Report 2023
Task 49

WindFloat Atlantic final hookup at Viana do Castelo, Northern Portugal.
Photo: The Windfloat Atlantic project / Principle Power. Artist: DOCK90.

Integrated Design on Floating Wind Arrays (IDeA)

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As floating wind technology expands to larger scales and a wider range of site conditions, the industry faces unique challenges associated with having many large floating wind energy systems in an array.

These challenges extend beyond individual turbines to encompass a multidisciplinary set of considerations including efficiency and reliability of components, site-specific layout optimisation, logistical requirements, environmental and ocean co-user impacts, and system-level risk mitigation. A holistic approach to these challenges will help ensure the efficient and responsible development of floating wind energy systems.

Task 49 is a four-year project initiated in December 2021, which focuses on collaboratively developing datasets, frameworks, and insights to facilitate more holistic floating wind research and development. In 2023, each work package (WP) made significant progress. WP1 assembled 11 datasets from reference floating wind site conditions that can be used in future research projects. WP2 created mooring system designs that will be part of three reference floating wind array designs in shallow, moderate, and deep water. WP3 gathered data and held workshops to create a failure mode, effects and criticality analysis for floating wind arrays. Finally, WP4 engaged experts to assess major marine spatial planning and innovation drivers facing the industry across participating countries. The publication of outputs from all Work Packages is in progress. Task participants include project developers, technology providers, universities, consultancies, regulatory agencies, and research institutions from 12 countries. This provides a comprehensive perspective to the challenges of floating wind arrays.

Introduction

Task 49 aims to accelerate the sustainable commercialisation of floating wind arrays by developing open-access reference information and designs. As floating wind technology expands to larger scales and a wider range of site conditions, the industry faces a unique set of challenges to scale existing demonstration projects to commercial-scale floating arrays. These challenges extend beyond individual turbines to encompass a multidisciplinary set of considerations. These include the efficiency and reliability of station-keeping systems and power cables across an array, layout optimisation for specific site conditions, installation and operational logistics, environmental and ocean co-user impacts, and failure risk mitigation in utility-scale floating wind projects. The overall goal of Task 49 is to facilitate international collaboration to research that helps address these challenges.
Task 49 leverages and integrates ongoing research activities to carry out its four work packages (Figure 1) with the following objectives:

- WP 1: Curate a set of site conditions representative of the global floating wind pipeline.
- WP 2: Develop reference array designs for typical site conditions and technology types.
- WP 3: Catalogue array-level failure risks, consequences, and mitigation strategies.
- WP 4: Identify critical innovation opportunities and marine spatial planning requirements.

The Task 49 membership includes 12 countries and 78 organisations, including a share of industry participants, some of whom have had strong involvement in meetings and discussions. Table 1 lists the countries participating.

Progress and Achievements

Task 49 is a four-year effort that began in December 2021. As the Task proceeds to its third year, the first work package comes to a conclusion, while the remaining three work packages are more than halfway through their scope of work.

Work Package 1 (reference sites) completed its development of reference site conditions for floating wind arrays and has prepared a comprehensive report. Following a metocean analysis of 49 sites that represent the global floating wind pipeline, the WP1 team assembled detailed metocean data for 11 selected reference sites along with generic characterisations of representative soil characteristics, infrastructure requirements, and other site-specific parameters. The site condition datasets have been published as an open-access resource [1].

