

FLOATING OFFSHORE WIND STRATEGIC INNOVATION AGENDA



Co-funded by
the European Union



About I3FLOAT

The I3FLOAT project has been launched with the objective of strengthening European competitiveness in floating offshore wind, supporting the transition from demonstration towards industrial and commercial deployment. Co-funded by the European Union under the Interregional Innovation Investments (I3) Instrument, the project brings together complementary industrial, technological and innovation capacities from different European regions to accelerate the development and market uptake of floating offshore wind solutions.

I3FLOAT promotes interregional collaboration and investment across the floating offshore wind value chain, connecting regional ecosystems and supporting companies in the development, demonstration and scale-up of innovative solutions. In doing so, the project seeks to address some of the key challenges facing the sector, particularly the need to reduce costs, scale up technologies and industrial processes, and strengthen European value chains for commercial deployment.

Within this framework, the Floating Offshore Wind Strategic Innovation Agenda provides a structured overview of the main innovation needs of the European floating offshore wind sector. Developed through a participatory process involving stakeholders from across the European ecosystem, it organises 105 innovation lines into 20 Subareas and 7 Strategic Areas, covering the full life cycle of floating offshore wind projects. These innovation lines have been characterised and prioritised according to their technical-industrial viability and expected impact on cost reduction.

The Agenda therefore provides a shared reference for understanding where innovation efforts are most needed and where they can contribute most effectively to the industrial and commercial deployment of floating offshore wind. By combining a life-cycle perspective with a structured prioritisation framework, it supports informed decision-making and facilitates the alignment of innovation efforts with market needs and industrial deployment objectives.

Within I3FLOAT, the Agenda also provides a strategic basis for the project's innovation support instruments, helping to direct support towards the innovation needs and priorities identified by the sector.

Acknowledgements

The I3FLOAT Floating Offshore Wind Strategic Innovation Agenda is the result of a collaborative process involving over 400 representatives from 195 organisations across the European floating offshore wind ecosystem.

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Minsait (an Indra company) is the consulting firm in charge of supporting the coordination and elaboration of the I3FLOAT Floating Offshore Wind Strategic Innovation Agenda

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Executive summary

Floating offshore wind is expected to become one of the key pillars of Europe's future energy system, offering access to high-quality wind resources in deep-water areas while supporting the decarbonisation of the energy sector and strengthening European industrial competitiveness. As the sector moves from technology demonstration towards commercial-scale deployment, **innovation is increasingly required not only to improve individual technologies, but also to accelerate industrialisation, reduce costs and strengthen the resilience of the European value chain.**

Against this background, the I3FLOAT project has developed the **Floating Offshore Wind Strategic Innovation Agenda**, providing a common strategic framework to identify, prioritise and coordinate the innovation efforts expected to deliver the greatest contribution to the future competitiveness of floating offshore wind in Europe.

The Agenda has been developed through a structured, evidence-based and participatory process involving over 400 representatives from 195 organisations across the European floating offshore wind ecosystem. Industry, research and technology organisations, universities, public authorities and cluster organisations have contributed to identifying, validating and prioritising the innovation needs addressed in the document. Through regional workshops, expert consultation and an online prioritisation exercise, **the process has combined technical knowledge with broad stakeholder consensus, ensuring that the resulting priorities reflect both industrial needs and strategic opportunities.**

The Strategic Innovation Agenda is organised around 7 Strategic Innovation Areas: (1) Floating substructures, mooring systems and dynamic cables; (2) Electrical infrastructure and grid connection; (3) Wind turbine, tower or alternative supporting structures and FOW-specific control; (4) Wind farm layout design and site planning; (5) Industrialisation; (6) Logistics and offshore installation; (7) Operation, Maintenance and Decommissioning. These are further structured into **20 Subareas and 105 Innovation Lines**, covering the entire floating offshore wind value chain. Each innovation line has been assessed according to its technical-industrial viability and expected impact on cost reduction, enabling the identification of the innovation priorities expected to deliver the greatest contribution to the industrial deployment and competitiveness of floating offshore wind.

The results reveal a clear strategic direction for the sector. The highest-priority innovation lines are concentrated around industrialisation, integrated system design, manufacturing, installation and operation and maintenance, indicating that **future competitiveness will depend less on the development of entirely new technological concepts than on the ability to industrialise, integrate and scale existing solutions.** Rather than optimising individual components in isolation, stakeholders consistently prioritise innovations capable of improving the performance of the complete floating offshore wind system throughout its lifecycle.

The prioritisation also highlights **the growing importance of system integration across the value chain.** Design decisions increasingly influence manufacturing efficiency, installation strategies directly affect operational performance, and operation and maintenance considerations are becoming integral to engineering decisions from the earliest stages of project development. More broadly, the Agenda reflects an evolution in the way innovation is understood within the sector. While technical excellence remains essential, innovation is increasingly expected to demonstrate industrial value through scalability, manufacturability, operational efficiency and measurable contributions to competitiveness.

More than a prioritisation exercise, the Strategic Innovation Agenda provides a shared strategic framework for the European floating offshore wind ecosystem. By identifying the technological, industrial and operational priorities expected to generate the greatest strategic impact, **it supports more coordinated decision-making, helps focus future investment and strengthens collaboration across industry, research and technology organisations, public authorities and funding bodies.** In doing so, it establishes a common direction for accelerating the industrial deployment, competitiveness and long-term resilience of floating offshore wind in Europe.



1

Introduction

Introduction

The **Floating Offshore Wind Strategic Innovation Agenda** provides a **structured and forward-looking overview** of the key innovation priorities and opportunities facing the floating offshore wind sector. Its objective is to **support the identification and prioritisation of innovation areas** with the potential to accelerate technological maturity, improve industrialisation, and reduce risks and costs across the value chain.

The Agenda is intended to serve as a **strategic reference** for a wide range of stakeholders, including industry actors, technology developers, research organisations and public authorities. It adopts a **market-oriented and impact-driven perspective**, addressing both technological and non-technological dimensions of innovation and considering the full life cycle of floating offshore wind projects.

By combining a life-cycle-based perspective with a decision-oriented analytical framework, the Agenda aims to **support informed decision-making** and to **facilitate the alignment of innovation efforts with market needs and industrial deployment objectives**.

1.1 Scope and structure of the Agenda

This document is structured into three main chapters, each addressing a specific level of analysis.

Chapter 1 introduces the Floating Offshore Wind Strategic Innovation Agenda and presents its scope, structure and overall vision, providing the strategic context for the analysis.

Chapter 2 describes the decision framework and assessment criteria used to analyse and prioritise innovation lines, and summarises the key findings and high-level observations of the Agenda.

Chapter 3 presents the detailed breakdown of the Agenda into strategic areas, subareas and innovation lines, organised according to the structure of the floating offshore wind value chain. Each innovation line is presented through a dedicated fact sheet to facilitate its interpretation and implementation.

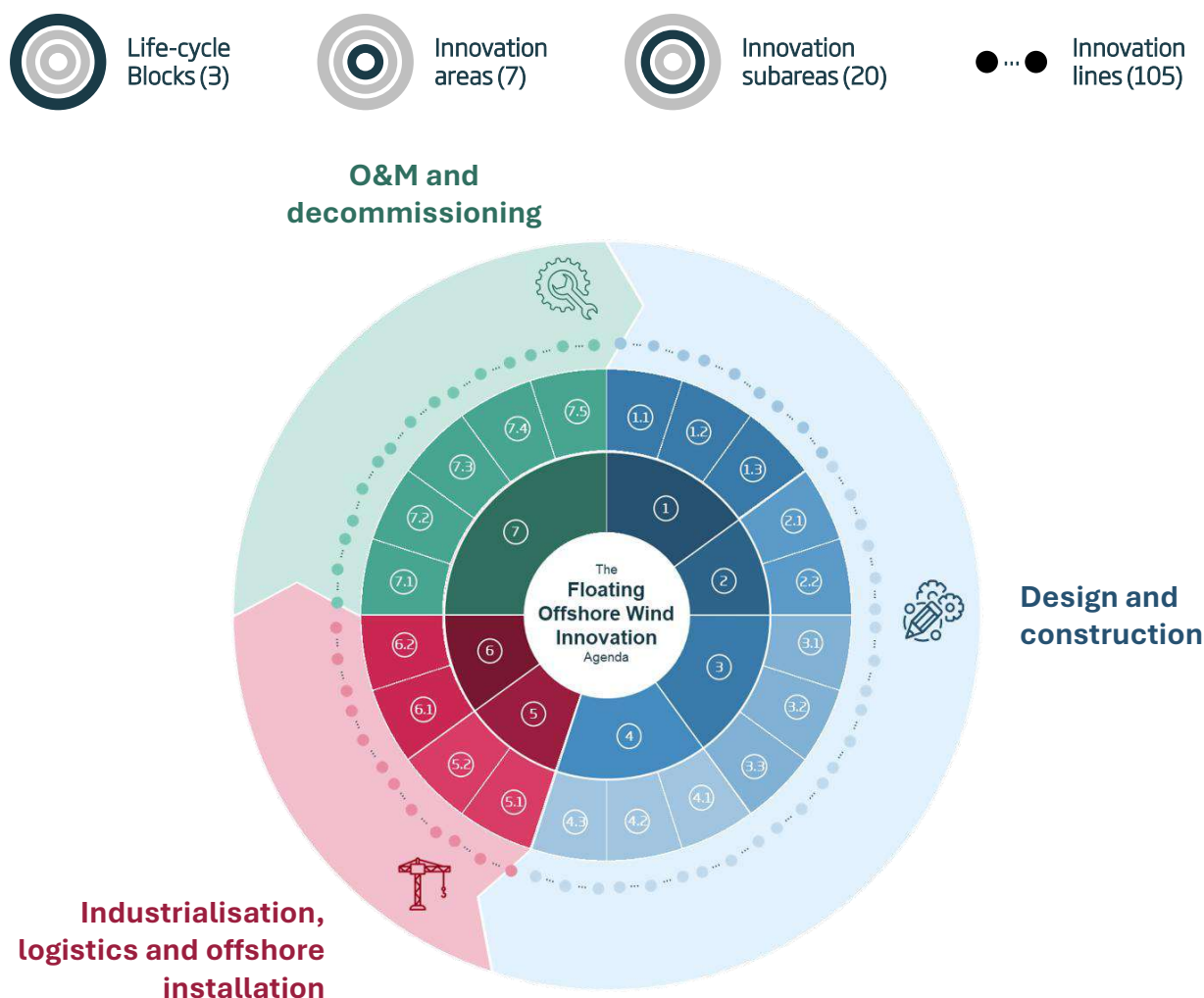
1.2 General overview of the Agenda

The **Floating Offshore Wind Strategic Innovation Agenda** provides a coherent and shared reference **framework** that organises innovation priorities across the full life cycle of floating offshore wind projects, supporting informed decision-making and the alignment of innovation efforts with market needs and industrial deployment objectives.

To this end, the **Agenda adopts a life-cycle-based structure** organised into **three main blocks** that reflect the **successive phases** of floating offshore wind development: **(1) design and construction, (2) industrialisation, logistics and offshore installation, and (3) operation, maintenance and decommissioning**. This structure enables a comprehensive and systematic consideration of innovation priorities across the different stages of project development.

Within these three life-cycle blocks, the Agenda is structured into **7 innovation areas**, each covering a distinct **set of priorities** within the floating offshore wind value chain: (1) Floating substructures, mooring systems and dynamic cables; (2) Electrical infrastructure and grid connection; (3) Wind turbine, tower or alternative supporting structures and FOW-specific control; (4) Wind farm layout design and site planning; (5) Industrialisation; (6) Logistics and offshore installation; (7) Operation, Maintenance and Decommissioning. These areas provide a clear and navigable framework for organising innovation efforts across the different stages of project development.

Each innovation area is further articulated through **20 innovation subareas** and **105 innovation lines**, which define specific directions for technological, industrial or operational advancement. Together, these elements constitute a coherent **innovation architecture**, supporting a clear identification of where innovation efforts can be most effectively focused to accelerate the large-scale deployment of floating offshore wind.



1.3 Agenda development approach and participatory process

The **Floating Offshore Wind Strategic Innovation Agenda** has been developed through a structured, multi-stage **participatory process** designed to ensure that its priorities reflect the needs, capabilities and strategic ambitions of the European floating offshore wind ecosystem. The Agenda has been defined **in close collaboration with stakeholders from industry, research organisations, universities, public authorities and cluster organisations**, combining regional perspectives with a shared European vision.

The development process has been articulated around **complementary participation mechanisms**, each addressing a specific objective within the **definition, validation and prioritisation** of the Agenda. **Regional workshops** have enabled the identification of innovation needs directly from the sector, while the **online consultation process** has provided a structured framework for validating and prioritising the proposed innovation lines. Together, these activities have combined qualitative discussion with quantitative assessment, ensuring that the final Agenda has been built upon both expert knowledge and broad stakeholder consensus.

A **first round of regional workshops** has been organised by each of the eight clusters and associations participating in I3FLOAT:

- BASQUENERGY Cluster (Basque Country, Spain)
- Pôle Mer Méditerranée (France)
- Blauwe Cluster (Belgium)
- Claner – Andalusian Renewable Energy Association (Andalusia, Spain)
- Cluster Marítimo de Canarias (Canary Islands, Spain)
- Blue Italian Growth Technology Cluster (Italy)
- Wind Industry Hub (Poland)
- Marine Cluster Bulgaria (Bulgaria)

These workshops have brought together representatives from across the floating offshore wind value chain (including technology developers, manufacturers, engineering companies, ports, research centres, universities, public bodies and industrial associations) to **identify technological challenges, discuss regional priorities and capture different perspectives on the future development of the sector**. A **second round** of regional workshops has been organised by the same clusters and associations to **present the results of the innovation lines prioritisation, validate the strategic conclusions of the Agenda and collect final stakeholder feedback**. The workshops have been complemented by a **two-phase online participatory process**:

- **Phase 1** has focused on the technical characterisation and validation of the proposed innovation lines. Stakeholders have reviewed the content of each innovation line, assessing its relevance, scope, consistency and alignment with current technological and industrial needs. The feedback collected during this phase has been consolidated and incorporated into the Agenda, strengthening its technical robustness and ensuring that the proposed innovation lines accurately reflect the priorities identified by the sector.
- **Phase 2** has focused on the prioritisation of the validated innovation lines. Participants have assessed each innovation line against two complementary criteria: **technical-industrial viability** and **expected impact on cost reduction**. The results of this exercise have formed the basis for identifying the most strategic innovation priorities and have supported the definition of the final Agenda.

Overall, the combination of regional workshops, expert consultation and structured online participation has resulted in an Agenda that reflects the collective knowledge of the European floating offshore wind community. This collaborative approach has enhanced the credibility, representativeness and practical relevance of the document, providing a robust and widely supported strategic framework for guiding future innovation efforts across the sector. **A detailed description of the participatory process, including stakeholder participation and consultation results, is provided in Annex II.**

2

Decision framework and key findings

Decision framework and key findings

Chapter 2 presents the prioritisation results of the I3FLOAT Floating Offshore Wind Strategic Innovation Agenda and provides an aggregated view of the main strategic insights emerging from the assessment of the identified innovation lines.

The Floating Offshore Wind Strategic Innovation Agenda comprises 105 innovation lines organised across 7 strategic areas, covering the full life cycle of floating offshore wind projects. All innovation lines included in the Agenda have emerged from an extensive participatory process involving stakeholders from across the European floating offshore wind value chain, and each represents a relevant technological or industrial innovation need. Their expected contribution to accelerating the deployment of floating offshore wind, however, differs according to their potential strategic impact and implementation viability.

This chapter presents the results of the prioritisation exercise, providing an overall view of the innovation priorities emerging from the Agenda before introducing the detailed analysis of each strategic area in Chapter 3. It also highlights the highest-priority innovation lines, identifies the main cross-cutting patterns observed across the Agenda, and summarises the key conclusions derived from the prioritisation exercise.

How to read this chapter

- **Section 2.1 Strategic overview of the innovation priorities**, provides an aggregated view of the prioritisation results, presenting the overall distribution of the innovation portfolio across Priority Levels, its positioning within the prioritisation matrix, the distribution across strategic areas and the relative positioning of all innovation lines according to their assessment scores.
- **Section 2.2 Highest-priority innovation lines**, presents the innovation lines with the greatest strategic relevance.
- **Section 2.3 Cross-cutting insights and strategic patterns**, explores the main trends and recurring themes identified across the Agenda, offering an integrated interpretation of the prioritisation results.
- **Section 2.4 Key conclusions**, summarises the main outcomes of the prioritisation exercise and outlines the key insights supporting future innovation and investment decisions.

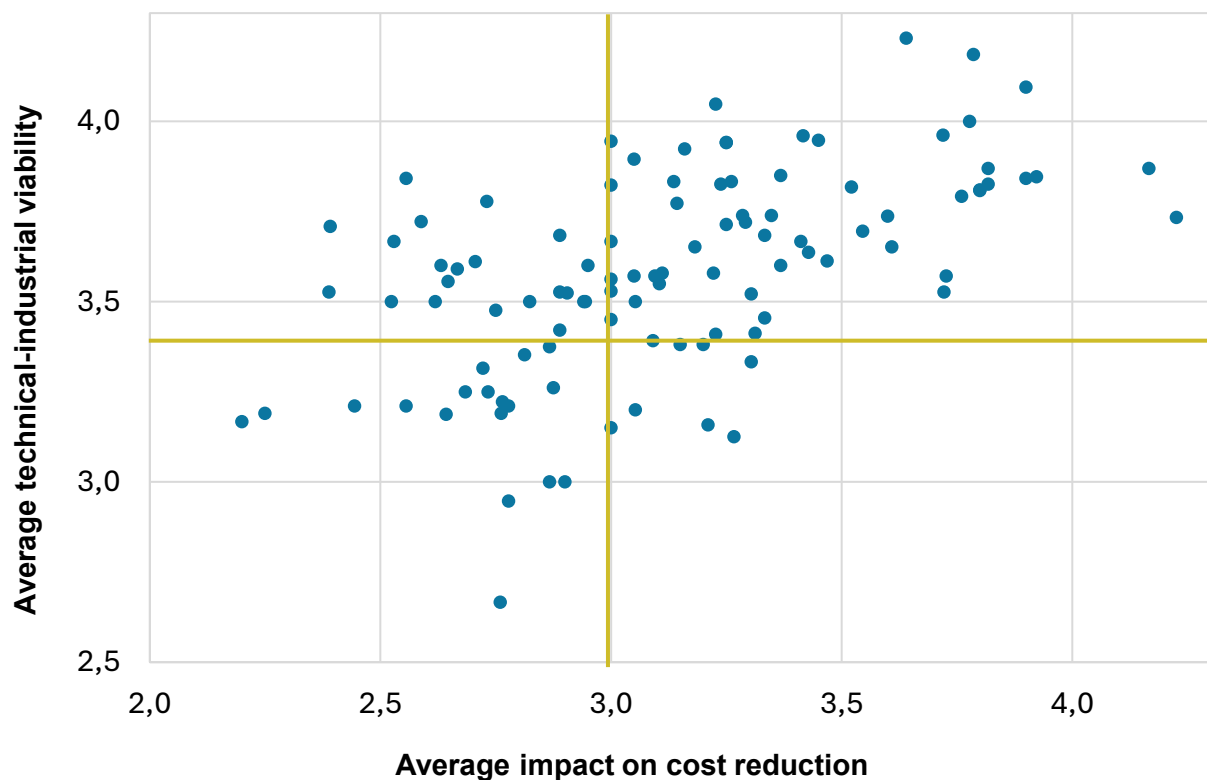
2.1 Strategic overview of the innovation priorities

The **I3FLOAT Floating Offshore Wind Strategic Innovation Agenda** brings together **105 innovation lines** organised into **20 innovation subareas**, which are grouped within **7 strategic areas** covering the **full floating offshore wind value chain**.

Together, these innovation lines represent the main **technological, industrial and operational challenges** identified throughout the **collaborative process** and constitute the **basis for the prioritisation exercise** presented in this chapter.

The following figure presents an overview of the complete innovation landscape by positioning all **105 innovation lines** according to their average scores in the two evaluation dimensions used throughout the assessment: **technical-industrial viability** and **impact on cost reduction**.

Innovation lines by average viability and cost-reduction impact



The **distribution** of the innovation lines reveals a **positive relationship** between the two assessment dimensions. Innovation lines expected to deliver a greater contribution to cost reduction also tend to achieve higher technical-industrial viability scores, resulting in a **clear concentration of innovation lines in the upper-right area** of the assessment space. This suggests that **strategic impact and implementation potential** are generally complementary rather than competing objectives.

Outside this area, the innovation lines are **distributed more progressively** across the remaining quadrants, reflecting different strategic profiles. Some innovations exhibit solid performance in only one assessment dimension, while others achieve more moderate scores in both, representing innovation needs that **remain relevant but are associated with a lower implementation priority or a longer-term development horizon**.

From assessment results to Priority Levels (PL)

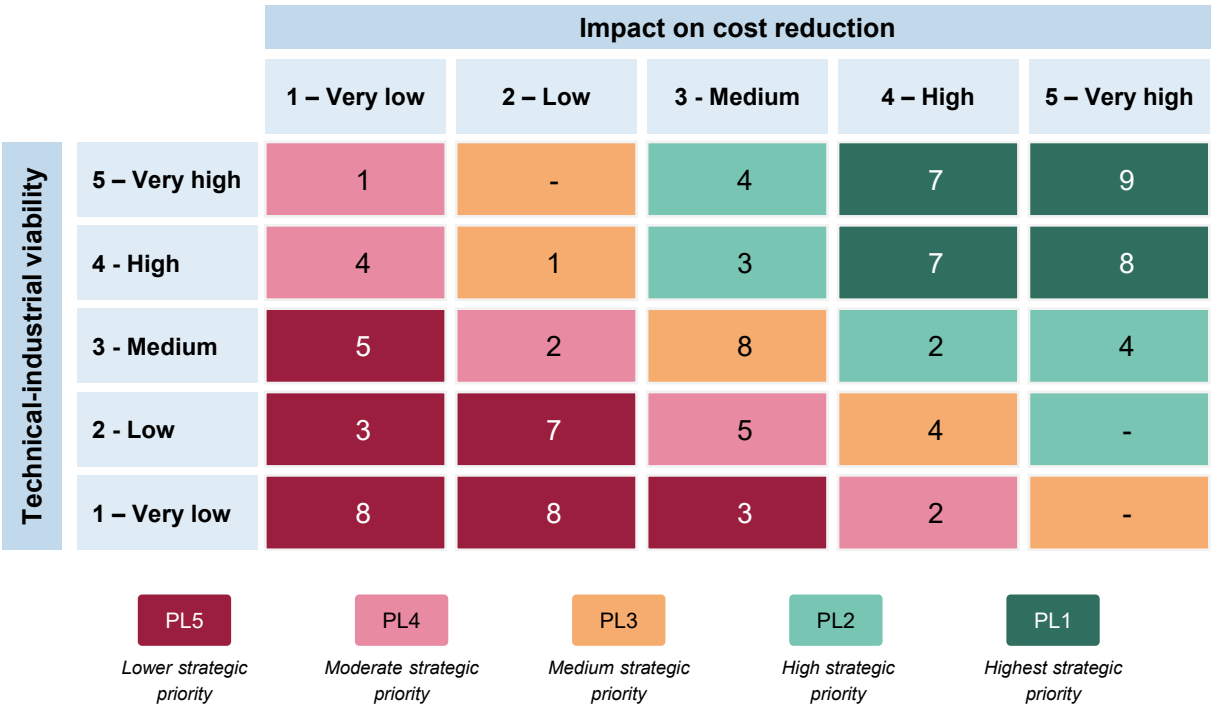
The 105 innovation lines included in the Agenda already represent a **selected set of relevant innovation needs** for the floating offshore wind sector, identified through the participatory process and supporting analysis. The prioritisation exercise **does not therefore determine whether an innovation line is relevant**, but rather establishes its **relative strategic priority** within this previously identified portfolio.

To enable a consistent **prioritisation** of the innovation lines, the **average scores** obtained for **technical-industrial viability and impact on cost reduction** are transformed into **standardised levels** ranging from **1 to 5**. These levels are then **combined within a 5×5 prioritisation matrix**, which assigns each innovation line to **one of five possible Priority Levels** (PL1–PL5, where PL1 represents the highest strategic priority and PL5 the lowest).

This approach preserves the **relative position of each innovation** line across both assessment dimensions while providing a **common framework for distinguishing between different levels of strategic priority**. The complete transformation and prioritisation process is described in detail in **Annex I**.

The following matrix shows the **number of innovation lines positioned in each combination** of technical-industrial viability and cost-reduction impact levels. The matrix is intentionally **asymmetric**, giving **greater weight to cost-reduction impact** than to technical-industrial viability. This reflects the current **maturity of the floating offshore wind sector**, where many technological solutions are considered technically deployable, while cost reduction remains a key challenge for achieving commercial-scale deployment. Consequently, innovations with greater potential to reduce costs are assigned a higher strategic priority, even when their technical-industrial viability is comparatively lower.

Number of innovation lines in each quadrant of the Prioritisation matrix



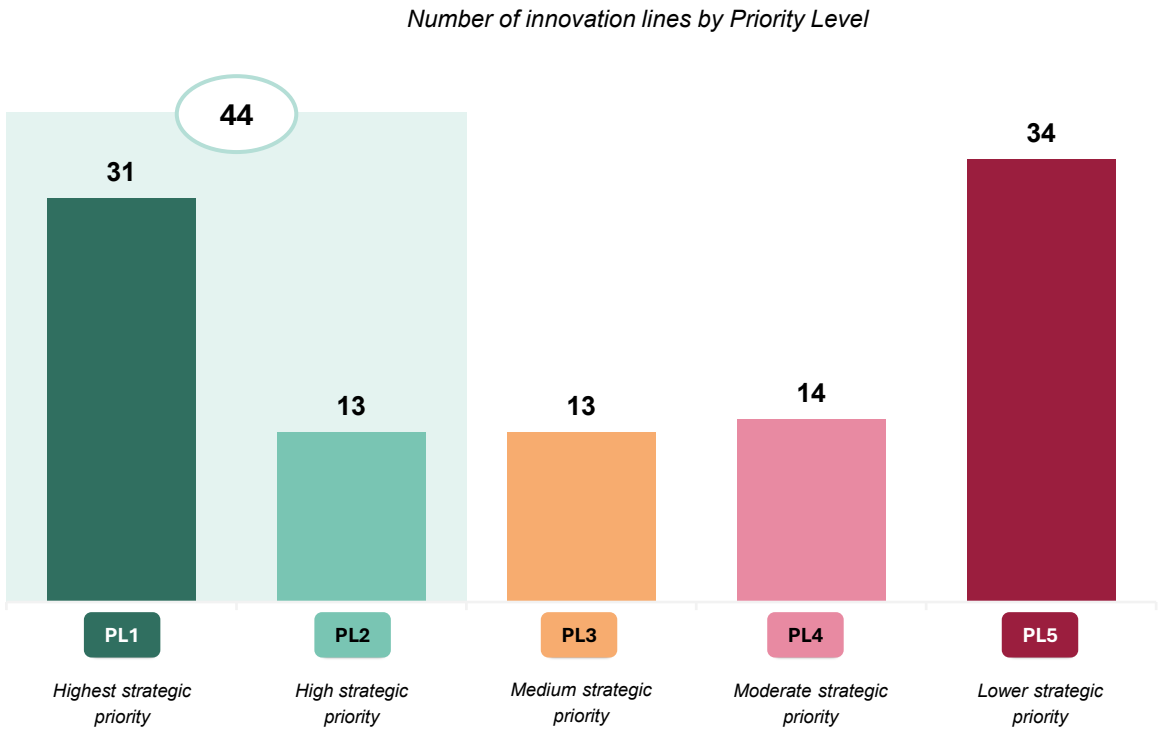
The results show a clear **concentration of innovation lines in the upper-right area of the matrix**, where **high technical-industrial viability coincides with a high expected impact on cost reduction**. This concentration confirms that many of the highest-priority innovation lines combine strong implementation potential with a significant expected contribution to improving the competitiveness of floating offshore wind.

Conversely, only a **limited number of innovation lines are positioned in the off-diagonal areas** of the matrix, indicating that relatively **few innovations exhibit high performance in one assessment dimension while remaining weak in the other**. This suggests that the prioritisation process has predominantly identified innovation lines that balance technical viability with strategic impact, rather than favouring innovations that excel in only one dimension.

The **remaining innovation lines are distributed across the central area and the lower-left region** of the matrix, reflecting innovations with **more moderate performance or longer-term implementation prospects**. These results illustrate the diversity of the innovation portfolio while providing a clear distinction between innovation lines requiring immediate attention and those representing future development opportunities.

Overall distribution across Priority Levels

Based on the prioritisation framework described in the previous section, the **105 innovation lines** are classified into **five Priority Levels (PL1–PL5)**, ranging from the **highest strategic priority (PL1)** to the **lowest (PL5)**. This distribution provides an overall view of the Strategic Innovation Agenda, showing how the identified innovation needs are allocated across the different priority levels.

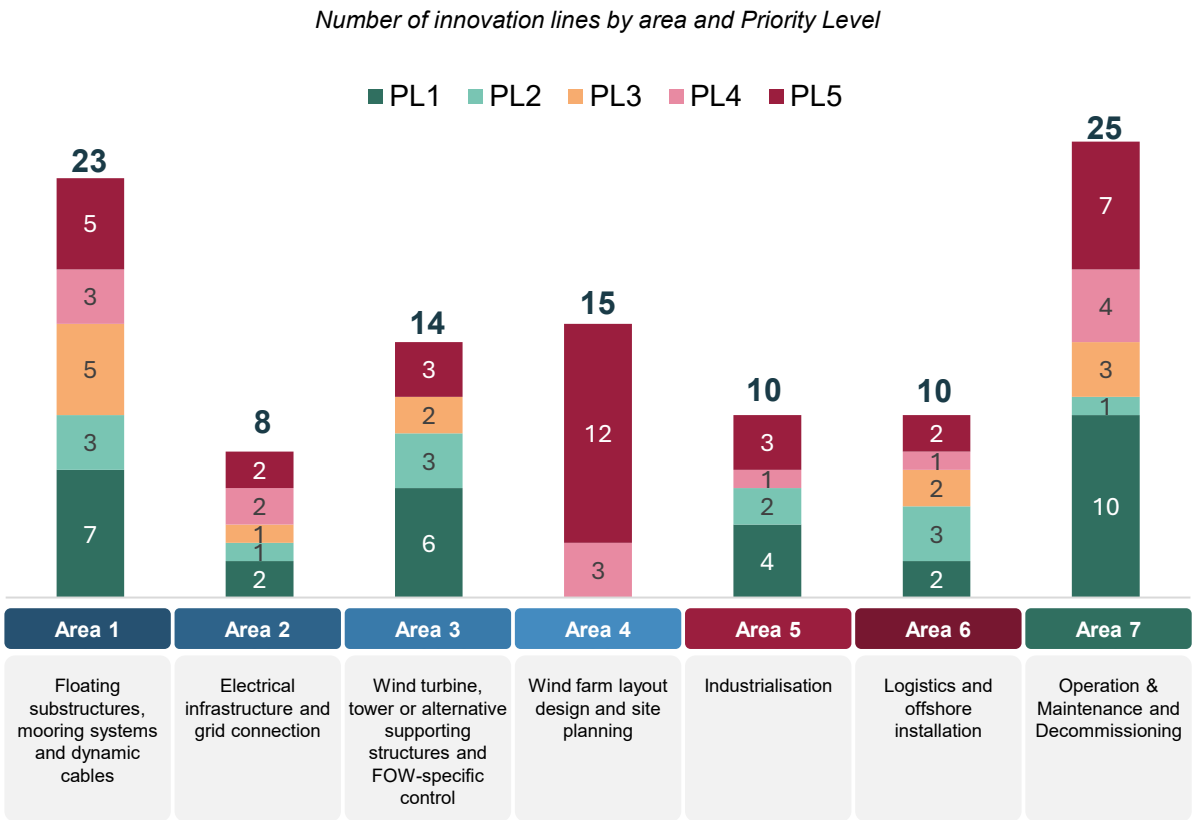


The prioritisation results show a clear differentiation across the innovation portfolio. A total of **44 innovation lines** (42%) are classified within **Priority Levels 1 and 2**, representing the innovations considered to offer the **greatest strategic value** for accelerating the deployment and competitiveness of floating offshore wind. The remaining innovation lines are distributed across Priority Levels 3 to 5, reflecting innovation needs with progressively lower implementation priority while remaining relevant for the medium and long-term evolution of the sector.

The comparatively large number of innovation lines classified as PL5 further illustrates the discriminatory capacity of the prioritisation framework, ensuring that **long-term or less mature innovation needs are clearly distinguished from those requiring more immediate attention**.

Distribution across strategic areas

The prioritisation results can also be analysed from the **perspective of the seven strategic areas**. Comparing the distribution of innovation lines across Priority Levels provides a **clearer understanding of the relative strategic profile of each area** and the extent to which **high-priority innovation needs are concentrated** within different parts of the floating offshore wind value chain.



The distribution of Priority Levels across the strategic areas reveals not only differences in the number of highly prioritised innovation lines, but also distinct innovation profiles along the floating offshore wind value chain. The concentration of PL1 and PL2 innovation lines in Areas 1, 3, 5 and 7 indicates that **stakeholders consistently prioritise innovations capable of accelerating industrial deployment through improvements in platform design, system integration, industrial manufacturing and operational performance**.

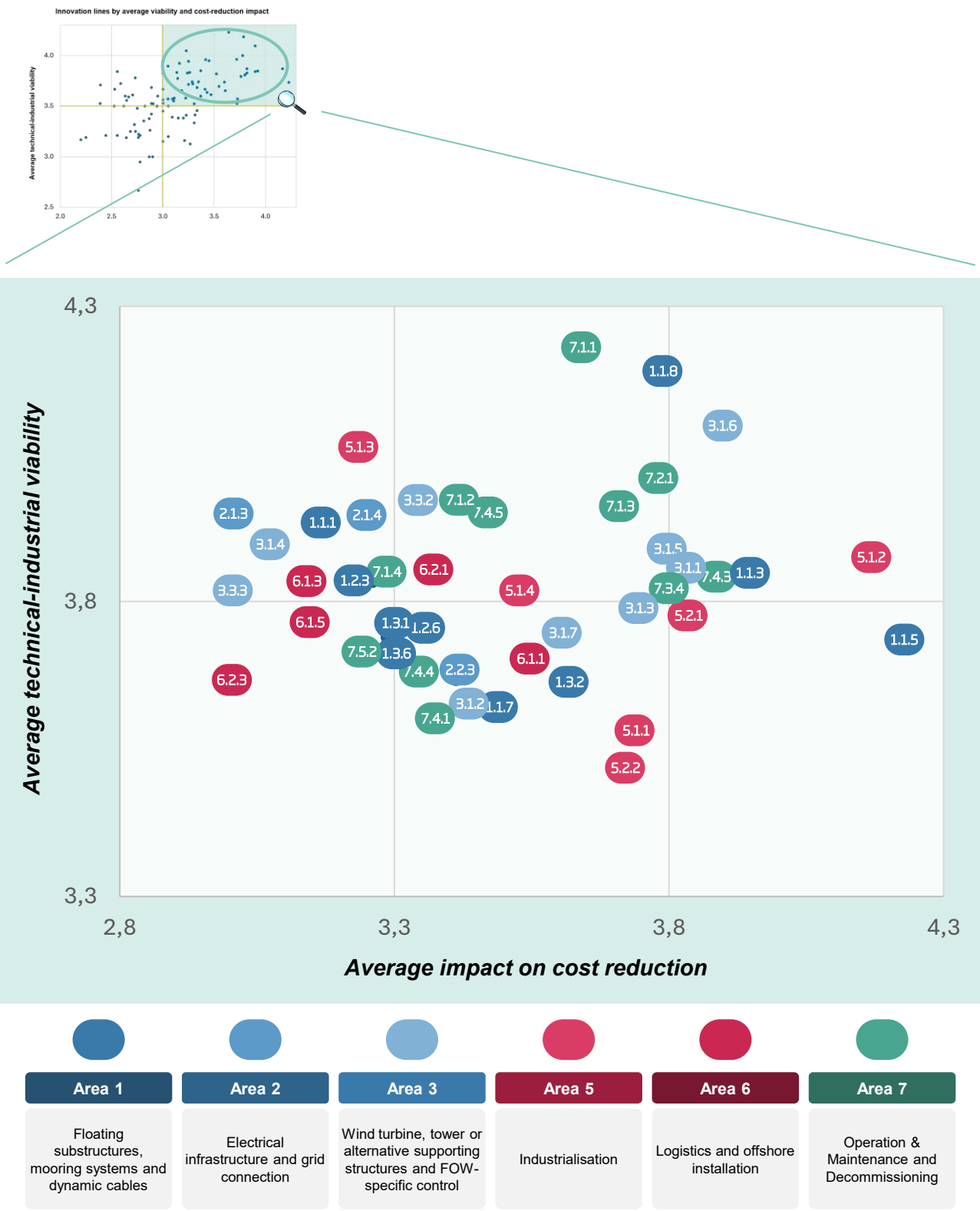
Area 7 stands out as the strongest contributor to the highest Priority Levels, reflecting the growing importance of operation and maintenance strategies that improve asset availability, enable predictive maintenance and reduce lifetime costs. **Areas 1 and 3** also show a high concentration of priority innovation lines, highlighting the central role of floating substructure design and the integration between turbines, towers and floating platforms in achieving commercially competitive floating wind systems. Meanwhile, the favourable profile of **Area 5** underlines the importance attributed to manufacturing scalability, standardisation and industrial processes as key enablers for cost reduction.

