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

Deliverable D7.9

Overall technical and sector recommendations

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0.1.1	26/3/2021	Draft contents with the inclusion of feedback and inputs from all partners	All partners
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EXECUTIVE SUMMARY

Deliverable D7.9 "Overall technical and sector recommendations" of the DTOceanPlus project is a report documenting the outcome of the work carried out in task T7.6.

The work performed within this task was organised to match different objectives.

The first objective was to deliver an overview of the outcomes of the verification tasks (testing of the tools in standalone mode) since the feedback from the users' experience will be useful to improve the performance of the tools beyond the project end. The results of the validation scenarios, based on the feedback produced by the validation partners, will generate useful recommendations for the stakeholders willing to improve global performance of ocean energy arrays, single devices or critical components and subsystems. The work developed throughout the validation tasks (to be documented in future deliverables D7.7 and D7.8) will benefit from DTOceanPlus tools to perform several activities, articulated in the respective reference validation scenarios, both for wave and tidal energy.

The validation tasks will be centred on (but not limited to):

- selecting the most promising investment potential to match the innovation targets at the lowest possible cost
- identifying innovation areas where improving or developing new energy concepts
- identifying enabling technologies
- pinpointing any gaps or obstacles for a new attractive concept to be commercialised
- comparing the output of the DTOceanPlus suite of tools with those calculated differently
- performing techno-economic analysis to understand the feasibility of the industrial partners' devices.

An overview of the ocean energy sector as a whole was subsequently provided, namely benefitting from feasibility and cost-benefit analysis of different funding mechanisms, business management models in ocean energy and potential opportunities of sector coupling for the ocean energy supply chain, to conclude with an assessment of the current legal framework governing ocean energy technologies.

A knowledge base comprehensive of interesting findings and lessons learnt from the project was built as added value.

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ABBREVIATIONS AND ACRONYMS

AD	Assessment Design
AEP	Annual Energy Production
DD	Deployment Design
DO	Design Objective
Dx.x	Deliverable x.x from a task or work package
EC	Energy Capture
ED	Energy Delivery
ESA	Environmental and Social Acceptance
ET	Energy Transformation
FMEA	Failure Modes and Effects Analysis
KPI	Key Performance Indicator
LCoE	Levelised Cost of Energy
LMO	Logistics and Marine Operations
MC	Machine Characterisation
MRE	Marine Renewable Energy
OE	Ocean Energy
O&M	Operation and Maintenance
PTO	Power Take Off
QFD	Quality Function-Deployment
RAMS	Reliability Availability Maintainability Survivability
RE	Renewable Energy
RM	Reference Model
SC	Site Characterisation
SG	Stage Gate
SI	Structured Innovation
SK	Station Keeping
SLC	System Lifetime Costs
TRIZ	Theory of Inventive Problem Solving
Tx.x	Task x.x within a work package
VC	Verification Case
VeS	Verification Scenario
VaS	Validation Scenario
WP	Work Package

1. INTRODUCTION

1.1 SCOPE OF REPORT

This report documents the overall technical and sector recommendations. It collects developers' and users' feedback for improving the 2nd generation design tools beyond the project end. It also produces useful recommendations for stakeholders to improve the global performance of ocean energy arrays, single devices or critical components and subsystems based on the tool testing and the planning of the validation activities of the tools. As added value of these outcomes, this report delivers a knowledge base with technical recommendations for the sector, built upon those results and highlights the most promising optimisation strategies for future commercial array deployment.

Finally, it demonstrates progress in reducing the technological risks for the next development stages.

1.2 OUTLINE OF REPORT

The public deliverable D7.9 presents the overall technical and sector recommendations and is structured as follows. For further information and background on the project, the reader is directed towards previous deliverables, from the verification tasks ([1], [2], [3], [4]) and the feedback on the validation scenarios, future deliverables D7.7 and D7.8.

- **Section 1: Introduction** — explains the context and the objectives of the DTOceanPlus project.
- **Section 2: Future improvements to the final release of tools** — presents the Verification feedback that gathered improvements to the 2nd generation of design tools, some already implemented and others to be considered in future developments, beyond the project end. This section presents as well, some preliminary outcomes collected from the validators experience while installing and using the DTOceanPlus integrated suite of tools, to perform the validation scenarios.
- **Section 3: Findings and lessons learned for the sector** — provides useful recommendations for the Ocean Energy (OE) Sector and its Stakeholders, based on learnings from the verification of the standalone tools, planning of the validation activities of the integrated design tools and other deliverables of DTOceanPlus about Market Analysis and Implementation Feasibility of Ocean Energy. The technical recommendations past the project end are also covered in this section.
- **Section 4: Knowledge base for future commercial array deployment** — addresses a knowledge base useful for the sector, and the future of the tools is addressed, reducing the technological risks for the next development stages. The contents in this section were possible to be obtained based on a questionnaire delivered to all partners of the DTOceanPlus project.
- **Section 5: Conclusions.**
- **Annex I** provides an analysis of the feedback from the Verification of all the standalone tools.
- **Annex II** describes the Validation Scenarios and Evaluation form for the demonstration of integrated design tools.
- **Annex III** presents the DTOceanPlus technical recommendations questionnaire.

1.3 DTOCEANPLUS PROJECT

DTOceanPlus will 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 DTOceanPlus includes:

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

This suite of design tools will reduce the technical and financial risks of the technology to achieve the deployment of cost-competitive wave and tidal arrays. DTOceanPlus will underpin a rapid reduction in the Levelised Cost of Energy (LCoE) offered by facilitating improvement in the reliability, performance and survivability of ocean energy systems and analysing the impact of design on energy yield, operations & maintenance (O&M) and the environment, thus making the sector more attractive for private investment.

These objectives and impacts will be achieved through the implementation of nine work packages covering user engagement, tool development, demonstration of tools against real projects (thus outputting a suite of tools at TRL 6), analysis of supply chains and potential markets, exploitation, dissemination, and education. Also, DTOceanPlus will produce a knowledge base with technical recommendations for the sector and deliver it through this report.

2. FUTURE IMPROVEMENTS TO THE FINAL RELEASE OF TOOLS

Even though the suite of design tools will be demonstrated within the project lifetime, the software will not be fully commercial at the end of DTOceanPlus, as the maturity of the tools by the end of the project will be at TRL 6 [5]. The pending phases will involve the following activities described in the exploitation plan D9.6 [5]:

- TRL 7: System prototype demonstration in a high-fidelity operational environment. First successful implementation on a large-scale project.
- TRL 8: Actual system completed and mission qualified through test and demonstration in an operational environment. All functionality tested in operational scenarios.
- TRL 9: Actual system proven through successful mission-proven operational capabilities. The level at which a software technology is readily repeatable and reusable. Successful operational experience and maintenance of software capabilities deployed.

The time-to-market to achieve TRL 9 is between 1 and 2 years after the project end, depending on the level of resources the exploitation partners will be able to deploy.

DTOceanPlus developers' and users' feedback while testing the standalone tools (verification tasks [1] [2] [3] [4] [6] [7]) generated both quantitative and qualitative results that allowed to gather a collection of improvements to be implemented in the DTOceanPlus suite of design tools.

While a great part of the improvements that resulted from the verification tasks were implemented during the project and are included in the final release of the tools; the improvements coming from the outcomes of the validation scenarios will remain to be considered in future developments beyond the project end.

2.1 ANALYSIS OF TOOLS TESTING FEEDBACK AND DEMONSTRATION OUTCOMES

The feedback while testing the standalone tools (verification tasks) and the methodology to obtain the demonstration outcomes was deeply analysed, and the results are described in this section.

Verification tasks

The goal of the verification tasks was to ensure that the tools:

- respond correctly to a varied set of inputs;
- perform their functions in an acceptable time and reasonable use of the computational resource;
- are adequate in terms of usability;
- are verified against control data.