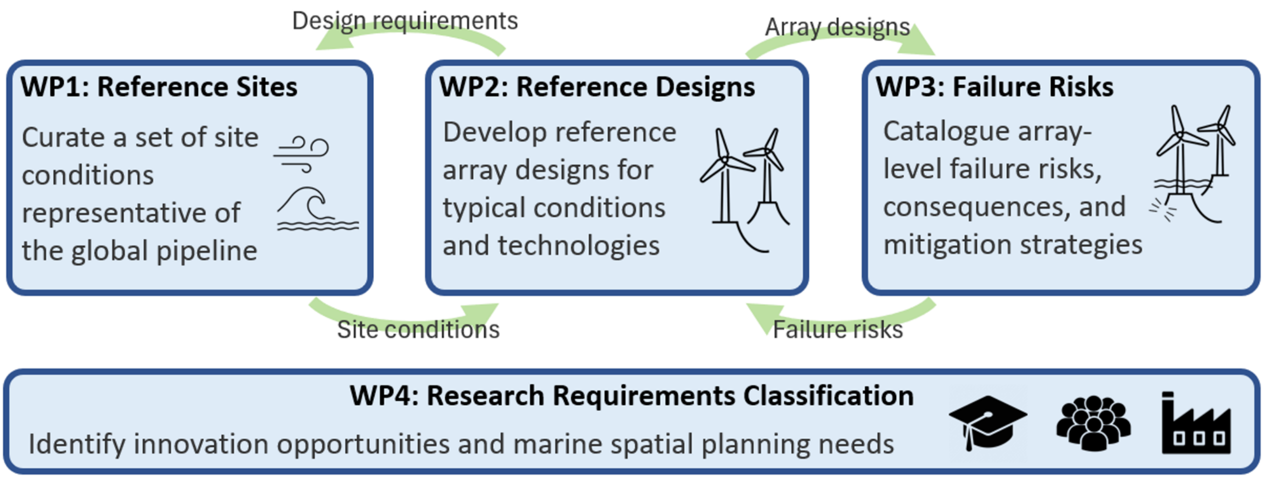


Figure 1: Task 49 work packages.

Table 1. Countries Participating in Task 49.

COUNTRY/SPONSOR	INSTITUTION(S)
China	CWEA; Dalian University; Goldwind
Denmark	DTU; PeakWind; DHI
France	BlueFloat; BV; BW Ideol; FEE; France Energies Marines; IFPEN; RWE; Safier; SBM Offshore; Supergrid Institute; Valorem; Technip Energies
Germany	Fraunhofer; Uni Aachen; GICON; Ramboll, Sowento; TUHH; Uni Stuttgart; Woelfel
Ireland	GDG; Subsea Micropiles; Tfl Marine; Trinity College Dublin; UCD; UCC
Italy	Politecnico di Tornio; RSE
Japan	Shimizu Corp; Ashikaga University
The Netherlands	TU Delft; MARIN; Vryhof; TNO; Deltares
Norway	4subsea; NGI; Norce; NTNU; Sintef Energy; Ui Agder; Ui Bergen; Ui Stavanger; IFE
South Korea	Institute for Advanced Engineering; KETEP; KIT Valley; Ulsan University
The United Kingdom	University of Edinburgh; Acteon; DNV GL; Interocean; JDR Cables; Lloyds Register; ORE Catapult; QUB; U Aberdeen; U Bristol; U Strathclyde; First Energy Development
The United States	ABS; BOEM; Delmar; Glosten; NREL; Ocergy; Principle Power; Ram Power; U Delaware; Triton Systems; UMaine; UMass; Woods Hole; DOE WETO

Work Package 2 (reference array designs) is developing three reference array designs, each for a different set of site conditions. The design teams have planned the mooring systems and addressed key array-level questions including load case selection, fatigue analysis methods, and inclusion of wake effects in the load analyses. These solutions have been incorporated into a comprehensive reference array design basis report, which will be published to provide guidance to future floating array design efforts. Once the teams design dynamic power cables and regular layouts, the reference array design will be published in the form of data files and design definition reports.

Work Package 3 (failure risks) has completed a failure modes, effects and criticality analysis (FMECA) for floating wind arrays based on expert inputs and several workshops. The resulting FMECA tables include component-level failures and rankings for potential array-level impact. These will be published in a report next year. WP3 is now extending the FMECA to consider how it can be applied at the array-level by mapping how failures can propagate. The resulting framework will be tested on the reference designs being developed in WP2.