By contrast, **Area 4** presents a markedly different prioritisation profile, with all innovation lines falling within PL4 and PL5. This does not imply that wind farm layout design and site planning are unimportant; rather, **stakeholders generally perceive these activities as enabling functions with a more indirect influence on cost reduction than innovations related to technology development, industrialisation or operational performance**.

2.2 Highest-priority innovation lines

Among the 105 innovation lines assessed, **44 are classified within the highest Priority Levels (PL1 and PL2)**. Together, these innovation lines represent the innovation needs **combining the highest expected contribution to cost reduction with the strongest technical-industrial viability**, constituting the **core strategic priorities of the I3FLOAT Strategic Innovation Agenda**.

Relative positioning of the 44 highest-priority innovation lines



The 44 highest-priority innovation lines

The **44 innovation lines** identified as the highest strategic priorities (PL1 and PL2) represent those combining the highest expected contribution to cost reduction with the strongest technical-industrial viability and therefore constitute the core innovation priorities of the Strategic Innovation Agenda.

The **prioritised innovation lines** are presented below, **organised by strategic area and subarea** and **ordered according to their position in the overall Top 44 ranking**. For each innovation line, the **assigned Priority Level (PL1 or PL2)** and its **ranking position** are provided.

Area 1 – Floating substructures, mooring systems and dynamic cables

1 Floating substructures, mooring systems and dynamic cables			
1.1 Design and engineering of floating substructures (floaters)			
1.1.5	Standardisation and modularisation of floating substructures	PL1	#1
1.1.3	Substructure design geared towards O&M and major component replacement	PL1	#4
1.1.8	Component reliability, structural health monitoring and digital twins for floating substructures	PL1	#7
1.1.7	Design of adaptable floating substructures compatible with multiple wind turbine tower configurations	PL2	#35
1.1.1	Multi-criteria hydrodynamic optimisation of floating substructures	PL2	#38
1.2 Mooring and anchoring design			
1.2.6	Mooring connectors and hook-up systems	PL1	#22
1.2.3	Probabilistic fatigue and failure models for mooring and anchoring systems	PL1	#31
1.3 Dynamic submarine cable systems for floating offshore wind			
1.3.6	Development of failure response and protection mechanisms for dynamic submarine cables	PL1	#24
1.3.1	Qualification and standardisation of dynamic cables	PL1	#25
1.3.2	Development of quick-connect and disconnect connectors	PL2	#34

Area 1 places strong emphasis on **improving the maturity, reliability and industrial readiness of floating foundations and their associated systems**. The prioritised innovation lines span the three core building blocks of floating offshore wind (floating substructures, mooring systems and dynamic cables) highlighting the need to optimise the integrated floating system, rather than individual components.

Within **floating substructures**, innovation is primarily directed towards standardisation, modularisation, design for operation and maintenance, structural health monitoring and adaptable platform concepts. Together, these priorities reflect an increasing focus on solutions that simplify industrial deployment and asset management, while placing greater emphasis on strengthening the robustness and scalability of existing concepts than on developing fundamentally new platform designs.

A similar trend can be observed for **mooring systems and dynamic cables**, where long-term reliability, qualification and operational efficiency emerge as the dominant priorities. Advanced connection systems, fatigue prediction, cable protection and standardisation are favoured over more novel mooring configurations or cable concepts, reflecting the importance of reducing technical risk, installation complexity and lifecycle costs.

Taken together, the results indicate that **optimising the integrated floating system** is considered a key enabler for the large-scale deployment of floating offshore wind, with innovation efforts centred on robust, standardised and maintainable solutions.

Area 2 – Electrical infrastructure and grid connection

2 Electrical infrastructure and grid connection



2.1 Floating substations and electrical conversion

2.1.4 Optimisation of intra-array electrical layouts for floating wind farms

PL1

#27

2.1.3 Protection and control systems for dynamic electrical systems

PL2

#42

2.2 Grid management and stability for floating wind farms

2.2.3 Grid-forming capabilities and energy storage integration for floating wind farms

PL1

#20

Area 2 reflects an evolution in innovation priorities from the development of individual electrical components towards the **optimisation of the overall electrical architecture of floating offshore wind farms**. The selected innovation lines focus on how electrical systems are designed, controlled and integrated, highlighting the increasing importance of system-level performance.

The prioritised topics span both internal wind farm design and grid interaction, with particular attention given to **optimised electrical layouts, advanced protection and control systems, and grid-forming capabilities**. This distribution indicates a growing emphasis on improving the resilience, controllability and flexibility of floating wind farms as they become more closely integrated into future power systems.

At the same time, innovations related to substation hardware, thermal management and DC switchgear receive comparatively lower priority, suggesting that **current innovation efforts are increasingly focused on system architecture and operational integration rather than on individual electrical components**.

Area 3 – Wind turbine, tower or alternative supporting structures and FOW-specific control

3 Wind turbine, tower or alternative supporting structures and FOW-specific control



3.1 Adaptation of the wind turbine (WTG) and tower to floating foundation

3.1.6 Adaptation of wind turbine design and control to floating platform dynamics

PL1

#3

3.1.5 O&M-oriented design of the wind turbine and tower for offshore applications

PL1

#6

3.1.1 Adaptive stiffness / Load-tuned structural designs and segmented concepts for floating applications in all phases of the lifecycle

PL1

#8

3.1.3 Standardised interfaces between wind turbine and floater

PL1

#12

3.1.7 Process-oriented standardisation and modular manufacturing of wind turbine components to facilitate integration with floating foundations and accommodate design variability

PL1

#15

3.1.2 Aerodynamic and aero-structural optimisation of wind turbines and blades for floating platforms

PL2

#36

3.1.4 Materials and coatings for wind turbine and tower in floating environments

PL2

#41

3.3 Validation and aero-hydro-servo modelling for FOW

3.3.2 Scaled testing campaigns and numerical-experimental correlation frameworks

PL1

#28

3.3.3 Guidelines for metocean binning and simulation lists for floating wind load analysis

PL2

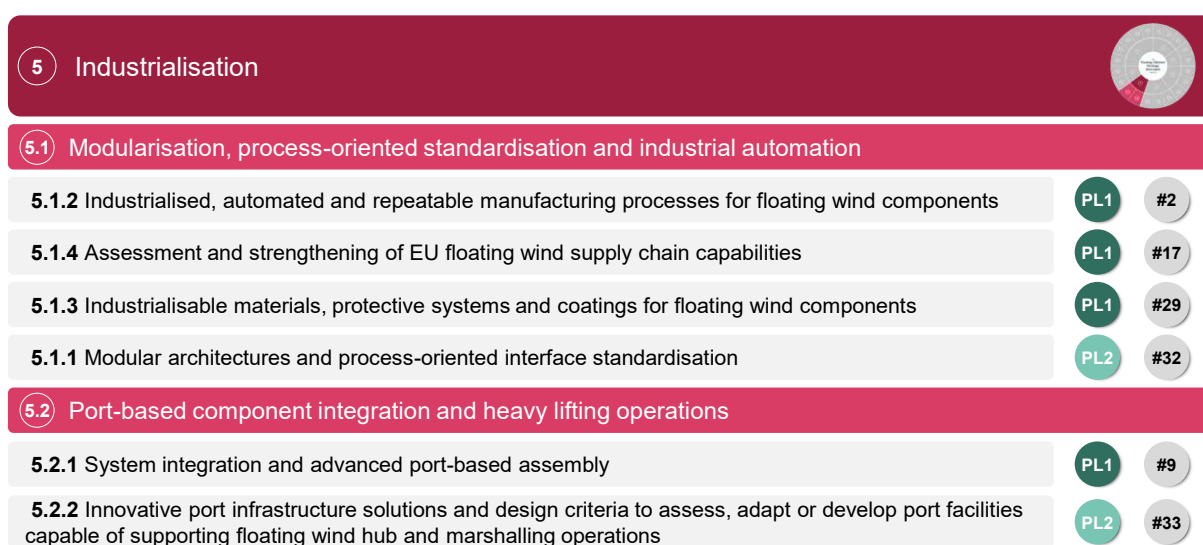
#43

Area 3 highlights the importance of **adapting existing wind turbine technologies to the specific requirements of floating offshore wind**. The prioritised innovation lines concentrate on strengthening the interface between the wind turbine and the floating foundation through structural adaptation, standardisation, modular manufacturing and design solutions that facilitate operation and maintenance.

The strong concentration of prioritised innovation lines within Subarea 3.1 (adaptation of the wind turbine) indicates that **improving compatibility, manufacturability and lifecycle performance is currently viewed as more critical and feasible than advancing floating-specific control strategies**. Notably, none of the innovation lines related to dedicated control systems have been prioritised, reinforcing the importance assigned to achieving robust and industrially deployable turbine–platform integration before further optimising system control.

In addition, the prioritisation of large-scale testing campaigns and numerical–experimental correlation frameworks underlines the need to validate and de-risk solutions under representative operating conditions. Collectively, these priorities suggest that **innovation is increasingly focused on consolidating technology integration and industrial readiness**.

Area 5 – Industrialisation



Area 5 clearly illustrates the **growing importance of industrial capability as floating offshore wind progresses towards commercial deployment**. The prioritised innovation lines concentrate on establishing the manufacturing capacity required to deliver floating wind systems at scale, with particular emphasis on repeatable production processes, modular architectures, industrialisable materials and the strengthening of the European supply chain.

The concentration of priorities within Subarea 5.1 highlights that **innovation is increasingly directed towards developing production systems capable of manufacturing floating technologies efficiently, consistently and at commercial scale**. Standardisation and industrialisation therefore emerge as fundamental enablers for reducing costs while expanding manufacturing capacity across the value chain.

Within port-based integration, the emphasis is placed on assembly operations and port infrastructure, whereas specialised installation vessels and digital solutions for port operations receive comparatively lower priority. This distribution suggests that **expanding physical integration capacity is currently perceived as a more immediate requirement than further optimising operational processes**.

Overall, the results point to **manufacturing readiness and supply chain capability** as essential conditions for strengthening the competitiveness and scalability of floating offshore wind.

Area 6 – Logistics and offshore installation

6 Logistics and offshore installation			
6.1 Logistics, load-out, float-off, wet storage and port-to-site transport			
6.1.1 Industrialised load-out and float-on/float-off solutions in port environments		PL1	#16
6.1.5 Dry transport and internal logistics solutions for large-scale floating wind components within and between fabrication, assembly, storage and port facilities		PL2	#39
6.1.3 Floating transport and optimised towing strategies		PL2	#40
6.2 Offshore installation and hook-up of platforms, cables and mooring systems			
6.2.1 Efficient offshore installation architectures, sequences, procedures and tools to increase operability for the complete system		PL1	#21
6.2.3 Accelerated procedures and SIMOPS for multi-unit installation		PL2	#44

Area 6 highlights the increasing importance of **efficient logistics and installation processes** for the commercial deployment of floating offshore wind. The prioritised innovation lines focus on transport, logistics and installation methodologies capable of supporting the serial deployment of floating wind farms, reflecting the need to improve efficiency across the entire deployment chain.

Particular attention is given to industrialised load-out operations, transport logistics, installation sequences and accelerated procedures for multi-unit deployment. These priorities indicate that **reducing installation time and improving operational efficiency** are currently considered more pressing than advancing highly specialised installation technologies or site-specific solutions.

By comparison, wet storage, automated hook-up technologies and geotechnical characterisation receive lower priority. This distribution highlights a stronger focus on overcoming the principal operational bottlenecks that determine deployment capacity and on streamlining installation workflows to **enable faster and more repeatable project execution**.

Area 7 – Operation, Maintenance and Decommissioning

7 Operation, Maintenance and Decommissioning			
7.1 Data acquisition for O&M digitalisation			
7.1.3 Autonomous Subsea Inspection Systems for Floating Infrastructures	PL1	#13	
7.1.1 Advanced structural and condition monitoring of critical equipment and components using physical sensing and model-based approaches	PL1	#14	
7.1.2 Autonomous aerial and ground-based inspection systems for above-water assets	PL1	#19	
7.1.4 Autonomous sensing and monitoring networks for floating wind environments	PL1	#26	
7.2 Data management and structuring for O&M digitalisation			
7.2.1 Operational digital twins for floating offshore wind behaviour monitoring, load tracking and degradation prediction	PL1	#11	
7.3 Data exploitation for O&M digitalisation			
7.3.4 Digital tools for floating asset lifetime extension assessment	PL1	#10	
7.4 Heavy offshore maintenance and major offshore interventions			
7.4.3 Procedures and tools for offshore replacement of critical components	PL1	#5	
7.4.5 Maintenance strategy trade-off analysis (in situ vs. offshore)	PL1	#18	
7.4.4 Advanced planning, risk modelling and decision-support systems for major interventions	PL1	#23	
7.4.1 Heavy lifting and motion-compensated handling solutions	PL2	#37	
7.5 Decommissioning, repowering and end-of-life strategies of the floating system			
7.5.2 Optimised strategies for removal and tow-back of floating platforms	PL1	#30	

Area 7 adopts a holistic approach to asset management, with the prioritised innovation lines spanning the full operational lifecycle of floating offshore wind assets, from data acquisition and digitalisation to major offshore interventions and end-of-life strategies. The selected priorities reflect the **growing importance of maximising asset performance while reducing lifecycle costs through integrated, data-driven operation and maintenance strategies.**

A strong emphasis is placed on technologies that enable continuous asset awareness through advanced monitoring, autonomous inspection systems and operational digital twins. The prioritisation therefore extends beyond data collection itself, highlighting the value of **transforming operational data into actionable information that supports condition assessment, lifetime extension and maintenance planning.**

The results also demonstrate the importance assigned to improving the execution of major offshore interventions. **Heavy lifting solutions, replacement procedures and decision-support tools receive greater priority than more specialised maintenance assets**, reflecting the need to reduce the complexity, cost and downtime associated with critical interventions.

Finally, the inclusion of **end-of-life strategies** reinforces the importance of considering lifecycle management beyond the operational phase, promoting solutions that remain efficient from deployment through to decommissioning.

2.3 Cross-cutting insights and strategic patterns

The prioritisation exercise identifies the innovation lines expected to make the greatest contribution to the future competitiveness of floating offshore wind. When analysed collectively, the prioritisation results reveal broader technological and industrial patterns that help explain where stakeholders expect innovation to deliver the greatest impact, which challenges are considered most critical for commercial deployment, and how innovation efforts should be balanced across the floating offshore wind value chain. **The cross-cutting insights presented below examine these strategic patterns and discuss their implications for the Strategic Innovation Agenda.**

2.3.1 From technical-industrial viability to cost competitiveness

Across the whole portfolio, **the panel rates viability systematically higher than cost impact:**

- **96 of the 105** lines score higher on technical-industrial viability than on cost reduction.
- The **average technical-industrial viability score** across the portfolio reached **3.58** (out of 5.0), compared with **3.13** for impact on cost reduction.

The European FOW supply chain believes that most of the technologies under consideration can be successfully deployed while their impact on LCOE varies. The implication for the agenda is that the bottleneck is no longer TRL progression in isolation; **it is the demonstration of cost causality – quantified, industrially credible evidence that a given technical solution translates into €/MWh at commercial scale, meaning multi-unit series, 15-20 MW class turbines, and deep-water, challenging metocean sites.**

Consequently, the Strategic Innovation Agenda highlights the need not only to demonstrate the technical-industrial viability of innovative solutions, but also to **provide clear and credible evidence of their potential to reduce the cost of commercial floating offshore wind deployment.** This reinforces the importance of validating innovations against transparent cost baselines, quantifying their expected contribution to cost reduction, and demonstrating their performance at representative commercial scale, where the benefits of industrialisation and repeatability can be fully realised.

2.3.2 Industrialisation and lifecycle optimisation as the main pathways to cost reduction

The prioritisation results indicate that the greatest opportunities for reducing the cost of floating offshore wind no longer lie primarily in developing entirely new technological concepts, but in improving the way projects are designed, industrialised, deployed and operated throughout their lifecycle. This shift is reflected in the highest-priority innovation lines, which consistently favour solutions aimed at **increasing industrial scalability, repeatability and operational efficiency over innovations focused solely on enhancing the performance of individual technologies.**

Only 9 of the 105 innovation lines received a higher score for impact on cost reduction than for technical-industrial viability, and six of these are included within the Top 44 prioritised innovation lines:

Innovation line	Viability	Cost impact	Ranking
1.1.5 Standardisation and modularisation of floating substructures	3.73	4.23	#1
5.1.2 Industrialised, automated and repeatable manufacturing processes	3.87	4.17	#2
1.1.3 Substructure design geared towards O&M and major component replacement	3.85	3.92	#4
7.4.3 Procedures and tools for offshore replacement of critical components	3.84	3.90	#5
5.1.1 Modular architectures and process-oriented interface standardisation	3.57	3.73	#32
5.2.2 Innovative port infrastructure and design criteria for FOW assembly	3.53	3.72	#33

Industrialisation and repeatability

The two innovation lines with the highest expected impact on cost reduction – 1.1.5 Standardisation and modularisation of floating substructures (4.23) and 5.1.2 Industrialised, automated and repeatable manufacturing processes (4.17) – highlight the **importance that stakeholders attribute to industrialisation as a pathway to reducing CAPEX.**

This interpretation is further supported by the position of other innovation lines within the ranking. Purely design-optimisation lines that do not change the industrialisation logic sit far lower: multi-criteria hydrodynamic optimisation (1.1.1) ranks 38 despite high feasibility (3.92) because its cost impact is low (3.16); concrete construction solutions (1.1.6) fall to PL5; specific multirotor designs (1.1.4) rank 93.

This industrialisation strategy extends beyond manufacturing itself. Several highly prioritised innovation lines focus on standardised interfaces, modular architectures and industrialised installation methods, highlighting that **repeatable manufacturing depends not only on the optimisation of individual components but also on their ability to be efficiently integrated across the value chain.**

Overall, the results suggest that the sector is no longer primarily seeking new floating platform concepts, but rather **proven solutions that can be efficiently manufactured, assembled and deployed at commercial scale.**

Design-for-O&M and major component replacement

Beyond manufacturing and industrialisation, the prioritisation exercise also highlights **lifecycle optimisation as one of the main pathways to reducing the cost of floating offshore wind.** Three of the top six innovation lines in the entire ranking are the same underlying idea expressed at three different points of the value chain:

Innovation line		Cost impact	Ranking
1.1.3	Substructure design geared towards O&M and major component replacement	3.92	#4
7.4.3	Procedures and tools for offshore replacement of critical components	3.90	#5
3.1.5	O&M-oriented design of the wind turbine and tower for offshore applications	3.82	#6

Other highly prioritised innovation lines include maintenance strategy trade-offs between in-situ repair and tow-to-port operations (7.4.5, rank 18), planning and decision-support tools for major offshore interventions (7.4.4, rank 23), removal and tow-back strategies (7.5.2, rank 30), and motion-compensated lifting technologies (7.4.1, rank 37).

The industry has converged on major component exchange as the defining unresolved operational problem of floating wind. Because tow-to-port implies disconnection, transit, quay slot, re-installation and lost production – and because jack-up vessels are unavailable at floating sites – the panel pushes the solution upstream into design: replacement paths, crane provisions, motion-compensated handling and modular interfaces specified at platform and turbine design stage rather than solved later by vessel innovation. Notably, the vessel-side answer alone (7.4.2, specialised offshore vessels and floating support platforms) falls just outside the priority set at rank 48, and the disconnect-and-tow answer (7.5.1) at rank 54.

2.3.3 System integration and digitalisation as cross-cutting enablers

The prioritisation exercise also identifies **system integration and digitalisation as key enablers supporting the next stage of floating offshore wind development.** These themes span multiple strategic areas and contribute to improving the design, operation and long-term performance of floating wind systems through greater integration of technologies and more effective use of operational data.

Digitalisation: from monitoring to decision-making

The prioritisation results indicate that **digitalisation and advanced monitoring technologies are among the most technically mature innovation domains** within the Strategic Innovation Agenda. Innovation lines related to advanced structural and condition monitoring (7.1.1), structural health monitoring and digital twins (1.1.8), operational digital twins (7.2.1) and autonomous inspection systems (7.1.2 and 7.1.3) all receive some of the highest technical-industrial viability scores across the portfolio.

However, stakeholders show less consensus regarding their expected contribution to cost reduction. While there is broad confidence in the maturity of sensing, monitoring and autonomous inspection technologies, some uncertainty remains around their ability to generate measurable economic benefits under commercial operating conditions.

From a technical perspective, sensing and autonomy are no longer the constraint; the decision layer is. Data acquisition (subarea 7.1) converts 4 of 8 lines into the priority set, but the lines that create economic value from that data – operational digital twins (7.2.1, rank 11) and lifetime extension assessment (7.3.4, rank 10) – are exactly the ones where dispersion is greatest, because their payback depends on inspection-interval extension, avoided vessel mobilisations and certified life extension, none of which is yet supported by an accepted evidence base or by class and certification frameworks.

System integration: designing the floating wind system as a whole

Subarea 3.1 (adaptation of the turbine and tower to floating foundations) is the only subarea in which all innovation lines have been prioritised: all 7 of its lines enter the prioritised 44, and 5 of them are PL1. It also records the highest subarea cost-impact average (3.62) of the 20 sub-areas. Its content is consistent: adaptation of turbine design and control to platform motion (3.1.6, rank 3), adaptive stiffness and load-tuned segmented structures (3.1.1, rank 8), standardised turbine–floater interfaces (3.1.3, rank 12), process-oriented standardisation of turbine and tower manufacturing (3.1.7, rank 15), aero-structural optimisation (3.1.2, rank 36), materials and coatings (3.1.4, rank 41) and O&M-oriented design (3.1.5, rank 6).

The contrast with subarea 3.2 is analytically important. Subarea 3.2 – control strategies implemented on top of existing systems – places none of its three innovation lines within the two highest Priority Levels; model-based and feedforward control integrated into existing systems (3.2.1) ranks 99 of 105. The only 3.2 line that comes close is 3.2.3, integrated co-control of floater, turbine and mooring, at rank 47. Taken together, these results suggest that stakeholders attribute greater strategic value and feasibility to the integrated design of turbines, towers, floating foundations and mooring systems than to adapting conventional onshore-derived turbine concepts through advanced control strategies alone. **This reinforces the need for closer collaboration between turbine manufacturers, floating foundation designers and project developers throughout the design process, ensuring that the different subsystems are engineered as a single integrated system.**

Supporting this, the validation lines behave accordingly: scaled testing campaigns with numerical–experimental correlation (3.3.2) enter at rank 28, while broader modelling lines – reduced-order tools (3.3.1, rank 55) and coupled aero-hydro-servo modelling under representative metocean conditions (1.1.2, rank 50) – fall just outside. **The panel prioritises validated coupled behaviour over additional simulation capability.**

2.3.4 Strategic interpretation of lower-priority innovation areas

One of the clearest patterns emerging from the prioritisation exercise is the **limited representation of innovation lines related to wind farm layout design and site planning (Area 4)**. None of the fifteen innovation lines within this strategic area is included among the 44 highest-priority innovation lines. Consistent with this result, Area 4 records the lowest average score for impact on cost reduction of all seven strategic areas (2.67, compared with a portfolio average of 3.13), with innovation lines such as Cumulative impact assessment (4.3.6) and Environmental risk assessment tools in the planning phase (4.1.3) ranking 104th and 103rd, respectively.

These results should not be interpreted as a lack of strategic importance. Stakeholders consistently recognise that spatial planning, permitting and environmental assessment are essential for the successful deployment of floating offshore wind projects. However, within the framework of this prioritisation exercise, **these activities are generally perceived as having a more limited direct contribution to reducing project costs than innovations targeting industrialisation, system integration or operation and maintenance.**

This interpretation is reinforced by the performance of Anchor and mooring line sharing between platforms (4.2.4), the highest-ranked innovation line within Area 4. Unlike the other innovation lines in the area, **this solution directly reduces infrastructure requirements, installation activities and offshore operations, providing a clearer pathway towards CAPEX reduction.**

A similar pattern can be observed in electrical infrastructure and grid connection (Area 2). Although three of its eight innovation lines are included within the Top 44, the area is characterised by high technical-industrial viability but a comparatively lower expected contribution to cost reduction. For example, Protection and control for dynamic electrical systems (2.1.3) receives one of the highest technical-industrial viability scores in the area (3.94). However, because its expected impact on cost reduction is comparatively lower, it is positioned 42nd in the overall prioritisation.

Overall, these findings highlight an important distinction between strategic importance and prioritisation. **Some innovation areas are essential to enable the deployment of floating offshore wind projects, even if their direct contribution to cost reduction is perceived to be lower than that of other innovation domains.**

2.3.5 A lifecycle perspective on the innovation priorities

A final cross-cutting perspective emerges when the 44 highest-priority innovation lines are examined according to the sequence of activities involved in the development of floating offshore wind projects, rather than by strategic area. Viewed from this perspective, **the prioritised portfolio spans almost the entire project lifecycle, from integrated system design through manufacturing, installation, operation and ultimately decommissioning.**

	Prioritised lines	Coverage
Design and construction		
Site characterisation and layout	–	Not represented
Integrated system design (turbine–floater–mooring)	3.1.6, 3.1.1, 3.1.2, 3.1.4, 1.1.1, 1.1.7, 1.2.3	Strong representation
Design for manufacture and for O&M	1.1.5, 1.1.3, 3.1.5, 3.1.7, 5.1.1	Strong representation
Electrical connection and grid	2.1.4, 2.1.3, 2.2.3	Limited representation
Validation and qualification	3.3.2, 3.3.3, 1.3.1	Strong representation
Industrialisation, logistics and offshore installation		
Series manufacturing and supply chain	5.1.2, 5.1.3, 5.1.4	Strong representation
Port integration and load-out	5.2.1, 5.2.2, 6.1.1	Strong representation
Tow-out, installation and hook-up	6.1.3, 6.1.5, 6.2.1, 6.2.3, 1.2.6, 1.3.2, 1.3.6, 3.1.3	Strong representation
O&M and decommissioning		
Operation, monitoring and diagnosis	7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.2.1, 7.3.4, 1.1.8	Strong representation
Heavy maintenance and component replacement	7.4.3, 7.4.4, 7.4.5, 7.4.1	Strong representation
Decommissioning and life extension	7.5.2, 7.3.4	Strong representation

The distribution of the prioritised innovation lines reveals a balanced innovation portfolio rather than a concentration on any single stage of development. **Strong representation is observed across integrated system design, design for manufacture, validation, industrialisation, installation and operation**, indicating that stakeholders consider progress across these stages to be mutually reinforcing.

The strongest concentration of prioritised innovation lines is found in the early engineering and industrialisation phases, highlighting the importance attributed to decisions taken before deployment. At the same time, the consistent presence of innovation lines related to operation, inspection, maintenance and end-of-life management demonstrates that long-term asset performance is considered an integral part of improving the competitiveness of floating offshore wind, rather than a separate operational challenge.

The lifecycle perspective also reinforces two of the patterns identified throughout this chapter. First, **no innovation lines related to site characterisation and wind farm layout design are included within the prioritised portfolio**, reflecting the comparatively limited direct contribution of these activities to cost reduction despite their importance for project development. Second, electrical infrastructure and grid connection is represented by a smaller number of innovation lines than other lifecycle stages, supporting the view that **stakeholders primarily regard this domain as an enabling technology rather than one of the principal drivers of cost competitiveness.**

Overall, the prioritisation results suggest that achieving commercially competitive floating offshore wind will depend on coordinated advances throughout the entire lifecycle. The Strategic Innovation Agenda therefore identifies not a single technological pathway, but a **coherent portfolio of complementary innovations that collectively support the industrial deployment and long-term operation of floating offshore wind projects.**

2.4 Key conclusions

The **prioritisation exercise** has identified the innovation lines expected to deliver the greatest contribution to the competitiveness of floating offshore wind. Taken together, however, the results provide a **broader strategic perspective on how the sector is expected to evolve** over the coming years. Rather than highlighting individual technological priorities, the assessment reveals the characteristics of the future floating offshore wind industry: an industry driven by **industrialisation, integrated system design, lifecycle optimisation** and **stronger collaboration across the value chain**. The following key conclusions summarise the principal strategic messages emerging from the prioritisation exercise and their implications for the Strategic Innovation Agenda.

Floating offshore wind is entering a new phase of industrial maturity

Floating offshore wind is entering a **new phase of industrial maturity**. While advancing technology remains essential, future competitiveness will increasingly depend on the **industry's ability to industrialise mature solutions, scale manufacturing processes and optimise project delivery throughout the asset lifecycle**. Rather than identifying the need for fundamentally new technological concepts, stakeholders consistently prioritised innovation aimed at improving repeatability, standardisation, integration and operational efficiency.

This evolution marks a **transition from technology demonstration towards industrial deployment** at commercial scale. The challenge is no longer limited to demonstrating that innovative technologies can function under offshore conditions, but to ensuring that proven solutions can be deployed **reliably, manufactured at scale and deliver measurable reductions in project costs** under commercial operating conditions. The **Strategic Innovation Agenda** therefore promotes an innovation model in which industrial deployment becomes as important as technological development, placing greater emphasis on scalability, manufacturability and lifecycle performance.

Competitiveness will depend on coordinated innovation across the value chain

The future competitiveness of floating offshore wind will depend not on isolated technological advances, but on the **coordinated evolution of the entire value chain**. The highest-priority innovation lines span integrated **system design, industrialisation, manufacturing, installation, operation and maintenance**, highlighting that cost reduction can only be achieved by optimising the interactions between these stages rather than maximising the performance of individual technologies.

This systems perspective is one of the strongest messages emerging from the **Strategic Innovation Agenda**. Decisions taken during the design phase directly influence manufacturing efficiency, installation strategies shape future operational requirements, and maintenance considerations increasingly inform engineering choices from the earliest stages of project development.

Achieving commercially competitive floating offshore wind will therefore require a **fully integrated approach** in which technological, industrial and operational advances are developed in a coordinated manner across the entire value chain. Many of the highest-priority innovation lines cannot be successfully delivered by **individual organisations acting independently**, but instead require **coordinated** action between turbine manufacturers, floating foundation designers, developers, ports, installation contractors, certification bodies, research and technology organisations, and public authorities. **Strengthening collaboration across the floating offshore wind ecosystem** will therefore be as important as technological innovation itself for accelerating industrial deployment and long-term competitiveness.

Technology validation should increasingly demonstrate industrial value

The **prioritisation results** indicate that the criteria for successful innovation in floating offshore wind are evolving. Demonstrating **technical performance under representative conditions** remains an essential step. Increasingly, however, **successful innovation** will also be expected to **demonstrate** that new solutions can be **manufactured efficiently, integrated into industrial processes, deployed at commercial scale and deliver tangible economic benefits throughout the project lifecycle**.

This evolution calls for a **broader understanding of technology validation**. Beyond confirming technical performance, innovation activities should **increasingly demonstrate that new solutions can be manufactured efficiently, integrated into industrial processes, deployed at commercial scale and deliver tangible economic benefits** throughout the project lifecycle.

This shift is particularly relevant for **digital technologies**. Their future contribution to competitiveness will depend not only on their ability to generate operational data, but also on demonstrating that this information can support better operational decisions, reduce maintenance interventions, optimise asset management and gain acceptance within certification and regulatory frameworks.

The **Strategic Innovation Agenda** therefore suggests that future innovation activities should increasingly **prioritise solutions capable of demonstrating industrial value** alongside technological performance, ensuring that promising technologies can be replicated at scale and translated into measurable improvements in the competitiveness of floating offshore wind.

A shared strategic direction for the future of floating offshore wind

The transition towards commercial-scale floating offshore wind requires a **shared vision of where innovation efforts should be concentrated**. Achieving this shared vision will depend not only on technological progress, but also on the ability of the sector to **align its efforts** around a common set of strategic priorities, enabling industry, research and technology organisations, public authorities and funding bodies to move in the same direction.

In this context, the **Strategic Innovation Agenda** provides a common **strategic framework** for the European floating offshore wind ecosystem. By identifying the technological, industrial and operational priorities expected to make the greatest contribution to future competitiveness, it helps focus investment, strengthen collaboration and promote a more coordinated approach to innovation across the value chain.

As the sector continues to mature, maintaining this shared strategic direction will be essential to maximise the impact of future innovation efforts. More than a prioritisation exercise, **the Strategic Innovation Agenda provides a common basis for coordinated action, supporting the industrialisation, competitiveness and long-term resilience of the European floating offshore wind sector**.

3

Life-Cycle-Based Structure: Innovation Areas, Subareas and Lines



Life-Cycle-Based Structure: Innovation Areas, Subareas and Lines

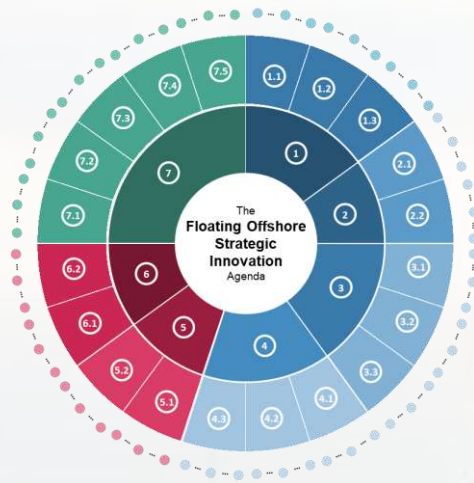
Chapter 3 presents the innovation areas, subareas and innovation lines identified through the Agenda, organised following a life-cycle-based structure across the different phases of floating offshore wind projects.

On this basis, the content is organised into **three main blocks** that reflect the different phases through which a floating offshore wind project evolves over its lifetime.