Overall, according to the quantitative results, the end-users involved in evaluating the standalone versions of the tools were satisfied with the usability, user-friendliness, performance, and value of the software. The qualitative assessment feedback gathered some improvements that were compiled and categorised by functionality, evaluation characteristics, and the frequency of comments. As a result, the following number of high-priority improvements were selected to be implemented in the final release of the DTOceanPlus suite of design tools:

- Structured Innovation tool: 15;
- Stage Gate tool: 13;
- Deployment Design tools:
  - 10 for Site Characterisation (SC);
  - 11 for Machine Characterisation (MC);
  - 7 for Energy Capture (EC);
  - 11 for Energy Transformation (ET);
  - 12 for Energy Delivery (ED);
  - 19 for Station Keeping (SK); and
  - 20 for Logistics and Marine Operations (LMO).
- Assessment tools:
  - 15 for System Performance and Energy Yield (SPEY);
  - 25 for System Lifetime Costs (SLC)
  - 9 for Reliability, Availability, Maintainability, and Survivability (RAMS); and
  - 26 for Environmental and Social Acceptance (ESA).

After the testing and verification of the design tools, a stable beta version was released and fully documented [8]. The tools will then be validated and demonstrated using real data from the first pilot experiences in WP7 through the validation tasks T7.4 and T7.5.

The proposed improvements suggested by users as further developments to the standalone tools, were already implemented in the integrated suite of tools. In ANNEX I: FEEDBACK ANALYSIS FROM THE VERIFICATION OF THE STANDALONE TOOLS, the feedback from the standalone tools' verification activities is presented.

Validation tasks

In order to ensure that the design tools (Stage gate, Structured Innovation, Deployment and Assessment) were achieving the expected objectives, quantitative and qualitative KPIs were defined [9] and will be used to validate the tools in the several validation scenarios, having the main goals of validating the interaction between the tools and the users and assess the performance of the tools.

TABLE 2.1: QUALITATIVE KPI's TO VALIDATE THE TOOLS

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

The Structured Innovation module developer analysed the "quantification" of the qualitative KPIs associated with the user interface performance to turn the qualitative KPIs more objective. The SI Tool was reviewed in its current state and drawn out some key areas of focus for qualitative assessments:

- Installation process (application & database);
- Minimising lib (Dependencies);
- Technology limitations (resource & design choices).

This allowed the identification of some additional/new requirements for improvements and additional features required to be a more effective tool.

Some of the Top-level Usability Requirements proposed (Structured Innovation tool developer tried it for the FMEA v1.0 review) are:

- Easy to navigate (step by step, tree view, Hub & Spoke);
- Easy to interact;
- Present information clearly;
- Export easily;
- Display results (legends, conditions, expectations, etc.);
- Provide trust in the output;
- Reduce the number of steps/ clicks;
- Reduce the number of errors;
- Show system status;
- Provide Consistency;
- Align to Authentic/ minimal Design;
- Provide help and Docs;
- Help users diagnose & recover from errors;
- Provide recognition than recall.

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

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

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

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

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

For further details on the Validation Scenarios and evaluation methodology of the Validation tasks, please check ANNEX II: VALIDATION SCENARIOS AND EVALUATION FORM FOR THE DEMONSTRATION OF INTEGRATED DESIGN TOOLS.

The results of the validation scenarios, based on the feedback produced by the validation partners, will generate useful recommendations for the stakeholders willing to improve global performance of ocean energy arrays, single devices or critical components and subsystems. The work developed throughout the validation tasks (to be documented in future deliverables D7.7 and D7.8) will benefit from DTOceanPlus tools to perform several activities, articulated in the respective reference validation scenarios, both for wave and tidal energy.

2.2 FUTURE IMPROVEMENTS

Verification tasks

As concluded on ANNEX I: FEEDBACK ANALYSIS FROM THE VERIFICATION OF THE STANDALONE TOOLS, the list of improvements at TABLE 2.2 was considered in the developments of the tools after the Verification tasks.

TABLE 2.2: IMPROVEMENTS GATHERED AFTER THE VERIFICATION OF THE TOOLS

Improvements to implement	Modules involved	Users' suggestions to implement the improvement	Already implemented? (Yes/No/Partially)
Interface not looking professional	11	A clearer separation between sections and input points. Graphical aspect. Improving data visualisation: • some dropdown menus could be added to make it more user-friendly. • split a big array into multiple subarrays sorted by parameter categories. Make it more "attractive". Better formatting.	Partially
Better presentation of values	5	Too many decimal places on the values. Too many zeros for large numbers.	Yes
Availability of information to the users	5	The software should have more contextual descriptions and help/glossary, etc. Include key to all abbreviations/acronyms and/or direct links to a glossary or appropriate user manual page. Include calculations reference - transparency on calculation is critical to user confidence.	Partially (for some tools)
Buttons to input data	4	Manipulating a slider could be better than the +/- buttons, adding 1 unit per click.	Yes
Presentation of Studies titles	2	The study title is not properly displayed in the study pages – "Study ID: 4 Page" etc. rather than the actual title.	Yes
Studies functionalities	All 13 modules	Saving, comparing, editing, copying/duplicating and presenting the list of studies.	Yes

Most of these improvements were already implemented, even before the Validation and Integration of the tools. The remaining improvements, not implemented, will be considered until the end of the integration of the tools.

Validation tasks

The work on the validation scenarios and the respective results based on the feedback produced by the validation partners, are still being developed throughout the validation tasks (to be documented in future deliverables D7.7 and D7.8).

Although these results won't be delivered before this present report finished to be written, some preliminary outcomes collected from the validators experience while installing and using the DTOceanPlus integrated suite of tools, were possible to be gathered and are presented in TABLE 2.3. These are essentially focusing on the issues experienced by validators.

TABLE 2.3: IMPROVEMENTS GATHERED BASED ON PRELIMINARY OUTCOMES FROM THE VALIDATION OF THE TOOLS

Preliminary improvements to implement	Issues experienced by validators	Partners experiencing the respective issue
To lower the minimum hardware requirements for installation	PC hardware and/or software requirements are not enough to allow the installation of the software	4 (from 8 that tried)
To make the flow of information smoother	Error messages preventing from moving to another module, before being resolved; The use of the module in the integrated mode presented problems with the data introduced from a specific module.	2 (from 4 that were succeeded in the installation)
To lower the complexity of data structures	Experiencing issues with complex data structures; Problems with shape files; Data formats issues.	2 (from 4 that were succeeded in the installation)
Improve how-to guides/documentation	Input and their use not clearly defined; Lack of information in the documentation; Several difficulties identifying what the inputs were referring to.	2 (from 4 that succeeded in the installation)
Improvements on technical features	Errors on calculations and calculations not starting and not finishing; Not possible to create a new project; Software returning not expected results when running in cmpx:3; The generation of the output took a long time (several hours) although input data appeared to be very simple.	3 (from 4 that were succeeded in the installation)

As this is still work in progress, most of the suggested improvements should remain past the project end and most of them are being addressed to be resolved prior delivering the final release of tools.

3. FINDINGS AND LESSONS LEARNED FOR THE SECTOR

Findings and useful recommendations for the overall Ocean Energy sector and its stakeholders were gathered by analysing the technical innovations introduced by the DTOceanPlus suite of tools (Structured Innovation and Stage Gate tool in particular) and the outcomes of DTOceanPlus WP8 deliverables ([10], [11], [12], [13] and [14]).

3.1 TECHNOLOGY DEVELOPMENT

3.1.1 Structured Innovation and Stage Gate tools

Companies are moving beyond traditional R&D innovation models to more open and structured approaches that combine additional elements other than the response to the market needs. Many companies rely on a form of the structured innovation process to identify, create and develop innovative solutions, measure 'success' against their competitors and manage the uncertainties and risks associated with the implementation processes [15]. Like other sectors, the Ocean Energy sector has adopted structured innovation methodologies: the US-based National Renewable Energy Laboratory (NREL) and Sandia National Laboratories use a structured innovation approach to identify and develop new wave energy converters concepts.

