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

Deliverable D7.3

Scenarios Input Data

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0.1	12/06/2020	Revised outline and draft contents	All partners
0.3	26/06/2020	Feedback from leaders of the VS	VS partners
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1.0	22/07/2020	Final version for the EC	EC

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 (SI) tool, for the technology concept selection, a Stage Gate (SG) tool, for the technology development process, as well as a set of Deployment and Assessment (D&A) tools for the design of the system and its validation.

The DTOceanPlus suite of tools will be validated by running a set of validation scenarios (VSs), which will demonstrate the different uses of the software under a wide set of conditions, including various deployment sites, technology types and maturity levels, as well as design objectives and project scales.

This report describes the compilation of required data inputs for the various VSs. Each scenario is characterised through a set of project data, inherent to the technology as well as metocean conditions and other location related data. Further engagement with the validation leaders is ensuring that the data is adequately formatted for the purposes of running the DTOceanPlus tools.

In order to avoid any harm to the commercialisation prospects of industrial partners, the consortium agreed on a data management methodology that will permit the validation whilst maintaining the required data privacy.

A thorough analysis of the current availability of the data for running the scenario has been carried out for each VS. Particularly, detailed data specifications related to the intended site, technology, development activities and catalogues have been gathered according to DTOceanPlus tools requirements.

No significant data gaps have been identified at this stage of the scenario definition. In some cases, the design tools will use default values or will be run at lower complexity level to deal with some limited data available to developers.

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ABBREVIATIONS AND ACRONYMS

D&A	Deployment and Assessment (DTOceanPlus tool)
DOF	Degree of Freedom
Dx.y	Deliverable "y" from work package "x"
EC	Energy Capture (DTOceanPlus module)
ED	Energy Delivery (DTOceanPlus module)
ESA	Environmental and Social Acceptance (DTOceanPlus module)
ET	Energy Transformation (DTOceanPlus module)
Hs	Significant wave height
LCOE	Levelised Cost of Energy
LMO	Logistics and Marine Operations (DTOceanPlus module)
MC	Machine Characterisation (DTOceanPlus module)
MSL	Mean Surface Level
PTO	Power Take Off
Tp	Peak wave period
TRL	Technology Readiness Level
RAMS	Reliability, Availability, Maintainability, Survivability (DTOceanPlus module)
ROV	Remote Operated Vehicle
SC	Site Characterisation (DTOceanPlus module)
SCIG	Squirrel Cage Induction Generator
SG	Stage Gate (DTOceanPlus tool)
SI	Structured Innovation (DTOceanPlus tool)
SK	Station Keeping (DTOceanPlus module)
SLC	System Lifetime Costs (DTOceanPlus module)
SPEY	System Performance and Energy Yield (DTOceanPlus module)
VS	Validation Scenario

1. INTRODUCTION

1.1 SCOPE OF THE REPORT

The objective of D7.3 "Scenarios Input Data" 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 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 identification of the data required to run the VSs as well as their characterisation have been accounted for and detailed in this report.

Validation partners have steadily refined the scope of individual scenarios. Firstly, they were defined in the form of preliminary objectives (D2.3), then the specific contents were refined (D7.2) and finally the scope was finalised considering availability of input data, partner interests and the current pipeline of projects.

Whereas D7.2 mainly focused on the refinement of the VSs, D7.3 is intended to characterise and compile the input data requirements. With further detail, each scenario is identified through a set of project data, inherent to the technology as well as metocean conditions and other location related data.

Even though the selected VSs 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.

Finally, 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 D7.3 reports on the results of input data compilation required for running the tools. Particularly, it describes the data availability for the highest complexity level of the DTOceanPlus tools, the source of the data (e.g. literature, simulation, experimental, suppliers) and level of confidentiality. Engagement with the validation leaders will ensure the data is adequately formatted.

The document is structured in 10 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.
- **Sections 2** summarises the process followed to compile the scenario characterisation data.
- **Sections 3 to 8** present a summary of each VS together with the data specifications related to the intended site, technology, development activities, catalogues and the management of any significant data gaps.
- **Section 9** draws some conclusions.
- **Section 10** present the list of public references.

1.3 SUMMARY OF THE DTOCEANPLUS PROJECT

DTOceanPlus aims to accelerate the commercialisation of the Ocean Energy sector by developing and demonstrating an open source suite of design tools for the selection, development, deployment and assessment of ocean energy systems (including subsystems, energy capture devices and arrays). At a high level, the suite of tools developed in a modular fashion for integrated purpose in DTOceanPlus will include:

- **Structured Innovation Tool (SI),** for concept creation, selection, and design.
- **Stage Gate Tool (SG),** using metrics to measure, assess and guide technology development.
- Deployment Tools, supporting optimal device and array deployment:
  - *Site Characterisation (SC),* to characterise the site, including met-ocean, geotechnical, and environmental conditions;
  - *Machine Characterisation (MC):* to characterise the prime mover;
  - *Energy Capture (EC),* to characterise the device at an array level;
  - *Energy Transformation (ET)*, to design PTO and control solutions;
  - *Energy Delivery (ED)*, to design electrical and grid connection solutions;
  - *Station Keeping (SK)*, to design moorings and foundations solutions;
  - *Logistics and Marine Operations (LMO)*, to design logistical solutions operation plans related to the installation, operation, maintenance, and decommissioning operations.
- **Assessment Tools,** to evaluate projects in terms of key parameters:
  - *System Performance and Energy Yield (SPEY),* to evaluate projects in terms of energy performance;
  - *System Lifetime Costs (SLC),* to evaluate projects from the economic perspective;
  - *System Reliability, Availability, Maintainability, Survivability (RAMS),* to evaluate the reliability aspects of a marine renewable energy project;
  - *Environmental and Social Acceptance (ESA),* to evaluate the environmental and social impacts of a given wave and tidal energy projects.

These will be supported by underlying common digital models and a global database, as shown graphically in Figure 1.1.

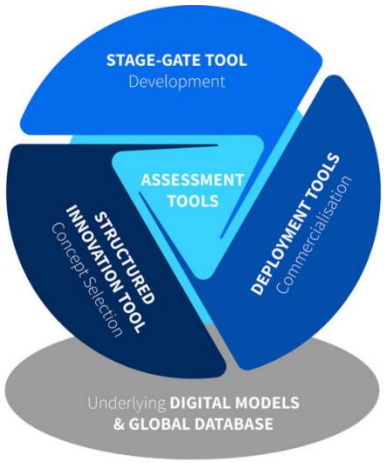

FIGURE 1.1 REPRESENTATION OF DTOCEANPLUS TOOLS

1.4 DATA MANAGEMENT METHODOLOGY

According to the H2020 Program Guidelines on FAIR Data [1], data should be "as open as possible and as closed as necessary", "open" in order to foster the reusability and to accelerate research, but at the same time they should be "closed" to safeguard the privacy of the subjects.

Partners are fully aware that **sensitive information** may be needed to validate the DTOceanPlus tools. In order to avoid any harm to the commercialisation prospects of industrial partners, the consortium agreed on the following data management methodology that will permit the validation whilst maintaining the required data privacy.

- Role of Partners – The *Lead Partner* collects input data; the *Technical Support Partner* assists in the use of input data and tools.
- Data Flow - The *Lead Partner* provides dummy data to the *Technical Support Partner* to check compatibility with regards to DTOceanPlus tools requirements.
- Validation – The *Lead Partner* provides the validation report based on qualitative/quantitative indicators.

Data privacy is described in further detail in deliverable D7.2, section 5.3 [2].

Nonetheless, the Consortium strongly believes in the concepts of open science, and in the benefits that the European innovation ecosystem and economy can draw from allowing the reuse of data at a larger scale. As users progress through the stages of creating a design in DTOceanPlus, they will require access to reference data to support decision-making. The long-standing reference data will be mainly collected in catalogues. Deliverable D9.11 [3] describes in more detail the public/reference datasets.

- Types of research data that will be generated or collected during the project,
- Standards that will be used,
- How the research data will be preserved, and
- What parts of the datasets will be shared for verification or reuse.

2. COMPILATION OF SCENARIO CHARACTERISATION DATA

The scenario refinement process produced a set of six main VSs and 11 subscenarios. Figure 2.1 and Figure 2.2 present a graphical overview of the wave and tidal scenarios respectively.

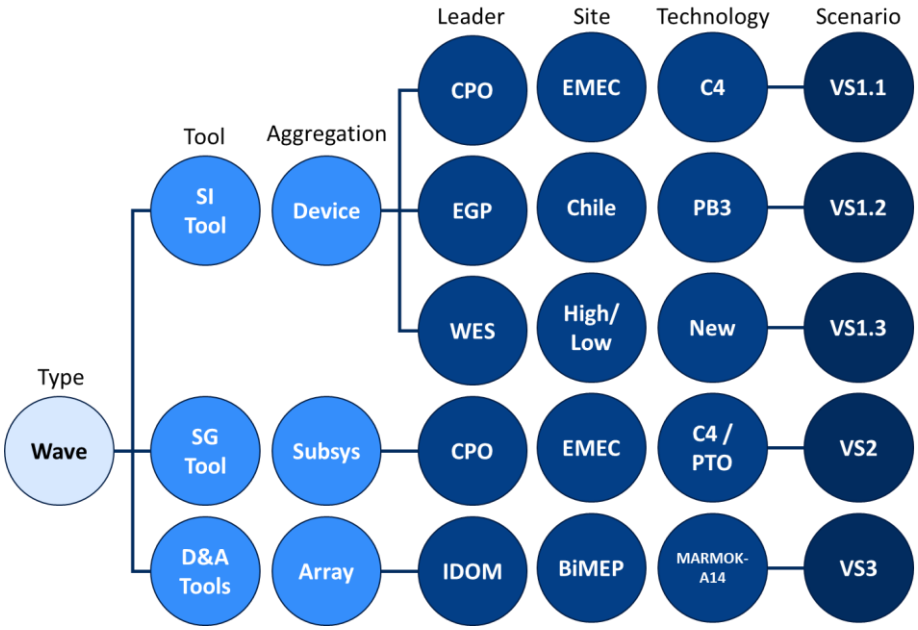

FIGURE 2.1 WAVE ENERGY VALIDATION SCENARIOS

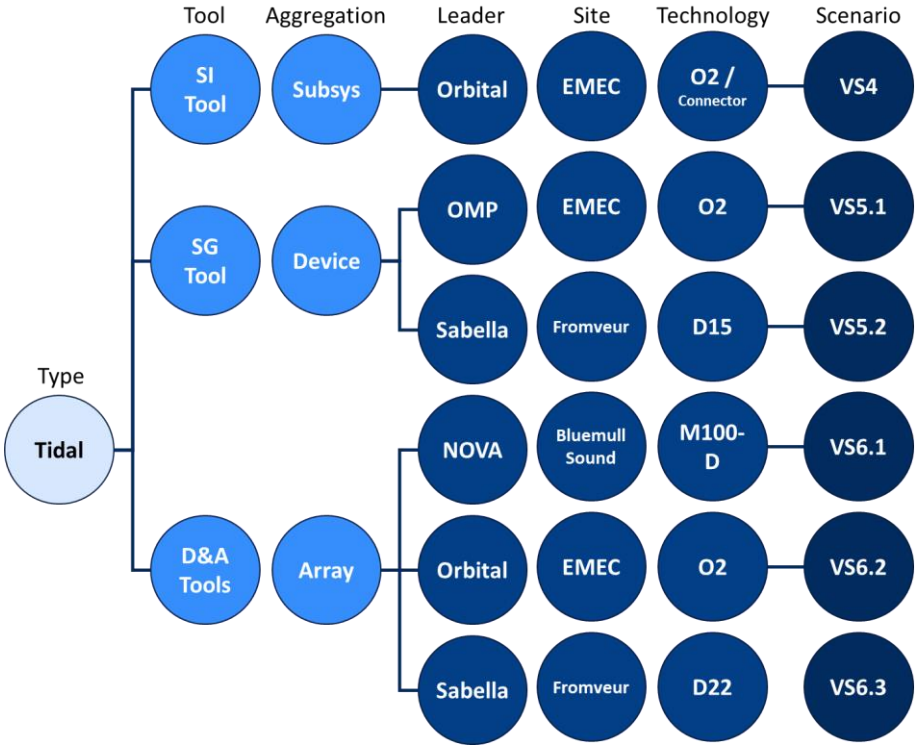

FIGURE 2.2 TIDAL ENERGY VALIDATION SCENARIOS

Following the methodology established in Task 7.2, the final step of the scenario refinement process is concluded by the collection of scenarios characterisation data, which is intended to provide a guideline for the input data requirements.