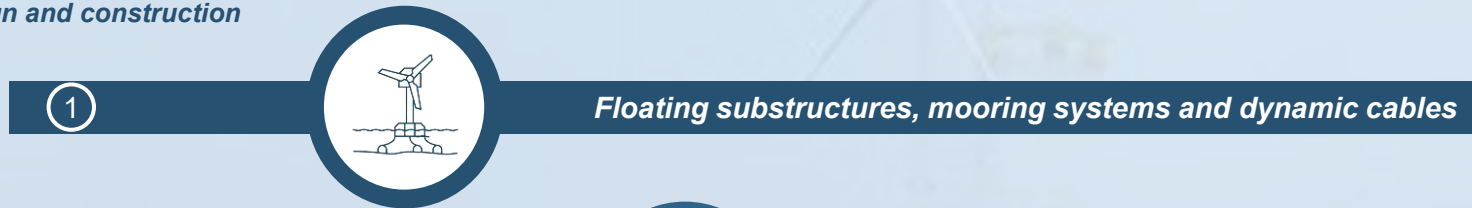
The **first block** corresponds to the **design and construction phases**, which form the foundation of technological development. This block encompasses **Areas 1 to 4** and addresses the key challenges related to the conception, design, validation and early integration of floating systems and wind farms, while considering technical, operational and environmental aspects from the initial stages.

The **second block** focuses on the **industrialisation, logistics and offshore installation phases**, which enable the deployment of technological solutions under real operating conditions. This block includes **Areas 5 and 6**, where innovation efforts are oriented towards industrial scale-up and the optimisation of logistics and installation processes, with the objective of improving efficiency, reducing costs and minimising risks during project execution.

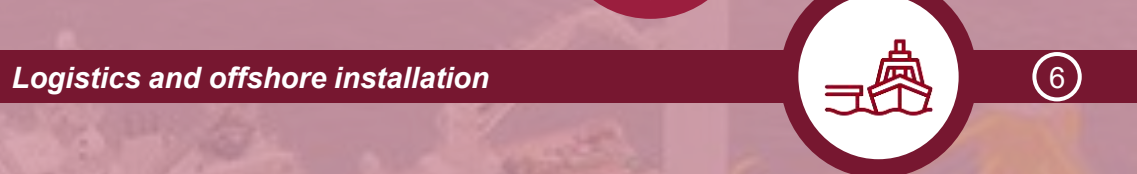
Finally, the **third block** corresponds to the **operation, maintenance and decommissioning phases**, addressed in **Area 7**. This final stage of the life cycle covers the challenges associated with the long-term management of assets, with the aim of maximising performance, extending operational lifetime and ensuring a sustainable and responsible end-of-life for floating offshore wind projects.



Design and construction

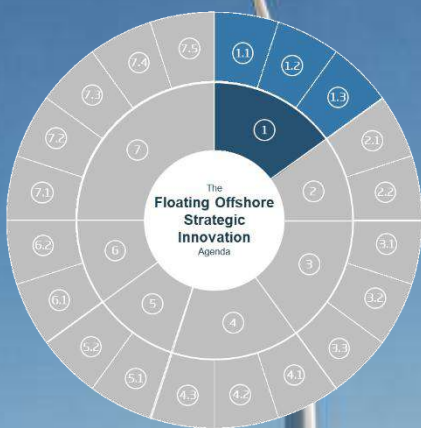


Industrialisation, logistics and offshore installation



O&M and decommissioning





Innovation Area 1

Floating substructures, mooring systems and dynamic cables

[Back to Innovation Areas](#)



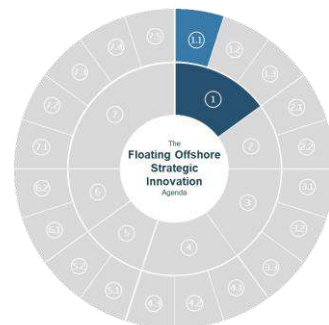
Subarea 1.1 Design and engineering of floating substructures (floaters)



Subarea 1.2 Mooring and anchoring design



Subarea 1.3 Dynamic submarine cable systems for floating offshore wind



Subarea 1.1 - Design and engineering of floating substructures (floaters)

Floating substructures are the foundation of floating offshore wind systems, determining their stability, structural behaviour and long-term operational performance. This subarea brings together the innovation required to **optimise floater design through advanced hydrodynamic analysis, coupled aero-hydro-servo modelling and engineering solutions** that enhance reliability, adaptability and lifecycle performance under representative operating conditions.

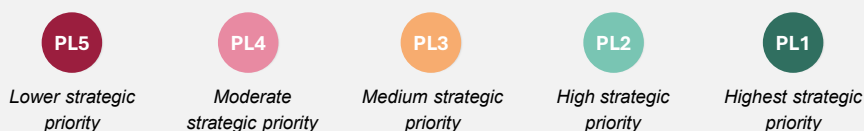
Innovation encompasses modular and standardised platform concepts, adaptable substructure designs and construction solutions that **improve manufacturability and deployment flexibility**. It also promotes operation and maintenance-oriented design, structural health monitoring, digital twins and biofouling-aware approaches to **enhance long-term reliability, facilitate major component replacement and support the industrial deployment of floating offshore wind**.

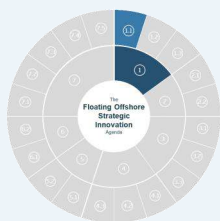
Innovation lines

- PL2 **1.1.1 Multi-criteria hydrodynamic optimisation of floating substructures:** optimisation methods to reduce movements and loads under different meteorological and oceanographic conditions.
- PL2 **1.1.2 Coupled aero-hydro-servo modelling under representative metocean conditions:** integrated tools capturing rotor-floater-environment interaction.
- PL1 **1.1.3 Substructure design geared towards O&M and major component replacement:** design criteria that facilitate accessibility, manoeuvring and replacement of major components.
- PL3 **1.1.4 Specific multirotor design:** substructure process design for multirotor solutions.
- PL1 **1.1.5 Standardisation and modularisation of floating substructures:** common interfaces and modules to enable mass production and reduce industrial complexity and costs.
- PL3 **1.1.6 Concrete construction solutions for floating substructures:** industrialised processes for concrete substructures, including sliding formwork, supporting scalable and efficient industrial production.
- PL2 **1.1.7 Design of adaptable floating substructures compatible with multiple wind turbine tower configurations.**
- PL1 **1.1.8 Component reliability, structural health monitoring and digital twins for floating substructures:** development and integration of monitoring systems, data-driven models and digital twin approaches to assess structural integrity under cyclic loads and extreme metocean events, enabling lifetime extension and improved maintenance planning.
- PL4 **1.1.9 Biofouling-aware design of floating substructures:** integration of marine biofouling effects into structural and hydrodynamic design to ensure long-term functionality and performance.



Priority level





Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.1 Multi-criteria hydrodynamic optimisation of floating substructures

Development and application of multi-criteria hydrodynamic optimisation methods for floating substructures, aiming to reduce structural loads and improve global dynamic response (e.g. motion amplitudes, acceleration levels and energy capture) under a wide range of meteorological and oceanographic conditions, while accounting for coupled floater–mooring–control interactions.



Priority level



Current TRL



Technological Objective

To improve floating substructure performance by optimising hull geometry and hydrodynamic behaviour, balancing multiple design criteria such as motions, loads, stability, structural response and response to waves, while accounting for site-specific metocean conditions and key system-level interactions.



Specific Actions

- Application and refinement of existing multi-criteria hydrodynamic optimisation approaches to floating substructure design, considering motions, loads, stability and cost-related drivers
- Integration of hydrodynamic optimisation workflows into early-stage and FEED-level floating wind design processes
- Assessment of coupled floater–mooring–control interactions and their influence on hydrodynamic optimisation outcomes
- Evaluation of reduced-order, surrogate and uncertainty-aware optimisation approaches for accelerated design-space exploration
- Validation using scaled physical model tests where appropriate, to confirm numerical predictions and optimisation outcomes under representative conditions



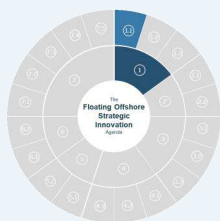
Validation and Trial Needs

- Verification of optimised designs through high-fidelity numerical hydrodynamic simulations against defined performance metrics (e.g. motion response, load reduction, fatigue behaviour and stability criteria)
- Comparison of optimised and baseline substructure designs to quantify performance improvements based on defined optimisation criteria and key performance indicators
- Assessment of global dynamic behaviour, including natural frequencies and representative coupled loading conditions, under operational and extreme metocean scenarios
- Validation using scaled physical model tests where appropriate



Expected Results

- Reduced hydrodynamic loads acting on floating substructures
- Improved global response and dynamic robustness of floating platforms under varying metocean conditions
- More robust and efficient hull designs supporting downstream structural and system-level optimisation



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.2 Coupled aero-hydro-servo modelling under representative metocean conditions

Development and application of fully coupled aero-hydro-servo-elastic numerical models for floating wind systems, enabling end-to-end system-level modelling by integrating rotor aerodynamics, floating substructure hydrodynamics and structural response, mooring system dynamics and control systems under representative and extreme metocean conditions.



Priority level



Current TRL



Technological Objective

To improve the accuracy and reliability of system-level simulations for floating wind systems, enabling robust prediction of coupled aerodynamic, hydrodynamic, structural and mooring responses to support design optimisation, control strategies and risk reduction.



Specific Actions

- Enhancement of coupled aero-hydro-servo-elastic modelling frameworks for floating systems
- Improved representation of non-linear hydrodynamic effects, aerodynamic-control interactions, structural flexibility and mooring dynamics
- Definition of representative metocean load cases for floating wind applications, including extreme and combined loading conditions
- Benchmarking and harmonisation of modelling approaches and assumptions
- Assessment of surrogate and reduced-order modelling approaches to support accelerated simulation and design workflows



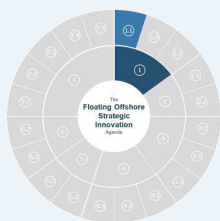
Validation and Trial Needs

- Verification against scaled physical model tests and available full-scale monitoring data, including the definition of benchmark cases and cross-validation against existing numerical tools and tank test results
- Cross-comparison of numerical tools using agreed reference cases to assess consistency and reliability of results, as well as sensitivity and uncertainty analyses to assess model robustness
- Assessment of model performance under representative extreme and coupled metocean loading scenarios



Expected Results

- Increased confidence in system-level design loads, dynamic behaviour and performance predictions for floating wind systems
- Reduced design conservatism and uncertainty margins
- Improved basis for control system development and integrated design decisions



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.3 Substructure design geared towards O&M and major component replacement

Design of floating substructures incorporating O&M-driven criteria to directly reduce operational costs, inspection requirements and major component replacement complexity, enabling safe access, inspection, maintenance and replacement of major wind turbine components through optimised geometry, layout and integration with support and lifting systems.



Priority level



5 4 3 2 1



Current TRL



5 6 7 8 9



Technological Objective

To reduce operational downtime, inspection requirements, logistical complexity and life-cycle costs by integrating O&M and major component replacement requirements into the early design of floating substructures.



Specific Actions

- Definition of design criteria for accessibility, manoeuvrability and safe working conditions on floating substructures
- Integration of concepts for major component replacement (for example, blades, nacelle, drivetrain) in floating configurations
- Assessment of interfaces with vessels, lifting solutions and port-based or offshore strategies
- Evaluation of O&M-driven design trade-offs at system level
- Assessment of ballast system lifecycle considerations, including corrosion management, inspection accessibility, ballast operations and implications for maintenance, repair and decommissioning activities



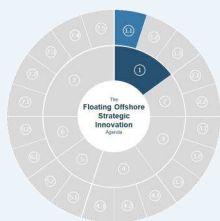
Validation and Trial Needs

- Simulation of O&M and major component replacement scenarios under representative offshore conditions, including case studies and associated success metrics (e.g. reduction in replacement time, cost and downtime)
- Validation through pilot projects, demonstrators or operational experience, including the assessment of defined performance and success metrics
- Numerical assessment of ballast system behaviour, corrosion mitigation approaches and operational constraints during representative lifecycle phases
- Validation using scaled physical model tests where appropriate



Expected Results

- Reduced O&M costs and downtime for floating wind turbines
- Increased feasibility of major component replacement strategies offshore or nearshore
- Improved operational safety and lifecycle performance



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.4 Specific multirotor design

Development and assessment of floating substructure process design approaches tailored to multirotor wind turbine concepts, supporting a promising pathway to reduce cost per MW by optimising load distribution, global stability and integration constraints associated with multiple rotors on a single floating platform.



Priority level



Current TRL



Technological Objective

To enable technically feasible and scalable floating multirotor solutions through dedicated substructure design approaches that account for the specific aerodynamic, structural and operational characteristics of multirotor configurations.



Specific Actions

- Definition of substructure design requirements for multirotor floating systems
- Development of design methodologies and tools adapted to multirotor concepts
- Analysis of load paths, structural interactions and dynamic coupling between multiple rotors and the floating platform
- Development of hybrid numerical-experimental approaches for modelling aerodynamic forces during wave-basin testing of multirotor floating wind systems
- Assessment of manufacturability, transport, installation and O&M implications of multirotor substructures



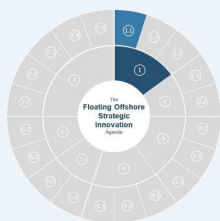
Validation and Trial Needs

- Validation of multirotor-specific substructure design approaches through advanced numerical modelling (e.g. multibody simulation) and comparative studies against single-rotor reference configurations
- Assessment of global load paths, stability margins and dynamic behaviour under representative floating wind conditions, supported by wind-tunnel and/or wave-basin testing of representative multi-turbine models



Expected Results

- Improved understanding of multirotor-specific substructure behaviour
- Design methodologies enabling reliable and optimised multirotor floating platforms
- Reduced technical uncertainty for future multirotor floating wind developments



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.5 Standardisation and modularisation of floating substructures

Development of standardised and modular design frameworks for floating substructures, aligned with industry trends towards modularisation for large-scale deployment, based on repeatable structural modules and common interfaces, enabling industrial series production through consistent fabrication, assembly and integration processes across floating wind projects.



Priority level



Current TRL



Technological Objective

To enable industrial-scale deployment of floating wind substructures by reducing design variability and engineering effort through modular construction approaches, while allowing controlled adaptation to different turbine configurations, site conditions, water depths and structural requirements without compromising fabrication and assembly efficiency.



Specific Actions

- Identification and definition of common structural and functional interfaces between substructure modules, turbine tower, mooring systems and auxiliary equipment
- Assessment of load transfer, tolerances and structural continuity at modular interfaces
- Development of modular substructure architectures allowing configuration flexibility without full redesign
- Evaluation of repeatable industrial processes for modular fabrication, assembly, transport and integration



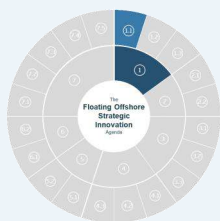
Validation and Trial Needs

- Numerical verification of structural, hydrodynamic and dynamic performance of modular configurations
- Prototype manufacturing and assembly of representative modules to validate interfaces, tolerances, compliance with standardisation requirements and construction sequences
- Demonstration of modular integration at pilot or pre-commercial project scale, including verification of standardised interfaces and assembly tolerances under realistic conditions



Expected Results

- Increased use of repeatable structural modules and common interfaces across floating substructure designs
- Improved scalability, consistency and efficiency of fabrication, assembly and integration processes for floating wind substructures
- Reduction of project-specific engineering effort and industrial complexity, supporting progressive industrialisation of floating wind



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.6 Concrete construction solutions for floating substructures

Development and optimisation of industrialised construction processes for concrete floating substructures, leveraging the structural, durability and cost advantages of concrete in marine environments. The line includes advanced concrete mix designs, reinforcement solutions and industrial construction techniques, such as sliding and climbing formwork, to improve structural performance, durability, production scalability and cost-efficiency.



Priority level



Current TRL



Technological Objective

To enable scalable and cost-effective deployment of concrete floating substructures by advancing industrial construction methods, concrete mix optimisation and reinforcement solutions that ensure structural quality, dimensional accuracy and long-term durability in offshore environments.



Specific Actions

- Adaptation of sliding and climbing formwork techniques to floating substructure geometries and construction sequences
- Development and optimisation of concrete mix designs, reinforcement solutions and construction materials suitable for offshore exposure, long-term durability and industrialised production
- Assessment of construction tolerances, quality control, repeatability and cost-efficiency in industrialised concrete fabrication processes
- Evaluation of interfaces between concrete substructures and steel components, mooring systems and towers
- Evaluation of pumping, placing and curing methodologies for large-scale concrete floating structures under representative industrial conditions



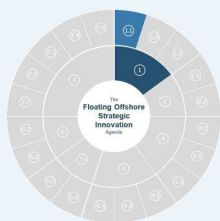
Validation and Trial Needs

- Prototype construction of representative concrete substructure elements using industrialised processes
- Validation of pumping, placing and curing procedures through representative industrial-scale trials
- Structural, durability and fatigue testing under representative environmental conditions, including accelerated ageing tests for concrete mixes and materials
- Monitoring of pilot or demonstration projects to validate construction quality, structural performance and long-term durability



Expected Results

- Reduced construction costs and improved scalability of concrete floating substructures
- Enhanced durability, reduced maintenance requirements and improved lifecycle cost-efficiency
- Increased industrial maturity and manufacturability of concrete-based floating solutions



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.7 Design of adaptable floating substructures compatible with multiple wind turbine tower configurations

Development of floating substructures with adaptable tower-floater interfaces to accommodate multiple wind turbine tower configurations within a defined geometry and load envelope. The line targets platform reuse across turbine suppliers and upscaling scenarios, reducing redesign effort while maintaining industrial manufacturability and integration readiness.



Priority level



Current TRL



Technological Objective

To enable reuse of a standard floater platform across multiple wind turbine configurations by standardising the tower-floater interface and defining the compatibility envelope in terms of turbine ratings, tower geometries, load sets and integration constraints, while ensuring stability, motions and structural margins under representative metocean conditions.



Specific Actions

- Definition of system compatibility envelope (geometry, loads, tolerances and design limits) for target turbine configurations, including tower, RNA and relevant interface constraints
- Development of modular interface / transition components and standardised load-transfer details (adapters, joints and bolted/flanged concepts), considering integration constraints related to tower access and internal equipment arrangement
- Integration of coupled aero-hydro-servo-elastic and structural checks into concept and FEED workflows to derive design rules across representative configuration ranges



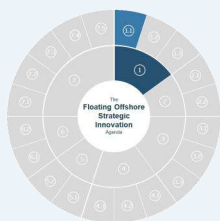
Validation and Trial Needs

- Verification through high-fidelity coupled simulations (ULS/FLS) across representative tower variants and site conditions, with particular focus on worst-case load combinations
- Detailed verification of interface integrity (local stresses, joints, fatigue hot-spots), accounting for tolerance and assembly sensitivity while ensuring structural margins across all configuration variations
- Prototype or scaled trials focused on interface behaviour, supported by pilot integration testing and assessment of manufacturability and installation sequence feasibility



Expected Results

- Adaptable tower-floater interface enabling turbine interchangeability within a defined envelope
- Reduced redesign and FEED rework when turbine/tower selection changes, shortening integration lead time
- Increased platform standardisation supporting serial manufacturing and repeatable integration/installation



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)



1.1.8 Component reliability, structural health monitoring and digital twins for floating substructures

Development and integration of reliability and structural health monitoring (SHM) solutions for floating substructures, combining sensor systems, data acquisition/management and hybrid (physics + data-driven) models to enable digital twins. The line targets early detection of degradation, improved integrity management and condition-based maintenance through actionable KPIs (fatigue, corrosion, joint integrity, motions/loads) and decision support for inspection and operations, with particular attention to ballast tanks, welded joints and other fatigue- and corrosion-sensitive areas.



Priority level



5 4 3 2 1



Current TRL



5 6 7 8 9



Technological Objective

To increase floater availability and lifetime by deploying integrated SHM + digital twin solutions that quantify structural condition, predict degradation and support risk-based inspection and maintenance under real operating conditions.



Specific Actions

- Perform degradation and failure mode analysis for critical floating substructure components and systems, identifying fatigue- and corrosion-sensitive areas to support SHM architecture definition
- Build hybrid digital twin models linking measured responses to loads, fatigue damage and remaining useful life (RUL) estimates
- Develop integrated SHM architectures (sensors, DAQ, telemetry and edge processing) tailored to critical floater components and degradation hotspots, including ballast tanks and welded connections, while addressing data integration, interoperability and system scalability challenges
- Define reliability KPIs, alert thresholds and decision workflows (inspection planning, repair triggers) compatible with O&M systems and risk-based integrity management approaches



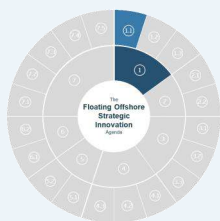
Validation and Trial Needs

- Lab and component-level validation of sensors and mounting solutions (durability, drift, marine environment, calibration)
- Offshore pilot deployment on representative operating floaters to validate anomaly detection, KPI accuracy and model updating across defined monitoring systems
- Demonstration of end-to-end integration (data pipeline, cybersecurity, SCADA/O&M interfaces) and performance benchmarking against baseline O&M practices



Expected Results

- Earlier detection of degradation and reduced unplanned interventions through condition-based maintenance
- Improved structural integrity management with quantified fatigue/corrosion evolution and RUL prediction
- Reduced inspection cost and downtime via risk-based inspection planning and digital evidence for decision-making



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.1 Design and engineering of floating substructures (floaters)

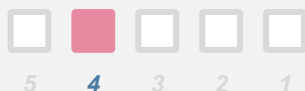


1.1.9 Biofouling-aware design of floating substructures

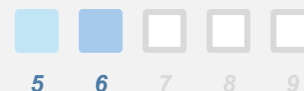
Integration of marine biofouling effects into the structural and hydrodynamic design of floating substructures to ensure long-term performance, integrity and operability. The line addresses the influence of biofouling growth on added mass and drag, motions and loads, corrosion protection systems, inspection accessibility and long-term weight distribution, enabling the development of design allowances and mitigation strategies compatible with industrial deployment while considering environmental constraints and potential risks associated with invasive aquatic species.



Priority level



Current TRL



Technological Objective

To ensure long-term floater performance and integrity by incorporating biofouling growth, location and evolution into design loads, accounting for uncertainties in biological processes (e.g. growth rates and distribution), integrating these effects into hydrodynamic response and maintenance strategies, and considering mitigation approaches to reduce operational, integrity and invasive aquatic species risks over the asset lifetime.

Specific Actions

- Define biofouling scenarios and design allowances by zone (splash / intertidal / submerged), including growth rates, roughness evolution and potential invasive aquatic species considerations for target sites
- Integrate biofouling-induced hydrodynamic penalties (drag, added mass, damping) into coupled analyses and design load case selection
- Develop design and mitigation solutions (coatings, surface treatments, geometry details and inspection access provisions) compatible with long-term inspection and maintenance

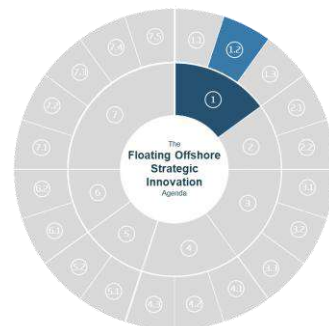
Validation and Trial Needs

- Validation of biofouling models and parameters using field data and monitoring campaigns in representative environments, in collaboration with marine biology experts to ensure realistic fouling assumptions
- Numerical verification of performance sensitivity (motions, loads, fatigue) with and without biofouling allowances across key metocean conditions
- Demonstration of mitigation effectiveness and long-term maintainability through pilot trials and field exposure testing, including inspection accessibility and cleanability assessment



Expected Results

- Design rules and validated allowances for biofouling impacts on hydrodynamics, loads and weight growth
- Improved long-term platform performance stability (motions, station-keeping margins, operability) and reduced uncertainty in design
- Reduced O&M burden and integrity risks through optimised mitigation, inspection and cleaning strategies compatible with long-term offshore operation and environmental constraints



Subarea 1.2 - Mooring and anchoring design

Mooring and anchoring systems provide the station-keeping capability that enables floating offshore wind turbines to operate safely and reliably under continuously changing environmental conditions. This subarea promotes innovation aimed at **improving the performance, durability and efficiency of these systems through advances in materials, structural configurations and engineering design.**

The innovation landscape encompasses synthetic materials, Single Point Mooring concepts, fatigue and failure assessment, multi-material configurations, low-impact anchoring solutions, connection systems and load reduction technologies. Together, these developments seek to **increase system reliability, optimise resource use and support more resilient and scalable station-keeping solutions for future floating wind farms.**

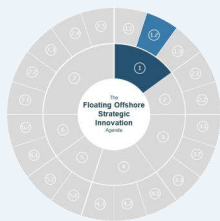
Innovation lines

- PL3 1.2.1 Qualification, certification and application of advanced synthetic materials for taut mooring systems:** accelerated testing and operational use of synthetic ropes (for example, polyester, nylon) to enable taut mooring configurations, reduce system weight and improve fatigue behaviour, particularly in deep-water applications.
- PL4 1.2.2 Single Point Mooring (SPM) design:** design criteria and analysis tools addressing station-keeping, load distribution, fatigue behaviour and operational reliability, including turbine-platform interaction aspects.
- PL1 1.2.3 Probabilistic fatigue and failure models for mooring and anchoring systems:** risk-based tools to estimate service fatigue life and support design and operational decisions.
- PL3 1.2.4 Multi-segment and multi-material designs for mooring lines:** hybrid configurations.
- PL5 1.2.5 Innovations in low environmental impact anchoring systems and shared mooring architectures:** development of shared anchors and non-dedicated mooring networks serving multiple turbines, reducing material use, seabed footprint, installation time and environmental impact at wind farm level.
- PL1 1.2.6 Mooring connectors and hook-up systems:** solutions that simplify the hooking and unhooking of mooring lines during installation, maintenance and decommissioning or retrieval operations.
- PL3 1.2.7 Load Reduction Devices for mooring systems:** active control of mooring lines tension, e.g., damping system.



Priority level





Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design



1.2.1 Qualification, certification and application of advanced synthetic materials for taut mooring systems

Qualification and application of advanced synthetic materials for floating wind taut mooring systems, focusing on testing, characterisation and operational use of high-performance synthetic ropes to enable taut mooring configurations, reduce system weight, improve fatigue performance and support reliable deployment in deep-water applications.



Priority level



Current TRL



Technological Objective

To enable reliable and widespread use of synthetic materials in floating wind taut mooring systems by developing qualification and certification approaches, improving long-term performance and ensuring integration under representative offshore conditions.



Specific Actions

- Mechanical and fatigue characterisation of advanced synthetic materials under cyclic and long-term loading, including accelerated testing methodologies and representative floating wind load spectra for lifetime prediction
- Assessment of creep, ageing (including UV exposure), abrasion, hysteresis and environmental degradation effects under offshore conditions, with focus on long-term performance and rope damping behaviour
- Development of qualification and certification methodologies and design guidelines for synthetic mooring systems, including rope protection and jacketing approaches
- Evaluation of handling, installation and inspection requirements compared to conventional steel solutions
- Assessment of interfaces between synthetic ropes, connectors, terminations and steel segments under representative operational loading conditions
- Development of load emulation methodologies for synthetic taut mooring systems in basin testing environments representative of coupled floating wind turbine behaviour



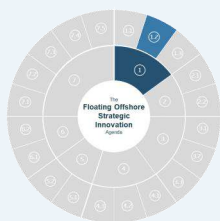
Validation and Trial Needs

- Laboratory testing at material and subcomponent level, including fatigue, durability and accelerated ageing tests using representative tension cycles and load amplitudes
- Monitoring of pilot or demonstration projects to validate construction quality and performance
- Full-scale, representative segment or basin-scale testing under realistic coupled load spectra and offshore operational conditions
- Long-term in-service monitoring to validate degradation behaviour, fatigue performance, inspection strategies and long-term operational reliability



Expected Results

- Reduced mooring system weight and improved dynamic response of floating wind platforms
- Enhanced fatigue life, damping behaviour and reliability of synthetic mooring systems
- Increased confidence and acceptance of synthetic materials in floating wind mooring design



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design

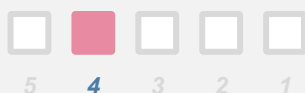


1.2.2 Single Point Mooring (SPM) design

Adaptation and application of established Single Point Mooring (SPM) design criteria and analysis tools to floating wind platforms, addressing station-keeping performance, load distribution, fatigue behaviour, operational reliability and turbine-platform interaction under floating wind operating conditions, with a focus on simplified mooring configurations that reduce system complexity and overall costs.



Priority level



Current TRL



Technological Objective

To enable safe, reliable and cost-effective application of SPM concepts in floating wind by adapting established offshore mooring approaches to the dynamic, operational and lifecycle requirements of wind turbine platforms, including turbine-platform interaction effects.



Specific Actions

- Definition of SPM-specific design requirements for floating wind applications
- Assessment of load distribution, redundancy and failure modes in SPM configurations
- Development and adaptation of numerical tools for coupled analysis of SPM systems, floating wind platforms and turbine-platform interaction effects
- Evaluation of fatigue behaviour of key SPM components under cyclic wind and wave loading
- Assessment of redundancy, failure consequences and emergency disconnection strategies in SPM configurations



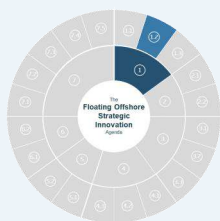
Validation and Trial Needs

- Numerical validation using representative floating wind SPM reference cases
- Monitoring of pilot or demonstration projects to validate operational performance and reliability
- Physical model testing to assess global behaviour and load paths
- Validation of SPM behaviour under extreme, transient and abnormal operational conditions



Expected Results

- Validated design criteria and analysis tools for SPM systems in floating wind
- Improved understanding of benefits and limitations of SPM concepts compared to multi-line mooring systems
- Enhanced confidence in operational reliability and station-keeping performance



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design



1.2.3 Probabilistic fatigue and failure models for mooring and anchoring systems

Development of probabilistic models to assess fatigue damage accumulation and failure likelihood in floating wind mooring and anchoring systems, explicitly accounting for uncertainties in loads, material properties, coupled floater-mooring-cable dynamics, degradation mechanisms and operational conditions. The line addresses time-varying degradation effects and monitoring-informed approaches to improve reliability, safety and robustness in system design and operation.



Priority level



5 4 3 2 1



Current TRL



5 6 7 8 9



Technological Objective

To support risk-informed design and operational decisions for floating wind mooring and anchoring systems by moving from deterministic safety factors to probabilistic assessment of fatigue life and failure probability, including integration with monitoring systems and operational data to support continuous model updating and decision-making.



Specific Actions

- Application of probabilistic fatigue and reliability modelling approaches to floating wind mooring and anchoring systems under representative operational conditions
- Development of uncertainty quantification frameworks covering metocean variability, modelling assumptions, material properties and degradation mechanisms relevant to floating wind applications
- Integration of monitoring and operational data (e.g. strain, tension and inspection measurements) into probabilistic fatigue models and risk-informed assessment methodologies
- Investigation of coupled floater-mooring-dynamic cable interactions and their implications for fatigue accumulation, degradation evolution and failure probability
- Investigation of degradation mechanisms affecting mooring materials and components, including corrosion, wear, creep, abrasion, ageing and biofouling



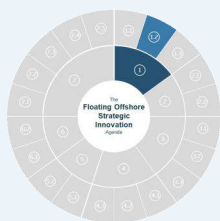
Validation and Trial Needs

- Calibration of probabilistic models using laboratory fatigue data, field measurements and long-term monitoring datasets representative of floating wind operational conditions
- Validation under both fatigue and extreme load conditions, including transient and rare environmental events relevant to floating wind systems
- Cross-validation between different modelling approaches and datasets to assess robustness, uncertainty sensitivity and industrial applicability
- Comparison between predicted degradation trends, monitored fatigue accumulation and observed failure cases where operational data are available
- Application to representative floating wind mooring and anchoring configurations through pilot or pre-commercial projects where possible



Expected Results

- Improved prediction accuracy and quantified probability of fatigue failure for floating wind mooring and anchoring systems
- Reduced uncertainty and design conservatism in mooring system assessment and lifetime prediction
- Improved basis for risk-informed design, inspection and maintenance interval optimisation strategies
- Increased reliability, transparency and confidence in mooring system performance under representative floating wind operating conditions



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design



1.2.4 Multi-segment and multi-material designs for mooring lines

Development and optimisation of mooring line architectures combining multiple segments and materials (for example, steel chains, qualified synthetic ropes and hybrid configurations), focusing on system-level design of hybrid mooring lines to optimise stiffness distribution, load sharing, fatigue performance and installation efficiency in floating wind applications.



Priority level



Current TRL



Technological Objective

To enable efficient and reliable hybrid mooring line configurations for floating wind by optimising the arrangement, length and material selection of individual segments, while accounting for multidisciplinary impacts on platform dynamics, structural response, inter-array cable feasibility and wind turbine performance under site-specific conditions.



Specific Actions

- Definition of representative multi-segment and multi-material mooring line configurations for floating wind systems
- Assessment of global and local load distribution, stiffness variation and dynamic response along hybrid mooring lines
- Evaluation of fatigue behaviour and degradation mechanisms at material transition zones and connectors
- Development of design guidelines for the selection, dimensioning and arrangement of mooring line segments at system level



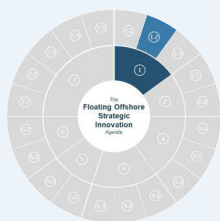
Validation and Trial Needs

- Numerical modelling of representative hybrid mooring line configurations under realistic operational and extreme load conditions
- Testing of critical interfaces and transition zones between different materials and segments
- Validation through application in pilot or demonstration floating wind projects



Expected Results

- Optimised hybrid mooring line designs with improved fatigue performance and reduced system weight
- Increased flexibility to tailor mooring systems to different site conditions and water depths without full redesign
- Reduced material usage and overall mooring system costs through system-level optimisation



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design



1.2.5 Innovations in low environmental impact anchoring systems and shared mooring architectures

Development and assessment of anchoring and mooring solutions for floating wind aimed at minimising seabed disturbance and overall environmental footprint under variable marine conditions, including innovative low-impact anchor concepts and shared mooring configurations enabling multiple floating units to connect to common anchoring systems while considering lifecycle, reuse and decommissioning aspects.



Priority level



Current TRL



Technological Objective

To reduce the environmental and spatial footprint of anchoring systems while ensuring structural integrity, operational safety and system reliability, through the development of low-impact anchor solutions and shared mooring configurations adapted to varying seabed conditions and optimised for efficient installation, material use and lifecycle performance at wind farm scale.



Specific Actions

- Development and assessment of low-impact anchor concepts suitable for different seabed conditions and environmental constraints
- Analysis and development of shared mooring architectures, including load sharing, network topology, redundancy and failure scenarios for multi-turbine configurations
- Evaluation of installation, removal, decommissioning, reuse and life-extension strategies with reduced seabed disturbance
- Assessment of environmental, operational and regulatory implications of low-impact and shared anchoring solutions, including ecological and lifecycle footprint considerations



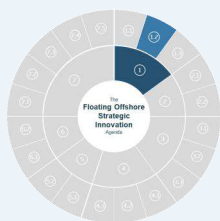
Validation and Trial Needs

- Numerical and physical testing of innovative anchoring concepts under representative load conditions
- Pilot-scale installation and monitoring to assess seabed interaction, environmental impact and operational performance
- Validation of shared anchoring concepts through representative case studies and demonstrators, including redundancy and failure response assessment



Expected Results

- Reduced environmental footprint of anchoring solutions through optimised design, installation and reuse strategies
- Improved compatibility of anchoring and mooring systems with seabed conditions, regulatory requirements and long-term operational constraints
- Improved feasibility and reliability of shared anchoring concepts to reduce seabed occupation and overall infrastructure footprint in floating wind farms



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design



1.2.6 Mooring connectors and hook-up systems

Development and optimisation of connectors and hook-up systems for floating wind mooring lines, focusing on solutions that simplify, accelerate and increase the safety of mooring line connection and disconnection during offshore installation, inspection, maintenance and decommissioning or retrieval operations, while minimising offshore personnel intervention and reducing operational time.



Priority level



Current TRL



Technological Objective

To reduce installation time, offshore operation complexity and safety risks by enabling reliable, efficient and repeatable mooring connection and hook-up solutions adapted to floating wind operational and lifecycle requirements.