The Structured Innovation (SI) design tool, developed as part of the DTOceanPlus suite of tools for ocean energy, allows for the first time to provoke innovation and help represent the voice of the customer through the design process, manage risk and produce new concepts by integrating the following approaches:

QFD (Quality-Function-Deployment)- A structured methodology used to identify, prioritise customer requirements and translate them into applicable technical requirements for each stage of product development and production.

TRIZ (Theory of Inventive Problem Solving) - A systematic problem-solving approach based on principles of creativity, patents and research; to generate potential solutions to the contradictions to meet customer requirements.

FMEA (Failure Modes and Effects Analysis) - Applied early in development to help designers identify and analyse all possible ways a design, process, or product can fail and design a strategy to prioritise and mitigate the biggest risks.

Since the number of design options in this sector is still very high, the integrated QFD and TRIZ process will allow the designers to thoroughly create innovative solutions using the TRIZ methodsand inventive solutions within the QFD process.

While the SI tool supports the user in the creation of a technology answering to their needs, the Stage Gate (SG) design tool provides a consistent assessment process for Ocean Energy subsystems, energy capture devices and arrays. This assessment process supports the decision-making activity of several user types, who all wish to have the best available information to support their decision [16]. An objective assessment of how well a technology performs against key metrics or criteria is performed at different levels of detail, with an increasing number of information required as the stages progress. Assessments are both quantitative and qualitative, or a combination of the two: in this last case, narrative information adding to the assessors' (potentially investors) understanding of a technology's development trajectory can add to the confidence they derive from the detailed quantitative assessment results [16].

3.2 OVERVIEW OF THE OCEAN ENERGY INDUSTRY

Ocean energy remains a nascent industry, with tidal range being the only ocean energy technology that has reached market-readiness and been commercially deployed [10]. Tidal stream technology is at a pre-commercial stage while wave technology is at a demonstration level. All technologies still require support (both technical, in terms of R&D efforts, and through funding mechanisms) to enter the competitive grid-power markets: their high costs and the embryonic stage of some ocean energy technologies are still perceived as limiting to their development.

Nevertheless, wave and tidal stream technologies in particular, have shown significant performance and reliability improvements lately [10]. The trend expected for these technologies is similar to other renewable energy sources such as wind turbines and solar photovoltaics, i.e consistent cost reductions as the technology proves to be reliable and ready to enter the market. DTOceanPlus D8.3 Feasibility and cost-benefit analysis [12] highlights the need for a mix of policies to drive down the LCOE of ocean energy whilst minimising the overall investment needed for a wide-scale deployment of these technologies. In particular, [12] demonstrates it is much cheaper to fund step-change innovation firsts then roll out subsidised deployment.

Even though the largest opportunity for ocean energy technology is the future market for grid power, niche markets matched to ocean energy generation may currently provide a clear sense of progression for ocean generation technologies and increase the confidence of the investors in the sector. Belong to this category three markets, namely primary power for subsystem, partial power for whole-system and resiliency markets for remote communities [13].

The most relevant application for the first market is the electrification of oil and gas platforms [13]: instead of providing electricity for the entire operation of an offshore rig, which is of a greater scale than most ocean energy demonstrators, accessible options are electrifying ancillary systems whose demand profiles are more in line with ocean generation, like hydraulic processes and monitoring activities.

Partial power for whole-system is a solution that may be suitable for demonstrators which are looking to achieve economies of scale [13]: fall under this category microgrids, aquaculture and desalination.

The final category covers areas which face risks resulting from climate change and/or unreliable power grids: here ocean energy could provide assurances around the security of the supply.

3.2.1 Instruments to accelerate technology development and commercialisation

The limitations and challenges experienced by the supply chain are broadly classified into technical and non-technical [11], and they are spread throughout the project lifecycle stages.

Cost competitiveness is identified as a major challenge facing the Ocean Energy sector, since the majority of the existing technologies are not yet in a commercial stage and cannot compete with other more mature renewable energy technologies. Whilst tidal energy technologies are currently more cost competitive than wave ones, both are still expensive when compared to other more mature technologies. The detailed assessment of costs is still a difficult task within the sector given the scale and number of deployments to date [11].

Ocean energy is bringing unique challenges to marine governance frameworks. Legal and regulatory aspects are frequently regarded as major non-technical challenges to the deployment of ocean energy, as a stable and complete policy framework for the ocean energy sector is currently missing, being currently tailored for more established uses of the sea, such as the oil and gas industry, fishing, and shipping.

Policy instruments are valid instruments to support technology development and commercialisation, though their effect is variable depending on the stage of the technology 'innovation chain' they are applied [12]. Normally, renewable energy funding mechanisms are classified as Technology Push (TP) and Market Pull (MP) funding options.

Within the first are included such mechanisms allowing innovation to be carried out at lower cost/time, particularly useful in the development of new technologies during a sector's nascent stages, like government R&D funds/grants, universities and R&I organisations, competitive grants, repayable advances/loans, tax incentives for R&D and support for education and training.

A Market Pull (MP) funding mechanism rewards the outcomes of successful innovation [12]. Some common examples are tax credits and rebates for consumers of new technologies, renewable energy portfolio standards, emissions/supply trading schemes, regulatory standards on competing technologies, tax incentives on IP gains and tendering processes for RE projects.

Several funding ratios have been considered in the assessment of a set of case studies addressing the balance of different policy mechanisms in other energy sectors (solar PV, onshore and offshore wind). The costs of commercialising ocean energy have then been calculated using a range of 'what-if' scenarios: the two most attractive ones appear to be those relying on step-change innovation, with the difference that in one case the subsided deployment is in parallel from the start and in the other one the deployment is after the step-change. The costs for the scenarios without enhanced learning rate or step-change cost reductions are significantly higher, showing the importance of these actions [12]. This requires a continuing process of research and development, bringing new innovations into the sector, and adopting technology transfer from other sectors. Policies and actions (such as the European Commission's Horizon 2020 and Horizon Europe programmes) to increase collaboration and knowledge sharing between those involved within the sector are also vital to maintain a high learning rate [12].

3.2.2 Potential opportunities of sector coupling for the Ocean Energy supply chain

In DTOceanPlus deliverable D8.2 Analysis of the European Supply Chain [11], the similarities between Offshore Wind and Ocean Energy were presented and it was concluded that they can be exploited to transfer knowledge and experience. These similarities can be found not only on the technological aspects but also on the installation, operations & maintenance, commissioning and decommissioning. Taking advantage of these potential synergies can help address the challenge related to the cost competitiveness of Ocean Energy technologies as well as encourage third parties to engage with the Ocean Energy sector and enter the value chain.

For the analysis of opportunities for the OE sector, an assessment was performed, considering the phases of a project's life and the five main criteria to assess the opportunities of the European supply chain, from the perspective of offshore wind companies:

- Synergies with offshore wind
- Appetite or awareness from ocean energy
- Potential for LCoE benefit
- Size and timing of investments
- Size of the opportunity

The scores and comments have been collected directly from a survey to industrial partners in the project (Bureau Veritas, Enel Green Power, EDP CNET, Nova Innovation, Orbital Marine Power, Sabella, CorPower and IDOM), resulting that the main opportunities for the supply chain are:

- Many synergies and little competition expected for the supply of the balance of plant and PTO components;
- Many synergies and minor upfront investments to provide project development, installation and O&M services;
- High benefit for LCoE reduction of device manufacturing costs and installation services;
- High market opportunity for the supply of ocean energy devices, balance of plant and O&M services.

Experience from other sectors that have had similar trajectories, not only provide key learnings to reduce costs, but also significant opportunities to reinforce the European supply chain. Potential sectors for cross-collaboration are aerospace, automotive, aquaculture, energy storage, oil & gas, shipbuilding and offshore wind. However, the incipient nature of the OE sector makes it difficult to make an appropriate analysis of these opportunities.

3.3 LEGAL, POLITICAL AND REGULATORY FRAMEWORK

Ocean Energy is bringing unique challenges to marine governance frameworks. Legal and regulatory aspects are frequently regarded as major non-technical challenges to the deployment of ocean energy, as a stable and complete policy framework for the ocean energy sector is currently missing, being currently tailored for more established uses of the sea, such as the oil and gas industry, fishing, and shipping.