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 [4] and Task 7.2 but likewise determined by the technical requirements of the different tools that are subject of the validation procedure. These requirements are described in Deliverables D3.1 [6], D4.1 [7], D5.1 [8] and D6.1 [9].

The end-user that will validate the scenario must reassure that the collected data complies with the requirements of the DTOceanPlus suite of tools to validate the identified VSs and selected Use Cases. This dependency is illustrated in Figure 2.3.

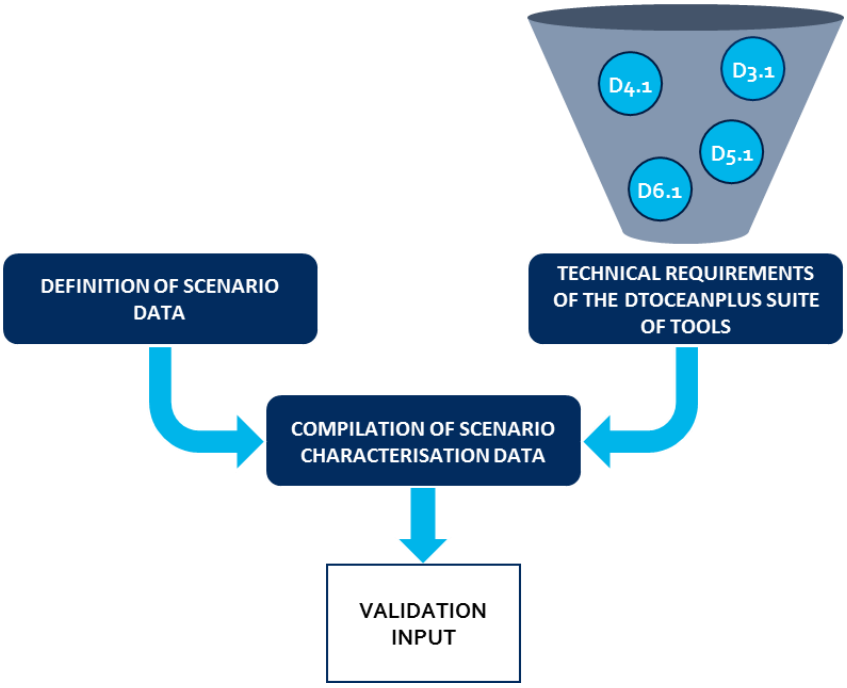

FIGURE 2.3 DEPENDENCIES ON THE COMPILATION OF SCENARIO CHARACTERISATION DATA [2]

In the next sections of the deliverable, a thorough analysis of the current availability of the data for running the scenario is carried out for each VS. Data requirements have been organised as follows:

- **Data Specifications related to the intended site**: this section compiles the data requirements for running the tools in terms of resource (wave, tidal), environmental conditions for design (wind, water levels), seabed properties and marine species present in the intended site
- **Data Specifications related to the technology description**: these specifications are related to a set of properties of the prime mover and the PTO system: physical (dimensions), economical (costs), hydrodynamic, operational and power and station keeping settings, as well as mechanical, electrical and grid conditioning properties.

- **Data Specifications related to the development activities**: these specifications are related to the stage gate tasks that need to be successfully completed during the development of any ocean energy technology.
- **Data Specifications related to Catalogues**: according to D7.5 [9], a set of catalogues, as source of data for running the tools/modules in DTOceanPlus are foreseen in DTOceanPlus. The catalogues will contain a set of reference data that could be read, filtered, updated by the user and exploited by the modules/tools for carrying out the computations and perform the design choices. Currently, the catalogues that are included in the DTOceanPlus project are:
  - *Operations, infrastructures and equipment*: Mostly used by the Logistic and Marine Operation (LMO) Module, it includes tables as Activities, Operation Type, Equipment (e.g. Pilling, Protection, Burial, Drivers, ROV), Terminals and Vessels
  - *Mooring Lines and Anchors*: mostly used by the Stationkeeping (SK) module, it will contain information about Anchors, and different types of mooring lines (e.g. Chains, Wire and Synthetic ropes)
  - *Power Take Off Components*: mostly used by the Energy Transformation (ET) module, it will contain information about subsystems such as Air Turbines, Generators and Power Converters
  - *Electrical Network Equipment*: mostly used by the Energy Delivery (ED) module, it will contain information about the Collection point, Transformer, Dry- and Wet-mate Connectors, together with Dynamic and Static cables.

3. VALIDATION SCENARIO 1: WAVE / SI TOOL / DEVICE LEVEL

3.1 SUMMARY OF THE VALIDATION SCENARIO

VS1 is representative of a **Wave Energy Technology**, using the **Structured Innovation Tool** at **Device Level**. The corresponding validation partners **CorPower**, **EGP** and **WES** have progressively refined the scenario scope. 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.

The Structured Innovation Tool will be tested considering the data of two real sites, namely Billia Croo - EMEC [5] and Las Cruces in Chile [6], and data of two reference sites provided by the Site Characterisation module (i.e. low and high wave energy sites). The technologies selected are CorPower C4 [7] and OPT PB3 [8] for the first two subscenarios. A new wave energy concept will be sought in the third subscenario (i.e. a device with LCOE below €150 €/MWh, high reliability and low environmental impact). Corpower, EGP and WES will be the *Lead Partners* for these intended sites, respectively, whereas the *Technical Support Partner* will be ESC in all the sub scenarios.

Table 3.1 presents the characterisation of each sub scenario of the refined VS1.

TABLE 3.1 SYNOPTICAL DESCRIPTION OF REFINED VS1

	VALIDATION SCENARIO 1		
Subscenario	**1.1**	**1.2**	**1.3**
Technology Type	Wave		
Tool to be Validated	Structured Innovation		
Aggregation Level	Device Level		
Lead Partner	Corpower	EGP	WES
Other Interested	WES		n/a
Technical Support	ESC	ESC	ESC
Technology	Corpower Ocean - C4	OPT - PB3	New concept
Total Power	300 kW x 1 device	3 kW x 1 device	n/a
Subsystem/Component	n/a	n/a	n/a
Intended Site	Billia Croo (EMEC)	Las Cruces (Chile)	Low & high energy

The following subsections provide details about the data specification related to the intended site, technology and catalogues (when needed) for each VS. Management of data gaps is also discussed.

3.2 VS1.1 - CORPOWER

3.2.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

TABLE 3.2 WAVE DATABASE – BILLIA CROO (EMEC)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries			-	-	-
	Wave height		NO	-	-
	Wave period		NO	-	-
	Wave direction, coming from		NO	-	-
	Wave energy flux		NO	-	-
Wave statistics			-	-	-
	Empirical probability distribution		-	-	-
		Wave height	YES	Experimental data	YES
		Wave height & period	YES	Experimental data	YES
		Wave height & direction	YES	Experimental data	YES
		Wave height, period & direction	YES	Experimental data	YES
	Extreme return values		-	-	-
		Wave height	YES	Experimental data	YES
		Wave period	YES	Experimental data	YES
		Wave contours	YES	Experimental data	YES

TABLE 3.3 CURRENT DATABASE – BILLIA CROO (EMEC)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries			-	-	-
	Current velocity		NO	-	-
	Current direction, coming from		NO	-	-
	Current zonal velocity		NO	-	-
	Current meridional velocity		NO	-	-
	Current available power		NO	-	-
Current statistics			-	-	-
	Empirical probability distribution		-	-	-
		Current velocity	YES	Experimental data	YES
		Current direction, coming from	YES	Experimental data	YES
		Current velocity & direction	YES	Experimental data	YES
	Extreme return values		-	-	-
		Current velocity	YES	Experimental data	YES
	Current profile		YES	Experimental data	YES

TABLE 3.4 WIND DATABASE – BILLIA CROO (EMEC)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries			-	-	-
	10m-wind velocity		NO	-	-
	10m-wind direction, coming from		NO	-	-
	10m-wind zonal velocity		NO	-	-
	10m-wind meridional velocity		NO	-	-
	10m-wind gusts		NO	-	-
Wind statistics					
	Empirical probability distribution		-	-	-
		10m-wind velocity	YES	Experimental data	YES
		10m-wind direction, coming from	YES	Experimental data	YES
		10m-wind velocity & direction	YES	Experimental data	YES
	Extreme return values		-	-	-
		10m-wind velocity	YES	Experimental data	YES
		10m-wind gusts	YES	Experimental data	YES

TABLE 3.5 WATER LEVEL DATABASE – BILLIA CROO (EMEC)

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries		-	-	-
	Water surface fluctuation, relative to MSL	NO	-	-
	Water level, relative to bottom	NO	-	-
Water level statistics		-	-	-
	Water level, relative to bottom	YES	Experimental data	YES
	Empirical probability distribution	NO	-	-
	Extreme return values	NO	-	-

TABLE 3.6 SEABED PROPERTIES – BILLIA CROO (EMEC)

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file		YES	Info from suppliers	YES
Contours		-	-	-
	Lease area shapefile	NO	-	-
	Corridor shapefile	YES	Info from suppliers	YES
	Competing Use of space: Existing cable routes	YES	Info from suppliers	YES
	Competing Use of space: Existing vessel routes	YES	Info from suppliers	YES
	Competing Use of space: No-go areas	YES	Info from suppliers	YES

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Info from suppliers	YES
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	NO	-	-
	Distance to rock bed	NO	-	-

TABLE 3.7 MARINE SPECIES FILE – BILLIA CROO (EMEC)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	NO	-	-
Initial environmental condition	NO	-	-
Endangered species	NO	-	-

3.2.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 3.8 PRIME MOVER DIMENSIONS & COST – CORPOWER OCEAN, C4

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	YES	CPO Design	YES
Height	YES	CPO Design	YES
Width	YES	CPO Design	YES
Length	YES	CPO Design	YES
Submerged Volume	YES	CPO Design	YES
Wetted Area	YES	CPO Design	YES
Mass and Inertial properties	YES	CPO Design	YES
Footprint radius	NO	-	-
Device cost	YES	Info from suppliers	YES

TABLE 3.9 HYDRODYNAMICS – CORPOWER OCEAN, C4

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Capture Width Ratio		-	-	-
	Tp capture width	YES	Simulation models	YES
	Hs capture width	YES	Simulation models	YES
	Wave angle capture width	N/A	-	-
Additional Damping		N/A	Simulation models	YES
Additional Stiffness		N/A	Simulation models	YES
Multibody - other dofs		YES	-	NO
Hydrodynamic Matrices (added mass, radiation damping, External excitation)		YES	Simulation models	YES

TABLE 3.10 POWER SETTINGS AND STATIONKEEPING – CORPOWER OCEAN, C4

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Info from suppliers	YES
Connector Type	YES	Info from suppliers	YES
Control Subsystem failure Rate	NO	-	-
Mooring Stiffness	YES	CPO Design	YES
Foundation preferred type	YES	CPO Design	YES

TABLE 3.11 MARINE OPERATIONS – CORPOWER OCEAN, C4

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	YES	CPO Design	NO
Min Installation Water depth	YES	CPO Design	NO
Min interdistance perpendicular to waves/current	YES	CPO Design	NO
Min interdistance parallel to waves/current	YES	CPO Design	NO

TABLE 3.12 PTO MECHANICAL – CORPOWER OCEAN, C4

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	YES	CPO Design	YES
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	CPO Design	YES
Weight	YES	CPO Design	YES
Primary materials	YES	CPO Design	YES
Transmission ratio	YES	CPO Design	YES
Rated power	YES	CPO Design	YES
Speed range	YES	CPO Design	YES
Input force, torque range	YES	CPO Design	YES
Maximum stroke (only for linear systems)	YES	Simulation models	YES
Efficiency	YES	Simulation models	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

TABLE 3.13 PTO ELECTRICAL CONVERSION – CORPOWER OCEAN, C4

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Number of pole pairs	YES	Info from suppliers	YES
Insulation class	NO	-	-
Main dimensions	YES	Info from suppliers	YES

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Nominal voltage	YES	Info from suppliers	YES
Nominal intensity	YES	Info from suppliers	YES
Maximum voltage	YES	Info from suppliers	YES
Maximum torque	YES	Info from suppliers	YES
Maximum speed	YES	Info from suppliers	YES
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

TABLE 3.14 PTO GRID CONDITIONING – CORPOWER OCEAN, C4

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Switching frequency	YES	Info from suppliers	YES
Grid voltage	YES	Info from suppliers	YES
Grid resistance	NO	-	-
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

3.2.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

TABLE 3.15 CATALOGUES – CORPOWER OCEAN, C4

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessel clusters	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		-	-	-
	Mooring Lines	YES	FEM	NO
	Drag Anchors	YES	FEM	NO
Power Take Off Components		-	-	-
	User Defined Air Turbine	N/A	-	-
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	YES	Tecnalia	NO
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	N/A	-	-
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	N/A	-	-
	Collection point	N/A	-	-

3.2.4 MANAGEMENT OF DATA GAPS

There are no critical data gaps for running this Validation Scenario. The design tools can either use default values or be run at lower complexity to deal with gaps in the data available to developers. For instance, reference values for resource timeseries, seabed properties, marine species and failure rates of PTO components can be provided by the DTOceanPlus suite of tools. Moreover, the catalogues will be populated to a sufficient level to run this scenario.

