conflicts. In this the Role of Partners, the Data Flow and the Validation were defined.

To conclude, this document intends to refine the definition of the validation scenarios that will be carry on in order to highlight the several uses of the design tools that this project aims to develop. This was made considering a very well-defined intellectual process that ensured that all these scenarios cover the scope of DTOceanPlus, testing all the design tools, for tidal and wave technologies for different levels of aggregation. Also, it was planned that this document would clarify and classify the necessary data for validation of the tools in each scenario, which was also achieved through the effort of the partners in this task, ensuring the proper data for needs. The deliverable: D7.3 "Scenarios input data", will address the data needs, as well as a more detailed and precise description of the Validation Scenario, the input data and the validation criteria.

7. REFERENCES

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ANNEX I: DATA STRUCTURES FOR THE DIGITAL REPRESENTATION

At the Annex of D7.1 [5] the structure and objects of the Digital Representation have been broken down and their attributes have been described, defining the format agreed with the partners at time of writing (September 2019).

In this deliverable D7.2, the data availability for each intended site of the validation scenarios, were characterized according to Technology Description, Site Characterisation, Catalogues and Phases, as detailed in [5].

ANNEX II: METRICS AND KPIS

Metrics		
SLC System Lifetime Costs	Affordability	LCOE (€/kWh)
		CAPEX (€)
		Internal Rate of Return (%)
RAMS	Reliability	Mean Time to Failure, MTTF (hours)
		Probability of failure (%)
	Availability	Availability (%) or Downtime
	Maintainability	Mean Time to Repair, MTTR (hours)
		Probability that a maintenance action can be carried out (%)
	Survivability	Probability of structural irreparable failure (%)
SPEY System Performance and Energy Yield	Energy Capture	Efficiencies: Captured, transformed, delivered (%)
		Total lost energy of the device or array during project lifetime (kWh)
ESA Environmental and Social Acceptance	Acceptability	Global Environmental Impact Assessment score (Global positive)
		Global Environmental Impact Assessment score (Global negative)
		Nb of jobs
		Cost of consenting (€/MW)
		GWP - Phase (gCO2/kWh)
		CED - Phase (kJ/kWh)
EC Energy Capture	Energy Capture	Device or Array Annual captured energy (kWh)
ET Energy Transformation	Energy Transformation	Energy output from PTO (kWh/year)
ED Energy Delivery	Energy Delivery	Device or Array Annual delivered energy (kWh/year)

LMO Logistics and Marine Operations	Installability	Installation duration (hours)
		Cost of Installation (€)
	Maintainability	Cost of Maintenance i.e. OPEX (€)

KPIs	
Usability	Usability of the tool and the implemented process
User-friendliness	User-friendliness of the tool
Explanatory/ informative value	Explanatory/ informative value of the tool
Accuracy of the tool	Level of Accuracy of the tool
Adequacy of the alternatives	Adequacy of the alternatives selected in the results

CONTACT DETAILS

Mr. Pablo Ruiz-Minguela

Project Coordinator, TECNALIA

www.dtoceanplus.eu

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