As part of DTOceanPlus task T8.5 "Legal, political and regulatory framework" [14], a questionnaire about regulatory and political barriers and enablers to ORE deployment, addressed to regulators, technology developers and test site managers, suggested that there are several non-technological forces hindering the development of the Ocean Energy sector. Above all, there are no specific national and international regulations governing the Ocean Energy sector. In addition to this, targets set by the sector appear to be unrealistic and unsuitable to funding schemes: this, of course, leads to lack of credibility to the eyes of the investors, which are reluctant to invest in the sector. Consenting processes also are perceived as a strong barrier: lengthy procedures, lack of clarity and a streamlined process, fragmentation of the consenting authority are mentioned as some of the most recurring obstacles to issuing consent for ocean energy projects. As for the environmental impact, uncertainties resulting from the lack of data from previous experiences, mismanagement of monitoring requirements and absence of integration with onshore EIA requirements are the main flaws.

On the other hand, results from the questionnaire identified a growing support from current EU policies and the importance of national policies as enablers to the creation of national financial incentives [14].

3.4 ENVIRONMENTAL AND SOCIAL IMPACT

The environmental and social impact generated by the various technological choices and array configurations of wave or tidal devices, are assessed by the Environmental and Social Acceptance (ESA) module [17], which provides recommendations to the user, based on four assessments:

- identification of the potential presence of endangered species in the area (i.e. species included in the IUCN red list);
- environmental impact estimated using relevant metrics such as the underwater noise or the collision risk between vessels/devices and the marine wildlife;
- estimation of the carbon footprint of the project in terms of two mid-point indicators, i.e Global Warming Potential (GWP) and Cumulative Energy Demand (CED); and
- information to improve the social acceptance of the project considering cost of consenting and jobs creation.

The following quantitative metrics were used to measure the environmental and social acceptance [9]: Global Environmental Impact Assessment score (Global positive); Global Environmental Impact Assessment score (Global negative); Number of jobs; Cost of consenting (€/MW); GWP - Phase (gCO_2/kWh); CED - Phase (kJ/kWh).

3.5 RECOMMENDATIONS PAST THE PROJECT END

As part of DTOceanPlus task T9.3 "Exploitation of Project Results", a questionnaire about Exploitation Routes and Market Value was launched during January 2021. It was designed to survey partners on the intended use of the DTOceanPlus suite after project end and to quantify the market value of this software product, regarding the commercialisation of the DTOceanPlus suite.

The respondents of the questionnaire were approximately 1/3 Academic/Research Organisations, 1/3 Technology Developers and 1/3 divided within Project Developers, Investors/Funders and Service Providers.

The aggregated results of this survey to project partners, showed that most of the respondents:

- would be willing to undertake with the DTOceanPlus suite after the project ends, by internal use of the software for own business activities (e.g. technology innovation, development, optimisation, assessment, decision-making);
- would be willing to support the commercialisation of DTOceanPlus by promoting software adoption and build a wider community of users;
- would use DTOceanPlus suite of tools in their organisations, regarding end-user modes, as multiple users, multiple projects, multiple tools and with an intermittent use thorough the year; and
- found all the tools capable to add value to their businesses.

The aggregated results on this survey are further detailed at D9.7 Plan for exploitation [18].

4. KNOWLEDGE BASE FOR FUTURE COMMERCIAL ARRAY DEPLOYMENT

As part of the DTOceanPlus T7.6 about learnings and recommendations for the Ocean Energy sector, a questionnaire (ANNEX III: DTOCEANPLUS TECHNICAL RECOMMENDATIONS QUESTIONNAIRE) intended to survey partners on suggestions for improving the DTOceanPlus suite of tools after the project end, and also to produce technical recommendations for the Ocean Energy stakeholders, was shared. It should be noted that the tools are at TRL 6 and the ultimate goal is to have a fully commercial array deployment.

All partners' individual responses were strictly confidential and used only in an aggregated manner to collect learnings and recommendations for this document, D7.9 'Overall technical and sector recommendations'.

Depending on the type of partner answering (Technology Developer; Project Developer; Public & Private Investor), the inputs collected were specific and oriented through specific questions.

Each question was rated, using a scale from 1 to 5, where 1 represents the most negative assessment and 5 the most positive one (1 - Strongly disagree; 2 - Disagree; 3 - Undecided; 4 - Agree; 5 - Strongly agree).

About the characterisation of the partners that answered the questionnaire and provided feedback, FIGURE 4.1 shows the distribution among the type of entity or main role in the project.

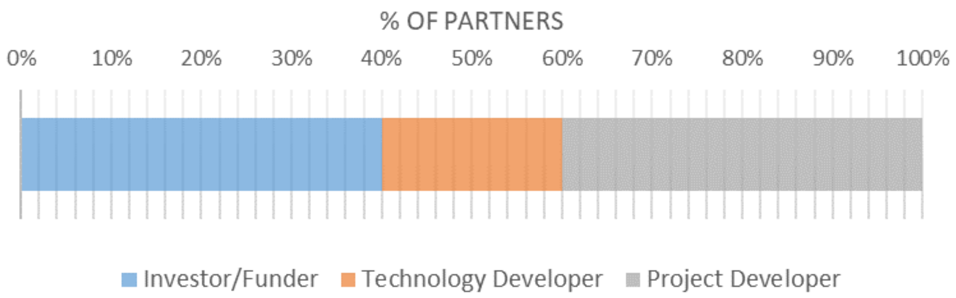

FIGURE 4.1: DISTRIBUTION OF THE ENTITY TYPE OR MAIN ROLE IN THE PROJECT

The statements presented on TABLE 4.1**¡Error! No se encuentra el origen de la referencia.** were assessed regarding the *Technical Recommendations Questionnaire* results.

TABLE 4.1: ASSESSED STATEMENTS OF THE TECHNICAL RECOMMENDATIONS QUESTIONNAIRE

ID	Statement
1.1	The process of inputting data is the one expected according to the level of detail
1.2	The use of catalogues is the one expected according to the level of detail
1.3	I'm able to identify, for each phase of a project's study (site assessment, decision-making and project development), which level of complexity is more adequate
1.4	The correlation between input data required and complexity level is clear
1.5	I would find it useful to have the comparison between project's metrics and minimum requirements (well-accepted values in the industry)
1.6	The modular architecture of the software provides me with the freedom to focus on the relevant design needs and at the same time it can handle the complex data flows efficiently
1.7	I'm willing to use the DTOceanPlus suite of tools in my organisation after the project ends
1.8	I find DTOceanPlus tools capable of adding value to my activity/business
1.9	A sensitivity analysis would be useful to evaluate the project's impact
1.10	I find it possible to use the suite of tools throughout the project lifecycle
1.11	The outputs provided by the tools (OPEX, CAPEX, LCOE, NPV, IRR and Payback Period) are useful enough to support the analysis of the investment

FIGURE 4.2**¡Error! No se encuentra el origen de la referencia.** presents in the form of stacked bars the user scores per each statement listed above. The same results are presented in FIGURE 4.3 using a spider chart, to highlight the mean, maximum and minimum values.