In addition, The SI tool is developed to include fundamental relationships between key parameters in ocean energy concepts, evidence from the first ocean energy arrays, and a standard library of problem solution inter-relationships. These fundamental relationships are the engineering, physics and fundamental economic relationships which drive the earliest stages of assessing the attractiveness of concepts, enabling the user to evaluate more widely how to deliver the concept creation use cases.

3.3 VS1.2 - EGP

3.3.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

TABLE 3.16 WAVE DATABASE – LAS CRUCES (CHILE)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries			-	-	-
	Wave height		YES	Info from suppliers	YES
	Wave period		YES	Info from suppliers	YES
	Wave direction, coming from		YES	Info from suppliers	YES
	Wave energy flux		YES	Info from suppliers	YES
Wave statistics			-	-	-
	Empirical probability distribution		-	-	-
		Wave height	NO	-	-
		Wave height & period	NO	-	-
		Wave height & direction	NO	-	-
		Wave height, period & direction	NO	-	-
	Extreme return values		-	-	-
		Wave height	YES	Info from suppliers	YES
		Wave period	YES	Info from suppliers	YES
		Wave contours	NO	-	-

TABLE 3.17 CURRENT DATABASE – LAS CRUCES (CHILE)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries			-	-	-
	Current velocity		YES	Info from suppliers	YES
	Current direction, coming from		YES	Info from suppliers	YES
	Current zonal velocity		YES	Info from suppliers	YES
	Current meridional velocity		YES	Info from suppliers	YES
	Current available power		YES	Info from suppliers	YES
Current statistics			-	-	-
	Empirical probability distribution		-	-	-
		Current velocity	NO	-	-
		Current direction, coming from	NO	-	-
		Current velocity & direction	NO	-	-
	Extreme return values		-	-	-
		Current velocity	NO	-	-
	Current profile		NO	-	-

TABLE 3.18 WIND DATABASE – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries	-	-	-
10m-wind velocity	NO	-	-
10m-wind direction, coming from	NO	-	-
10m-wind zonal velocity	NO	-	-
10m-wind meridional velocity	NO	-	-
10m-wind gusts	NO	-	-
Wind statistics			
Empirical probability distribution	-	-	-
10m-wind velocity	NO	-	-
10m-wind direction, coming from	NO	-	-
10m-wind velocity & direction	NO	-	-
Extreme return values	-	-	-
10m-wind velocity	NO	-	-
10m-wind gusts	NO	-	-

TABLE 3.19 WATER LEVEL DATABASE – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries	-	-	-
Water surface fluctuation, relative to MSL	NO	-	-
Water level, relative to bottom	NO	-	-
Water level statistics	-	-	-
Water level, relative to bottom	NO	-	-
Empirical probability distribution	NO	-	-
Extreme return values	NO	-	-

TABLE 3.20 SEABED PROPERTIES – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file	YES	Info from suppliers	YES
Contours	-	-	-
Lease area shapefile	NO	-	-
Corridor shapefile	N/A*	-	-
Competing Use of space: Existing cable routes	YES	Info from suppliers	YES
Competing Use of space: Existing vessel routes	NO	-	-
Competing Use of space: No-go areas	NO	-	-

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Info from suppliers	YES
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	NO	-	-
	Distance to rock bed	NO	-	-

*Device not connected to the grid

TABLE 3.21 MARINE SPECIES FILE – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	NO	-	-
Initial environmental condition	NO	-	-
Endangered species	NO	-	-

3.3.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 3.22 PRIME MOVER DIMENSIONS & COST VS1.2 – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	YES	Info from suppliers	YES
Height	YES	Info from suppliers	YES
Width	YES	Info from suppliers	YES
Length	YES	Info from suppliers	YES
Submerged Volume	YES	Info from suppliers	YES
Wetted Area	YES	Info from suppliers	YES
Mass and Inertial properties	YES	Info from suppliers	YES
Footprint radius	NO	-	-
Device cost	NO	-	-

TABLE 3.23 HYDRODYNAMICS VS1.2 – LAS CRUCES (CHILE)

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Capture Width Ratio		-	-	-
	Tp capture width	NO	-	-
	Hs capture width	NO	-	-
	Wave angle capture width	NO	-	-
Additional Damping		NO	-	-
Additional Stiffness		NO	-	-
Multibody - other dofs		NO	-	-
Hydrodynamic Matrices (added mass, radiation damping, External excitation)		NO	-	-

TABLE 3.24 POWER SETTINGS AND STATIONKEEPING VS1.2 – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Info from supplier	NO
Connector Type	YES	Info from supplier	YES
Control Subsystem failure Rate	NO	-	-
Mooring Stiffness	NO	-	-
Foundation preferred type	YES	Info from supplier	YES

TABLE 3.25 MARINE OPERATIONS VS1.2 – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	YES	Info from supplier	NO
Min Installation Water depth	YES	Info from supplier	NO
Min interdistance perpendicular to waves/current	N/A*	-	-
Min interdistance parallel to waves/current	N/A*	-	-

*Device not connected to the grid

TABLE 3.26 PTO MECHANICAL CONVERSION VS1.2 – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	YES	Info from supplier	YES
Manufacturer reference	NO	-	-
Main dimensions	NO	-	-
Weight	NO	-	-
Primary materials	NO	-	-
Transmission ratio	NO	-	-
Rated power	YES	Info from supplier	YES
Speed range	NO	-	-
Input force, torque range	NO	-	-
MAXIMUM stroke (only for linear systems)	NO	-	-
Efficiency	NO	-	-
Cost	NO	-	-
Failure rate	NO	-	-

TABLE 3.27 PTO ELECTRICAL CONVERSION VS1.2 – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	YES	Info from supplier	YES
Manufacturer reference	NO	-	-
Number of pole pairs	NO	-	-
Insulation class	NO	-	-
Main dimensions	NO	-	-

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	NO	-	-
Primary materials	NO	-	-
Rated power	YES	Info from supplier	YES
Nominal voltage	NO	-	-
Nominal intensity	NO	-	-
Maximum voltage	NO	-	-
Maximum torque	NO	-	-
Maximum speed	NO	-	-
Efficiency	NO	-	-
Power factor	NO	-	-
Cost	NO	-	-
Failure rate	NO	-	-

TABLE 3.28 PTO GRID CONDITIONING VS1.2 – LAS CRUCES (CHILE)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	N/A*	-	-
Manufacturer reference	N/A*	-	-
Main dimensions	N/A*	-	-
Weight	N/A*	-	-
Primary materials	N/A*	-	-
Rated power	N/A*	-	-
Switching frequency	N/A*	-	-
Grid voltage	N/A*	-	-
Grid resistance	N/A*	-	-
Efficiency	N/A*	-	-
Power factor	N/A*	-	-
Cost	N/A*	-	-
Failure rate	N/A*	-	-

*Device not connected to the grid

3.3.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

TABLE 3.29 CATALOGUES – LAS CRUCES (CHILE)

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessels	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		-	-	-
	Mooring Lines	YES	FEM	NO
	Drag Anchors	YES	FEM	NO
Power Take Off Components		-	-	-
	User Defined Air Turbine	N/A	-	-
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	YES	Tecnalia	NO
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	N/A	-	-
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	N/A	-	-
	Collection point	N/A	-	-

3.3.4 MANAGEMENT OF DATA GAPS

There are no significant gaps in order to run this Validation Scenario in a standalone mode. As an embedded mode scenario, the user will be prompted to open up each of the Deployment and Assessment tools sequentially. In the case where data is not available, minimal inputs will be required from the user to enable the modules to run at lower level of complexity by using default values from the catalogues within the DTOceanPlus suite of tools. For instance, reference values for resource statistics, seabed properties, marine species, PTO can be provided by the DTOceanPlus suite of tools. Fundamental relationships will be used to determine device hydrodynamics.

3.4 VS1.3 - WES

3.4.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

This VS will investigate a high and low energy reference site instead of a concrete deployment site. DTOceanPlus will provide site data using the complexity level 1 version of the SC tool.

TABLE 3.30 WAVE DATABASE – HIGH AND LOW ENERGY WAVE SITE (SC)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries			-	-	-
	Wave height		YES	Simulation models	NO
	Wave period		YES	Simulation models	NO
	Wave direction, coming from		YES	Simulation models	NO
	Wave energy flux		YES	Simulation models	NO
Wave statistics			-	-	-
	Empirical probability distribution		-	-	-
		Wave height	YES	Simulation models	NO
		Wave height & period	YES	Simulation models	NO
		Wave height & direction	YES	Simulation models	NO
		Wave height, period & direction	YES	Simulation models	NO
	Extreme return values		YES	Simulation models	NO
		Wave height	YES	Simulation models	NO
		Wave period	YES	Simulation models	NO
		Wave contours	YES	Simulation models	NO

TABLE 3.31 CURRENT DATABASE – HIGH AND LOW ENERGY WAVE SITE (SC)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries			-	-	-
	Current velocity		YES	Simulation models	NO
	Current direction, coming from		YES	Simulation models	NO
	Current zonal velocity		YES	Simulation models	NO
	Current meridional velocity		YES	Simulation models	NO
	Current available power		YES	Simulation models	NO
Current statistics			-	-	-
	Empirical probability distribution		YES	Simulation models	NO
		Current velocity	YES	Simulation models	NO
		Current direction, coming from	YES	Simulation models	NO
		Current velocity & direction	YES	Simulation models	NO
	Extreme return values		YES	Simulation models	NO
		Current velocity	YES	Simulation models	NO
	Current profile		NO	-	-

TABLE 3.32 WIND DATABASE – HIGH AND LOW ENERGY WAVE SITE (SC)

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries			-	-	-
	10m-wind velocity		YES	Simulation models	NO
	10m-wind direction, coming from		YES	Simulation models	NO
	10m-wind zonal velocity		YES	Simulation models	NO
	10m-wind meridional velocity		YES	Simulation models	NO
	10m-wind gusts		YES	Simulation models	NO
Wind statistics					
	Empirical probability distribution		-	-	-
		10m-wind velocity	YES	Simulation models	NO
		10m-wind direction, coming from	YES	Simulation models	NO
		10m-wind velocity & direction	YES	Simulation models	NO
	Extreme return values		YES	Simulation models	NO
		10m-wind velocity	YES	Simulation models	NO
		10m-wind gusts	YES	Simulation models	NO

TABLE 3.33 WATER LEVEL DATABASE – HIGH AND LOW ENERGY WAVE SITE (SC)

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries		-	-	-
	Water surface fluctuation, relative to MSL	YES	Simulation models	NO
	Water level, relative to bottom	YES	Simulation models	NO
Water level statistics		-	-	-
	Water level, relative to bottom	YES	Simulation models	NO
	Empirical probability distribution	YES	Simulation models	NO
	Extreme return values	YES	Simulation models	NO

TABLE 3.34 SEABED PROPERTIES – HIGH AND LOW ENERGY WAVE SITE (SC)

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file				
Contours		-	-	-
	Lease area shapefile	YES	Simulation models	NO
	Corridor shapefile	YES	Simulation models	NO
	Competing Use of space: Existing cable routes	NO	-	-
	Competing Use of space: Existing vessel routes	NO	-	-
	Competing Use of space: No-go areas	NO	-	-

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type				
	Soil type/classification	YES	Simulation models	NO
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	NO	-	-
	Distance to rock bed	NO	-	-

3.4.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

As this VS is intended for concept creation, the data specifications for the technology description are high level aims which include the key features sought in the innovative design, which are as follows:

- Wave energy device with an LCOE < 150 €/MWh
- High reliability
- Low environmental impact

3.4.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

The catalogues will not be required for this Validation Scenario.