Specific Actions

- Development of connector concepts suitable for offshore installation with limited vessel capability, including the definition of key design criteria (e.g. blind-mate hydraulic systems) and compatibility with high mooring line tensions representative of commercial floating wind applications
- Design of hook-up procedures compatible with floating platform motions and operational constraints
- Assessment of mechanical performance, fatigue behaviour and durability of connectors under cyclic loading
- Evaluation of inspection, replacement and disconnection strategies for connectors during operation, maintenance and decommissioning phases, prioritising diverless and reduced-personnel offshore operations
- Validation of connector prototypes through diver- and ROV-assisted dry runs under representative offshore conditions



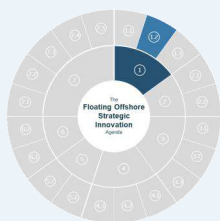
Validation and Trial Needs

- Mechanical and fatigue testing of connectors at component level
- Offshore trials or pilot-scale demonstrations of hook-up and unhooking procedures
- Validation of installation time, safety and operability under representative sea states



Expected Results

- Faster and safer mooring installation and connection operations
- Reduced dependence on highly specialised vessels and weather windows
- Improved reliability and maintainability of mooring systems over the lifecycle



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.2 Mooring and anchoring design



1.2.7 Load Reduction Devices for mooring systems

Development and integration of active or passive load management solutions for mooring systems, aimed at mitigating extreme and fatigue loads and improving overall system durability and performance.



Priority level



Current TRL



Technological Objective

To reduce peak and cyclic loads in mooring systems through active tension management, thereby improving fatigue life, operational reliability and overall system performance without oversizing mooring components.



Specific Actions

- Identification of the main mooring load drivers that can be influenced through active or semi-active control strategies
- Integration of control algorithms linking environmental conditions, platform response and mooring tension
- Development of active, passive or semi-active load reduction device concepts (e.g. hydraulic tension management, damping and energy dissipation systems) compatible with floating wind mooring configurations
- Assessment of system-level impacts, including reliability, redundancy, robustness and failure consequences



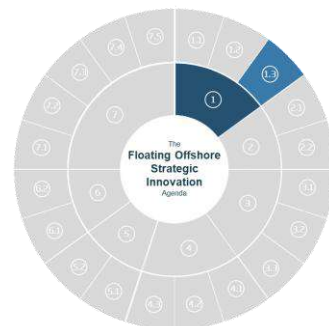
Validation and Trial Needs

- Numerical simulation and scaled experimental validation of controlled mooring systems under operational and extreme load scenarios
- Hardware-in-the-loop or component-level testing of load reduction devices and control strategies
- Demonstration of load reduction performance, component reliability and system robustness through pilot integration on a single mooring line, including real-time load monitoring under representative sea conditions



Expected Results

- Reduced extreme loads and fatigue damage in mooring lines
- Extended mooring system service life and reduced inspection and replacement needs
- Increased design flexibility and potential reduction of mooring system oversizing



Subarea 1.3 - Dynamic submarine cable systems for floating offshore wind

Dynamic submarine cables are essential to ensure reliable power transmission between floating wind turbines and the electrical network while accommodating continuous platform motion. This subarea brings together the innovation needed to **improve cable performance under demanding offshore conditions, enhancing reliability, durability and system integration throughout the operational lifetime of floating wind farms.**

Innovation covers cable qualification and standardisation, advanced connection systems, dynamic behaviour analysis, direct current (DC) cable technologies for long-distance transmission, protection mechanisms and integrated cable–mooring design approaches. Collectively, these developments aim to **reduce mechanical stresses and failure risks while enabling more reliable and efficient electrical transmission for larger and more distant floating offshore wind projects.**

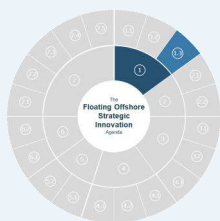
Innovation lines

- PL1 1.3.1 Qualification and standardisation of dynamic cables:** combined testing programmes.
- PL2 1.3.2 Development of quick-connect and disconnect connectors:** development of smart connectors.
- PL5 1.3.3 Integrated dynamic cable curvature and shape control systems:** including bend stiffeners, buoyancy modules, clump weight, especially for EHV (extra high voltage) cables.
- PL4 1.3.4 Studies on the dynamic behaviour and environmental interactions of submarine cables:** including electromagnetic fields, seabed interaction and potential effects on marine ecosystems.
- PL4 1.3.5 Development of new direct current (DC) cable technologies to address the technical challenges that arise as projects move further offshore** (while alternating current – AC – remains suitable for shorter distances).
- PL1 1.3.6 Development of failure response and protection mechanisms for dynamic submarine cables,** including fuse-type systems that can be connected without compromising cable integrity.
- PL3 1.3.7 Integrated design of dynamic cables and mooring systems:** coupled analysis and layout optimisation to avoid interference, reduce fatigue loads and improve overall system reliability.



Priority level





Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.3 Dynamic submarine cable systems for floating offshore wind



1.3.1 Qualification and standardisation of dynamic cables

Qualification and standardisation of dynamic submarine cable solutions for floating wind applications through coordinated testing and assessment programmes, building on existing dynamic cable designs to support reliable deployment and industrialisation.



Priority level



Current TRL



Technological Objective

To increase confidence, reliability and industrial readiness of dynamic cables for floating wind by establishing consistent qualification methodologies and standard testing frameworks applicable across projects and cable configurations.



Specific Actions

- Definition of representative load cases and test conditions for dynamic cables in floating wind applications
- Assessment of fatigue behaviour, degradation mechanisms and failure modes under coupled loading conditions
- Development of combined testing programmes addressing mechanical, electrical and environmental performance simultaneously
- Alignment of qualification approaches with certification bodies and industry standards



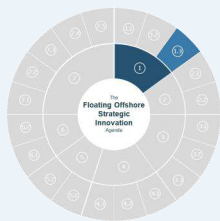
Validation and Trial Needs

- Execution of laboratory testing campaigns using representative dynamic cable sections and test setups
- Comparison of test results across different cable designs and manufacturers to assess repeatability
- Validation of qualification methodologies through application in pilot or demonstration floating wind projects



Expected Results

- Improved reliability and predictability of dynamic cable performance
- Reduced project-specific qualification effort and testing duplication
- Increased standardisation and acceptance of dynamic cable solutions across the floating wind sector



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.3 Dynamic submarine cable systems for floating offshore wind



1.3.2 Development of quick-connect and disconnect connectors

Development and adaptation of quick-connect and disconnect connector solutions for dynamic submarine power cables in floating wind, enabling efficient, safe and repeatable connection and disconnection during installation, commissioning and maintenance operations. These solutions aim to reduce offshore intervention time, dependence on specialised cable installation vessels and operational downtime by enabling simplified installation, tow-to-port maintenance strategies and faster replacement of damaged dynamic cables, while incorporating smart functionalities for monitoring and connection status verification.



Priority level



Current TRL



Technological Objective

To reduce offshore installation complexity, intervention time and operational risks associated with dynamic cable connection by enabling reliable connector systems capable of withstanding mechanical and environmental loads during connection, disconnection and operation, while supporting diver-less installation strategies, simplified cable replacement operations and reduced dependence on specialised installation vessels.



Specific Actions

- Development of connector concepts suitable for dynamic cable applications under cyclic mechanical and environmental loading, including smart functionalities for alignment assistance, condition monitoring and connection verification
- Definition of installation and disconnection procedures compatible with floating platform motions, offshore constraints and diver-less operations
- Assessment of connector integrity, sealing performance and operational reliability under representative offshore conditions
- Evaluation of compatibility with existing dynamic cable designs, maintenance strategies and qualification frameworks
- Assessment of connector-enabled logistics and replacement strategies supporting tow-to-port operations and faster cable replacement



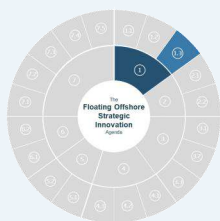
Validation and Trial Needs

- Validation of connector concepts through laboratory and controlled offshore testing under representative mechanical and environmental conditions, including assessment of alignment tolerances and pull-in loads where relevant
- Demonstration of installation and disconnection procedures through pilot-scale or representative floating wind scenarios, including ROV-assisted and diver-less operations where applicable
- Verification of operational reliability, sealing integrity and maintenance performance under representative offshore conditions



Expected Results

- Reduced offshore installation and intervention time for dynamic cables
- Improved flexibility and cost-effectiveness of installation, commissioning and maintenance operations, including tow-to-port and cable replacement strategies
- Reduced dependence on specialised cable installation vessels and enhanced operational safety through diver-less connection approaches
- Reduced risk of cable and ancillary component damage during connection and disconnection activities



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.3 Dynamic submarine cable systems for floating offshore wind



1.3.3 Integrated dynamic cable curvature and shape control systems

Development and integration of coordinated cable curvature and shape control solutions for floating wind applications, combining elements such as bend stiffeners, buoyancy modules and clump weights to manage dynamic cable behaviour under representative operating conditions, including applications involving large-diameter and extra-high-voltage (EHV) cables.



Priority level



Current TRL



Technological Objective

To ensure long-term integrity and fatigue performance of dynamic cables by actively managing cable geometry and curvature along the water column under variable environmental and operational conditions, including configurations involving large-diameter or extra-high-voltage cables.



Specific Actions

- Assessment of cable curvature drivers and critical zones along dynamic cable configurations, including implications of larger diameter and stiffness associated with extra-high-voltage cables
- Development and optimisation of integrated shape control solutions combining bend stiffeners, buoyancy elements and clump weights
- System-level design of cable configuration layouts adapted to floating platform motions and site-specific conditions



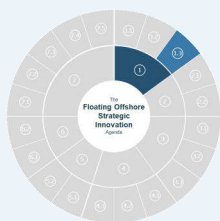
Validation and Trial Needs

- Numerical simulation of controlled mooring systems under operational and extreme load scenarios
- Demonstration of load reduction performance and system robustness in pilot or demonstration floating wind project



Expected Results

- Improved control of dynamic cable curvature and configuration, reducing local stress concentrations and fatigue drivers
- Increased reliability and robustness of dynamic cable systems across a wider range of floating wind configurations
- Reduced need for project-specific cable configuration redesign through more systematic and repeatable integration approaches



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.3 Dynamic submarine cable systems for floating offshore wind

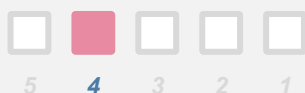


1.3.4 Studies on the dynamic behaviour and environmental interactions of submarine cables

Applied assessment and integration of submarine cable dynamic behaviour and environmental interactions into cable design and project engineering. The line covers coupled fatigue/response and seabed interaction (touchdown, trenching/burial, scour, sediment mobility) together with electromagnetic field (EMF) characterisation and potential effects on marine receptors, to support design choices, routing, protection measures and permitting with reduced uncertainty.



Priority level



Current TRL



Technological Objective

To de-risk dynamic cable design and consenting by quantifying cable-seabed-environment interactions and key dynamic response drivers (including fatigue- and vibration-related effects), and translating them into engineering design criteria, routing/protection solutions and monitoring/mitigation measures.



Specific Actions

- Develop coupled modelling workflows for dynamic response, bend stiffer and hang-off behaviour, and seabed interaction (touchdown dynamics, friction, burial / trenching, scour / sediment mobility) to predict loads and fatigue drivers
- Characterise EMF signatures for IAC/export configurations (current levels, shielding, burial depth) and link to route-specific environmental conditions and receptors
- Define design/mitigation guidelines combining routing, burial/protection, operational limits and monitoring requirements to meet performance and environmental constraints



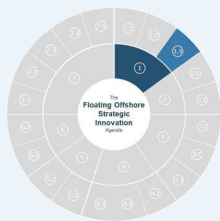
Validation and Trial Needs

- Field data acquisition on cable motions, touchdown behaviour and seabed conditions to calibrate/validate interaction models
- Verification of EMF predictions with in-situ measurements for representative cable types, burial depths and operating regimes
- Pilot demonstration of integrated “engineering + environmental” workflow in a project case (route selection, protection design and monitoring plan)



Expected Results

- Validated design criteria and modelling methods for cable dynamics and seabed interaction, reducing fatigue and failure risk
- Quantified EMF envelopes and practical mitigation options (routing/burial/shielding) to support permitting and stakeholder acceptance
- More robust cable routing and protection strategies with reduced uncertainty, rework and environmental compliance risk



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.3 Dynamic submarine cable systems for floating offshore wind

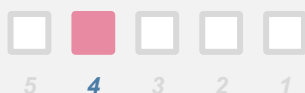


1.3.5 Development of new direct current (DC) cable technologies to address the technical challenges that arise as projects move further offshore

Development of HVDC cable technologies and associated dynamic export solutions to enable floating wind projects located at longer distances from shore, where AC export becomes technically and economically limiting. The line targets cable designs, materials, accessories and dynamic sections capable of withstanding higher electrical stresses and floating-specific mechanical demands, while improving manufacturability, installation and long-term reliability.



Priority level



Current TRL



Technological Objective

To enable reliable and cost-effective far-offshore export by developing HVDC cable systems (cables + joints/terminations + dynamic sections) that meet floating wind mechanical and electrical requirements and can be industrialised for large-scale deployment.



Specific Actions

- Develop HVDC cable designs and insulation/material systems suited to floating wind duty cycles and higher voltage levels, including thermal and electrical stress management
- Develop and qualify HVDC accessories for offshore use (joints, terminations, hang-offs, transition zones) compatible with dynamic operation and marine environment
- Define integrated design rules and installation concepts for HVDC export from floating platforms (dynamic-to-static interfaces, protection, bending management, repair strategy)



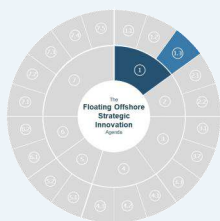
Validation and Trial Needs

- Electrical qualification testing under HVDC operating conditions (PD, ageing, thermal cycles) adapted to offshore environments
- Comparison of optimised and baseline substructure designs to quantify performance improvements
- Validation using scaled physical model tests where appropriate



Expected Results

- HVDC cable system solutions suitable for far-offshore floating wind export, including qualified accessories and dynamic interfaces
- Reduced technical risk and improved reliability for long-distance export, lowering downtime and repair exposure
- Improved industrial readiness through standardised designs, test protocols and installation procedures



Lifecycle Stage *Design and construction*

Area 1 Floating substructures, mooring systems and dynamic cables

Subarea 1.3 Dynamic submarine cable systems for floating offshore wind



1.3.6 Development of failure response and protection mechanisms for dynamic submarine cables

Development of protection and failure-response solutions for dynamic submarine cables to limit damage propagation and enable controlled disconnection/recovery in abnormal events. The line includes “fuse-type” mechanical systems, weak-link concepts and protective elements that can be integrated at defined locations and connected/handled without compromising cable integrity, aiming to reduce repair complexity, downtime and secondary failures.



Priority level



Current TRL



Technological Objective

To improve dynamic cable system availability and safety by implementing protection mechanisms that mitigate overload events, prevent cascading damage and enable rapid, controlled intervention with minimal impact on cable integrity.



Specific Actions

- Define failure modes and triggering criteria (over-tension, excessive bending, snagging, impact) and translate them into protection requirements and design limits
- Develop and engineer fuse/weak-link and protection concepts compatible with dynamic cable interfaces (hang-off, transition, I-tube) and standard installation practices
- Establish qualification methodologies and acceptance criteria for combined mechanical and operational performance, including maintainability and reset/replace procedures

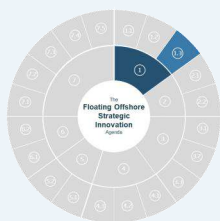
Validation and Trial Needs

- Component and system-level mechanical testing (tension/bending/torsion, cyclic fatigue) to validate trigger behaviour and durability under representative load spectra
- Integration trials to confirm connection procedures, handling, and that cable electrical/mechanical integrity is not compromised by the protection device
- Demonstration in representative offshore installation/O&M scenarios (deployment, emergency disconnection, recovery and replacement workflow)



Expected Results

- Qualified fuse-type / protection solutions that limit damage propagation and protect critical cable sections
- Reduced repair time and offshore intervention complexity through controlled disconnection and recoverability
- Improved reliability and lower lifecycle risk for dynamic cable systems, increasing project bankability



Lifecycle Stage *Design and construction*

Area **1** Floating substructures, mooring systems and dynamic cables

Subarea **1.3** Dynamic submarine cable systems for floating offshore wind



1.3.7 Integrated design of dynamic cables and mooring systems

Integrated engineering of dynamic cables and mooring systems through coupled analysis and joint layout optimisation. The line addresses fully coupled floater–mooring–cable interactions, including dynamic response, installation constraints and critical interfaces (hang-offs, touchdown zones, fairleads), aiming to reduce interference and fatigue risks, improve operability and optimise allowable floater offsets under representative and extreme metocean conditions.



Priority level



Current TRL



Technological Objective

To improve system reliability and reduce lifecycle cost by co-designing mooring systems and dynamic cables as interdependent parts of the floating wind system, optimising layouts, interfaces, installation constraints and allowable floater offsets to minimise interference risk, fatigue damage and operational limitations under representative and extreme metocean conditions.



Specific Actions

- Development of fully coupled simulation workflows capturing floater motions, mooring dynamics, cable response and control-system interactions, including interference/contact modelling and shared design load cases
- Investigation of interaction and failure propagation mechanisms between cables and mooring systems under representative operational and extreme conditions, including assessment of critical interfaces and clash-risk mitigation solutions
- Development of integrated layout optimisation methodologies considering anchor patterns, cable corridors, allowable floater offsets, installation and maintenance constraints, and seabed conditions
- Definition of integrated design rules and standard interface solutions for cable-mooring systems to improve operability, reduce fatigue hot-spots and support robust lifecycle performance



Validation and Trial Needs

- Verification through high-fidelity coupled analyses across representative floater/mooring/cable configurations, including sensitivity to offsets, installation tolerances and extreme events
- Cross-validation of numerical tools and modelling approaches using long-term monitoring data and demonstrator project information where available
- Physical model testing of combined cable–mooring configurations to validate coupled behaviour under representative operational and accidental load cases
- Demonstration through FEED-level studies and pilot or pre-commercial projects, including installation methodologies and early operational considerations



Expected Results

- Optimised cable-mooring layouts with reduced interference risk, improved allowable floater offsets and fewer operational constraints
- Improved predictability and reliability of coupled cable-mooring system behaviour under representative floating wind operating conditions
- Lower fatigue loads and improved lifetime margins at critical cable and mooring interfaces
- More robust and repeatable engineering workflows supporting faster design cycles, improved operability and reduced lifecycle risk



Innovation Area 2

Electrical infrastructure and grid connection

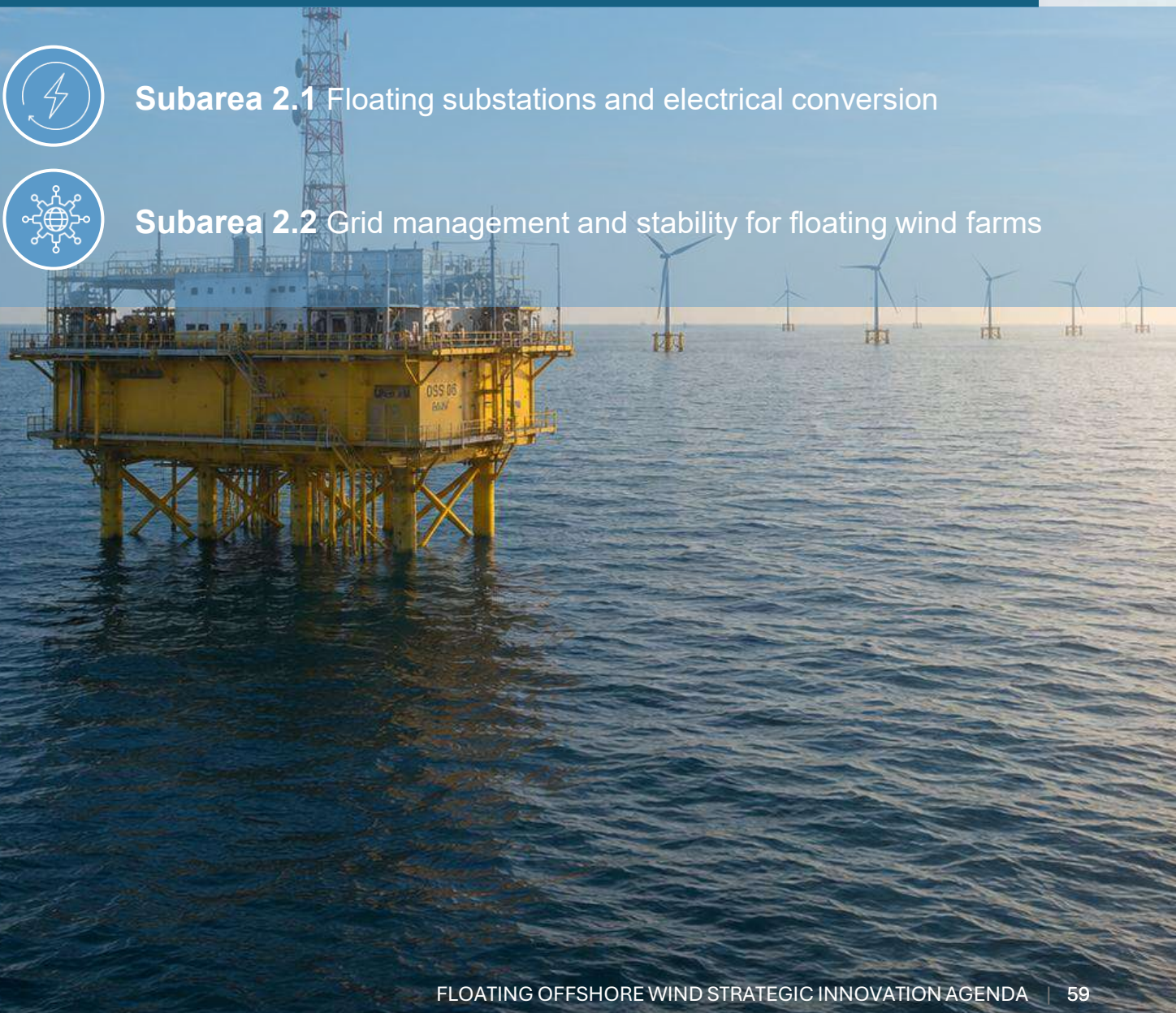
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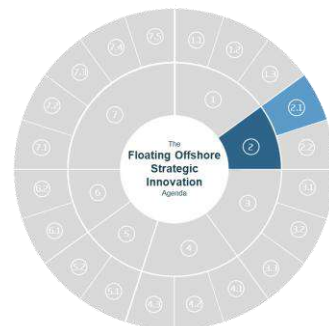


Subarea 2.1 Floating substations and electrical conversion



Subarea 2.2 Grid management and stability for floating wind farms





Subarea 2.1 - Floating substations and electrical conversion

Reliable electrical infrastructure is fundamental to collect, convert and transmit the energy generated by floating offshore wind farms. This subarea brings together the innovation required to **develop floating substations and electrical systems capable of operating under the dynamic mechanical and environmental conditions associated with floating platforms**.

Innovation covers the **design and integration of key electrical equipment**, including protection systems, thermal management solutions and optimised intra-array electrical layouts. It also considers **emerging technologies** such as DC switchgear for offshore applications, contributing to more resilient, efficient and scalable electrical infrastructure for future floating wind developments.

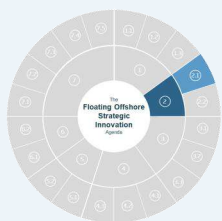
Innovation lines

- PL4 2.1.1 Topside design of floating substations adapted to dynamic environments:** integration of transformers, conversion equipment and switchgear considering movements and dynamic loads.
- PL5 2.1.2 Cooling and thermal management systems for offshore electrical equipment:** cooling solutions adapted to marine environments to improve equipment reliability and service life.
- PL2 2.1.3 Protection and control systems for dynamic electrical systems**
- PL1 2.1.4 Optimisation of intra-array electrical layouts for floating wind farms:** design and optimisation of dynamic and static cable layouts to reduce overall plant costs while ensuring reliable power transmission under floating-specific constraints.
- PL3 2.1.5 Technological challenge related to the development of electrical switchgear for DC applications in offshore substations.**



Priority level





Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.1** Floating substations and electrical conversion

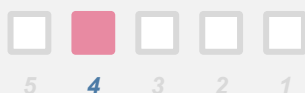


2.1.1 Integration of electrical equipment and topside systems in floating substations under dynamic conditions

Design and integration of electrical equipment and topside systems for floating substations, addressing the installation, operation and interface requirements of transformers, power conversion equipment and switchgear under platform motions and dynamic offshore loads.



Priority level



Current TRL



Technological Objective

To enable the reliable and safe operation of floating substations by adapting the integration, interfaces and functional arrangement of electrical equipment to platform motions, accelerations and dynamic offshore conditions.



Specific Actions

- Definition of functional and design requirements for electrical equipment integration on floating substations subject to motions, accelerations and dynamic loads
- Integration of transformers, converters, switchgear and auxiliary electrical systems considering dynamic behaviour and offshore operational constraints
- Assessment of electrical, mechanical and structural interfaces between topside equipment and floating platform systems
- Evaluation of operational limits, equipment tolerances and performance constraints associated with floating motions and dynamic environmental conditions



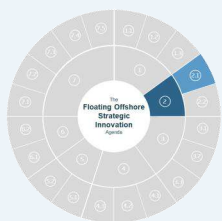
Validation and Trial Needs

- Validation of equipment integration concepts and operational performance through numerical analysis and component- or subsystem-level testing under representative motion, inclination and load conditions
- Demonstration of floating-specific electrical equipment integration and interface solutions using pilot-scale or representative test platforms, where applicable



Expected Results

- Reliable operation of electrical conversion and transmission equipment on floating substations under representative offshore dynamic conditions
- Reduced technical uncertainty and increased confidence in floating substation concepts for large-scale deployment



Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.1** Floating substations and electrical conversion



2.1.2 Cooling and thermal management systems for offshore electrical equipment

Development and adaptation of cooling and thermal management solutions for electrical equipment installed offshore, with specific focus on floating substations operating in dynamic marine environments.



Priority level



Current TRL



Technological Objective

To ensure reliable operation and extended service life of offshore electrical equipment by implementing cooling and thermal management systems robust to platform motions, ambient marine conditions and variable electrical loading.



Specific Actions

- Assessment of thermal loads and heat dissipation requirements for key offshore electrical equipment under floating operation
- Development and adaptation of cooling concepts suitable for dynamic environments (for example, air, liquid or hybrid systems)
- Evaluation of the impact of platform motions, inclination and accelerations on cooling performance and reliability
- Integration of thermal management solutions with floating substation layout and operational constraints



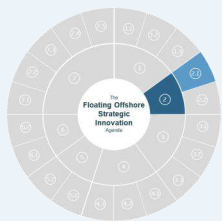
Validation and Trial Needs

- Laboratory testing of cooling systems under representative thermal loads and dynamic conditions
- Validation of thermal performance and reliability through pilot-scale demonstrations or representative offshore test platforms



Expected Results

- Improved reliability and lifetime of offshore electrical equipment
- Reduced risk of overheating-related failures and operational restrictions in floating substations



Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.1** Floating substations and electrical conversion



2.1.3 Protection and control systems for dynamic electrical systems

Development and adaptation of protection and control systems for electrical infrastructure operating on floating platforms, addressing the challenges introduced by platform motions, dynamic loads, variable operating conditions and transient or abnormal platform displacements.



Priority level



Current TRL



Technological Objective

To ensure safe, reliable and selective protection of electrical systems in floating wind applications by adapting protection schemes and control strategies to dynamic behaviour and non-stationary operating conditions.



Specific Actions

- Assessment of the impact of platform motions and dynamic behaviour on the performance of existing electrical protection schemes
- Adaptation of protection and disconnection strategies, including sensing and threshold settings, to electrical systems subject to movement
- Evaluation of protection selectivity and robustness under dynamic operating conditions



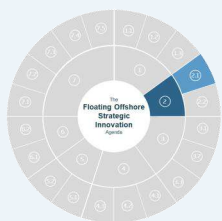
Validation and Trial Needs

- Simulation and testing of protection and control systems under representative dynamic electrical and mechanical conditions
- Validation of protection performance and coordination through pilot-scale demonstrations or representative test platforms



Expected Results

- Reliable fault detection and disconnection under dynamic operating conditions
- Reduced risk of false trips and improved operational continuity of floating electrical systems



Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.1** Floating substations and electrical conversion



2.1.4 Optimisation of intra-array electrical layouts for floating wind farms

Design and optimisation of intra-array electrical architectures for floating wind, combining dynamic and static cable routing, protection and installation constraints. The line targets layout solutions that minimise total cable and installation cost while ensuring electrical performance and long-term reliability under floating-specific motions, offsets and seabed interaction conditions, including interfaces with floating substations and export system configurations where relevant.



Priority level



Current TRL



Technological Objective

To reduce floating wind plant LCoE by optimising intra-array cable layouts (dynamic + static sections) that meet electrical, mechanical and installation constraints while improving reliability, maintainability and cost performance.



Specific Actions

- Develop layout optimisation solutions integrating electrical design (topology, losses, redundancy) with dynamic cable constraints (offsets, fatigue drivers, bend limits)
- Integrate route engineering and seabed constraints (bathymetry, geohazards, crossings, burial/protection) into early-stage layout tools and rules
- Define adaptable layout configurations and design guidelines for typical floating wind farm conditions, including floater spacing, mooring patterns and electrical system voltage levels
- Assessment of integration constraints and reliability implications associated with floating substations and dynamic export cable interfaces where applicable



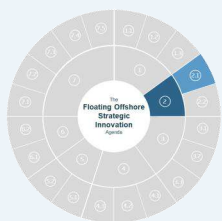
Validation and Trial Needs

- Verification via coupled analyses of representative layouts (electrical performance + mechanical response/fatigue) under project metocean conditions
- Demonstration in FEED / project case studies including installation methodology, protection design and maintainability assessment
- Benchmarking against baseline layouts to quantify cost, installation time and reliability improvements
- Validation of cost impacts of optimised layouts, including CAPEX, installation and lifecycle cost assessments under representative conditions



Expected Results

- Cost-optimised intra-array layouts reducing cable length, protection scope and installation complexity
- Improved reliability through reduced fatigue exposure and better interface/route design
- Repeatable design guidance and tools supporting faster FEED and reduced redesign iterations



Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.1** Floating substations and electrical conversion



2.1.5 Technological challenge related to the development of electrical switchgear for DC applications in offshore substations

Development and qualification of DC switchgear technologies for offshore substations (incl. floating substations) to enable reliable protection, isolation and operability in HVDC transmission and collection systems. The line addresses DC-specific challenges (fast fault interruption, protection selectivity, insulation/arc management) and offshore constraints (SWaP, marine environment, maintainability), targeting industrial-ready solutions for far-offshore projects.



Priority level



Current TRL



Technological Objective

To enable safe and reliable offshore HVDC operation by developing DC switchgear and protection functions capable of fast fault detection and interruption, suitable for integration in offshore (floating) substations and compatible with lifecycle O&M requirements.



Specific Actions

- Develop DC switchgear concepts (breakers, disconnectors, earthing/isolators) adapted to HVDC fault behaviour and offshore SWaP constraints
- Engineer insulation systems, arc/quenching and thermal management suitable for marine environments and high availability targets
- Define integration requirements and qualification routes (interfaces with converters, protection/control, redundancy, maintainability)



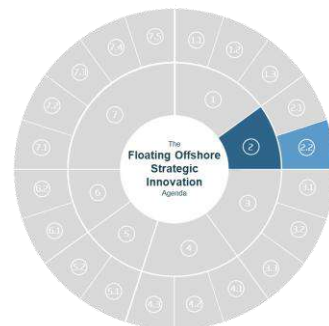
Validation and Trial Needs

- Type/qualification testing under representative HVDC fault scenarios (interruption capability, dielectric withstand, endurance)
- Integration trials with HVDC protection and control to validate speed, selectivity and operational procedures
- Demonstration in an offshore-relevant setup (substation mock-up/pilot), including maintainability and safety case validation



Expected Results

- Qualified offshore-ready DC switchgear enabling HVDC protection and isolation in offshore substations
- Reduced technical risk and improved availability for far-offshore HVDC export solutions
- Standardised specifications and qualification pathway supporting industrial deployment



Subarea 2.2 - Grid management and stability for floating wind farms

As floating offshore wind farms increase in size and electrical capacity, their interaction with the power system becomes increasingly important. This subarea explores the innovation needed to **ensure stable, reliable and flexible grid integration**, enabling floating wind farms to operate as active contributors to future electricity networks rather than simply as energy generators.

Its innovation scope includes electrical stability assessment, advanced plant control strategies and grid-forming capabilities supported by energy storage integration. Together, these developments seek to **strengthen system stability, improve the coordination between wind farms and the grid, and enhance the ability of floating offshore wind to support future power system operation**.

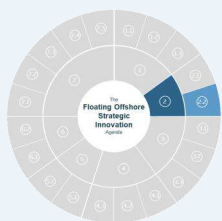
Innovation lines

- PL4 2.2.1 Electrical stability analysis tools for floating wind farms:** models and tools to assess the electrical stability of the wind farm, considering the interaction between generation, conversion and the grid.
- PL5 2.2.2 Plant control strategies to reduce electro-mechanical interactions:** coordinated control between wind turbines, electrical systems and substations to minimise the effects of electrical-structural coupling, including improved measurement architectures and reliability of system monitoring and control methods.
- PL1 2.2.3 Grid-forming capabilities and energy storage integration for floating wind farms:** development and integration of grid-forming converters and energy storage solutions enabling floating wind farms to actively contribute to power system stability.



Priority level





Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.2** Grid management and stability for floating wind farms

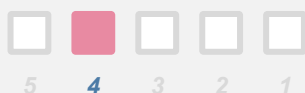


2.2.1 Electrical stability analysis tools for floating wind farms

Development and application of electrical stability analysis tools tailored to floating wind farms, enabling the assessment of system stability under dynamic operating conditions and accounting for the interaction between wind generation, power electronic conversion and the onshore grid.



Priority level



Current TRL



Technological Objective

To improve the capability to assess and predict electrical stability phenomena in floating wind farms by adapting and applying existing analysis tools to floating-specific operating conditions and grid interactions.



Specific Actions

- Identification of relevant electrical stability phenomena in floating wind farms and assessment of their implications for electrical design decisions, equipment specification and operating conditions
- Development or adaptation of modelling approaches suitable for analysing electrical stability in systems with high penetration of converter-based generation
- Integration of floating wind-specific characteristics into stability analysis tools, including variability in operating conditions and interaction with offshore and onshore grid infrastructure



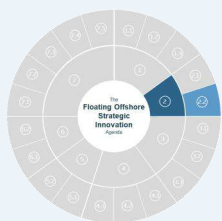
Validation and Trial Needs

- Validation of stability analysis tools against representative floating wind farm configurations and grid connection scenarios
- Comparison of analysis results with available operational data or detailed simulation benchmarks to assess model credibility
- Validation of the effectiveness of representative control strategies and mitigation approaches for managing floating-specific electrical stability issues



Expected Results

- Improved capability to identify potential electrical stability issues at early design stages
- Increased confidence in grid connection studies and system integration of floating wind farms



Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.2** Grid management and stability for floating wind farms



2.2.2 Plant control strategies to reduce electro-mechanical interactions

Development and adaptation of plant-level control strategies for floating wind farms aimed at mitigating electro-mechanical interactions between wind turbines, electrical infrastructure and floating platforms under dynamic operating and grid conditions, including improved measurement architectures and reliable monitoring systems supporting coordinated control.



Priority level



Current TRL



Technological Objective

To enhance the electrical stability and operational robustness of floating wind farms by coordinating turbine, electrical system and substation controls, supported by improved measurement architectures and reliable monitoring of electro-mechanical interactions.