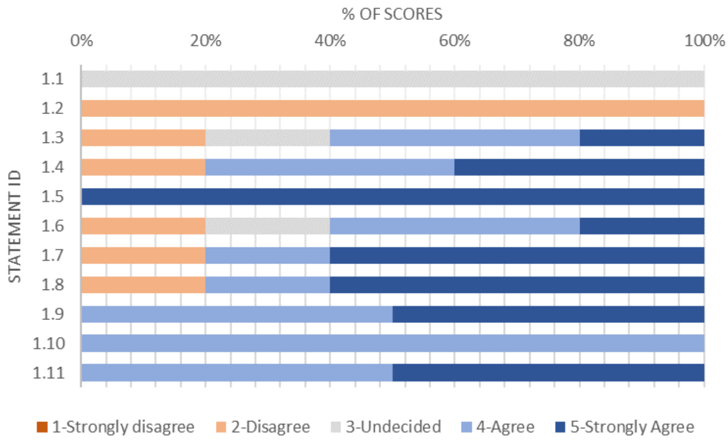

FIGURE 4.2: DISTRIBUTION OF USER SCORES PER STATEMENT

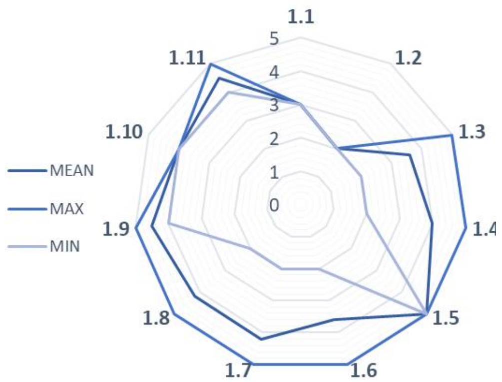

FIGURE 4.3: MEAN, MAXIMUM AND MINIMUM SCORES PER STATEMENT

FIGURE 4.2**¡Error! No se encuentra el origen de la referencia.** shows that all the respondents are undecided whether the process of inputting data is the one expected according to the level of detail (ID-1.1) and encountered as main obstacles faced by the users:

- Difficulties in formatting the input data;
- Not clear enough descriptions or examples given for the user to know what each input is;
- Lack of description in general given for the user.

Following on the results, all the respondents disagreed that the use of catalogues is the one expected according to the level of detail (ID-1.2); 60% of the respondents were able to identify, for each phase of a project's study (site assessment, decision-making and project development), which level of complexity is more adequate (ID-1.3); 80% found the correlation between input data required and complexity level is clear (ID-1.4); all the respondents strongly agreed that it would be useful to have the comparison between project's metrics and minimum requirements (well-accepted values in the industry) (ID-1.5) and suggested as parameters for which they would like this comparison:

- AEP per tonne of device installed, including foundations (as the most important), since this would be the only metric that can tell how competitive the device can be.

60% of the respondents considered that the modular architecture of the software provides the freedom to focus on the relevant design needs and that can handle the complex data flows efficiently (ID-1.6); 80% are willing to use the DTOceanPlus suite of tools in their organisations after the project ends (ID-1.7) and found DTOceanPlus tools capable of adding value to their activities/businesses (ID-1.8); all the respondents considered that a sensitivity analysis would be useful to evaluate the project's impact (ID-1.9) and selected as correlations they would like to see:

- LCOE/ Array size;
- LCOE/ Single device size;
- Payback period/ Single device size;
- Payback period/ Array size.

All the respondents found it possible to use the suite of tools throughout the project lifecycle (ID-1.10) and considered that the outputs provided by the tools (OPEX, CAPEX, LCOE, NPV, IRR and Payback Period) are useful enough to support the analysis of the investment (ID-1.11).

From the spider graph (FIGURE 4.3**¡Error! No se encuentra el origen de la referencia.**), the mean, maximum and minimum scores are balanced regarding the performance and accuracy of this tool, except for statements ID-1.3, ID-1.4 , ID-1.6 , ID-1.7 and ID-1.8, showing a diversity in the opinions collected from the results of the questionnaire and different types of view and needs from the different partners.

It was possible, as well, to collect other comments that might be useful to produce technical recommendations for Ocean Energy stakeholders:

- In order for the wave energy sector to converge on a winning concept, AEP per tonne of device installed including foundations mass, must be included. If not considered, then very inefficient designs will get too far in funding processes than they should. One should only invest in design with a threshold below a certain value in AEP/Tonne of device as this metric dictates all downstream metrics such as LCOE, CAPEX, OPEX, Install costs, O&M etc. With this metric the sector can converge in a winning concept much faster and waste less capital on inferior designs that distract project developers and engineering skill base working on the wrong projects.
- If every module followed the same layout mainly for data introduction and extraction, information of variables and calculation logs it would be much easier to use

The investors/funders that responded to the questionnaire, identified as needed regulatory changes to facilitate a speedy upscale of the Ocean Energy sector:

- Auction systems & "innovation" funding mechanisms to be adapted to new or Low TRL technologies;
- Simplified and accelerated consenting;
- Market support mechanisms.

At the same time, as a complementary inquiry of the questionnaire, it resulted that 66% of the respondents are willing to use the knowledge gathered from DTOceanPlus in other R&D activities and all the respondents are willing to use the knowledge gathered from DTOceanPlus in technical and economic feasibility studies of new projects helping decisional processes.

5. CONCLUSIONS

The objective of Task 7.6 of the DTOceanPlus project was a report documenting the outcome of the work carried out about "Overall technical and sector recommendations", the deliverable D7.9.

This deliverable collected developers' and users' feedback for improving the 2nd generation design tools beyond the project end, detailed in Section 2. It also produced useful recommendations for stakeholders to improve the global performance of ocean energy arrays, single devices or critical components and subsystems based on the tool testing. The work to be developed throughout the validation tasks (documented in future deliverables D7.7 and D7.8) will benefit from DTOceanPlus tools to perform several activities, articulated in the respective reference scenarios, both for wave and tidal energy.

An overview of the ocean energy sector as a whole was subsequently provided in Section 3, namely benefitting from feasibility and cost-benefit analysis of different funding mechanisms, business management models in ocean energy and potential opportunities of sector coupling for the ocean energy supply chain, to conclude with an assessment of the current legal framework governing ocean energy technologies.

Section 4 of this report delivered a knowledge base with technical recommendations for the sector and the most promising optimisation strategies for future commercial array deployment, built upon the analysis of the results of the "Technical Recommendations Questionnaire", that was intended to survey all partners of DTOceanPlus project, so that progress in reducing the technological risks for the next development stages could be addressed.

6. REFERENCES

[1] Tunga, I., Ball, K., Tatlock, B., Abrahams, M., Khan, H., Sanchez-Lara, M.J., Ruiz-Minguela, P., Robles, E., "DTOceanPlus Deliverable 3.3 "Testing and verification results of the Structured Innovation tool - Beta version"," 2020.

[2] Marques, M.I., Langiano, S., Harvey, C., Lourenço, T., Ruiz-Minguela, P., Nava, V., Henderson, J., Hudson, B., Tunga, I., Fonseca, F., "DTOceanPlus Deliverable 4.3 "Testing and verification results of the Stage Gate tool - Beta version"," 2020.

[3] Marques, M.I., Langiano, S., Harvey, C., Lourenço, T., Tunga, I., Ruiz-Minguela, P., Nava, V., Grispiani, L., Robles, E., Lopez Mendia, J., Fonseca, F., Luxcey, N., Michelet, N., Araignous, E., Ferri, F., Noble, D. , "DTOceanPlus Deliverable 5.8 "Testing and verification results of the Deployment Design tools - Beta version"," 2021.

[4] Marques, M.I., Langiano, S., Harvey, C., Lourenço, T., Tunga, I., Ruiz-Minguela, P., Nava, V., Fonseca, F., Amaral, L., Safi, G., Araignous, E., Yang, Y., "DTOceanPlus Deliverable 6.6 "Testing and verification results of the Assessment Design tools – beta version"," 2021.

[5] Tecnalia, "DTOceanPlus Deliverable D9.6 "Plan for Exploitation – initial version"," 2019.

[6] Noble, D., Medina-Lopez, E., , "DTOceanPlus Deliverable 2.1 "Results from user-groups consultation"," 2018.

[7] Hudson, B., Henderson, J., Hodges, J., Holland, M., Noble, D., Tunga, I., Fonseca, F., Ruiz-Minguela, P., "DTOceanPlus Deliverable 4.2 "Stage Gate tool-Alpha version"," 2020.

[8] Noble, D., Ruiz-Minguela, P., Gaillard, M., "DTOceanPlus Deliverable 9.9 "Knowledge exchange of educational and training material"," 2021.

[9] Marques, M.I., Marques, M.J., Lopes Filipe, N., Kessler, P., Lourenço, T., Tunga, I., Ruiz-Minguela, P., Nava, V., Noble, D., Henderson, J., Luxcey, N., Germain, N., "DTOceanPlus Deliverable 7.2 "Detailed description of demonstration scenarios"," 2019.