3.4.4 MANAGEMENT OF DATA GAPS

There are no significant gaps in order to run the SI tool. If further information is required, such as Fundamental Relationships, WES will access the Scenario Creation functionality, an add-on tool created in Excel.

The other data needed to run this VS is the Solution Hierarchy within the SI tool. The Solution Hierarchy is a multi-level list of potential solutions for ocean energy systems. It has been developed and completed in five levels for ocean energy projects.

4. VALIDATION SCENARIO 2: WAVE / SG TOOL / SUBSYSTEM LEVEL

4.1 SUMMARY OF THE VALIDATION SCENARIO

This Validation Scenario is related to the VS1 and it is representative of a **Wave Energy technology**, using the **Stage Gate Tool** at **Subsystem Level**. Within the scenario refinement process of VS2, the corresponding validation partners CorPower, EGP and WES decided to reduce and refine the number of objectives to a single design objective and to assign **CorPower** the leadership. The refined design objective therefore incorporates and conjoins the specific contents of the preliminary defined objectives:

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

The SG tool will be tested according to the information of the site (Billia Croo – EMEC [5]), will have Corpower as *Lead Partner* and WES as *Technical Support Partner*. This information and other complementary can be viewed in Table 4.1.

TABLE 4.1 SYNOPTICAL DESCRIPTION OF REFINED VS2

	VALIDATION SCENARIO 2
Subscenario	-
Technology Type	Wave
Tools to be Validated	Stage Gate
Aggregation Level	Subsystem Level
Lead Partner	Corpower
Other Interested	EGP, WES
Technical Support	WES
Technology	Corpower Ocean - C4
Total Power	300 kW x 1 device
Subsystem/Component	PTO
Intended Site	Billia Croo (EMEC)

The following subsections provide details about the data specification related to the intended site, technology, catalogues (when needed) and development activities for this VS. Management of data gaps is also discussed.

4.2 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

The data specification related to the intended site described in section 3.2.1 are also applicable to VS2.

4.3 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

The data specification related to the technology described in section 3.2.2 are also applicable to VS2.

4.4 DATA SPECIFICATIONS RELATED TO CATALOGUES

The data specification related to the catalogues, particularly data associated to Power Take Off Components, which are described in section 3.2.3 are also applicable to VS2.

4.5 DATA SPECIFICATIONS RELATED TO DEVELOPMENT ACTIVITIES

TABLE 4.2 ACTIVITY CHECKLIST – CORPOWER

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Concept creation and description	YES	Concept Design Report	YES
Concept characterisation	YES	Concept Design Report	YES
Comparable technology evaluation	YES	Literature	NO
Novel technology evaluation	YES	Technology Assessment	YES
Selection of targets for performance metrics	YES	System Requirements	YES
Preliminary economic assessment	YES	CorPower	YES
LCOE model	YES	CorPower	YES
Numerical modelling	YES	CorPower Internal model	YES
Rig testing	YES	CorPower tests	YES
Tank testing	NO	-	-
Survival tank testing	YES	CorPower tests	YES
Open-water testing	YES	CorPower tests	YES
Hydrodynamic performance assessment	YES	CorPower	YES
Power take off (PTO) considerations	YES	CorPower	YES
Device and PTO integration	YES	CorPower	YES
Design and analysis of control systems	YES	CorPower model	YES
Design limit identification	YES	CorPower Design Report	YES
Design solution optimisation	YES	CorPower Design Report	YES
Array configuration	NO	-	-
Manufacturing processes	YES	Suppliers	YES
Structural material assessment	YES	Suppliers	YES
Load and safety factor assessment	YES	CorPower Design Report	YES
Reliability analyses	YES	CorPower	YES
Installation plan	YES	CorPower	YES
FMEA, O&M model and plan	YES	CorPower	YES
Measurement and monitoring	YES	CorPower sensors	YES
Environmental impact assessment	NO	-	-
Greenhouse gas emissions	NO	-	-
Environmental and social impacts	YES	Project partnerships	NO

4.6 MANAGEMENT OF DATA GAPS

There are no critical data gaps for running this Validation Scenario. Information required to complete the Activity Checklist is catered for even TRL 1 technologies.

In a standalone mode, the SG tool can provide the full list of metrics and all validation partners will be able to answer the qualitative questions.

As an embedded mode scenario, the user will be prompted to open up each of the Deployment and Assessment tools sequentially. In this case, the design tools can either use default values or be run at lower complexity to deal with gaps in the data available to developers, as explained in VS1.1.

5. VALIDATION SCENARIO 3: WAVE / DEPLOYMENT TOOLS / ARRAY LEVEL

5.1 SUMMARY OF THE VALIDATION SCENARIO

VS3 is representative for a **Wave Technology**, using the **Deployment Design Tools** at **Array level**. 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 and assigned **IDOM** the leadership. The refined design objective therefore incorporates and conjoins the specific contents of the preliminary defined objectives:

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

The intended site that will be used in this scenario is BiMEP [9]. The technology selected is IDOM MARMOK - A14 [10]. 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 seen in Table 5.1.

TABLE 5.1 SYNOPTICAL DESCRIPTION OF REFINED VS3

	VALIDATION SCENARIO 3
Subscenario	-
Technology Type	Wave
Tools to be Validated	Deployment Design
Aggregation Level	Array Level
Lead Partner	IDOM
Other Interested	EGP, WES
Technical Support	Tecnalia
Technology	MARMOK - A14; 250 kW
Total Power	250 kW x 8 devices
Subsystem/Component	n/a
Intended Site	BiMEP

The following subsections provide details about the data specification related to the intended site, technology and catalogues (when needed) for this VS. Management of data gaps is also discussed.

5.2 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

TABLE 5.2 WAVE DATABASE – BIMEP

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries			-	-	-
	Wave height		NO	-	-
	Wave period		NO	-	-
	Wave direction, coming from		NO	-	-
	Wave energy flux		NO	-	-
Wave statistics			-	-	-
	Empirical probability distribution		-	-	-
		Wave height	YES	Literature	NO
		Wave height & period	YES	Literature	NO
		Wave height & direction	YES	Literature	NO
		Wave height, period & direction	NO	-	-
	Extreme return values		-	-	-
		Wave height	YES	Literature	NO
		Wave period	NO	-	-
		Wave contours	YES	Literature	NO

TABLE 5.3 CURRENT DATABASE – BIMEP

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries			-	-	-
	Current velocity		NO	-	-
	Current direction, coming from		NO	-	-
	Current zonal velocity		NO	-	-
	Current meridional velocity		NO	-	-
	Current available power		NO	-	-
Current statistics			-	-	-
	Empirical probability distribution		-	-	-
		Current velocity	YES	Literature	NO
		Current direction, coming from	YES	Literature	NO
		Current velocity & direction	YES	Literature	NO
	Extreme return values		-	-	-
		Current velocity	YES	Literature	NO
	Current profile		NO	-	-

TABLE 5.4 WIND DATABASE – BIMEP

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries			-	-	-
	10m-wind velocity		NO	-	-
	10m-wind direction, coming from		NO	-	-
	10m-wind zonal velocity		NO	-	-
	10m-wind meridional velocity		NO	-	-
	10m-wind gusts		NO	-	-
Wind statistics					
	Empirical probability distribution		-	-	-
		10m-wind velocity	YES	Literature	NO
		10m-wind direction, coming from	YES	Literature	NO
		10m-wind velocity & direction	YES	Literature	NO
	Extreme return values		-	-	-
		10m-wind velocity	YES	Literature	NO
		10m-wind gusts	NO	-	-

TABLE 5.5 WATER LEVEL DATABASE – BIMEP

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries		-	-	-
	Water surface fluctuation, relative to MSL	NO	-	-
	Water level, relative to bottom	NO	-	-
Water level statistics		-	-	-
	Water level, relative to bottom	NO	-	-
	Empirical probability distribution	YES	Literature	NO
	Extreme return values	YES	Literature	NO

TABLE 5.6 SEABED PROPERTIES – BIMEP

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file		YES	Literature	NO
Contours		-	-	-
	Lease area shapefile	YES	Literature	NO
	Corridor shapefile	NO	-	-
	Competing Use of space: Existing cable routes	YES	Literature	NO
	Competing Use of space: Existing vessel routes	YES	Literature	NO
	Competing Use of space: No-go areas	YES	Literature	NO

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Literature	NO
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	YES	Literature	NO
	Distance to rock bed	YES	Literature	NO

TABLE 5.7 MARINE SPECIES FILE – BIMEP

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	NO	-	-
Initial environmental condition	NO	-	-
Endangered species	NO	-	-

5.3 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 5.8 PRIME MOVER DIMENSIONS & COST – MARMOK A-14

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	YES	Simulation models	YES
Height	YES	Simulation models	YES
Width	YES	Simulation models	YES
Length	YES	Simulation models	YES
Submerged Volume	YES	Simulation models	YES
Wetted Area	YES	Simulation models	YES
Mass and Inertial properties	YES	Simulation models	YES
Footprint radius	YES	Simulation models	YES
Device cost	YES	Simulation models	YES

TABLE 5.9 HYDRODYNAMICS – MARMOK A-14

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Capture Width Ratio		-	-	-
	Tp capture width	YES	Simulation models	YES
	Hs capture width	YES	Simulation models	YES
	Wave angle capture width	NO	-	-
Additional Damping		YES	Experimental data	YES
Additional Stiffness		YES	Simulation models	YES
Multibody - other dofs		YES	Simulation models	YES
Hydrodynamic Matrices (added mass, radiation damping, External excitation)		YES	Simulation models	YES

TABLE 5.10 POWER SETTINGS AND STATIONKEEPING – MARMOK A-14

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Simulation models	NO
Connector Type	NO	-	-
Control Subsystem failure Rate	NO	-	-
Mooring Stiffness	YES	Experimental data	YES
Foundation preferred type	YES	Experimental data	YES

TABLE 5.11 MARINE OPERATIONS – MARMOK A-14

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	N/A	-	-
Min Installation Water depth	YES	Experimental data	NO
Min interdistance perpendicular to waves/current	YES	Literature	NO
Min interdistance parallel to waves/current	YES	Literature	NO

TABLE 5.12 PTO MECHANICAL CONVERSION – MARMOK A-14

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	YES	Info from suppliers	NO
Manufacturer reference	YES	Info from suppliers	NO
Main dimensions	YES	Simulation models	YES
Weight	YES	Info from suppliers	NO
Primary materials	YES	Info from suppliers	NO
Transmission ratio	N/A	-	-
Rated power	YES	Simulation models	NO
Speed range	YES	Info from suppliers	YES
Input force, torque range	YES	Info from suppliers	YES
Maximum stroke (only for linear systems)	N/A	-	-
Efficiency	YES	Simulation models	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