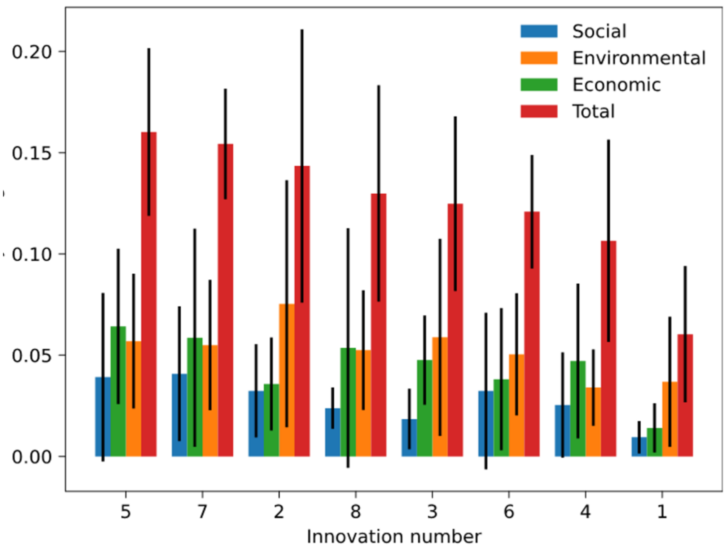
Work Package 4 (innovations and marine spatial planning) has engaged with representatives from each participating country to understand major research and deployment questions for floating wind. The team completed an analysis of key marine spatial planning issues for floating wind arrays, and a survey of floating wind innovations in an analytical hierarchical process. Both of these are in the process of being published in reports. The findings detailing innovation needs and opportunities for floating wind arrays will inform the direction of other Task 49 activities and potential follow-on work after the Task ends.

Highlight(s)

In addition to steady activity in each work package, Task 49 has kept up engagement of the larger group of over 250 participants through quarterly whole-Task meetings and periodic in-person meetings. Task 49 had day-long in-person meetings at the Wind Energy Science Conference in Glasgow in May 2023 (Figure 2) and at the DeepWind conference in Trondheim in January 2024. Task 49 also organised a mini-symposium at WESC, which included presentations of each WP to conference attendees. WP3 also held an in-person workshop in Paris in October 2023. The most recent in-person meeting was held at the Torque conference in Florence in May 2024.

One of the most broadly applicable findings of Task 49 is the ranking of floating wind innovations carried out by WP4. Figure 3 shows how the top innovations compare by prioritisation

Figure 2: Task 49 in-person meeting participants at WESC 2023, in Glasgow.



Innovations (in order of total priority)

5. Optimised O&M and major component service strategies and condition monitoring for floating conditions.
7. Port infrastructure improvement to enable substructure manufacturing.
2. Manufacturing of current and disruptive floating concepts.
7. Floating electrical and mooring system connections.
3. Design for whole lifecycle cost reduction.
5. Design of a floating platform substation.
4. Consolidation in the number of designs.
1. New floating WTG configurations.

Figure 3: Top-ranked floating wind innovations with categorised priority rankings.

according to social, environmental, and economic categories. These results can inspire further studies to apply the reference array designs and inform future floating wind array research efforts.

Outcomes and Significance

Research and development (R&D) projects addressing large-scale deployment of floating wind energy often begin with the same tasks. The reference site conditions datasets, developed by WP1, are a new and noteworthy resource for representative site conditions. Particularly, for R&D projects that can now avoid gathering their own site data for each new project. Researchers and industry members alike have therefore been eager to access these reference site datasets. The reference array designs being developed by WP2 will offer a similar benefit to research projects by providing a starting point for array designs. This allows projects to focus more on their specific innovations or topics. In the meantime, the design basis from WP2 will offer guidance for array design efforts by sharing the findings of the WP2 design teams regarding the various uncertainties that currently exist around floating array design practices.

As floating wind development continues to expand, the risks of failures at the array scale are a key uncertainty to be addressed. The FMECA analysis in WP3 provides an extensive perspective on these risks that can inform industry decisions and focus mitigation efforts. The floating wind innovations register, developed by WP4, will provide a comprehensive map of innovation opportunities that can shape future R&D directions.

Next Steps

WP1 will conclude with the publication of its site condition datasets and a comprehensive report.

WP2 will publish its design basis report and is working on the array-level design stage of the reference designs where moorings, cables, and array layout are adjusted to work together.

WP3 will publish its floating wind array FMECA report and focus on extending the FMECA approach for array-level failure analysis.

WP4 will publish its marine spatial planning and innovation register reports. Next, it will work on applying its results to advise WP2 and WP3 efforts and identify subsequent research priorities for potential follow-on from Task 49.

References

[1] Santos, P., Creane, S., Kölle, K., Airoldi, D., Biglu, M., Cheynet, E., Frøyd, L., Hall, M., Kim, Y.-Y., Lanni, F., Larsén, X. G., Li, L., Lozon, E., Paskyabi, M. B., Yamagushi, A., & You, Y.-J. (2024). Reference site conditions for floating wind arrays: dataset of reference sites (1.0.0) [Data set]. International Energy Agency.
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