[10] Vanegas Cantarero, M., Avellaneda Domene, G., Noble, D., Pennock, S., Jeffrey, H., Ruiz Minguela, P., Tunga, I., Morrison, N., Apolonia, M., Luxcey, N., Gaborieau Robidou, H., Colucci, A., Aldaiturriaga Garcia, E., Murray, J., Moutel, M., "DTOceanPlus Deliverable 8.1 "Potential Markets for Ocean Energy"," 2021.

[11] Marques, M.I., Marques, M.J., Langiano, S., Lourenço, T., Harvey, C., Ruiz-Minguela, P., Tunga, I., Noble, D., Talukdar, S., Vanegas Cantarero, M., Henderson, J., Holland, M., Morrison, N., Goubert, P., "DTOceanPlus Deliverable 8.2 "Analysis of the European Supply Chain"," 2020.

[12] Noble, D., Kerr, P., Talukdar, S., Vanegas Cantarero, M., Pennock, S., Jeffrey, H., Ruiz-Minguela, P., Tunga, I., Hodges, J., Henderson, J., Gaborieau, H., Candido, J., Colucci, A., Chambon, B., Goubert, P., Murray, J., Marques, M.I., Lourenço, T., "DTOceanPlus Deliverable 8.3 "Feasibility and cost-benefit analysis"," 2021.

[13] Tunga, I., Yates, M., Vyas, A., Briggs, S., Elliott, T., Ruiz-Minguela, P., Salcedo, F., Noble, D., Marques, M.I., Connor, G., Hodges, J., "DTOceanPlus Deliverable 8.4 "Developing Ocean Energy standards for Business management models in Ocean Energy"," 2021.

[14] WavEC, "DTOceanPlus Deliverable 8.5 "Relevant legal, institutional and political framework"," 2021.

[15] Tunga, I., Bradley, S., Eraut, N., Bowick, L., Noble, D., Henderson, J., "DTOceanPlus Deliverable 3.1 "Technical Requirements for the implementation of Structured Innovation in Ocean Energy Systems"," 2019.

[16] Hodges, J., Henderson, J., Holland, M., Nava, V., Touzon Gonzalez, I., Lopez Mendia, J., Silva, M., Fonseca, F., Tunga, I., Germain, N., Safi, G., Ferri, F., Yang, Y., Pons, F., Noble, D., Nambiar, A., "DTOceanPlus Deliverable D4.1 "Technical requirements for the implementation of a world class Stage Gate Assessment Framework in Ocean Energy"," 2019.

[17] E. Araignous and G. Safi, "DTOceanPlus Deliverable D6.5 "Environmental and Social Acceptance Tools – alpha version"," 2020.

[18] Tecnalia, "DTOceanPlus Deliverable D9.7 "Plan for Exploitation – final version"," 2021.

7. ANNEX I: FEEDBACK ANALYSIS FROM THE VERIFICATION OF THE STANDALONE TOOLS

An analysis of the Verification tasks feedback from industrial partners about the tools, run in standalone mode, was performed with the objective of identifying common improvements to the tools. The results were used in the integration of the tools and in this report, to collect feedback from the verification and experience from the use of the tools.

Having 964 comments collected from all the evaluation forms [1, 2, 3, 4], it is not possible to analyse all comments individually. Then to better understand the underlying data, a general analysis helped start exploring the whole universe of comments:

TABLE 7.1: COMMENTS PER VERIFIED TOOL/MODULE

Tool / Module	Number of comments
SI	144
SG	75
SC	57
MC	68
EC	76
ET	57
ED	40
SK	36
LMO	78
SPEY	79
SLC	76
RAMS	90
ESA	70
Total	946

The number of comments per Tool/Module can be related with the time available to run the verification of each Tool/Module and the number of partners running them.

TABLE 7.2: COMMENTS PER FEATURE (ALL TOOLS)

Feature analysed	Number of comments
Usability	191
User-friendliness	270
Performance and Accuracy	320
Value	89
General remarks	76
Total	946

Most of the comments are related with User-friendliness and Performance and Accuracy.

Having so many comments it is easy to misunderstand the general idea from the users: if they are happy or not with the tools, and their sentiment while using them.

The comment of the functioning of a tool is very much qualitative and subject to personal opinion, then to better understand the sentiment of the users using the tool, a *Sentiment Analysis* was performed and fully explained. The objective in this kind of analysis is the interpretation and classification of emotions within text data, using text analysis techniques, in order to make it possible to characterise a huge number of comments (not possible to be interpreted by humans) in a coherent and standardised way.

For this *Sentiment Analysis*, Azure Machine Learning add-in at Excel was used, having result in a score (from 0 to 1, being 0 totally negative and 1 totally positive) and classification (positive, negative and neutral) for each of the 1196 sentences from the 946 comments.

TABLE 7.3: SENTIMENT ANALYSIS RESULTS

Sentiment classification	Number of comments	% of comments
Negative	470	39.3%
Positive	579	48.4%
Neutral	147	12.3%

The average score for all the sentences returned 0.51, meaning that the score is mostly neutral (tending to positive).

This way it can objectively be concluded that the users' sentiment while writing the comments about the usage of these new tools (always subject to adaptation for being new) is neutral and tending to be positive. This can be interpreted as being a very good result, because the comments are most of the times written when the user wants to raise attention on an issue, which means a fail or malfunction of the software or an unsatisfaction of the user.

Continuing the analysis on the 946 feedback comments, to identify common improvements to be implemented in different modules, it seems to make sense to analyse them all objectively, without preconceived ideas (that may exist from the modules verification phase).

Having that in mind, the next analysis used *Wordcloud* (counting the repeated words, https://monkeylearn.com) and *top phrases* (counting the repeated phrases, https://www.online-utility.org/text/analyzer.jsp).

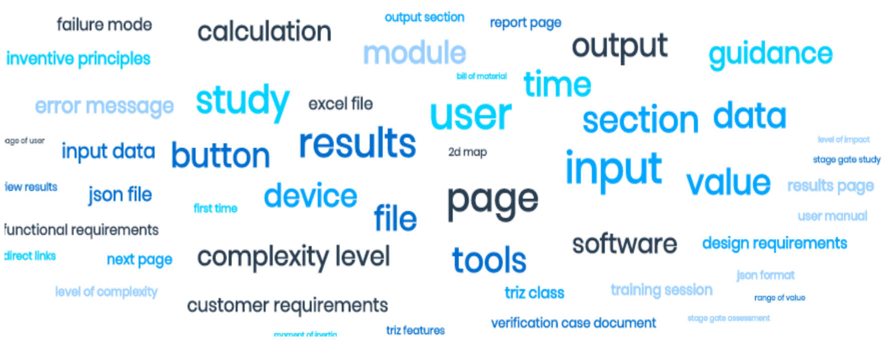

FIGURE 7.1: WORDCLOUD RESULTS

Based on the *Wordcloud* results, all words repeated more than 20 times in all comments were identified and to all of them, the respective comments and the related idea or improvement needed to be implemented to the tool was collected. The identified improvements were then characterised as being common to different modules or needed for only one module TABLE 7.4, so that the way to address these improvements should be the same to all modules they were identified to.