TABLE 5.13 PTO ELECTRICAL CONVERSION – MARMOK A-14

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	YES	Simulation models	YES
Manufacturer reference	YES	Info from suppliers	NO
Number of pole pairs	YES	Simulation models	YES
Insulation class	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	NO

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	YES	Info from suppliers	NO
Primary materials	YES	Info from suppliers	NO
Rated power	YES	Info from suppliers	NO
Nominal voltage	YES	Info from suppliers	NO
Nominal intensity	YES	Info from suppliers	NO
Maximum voltage	YES	Info from suppliers	NO
Maximum torque	YES	Info from suppliers	NO
Maximum speed	YES	Info from suppliers	NO
Efficiency	YES	Info from suppliers	NO
Power factor	YES	Info from suppliers	NO
Cost	NO	-	-
Failure rate	NO	-	-

TABLE 5.14 PTO GRID CONDITIONING – MARMOK A-14

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	NO
Main dimensions	YES	Info from suppliers	NO
Weight	YES	Info from suppliers	NO
Primary materials	YES	Info from suppliers	NO
Rated power	YES	Simulation models	YES
Switching frequency	NO	-	-
Grid voltage	YES	Simulation models	YES
Grid resistance	YES	Simulation models	YES
Efficiency	YES	Simulation models	YES
Power factor	NO	-	-
Cost	NO	-	-
Failure rate	NO	-	-

5.4 DATA SPECIFICATIONS RELATED TO CATALOGUES

TABLE 5.15 CATALOGUES – MARMOK A-14

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessel clusters	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		-	-	-
	Mooring Lines	YES	FEM	NO
	Drag Anchors	YES	FEM	NO
Power Take Off Components		-	-	-
	User Defined Air Turbine	YES	Tecnalia	NO
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	N/A	-	-
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	YES	UEDIN	NO
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	YES	UEDIN	NO
	Collection point	YES	UEDIN	NO

5.5 MANAGEMENT OF DATA GAPS

There are no significant data gaps for running this Validation Scenario. However, the design tools will need some default values if run at the highest complexity 3.

The DTOceanPlus suite of tools will provide reference values for seabed properties and failure rates of PTO components. Synthetic timeseries needed for marine operations could be created from the available statistic information. Marine species data can be retrieved from global databases or this functionality skipped in the VS.

Finally, IDOM should provide a detailed mooring system configuration and some additional information for the planning of marine operations for this scenario, such as the device draft in a tow position or whether maintenance is performed off-site.

6. VALIDATION SCENARIO 4: TIDAL / SI TOOL / SUBSYSTEM LEVEL

6.1 SUMMARY OF THE VALIDATION SCENARIO

VS4 is representative of a **Tidal Energy technology** and the **Structured Innovation Tool** will be validated at a **Subsystem level**. The corresponding validation partners Orbital and ESC decided to refine the objectives and to assign **Orbital** the leadership. These refined design objectives therefore incorporate and conjoin the specific contents of the preliminary defined objectives:

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.

The SI Tool will be tested based on the data of the selected site: Fall of Warness (EMEC Berth 5) [11]. The technology selected is Orbital o2 [12] and the focus will mainly be on improving connectors. The role of *Lead Partner* will be assumed by Orbital and the *Technical Supporter Partner* will be ESC.

The characterisation of this validation scenario can be observed on Table 6.1.

TABLE 6.1 SYNOPTICAL DESCRIPTION OF REFINED VS4

	VALIDATION SCENARIO 4
Subscenario	-
Technology Type	Tidal
Tools to be Validated	Structured Innovation
Aggregation Level	Subsystem Level
Lead Partner	Orbital
Other Interested	-
Technical Support	ESC
Technology	Orbital O2
Total Power	2 MW x 1 device
Subsystem/Component	Connectors
Intended Site	Fall of Warness (EMEC Berth 5)

The following subsections provide details about the data specification related to the intended site, technology and catalogues (when needed) for the VS. Management of data gaps is also discussed.

6.2 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

TABLE 6.2 WAVE DATABASE – FALL OF WARNESS (EMEC BERTH 5)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries	-	-	-
Wave height	YES	Simulation models	YES
Wave period	YES	Simulation models	YES
Wave direction, coming from	YES	Simulation models	YES
Wave energy flux	YES	Simulation models	YES
Wave statistics	-	-	-
Empirical probability distribution	-	-	-
Wave height	NO	-	-
Wave height & period	NO	-	-
Wave height & direction	NO	-	-
Wave height, period & direction	NO	-	-
Extreme return values	-	-	-
Wave height	NO	-	-
Wave period	NO	-	-
Wave contours	NO	-	-

TABLE 6.3 CURRENT DATABASE – FALL OF WARNESS (EMEC BERTH 5)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries	-	-	-
Current velocity	YES	Simulation models	YES
Current direction, coming from	YES	Simulation models	YES
Current zonal velocity	YES	Simulation models	YES
Current meridional velocity	YES	Simulation models	YES
Current available power	NO	-	-
Current statistics	-	-	-
Empirical probability distribution	-	-	-
Current velocity	NO	-	-
Current direction, coming from	NO	-	-
Current velocity & direction	NO	-	-
Extreme return values	-	-	-
Current velocity	NO	-	-
Current profile	NO	-	-

TABLE 6.4 WIND DATABASE – FALL OF WARNESS (EMEC BERTH 5)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries	-	-	-
10m-wind velocity	YES	Simulation models	YES
10m-wind direction, coming from	YES	Simulation models	YES
10m-wind zonal velocity	NO	-	-
10m-wind meridional velocity	NO	-	-
10m-wind gusts	NO	-	-
Wind statistics			
Empirical probability distribution	-	-	-
10m-wind velocity	NO	-	-
10m-wind direction, coming from	NO	-	-
10m-wind velocity & direction	NO	-	-
Extreme return values	-	-	-
10m-wind velocity	NO	-	-
10m-wind gusts	NO	-	-

TABLE 6.5 WATER LEVEL DATABASE – FALL OF WARNESS (EMEC BERTH 5)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries	-	-	-
Water surface fluctuation, relative to MSL	YES	Simulation models	YES
Water level, relative to bottom	YES	Simulation models	YES
Water level statistics	-	-	-
Water level, relative to bottom	NO	-	-
Empirical probability distribution	NO	-	-
Extreme return values	NO	-	-

TABLE 6.6 SEABED PROPERTIES – FALL OF WARNESS (EMEC BERTH 5)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file	YES	Info from suppliers	YES
Contours	-	-	-
Lease area shapefile	NO	-	-
Corridor shapefile	NO	-	-
Competing Use of space: Existing cable routes	YES	Info from suppliers	YES
Competing Use of space: Existing vessel routes	YES	Info from suppliers	YES
Competing Use of space: No-go areas	NO	-	-

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Info from suppliers	YES
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	NO	-	-
	Distance to rock bed	YES	Info from suppliers	YES

TABLE 6.7 MARINE SPECIES FILE – FALL OF WARNESS (EMEC BERTH 5)

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	NO	-	-
Initial environmental condition	NO	-	-
Endangered species	NO	-	-

6.3 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 6.8 PRIME MOVER DIMENSIONS & COST – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	YES	Simulation models	YES
Height	YES	Simulation models	YES
Width	YES	Simulation models	YES
Length	YES	Simulation models	YES
Submerged Volume	YES	Simulation models	YES
Wetted Area	YES	Simulation models	YES
Mass and Inertial properties	YES	Simulation models	YES
Footprint radius	YES	Simulation models	YES
Device cost	YES	Info from suppliers	YES

TABLE 6.9 HYDRODYNAMICS – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Tip Speed Ratio	YES	Simulation models	YES
Power Coefficient Curve	YES	Simulation models	YES
Thrust Coefficient Curve	YES	Simulation models	YES
Cp/Ct Velocity Definition	YES	Simulation models	YES
Orientation Angle	YES	Simulation models	YES
Cut In Velocity	YES	Simulation models	YES
Cut Out Velocity	YES	Simulation models	YES
Heading Angle Span	YES	Simulation models	YES
Bidirectional Turbine	YES	Simulation models	YES

TABLE 6.10 POWER SETTINGS AND STATIONKEEPING – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Simulation models	YES
Connector Type	YES	Simulation models	YES
Control Subsystem failure Rate	YES	Simulation models	YES
Mooring Stiffness	YES	Simulation models	YES
Foundation preferred type	YES	Simulation models	YES

TABLE 6.11 MARINE OPERATIONS – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	YES	Simulation models	YES
Min Installation Water depth	YES	Simulation models	YES
Min interdistance perpendicular to waves/current	YES	Simulation models	YES
Min interdistance parallel to waves/current	YES	Simulation models	YES

TABLE 6.12 PTO MECHANICAL CONVERSION – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	YES	Simulation models	NO
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES
Weight	YES	Info from suppliers	YES
Primary materials	NO	-	-
Transmission ratio	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Speed range	YES	Info from suppliers	YES
Input force, torque range	YES	Info from suppliers	YES
Maximum stroke (only for linear systems)	N/A	-	-
Efficiency	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

TABLE 6.13 PTO ELECTRICAL CONVERSION – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Number of pole pairs	YES	Info from suppliers	YES
Insulation class	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Nominal voltage	YES	Info from suppliers	YES
Nominal intensity	YES	Info from suppliers	YES
Maximum voltage	YES	Info from suppliers	YES
Maximum torque	YES	Info from suppliers	YES
Maximum speed	YES	Info from suppliers	YES
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

TABLE 6.14 PTO GRID CONDITIONING – ORBITAL O2

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Switching frequency	YES	Info from suppliers	YES
Grid voltage	YES	Info from suppliers	YES
Grid resistance	YES	Info from suppliers	YES
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	YES	Info from suppliers	YES

6.4 DATA SPECIFICATIONS RELATED TO CATALOGUES

TABLE 6.15 CATALOGUES – ORBITAL O2

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessel clusters	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		-	-	-
	Mooring Lines	YES	FEM	NO
	Drag Anchors	YES	FEM	NO
Power Take Off Components		-	-	-
	User Defined Air Turbine	N/A	-	-
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	YES	Tecnalia	NO
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	N/A	-	-
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	N/A	-	-
	Collection point	N/A	-	-

6.5 MANAGEMENT OF DATA GAPS

There are no critical data gaps for running VS4. The design tools can either use default values or be run at lower complexity to deal with gaps in the data available to developers. For instance, reference values for seabed properties, marine species and failure rates of PTO components can be provided by the DTOceanPlus suite of tools. Moreover, the catalogues will be populated to a sufficient level to run this scenario.

In addition, The SI tool is developed to include fundamental relationships between key parameters in ocean energy concepts, evidence from the first ocean energy arrays, and a standard library of problem solution inter-relationships.

7. VALIDATION SCENARIO 5: TIDAL / SG TOOL / DEVICE LEVEL

7.1 SUMMARY OF THE VALIDATION SCENARIO

VS5 is representative for a **Tidal Energy Technology,** using the **Stage Gate Tool** at **Device level**. The corresponding validation partners **Orbital** and **Sabella** decided to refine the objectives. This refined design objective therefore incorporates and conjoins the specific contents of the preliminary defined objectives:

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.

The SG tool will be tested considering the information of EMEC Berth 5 [11] and Fromveur [13]. The first subscenario will be led by Orbital and the second one will be led by Sabella. The technologies selected are Orbital o2 [12] and Sabella D15-500 [14] respectively. WES will provide the technical support for both subscenarios.

Table 7.1 presents the characterisation of this Validation Scenario.

TABLE 7.1 SYNOPTICAL DESCRIPTION OF REFINED VS5

	VALIDATION SCENARIO 5	
Subscenario	**5.1**	**5.2**
Technology Type	Tidal	
Tools to be Validated	Stage Gate	
Aggregation Level	Device Level	
Lead Partner	Orbital	Sabella
Other Interested	-	
Technical Support	WES	WES
Technology	Orbital O2	SABELLA D15-500
Total Power	2 MW x 1 device	500 kW x 1 device
Subsystem/Component	n/a	n/a
Intended Site	EMEC Berth 5	Fromveur

The following subsections provide details about the data specification related to the intended site, technology, catalogues (when needed) and development activities for each VS. Management of data gaps is also discussed.