Specific Actions

- Identification of electro-mechanical interaction mechanisms in floating wind farms, including measurement requirements and monitoring architectures needed to support plant-level control strategies
- Development of coordinated plant-level control strategies linking wind turbine controls, electrical systems and offshore substations
- Assessment of control trade-offs between electrical stability, mechanical loads and power quality



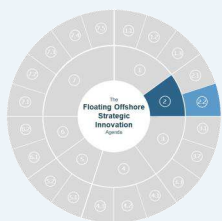
Validation and Trial Needs

- Validation of coordinated plant-level control strategies through integrated electro-mechanical simulations representative of floating wind farm operation
- Assessment of control effectiveness using representative case studies and, where available, data from pilot or demonstration floating wind projects



Expected Results

- Reduced adverse electro-mechanical interactions affecting floating wind farm operation
- Improved electrical stability and reduced dynamic loading through coordinated plant control strategies



Lifecycle Stage *Design and construction*

Area **2** Electrical infrastructure and grid connection

Subarea **2.2** Grid management and stability for floating wind farms



2.2.3 Grid- forming capabilities and energy storage integration for floating wind farms

Development and integration of grid-forming (GFM) control capabilities and energy storage systems (ESS) for floating wind farms to provide stable voltage/frequency support and improved dynamic performance under weak-grid and far-offshore conditions. The line targets converter control functions, protection coordination and ESS sizing/architecture to deliver services such as inertia emulation, fast frequency response, voltage support, fault ride-through and power smoothing, while ensuring offshore operability and industrial deployment readiness.



Priority level



Current TRL



Technological Objective

To enable stable and compliant grid connection of floating wind farms in weak-grid/HVDC-linked scenarios by deploying grid-forming control strategies and integrated energy storage solutions that deliver required grid services and improve system resilience.



Specific Actions

- Develop and tune grid-forming control strategies for wind farm converters (WTGs, STATCOM/HVDC interfaces), including interoperability and multi-converter coordination
- Define ESS integration architectures (centralised vs distributed, DC-coupled vs AC-coupled) and sizing rules linked to target grid services and offshore constraints (SWaP, availability)
- Establish protection, stability and compliance design rules (fault behaviour, ride-through, harmonics, black-start/restoration where applicable) for combined GFM + ESS systems



Validation and Trial Needs

- EMT-level simulations and hardware-in-the-loop validation to demonstrate stability and performance under weak-grid and fault scenarios
- Verification of coordinated operation (GFM + ESS + farm-level controller) including protection selectivity and interactions with HVDC/offshore substation controls
- Pilot demonstration in a representative environment (test site or project pilot) validating performance KPIs, availability and O&M procedures



Expected Results

- Proven GFM control packages and integration guidelines enabling floating wind operation in weak-grid conditions
- ESS integration solutions delivering frequency/voltage services, smoothing and improved ride-through performance
- Reduced curtailment and improved compliance, supporting higher penetration and bankability of far-offshore floating wind



Innovation Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

[Back to Innovation Areas](#)



Subarea 3.1 Adaptation of the wind turbine (WTG) and tower to floating foundation

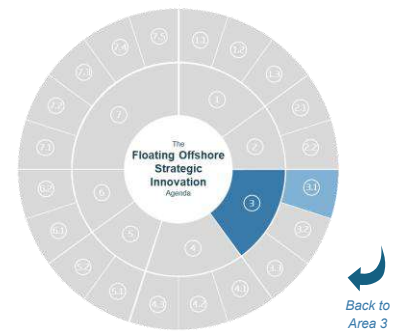


Subarea 3.2 Control and dynamic behaviour of the floating system



Subarea 3.3 Validation and aero-hydro-servo modelling for FOW

POWER OUTPUT
8.6 MW



Subarea 3.1 - Adaptation of the wind turbine (WTG) and tower to floating foundation

Conventional wind turbines require significant adaptation to operate efficiently on floating foundations, where continuous platform motion introduces new structural and operational challenges. This subarea brings together the innovation needed to **optimise wind turbine and tower design for floating applications, ensuring reliable performance under coupled aerodynamic, structural and hydrodynamic conditions.**

Innovation encompasses structural concepts, aerodynamic optimisation, materials, standardised interfaces and modular manufacturing approaches that **facilitate integration with floating substructures while improving durability and industrial scalability.** It also incorporates design strategies that enhance operation and maintenance and ensure **compatibility with floating-specific behaviours such as weathervaning.**

Innovation lines

- PL1

3.1.1 Adaptive stiffness / Load-tuned structural designs and segmented concepts for floating applications in all phases of the lifecycle: supporting structure configurations (tower or alternative supporting structures) that optimise global stiffness while facilitating transport, integration, and installation.
- PL2

3.1.2 Aerodynamic and aero-structural optimisation of wind turbines and blades for floating platforms: to mitigate motion-induced loads and improve power capture and structural reliability.
- PL1

3.1.3 Standardised interfaces between wind turbine and floater: common technical specifications enabling co-design, scalability, and industrial integration, allowing for different interface locations (for example, tower base or RNA level).
- PL2

3.1.4 Materials and coatings for wind turbine and tower in floating environments: solutions aimed at improving durability and reducing maintenance requirements under harsh marine conditions and environmental regulations.
- PL1

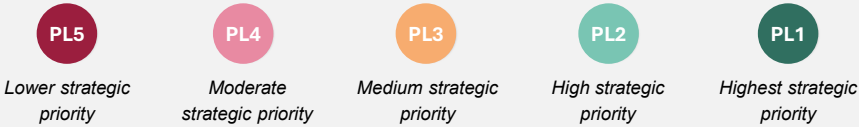
3.1.5 O&M-oriented design of the wind turbine and tower for offshore applications: design criteria that facilitate inspection, access, maintenance, repair, and replacement of main components.
- PL1

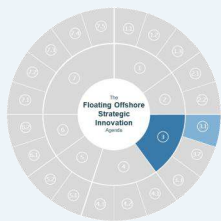
3.1.6 Adaptation of wind turbine design and control to weathervaning floating structures: WTG architectures and control strategies compatible with passive or semi-passive yaw behaviour of the floating platform.
- PL1

3.1.7 Process-oriented standardisation and modular manufacturing of wind turbine components to facilitate integration with floating foundations and accommodate design variability.



Priority level





Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.1 Adaptive stiffness / Load-tuned structural designs and segmented concepts for floating applications in all phases of the lifecycle

Development and assessment of adaptive stiffness and load-tuned structural designs and segmented supporting structure concepts (tower or alternative supporting structures) for floating wind applications, aiming to optimise global structural stiffness, damping behaviour and load distribution while facilitating transport, integration, installation and lifecycle operation.



Priority level



Current TRL



Technological Objective

To improve the structural and dynamic performance and installability of wind turbine supporting structures for floating wind by optimising stiffness, damping behaviour and load distribution, while enabling modular or segmented configurations compatible with floating foundation constraints across the lifecycle.



Specific Actions

- Assessment of global stiffness and damping requirements for wind turbine supporting structures in floating applications, building on existing offshore and onshore tower design practices
- Investigation of damping enhancement concepts for floating wind supporting structures, including integrated or retrofit-compatible vibration control approaches
- Development and evaluation of segmented and modular supporting structure configurations optimised for floating wind, including load-tuned stiffness distribution, vibration mitigation and structural performance
- Evaluation of transport, integration and installation implications of segmented designs under realistic offshore deployment scenarios



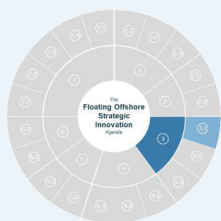
Validation and Trial Needs

- Numerical validation of structural and dynamic response under representative floating wind load cases
- Experimental evaluation of damping behaviour in representative supporting structures and floating components to support model calibration and validation
- Numerical assessment of damping enhancement concepts and vibration mitigation strategies to evaluate feasibility and impact on structural response and fatigue behaviour



Expected Results

- Supporting structure designs with optimised stiffness, damping behaviour and reduced structural loads
- Improved transportability, installation flexibility and integration with floating foundations
- Improved reliability of vibration and dynamic response prediction models for floating wind supporting structures
- Availability of validated damping enhancement approaches for vibration control and fatigue reduction



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.2 Aerodynamic and aero-structural optimisation of wind turbines and blades for floating platforms

Development and assessment of aerodynamic and aero-structural optimisation approaches for wind turbines and blades in floating applications, aiming to mitigate motion-induced loads, reduce fatigue, improve power capture and enhance overall turbine reliability under coupled aero-hydrodynamic conditions.



Priority level



Current TRL



Technological Objective

To improve aerodynamic performance, structural integrity and fatigue behaviour of floating wind turbines by optimising aerodynamic and aero-structural blade designs, accounting for damping behaviour and tower-blade-platform interactions in order to mitigate platform-induced loads and dynamic coupling under floating operating conditions.



Specific Actions

- Identification of blade load drivers specific to floating wind conditions, including platform motions, coupled dynamics, tower stiffness interactions and vibration-related effects
- Assessment of aerodynamic and aero-structural blade design adaptations, including damping-related approaches, to mitigate motion-induced loads while maintaining or improving power capture and fatigue performance
- Evaluation of trade-offs between aerodynamic performance, structural response and fatigue life in floating-specific blade designs
- Investigation of blade damping behaviour and potential damping treatment concepts to reduce vibration coupling effects and fatigue damage in floating wind applications



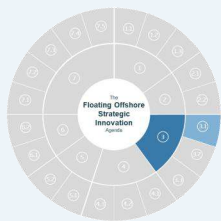
Validation and Trial Needs

- Numerical validation of adapted blade designs using coupled aero-elastic models representative of floating wind operation
- Verification of fatigue load reductions and vibration behaviour through comparative analysis against baseline blade designs
- Validation of coupled aero-elastic blade models through basin-scale testing under representative coupled wind-wave operational conditions
- Experimental and numerical evaluation of blade damping behaviour and damping-related mitigation concepts under representative operational conditions
- Comparative fatigue testing of turbine blades versus baseline designs under representative wave and current conditions (e.g. wave/current test rigs or hybrid testing environments)



Expected Results

- Reduced motion-induced loads, vibration coupling effects and fatigue damage while maintaining or improving aerodynamic power capture in floating wind turbine blades
- Improved blade reliability, vibration robustness and lifetime under floating-specific operating conditions



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.3 Standardised interfaces between wind turbine and floater

Development of standardised technical interfaces between the wind turbine (WTG) and the floating substructure, enabling consistent mechanical, structural and functional integration across different floating wind concepts while reducing project-specific customisation, simplifying integration requirements and supporting interoperability and accelerated deployment.



Priority level



Current TRL



Technological Objective

To facilitate co-design, scalability and industrial integration of wind turbines and floating substructures by defining common interface requirements and adaptable connection approaches that improve compatibility, reduce integration risks and support reliable, low-maintenance integration across floating wind projects, while maintaining sufficient flexibility to avoid constraining innovation.



Specific Actions

- Identification of critical mechanical, structural and functional interface requirements between WTG and floating substructures
- Assessment of interface concepts across representative turbine and floater configurations to ensure broad applicability and compatibility with different supporting structure concepts
- Development of standardised interface specifications addressing load transfer, tolerances, integration constraints, accessibility and maintainability requirements
- Investigation of connection approaches enabling simplified installation, reduced external intervention requirements and low-maintenance operation



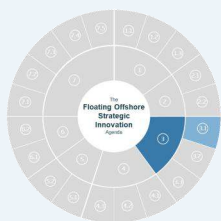
Validation and Trial Needs

- Numerical validation of standardised interface concepts under representative floating wind load cases
- Demonstration of interface compatibility through application to multiple turbine–floater integration scenarios
- Scale testing of representative connection concepts to verify load-transfer capacity, structural behaviour and maintainability assumptions
- Definition of an evolutionary approach for interface standardisation, including progressive validation and industry engagement to ensure applicability and sector-wide adoption



Expected Results

- Reduced integration effort and technical risk between wind turbines and floating substructures
- Increased flexibility to combine different turbine and floater designs, supporting scalability and industrial deployment



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.4 Materials and coatings for wind turbine and tower in floating environments

Development and application of materials and protective coating solutions for wind turbine components and towers operating in floating offshore environments, aimed at improving durability, reducing degradation under harsh marine conditions and ensuring compliance with environmental regulations.



Priority level



Current TRL



Technological Objective

To enhance the long-term durability and availability of wind turbines in floating wind applications by reducing corrosion, wear and material degradation while ensuring compatibility with environmental regulations governing offshore materials and coatings.



Specific Actions

- Identification of dominant degradation mechanisms affecting wind turbine and tower materials in floating offshore environments
- Assessment of advanced materials and coating solutions suitable for long-term exposure to marine conditions and dynamic operation
- Evaluation of compatibility between materials, coatings, manufacturing or repair processes and environmental regulations applicable to offshore wind applications



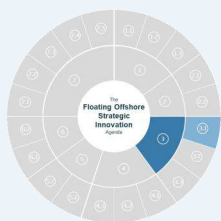
Validation and Trial Needs

- Laboratory testing of materials and coatings under representative marine exposure and mechanical loading conditions
- Validation of durability and performance through long-term exposure testing, including accelerated ageing approaches and, where feasible, pilot-scale offshore applications



Expected Results

- Improved resistance to corrosion and environmental degradation of wind turbine and tower components
- Reduced maintenance requirements and increased service life in floating wind environments



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.5 O&M-oriented design of the wind turbine and tower for offshore applications

Development and application of O&M-oriented design criteria for wind turbines and towers in offshore and floating wind applications, focusing on improving accessibility, reducing intervention complexity and enabling efficient inspection, maintenance, repair and replacement of key components throughout the asset lifecycle.



Priority level



Current TRL



Technological Objective

To reduce operational complexity, downtime and lifecycle costs of floating wind turbines by integrating O&M considerations into the design of the wind turbine and tower from early design stages.



Specific Actions

- Identification of O&M-critical components and activities specific to floating wind turbines and towers
- Definition of design features that facilitate offshore access, inspection and maintenance under floating conditions
- Assessment of design trade-offs between structural performance, accessibility and maintainability
- Definition of key performance indicators (KPIs) for O&M-oriented design (e.g. intervention time, accessibility, component replacement strategies) to support design optimisation and benchmarking



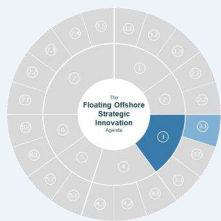
Validation and Trial Needs

- Validation of O&M-oriented design solutions through simulated offshore maintenance scenarios and representative case studies
- Demonstration of improved accessibility and maintainability in pilot-scale or demonstration floating wind projects, including, where feasible, pilot maintenance exercises



Expected Results

- Reduced offshore intervention time and operational downtime
- Improved safety, accessibility and efficiency of maintenance activities in floating wind applications



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.6 Adaptation of wind turbine design and control to floating platform dynamics

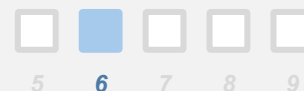
Adaptation of wind turbine design features and control strategies to floating wind concepts characterised by platform-induced motions and dynamic responses, including yaw behaviour, passive or semi-passive platform alignment effects and floating-specific operational conditions.



Priority level



Current TRL



Technological Objective

To ensure stable and efficient operation of wind turbines installed on floating platforms by adapting turbine design and control strategies to platform-induced motions and dynamic response, accounting for the impact of yaw behaviour and floating platform dynamics on control performance, structural loading and operational stability.



Specific Actions

- Identification of dynamic and control challenges associated with floating platform motions, yaw behaviour and floating-specific operating conditions
- Adaptation of wind turbine design and control strategies, including pitch and yaw control interactions, to improve stability, load mitigation and operational performance on floating platforms
- Assessment of interactions between platform motions, turbine control response and structural loading under representative floating wind operating conditions



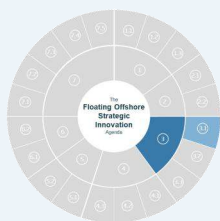
Validation and Trial Needs

- Validation of adapted turbine design and control strategies through advanced coupled aero-hydro-servo simulations representative of floating wind concepts
- Assessment of control performance, platform response and load mitigation using representative case studies and demonstrator data where available
- Targeted control simulation studies under representative floating operational conditions, complemented where possible by pilot-scale testing



Expected Results

- Improved stability and operational performance of floating wind turbines under platform-induced motions
- Reduced structural loads and improved interaction management between turbine control systems and floating platform dynamics



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.1

Adaptation of the wind turbine (WTG) and tower to floating foundation



3.1.7 Process-oriented standardisation and modular manufacturing of wind turbine components to facilitate integration with floating foundations and accommodate design variability

Development of process-oriented standardisation and modular manufacturing approaches for wind turbine and tower components to simplify and accelerate integration with floating foundations. The line targets standardised interfaces, modular sub-assemblies and repeatable manufacturing/assembly processes that can accommodate design variability (turbine models, tower geometries, floater interface requirements) while improving industrial scalability, quality and integration performance.



Priority level



Current TRL



Technological Objective

To reduce integration time, risk and cost by standardising WTG/tower–floater interfaces and enabling modular, repeatable manufacturing and assembly processes that remain compatible with different floating foundation concepts and turbine configurations.



Specific Actions

- Define standardised mechanical and functional interfaces for WTG/tower integration with floaters (load paths, flange/joint concepts, tolerances, installation constraints)
- Establish process standards and design rules enabling interchangeability and configuration management across turbine variants and floating foundation requirements, supporting alignment across stakeholders
- Develop modular component architectures and manufacturing/assembly sequences (transportable submodules, pre-assembly, QA/QC standard procedures)
- Assessment of cost-benefit trade-offs between modular and bespoke design and manufacturing approaches for different floating wind deployment scenarios



Validation and Trial Needs

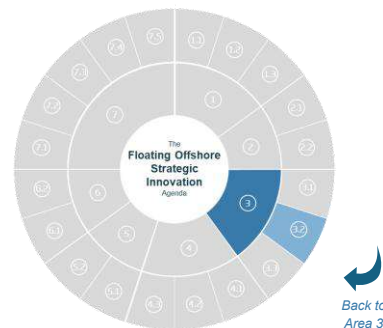
- Industrial trials of modular manufacturing and assembly processes (repeatability, tolerances, cycle time, QA/QC performance)
- Interface fit-up and load-transfer verification (structural checks, fatigue screening) across representative configuration variants
- Demonstration in an integration pilot (port-side integration and installation readiness) validating logistics, handling and schedule benefits



Expected Results

- Standardised interface specifications enabling faster WTG/tower–floater integration across projects
- Modular manufacturing processes reducing production time, rework and integration risk while improving scalability
- Improved flexibility to accommodate design variability (turbine supplier choices, upscaling) without major process redesign

Subarea 3.2 - Control and dynamic behaviour of the floating system



The dynamic response of floating offshore wind systems depends on the continuous interaction between the wind turbine, floating platform and mooring system. This subarea explores advanced control approaches capable of managing these coupled behaviours, **improving system stability, reducing structural loads and maintaining efficient operation under continuously changing environmental conditions.**

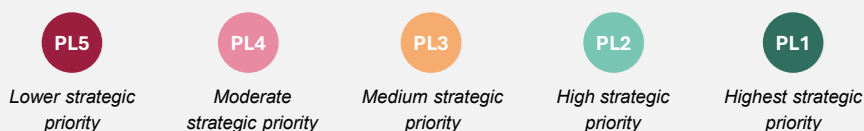
Its innovation scope includes predictive and model-based control strategies, operational criteria that support adaptive system behaviour, and integrated co-control approaches that coordinate the response of multiple system components. Together, these developments seek to **enhance operational performance while increasing the robustness and reliability of floating wind systems.**

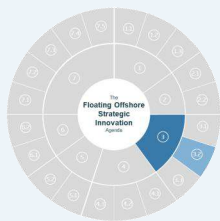
Innovation lines

- PL5 3.2.1 Model-based and feedforward control strategies integrated into existing systems:** control algorithms combining wind and wave information to reduce loads and motions.
- PL5 3.2.2 Operational implementation of motion-and operability-based (e.g. MOSE-type envelopes) criteria in control systems:** use of multivariable operational envelopes to support control decisions under demanding conditions.
- PL3 3.2.3 Integrated co-control strategies for floater–turbine–mooring systems:** coordinated control of the complete system to improve global stability and the management of extreme events (e.g. blade breakage, mooring line snap, etc.).



Priority level





Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.2

Control and dynamic behaviour of the floating system



3.2.1 Model based and feedforward control strategies integrated into existing systems

Development and application of model-based and feedforward control strategies for floating wind systems, integrated into existing turbine and platform control architectures. These strategies combine wind, wave and platform motion information to anticipate system response and reduce structural loads and motions under dynamic operating conditions.



Priority level



Current TRL



Technological Objective

To enhance the dynamic performance and operational robustness of floating wind turbines by improving load mitigation and motion control through model-based and anticipative control strategies compatible with existing turbine and platform control systems, including pitch, yaw and generator load control approaches, while accounting for uncertainties in environmental input data.



Specific Actions

- Identification of key load and motion drivers in floating wind systems that can be effectively addressed through predictive or feedforward control approaches
- Integration of these control strategies within existing turbine and platform control frameworks, ensuring stability and compatibility with standard operational modes
- Adaptation and tuning of model-based, predictive and feedforward control algorithms incorporating wind, wave and platform motion information, including pitch, yaw and generator load control functions
- Integration and assessment of ahead-sensing technologies (e.g. nacelle-mounted lidar or radar systems) to support predictive and feedforward control strategies



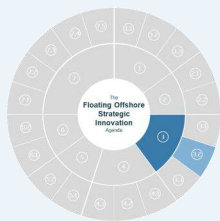
Validation and Trial Needs

- Validation of predictive and feedforward control strategies through advanced coupled aero-hydro-servo simulations representative of floating wind operating conditions, including the use of measured or ahead-sensed input data where available
- Comparative assessment of load and motion reduction performance against baseline control strategies using representative floating wind case studies
- Where applicable, verification of control performance using data from pilot or demonstration floating wind projects



Expected Results

- Reduced dynamic loads and platform motions under normal and demanding operating conditions
- Improved overall system stability and fatigue performance without increasing control complexity or operational risk
- Increased confidence in the use of anticipative control strategies for floating wind applications



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.2

Control and dynamic behaviour of the floating system



3.2.2 Operational implementation of motion-and operability-based (e.g. MOSE-type envelopes) criteria in control systems

Development and operational implementation of motion- and operability-based operational envelope criteria (e.g. MOSE-type envelopes) within floating wind control systems. These criteria define safe and efficient operating envelopes based on multiple coupled variables, supporting control decisions under demanding and highly dynamic operating conditions.



Priority level



Current TRL



Technological Objective

To improve the operational robustness and safety of floating wind turbines by embedding motion- and operability-based multivariable operational envelopes into control systems, enabling informed and coordinated pitch, yaw and generator load control actions when approaching operational limits.



Specific Actions

- Definition of motion- and operability-based operational envelope criteria relevant to floating wind operation, considering coupled aerodynamic, hydrodynamic, structural and control-related variables
- Translation of MOSE criteria into control-relevant parameters and logic compatible with existing turbine and platform control architectures, including pitch, yaw and generator load control functions
- Assessment of how MOSE-based control decisions interact with standard control modes, including power regulation, load mitigation and shutdown strategies
- Definition and tuning of control strategies incorporating hysteresis, predictive shutdown criteria and re-start logic to improve operational stability and avoid unnecessary trips under transient conditions

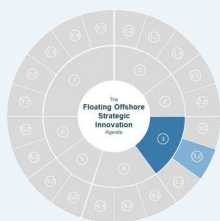
Validation and Trial Needs

- Validation of MOSE-based control approaches through coupled aero-hydro-servo simulations covering normal, extreme and transient operating conditions
- Evaluation of control system behaviour near operational boundaries using representative floating wind case studies
- Where feasible, verification of MOSE implementation using data from pilot or demonstration floating wind projects



Expected Results

- Improved awareness of proximity to operational limits during floating wind operation
- More robust and coordinated control responses under demanding environmental conditions
- Reduced risk of unnecessary shutdowns or overly conservative operation while maintaining system safety



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.2

Control and dynamic behaviour of the floating system



3.2.3 Integrated co-control strategies for floater-turbine-mooring systems

Development and application of integrated coordinated control strategies that jointly consider the dynamic behaviour of the floating platform, the wind turbine and the mooring system. These co-control approaches aim to manage system-wide interactions and improve global stability, particularly under extreme or highly dynamic operating conditions.



Priority level



Current TRL



Technological Objective

To improve the overall dynamic stability and resilience of floating wind systems by coordinating control actions across the turbine, floating substructure and mooring system, reducing adverse interactions and enhancing system response during demanding conditions.



Specific Actions

- Identification of key dynamic interactions between turbine control, platform motion and mooring system response that can benefit from coordinated control
- Assessment of control allocation strategies to balance load reduction, motion control and mooring system performance without compromising operational robustness
- Development of co-control concepts that enable information exchange and coordinated actions between turbine, platform and mooring subsystems
- Exploration of advanced coordination approaches, including data-driven and machine learning-based methods, to manage complex interactions between turbine, platform and mooring system dynamics



Validation and Trial Needs

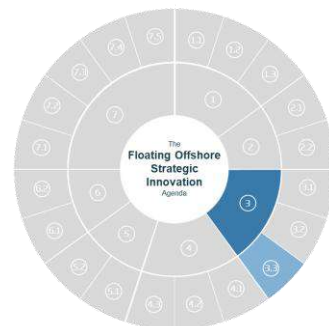
- Validation of co-control strategies through fully coupled aero-hydro-servo-elastic simulations representative of floating wind systems
- Evaluation of system-level performance improvements under extreme events and transient conditions using representative floating wind case studies
- Where applicable, assessment of co-control concepts using data from pilot-scale or demonstration floating wind projects



Expected Results

- Improved global stability of the floating wind system under combined wind, wave and current loading
- Reduced adverse interactions between turbine control actions and mooring system response
- Enhanced capability to manage extreme events and transient operating conditions in floating wind applications

Subarea 3.3 - Validation and aero-hydro-servo modelling for FOW



Back to
Area 3

Reliable modelling and experimental validation are essential to accelerate the development and industrial deployment of floating offshore wind technologies. This subarea promotes the **tools, methodologies and testing approaches** required to **improve confidence** in the design, **optimisation and certification** of floating wind systems throughout their development lifecycle.

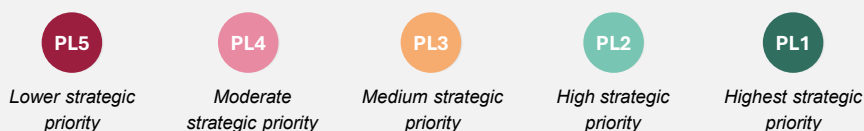
Innovation covers reduced-order modelling techniques, numerical–experimental validation frameworks, common methodologies for load definition and simulation, and the assessment of advanced turbine configurations. Collectively, these developments contribute to **more accurate design tools, improved model reliability and greater consistency** across floating offshore wind projects.

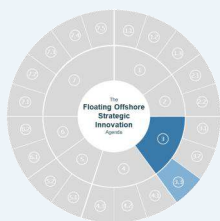
Innovation lines

- PL3 3.3.1 Reduced-order and modelling tools for rapid and early FOW design and optimisation:** validated reduced-order models enabling fast assessment and optimisation of floating wind configurations.
- PL1 3.3.2 Scaled testing campaigns and numerical-experimental correlation frameworks:** dedicated testing campaigns to validate models and improve design reliability through numerical–experimental correlation.
- PL2 3.3.3 Guidelines for metocean binning and simulation lists for floating wind load analysis:** standardised criteria for defining load cases and simulation sets to support validation, certification and comparison of solutions.
- PL5 3.3.4 Analysis of Small-Scale Turbines with Complex 3D Blade Shape.**



Priority level





Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.3

Validation and aero-hydro-servo modelling for FOW



3.3.1 Reduced-order and modelling tools for rapid and early FOW design and optimisation

Development and application of validated reduced-order modelling tools to support rapid design assessment and optimisation of floating offshore wind (FOW) configurations. These tools enable fast evaluation of system behaviour, energy production performance and key design trade-offs during early design stages, supporting informed decision-making across a wide range of floating wind concepts.



Priority level



Current TRL



Technological Objective

To improve the efficiency, consistency and robustness of early-stage floating wind design by enabling rapid, reliable assessment of system behaviour and performance using reduced-order models validated against higher-fidelity tools and experimental data.



Specific Actions

- Adaptation and refinement of existing reduced-order modelling approaches to capture the dominant aero-hydro-servo dynamics of floating wind systems, while assessing their applicability limits under highly non-linear or extreme operating conditions
- Validation of reduced-order models against high-fidelity numerical simulations and available experimental data for representative floating wind configurations
- Integration of reduced-order tools into early-stage design and optimisation workflows to support concept screening, trade-off analysis and identification of cases where higher-fidelity modelling provides added value



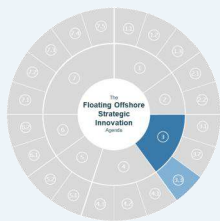
Validation and Trial Needs

- Benchmarking of reduced-order model predictions against detailed numerical models for a range of floating wind concepts and operating conditions, including assessment under non-linear and extreme scenarios
- Verification of model accuracy and robustness through comparison with data from scaled physical tests or demonstrator projects, where available



Expected Results

- Faster and more efficient assessment of floating wind design options during early project phases
- Improved consistency and transparency in concept comparison and optimisation studies
- Reduced reliance on computationally intensive simulations during preliminary design, while maintaining sufficient accuracy for decision-making and identifying conditions where advanced high-fidelity modelling becomes necessary



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.3

Validation and aero-hydro-servo modelling for FOW



3.3.2 Scaled testing campaigns and numerical-experimental correlation frameworks

Design and execution of dedicated scaled testing campaigns for floating offshore wind systems, combined with systematic numerical–experimental correlation frameworks and validation activities. These campaigns aim to validate aero-hydro-servo modelling approaches and improve confidence in design tools through comparison between physical test data and numerical simulations.



Priority level



5 4 3 2 1



Current TRL



5 6 7 8 9



Technological Objective

To increase the reliability and credibility of floating wind design and analysis tools by strengthening numerical-experimental correlation, supporting model validation, uncertainty reduction and improved design robustness.



Specific Actions

- Definition of representative scaled testing programmes addressing key floating wind load cases and dynamic response
- Execution of physical model tests under controlled laboratory conditions, including wind, wave and coupled loading scenarios
- Systematic comparison and calibration of numerical models against experimental results to identify model limitations and uncertainties



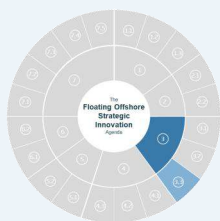
Validation and Trial Needs

- Benchmarking of reduced-order model predictions against detailed numerical models for a range of floating wind concepts and operating conditions
- Verification of model accuracy and robustness through comparison with data from scaled physical tests, demonstrator projects and shared benchmark datasets where available
- Assessment of scaling effects and application of appropriate similarity laws (e.g. Froude, Reynolds and Strouhal scaling), including uncertainty analysis to evaluate propagation of scaling-related errors and their impact on model validation and design robustness



Expected Results

- Improved confidence in numerical simulation tools used for floating wind design and assessment
- Reduced uncertainty in predicted loads, motions and dynamic response of floating wind systems
- Enhanced consistency between experimental testing and numerical modelling practices across the sector



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.3

Validation and aero-hydro-servo modelling for FOW



3.3.3 Guidelines for metocean binning and simulation lists for floating wind load analysis

Development of harmonised guidelines for metocean binning and the definition of simulation lists for floating offshore wind applications, to standardise the selection and combination of environmental conditions and load cases used in numerical simulations, while accounting for site-specific metocean characteristics and complex combined loading conditions relevant to floating wind systems.



Priority level



Current TRL



Technological Objective

To improve consistency, transparency and comparability of floating wind design and validation studies by establishing common criteria for defining metocean bins and simulation sets accounting for floating wind operating conditions and combined environmental loading scenarios.



Specific Actions

- Review and consolidation of existing practices for metocean binning and simulation list definition used across floating wind projects and certification frameworks, ensuring alignment with relevant standards and industry practices
- Identification of key environmental parameters and combinations governing floating wind loads and dynamic behaviour, including directional misalignment effects and complex sea-state conditions where relevant
- Development of guideline-based approaches for defining representative and efficient simulation sets suitable for floating wind validation and assessment



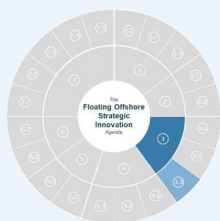
Validation and Trial Needs

- Application of proposed guidelines to representative floating wind case studies to assess their adequacy and robustness under site-specific metocean conditions
- Comparison of results obtained using guideline-based simulation lists versus project-specific approaches, including the representation of combined environmental loading events
- Review and feedback from industry stakeholders and certification bodies to support acceptance and refinement of the guidelines



Expected Results

- Improved consistency in the definition of metocean conditions and simulation lists across floating wind projects
- Reduced variability in design and validation outcomes driven by methodological choices rather than technical performance
- Enhanced comparability and transparency of floating wind designs in validation and certification processes



Lifecycle Stage *Design and construction*

Area 3

Wind turbine, tower or alternative supporting structures and FOW-specific control

Subarea 3.3

Validation and aero-hydro-servo modelling for FOW



3.3.4 Analysis of Small-Scale Turbines with Complex 3D Blade Shape

Development and validation of modelling and testing approaches for small-scale wind turbines featuring complex 3D blade geometries, aimed at improving the fidelity of aero-hydro-servo-elastic simulations and physical model tests for floating wind. The line focuses on capturing 3D aerodynamic effects, scaled Reynolds impacts, control interactions, tower–rotor coupling and platform motions to ensure that small-scale experimental results are representative and transferable to full-scale FOW design and validation.



Priority level



Current TRL



Technological Objective

To improve the reliability of FOW validation campaigns by enabling accurate representation of complex 3D blade aerodynamics, tower–rotor–platform coupling and floating motions in small-scale turbines, ensuring scalable and traceable correlation between experimental results and full-scale aero-hydro-servo models.