TABLE 7.4: WORDCLOUD RESULTS INTERPRETATION

Most repeated words (>20)	Count	Related idea / Improvement needed	Common to dif. modules
user	264	not clear (many different ideas)	n/a
complexity level	249	not clear (many different ideas)	n/a
input	192	how to input data	Yes
tools	171	not clear (many different ideas)	n/a
results	140	how to interpret outputs - availability of information to the users	Yes
customer requirements	112	availability of information to the users	Yes
button	105	buttons to input data, +/- buttons, adding 1 unit per click	Yes
input data	98	how to input data	Yes
json file	97	how to input data	Yes
error message	90	correction on the software performance	No
verification case document	90	availability of information to the users	Yes
page	84	not clear (many different ideas)	n/a
excel file	73	how to input data	Yes
study	66	not clear (many different ideas)	n/a
level of complexity	58	how to input data and how to interpret outputs	Yes
data	50	how to input data and how to interpret outputs	Yes
guidance	42	availability of information to the users	Yes
results page	39	how to interpret outputs - availability of information to the users	Yes
calculation	38	availability of information to the users - calculations reference, transparency	Yes
output	21	how to interpret outputs - availability of information to the users	Yes

Following with the repeated phrases analysis, *top phrases*, the most repeated ones where analysed and resulted on 6 improvements, coherent with the previous *Wordcloud* results, showing that the following list of improvements is the most reliable possible to be used on further developments to the tools (namely at the integration of the tools):

- 16 comments about the interface not looking professional (for 11 of the 13 modules: SI, SG, SC, MC, EC, ET, SK, LMO, SPEY, RAMS, ESA), suggested on comments:
  - some clearer separation between sections and input points
  - graphical aspect
  - improving data visualisation
    - some dropdown menus could be added to make it more user-friendly, instead of the [...],
    - splitting the big array in multiple subarrays sorted by parameter categories, ...

  - make it more "attractive"
  - better formatting
- 14 comments about the presentation of values (for 5 of the 13 modules: ET, SPEY, SLC, RAMS, ESA), suggested on comments:
  - too many decimal places on the values
  - too many zeros for large numbers
- 7 comments about the availability of information to the users (for 5 of the 13 modules: SC, MC, EC, SK, ESA), suggested on comments:
  - software should have more contextual description and help/ glossary, etc.
  - include key to all abbreviations/acronyms, and/or direct links to a glossary or appropriate page of user manual
  - include calculations reference - transparency on calculation is critical to user confidence
- 4 comments about the buttons to input data (for 4 of the 13 modules: SG, ET, SPEY, SLC), suggested on comments:
  - manipulating a slider could be better than the +/- buttons, adding 1 unit per click
- 4 comments about the names of the Studies (for 2 of the 13 modules: MC, EC), suggested on comments:
  - the study title is not properly displayed when in the study pages – "Study ID: 4 Page" etc. rather than actual title
- and other different comments about studies functionalities for all modules: saving, comparing, editing, copying/duplicating and presenting the list of studies.

This list of improvements was already considered and included as further developments to the standalone tools and to the integration of the tools.

8. ANNEX II: VALIDATION SCENARIOS AND EVALUATION FORM FOR THE DEMONSTRATION OF INTEGRATED DESIGN TOOLS

This annex is intended to describe the wave and tidal scenarios for the demonstration of integrated design tools.

While writing this deliverable, D7.9, the selected Validation Scenarios that are being used to demonstrate the integrated suite of tools, are the following described at TABLE 8.1. It should be noted that the deliverables D7.7 and D7.8, that will detail the outcomes of these scenarios for the demonstration of integrated design tools, will be delivered after D7.9.

TABLE 8.1: VALIDATION SCENARIOS FOR THE DEMONSTRATION OF INTEGRATED DESIGN TOOLS

Aggregation	Wave	Tidal
Array	VS3: Deployment Design Lead: IDOM Array: IDOM MARMOK A14 x 8 Site: *BiMEP*	VS6: Deployment Design Lead: NOVA; SABELLA; OMP Array: NOVA M100DD x 10-50; 1,5 MW SABELLA turbines; Orbital O2 Drivetrain Scaling Site: *Bluemull; Fromveur; EMEC Berth 5*
Device	VS1: Structured Innovation Lead: CPO; EGP; WES Device: CorPower C4; OPT-PB3; New concept Site: *Aguçadoura; Chile*	VS5: Stage Gate Lead: OMP; SABELLA Device: Orbital O2; SABELLA D15 Site: *EMEC Berth 5; Fromveur*
Subsystem	VS2: Stage Gate Lead: CPO Subsystem: CorPower C4 Site: *Aguçadoura*	VS4: Structured Innovation Lead: OMP Subsystem: Orbital O2 Connectors Site: *EMEC Berth 5*

To perform the demonstration of the integrated suite of tools, the Validation Scenarios at TABLE 8.1 will be demonstrated and evaluated, using an evaluation form, particularly created for that and detailed in section 8.1.

8.1 SOFTWARE EVALUATION FORM – VALIDATION TASKS T7.4 & 7.5

Name (user)	
Company	
Validation Scenario (s) tested	e.g. VS1.1 & VS2
Installation date and version	
System Specs (Total memory, CPUs…)	
List the stakeholders involved, e.g. Technology developer/ public funder etc	

8.1.1 Instructions

8.1.1.1 Numeric assessment

Please rate each field in the tables using a scale from 1 to 5, where 1 represents the most negative assessment and 5 the most positive.

Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

8.1.1.2 Qualitative assessment

Please use the box in each section to add comments, overall experience, or other points that may be useful to record.

8.1.2 Individual Design Tools

The following sections aim to assess the user interface of the software.

8.1.2.1 Structured Innovation Tool

ID	**Statement**	**Rating**
1.1	The SI tool helped find new solutions or new technology development paths to improve the relevant design.	[Select]
Comments		

ID	**Statement**	**Rating**
1.2	Among the solutions achieved using the SI tool, there were solutions already obtained by adopting traditional engineering methods (optimisation by trade-off solutions).	[Select]
Comments		

ID	**Statement**	**Rating**
1.3	There are value-added in using SI tools methods (QFD, TRIZ and FMEA). Specify the most helpful steps for obtaining innovative results.	[Select]
Comments		

ID	**Statement**	**Rating**
1.4	Specify, among the SI tool's methods, the least user-friendly steps.	[Select]
Comments		

ID	Statement	Rating
1.5	The steps are clear and well structured. The information flow is smooth. The documentation and supporting material was sufficient.	[Select]
Comments		

ID	Statement	Rating
1.6	Is there any critical feature missing? Indicate how much effort you spent using external software to manage DTOcean+ functionality gaps.	[Select]
Comments		

ID	Statement	Rating
1.7	The results of the QFD/TRIZ and FMEA can be exported for further post-processing or reused in additional design activities/tools	[Select]
Comments		

Comments

[Please add other key points and comments about the Structured Innovation tool]

8.1.2.2 Stage Gate Tool

ID	Statement	Rating
2.1	The SG tool helped in my decision making, e.g. Where to focus technology development activities, areas of improvement to work on, or R&D focus required	[Select]
Comments		

ID	Statement	Rating
2.2	The SG tool gave me a greater understanding of where my technology is in the technology development pathway	[Select]
Comments		

ID	Statement	Rating
2.3	I found the tool easy to use	[Select]
Comments		

ID	Statement	Rating
2.4	The study comparison feature was useful	[Select]
Comments		

ID	Statement	Rating
2.5	The Activity Checklist was straightforward to fill out	[Select]
Comments		

ID	Statement	Rating
2.6	I understood the steps in using the tool as the documentation and support provided was sufficient	[Select]
Comments		

ID	Statement	Rating
2.7	The SG tool helped align (or confirm alignment) of my technology development activities with funder expectations	[Select]
Comments		

Comments

[Please add other key points and comments about the Stage Gate tool]

8.1.2.3 Deployment Tools: SC/ MC/ EC/ ET/ ED/ SK/ LMO

ID	Statement	Rating
3.1	The use of studies and entities allows comparing advantages and limitations of various design alternatives	[Select]
Comments		

ID	Statement	Rating
3.2	The design steps are very clear and well structured. The information flow is smooth. Do you miss any critical design feature that is not computed?	[Select]
Comments		

ID	Statement	Rating
3.3	Deployment modules are sufficiently flexible to capture my project-specific needs, technology characteristics and desired solutions. If	[Select]

	not, please indicate which module (and why) does not meet your expectations.	
Comments		

ID	Statement	Rating
3.4	Deployment modules produced results that are realistic considering the level of detail of the inputs provided. If not, please indicate which module (and why) does not meet your expectations.	[Select]
Comments		

ID	Statement	Rating
3.5	Results can be exported for further post-processing or reused in additional design activities/tools	[Select]
Comments		

ID	Statement	Rating
3.6	The catalogues are populated with relevant information to build credible designs.	[Select]
Comments		

Comments

[Please add other key points and comments about the deployment design tools]

8.1.2.4 Assessment Tools: SPEY/ RAMS/ ESA/ SLC

ID	Statement	Rating
4.1	The four categories of assessments provide sufficient evaluation criteria to assess the strengths and weaknesses of my technology. If no, please identify which metric is not covered	[Select]
Comments		

ID	Statement	Rating
4.2	The assessment results are clear and presented in a structured manner. They are relevant for communication with decision-makers	[Select]
Comments		

ID	Statement	Rating
4.3	The assessment modules produced results that are realistic considering the level of detail of the inputs provided. If not, please indicate which module (and why) does not meet your expectations.	[Select]
Comments		

ID	Statement	Rating
4.4	Results can be exported for further post-processing or reused in additional activities	[Select]
Comments		

Comments

[Please add other key points and comments about the Assessment Design tools]

8.1.3 Global Suite of Tools

This section aims to assess the user experience of the suite of tools as a whole.