7.2 VS5.1 - ORBITAL

7.2.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

The data specification related to the intended site, technology and catalogues described in section 6.2 are also applicable to VS5.1.

7.2.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

The data specification related to the intended site, technology and catalogues described in section 6.3 are also applicable to VS5.1.

7.2.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

The data specification related to the intended site, technology and catalogues described in section 6.4 are also applicable to VS5.1.

7.2.4 DATA SPECIFICATIONS RELATED TO DEVELOPMENT ACTIVITIES

TABLE 7.2 ACTIVITY CHECKLIST – ORBITAL

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Concept creation and description	YES	In house engineering	YES
Concept characterisation	YES	In house engineering	YES
Comparable technology evaluation	NO	-	-
Novel technology evaluation	NO	-	-
Selection of targets for performance metrics	YES	In house engineering	YES
Preliminary economic assessment	YES	In house engineering	YES
LCOE model	YES	In house engineering	YES
Numerical modelling	YES	In house engineering	YES
Rig testing	NO	-	-
Tank testing	NO	-	-
Survival tank testing	NO	-	-
Open-water testing	NO	-	-
Hydrodynamic performance assessment	YES	In house engineering	YES
Power take off (PTO) considerations	YES	In house engineering	YES
Device and PTO integration	YES	In house engineering	YES
Design and analysis of control systems	YES	In house engineering	YES
Design limit identification	YES	In house engineering	YES

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Design solution optimisation	YES	In house engineering	YES
Array configuration	YES	In house engineering	YES
Manufacturing processes	NO	-	-
Structural material assessment	YES	In house engineering	YES
Load and safety factor assessment	YES	In house engineering	YES
Reliability analyses	YES	In house engineering	YES
Installation plan	YES	In house engineering	YES
FMEA, O&M model and plan	YES	In house engineering	YES
Measurement and monitoring	YES	In house engineering	YES
Environmental impact assessment	YES	In house engineering	YES
Greenhouse gas emissions	YES	In house engineering	YES
Environmental and social impacts	YES	In house engineering	YES

7.2.5 MANAGEMENT OF DATA GAPS

There are no critical data gaps for running this Validation Scenario. Information required to complete the Activity Checklist is catered for even TRL 1 technologies.

In a standalone mode, the SG tool can provide the full list of metrics and all validation partners will be able to answer the qualitative questions.

As an embedded mode scenario, the user will be prompted to open up each of the Deployment and Assessment tools sequentially. In this case, the design tools can either use default values or be run at lower complexity to deal with gaps in the data available to developers, as explained in VS4.

7.3 VS5.2 - SABELLA

7.3.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

TABLE 7.3 WAVE DATABASE – FROMVEUR

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries			-	-	-
	Wave height		YES	Info from suppliers	YES
	Wave period		YES	Info from suppliers	YES
	Wave direction, coming from		YES	Info from suppliers	YES
	Wave energy flux		N/A	-	-
Wave statistics			-	-	-
	Empirical probability distribution		-	-	-
		Wave height	YES	Info from suppliers	YES
		Wave height & period	YES	Info from suppliers	YES
		Wave height & direction	YES	Info from suppliers	YES
		Wave height, period & direction	YES	Info from suppliers	YES
	Extreme return values		-	-	-
		Wave height	YES	Info from suppliers	YES
		Wave period	YES	Info from suppliers	YES
		Wave contours	YES	Info from suppliers	YES

TABLE 7.4 CURRENT DATABASE – FROMVEUR

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries			-	-	-
	Current velocity		YES	Info from suppliers	YES
	Current direction, coming from		YES	Info from suppliers	YES
	Current zonal velocity		YES	Info from suppliers	YES
	Current meridional velocity		YES	Info from suppliers	YES
	Current available power		YES	Simulation models	YES
Current statistics			-	-	-
	Empirical probability distribution		-	-	-
		Current velocity	YES	Info from suppliers	YES
		Current direction, coming from	YES	Info from suppliers	YES
		Current velocity & direction	YES	Info from suppliers	YES
	Extreme return values		-	-	-
		Current velocity	YES	Simulation models	YES
	Current profile		NO	-	-

TABLE 7.5 WIND DATABASE – FROMVEUR

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries			-	-	-
	10m-wind velocity		YES	Simulation models	YES
	10m-wind direction, coming from		YES	Simulation models	YES
	10m-wind zonal velocity		NO	-	-
	10m-wind meridional velocity		NO	-	-
	10m-wind gusts		YES	Simulation models	YES
Wind statistics					
	Empirical probability distribution		-	-	-
		10m-wind velocity	YES	Simulation models	YES
		10m-wind direction, coming from	YES	Simulation models	YES
		10m-wind velocity & direction	NO	-	-
	Extreme return values		-	-	-
		10m-wind velocity	YES	Simulation models	YES
		10m-wind gusts	YES	Simulation models	YES

TABLE 7.6 WATER LEVEL DATABASE – FROMVEUR

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries		-	-	-
	Water surface fluctuation, relative to MSL	NO	-	-
	Water level, relative to bottom	YES	Simulation models	YES
Water level statistics		-	-	-
	Water level, relative to bottom	YES	Simulation models	YES
	Empirical probability distribution	YES	Simulation models	YES
	Extreme return values	YES	Simulation models	YES

TABLE 7.7 SEABED PROPERTIES – FROMVEUR

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file		YES	Experimental data	YES
Contours		-	-	-
	Lease area shapefile	YES	Info from suppliers	NO
	Corridor shapefile	YES	Info from suppliers	NO
	Competing Use of space: Existing cable routes	YES	Info from suppliers	NO
	Competing Use of space: Existing vessel routes	YES	Info from suppliers	NO
	Competing Use of space: No-go areas	YES	Info from suppliers	NO

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Info from suppliers	YES
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	NO	-	-
	Distance to rock bed	NO	-	-

TABLE 7.8 MARINE SPECIES FILE – FROMVEUR

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	YES	Info from suppliers	YES
Initial environmental condition	YES	Info from suppliers	YES
Endangered species	YES	Info from suppliers	YES

7.3.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 7.9 PRIME MOVER DIMENSIONS & COST – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	YES	Info from suppliers	NO
Height	YES	Info from suppliers	NO
Width	YES	Info from suppliers	NO
Length	YES	Info from suppliers	NO
Submerged Volume	YES	Info from suppliers	NO
Wetted Area	YES	Info from suppliers	NO
Mass and Inertial properties	YES	Info from suppliers	YES
Footprint radius	YES	Info from suppliers	NO
Device cost	YES	Info from suppliers	YES

TABLE 7.10 HYDRODYNAMICS – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Tip Speed Ratio	YES	Simulation models	YES
Power Coefficient Curve	YES	Simulation models	YES
Thrust Coefficient Curve	YES	Simulation models	YES
Cp/Ct Velocity Definition	YES	Simulation models	YES
Orientation Angle	YES	Info from suppliers	YES
Cut In Velocity	YES	Info from suppliers	YES
Cut Out Velocity	YES	Info from suppliers	YES
Heading Angle Span	YES	Info from suppliers	YES
Bidirectional Turbine	YES	Info from suppliers	YES

TABLE 7.11 POWER SETTINGS AND STATIONKEEPING – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Simulation models	NO
Connector Type	YES	Info from suppliers	YES
Control Subsystem failure Rate	YES	Info from suppliers	YES
Mooring Stiffness	N/A	-	-
Foundation preferred type	YES	Info from suppliers	YES

TABLE 7.12 MARINE OPERATIONS – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	YES	Info from suppliers	YES
Min Installation Water depth	YES	Info from suppliers	YES
Min interdistance perpendicular to waves/current	N/A	-	-
Min interdistance parallel to waves/current	N/A	-	-

TABLE 7.13 PTO MECHANICAL CONVERSION – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Transmission ratio	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Speed range	YES	Info from suppliers	YES
Input force, torque range	YES	Info from suppliers	YES
Maximum stroke (only for linear systems)	N/A	-	-
Efficiency	NO	-	-
Cost	YES	Info from suppliers	YES
Failure rate	YES	Simulation models	YES

TABLE 7.14 PTO ELECTRICAL CONVERSION – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	YES	Info from suppliers	NO
Manufacturer reference	YES	Info from suppliers	YES
Number of pole pairs	YES	Info from suppliers	YES
Insulation class	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	NO

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	YES	Info from suppliers	NO
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	NO
Nominal voltage	YES	Info from suppliers	YES
Nominal intensity	YES	Info from suppliers	YES
Maximum voltage	YES	Info from suppliers	YES
Maximum torque	YES	Info from suppliers	YES
Maximum speed	YES	Info from suppliers	NO
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	YES	Simulation models	YES

TABLE 7.15 PTO GRID CONDITIONING – SABELLA D15-500

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	NO
Weight	YES	Info from suppliers	NO
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Switching frequency	YES	Info from suppliers	YES
Grid voltage	YES	Info from suppliers	YES
Grid resistance	YES	Info from suppliers	YES
Efficiency	NO	-	-
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	YES	Simulation models	YES

7.3.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

TABLE 7.16 CATALOGUES – SABELLA D15-500

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessel clusters	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		-	-	-
	Mooring Lines	N/A	-	-
	Drag Anchors	N/A	-	-
Power Take Off Components		-	-	-
	User Defined Air Turbine	N/A	-	-
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	YES	Tecnalia	NO
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	N/A	-	-
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	N/A	-	-
	Collection point	N/A	-	-

7.3.4 DATA SPECIFICATIONS RELATED TO DEVELOPMENT ACTIVITIES

TABLE 7.17 ACTIVITY CHECKLIST – SABELLA D15

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Concept creation and description	YES	Info from suppliers	YES
Concept characterisation	YES	Info from suppliers	YES
Comparable technology evaluation	NO	-	-
Novel technology evaluation	NO	-	-
Selection of targets for performance metrics	YES	Info from suppliers	YES
Preliminary economic assessment	YES	Info from suppliers	YES
LCOE model	YES	Simulation models	YES
Numerical modelling	YES	Simulation models	YES
Rig testing	NO	-	-
Tank testing	YES	Experimental data	YES
Survival tank testing	NO	-	-
Open-water testing	NO	-	-
Hydrodynamic performance assessment	YES	Simulation models	YES
Power take off (PTO) considerations	YES	Simulation models	YES
Device and PTO integration	YES	Simulation models	YES
Design and analysis of control systems	YES	Simulation models	YES
Design limit identification	YES	Simulation models	YES
Design solution optimisation	YES	Simulation models	YES
Array configuration	YES	Simulation models	YES
Manufacturing processes	YES	Info from suppliers	YES
Structural material assessment	YES	Info from suppliers	YES
Load and safety factor assessment	YES	Info from suppliers	YES
Reliability analyses	YES	Simulation models	YES
Installation plan	YES	Info from suppliers	YES
FMEA, O&M model and plan	YES	Simulation models	YES
Measurement and monitoring	YES	Experimental data	YES
Environmental impact assessment	YES	Literature & Experimental data	YES
Greenhouse gas emissions	YES	Simulation models	YES
Environmental and social impacts	YES	Info from suppliers	YES

7.3.5 MANAGEMENT OF DATA GAPS

There are no critical data gaps for running this Validation Scenario. Information required to complete the Activity Checklist is catered for even TRL 1 technologies.

In a standalone mode, the SG tool can provide the full list of metrics and all validation partners will be able to answer the qualitative questions.

As an embedded mode scenario, the user will be prompted to open up each of the Deployment and Assessment tools sequentially. In this case, the design tools can either use default values or be run at lower complexity to deal with gaps in the data available to developers.

8. VALIDATION SCENARIO 6: TIDAL / DEPLOYMENT TOOLS / ARRAY LEVEL

8.1 SUMMARY OF THE VALIDATION SCENARIO

VS6 is representative for a **Tidal Energy Technology**, using the **Deployment Design Tools** at **Array Level**. The corresponding validation partners **Nova, Orbital** and **Sabella** decided to refine the objectives. This refined design objectives represents the specific contents of the preliminary defined objectives:

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.