Specific Actions

- Develop aerodynamic modelling approaches for complex 3D blade effects at model scale (3D corrections, Reynolds scaling strategies, unsteady aerodynamics)
- Integrate validated turbine and rotor models into coupled aero-hydro-servo-elastic frameworks, including representative tower stiffness and platform motion effects, for floating wind validation
- Define calibration procedures linking small-scale turbine behaviour (thrust, torque, control response and structural dynamics) to full-scale targets for FOW testing
- Develop and validate correlation methodologies between small-scale experimental data, numerical simulations and full-scale floating wind behaviour to improve extrapolation reliability and scaling consistency



Validation and Trial Needs

- Wind tunnel and/or towing basin tests with instrumented small-scale rotors and representative 6DoF platform motions to characterise aerodynamic polars, unsteady response and control behaviour
- Correlation of measured loads and performance with numerical models (BEM/CFD/hybrid) and Software-in-the-Loop approaches, including quantification of scaling uncertainty
- Round-robin or benchmark campaigns to demonstrate repeatability and transferability of methodologies across facilities and turbine designs
- Definition and application of scaling and correlation methodologies to ensure reliable extrapolation of test and simulation results to full-scale conditions



Expected Results

- Validated modelling guidelines for small-scale turbines with complex 3D blades in FOW testing
- Improved consistency between experimental validation data and aero-hydro-servo-elastic simulations used in design
- Reduced uncertainty when extrapolating model-scale results to full-scale FOW performance, loads and dynamic behaviour
- Enhanced capability to assess and compare advanced blade geometries and aeroelastic design concepts under representative floating wind condition



Innovation Area 4

Wind farm layout design and site planning

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Subarea 4.1 Site characterisation and wind farm planning

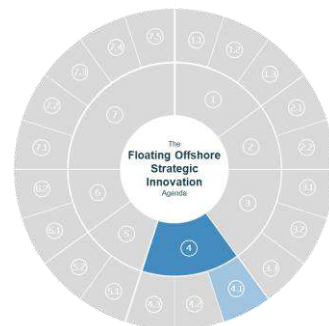


Subarea 4.2 Integrated wind farm design (co-design)



Subarea 4.3 Environmental impact and ecosystem effect mitigation

Subarea 4.1 - Site characterisation and wind farm planning



A thorough understanding of site conditions is essential to ensure the technical, environmental and economic viability of floating offshore wind projects. This subarea brings together the knowledge and tools required to **characterise the natural, geophysical and spatial conditions that influence project planning, supporting informed decision-making from the earliest stages of development.**

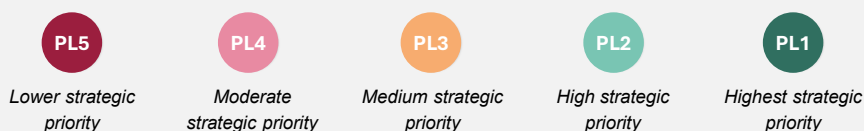
Innovation spans the integrated assessment of wind, wave and oceanographic resources, seabed conditions for anchoring systems, environmental and socio-economic constraints, and opportunities for coexistence with other maritime activities. It also explores planning approaches that **optimise the use of marine space, including co-location strategies and multi-use concepts.**

Innovation lines

- PL5 4.1.1 Integrated characterisation of wind-wave-current resources:** solutions for characterising metocean and oceanographic resources at deep offshore sites.
- PL5 4.1.2 Assessment of seabed-anchor interaction under complex conditions:** methodologies to reduce uncertainties in site selection and mooring design.
- PL5 4.1.3 Environmental risk assessment tools in the planning phase:** solutions to identify environmental risks from early stages and support the selection of wind farm areas and export cable routing by balancing technical design requirements with marine environmental protection objectives.
- PL4 4.1.4 Socio-economic analysis and maritime space use conflicts:** mapping tools.
- PL5 4.1.5 Co-location solutions and compatible uses of maritime space, including multi-use platforms.**



Priority level





Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.1** Site characterisation and wind farm planning



4.1.1 Integrated characterisation of wind-wave-current resources

Integrated and site-specific characterisation of wind, wave and current resources at deep offshore locations, combining measurements, numerical models and reanalysis datasets into a harmonised metocean framework. This enables a robust understanding of coupled environmental conditions driving floating wind performance, loads, operability and energy yield assumptions, supporting informed decisions from early planning to detailed design.



Priority level



Current TRL



Technological Objective

To improve the accuracy, consistency and physical coherence of resource assessments for floating offshore wind projects by integrating and harmonising existing wind, wave and current datasets and assessment tools, thereby supporting robust site selection, layout design and early-stage engineering decisions.



Specific Actions

- Inventory and assessment of existing wind, wave and current datasets, modelling tools and integration opportunities for floating wind site characterisation
- Assessment of spatial and temporal variability of coupled metocean conditions relevant for floating wind deployment, including joint wind-wave-current extremes
- Investigation of coupled environmental processes (e.g. wind-wave misalignment, wave-current interaction and stratification effects) and their implications for floating wind resource characterisation and engineering assumptions
- Evaluation of implications of combined wind-wave-current conditions on floating wind farm layout design, operability and engineering assumptions



Validation and Trial Needs

- Validation of integrated resource characterisation approaches through comparison with long-term measurement campaigns and representative offshore datasets where available
- Validation under extreme and coupled metocean conditions to assess the capability of integrated datasets and models to represent rare events and joint environmental states
- Cross-checking of integrated datasets against independent modelling tools, historical offshore data and alternative reanalysis frameworks to assess robustness and consistency
- Multi-site intercomparison and application of integrated characterisation methodologies across representative floating wind regions and metocean regimes



Expected Results

- More reliable, physically consistent and harmonised descriptions of offshore wind, wave and current conditions relevant to floating wind projects
- Improved understanding and representation of coupled wind-wave-current conditions and extreme environmental states relevant to floating wind systems
- Reduced and better-quantified uncertainty in site selection, layout design, operability assessment and early-stage engineering assumptions
- Improved comparability and transparency of site characterisation studies across different floating wind projects through aligned datasets, metrics and methodologies



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.1** Site characterisation and wind farm planning



4.1.2 Assessment of seabed-anchor interaction under complex conditions

Assessment of seabed-anchor interaction under complex geological and geotechnical conditions using integrated methodologies that combine site data, modelling and uncertainty analysis. The aim is to reduce uncertainties in site selection and mooring system design for floating wind projects, while improving understanding of anchor behaviour under long-term and cyclic loading conditions.



Priority level



Current TRL



Technological Objective

To improve confidence in site suitability and mooring system performance by enhancing the assessment of seabed-anchor interaction under variable and uncertain offshore conditions, including implications for long-term anchoring behaviour, cyclic loading response and retention needs.



Specific Actions

- Integration of geophysical and geotechnical site data into standardised assessment workflows for seabed conditions relevant to floating wind anchoring systems
- Application and refinement of seabed-anchor interaction models for floating wind anchoring solutions under representative offshore loading conditions
- Investigation of cyclic and long-term loading effects on anchor performance, including degradation and creep behaviour
- Development of probabilistic and reliability-based design approaches to account for geotechnical uncertainty and spatial variability
- Evaluation of uncertainty drivers associated with seabed variability and their influence on anchor performance, reliability and design margins



Validation and Trial Needs

- Validation of seabed-anchor interaction assessment approaches through comparison with field data, laboratory tests and full-scale anchor test results where available
- Application of assessment methodologies to representative floating wind site studies to evaluate robustness and sensitivity to seabed uncertainties



Expected Results

- Reduced uncertainty in anchor selection and mooring system design at early project stages
- Improved alignment between site characterisation outcomes and anchoring design assumptions
- More robust and cost-effective anchoring solutions through better-informed site planning decisions and reliability-based assessment approaches



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.1** Site characterisation and wind farm planning



4.1.3 Environmental risk assessment tools in the planning phase

Application and refinement of environmental risk assessment tools during the early planning stages of floating wind projects, enabling the systematic identification, characterisation and evaluation of potential environmental risks associated with site selection, wind farm layout design, export cable routing and infrastructure deployment, supporting environmentally informed planning and more sustainable project development.



Priority level



Current TRL



Technological Objective

To support informed decision-making in floating wind project planning by identifying environmental risks at early stages, reducing uncertainty and facilitating environmentally responsible site selection, layout design, export cable routing and infrastructure deployment planning.



Specific Actions

- Adaptation of existing environmental assessment methodologies to account for floating wind-specific features such as mooring systems, dynamic cables and deep offshore locations
- Integration of environmental risk assessment tools into early-stage site planning, layout design and infrastructure deployment workflows, including implications for installation windows and weather-related constraints
- Development of approaches to screen and prioritise environmental risks based on their potential impact and likelihood

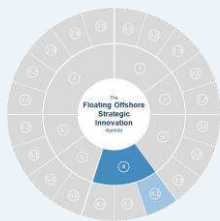
Validation and Trial Needs

- Application of environmental risk assessment tools to representative floating wind planning case studies to evaluate effectiveness, usability and relevance for early-stage decision-making
- Comparison of early-stage environmental risk assessments with outcomes from more detailed Environmental Impact Assessments (EIAs) where available, to assess consistency and identify gaps
- Structured review and feedback from regulatory authorities and environmental stakeholders to support validation, regulatory alignment and refinement of the assessment tools



Expected Results

- Earlier and more systematic identification of environmental risks relevant to floating wind projects
- Improved alignment between site planning decisions and environmental constraints, supporting more robust and environmentally informed project development
- Reduced likelihood of late-stage design changes, permitting delays or additional mitigation measures driven by previously unidentified environmental issues



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.1** Site characterisation and wind farm planning

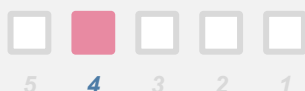


4.1.4 Socio-economic analysis and maritime space use conflicts

Application and further development of socio-economic analysis and mapping tools to identify, assess and visualise potential conflicts and interactions between floating wind projects, adjacent floating wind developments and existing maritime uses at project and site level, within the boundaries and conditions established by existing marine spatial planning and regulatory frameworks. These tools facilitate informed site selection, optimise distribution and streamline the planning permission process by integrating spatial, socio-economic and sector-specific information relevant to the development of specific projects.



Priority level



Current TRL



Technological Objective

To support strategic planning and decision-making for floating wind deployment by improving the identification and interpretation of socio-economic impacts and maritime space-use constraints at early project stages within existing planning and regulatory frameworks.



Specific Actions

- Integration of spatial datasets related to existing maritime activities, infrastructure and socio-economic factors relevant to specific floating wind project areas, consistent with approved marine spatial plans
- Development of mapping and visualisation approaches to assess project compatibility with existing maritime uses, planning constraints, stakeholder sensitivities and interactions between adjacent floating wind developments
- Assessment of how different layout and siting options influence socio-economic impacts and space-use interactions within predefined planning, licensing and cross-boundary marine spatial planning frameworks where relevant



Validation and Trial Needs

- Application of mapping tools to representative floating wind planning case studies to evaluate usability and decision-support value
- Comparison of mapping outputs with outcomes from stakeholder consultations and regulatory planning processes
- Review and feedback from relevant maritime stakeholders to refine mapping approaches and improve acceptance



Expected Results

- Improved visibility and understanding of potential socio-economic impacts and space-use conflicts associated with floating wind projects
- Better-informed site selection and layout decisions that reduce conflict risks, planning delays and cumulative interaction effects between adjacent developments
- Enhanced transparency and communication with stakeholders and authorities during the planning phase



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.1** Site characterisation and wind farm planning



4.1.5 Co-location solutions and compatible uses of maritime space

Identification and assessment of co-location solutions and compatible uses of maritime space associated with floating wind projects, including multi-use concepts where appropriate. This line focuses on understanding technical, operational and planning conditions under which floating wind can coexist with other maritime activities.



Priority level



Current TRL



Technological Objective

To enable more efficient and socially acceptable use of maritime space by identifying conditions and configurations that allow floating wind projects to coexist with other maritime uses without compromising safety, operability or project viability.



Specific Actions

- Identification of maritime activities with potential compatibility or partial co-location opportunities with floating wind projects
- Assessment of technical and operational constraints affecting co-location, including safety distances, access requirements, infrastructure interactions and military/naval operational considerations
- Evaluation of planning and regulatory considerations influencing the feasibility of co-location and multi-use concepts



Validation and Trial Needs

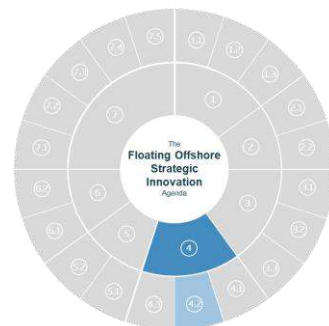
- Application of co-location assessment approaches to representative floating wind planning case studies
- Review of existing pilot projects or demonstrators involving multi-use or co-location concepts where available
- Engagement with relevant stakeholders, authorities and maritime users to assess practical feasibility, operational compatibility and acceptance



Expected Results

- Improved understanding of realistic co-location opportunities for floating wind projects
- Early identification of constraints and risks associated with multi-use of maritime space
- Better-informed planning decisions that balance floating wind deployment with other maritime activities

Subarea 4.2 - Integrated wind farm design (co-design)



Back to Area 4

The performance of floating offshore wind farms depends on the ability to optimise multiple interconnected systems simultaneously rather than independently. This subarea **promotes integrated design approaches** that consider the interactions between turbines, floating platforms, mooring systems, electrical infrastructure and wind farm layout as a single engineering system.

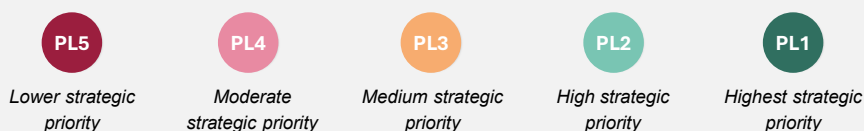
Innovation focuses on **multidisciplinary modelling and optimisation tools** capable of accounting for platform motion, wake effects, mooring footprints and infrastructure interactions. It also explores shared infrastructure concepts that **improve resource efficiency while reducing material requirements and the overall spatial footprint of floating wind developments**.

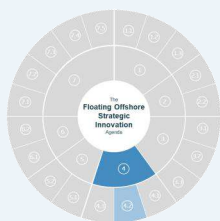
Innovation lines

- PL5 4.2.1 Integrated wake modelling solutions considering the movement of floaters:** wake modelling incorporating the movement of floating platforms, with its mooring system stiffness.
- PL5 4.2.2 Layout optimisation considering movement ranges and mooring footprint:** layout design considering displacement and mooring footprint.
- PL5 4.2.3 Multi-disciplinary tools for floater-mooring-cabling-layout co-optimisation:** integrated design flows to evaluate complete farm configurations.
- PL4 4.2.4 Anchor and mooring line sharing strategies between platforms:** solutions to reduce material and environmental footprint of the mooring system.



Priority level





Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.2** Integrated wind farm design (co-design)



4.2.1 Integrated wake modelling solutions considering the movement of floaters

Development and application of wake modelling approaches for floating wind farms that explicitly account for the dynamic movement of floating platforms and the influence of mooring system stiffness on platform motion. These models aim to capture the impact of floater motions on wake generation, propagation and interaction at intra-farm and extra-farm (adjacent farms) scale.



Priority level



Current TRL



Technological Objective

To improve the accuracy of energy yield estimation and layout design for floating wind farms by incorporating the effects of floater motion and mooring system stiffness into wake modelling and farm-level performance assessment.



Specific Actions

- Identification of floater motion characteristics and mooring system stiffness parameters that significantly influence wake behaviour in floating wind farms
- Adaptation of existing wake modelling approaches to include the effects of platform motion and orientation variability
- Integration of motion-aware wake models into wind farm analysis and layout design workflows, including assessment of adjacent-farm interaction effects



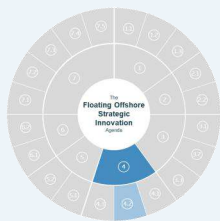
Validation and Trial Needs

- Validation of motion-aware wake models through comparison with high-fidelity simulations or experimental data where available
- Sensitivity studies to assess the impact of platform motion assumptions on wake interaction and energy yield predictions
- Application of integrated wake modelling approaches to representative floating wind farm case studies



Expected Results

- Improved prediction of wake effects and energy production in floating wind farms
- More robust layout design decisions that account for platform motion and its influence on wake interactions
- Reduced uncertainty in farm-level performance assessments for floating wind projects



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.2** Integrated wind farm design (co-design)



4.2.2 Layout optimisation considering movement ranges and mooring footprint

Optimisation of floating wind farm layouts considering the allowable movement ranges of floating platforms and the spatial footprint of mooring systems. This line addresses the integration of dynamic platform displacement and mooring constraints into wind farm layout design.



Priority level



Current TRL



Technological Objective

To improve floating wind farm layout efficiency and feasibility by explicitly accounting for platform movement envelopes and mooring system footprints during layout optimisation and site planning.



Specific Actions

- Characterisation of typical platform movement ranges and mooring footprints for representative floating wind configurations
- Integration of movement envelopes and mooring constraints into layout optimisation algorithms and design workflows
- Evaluation of trade-offs between layout density, energy production, mooring system complexity and spatial constraints



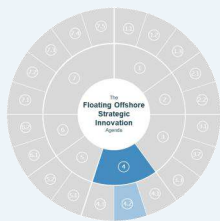
Validation and Trial Needs

- Application of layout optimisation approaches to representative floating wind farm case studies considering realistic movement and mooring constraints
- Sensitivity analysis to assess the impact of movement ranges and mooring footprints on layout performance and feasibility
- Comparison of optimised layouts against conventional approaches that neglect dynamic displacement effects



Expected Results

- Layout designs that better reflect the physical space required by floating platforms and their mooring systems
- Reduced risk of spatial conflicts between neighbouring platforms, moorings and other infrastructure
- More realistic and robust wind farm layouts supporting efficient deployment of floating wind projects



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.2** Integrated wind farm design (co-design)



4.2.3 Multi-disciplinary tools for floater-mooring-cabling-layout co-optimisation

Development and application of integrated multi-disciplinary design tools to support the farm-level co-optimisation of floating platforms, mooring systems, cable corridors and wind farm layout. These tools enable evaluation of complete floating wind farm configurations, capturing key interactions and trade-offs across disciplines without duplicating component-level optimisation tasks.



Priority level



Current TRL



Technological Objective

To improve the overall efficiency, feasibility and robustness of floating wind farm designs by enabling coordinated farm-level optimisation across floating platforms, mooring systems, cable routing and layout configuration, including trade-offs between performance, cost, installability and replaceability.



Specific Actions

- Integration of existing disciplinary design tools for floaters, moorings, dynamic cables and layout analysis into coordinated design workflows
- Identification and representation of key interactions and constraints across disciplines that influence farm-level performance and feasibility
- Development of co-optimisation approaches to evaluate trade-offs between energy yield, structural performance, installation complexity, lifecycle cost, replaceability and spatial constraints



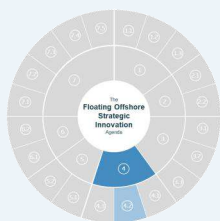
Validation and Trial Needs

- Application of multi-disciplinary co-optimisation tools to representative floating wind farm case studies
- Comparison of integrated co-optimisation results with sequential or discipline-by-discipline design approaches
- Sensitivity analysis to assess the robustness of co-optimised solutions to key design assumptions and uncertainties



Expected Results

- More coherent and realistic floating wind farm designs accounting for cross-disciplinary interactions
- Reduced risk of late-stage design conflicts between platforms, moorings, cabling and layout
- Improved ability to identify balanced farm-level solutions that optimise performance, cost, feasibility and replaceability



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.2** Integrated wind farm design (co-design)

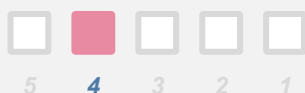


4.2.4 Anchor and mooring line sharing strategies between platforms

Assessment and development of anchor and mooring line sharing strategies between floating wind platforms to reduce material use, installation effort and environmental footprint of mooring systems. This line focuses on identifying conditions under which shared anchoring and mooring configurations can be safely and efficiently implemented at wind farm scale.



Priority level



Current TRL



Technological Objective

To improve the efficiency and sustainability of floating wind mooring systems by enabling the use of shared anchors and mooring line configurations across multiple floating platforms where technically and operationally feasible.



Specific Actions

- Identification of floating wind configurations and site conditions suitable for anchor sharing solutions
- Assessment of load sharing mechanisms and load redistribution effects in shared anchoring and mooring line configurations across multiple floating platforms
- Evaluation of design, installation and operational implications of anchor sharing at wind farm scale



Validation and Trial Needs

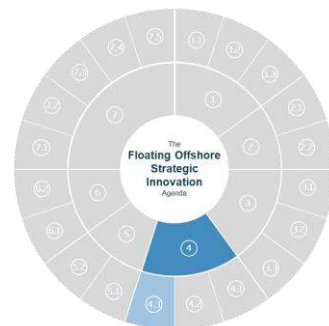
- Application of anchor sharing concepts to representative floating wind farm layout and mooring design case studies
- Comparative analysis of shared versus individual anchoring solutions in terms of loads, redundancy, installation complexity and environmental impact
- Where available, review of relevant offshore experience or pilot applications involving shared anchoring concepts



Expected Results

- Reduced number of anchors and mooring components and associated seabed footprint in floating wind farms
- Improved material efficiency and potential cost reductions in mooring systems
- Clear understanding of technical and operational constraints governing the feasibility of anchor sharing

Subarea 4.3 - Environmental impact and ecosystem effect mitigation



Ensuring that floating offshore wind develops in harmony with the marine environment is a fundamental aspect of long-term sector growth. This subarea **promotes the tools, methodologies and solutions** needed to **understand, monitor and minimise the environmental effects of floating wind farms while supporting their coexistence with marine ecosystems and other maritime activities**.

Its innovation scope ranges from **advanced environmental assessment and continuous monitoring systems to mitigation, compensation and eco-design measures**. Particular attention is also given to cumulative impact assessment and to solutions that facilitate the compatibility of floating wind farms with activities such as fisheries, contributing to a more sustainable and balanced use of marine space.

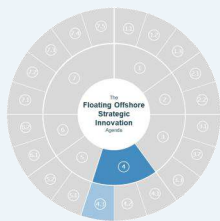
Innovation lines

- PL5 4.3.1 Advanced tools for predicting and assessing environmental and socio-ecological impacts of floating wind farms, including ecosystem service interactions.**
- PL5 4.3.2 Tools for simulating and monitoring interactions between floating wind infrastructure and marine ecosystems:** solutions for analysing interactions between floating infrastructure, marine wildlife and habitats to support environmental monitoring and mitigation strategies.
- PL4 4.3.3 Continuous environmental monitoring systems:** continuous environmental monitoring.
- PL5 4.3.4 Mitigation, compensation and eco-design measures for wind farm:** mitigation and eco-design solutions aimed at reducing the overall environmental footprint.
- PL5 4.3.5 Solutions to enable compatibility and co-activity between floating wind farms and fishing activities:** tools and design approaches to support coexistence, safety, and shared use of maritime space.
- PL5 4.3.6 Advanced solutions for cumulative impact assessment:** development of solutions taking into the cumulative effect of several wind farms and anthropic activities on the whole-trophic food web.



Priority level





Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.3** Environmental impact and ecosystem effect mitigation



4.3.1 Advanced tools for predicting and assessing environmental and socio-ecological impacts of floating wind farms, including ecosystem service interactions

Application and enhancement of advanced tools and methodologies for predicting and assessing environmental and socio-ecological impacts associated with floating wind projects, including impacts linked to floating-specific infrastructure, marine ecosystem interactions and ecosystem services. These solutions support early identification, evaluation and management of potential impacts throughout the planning and design phases.



Priority level



Current TRL



Technological Objective

To improve the accuracy, consistency and usefulness of impact assessment tools for floating wind projects by applying advanced predictive approaches that account for floating-specific infrastructure, operational characteristics and interactions with marine ecosystems and ecosystem services.



Specific Actions

- Adaptation of existing environmental impact assessment models to incorporate floating wind-specific elements such as mooring systems, anchors, floating substructures, offshore footprints and their interactions with marine ecosystems and ecosystem services
- Integration of predictive environmental tools into early-stage project planning and design workflows
- Assessment of cumulative and combined impacts associated with floating wind farm deployment



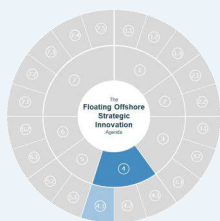
Validation and Trial Needs

- Application of advanced environmental impact assessment tools to representative floating wind planning case studies
- Comparison of predicted impacts with outcomes from monitoring data and environmental studies where available
- Review of assessment approaches with environmental authorities and stakeholders to support acceptance and robustness



Expected Results

- More reliable and comprehensive prediction of environmental impacts associated with floating wind projects
- Improved ability to identify and address potential environmental risks at early project stages
- Enhanced consistency and transparency in environmental assessments supporting permitting and planning processes



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.3** Environmental impact and ecosystem effect mitigation



4.3.2 Tools for simulating and monitoring interactions between floating wind infrastructure and marine ecosystems

Development and application of tools for simulating and monitoring interactions between floating wind infrastructure and marine ecosystems. These tools combine modelling approaches and monitoring technologies to analyse how floating platforms, mooring systems and dynamic cables interact with marine wildlife, habitats and ecosystem processes during project operation.



Priority level



Current TRL



Technological Objective

To improve understanding and management of interactions between floating wind infrastructure and marine ecosystems by enabling predictive assessment and continuous monitoring of impacts on marine wildlife, habitats and ecosystem processes, supporting environmentally responsible project planning and operation.



Specific Actions

- Adaptation of existing ecological and wildlife interaction models to account for floating wind-specific infrastructure and operational characteristics
- Integration of simulation tools with monitoring technologies such as acoustic sensors, visual systems, environmental DNA techniques and biological observations to capture wildlife and habitat responses to floating wind infrastructure
- Development of approaches to link predicted interaction patterns with observed monitoring data to improve ecosystem interaction models and mitigation strategies



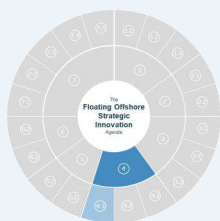
Validation and Trial Needs

- Application of simulation and monitoring tools to representative floating wind case studies
- Validation of model predictions through comparison with data collected from monitoring campaigns where available
- Evaluation of tool performance and usability in supporting environmental assessment and mitigation planning



Expected Results

- Improved ability to predict and observe interactions between floating wind infrastructure and marine ecosystems, including wildlife and habitat responses
- Reduced uncertainty in environmental impact assessments related to fauna-infrastructure interactions
- Enhanced basis for defining mitigation measures and operational adjustments where required



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.3** Environmental impact and ecosystem effect mitigation



4.3.3 Continuous environmental monitoring systems

Deployment and integration of continuous environmental monitoring systems for floating wind farms, enabling long-term observation of key environmental indicators during construction, operation and decommissioning phases. These include parameters such as underwater noise, seabed disturbance, biodiversity, habitat interactions and species identification through automated monitoring approaches, supporting environmental management, regulatory compliance and adaptive mitigation.



Priority level



Current TRL



Technological Objective

To support effective environmental management of floating wind projects by enabling continuous, reliable and automated monitoring of environmental conditions and ecological indicators through interoperable and decision-ready data collection approaches throughout the project lifecycle.



Specific Actions

- Integration of existing environmental monitoring technologies into coherent, long-term monitoring systems suitable for offshore floating environments
- Definition of relevant environmental and ecological indicators, including underwater noise, seabed disturbance, species presence, habitat condition and biodiversity trends, aligned with regulatory and project needs
- Adaptation of monitoring systems to floating wind infrastructure, including power supply, data transmission and robustness under dynamic conditions
- Development of automated data integration and analysis approaches enabling continuous processing of environmental, acoustic and visual monitoring data into ecologically meaningful and reporting-ready outputs

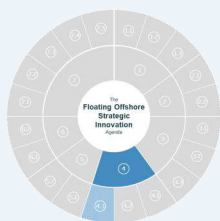
Validation and Trial Needs

- Deployment of continuous monitoring systems in representative floating wind project environments
- Comparative validation against conventional campaign-based monitoring approaches where relevant
- Verification of system reliability, data quality and operational robustness over extended monitoring periods
- Validation of monitoring approaches to support regulatory acceptance and scalable replication across floating wind projects
- Assessment of data usability for regulatory reporting, environmental management and adaptive mitigation actions



Expected Results

- Reliable long-term environmental datasets supporting floating wind project operation, compliance and environmental assessment
- Reduced reliance on discontinuous or campaign-based monitoring approaches
- Improved ability to detect environmental changes and ecosystem interactions during project operation
- Improved comparability and usability of environmental monitoring outputs through standardised and interoperable ecological metrics



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.3** Environmental impact and ecosystem effect mitigation



4.3.4 Mitigation, compensation and eco-design measures for wind farm

Development and application of mitigation, compensation and eco-design measures for floating wind farms, aimed at reducing environmental impacts and supporting ecosystem resilience through informed design choices, layout decisions, operational strategies and nature-inclusive approaches across the project lifecycle.



Priority level



Current TRL



Technological Objective

To minimise the environmental impact of floating wind projects by integrating mitigation, compensation, eco-design and adaptive environmental management principles into park design and planning, supporting lower environmental footprint and improved ecosystem resilience across the project lifecycle.



Specific Actions

- Identification of design and layout features that can reduce environmental impacts associated with floating wind infrastructure
- Assessment of eco-design solutions addressing key impact drivers such as seabed disturbance, underwater noise, habitat interaction and end-of-life environmental implications
- Evaluation of compensation measures applicable where mitigation at source is not feasible
- Assessment of nature-inclusive and ecosystem restoration approaches, supported by environmental monitoring and adaptive management strategies where relevant



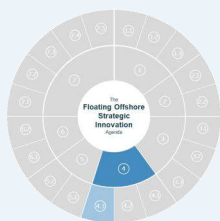
Validation and Trial Needs

- Application of mitigation and eco-design measures to representative floating wind park design studies
- Assessment of the effectiveness of proposed measures through modelling, monitoring data or documented offshore experience
- Pilot validation and long-term monitoring of selected mitigation, eco-design or nature-inclusive measures under representative offshore conditions
- Review of proposed measures with environmental authorities and stakeholders to support acceptance and practical implementation



Expected Results

- Reduced environmental footprint of floating wind farms through design-driven mitigation measures
- Clear understanding of the effectiveness and limitations of mitigation, compensation and nature-inclusive approaches
- Improved integration of environmental considerations into floating wind park design and planning processes



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.3** Environmental impact and ecosystem effect mitigation



4.3.5 Solutions to enable compatibility and co-activity between floating wind farms and fishing activities

Development and application of practical design, access and operational solutions to enable safe coexistence between floating wind farms and fishing activities. The focus is on reducing operational conflicts, improving navigation and access compatibility, and enabling fisheries-specific co-activity arrangements within floating wind farm areas.



Priority level



Current TRL



Technological Objective

To improve coexistence between floating wind projects and fishing activities by identifying practical solutions that enhance navigation safety, access compatibility and operational coordination in shared maritime areas.



Specific Actions

- Assessment of technical and operational constraints affecting coexistence, including mooring layouts, exclusion zones and navigation safety
- Development of fisheries-specific design and operational approaches that facilitate safe access, navigation and co-activity, such as layout adaptations or dedicated transit corridors



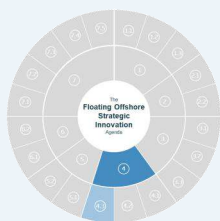
Validation and Trial Needs

- Application of compatibility assessment tools to representative floating wind planning case studies involving fishing activities
- Review of existing offshore experience and pilot initiatives involving coexistence between wind farms and fishing activities
- Engagement with fishing stakeholders and authorities to assess feasibility, safety and acceptance of proposed solutions



Expected Results

- Improved understanding of realistic coexistence options between floating wind farms and fishing activities
- Reduced risk of operational conflicts and safety issues during project development and operation
- Better-informed planning decisions supporting socially acceptable deployment of floating wind projects



Lifecycle Stage *Design and construction*

Area **4** Wind farm layout design and site planning

Subarea **4.3** Environmental impact and ecosystem effect mitigation



4.3.6 Advanced solutions for cumulative impact assessment

Development of applied methodologies and decision-support tools to support project-level cumulative impact assessment for floating wind developments, using available regional environmental baselines, ecosystem sensitivities and relevant information on other marine activities. The line focuses on improving consistency, transparency and usability in the treatment of cumulative effects within planning, consenting and adaptive management processes.



Priority level



Current TRL



Technological Objective

To improve the consistency and transparency of cumulative impact assessment for floating wind projects by providing practical tools and workflows that place project-related environmental effects in the context of existing environmental conditions and ecosystem sensitivities.



Specific Actions

- Develop practical cumulative assessment approaches that combine project-related pressures with available regional environmental baselines, ecosystem sensitivities and monitoring datasets
- Define standardised pressure–pathway–receptor frameworks to support consistent treatment of cumulative effects across projects and consenting processes
- Build decision-support workflows linking cumulative assessment outputs to mitigation, monitoring and adaptive management actions where relevant



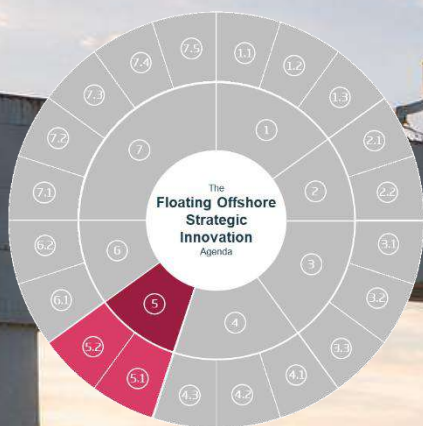
Validation and Trial Needs

- Calibration and validation using regional monitoring datasets and historical baselines (species, habitats, fisheries, oceanographic drivers)
- Application to representative case studies to test sensitivity to scenarios, data gaps and model assumptions, and to benchmark against current planning and consenting practice
- Demonstration with stakeholder/regulator engagement to validate usability, transparency and traceability for consenting and maritime spatial planning



Expected Results

- Operational cumulative assessment tools supporting more consistent treatment of project-level cumulative effects within planning and consenting workflows
- More consistent, transparent and defensible consenting dossiers, reducing rework and dispute risk
- Improved mitigation and monitoring strategies aligned with cumulative pressures and ecosystem-level thresholds



Innovation Area 5

Industrialisation

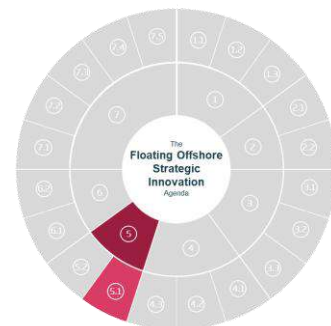
[Back to Innovation Areas](#)



Subarea 5.1 Modularisation, process-oriented standardisation and industrial automation



Subarea 5.2 Port-based component integration and heavy lifting operations



Subarea 5.1 - Modularisation, process-oriented standardisation and industrial automation

Achieving cost-competitive floating offshore wind requires manufacturing systems capable of delivering large and complex components efficiently, consistently and at industrial scale. This subarea brings together the innovation needed to support this transition, **promoting modular architectures, standardised interfaces and automated production processes that simplify integration, reduce manufacturing complexity and improve productivity across the value chain.**

Innovation also encompasses the development of industrialisable materials and protective systems, together with the strengthening of European supply chain capabilities to increase manufacturing capacity, resilience and competitiveness. In parallel, it recognises the need to balance standardisation with design flexibility, acknowledging that different floating concepts and project requirements may limit the adoption of fully standardised industrial solutions.

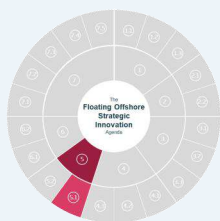
Innovation lines

- PL2 5.1.1 Modular architectures and process-oriented interface standardisation:** definition of common modular solutions and standardised interfaces to reduce customisation, facilitate component integration and enable repeatable industrial manufacturing of floating wind systems.
- PL1 5.1.2 Industrialised, automated and repeatable manufacturing processes for floating wind components:** enabling the transition from prototype-based production to scalable industrial manufacturing through component designs compatible with automated production and consistent, high-volume fabrication processes.
- PL1 5.1.3 Industrialisable materials, protective systems and coatings for floating wind components:** scalable material solutions supporting durability, reduced maintenance, circular design principles and modular replacement strategies for long operational lifetimes under floating offshore wind conditions.
- PL1 5.1.4 Assessment and strengthening of EU floating wind supply chain capabilities:** identification of industrial capacities, knowledge gaps, bottlenecks and collaboration opportunities across the value chain to enhance competitiveness, scalability and resilience of the European floating wind supply chain.
- PL5 5.1.5 Standardisation boundaries and interoperability across floating wind platform designs:** understanding where standardisation is feasible across floating foundation concepts and where site-specific design constraints limit standardisation.



Priority level





Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.1** Modularisation, process-oriented standardisation and industrial automation



5.1.1 Modular architectures and process-oriented interface standardisation

Development and adoption of modular architectures and fit-for-purpose standardised interfaces for floating wind systems and subsystems, enabling easier integration, installation, maintenance and replacement of components. This line focuses on identifying and harmonising interface solutions where standardisation can deliver industrial benefits – such as reduced engineering effort, improved interoperability and repeatability – while preserving the flexibility needed to accommodate different floating concepts, suppliers and project-specific conditions.



Priority level



Current TRL



Technological Objective

To accelerate floating wind industrialisation by enabling interoperable, repeatable and scalable system integration through the selective standardisation of key mechanical, electrical and functional interfaces.