8.1.3.1 INSTALLATION

ID	Statement	Rating
5.1	The installation guideline is clear and easy to complete	[Select]
5.2	The installation process was completed without errors	[Select]
5.3	The software can be run from my local workstation without any issue	[Select]
5.4	The prerequisite specifications were clear (memory, OS, processor..)	[Select]

8.1.3.2 OPERATION

ID	Statement	Rating
5.5	The process of inputting and formatting data is expected with the level of detail	[Select]
5.6	The description/guidance is useful for learning how to use the software	[Select]
5.7	I am satisfied with the overall speed of computation	[Select]
5.8	The tool met my needs in the relevant stage of the project lifecycle	[Select]
5.9	The modular architecture of the software provides me with the freedom to focus on the relevant design needs	[Select]
5.10	The tools can handle the complex data flows efficiently for the relevant stage of the project lifecycle	[Select]

Comments

[Please add other key points and comments about the global suite of tools]

8.1.3.3 INTEGRATION

ID	Statement	Rating
6.1	I was able to use the tools in Standalone mode	[Select]
6.2	I was able to use the tools in Integrated mode	[Select]
6.3	The tools are flexible to use for different design objectives and iteration cycles.	[Select]
6.4	Dataflow is efficient	[Select]
6.5	The user has control of the design process	[Select]
6.6	The tools can handle the complex data flows efficiently for the relevant stage of the project lifecycle	[Select]

Comments

[Please add other key points and comments] *e.g. Are there functionalities gaps? ……*

8.1.3.4 OTHER

This section aims to record other qualitative aspects not mentioned above.

[Please add any final remarks]

9. ANNEX III: DTOCEANPLUS TECHNICAL RECOMMENDATIONS QUESTIONNAIRE

As part of the DTOceanPlus T7.6 about learnings and recommendations for the Ocean Energy sector, this questionnaire is intended to survey partners on suggestions for improving the DTOceanPlus suite of tools after the project end, and also to produce technical recommendations for the Ocean Energy stakeholders. Please remember that the tools are at TRL 6 and our ultimate goal is to have a fully commercial array deployment.

Your individual responses will be strictly confidential and used only in an aggregated manner to help us following the right path on D7.9 'Overall technical and sector recommendations'.

This questionnaire was created using MS Forms and it should take you 5 min to complete.

It has a different number of specific questions depending on the type of partner answering (Technology Developer; Project Developer; Public & Private Investor). It comprises scoring questions and some free-text boxes to add further details when appropriate.

Please rate each question, where indicated, using a scale from 1 to 5, where 1 represents the most negative assessment and 5 the most positive.

Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

9.1 RESPONDENT DETAILS

1. Organisation name

2. Entity type or main role in the project

☐Technology Developer ☐Project Developer ☐Investor/ Funder

9.2 TECHNOLOGY DEVELOPER

TOOLS' IMPROVEMENT

1. The process of inputting data is the one expected according to the level of detail.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

If not, please select the main obstacles faced by the users (check all that apply)

☐Difficulties in formatting the input data ☐Other:_______
☐Difficulties in retrieving all the necessary input data

2. The use of catalogues is the one expected according to the level of detail.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

3. I'm able to identify, for each phase of a project's study (site assessment, decision-making and project development), which level of complexity is more adequate.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

4. The correlation between input data required and complexity level is clear.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

5. I would find it useful to have the comparison between project's metrics and minimum requirements (well-accepted values in the industry).

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

If so, please select the parameters for which you would you like this comparison (check all that apply)
☐Utilisation factor ☐Other:_______
☐Reliability

6. The modular architecture of the software provides me with the freedom to focus on the relevant design needs and at the same time it can handle the complex data flows efficiently.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

7. I'm willing to use the DTOceanPlus suite of tools in my organisation after the project ends.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

8. I find DTOceanPlus tools capable of adding value to my activity.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

RECOMMENDATIONS FOR THE OCEAN ENERGY STAKEHOLDERS

1. Apart from catalogues and logistics database, do you identify any other valuable research data produced within the project, that can be considered as relevant results or knowledge base of the project?

2. I am willing to use the knowledge gathered from DTOceanPlus in other R&D activities.
☐Yes
☐No
☐Maybe

OTHER COMMENTS

If you have any other comments that might be useful to produce technical recommendations for Ocean Energy stakeholders, please add them here.

9.3 PROJECT DEVELOPER

TOOLS' IMPROVEMENT

1. I'm able to identify, for each phase of a project's study (site assessment, decision-making and project development), which level of complexity is more adequate.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

2. The correlation between input data required and complexity level is clear.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

3. A sensitivity analysis would be useful to evaluate the project's impact.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

If so, please select the correlation you would like to see (check all that apply)
☐LCOE/ Array size ☐Payback period/ Array size ☐Other:________
☐LCOE/ Single device size ☐Payback period/ Single device size

4. I find it possible to use the suite of tools throughout the project lifecycle.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

If not, why?

5. The modular architecture of the software provides me with the freedom to focus on the relevant design needs and at the same time it can handle the complex data flows efficiently.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

6. I'm willing to use the DTOceanPlus suite of tools in my organisation after the project ends.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

7. I find DTOceanPlus tools capable of adding value to my business.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

RECOMMENDATIONS FOR THE OCEAN ENERGY STAKEHOLDERS

1. I have some results that show interesting trends that I would like to share (perhaps in relation to device/array sizes, or planning of logistical operations).

2. I'm willing to use the knowledge gathered from DTOceanPlus in other R&D activities.

☐Yes
☐No
☐Maybe

OTHER COMMENTS

If you have any other comments that might be useful to produce technical recommendations for Ocean Energy stakeholders, please add them here.

9.4 PUBLIC & PRIVATE INVESTORS

TOOLS' IMPROVEMENT

1. I'm able to identify, for each phase of a project's study (site assessment, decision-making and project development), which level of complexity is more adequate.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

2. The correlation between input data required and complexity level is clear.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

3. The outputs provided by the tools (OPEX, CAPEX, LCOE, NPV, IRR and Payback Period) are useful enough to support the analysis of the investment.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

If not, please identify which other financial indicators you would like to have

4. The modular architecture of the software provides me with the freedom to focus on the relevant design needs and at the same time it can handle the complex data flows efficiently.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

5. I'm willing to use the DTOceanPlus suite of tools in my organisation after the project ends.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

6. I find DTOceanPlus tools capable of adding value to my business.

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

RECOMMENDATIONS FOR THE OCEAN ENERGY STAKEHOLDERS

1. Please identify the needed regulatory changes to facilitate a speedy upscale of the Ocean Energy sector.

2. I'm willing to use the knowledge gathered from DTOceanPlus in technical and economic feasibility studies of new projects helping decisional processes.

☐Yes
☐No
☐Maybe

OTHER COMMENTS

If you have any other comments that might be useful to produce technical recommendations for Ocean Energy stakeholders, please add them here.

CONTACT DETAILS

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