The Deployment tools will be tested considering the information of Bluemull Sound [15], EMEC Berth 5 [11] and Fromveur [13]. UEDIN will support them in technical matters. The technologies selected are Nova M100-D [16], Orbital o2 [12] and Sabella D22-2000 [14]. The *Lead Partners* of sub scenarios 6.1, 6.2 and 6.3 will be Nova, Orbital and Sabella, respectively.

The characterisation of VS6 is provided in Table 8.1.

TABLE 8.1 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 M100-D	Orbital O2	SABELLA D22-2000
Total Power/Number of Devices	100 kW x 10-50 devices	2 MW x 5 devices	2 MW x 50 devices
Subsystem/Component	n/a	drivetrain scaling	n/a
Intended Site	Bluemull Sound	EMEC Berth 5	Fromveur

The following subsections provide details about the data specification related to the intended site, technology and catalogues (when needed) for each VS. Management of data gaps is also discussed.

8.2 V6.1 - NOVA

TABLE 8.2 WAVE DATABASE – BLUEMULL SOUND

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries			-	-	-
	Wave height		YES	Simulation models	YES
	Wave period		YES	Simulation models	YES
	Wave direction, coming from		YES	Simulation models	YES
	Wave energy flux		NO	-	-
Wave statistics			-	-	-
	Empirical probability distribution		-	-	-
		Wave height	NO	-	-
		Wave height & period	NO	-	-
		Wave height & direction	NO	-	-
		Wave height, period & direction	NO	-	-
	Extreme return values		-	-	-
		Wave height	NO	-	-
		Wave period	NO	-	-
		Wave contours	NO	-	-

TABLE 8.3 CURRENT DATABASE – BLUEMULL SOUND

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries			-	-	-
	Current velocity		YES	Simulation models	YES
	Current direction, coming from		YES	Simulation models	YES
	Current zonal velocity		YES	Simulation models	YES
	Current meridional velocity		YES	Simulation models	YES
	Current available power		YES	Simulation models	YES
Current statistics			-	-	-
	Empirical probability distribution		-	-	-
		Current velocity	YES	Simulation models	YES
		Current direction, coming from	YES	Simulation models	YES
		Current velocity & direction	YES	Simulation models	YES
	Extreme return values		-	-	-
		Current velocity	YES	Simulation models	YES
	Current profile		YES	Simulation models	YES

TABLE 8.4 WIND DATABASE – BLUEMULL SOUND

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries			-	-	-
	10m-wind velocity		YES	Simulation models	YES
	10m-wind direction, coming from		YES	Simulation models	YES
	10m-wind zonal velocity		N/A	-	-
	10m-wind meridional velocity		N/A	-	-
	10m-wind gusts		N/A	-	-
Wind statistics					
	Empirical probability distribution		-	-	-
		10m-wind velocity	N/A	-	-
		10m-wind direction, coming from	N/A	-	-
		10m-wind velocity & direction	N/A	-	-
	Extreme return values		-	-	-
		10m-wind velocity	N/A	-	-
		10m-wind gusts	N/A	-	-

TABLE 8.5 WATER LEVEL DATABASE – BLUEMULL SOUND

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries		-	-	-
	Water surface fluctuation, relative to MSL	YES	Simulation models	YES
	Water level, relative to bottom	YES	Simulation models	YES
Water level statistics		-	-	-
	Water level, relative to bottom	NO	-	-
	Empirical probability distribution	NO	-	-
	Extreme return values	NO	-	-

TABLE 8.6 SEABED PROPERTIES – BLUEMULL SOUND

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file		YES	Experimental data	YES
Contours		-	-	-
	Lease area shapefile	YES	Info from suppliers	YES
	Corridor shapefile	YES	Info from suppliers	YES
	Competing Use of space: Existing cable routes	YES	Info from suppliers	YES
	Competing Use of space: Existing vessel routes	N/A	-	-
	Competing Use of space: No-go areas	N/A	-	-

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Experimental data	YES
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	YES	Experimental data	YES
	Distance to rock bed	YES	Experimental data	YES

TABLE 8.7 MARINE SPECIES FILE – BLUEMULL SOUND

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	YES	Experimental data	YES
Initial environmental condition	YES	Experimental data	YES
Endangered species	YES	Experimental data	YES

8.2.1 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 8.8 PRIME MOVER DIMENSIONS & COST – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	N/A	-	-
Height	YES	Info from suppliers	YES
Width	YES	Info from suppliers	YES
Length	YES	Info from suppliers	YES
Submerged Volume	YES	Info from suppliers	YES
Wetted Area	N/A	-	-
Mass and Inertial properties	YES	Info from suppliers	YES
Footprint radius	YES	Info from suppliers	YES
Device cost	YES	Info from suppliers	YES

TABLE 8.9 HYDRODYNAMICS – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Tip Speed Ratio	YES	Info from suppliers	YES
Power Coefficient Curve	YES	Info from suppliers	YES
Thrust Coefficient Curve	YES	Info from suppliers	YES
Cp/Ct Velocity Definition	YES	Info from suppliers	YES
Orientation Angle	YES	Info from suppliers	YES
Cut In Velocity	YES	Info from suppliers	YES
Cut Out Velocity	YES	Info from suppliers	YES
Heading Angle Span	YES	Info from suppliers	YES
Bidirectional Turbine	YES	Info from suppliers	YES

TABLE 8.10 POWER SETTINGS AND STATIONKEEPING – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Info from suppliers	NO
Connector Type	YES	Info from suppliers	YES
Control Subsystem failure Rate	YES	Info from suppliers	YES
Mooring Stiffness	N/A	-	-
Foundation preferred type	YES	Info from suppliers	NO

TABLE 8.11 MARINE OPERATIONS – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	YES	Info from suppliers	NO
Min Installation Water depth	YES	Info from suppliers	NO
Min interdistance perpendicular to waves/current	YES	Info from suppliers	NO
Min interdistance parallel to waves/current	YES	Info from suppliers	NO

TABLE 8.12 PTO MECHANICAL CONVERSION – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	YES	Info from suppliers	YES
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Transmission ratio	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Speed range	YES	Info from suppliers	YES
Input force, torque range	YES	Info from suppliers	YES
Maximum stroke (only for linear systems)	N/A	-	-
Efficiency	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	YES	Info from suppliers	YES

TABLE 8.13 PTO ELECTRICAL CONVERSION – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	YES	Info from suppliers	NO
Manufacturer reference	YES	Info from suppliers	YES
Number of pole pairs	YES	Info from suppliers	YES
Insulation class	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Nominal voltage	YES	Info from suppliers	YES
Nominal intensity	YES	Info from suppliers	YES
Maximum voltage	YES	Info from suppliers	YES
Maximum torque	YES	Info from suppliers	YES
Maximum speed	YES	Info from suppliers	YES
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	NO	-	-

TABLE 8.14 PTO GRID CONDITIONING – NOVA M100-D

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	YES	Info from suppliers	NO
Manufacturer reference	YES	Info from suppliers	YES
Main dimensions	YES	Info from suppliers	YES
Weight	YES	Info from suppliers	YES
Primary materials	YES	Info from suppliers	YES
Rated power	YES	Info from suppliers	YES
Switching frequency	YES	Info from suppliers	YES
Grid voltage	YES	Info from suppliers	YES
Grid resistance	YES	Info from suppliers	YES
Efficiency	YES	Info from suppliers	YES
Power factor	YES	Info from suppliers	YES
Cost	YES	Info from suppliers	YES
Failure rate	YES	Info from suppliers	YES

8.2.2 DATA SPECIFICATIONS RELATED TO CATALOGUES

TABLE 8.15 CATALOGUES – NOVA M100-D

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessel clusters	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		-	-	-
	Mooring Lines	N/A	-	-
	Drag Anchors	N/A	-	-
Power Take Off Components		-	-	-
	User Defined Air Turbine	N/A	-	-
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	YES	Tecnalia	NO
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	YES	UEDIN	NO
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	YES	UEDIN	NO
	Collection point	YES	UEDIN	NO

8.2.3 MANAGEMENT OF DATA GAPS

There are no significant data gaps for running VS6.1. Nova has deployed and operated a 3-unit tidal array using the data available. The design tools will need some default values if run at the highest complexity 3. This situation would reflect the limited data availability during the project assessment and planning phase. In that case, the DTOceanPlus suite of tools will provide reference values for seabed properties and failure rates of PTO components.

Wave and water level statistics can be computed from available timeseries if needed. Moreover, the catalogues will be populated to a sufficient level to run this scenario.

8.3 V6.2 - ORBITAL

8.3.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

The data specification related to the intended site, technology and catalogues described in section 6.2 for VS4 are also applicable to VS5.1 and VS6.2.

8.3.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

The data specification related to the intended site, technology and catalogues described in section 6.3 for VS4 are also applicable to VS5.1 and VS6.2.

8.3.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

The data specification related to the intended site, technology and catalogues described in section 6.3 for VS4 are also applicable to VS5.1 and VS6.2.

8.3.4 MANAGEMENT OF DATA GAPS

There are no significant data gaps for running this Validation Scenario. Wave, current, wind and water level statistics can be computed from available timeseries if required.

However, the design tools will need some default values if run at the highest complexity 3. The DTOceanPlus suite of tools will provide reference values for seabed properties and failure rates of PTO components. Marine species data can be retrieved from global databases, EMEC website (at low resolution) or this functionality skipped in the VS.

8.4 V6.3 - SABELLA

8.4.1 DATA SPECIFICATIONS RELATED TO THE INTENDED SITE

TABLE 8.16 WAVE DATABASE – FROMVEUR

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Wave timeseries	-	-	-
Wave height	NO	-	-
Wave period	NO	-	-
Wave direction, coming from	NO	-	-
Wave energy flux	NO	-	-
Wave statistics	-	-	-
Empirical probability distribution	-	-	-
Wave height	NO	-	-
Wave height & period	NO	-	-
Wave height & direction	NO	-	-
Wave height, period & direction	NO	-	-
Extreme return values	-	-	-
Wave height	NO	-	-
Wave period	NO	-	-
Wave contours	NO	-	-

TABLE 8.17 CURRENT DATABASE – FROMVEUR

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Current timeseries	-	-	-
Current velocity	YES	Simulation models	YES
Current direction, coming from	YES	Simulation models	YES
Current zonal velocity	YES	Simulation models	YES
Current meridional velocity	YES	Simulation models	YES
Current available power	NO	-	-
Current statistics	-	-	-
Empirical probability distribution	-	-	-
Current velocity	YES	Simulation models	YES
Current direction, coming from	YES	Simulation models	YES
Current velocity & direction	YES	Simulation models	YES
Extreme return values	-	-	-
Current velocity	NO	-	-
Current profile	YES	Simulation models	YES

TABLE 8.18 WIND DATABASE – FROMVEUR

DATASET			AVAILABLE?	SOURCE	CONFIDENTIAL?
Wind timeseries			-	-	-
	10m-wind velocity		NO	-	-
	10m-wind direction, coming from		NO	-	-
	10m-wind zonal velocity		NO	-	-
	10m-wind meridional velocity		NO	-	-
	10m-wind gusts		NO	-	-
Wind statistics					
	Empirical probability distribution		-	-	-
		10m-wind velocity	NO	-	-
		10m-wind direction, coming from	NO	-	-
		10m-wind velocity & direction	NO	-	-
	Extreme return values		-	-	-
		10m-wind velocity	NO	-	-
		10m-wind gusts	NO	-	-

TABLE 8.19 WATER LEVEL DATABASE – FROMVEUR

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Water level timeseries		-	-	-
	Water surface fluctuation, relative to MSL	NO	-	-
	Water level, relative to bottom	YES	Simulation models	YES
Water level statistics		-	-	-
	Water level, relative to bottom	YES	Simulation models	YES
	Empirical probability distribution	YES	Simulation models	YES
	Extreme return values	NO	-	-