Specific Actions

- Identification and prioritisation of interface types across floating wind systems and subsystems (e.g. mechanical connection points, electrical interfaces, auxiliary systems, monitoring and control interfaces, lifting and handling interfaces), including functional requirements and acceptable boundary conditions
- Development of fit-for-purpose interface specifications, tolerances and verification approaches for selected interface categories with cross-concept and cross-supplier standardisation potential
- Assessment of standardisation and modularisation trade-offs (cost, weight, manufacturability, maintainability, logistics and performance) to identify where harmonisation supports industrial scalability without constraining design optimisation or innovation



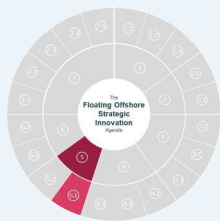
Validation and Trial Needs

- Validation of proposed interface solutions through representative design studies, integration exercises and selected cross-supplier compatibility assessments
- Verification of interface robustness and performance through component-level testing and integration trials, where relevant
- Review and alignment with industry stakeholders and certification bodies to support acceptance, qualification and uptake



Expected Results

- Reduced project-specific engineering effort and improved integration efficiency across floating wind projects
- Improved compatibility and interchangeability of components, supporting faster installation and easier replacement
- Increased repeatability and scalability of floating wind industrial processes enabled by common interface solutions



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 5 Industrialisation

Subarea 5.1 Modularisation, process-oriented standardisation and industrial automation



5.1.2 Industrialised, automated and repeatable manufacturing processes for floating wind components

Development and deployment of industrialised, automated and repeatable manufacturing processes for floating wind components and subassemblies, supporting the transition from prototype-based production to scalable industrial manufacturing. This includes adapting manufacturing technologies from other industries, incorporating design-for-manufacturing approaches and developing component designs compatible with automated and robotised production while ensuring consistent quality, fatigue performance, production efficiency and industrial viability.



Priority level



Current TRL



Technological Objective

To enable scalable and cost-effective manufacturing of floating wind components by increasing industrialisation, automation and process repeatability across the supply chain, while integrating manufacturing-oriented design approaches that support reliable large-scale production and structural performance of floating wind systems.



Specific Actions

- Identification of floating wind components and manufacturing steps with the highest potential for industrialisation, automation and robotisation, considering production scalability, fatigue-critical requirements and applicability across steel, composite and concrete structures
- Development and adaptation of automated and semi-automated manufacturing processes for floating wind components, including design-for-manufacturing approaches compatible with industrial production and process repeatability requirements
- Definition of quality control, traceability and process standardisation frameworks enabling repeatable, high-volume manufacturing across the floating wind supply chain
- Assessment of the techno-economic viability and industrial scalability of automated manufacturing routes, including trade-offs between capital investment, production speed, quality performance and manufacturability



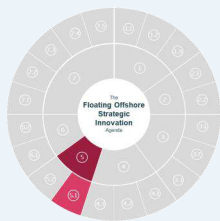
Validation and Trial Needs

- Demonstration of industrialised and automated manufacturing processes through pilot production lines or representative manufacturing campaigns
- Verification of process repeatability, quality consistency and productivity gains compared to conventional manufacturing approaches
- Assessment of manufacturing process robustness under increased production rates and varying component configurations



Expected Results

- Increased production capacity, repeatability and industrial readiness for floating wind components
- Reduced manufacturing costs and improved production efficiency through automation and process repeatability
- Improved quality assurance, traceability and fatigue-oriented manufacturing consistency, including reduced defect rates, lower rework needs and improved compliance with manufacturing tolerances



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 5 Industrialisation

Subarea 5.1 Modularisation, process-oriented standardisation and industrial automation



5.1.3 Industrialisable materials, protective systems and coatings for floating wind components

Selection, adaptation and qualification of materials, protective systems and coating solutions compatible with industrial-scale manufacturing and long-term operation of floating wind components. The focus is on scalable material solutions that enhance durability, reduce maintenance requirements and support circular design approaches and modular replacement strategies under harsh offshore conditions.



Priority level



Current TRL



Technological Objective

To enable reliable and cost-effective industrial production of floating wind components by developing materials and protective systems that combine offshore durability, manufacturability, reduced maintenance requirements and compatibility with circular design and modular replacement strategies.



Specific Actions

- Identification and qualification of materials, protective systems and coatings suitable for floating wind components, ensuring offshore durability and compatibility with industrial manufacturing
- Assessment of the compatibility between selected materials and scalable manufacturing processes for floating wind components, supporting modular production approaches
- Characterisation of degradation mechanisms and lifecycle performance of materials and coatings under floating offshore conditions to support maintenance optimisation, component replacement and circular material use



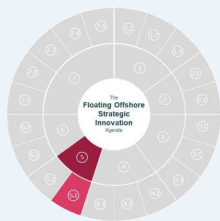
Validation and Trial Needs

- Validation of materials and coatings through laboratory testing and exposure data from offshore or marine environments
- Review of operational experience from offshore wind, oil & gas and maritime sectors to support material selection
- Application of selected solutions in representative floating wind component designs to assess industrial suitability



Expected Results

- Improved durability and service life of floating wind components
- Reduced maintenance and lifecycle costs through appropriate material and coating selection
- Increased confidence in industrial-scale production using standardised and proven protection solutions



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.1** Modularisation, process-oriented standardisation and industrial automation



5.1.4 Assessment and strengthening of EU floating wind supply chain capabilities

Assessment and strengthening of European supply chain capabilities for floating wind, focusing on the identification of industrial capacities, knowledge gaps, bottlenecks and collaboration opportunities across key segments of the value chain such as manufacturing, assembly and logistics. The analysis considers the readiness and scalability of the European industrial ecosystem to support large-scale deployment of floating wind technologies, considering the evolving nature of the supply chain and the need for periodic updates.



Priority level



Current TRL



Technological Objective

To support large-scale deployment of floating wind in Europe by improving the readiness, robustness and competitiveness of the European industrial supply chain through a better understanding of industrial capacities, capability gaps and opportunities for collaboration across the value chain.



Specific Actions

- Mapping of European industrial capabilities relevant to floating wind manufacturing, assembly and logistics across the supply chain
- Identification of critical bottlenecks, knowledge gaps and capacity constraints affecting large-scale deployment of floating wind
- Definition and monitoring of key performance indicators (e.g. production capacity, lead times, utilisation rates) to track supply chain readiness and evolution over time
- Assessment of collaboration opportunities and strategic actions to strengthen supply chain resilience, scalability and competitiveness, considering evolving market conditions



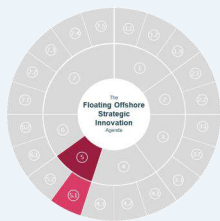
Validation and Trial Needs

- Application of supply chain assessment methodologies to representative floating wind deployment scenarios
- Comparison of identified capabilities and gaps with projected deployment volumes and timelines
- Engagement with industry stakeholders to validate findings, refine prioritised actions and support periodic updates of the assessment



Expected Results

- Clear and updated overview of European floating wind supply chain capabilities and limitations
- Identification of priority actions to support industrial scale-up and reduce deployment risks, supported by measurable indicators such as capacity, lead times and supply chain performance
- Improved alignment between industrial capacity development and floating wind deployment targets



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.1** Modularisation, process-oriented standardisation and industrial automation



5.1.5 Standardisation boundaries and interoperability across floating wind platform designs

Development of frameworks and engineering guidelines to define where standardisation and interoperability are feasible across different floating foundation concepts, and where site-specific constraints impose limits. The line targets identification of “standardisable” subsystems and interfaces (tower–floater, mooring/fairleads, dynamic cable interfaces, auxiliaries, access systems), and the translation of boundary conditions (metocean, water depth, soils, port/installation constraints, certification) into clear design envelopes to support industrial-scale serialisation without compromising performance.



Priority level



Current TRL



Technological Objective

To enable industrial-scale deployment by defining standardisation domains and interoperability rules across floater concepts, establishing practical design envelopes that maximise commonality while managing site-driven constraints.



Specific Actions

- Map and classify subsystems/interfaces with standardisation potential across concepts, defining functional requirements and minimum common specifications
- Quantify site-driven boundary conditions that limit standardisation (metocean classes, depth/soils, logistics/ports, installation methods, grid/interface constraints) and translate into design envelopes
- Develop interoperability guidelines, interface standards and configuration management rules to support product platforms and certification pathways



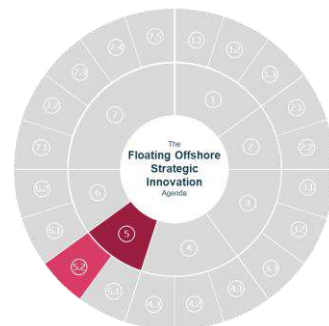
Validation and Trial Needs

- Application to multiple floater concepts and representative sites to demonstrate transferability of proposed standards and envelopes
- Benchmarking against existing industrial designs to quantify commonality gains, cost impacts and performance trade-offs
- Engagement/validation with OEMs, developers and certifiers to confirm acceptability, certification alignment and implementation feasibility



Expected Results

- Defined standardisation boundaries and design envelopes identifying what can be standardised vs site-specific
- Interface/interoperability specifications enabling modular product platforms and reduced redesign effort
- Improved industrialisation readiness through higher repeatability, simplified certification and supply-chain scalability



Subarea 5.2 - Port-based component integration and heavy lifting operations

Port facilities play a central role in the industrialisation of floating offshore wind, enabling major assembly and integration activities to be completed onshore before deployment. This subarea brings together the innovation required to **optimise port-based assembly, heavy lifting operations and infrastructure capable of supporting large-scale floating wind integration, marshalling and pre-commissioning activities.**

Its scope also includes specialised vessel concepts, digital planning tools and AI-enabled monitoring systems that support port logistics, assembly operations and asset tracking. Collectively, these innovation areas seek to **improve the efficiency, safety and scalability of port-based integration while reducing offshore installation complexity, weather dependency and overall project risk.**

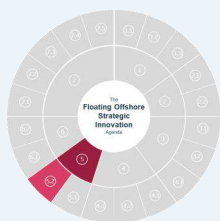
Innovation lines

- PL1 5.2.1 System integration and advanced port-based assembly:** industrialised integration and assembly of floating wind components in port to reduce offshore installation complexity, vessel requirements and weather dependency.
- PL2 5.2.2 Innovative port infrastructure solutions and design criteria to assess, adapt or develop port facilities capable of supporting floating wind hub and marshalling operations:** infrastructure and planning approaches focused on assembly and integration activities, including floating port infrastructure concepts where existing port surface is insufficient, while addressing requirements such as quay strength, ground bearing capacity, available space, draft constraints and wet/dry storage.
- PL5 5.2.3 Innovative specialised and hybrid vessel solutions supporting installation, towing and decommissioning operations for floating wind systems:** addressing lifting constraints such as crane height and outreach while adapting to next-generation turbine sizes.
- PL4 5.2.4 Digital tools for planning and operational execution of port activities:** including digital tools for heavy lifting planning, component logistics, assembly sequencing and port operations optimisation.
- PL5 5.2.5 AI- and digital twin-based monitoring systems for port operations, asset tracking and safety management during floating wind assembly and integration.**



Priority level





Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.2** Port-based component integration and heavy lifting operations



5.2.1 System integration and advanced port-based assembly

Development and application of advanced system integration and port-based assembly approaches for floating wind components and subsystems. The focus is on maximising system integration in port environments to reduce offshore installation complexity, vessel requirements and weather dependency.



Priority level



Current TRL



Technological Objective

To improve efficiency, safety and predictability of floating wind installation campaigns by shifting integration and assembly activities from offshore environments to controlled port-based facilities.



Specific Actions

- Identification of floating wind components and subsystems suitable for full or partial integration at port, considering spatial, lifting, transport and handling constraints
- Assessment of port facility requirements for advanced assembly and integration operations, including quay capacity, crane requirements, draft, laydown areas and load-out constraints
- Definition of industrialised port-based assembly sequences compatible with floating wind platform sizes and configurations
- Assessment of interfaces between integrated systems to ensure transportability, structural integrity, installation readiness and compatibility with port handling and load-out operations



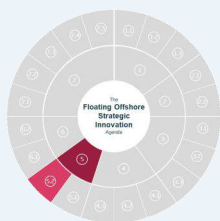
Validation and Trial Needs

- Demonstration of port-based integration and assembly approaches through representative integration campaigns, pilot projects or trial assembly activities at suitable existing port facilities
- Verification of structural, stability and handling performance during transport and tow-out operations
- Assessment of installation efficiency gains and reduction of offshore work compared to conventional approaches



Expected Results

- Increased proportion of floating wind system integration completed in port
- Reduced offshore installation time, vessel dependency and weather exposure
- Improved installation reliability, safety and schedule predictability through better alignment between assembly strategies and port capabilities



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.2** Port-based component integration and heavy lifting operations



5.2.2 Innovative port infrastructure solutions and design criteria to assess, adapt or develop port facilities capable of supporting floating wind hub and marshalling operations

Development and application of design criteria and infrastructure solutions to assess, adapt or develop port facilities capable of supporting floating wind hub and marshalling operations. The focus is on port configurations supporting assembly and system integration activities, including alternative infrastructure concepts such as floating port structures where conventional port surface is insufficient, while addressing requirements related to ground bearing capacity, quay strength, available space, draft constraints, wet and dry storage needs, scalability considerations and integration with installation and logistics strategies for large-scale deployment.



Priority level



Current TRL



Technological Objective

To enable ports to effectively support large-scale floating wind deployment by defining clear technical criteria and infrastructure solutions aligned with floating wind assembly, integration and marshalling requirements, while enabling cost-efficient, scalable and repeatable industrial operations.



Specific Actions

- Definition of technical requirements for ports supporting floating wind activities, including structural capacity, draft, spatial layout, logistics flows and throughput constraints
- Assessment of existing port infrastructure against floating wind requirements to identify adaptation needs and development options
- Development of design guidelines, planning methodologies and digital assessment tools to support port optimisation, bottleneck identification and investment decisions for floating wind hubs
- Integration of port design approaches with installation, towing and offshore logistics strategies to improve compatibility with large-scale deployment operations



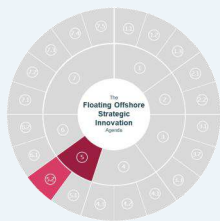
Validation and Trial Needs

- Application of port assessment and design criteria to representative European ports under large-scale floating wind deployment scenarios
- Evaluation of infrastructure solutions through feasibility studies, logistics simulations and implementation of selected port upgrades where available
- Validation of integration between port operations, installation strategies and towing/logistics workflows under representative operational scenarios
- Review of outcomes with port authorities, developers and industrial stakeholders to validate applicability and robustness



Expected Results

- Clear and consistent criteria for assessing port readiness for floating wind activities
- Increased deployment capacity and reduced logistical bottlenecks for large-scale floating wind operations
- Improved alignment between floating wind industrial needs and port infrastructure capabilities
- More efficient planning and investment decisions for port adaptation and development supporting floating wind hubs



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.2** Port-based component integration and heavy lifting operations



5.2.3 Innovative specialised and hybrid vessel solutions supporting installation, towing and decommissioning operations for floating wind systems

Development and adaptation of specialised and hybrid vessel concepts for floating wind installation, towing and decommissioning operations, addressing lifting constraints associated with large turbine components and improving operational flexibility for next-generation floating wind systems.



Priority level



Current TRL



Technological Objective

To improve the efficiency, safety and predictability of floating wind installation and removal operations by developing specialised and hybrid vessel solutions adapted to large turbine components, towing operations and floating wind system requirements.



Specific Actions

- Identification of installation, towing and decommissioning operations that define vessel capability requirements for floating wind systems
- Assessment of existing vessel fleets and identification of capability gaps related to lifting capacity, crane outreach, deck space and station-keeping requirements for floating wind operations
- Development and evaluation of innovative and hybrid vessel concepts adapted to next-generation turbine sizes and floating wind installation strategies



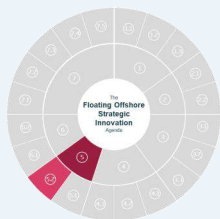
Validation and Trial Needs

- Demonstration of adapted or specialised vessels in representative floating wind installation or removal campaigns
- Assessment of operational performance, safety and weather sensitivity compared to conventional vessel approaches
- Review of vessel utilisation efficiency and availability across multiple floating wind projects



Expected Results

- Improved suitability of vessel fleets for floating wind installation and removal operations
- Reduced installation and decommissioning risk and weather-related delays
- Increased operational flexibility and predictability for floating wind project execution



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.2** Port-based component integration and heavy lifting operations



5.2.4 Digital tools for planning and operational execution of port activities

Development and application of digital tools to support planning, coordination and operational execution of port activities related to floating wind projects. These tools enable improved scheduling, heavy lifting planning, component logistics management, assembly sequencing and operational optimisation for port-based integration and marshalling operations.



Priority level



Current TRL



Technological Objective

To improve efficiency, predictability and coordination of port operations supporting floating wind projects by enabling data-driven planning and real-time operational decision-making.



Specific Actions

- Adaptation of existing port and logistics digital tools to floating wind assembly and marshalling operations, enabling coordinated planning of heavy lifting activities, component logistics and assembly sequencing in port environments
- Integration of scheduling, resource management and risk assessment functions into unified digital planning environments
- Development of interfaces to support coordination between port operators, developers, vessel operators and contractors



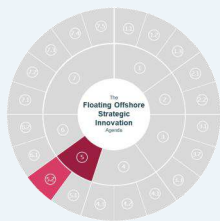
Validation and Trial Needs

- Application of digital planning and operational tools to representative floating wind port operations and integration campaigns
- Verification of improvements in scheduling accuracy, resource utilisation and operational robustness compared to conventional planning approaches
- Assessment of usability and decision-support value through feedback from port operators and project teams



Expected Results

- Improved planning and execution of port-based floating wind activities
- Reduced delays and inefficiencies driven by poor coordination or reactive decision-making
- Enhanced transparency and predictability of port operations supporting floating wind deployment



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **5** Industrialisation

Subarea **5.2** Port-based component integration and heavy lifting operations



5.2.5 AI-digital twin-based monitoring systems for port operations, asset tracking and safety management during floating wind assembly and integration

Development and deployment of AI-enabled monitoring and digital twin systems to improve port-side assembly, integration and heavy lifting operations for floating wind. The line targets real-time visibility of assets, equipment and workforce status (components, cranes, transporters, quayside constraints), together with predictive safety and risk management during complex lifts and concurrent operations, enabling higher throughput and reduced incidents.



Priority level



Current TRL



Technological Objective

To increase port integration capacity, schedule reliability and safety by implementing digital twin + AI solutions that provide real-time situational awareness, predictive risk alerts and decision support for heavy lifting and assembly operations.



Specific Actions

- Develop port operation digital twins integrating layout, equipment capacity, constraints and real-time data streams (IoT, GPS/RFID, vision, crane telemetry)
- Implement AI models for asset tracking, congestion detection, lift-path monitoring and anomaly/risk prediction (exclusion zones, near-miss patterns)
- Define data standards, interfaces and cybersecurity requirements to connect digital tools with port TOS, HSE systems and contractor workflows



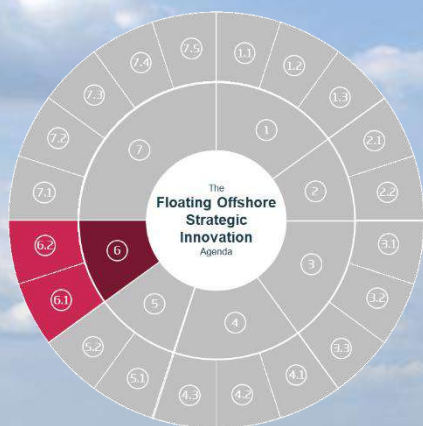
Validation and Trial Needs

- Pilot deployment in an operational port environment to validate tracking accuracy, latency and robustness under marine/industrial conditions
- Demonstration of safety use-cases (automated exclusion zones, lift monitoring, near-miss detection) and benchmarking vs baseline HSE performance
- Verification of operational KPIs (turnaround time, crane utilisation, rework reduction) and user adoption across multiple contractors



Expected Results

- Real-time port operational visibility (assets, workforce status, equipment utilisation) supporting higher throughput
- Improved safety performance via predictive alerts, better situational awareness and reduced human-error exposure during lifts
- Reduced delays and integration cost through optimised sequencing, fewer conflicts and data-driven decision-making



Innovation Area 6

Logistics and offshore installation

[Back to Innovation Areas](#)

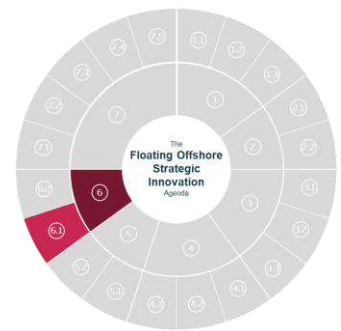


Subarea 6.1 Logistics, load-out, float-off, wet storage and port-to-site transport



Subarea 6.2 Offshore installation and hook-up of platforms, cables and mooring systems





Subarea 6.1 - Logistics, load-out, float-off, wet storage and port-to-site transport

The transition from port assembly to offshore installation represents one of the most complex logistical stages in the floating offshore wind value chain. This subarea brings together the innovation needed to **ensure that floating wind systems can be transported, handled and transferred safely, efficiently and at industrial scale**, while minimising operational constraints, costs and weather dependency.

Its scope covers the complete pre-installation logistics chain, including load-out and float-off operations, wet storage, towing strategies, handling methodologies for dynamic power cables, and transport solutions for large floating wind components. Together, these innovation areas seek to **improve logistics efficiency, increase deployment readiness and enable repeatable project execution** across different floating wind developments.

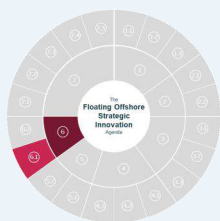
Innovation lines

- PL1 6.1.1 Industrialised load-out and float-on/float-off solutions in port environments:** scalable and reusable concepts enabling modular integration zones and efficient handling of large floating wind modules while reducing reliance on project-specific equipment.
- PL4 6.1.2 Mature wet-storage solutions and temporary management of floating assets:** optimised temporary mooring strategies and storage configurations adapted to different port layouts, sheltered-water opportunities and location-specific operability constraints.
- PL2 6.1.3 Floating transport and optimised towing strategies:** logistics approaches enabling safe and cost-efficient transport of floating wind units adapted to metocean conditions and supporting industrialised multi-unit deployment.
- PL5 6.1.4 Industrialised methodologies for handling and loading dynamic power cables and accessories.**
- PL2 6.1.5 Dry transport and internal logistics solutions for large-scale floating wind components within and between fabrication, assembly, storage and port facilities:** addressing the limited compatibility between current component designs and industrial transport chains.



Priority level





Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **6** Logistics and offshore installation

Subarea **6.1** Logistics, load-out, float-off, wet storage and port-to-site transport



6.1.1 Industrialised load-out and float-on/float-off solutions in port environments

Development and industrialisation of load-out and float-on/float-off solutions for floating wind platforms and integrated modules in port environments. These solutions aim to establish repeatable, safe and efficient methodologies for transferring large floating structures from fabrication or assembly areas to water, supporting modular integration zones in ports and reducing operational risk, weather dependency and reliance on project-specific equipment.



Priority level



Current TRL



Technological Objective

To improve safety, efficiency and scalability of floating wind deployment by standardising and industrialising load-out and float-on/float-off operations in port environments, enabling modular assembly and repeatable transfer of large floating wind modules to water.



Specific Actions

- Identification of load-out and float-on/float-off methodologies suitable for different floating platform typologies and port configurations
- Definition of repeatable operational sequences, structural checks and stability criteria enabling safe transfer of large floating wind modules to water
- Assessment of load distribution, structural reinforcement needs and temporary support systems required during load-out and float-on/float-off operations
- Assessment of workability limits and weather-related operational risks associated with identified load-out and float-on/float-off methodologies, considering port-specific environmental conditions such as tides, wind and wave exposure
- Evaluation of integration opportunities and operational synergies with other marine logistics activities, including transport strategies and pre- or post-load-out WTG integration approaches



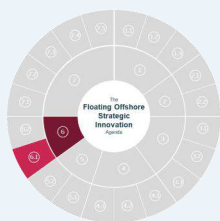
Validation and Trial Needs

- Demonstration of industrialised load-out and float-on/float-off procedures in representative floating wind integration campaigns
- Verification of structural integrity, stability margins and operational safety during transfer operations
- Evaluation of time efficiency and risk reduction compared with project-specific or ad hoc load-out approaches



Expected Results

- Increased repeatability and predictability of load-out and float-on/float-off operations
- Reduced operational risk and weather sensitivity during port-based deployment phases
- Improved scalability of floating wind industrial campaigns through standardised and reusable port integration solutions



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 6 Logistics and offshore installation

Subarea 6.1 Logistics, load-out, float-off, wet storage and port-to-site transport



6.1.2 Mature wet-storage solutions and temporary management of floating assets

Development and application of mature wet-storage solutions and associated procedures for temporary management of floating wind assets during fabrication, integration, tow-out, installation and maintenance phases. This includes optimisation of temporary mooring strategies, storage configurations, monitoring approaches and operational planning adapted to project execution schedules, port layouts, sheltered-water opportunities and location-specific environmental and operability constraints.



Priority level



Current TRL



Technological Objective

To enable reliable and scalable wet-storage operations for floating wind assets by optimising temporary mooring strategies, storage configurations, operational planning and monitoring procedures under varying project execution schedules, port layouts and environmental conditions.



Specific Actions

- Definition of wet-storage configurations, temporary mooring strategies and storage requirements for floating wind platforms under representative harbour and nearshore conditions, considering asset configurations, storage durations and project execution schedules
- Assessment of operational procedures for asset handling, access planning, safety management and contingency response during wet-storage operations
- Development of monitoring and inspection approaches to ensure asset integrity, stability and operational readiness during temporary storage periods
- Assessment of environmental constraints, regulatory requirements and port infrastructure needs associated with wet-storage deployment and temporary floating asset management



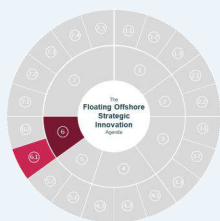
Validation and Trial Needs

- Demonstration of wet-storage procedures through representative floating wind port operations or pilot projects
- Evaluation of operational reliability under varying environmental conditions, port layouts and sheltered-water constraints
- Verification of mooring performance, asset integrity and monitoring effectiveness during extended storage periods
- Validation of compatibility between wet-storage strategies and project execution schedule requirements, including environmental and regulatory compliance aspects



Expected Results

- Safer and more predictable wet-storage operations for floating wind platforms
- Improved logistics flexibility and compatibility with industrial-scale deployment and installation schedules
- Reduced risk of asset damage, drift or loss of availability during temporary storage phases
- Increased confidence in wet-storage solutions under varying port, environmental and regulatory conditions



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **6** Logistics and offshore installation

Subarea **6.1** Logistics, load-out, float-off, wet storage and port-to-site transport



6.1.3 Floating transport and optimised towing strategies

Development and optimisation of floating transport and towing strategies for floating wind assets, including wet-tow and floating transport operations during pre-service, integration and deployment phases. The line focuses on logistics approaches that improve tow-out and tow-back operations through optimised routing, operational planning and tug configurations, enabling safe, cost-efficient transport and supporting industrialised multi-unit deployment campaigns under site-specific metocean conditions.



Priority level



Current TRL



Technological Objective

To increase the safety, reliability and efficiency of floating asset transport operations by applying optimised towing strategies, logistics planning and vessel coordination adapted to environmental conditions, operational constraints and project execution schedules.



Specific Actions

- Definition of towing strategies and operational limits considering platform hydrodynamic behaviour, stability, transport configuration and metocean constraints
- Assessment of hull adaptations, towing interfaces and access arrangements to improve transport efficiency and operational robustness
- Development of planning approaches for route optimisation, towing timing and tug selection / configuration for representative floating wind transport scenarios
- Assessment of contingency procedures, vessel availability and risk mitigation strategies supporting safe and efficient towing operations during large-scale deployment campaigns



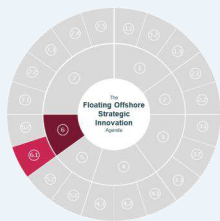
Validation and Trial Needs

- Validation of towing strategies through representative transport case studies and operational simulations
- Verification of operability assumptions and risk controls against recorded metocean data and observed towing conditions
- Review of towing performance and operational outcomes from pilot or pre-commercial floating wind projects where available
- Assessment of transport strategy compatibility with vessel market availability and representative project execution schedule assumptions



Expected Results

- Improved operability and reduced weather-related delays during towing operations
- Improved logistics planning and transport flexibility under representative deployment conditions
- Increased safety margins and clearer operational limits for floating asset transport
- More predictable and cost-efficient transport operations supporting industrial-scale floating wind deployment



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **6** Logistics and offshore installation

Subarea **6.1** Logistics, load-out, float-off, wet storage and port-to-site transport



6.1.4 Industrialised methodologies for handling and loading dynamic power cables and accessories

Development and industrialisation of methodologies for handling, loading, storage and deployment preparation of dynamic power cables used in floating wind projects. This line focuses on improving the safety, reliability and repeatability of cable logistics operations while reducing damage risk and enabling efficient port-to-installation cable handling workflows at industrial deployment scale.



Priority level



5



4



3



2



1



Current TRL



5



6



7



8



9



Technological Objective

To increase the reliability, safety and scalability of dynamic cable logistics by implementing standardised and industrialised handling, storage and loading procedures compatible with large-scale floating wind deployment.



Specific Actions

- Identification of critical handling steps and risk factors associated with dynamic cable transport, storage and loading operations
- Development of standardised procedures, equipment configurations and inspection protocols for cable storage, handling and loading activities
- Assessment of cable bending limits, tension control and protection requirements during port-based logistics and pre-installation handling phases



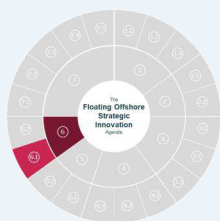
Validation and Trial Needs

- Demonstration of industrialised cable handling procedures during representative port logistics or installation preparation campaigns
- Verification of cable integrity and mechanical performance following handling and loading operations
- Evaluation of operational efficiency gains and reduction of damage incidents compared with non-standardised approaches



Expected Results

- Reduced risk of mechanical damage to dynamic cables during logistics and pre-installation phases
- Increased repeatability and predictability of cable handling operations
- Improved readiness and reliability of dynamic cables prior to offshore installation



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **6** Logistics and offshore installation

Subarea **6.1** Logistics, load-out, float-off, wet storage and port-to-site transport



6.1.5 Dry transport and internal logistics solutions for large-scale floating wind components within and between fabrication, assembly, storage and port facilities

Development and optimisation of onshore transport and internal logistics solutions for large-scale floating wind components within and between fabrication yards, assembly facilities, storage areas and port infrastructures. The line addresses the limited compatibility between current component designs and industrial transport chains, focusing on improving safety, efficiency and scalability of oversized component transport and handling operations.



Priority level



Current TRL



Technological Objective

To develop and optimise integrated onshore transport and handling solutions for large-scale floating wind components by improving compatibility between component design, transport infrastructure and logistics systems, thereby increasing safety, efficiency and scalability.



Specific Actions

- Assessment and optimisation of transport corridors and supporting infrastructure (roads, bridges, marshalling areas and port interfaces) for oversized component movements, including bottleneck identification and upgrade needs
- Assessment of component design features, modularisation strategies and transport constraints to improve compatibility with industrial transport chains and logistics infrastructure
- Development of standardised handling methodologies and equipment configurations enabling safe and efficient onshore and yard transport of large-scale floating wind components
- Evaluation of coordination and operational interfaces between fabrication yards, storage areas, transport systems and port integration facilities to support scalable industrial deployment of floating wind components



Validation and Trial Needs

- Demonstration of optimised onshore transport and logistics solutions in representative industrial environments handling large-scale floating wind components
- Evaluation of coordination between fabrication, storage and integration phases under increased production volumes and industrial deployment scenarios
- Verification of operational safety, handling efficiency and infrastructure compatibility for oversized component transport and yard operations
- Assessment of transport corridor readiness and operational constraints under representative oversized component logistics conditions, including bottleneck identification and infrastructure limitations



Expected Results

- Validated and standardised logistics and handling solutions applicable across multiple industrial contexts
- Enhanced readiness of transport corridors, fabrication yards and port interfaces to support oversized floating wind component logistics
- Improved cost-efficiency and reduced logistical complexity for large-scale floating wind deployment
- Increased compatibility between component design, industrial transport systems and large-scale deployment requirements for floating wind projects



Back to
Area 6

Subarea 6.2 - Offshore installation and hook-up of platforms, cables and mooring systems

The **offshore installation** phase is one of the most operationally demanding and weather-sensitive stages of floating offshore wind projects. This subarea brings together the **innovation needed to improve the efficiency, safety and repeatability of offshore installation activities**, supporting the transition from one-off operations to industrial-scale project execution.

Its scope encompasses installation architectures and methodologies, positioning and verification technologies, accelerated multi-unit installation procedures, automated hook-up solutions, and geotechnical characterisation for anchoring systems. Collectively, these innovation areas aim to **increase installation operability, shorten offshore campaigns and reduce execution risks** while enabling the large-scale deployment of floating offshore wind.

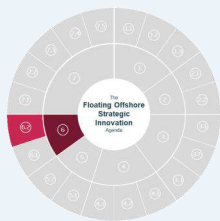
Innovation lines

- PL1 6.2.1 Efficient offshore installation architectures, sequences, procedures and tools to increase operability for the complete system.**
- PL3 6.2.2 In-situ positioning, balancing connection, and verification technologies:** including advanced sensing used throughout the life cycle and automation.
- PL2 6.2.3 Accelerated procedures and SIMOPS for multi-unit installation:** operational strategies enabling sequential and partially parallel installation of floating wind units to reduce installation time and vessel utilisation.
- PL5 6.2.4 Highly automated hook-up equipment and procedures ideally standardised.**
- PL3 6.2.5 Geotechnical characterisation oriented to the execution of FOW anchoring systems:** addressing the gap between current site characterisation practices and the requirements of scalable anchoring execution, particularly regarding geophysical interpretation, anchor positioning uncertainty and the cost of repeated borehole campaigns.



Priority level





Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area **6** Logistics and offshore installation

Subarea **6.2** Offshore installation and hook-up of platforms, cables and mooring systems



6.2.1 Efficient offshore installation architectures, sequences, procedures and tools to increase operability for the complete system

Development and optimisation of offshore installation architectures, operational sequences, procedures and supporting tools for the complete floating wind system, including platforms, mooring systems and dynamic cables. This line aims to increase operability, reduce offshore time and improve coordination of multi-asset installation campaigns.



Priority level



Current TRL



Technological Objective

To enhance safety, efficiency and predictability of offshore installation operations by defining optimised architectures, sequences and tools adapted to floating wind system characteristics.



Specific Actions

- Analysis and optimisation of installation sequences for floating platforms, mooring systems and dynamic cables
- Development of procedures and operational limits to increase weather operability and reduce offshore exposure time
- Assessment of installation tool requirements and compatibility with floating wind system interfaces



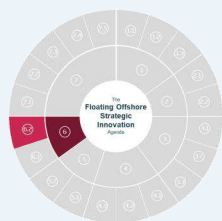
Validation and Trial Needs

- Application of optimised installation architectures to representative floating wind deployment scenarios
- Verification of operability improvements through simulation, operational analysis or pilot installation campaigns
- Comparison of optimised procedures with conventional offshore approaches in terms of time, risk and vessel utilisation



Expected Results

- Reduced offshore installation time and improved schedule predictability
- Increased weather operability and operational flexibility
- Improved coordination and efficiency of multi-unit installation campaigns



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 6 Logistics and offshore installation

Subarea 6.2 Offshore installation and hook-up of platforms, cables and mooring systems



6.2.2 In-situ positioning, balancing connection, and verification technologies

Development and deployment of advanced in-situ positioning, connection balancing and verification technologies for floating wind installation operations. These solutions integrate high-precision positioning systems, advanced sensing and automation tools to support accurate alignment, controlled connection and real-time validation of platforms, mooring systems and dynamic cables, while considering installation-driven design constraints and operability requirements.