TABLE 8.20 SEABED PROPERTIES – FROMVEUR

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Bathymetry file		YES	Info from suppliers	YES
Contours		-	-	-
	Lease area shapefile	NO	-	-
	Corridor shapefile	YES	Info from suppliers	NO
	Competing Use of space: Existing cable routes	YES	Info from suppliers	NO
	Competing Use of space: Existing vessel routes	YES	Info from suppliers	NO
	Competing Use of space: No-go areas	YES	Info from suppliers	NO

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Seabed type		-	-	-
	Soil type/classification	YES	Info from suppliers	YES
	Soil submerged density	NO	-	-
	Undrained cohesion	NO	-	-
	Effective friction angle	NO	-	-
	Layer thickness	NO	-	-
	Distance to rock bed	NO	-	-

TABLE 8.21 MARINE SPECIES FILE – FROMVEUR

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Receptors	YES	Simulation models	YES
Initial environmental condition	YES	Simulation models	YES
Endangered species	YES	Simulation models	YES

8.4.2 DATA SPECIFICATIONS RELATED TO TECHNOLOGY DESCRIPTION

TABLE 8.22 PRIME MOVER DIMENSIONS & COST – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Draft	YES	Simulation models	YES
Height	YES	Simulation models	YES
Width	YES	Simulation models	YES
Length	YES	Simulation models	YES
Submerged Volume	NO	-	-
Wetted Area	NO	-	-
Mass and Inertial properties	NO	-	-
Footprint radius	YES	Simulation models	YES
Device cost	YES	Suppliers & Simulation	YES

TABLE 8.23 HYDRODYNAMICS – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Tip Speed Ratio	YES	Simulation models	YES
Power Coefficient Curve	YES	Simulation models	YES
Thrust Coefficient Curve	YES	Simulation models	YES
Cp/Ct Velocity Definition	YES	Simulation models	YES
Orientation Angle	NO	-	-
Cut In Velocity	NO	-	-
Cut Out Velocity	NO	-	-
Heading Angle Span	NO	-	-
Bidirectional Turbine	NO	-	-

TABLE 8.24 POWER SETTINGS AND STATIONKEEPING – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Rated Capacity	YES	Info from suppliers	NO
Connector Type	NO	-	-
Control Subsystem failure Rate	NO	-	-
Mooring Stiffness	N/A	-	-
Foundation preferred type	YES	Info from suppliers	NO

TABLE 8.25 MARINE OPERATIONS – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Max Installation Water depth	YES	Info from suppliers	YES
Min Installation Water depth	YES	Info from suppliers	YES
Min interdistance perpendicular to waves/current	YES	Info from suppliers	YES
Min interdistance parallel to waves/current	YES	Info from suppliers	YES

TABLE 8.26 PTO MECHANICAL CONVERSION – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of mechanical conversion	NO	-	-
Manufacturer reference	NO	-	-
Main dimensions	NO	-	-
Weight	NO	-	-
Primary materials	NO	-	-
Transmission ratio	NO	-	-
Rated power	YES	Info from suppliers	NO
Speed range	NO	-	-
Input force, torque range	NO	-	-
Maximum stroke (only for linear systems)	N/A	-	-
Efficiency	NO	-	-
Cost	NO	-	-
Failure rate	NO	-	-

TABLE 8.27 PTO ELECTRICAL CONVERSION – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of electrical conversion	NO	-	-
Manufacturer reference	NO	-	-
Number of pole pairs	NO	-	-
Insulation class	NO	-	-
Main dimensions	NO	-	-

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Weight	NO	-	-
Primary materials	NO	-	-
Rated power	YES	Info from suppliers	NO
Nominal voltage	NO	-	-
Nominal intensity	NO	-	-
Maximum voltage	NO	-	-
Maximum torque	NO	-	-
Maximum speed	NO	-	-
Efficiency	NO	-	-
Power factor	NO	-	-
Cost	NO	-	-
Failure rate	NO	-	-

TABLE 8.28 PTO GRID CONDITIONING – SABELLA D22-2000

DATASET	AVAILABLE?	SOURCE	CONFIDENTIAL?
Type of grid conditioning	NO	-	-
Manufacturer reference	NO	-	-
Main dimensions	NO	-	-
Weight	NO	-	-
Primary materials	NO	-	-
Rated power	YES	Info from suppliers	NO
Switching frequency	NO	-	-
Grid voltage	NO	-	-
Grid resistance	NO	-	-
Efficiency	NO	-	-
Power factor	NO	-	-
Cost	NO	-	-
Failure rate	NO	-	-

8.4.3 DATA SPECIFICATIONS RELATED TO CATALOGUES

DATASET		AVAILABLE?	SOURCE	CONFIDENTIAL?
Operations, infrastructures and equipment		-	-	-
	Activities	YES	WavEC	NO
	Operation (installation, maintenance, decommissioning)	YES	WavEC	NO
	Equipment: ROV	YES	WavEC	NO
	Equipment: Divers	YES	WavEC	NO
	Equipment: Burial	YES	WavEC	NO
	Equipment: Protection	YES	WavEC	NO
	Equipment: Piling	YES	WavEC	NO
	Vessel and Equipment Combination	YES	WavEC/ GRS	NO
	Vessel clusters	YES	WavEC/ GRS	NO
	Terminals (ports)	YES	WavEC/ GRS/ BV/ Tecnalia/ AAU	NO
Mooring Lines and Anchors		Activities	YES	WavEC
	Mooring Lines	YES	FEM	NO
	Drag Anchors	YES	FEM	NO
Power Take Off Components		-	-	-
	User Defined Air Turbine	N/A	-	-
	User Defined Hydraulic PTO	N/A	-	-
	User Defined Gearbox	YES	Tecnalia	NO
	User Defined SCIG	YES	Tecnalia	NO
	User Defined Power Converter	YES	Tecnalia	NO
Electrical Network Equipment		-	-	-
	Static Cables	YES	UEDIN	NO
	Dynamic Cables	YES	UEDIN	NO
	Wet Mate Connectors	YES	UEDIN	NO
	Dry Mate Connectors	YES	UEDIN	NO
	Transformer	YES	UEDIN	NO
	Collection point	YES	UEDIN	NO

8.4.4 MANAGEMENT OF DATA GAPS

Characterisation of the intended site and technology might have important data gaps that need to be adequately addressed to make this Validation Scenario feasible.

Even though the deployment site will be the same for VS5.2 and VS6.3, there is only limited site data about current/wave climate and bathymetry as this scenario covers a much larger area where 50 turbines will be located. This is the reason why most of the data related to the intended site has been marked as unavailable.

Consequently, the design tools must either use default values or be run at lower complexity to deal with gaps in the data available to Sabella. For instance, wave/wind timeseries for VS5 should be used for the planning of marine operations. Sabella will also have return values for Fromveur at some locations in the channel. Finally, the scenario could explore the sensitivity on designs for different lease area options.

On the other hand, in order to deal with the limited information regarding the technology, it may be also needed to run the tools at a lower level of complexity or to use engineering judgement to give appropriate approximations for these parameters. This is the case of cut in/out velocities, where a rough estimate could be provided with little design activity.

Finally, the catalogues should be populated to a sufficient level to run this scenario.

9. CONCLUSIONS

The DTOceanPlus suite of tools will be validated by running a set of scenarios, which will demonstrate the different uses of the software under a wide set of conditions, including various deployment sites, technology types and maturity levels, as wells as design objectives and project scales.

This report describes the compilation of required data inputs for the various VSs. Each scenario is characterised through a set of project data, inherent to the technology as well as metocean conditions and other location related data. Further engagement with the validation leaders is ensuring that the data is adequately formatted for the purposes of running the DTOceaanPlus tools.

In order to avoid any harm to the commercialisation prospects of industrial partners, the consortium agreed on a data management methodology that will permit the validation whilst maintaining the required data privacy. The Lead Partner for each VS will collect input data and a Technical Support Partner will assist in the correct use of the data and tools. After running the scenario, the Lead Partner will provide a validation report based on qualitative/quantitative indicators. The validation report will not require any input or output specific to the VS to be presented.

The following table shows a summary of the six main VSs and 11 subscenarios to be used in the demonstration activities in DTOceanPlus.

TABLE 9.1 SYNOPTICAL DESCRIPTION OF REFINED VALIDATION SCENARIOS

	VS1			VS2	VS3	VS4	VS5		VS6		
Subscenario	1.1	1.2	1.3	-	-	-	5.1	5.2	6.1	6.2	6.3
Technology	Wave					Tidal					
Tool	SI			SG	D&A	SI	Stage Gate		D&A		
Aggregation	Device			Subsyst	Array	Subsyst	Device		Array		
Lead Partner	CPO	EGP	WES	CPO	IDOM	OMP	OMP	Sabella	Nova	OMP	Sabella
Tech Support	ESC			WES	Tecnalia	ESC	WES				
Technology	C4	PB3	New	C4	M-A14	Orbital O2		D15-500	M100-D	Orbital O2	D22-2000
Total Power	300kW	3kW	n/a	300kW	2 MW	2MW		500 kW	<5 MW	10 MW	100 MW
Subsyst/Comp	n/a	n/a	n/a	PTO	n/a	Connectors	n/a	n/a	n/a	Drivetrain	n/a
Intended Site	EMEC	Chile	Low & high	EMEC	BiMEP	EMEC	EMEC	Fromveur	Bluemull Sound	EMEC	Fromveur

A thorough analysis of the current availability of the data for running the scenario has been carried out for each VS. Particularly, detailed data specifications related to the intended site, technology, development activities and catalogues have been gathered according to DTOceanPlus tools requirements.

No significant data gaps have been identified at this stage of the scenario definition. In some cases, the design tools will use default values or will be run at lower complexity level to deal with some limited data available to developers.

10. REFERENCES

[1] H2020 Programme, "Guidelines on FAIR Data Managementin Horizon 2020," European Commission, 2016.

[2] M. I. Marques, "D7.2 Detailed description of demonstration scenarios," DTOceanPlus, 2019.

[3] P. Ruiz-Minguela and M. J. Sanchez-Lara, "D9.11 Data Management Plan – final version," DTOceanPlus, 2020.

[4] V. Nava and P. Ruiz-Minguela, "D2.3 Demonstration Methodology," DTOceanPlus, 2019.

[5] EMEC, "Grid-connected wave test site - Billia Croo," 2020. [Online]. Available: http://www.emec.org.uk/facilities/wave-test-site/.

[6] Dynamic Ecological Information Management System, "Estación Costera de Investigaciones Marinas, Las Cruces - Chile," 2020. [Online]. Available: https://deims.org/c9fc7c77-5281-4883-8905-c2236394a70b.

[7] CorPower Ocean, "Wave Power Technology," 2020. [Online]. Available: https://www.corpowerocean.com/technology/.

[8] OPT, "PB3 Powerbuoy," 2020. [Online]. Available: https://oceanpowertechnologies.com/pb3-powerbuoy/.

[9] BiMEP, "About the BiMEP site," 2020. [Online]. Available: https://bimep.com/pages/bimep.

[10] IDOM, "Pitch presentations - IDOM Oceantec, page 37," 2020. [Online]. Available: https://www.blauwecluster.be/sites/default/files/attachments/pitches.pdf.

[11] EMEC, "Grid-connected tidal test site - Fall of Warness," 2020. [Online]. Available: http://www.emec.org.uk/facilities/tidal-test-site/.

[12] Orbital Marine Power, "Orbital O2 2MW," 2020. [Online]. Available: https://orbitalmarine.com/technology-development/catching-the-tide/orbital-o2.

[13] Wikipedia, "Fromveur Passage," 2020. [Online]. Available: https://en.wikipedia.org/wiki/Fromveur_Passage.

[14] Sabella, "Sabella Technology," 2020. [Online]. Available: https://www.sabella.bzh/en/solutions/technology.

[15] Tethys, "Shetland Tiday Array (Bluemull Sound)," 2020. [Online]. Available: https://tethys.pnnl.gov/project-sites/nova-innovation-shetland-tiday-array-bluemull-sound.

[16] Nova Innovation, "Nova M100-D," 2020. [Online]. Available: https://www.novainnovation.com/tidalturbines.

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