Priority level



Current TRL



Technological Objective

To improve the accuracy, safety and efficiency of offshore installation and hook-up operations by integrating advanced positioning, sensing, automation and verification technologies adapted to floating wind environments.



Specific Actions

- Assessment of positioning accuracy requirements for floating platform alignment, mooring connection balancing and dynamic cable hook-up operations across representative floating wind configurations
- Evaluation of trade-offs between mooring/IAC design configurations, installation efficiency, operational workability and risk reduction objectives
- Integration of advanced sensing, monitoring and automation systems into offshore installation workflows
- Development of verification protocols to confirm correct connection, tensioning and system readiness in real time



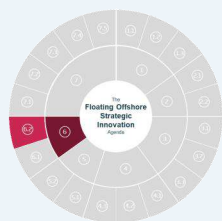
Validation and Trial Needs

- Demonstration of in-situ positioning and verification technologies during representative floating wind installation campaigns
- Assessment of how installation experience and operational constraints can be translated into design requirements and optimisation criteria for mooring and inter-array cable systems
- Verification of alignment precision, connection reliability and data accuracy under real offshore conditions
- Evaluation of operational efficiency improvements compared to conventional positioning and manual verification approaches



Expected Results

- Increased precision and reduced error rates during offshore positioning and connection operations
- Improved safety through enhanced real-time monitoring and verification
- Reduced need for corrective interventions and associated delays offshore



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 6 Logistics and offshore installation

Subarea 6.2 Offshore installation and hook-up of platforms, cables and mooring systems



6.2.3 Accelerated procedures and SIMOPS for multi-unit installation

Development and optimisation of accelerated offshore installation procedures and SIMOPS (simultaneous operations) strategies to enable efficient sequential or partially parallel installation of multiple floating wind units. These approaches improve coordination of vessels, assets and installation activities, reducing campaign duration and increasing operational efficiency at wind farm scale.



Priority level



Current TRL



Technological Objective

To reduce installation timelines and offshore exposure by enabling safe and efficient simultaneous or partially parallel installation of floating wind platforms and associated systems through coordinated multi-vessel operations.



Specific Actions

- Definition of optimised installation sequences enabling sequential or partially parallel operations while maintaining safe operational limits
- Identification of operational interfaces, safety constraints and risk management strategies associated with SIMOPS in floating wind environments
- Development of coordination frameworks and decision-support tools for planning multi-vessel and multi-asset installation campaigns



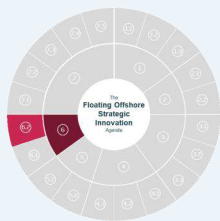
Validation and Trial Needs

- Application of accelerated and SIMOPS-based installation procedures to representative floating wind installation scenarios
- Assessment of safety performance, coordination efficiency and time savings compared with conventional sequential installation approaches, including evaluation under realistic seasonal weather downtime conditions
- Verification of risk mitigation measures and schedule robustness under simulated or real offshore operational conditions using representative metocean and weather-window datasets



Expected Results

- Reduced total installation campaign duration for floating wind farms
- Improved vessel utilisation and offshore operational efficiency
- Increased confidence in the safe execution of multi-unit offshore installation campaigns



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 6 Logistics and offshore installation

Subarea 6.2 Offshore installation and hook-up of platforms, cables and mooring systems



6.2.4 Highly automated hook-up equipment and procedures ideally standardised

Development and deployment of highly automated equipment and standardised procedures for offshore hook-up operations, including mooring line connection, dynamic cable connection and associated mechanical and electrical interfaces. These solutions aim to reduce manual intervention, increase safety and enable repeatable and standardised offshore connection activities across floating wind projects while improving operational workability under offshore conditions.



Priority level



Current TRL



Technological Objective

To enhance the safety, efficiency and repeatability of offshore hook-up operations by introducing automated equipment, remote-assisted procedures and standardised connection methods adapted to floating wind systems.



Specific Actions

- Identification of hook-up operations with high manual workload, safety exposure or variability that could benefit from automation and procedural standardisation
- Assessment of workability limits, weather operability impacts and mechanical downtime risks associated with automated hook-up systems compared with baseline procedures
- Development and integration of automated or remotely operated connection tools and monitoring systems
- Definition of standardised operational procedures and interface requirements enabling repeatable hook-up operations across floating wind installations



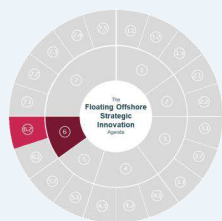
Validation and Trial Needs

- Demonstration of automated hook-up equipment in representative offshore installation campaigns or controlled offshore trials
- Verification of connection reliability, tension control, positional accuracy and alignment under realistic metocean conditions
- Assessment of safety improvements, personnel-on-board reduction, operational robustness and weather-related operability impacts compared with conventional manual procedures



Expected Results

- Reduced manual intervention and offshore personnel exposure during hook-up operations
- Increased repeatability, precision and reliability of connection activities
- Shorter, more predictable and less weather-dependent offshore connection timelines
- Potential reduction of installation costs at wind-farm scale through standardised and automated hook-up procedures



Lifecycle Stage *Industrialisation, logistics and offshore installation*

Area 6 Logistics and offshore installation

Subarea 6.2 Offshore installation and hook-up of platforms, cables and mooring systems



6.2.5 Geotechnical characterisation oriented to the execution of FOW anchoring systems

Geotechnical characterisation approaches specifically oriented to the execution of floating offshore wind anchoring systems, addressing the gap between current site characterisation practices and the requirements of scalable anchoring installation. This includes improving geophysical interpretation, reducing anchor positioning uncertainty and optimising site investigation strategies to minimise the need for repeated borehole campaigns while supporting reliable offshore execution.



Priority level



Current TRL



Technological Objective

To improve the reliability, efficiency and predictability of anchoring system installation by aligning geotechnical investigation, geophysical interpretation and site investigation strategies with installation requirements and offshore execution constraints.



Specific Actions

- Definition of geotechnical data requirements and investigation scopes tailored to anchoring system design, positioning accuracy and installation methods
- Development of improved interpretation methodologies linking geophysical survey results, soil properties and anchor installation behaviour
- Integration of geotechnical deliverables into installation planning workflows to reduce positioning uncertainty and avoid repeated borehole campaigns

Validation and Trial Needs

- Application of execution-oriented geotechnical methodologies to representative floating wind anchoring projects
- Comparison of predicted installation behaviour with observed offshore anchoring performance and positioning accuracy
- Review of geotechnical deliverables with installers and contractors to confirm usability, reliability and decision-support value



Expected Results

- Reduced installation uncertainty and fewer offshore surprises during anchoring operations
- Improved alignment between anchor design assumptions, geophysical interpretation and execution realities
- More efficient and predictable anchoring installation campaigns with reduced need for repeated site investigation campaigns



Innovation Area 7

Operation & Maintenance and Decommissioning

[Back to Innovation Areas](#)



Subarea 7.1 Data acquisition for O&M digitalisation



Subarea 7.2 Data management and structuring for O&M digitalisation



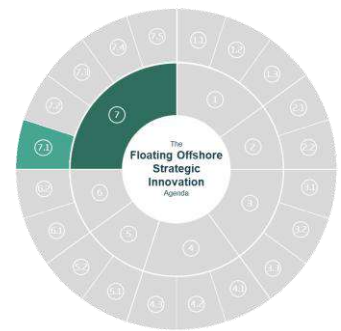
Subarea 7.3 Data exploitation for O&M digitalisation



Subarea 7.4 Heavy offshore maintenance and major offshore interventions



Subarea 7.5 Decommissioning, repowering and end-of-life strategies of the floating system



Subarea 7.1 - Data acquisition for O&M digitalisation

Effective operation and maintenance begins with the ability to continuously understand the condition of floating offshore wind assets. This subarea promotes the technologies and sensing approaches required to **capture reliable information on the structural, mechanical and operational status of floating wind systems under real operating conditions.**

Innovation encompasses advanced structural monitoring, autonomous aerial, subsea and surface-based inspection systems, distributed sensing networks, virtual sensing techniques and event-triggered inspection approaches. Together, these developments seek to **improve asset visibility, increase inspection efficiency and provide the high-quality data** required to support digital operation and maintenance strategies.

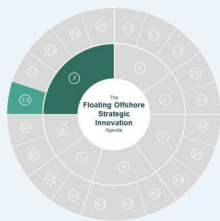
Innovation lines

- PL1 7.1.1 Advanced structural and condition monitoring of critical equipment and components using physical sensing and model-based approaches:** continuous monitoring systems for the structural and operational condition of key floating wind farm assets.
- PL1 7.1.2 Autonomous aerial and ground-based inspection systems for above-water assets:** use of drones and robotic systems capable of operating on floating wind structures, enabling automated inspections, onboard defect detection and high-frequency monitoring of turbines, towers and exposed substructure elements in harsh offshore environments.
- PL1 7.1.3 Autonomous subsea inspection systems for floating infrastructures:** ROV/AUV Deployment with Environmental Monitoring Sensors and Data Acquisition, Cost-Reducing USV/ASV Support, and Innovation in Sensor Payloads, Collaborative Vehicle Swarms, and AI-Driven Sonar Imagery Analytics for Routine Inspection of Moorings, Anchors, Dynamic Cables, and Submerged Elements.
- PL1 7.1.4 Autonomous sensing and monitoring networks for floating wind environments:** integration of robust sensor systems, energy harvesting technologies and low-power underwater communication solutions to enable continuous monitoring of loads, structural behaviour and environmental conditions in harsh offshore environments.
- PL5 7.1.5 Improvement of dynamic cable design and technical definition processes:** integration of operational data and performance insights to enhance the design and technical specification.
- PL5 7.1.6 Means of inspecting structural and operational status triggered on demand by environmental events rather than through continuous monitoring.**
- PL5 7.1.7 Virtual sensing:** development of methodologies for virtual sensing based on numerical coupled models.
- PL4 7.1.8 Implementation of lightweight, multi-vector inspection methods for conducting group inspections, including deployment from Uncrewed Surface Vessels.**



Priority level





Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation



7.1.1 Advanced structural and condition monitoring of critical equipment and components using physical sensing and model-based approaches

Development and deployment of advanced monitoring systems for the structural and operational condition of critical floating wind assets, combining physical sensing technologies with model-based monitoring approaches to capture degradation mechanisms, abnormal behaviour, operational loads and structural responses under representative environmental and operational conditions.



Priority level



Current TRL



Technological Objective

To enable earlier detection of failures, more accurate condition assessment and improved O&M planning by integrating advanced sensing technologies, metocean data and model-based monitoring approaches into floating wind farm operations.



Specific Actions

- Development of advanced sensing systems for continuous monitoring of structural loads, fatigue behaviour, degradation mechanisms and operational performance of floating wind components under representative environmental conditions
- Integration of physics-informed and model-based monitoring approaches with advanced signal processing methods and metocean data to distinguish degradation mechanisms from floating-specific operational variability
- Development of diagnostic and prognostic methodologies linking monitoring data with asset condition assessment, remaining useful life estimation and predictive maintenance strategies, including scalable inspection and monitoring approaches where relevant



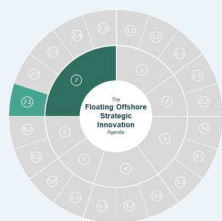
Validation and Trial Needs

- Validation of monitoring system performance through representative experimental data, controlled testing environments, numerical reference cases and operational project data where available
- Verification of detection capability for relevant degradation mechanisms through controlled tests, historical failure data or correlated inspection findings
- Evaluation of system reliability, false-alarm rate, robustness and long-term stability under representative offshore conditions
- Validation under varying metocean and operational conditions, including seasonal variability, transient events and long-term degradation processes
- Comparison of monitoring outputs with conventional inspection and maintenance practices to assess added value, reliability and operational relevance



Expected Results

- Earlier detection of degradation and abnormal behaviour, reducing unplanned downtime and failure risk
- Improved, data-driven maintenance planning and reduced reliance on reactive interventions
- Increased confidence in asset condition assessment, supporting more efficient O&M strategies and reducing lifecycle costs



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation



7.1.2 Autonomous aerial and ground-based inspection systems for above-water assets

Deployment of autonomous aerial and robotic inspection systems for above-water and air-sea transition zone components of floating wind assets, supporting inspection activities across installation, commissioning and operational phases. These systems enable automated inspections, onboard defect detection and recurrent asset assessment while reducing offshore personnel exposure and improving inspection efficiency and data quality.



Priority level



Current TRL



Technological Objective

To enhance the efficiency, safety and cost-effectiveness of inspection activities for floating wind farms by integrating autonomous and remotely operated inspection systems into floating wind inspection and asset management workflows.



Specific Actions

- Adaptation of aerial and robotic inspection systems to floating-specific motion and environmental conditions, including inspection activities around the air-sea transition zone and offshore structures
- Development of inspection protocols, data acquisition standards and repeatable inspection methodologies tailored to floating wind components and offshore operational conditions
- Integration of inspection outputs into digital asset management and maintenance decision systems, supporting remote operations and predictive maintenance workflows
- Assessment of long-range and persistent autonomous inspection capabilities to support reduced vessel dependency and increased inspection coverage in offshore wind farms



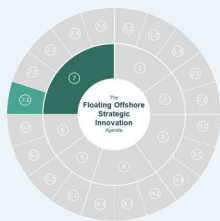
Validation and Trial Needs

- Pilot deployment of autonomous aerial and robotic inspection systems on operating floating wind assets under representative offshore conditions
- Verification of inspection performance, navigation stability and defect detection capability under representative offshore and air-sea transition zone conditions
- Evaluation of operational reliability, data acquisition quality and repeatability during extended inspection campaigns under varying metocean conditions



Expected Results

- Increased inspection frequency, flexibility and consistency without increasing operational risk
- Reduced need for manual offshore inspection campaigns
- Improved traceability, repeatability and quality of inspection data supporting predictive maintenance and asset integrity management
- Enhanced operational efficiency and reduced vessel dependency through autonomous and remotely operated inspection systems



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation



7.1.3 Autonomous subsea inspection systems for floating infrastructures

Development of autonomous subsea inspection systems for floating wind infrastructures using ROV and AUV platforms equipped with advanced sensor payloads and supported by autonomous surface vehicles. These systems enable efficient and repeatable inspection and cleaning of moorings, anchors, dynamic cables and other submerged structural components, reducing vessel dependency, offshore personnel exposure and operational costs.



Priority level



Current TRL



Technological Objective

To improve the safety, efficiency, reliability and cost-effectiveness of subsea inspections in floating wind farms by deploying autonomous underwater inspection systems capable of performing detailed inspections with minimal vessel support.



Specific Actions

- Development of autonomous subsea inspection systems using ROV and AUV platforms adapted to floating wind infrastructures
- Development of advanced sensor payloads, inspection methodologies and biofouling assessment approaches for detecting degradation in moorings, anchors, dynamic cables and submerged structures
- Development of cleaning and maintenance support tools for submerged structures, mooring systems and dynamic cables compatible with autonomous inspection platforms
- Integration of autonomous surface support platforms and operational workflows to improve inspection efficiency and reduce vessel dependency



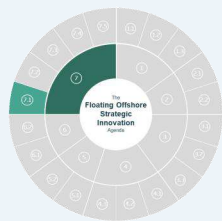
Validation and Trial Needs

- Real-site offshore trials in representative floating wind assets to validate autonomous navigation, inspection stability and data acquisition performance
- Verification of inspection accuracy and defect detection capability compared with diver-based or vessel-based inspection methods
- Assessment of operational efficiency, inspection coverage and reduced vessel dependency enabled by autonomous inspection campaigns



Expected Results

- Increased inspection frequency and consistency across floating wind
- Earlier detection of degradation and biofouling in moorings, anchors and dynamic cables
- Reduced vessel dependency, lower offshore personnel exposure and improved cost-efficiency for subsea monitoring operations



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation



7.1.4 Autonomous sensing and monitoring networks for floating wind environments

Development of autonomous sensing and monitoring networks for floating wind environments that combine robust sensor technologies with energy harvesting solutions and low-power underwater communication systems. These networks enable continuous monitoring of structural loads, fatigue behaviour, corrosion processes and environmental conditions across floating wind assets, including moorings, dynamic cables and submerged structures, while ensuring reliable data acquisition under harsh offshore conditions.



Priority level



Current TRL



Technological Objective

To enable long-term, low-maintenance monitoring of floating wind assets by integrating durable sensing technologies with autonomous power supply and reliable underwater communication systems capable of operating in dynamic offshore environments.



Specific Actions

- Identification of critical sensing requirements and measurement points across floating wind systems, including moorings, dynamic cables and substructures
- Development of robust sensing technologies for long-term monitoring of loads, fatigue and degradation in harsh offshore environments
- Development of autonomous sensing networks integrating energy harvesting and low-power underwater communication technologies

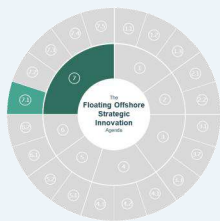
Validation and Trial Needs

- Laboratory and offshore testing of sensing technologies to verify long-term performance under representative dynamic loads, corrosion exposure and environmental conditions
- Field validation of autonomous sensing networks deployed on floating wind assets, including moorings, dynamic cables and submerged structural components
- Verification of reliable underwater communication, including wireless subsea transmission, together with energy autonomy and data integrity during long-term operation in realistic offshore environments



Expected Results

- Reliable and continuous monitoring of structural loads, degradation mechanisms and environmental conditions across floating wind assets
- Reduced dependence on wired power and communication systems for subsea monitoring applications
- Improved robustness and resilience of offshore sensing systems, enabling more efficient inspection, maintenance planning and asset integrity management



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation



7.1.5 Improvement of dynamic cable design and technical definition processes

Integration of operational and in-service performance data into dynamic cable design and specification processes for floating wind applications. The focus is on improving design accuracy, reducing uncertainty in cable behaviour and fatigue assessment, and ensuring that cable configurations are optimised for real operating conditions through the use of validated operational datasets.



Priority level



Current TRL



Technological Objective

To develop more reliable operational-data-informed design methodologies for dynamic cables that enhance lifetime prediction, improve prediction of cable response under real operating conditions, reduce risk of failure, and support more efficient O&M planning.



Specific Actions

- Identification of key operational parameters influencing dynamic cable performance (motions, bending cycles, tension, temperature, soil-cable interaction, marine growth characteristics, thickness and weight per metre)
- Use of operational feedback, monitoring outputs and available in-service performance evidence to refine predictions of curvature variations, touchdown behaviour and global cable response under representative offshore conditions
- Improvement and adaptation of existing modelling tools and workflows through integration of operational datasets, advanced modelling options and user-defined cable properties
- Creation of design guidelines and modelling recommendations adapted to floating wind-specific dynamic behaviour conditions



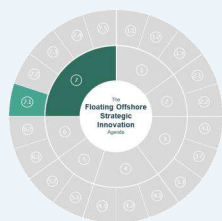
Validation and Trial Needs

- Collection, recovery and analysis of operational data from existing dynamic cable installations under representative environmental and operational conditions
- Application of data-informed design improvements to new dynamic cable projects and comparison with legacy designs
- Verification of improved performance or reduced degradation through monitored operational periods
- Engagement with certification bodies and suppliers to validate revised specification frameworks



Expected Results

- More accurate and reliable dynamic cable designs with reduced uncertainty
- Better alignment between design assumptions and real operational cable behaviour
- Lower failure risk and reduced O&M costs associated with cable issues



Lifecycle Stage *O&M and decommissioning*

Area **7** Operation, Maintenance and Decommissioning

Subarea **7.1** Data acquisition for O&M digitalisation



7.1.6 Means of inspecting structural and operational status triggered on demand by environmental events rather than through continuous monitoring

Development of on-demand inspection and diagnostic approaches that are activated by environmental events rather than relying on continuous monitoring. The line targets event-trigger definitions, rapid data acquisition (temporary sensors, drones/ROVs, vessel-based surveys) and fast analytics to confirm structural/operational integrity, supporting risk-based decisions on restart, inspection scope and maintenance actions.



Priority level



Current TRL



Technological Objective

To reduce O&M cost and data burden while maintaining integrity assurance by enabling reliable event-triggered inspections that rapidly verify structural condition and operational readiness after extreme or abnormal environmental events.



Specific Actions

- Define event triggers and thresholds linked to integrity risks (motions/accelerations, mooring tensions, wave/wind exceedance, abnormal offsets) and inspection decision logic
- Develop rapid-deploy inspection toolkits and data capture methods (portable sensors, UAV/ROV payloads, quick-connect instrumentation, NDT spot checks)
- Implement fast processing and assessment workflows (automated reporting, damage indicators, acceptance criteria) integrated with O&M and risk management systems



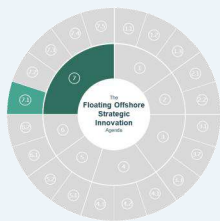
Validation and Trial Needs

- Demonstration through storm/event case studies to validate trigger thresholds, false alarm rates and decision outcomes
- Field trials of rapid-deploy inspection methods in offshore conditions, verifying data quality and time-to-assessment
- Benchmarking against continuous monitoring approaches to quantify cost, response time and integrity assurance performance



Expected Results

- Event-triggered inspection protocols and toolkits enabling faster post-event integrity confirmation
- Reduced O&M and inspection costs through targeted post-event assessment and more efficient mobilisation of inspection resources
- Improved decision-making for restart, inspection prioritisation and maintenance planning after extreme events



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation



7.1.7 Virtual sensing

Development of virtual sensing methodologies that estimate unmeasured loads, motions and structural states using numerical coupled models (aero-hydro-servo-elastic, mooring and structural response) updated with limited measured data. The line targets reducing physical sensor footprint while enabling reliable condition indicators (fatigue damage, extreme loads, offsets, component utilisation) for integrity management, anomaly detection and digital O&M workflows.



Priority level



Current TRL



Technological Objective

To enable cost-effective, scalable O&M digitalisation by providing validated virtual sensors that deliver accurate estimates of key structural and operational parameters, supporting condition-based maintenance and reliability management with reduced instrumentation.



Specific Actions

- Develop coupled-model-based virtual sensing architectures (state estimation, model updating, observers) using limited measurements (SCADA, IMUs, strain/acceleration, mooring tension)
- Define data assimilation and uncertainty quantification methods to ensure traceable accuracy of estimated states and derived KPIs (fatigue, utilisation, offsets)
- Implement deployment-ready workflows integrating virtual sensing outputs into O&M systems (alerts, dashboards, inspection planning, digital twin interfaces)



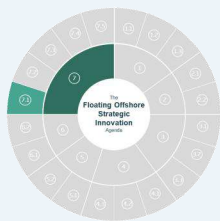
Validation and Trial Needs

- Validation against instrumented reference assets (full/partial sensor suites) to quantify accuracy across operational and extreme conditions
- Robustness testing for model uncertainty, sensor failures and changing environmental conditions (drift, biofouling, degradation)
- Pilot deployment demonstrating O&M value (reduced sensors, improved diagnostics, maintenance decisions) and benchmarking vs traditional sensing



Expected Results

- Virtual sensing toolchain providing reliable estimates of critical loads and structural states with quantified uncertainty
- Reduced sensor CAPEX/OPEX and simplified offshore instrumentation/maintenance
- Improved integrity management and condition-based maintenance through model-informed KPIs and anomaly detection



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.1 Data acquisition for O&M digitalisation

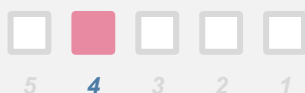


7.1.8 Implementation of lightweight, multi-vector inspection methods for conducting group inspections, including deployment from Uncrewed Surface Vessels

Implementation of lightweight, multi-vector inspection methods to perform group inspections across floating wind assets using coordinated deployment of multiple platforms and sensors. The line targets scalable inspection concepts for structural and operational condition checks (hull, freeboard zone, moorings, dynamic cable interfaces, topside elements), improving coverage, reducing vessel time and enabling rapid inspection campaigns with standardised data outputs.



Priority level



Current TRL



Technological Objective

To enable efficient, repeatable group inspections of multiple floating wind units through coordinated multi-vector deployments integrating USVs, UAVs and UUVs, delivering reliable condition information with reduced offshore logistics, improved HSE and seamless integration into digital O&M workflows.



Specific Actions

- Develop multi-vector inspection concepts and mission planning tools (tasking, navigation, comms, safety/exclusion zones)
- Integrate lightweight sensor payloads and standardised data formats (vision/sonar/LiDAR as applicable) with automated processing pipelines
- Define operational procedures and acceptance criteria for group inspections (coverage metrics, detectability thresholds, reporting templates)

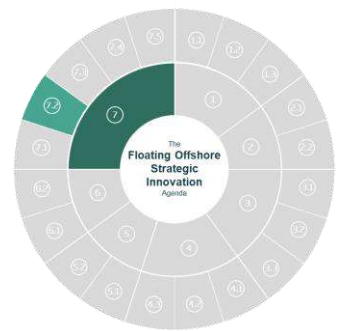
Validation and Trial Needs

- Field trials of coordinated multi-vector inspection missions integrating USVs, UAVs and UUVs under representative sea states and operational conditions, including validation of multi-platform deployment, recovery and operational coordination procedures
- Verification of data quality and defect/condition detectability versus baseline inspection methods for subsea and topside assets (manned vessel/diver/standalone ROV/manual topside inspection methods)
- Demonstration of end-to-end workflow with quantified time/cost/HSE benefits



Expected Results

- Scalable group inspection capability with reduced vessel days and demonstrable reductions in vessel support requirements compared with conventional inspection plans
- Higher consistency and traceability of inspection outputs through standardised multi-vector methods
- Faster condition assessment and prioritised maintenance planning via digital, semi-automated reporting



Subarea 7.2 - Data management and structuring for O&M digitalisation

Transforming large volumes of operational data into structured and accessible information is a key requirement for digital asset management. This subarea brings together the **digital infrastructure needed to organise, integrate and analyse data generated throughout the operation of floating offshore wind farms**.

Innovation focuses on operational digital twins, industrial data platforms and multi-component data integration environments that enable a comprehensive understanding of asset behaviour. These capabilities provide the **foundation for more informed decision-making and support advanced digital operation and maintenance solutions**.

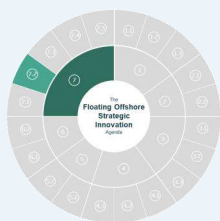
Innovation lines

- PL1 7.2.1 Operational digital twins for floating offshore wind behaviour monitoring, load tracking and degradation prediction:** digital twins integrating real-time operational data with validated physics-based models to support O&M decision-making.
- PL4 7.2.2 Industrial data platforms and advanced analytics for floating wind operations:** scalable digital infrastructures enabling integration, management and analysis of operational data from monitoring systems and digital twins.
- PL4 7.2.3 Holistic multi-component data integration platforms:** systems that correlate data from multiple components to identify failure patterns at asset and wind farm level.



Priority level





Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.2 Data management and structuring for O&M digitalisation



7.2.1 Operational digital twins for floating offshore wind behaviour monitoring, load tracking and degradation prediction

Development of operational digital twins combining real-time data, historical performance records, validated physics-based models and data-driven / machine learning approaches to simulate structural behaviour, track loads, predict degradation and support secure predictive maintenance strategies for floating wind assets.



Priority level



Current TRL



Technological Objective

To improve prediction of structural and mechanical degradation mechanisms and enable risk-informed O&M planning through digital twin systems that reflect real operating conditions, asset response, evolving degradation behaviour and predictive maintenance needs under secure operational architectures.



Specific Actions

- Identification of key parameters and degradation mechanisms to be captured for turbines, floating platforms, moorings and dynamic cables
- Development of digital twin models integrating aerodynamics, hydrodynamics, control dynamics, structural dynamics, fatigue behaviour and validated data-driven prediction capabilities
- Integration of multi-source data streams (monitoring sensors, inspection data, SCADA, metocean observations) into secure real-time twin updating algorithms
- Development of methodologies for model validation, uncertainty reduction, long-term performance prediction and predictive maintenance support



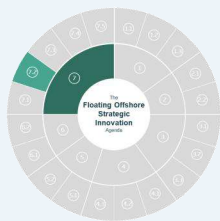
Validation and Trial Needs

- Pilot implementation of operational digital twins in active floating wind turbines and platforms
- Validation of model predictions against measured responses, degradation indicators and historical failure patterns
- Assessment of data quality, update frequency, computational performance and robustness under variable operating conditions
- Evaluation of impact on maintenance planning, inspection intervals and cost reduction



Expected Results

- Improved understanding of asset behaviour and degradation under real offshore conditions
- More accurate prediction of fatigue, wear and failure mechanisms
- Better-informed O&M strategies, including optimised inspection and predictive maintenance schedules
- Reduction of unexpected failures and increased floating wind asset availability



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.2 Data management and structuring for O&M digitalisation

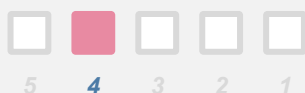


7.2.2 Industrial data platforms and advanced analytics for floating wind operations

Development of industrial data platforms, cybersecurity frameworks and advanced analytics solutions for floating wind operations, capable of ingesting, structuring and managing large volumes of operational data from monitoring systems, inspections and digital twins. These platforms enable scalable data integration, interoperability and advanced analytics to support O&M digitalisation and asset performance optimisation.



Priority level



Current TRL



Technological Objective

To enable scalable integration, management and advanced analytics of operational data from floating wind assets through interoperable industrial data platforms supporting digital twins and data-driven O&M strategies.



Specific Actions

- Definition of data governance and architecture frameworks for floating wind digital ecosystems
- Integration of heterogeneous operational data sources (SCADA, monitoring systems, inspection data and digital twins) into unified industrial data platforms
- Development of advanced analytics environments enabling large-scale data processing, predictive modelling and operational optimisation
- Implementation of cybersecurity, access control and data lineage mechanisms to ensure secure and traceable management of critical operational data
- Development of edge-level data acquisition and communication architectures for reliable collection and transmission



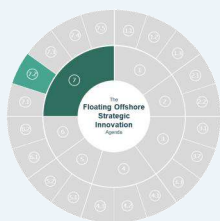
Validation and Trial Needs

- Deployment of industrial data platforms in representative floating wind operational environments
- Verification of data integrity, interoperability and traceability across monitoring systems, digital twins and operational platforms
- Assessment of analytics performance and platform robustness under high data volumes and limited offshore communication bandwidth
- Validation of platform integration with operational decision-making and asset management workflows



Expected Results

- Improved accessibility, traceability and quality of operational data from floating wind assets
- Enhanced capability to deploy advanced analytics and predictive models at operational scale
- Improved coordination between operators, OEMs and service providers through interoperable digital ecosystems
- Reduced O&M costs through data-driven decision-making and scalable analytics workflows



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.2 Data management and structuring for O&M digitalisation



7.2.3 Holistic multi-component data integration platforms

Development of integrated data platforms capable of merging information from multiple floating wind components - turbine, platform, moorings, dynamic cables, electrical systems and environmental data - into a unified and interoperable framework. The focus is on enabling cross-component correlation to identify emerging degradation and failure patterns at both asset and wind-farm scale, supporting advanced diagnostics, predictive analytics and lifecycle-informed O&M decision-making.



Priority level



Current TRL



Technological Objective

To provide comprehensive asset-level and farm-level situational awareness by correlating diverse data streams through interoperable and robust data integration frameworks, improving detection of complex degradation mechanisms, cascading failure risks and advanced O&M decision-making.



Specific Actions

- Definition of prioritised cross-component data models focusing on the most relevant interactions between key subsystems (e.g. floater-mooring, mooring-dynamic cable, turbine-floater) and environmental inputs
- Development of interoperable integration frameworks capable of merging structural, mechanical, electrical, environmental and SCADA data
- Integration of multi-component analysis outputs into asset-level and fleet-level integrity management and predictive maintenance frameworks
- Development of data governance and consistency verification approaches supporting reliable lifecycle integrity assessment, Remaining Useful Life (RUL) estimation and configuration traceability



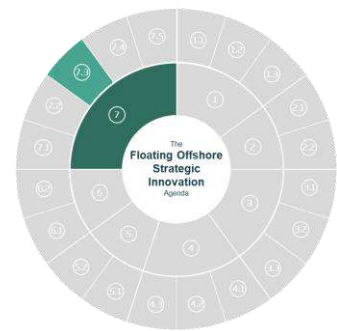
Validation and Trial Needs

- Application of multi-component integration platforms to representative floating wind operational datasets
- Verification of platform performance in identifying correlated degradation and failure indicators across moorings, cables, structures and turbine components
- Assessment of data quality, interoperability, latency and consistency in representative operational environments
- Validation of robustness against configuration evolution, component replacement and long-term dataset continuity scenarios



Expected Results

- Improved understanding of system-level behaviour, interdependencies and degradation propagation mechanisms
- Earlier identification of complex failure mechanisms driven by multi-component interactions
- More effective O&M planning through integrated diagnostics, predictive analytics and lifecycle-informed decision-making
- Improved reliability and consistency of multi-component integrity assessment and Remaining Useful Life estimation



Subarea 7.3 - Data exploitation for O&M digitalisation

The value of digitalisation ultimately depends on the ability to convert operational data into effective maintenance decisions. This subarea explores digital tools and methodologies that support **integrity management, maintenance planning and asset lifetime optimisation throughout the operational life of floating offshore wind farms.**

Innovation includes probabilistic integrity management frameworks, digital workflows for different maintenance strategies and tools that support lifetime extension assessments. Collectively, these developments aim to **optimise maintenance interventions, improve asset availability and maximise long-term operational performance.**

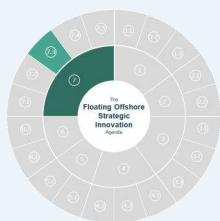
Innovation lines

- PL5 7.3.1 Probabilistic integrity management frameworks (MIM / CMIM) at commercial scale:** probabilistic models for the integrity management of mooring lines and station-keeping systems.
- PL4 7.3.2 Digital workflows and tools for tow-to-port and on-site maintenance:** digital solutions to plan and execute tow-to-port operations and major maintenance activities.
- PL5 7.3.3 Digital workflows and tools for site-replacement maintenance:** digital solutions enabling the offshore replacement of critical components.
- PL1 7.3.4 Digital tools for floating asset lifetime extension assessment.**



Priority level





Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.3 Data exploitation for O&M digitalisation



7.3.1 Probabilistic integrity management frameworks (MIM / CMIM) at commercial scale

Development and implementation of probabilistic integrity management frameworks for floating wind mooring systems, integrating inspection data, monitoring results, load history, degradation models and structured lifecycle datasets. These frameworks aim to quantify failure probabilities, optimise inspection intervals and support risk-informed and predictive O&M decisions at commercial wind farm scale while accounting for operational uncertainty, data quality and configuration variability.



Priority level



Current TRL



Technological Objective

To provide robust, data-driven methodologies for managing the integrity of mooring lines and station-keeping systems through probabilistic models that reflect real asset behaviour, uncertainty, operational variability, predictive maintenance needs and lifecycle data consistency.



Specific Actions

- Development of probabilistic models incorporating monitoring data, inspection records, fatigue analysis, corrosion progression, metocean and uncertainty propagation methodologies
- Integration of MIM/CMIM methodologies with digital twins, predictive analytics and O&M planning workflows for risk-informed maintenance and intervention decision-making
- Definition of risk-based inspection and maintenance criteria aligned with floating wind operational constraints and data quality management requirements
- Development of data governance, consistency verification and configuration management approaches supporting reliable integrity assessment and Remaining Useful Life (RUL) estimation

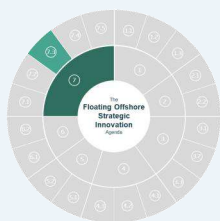
Validation and Trial Needs

- Application of probabilistic integrity management models to operational floating wind datasets at asset or farm scale
- Verification of predicted degradation trends against inspection findings and observed performance
- Assessment of risk reduction and OPEX impacts compared with deterministic or time-based integrity management approaches



Expected Results

- Improved prediction of degradation and failure likelihood for station-keeping systems with increased confidence in integrity and RUL estimates
- More efficient, predictive and risk-based inspection and maintenance planning supported by probabilistic and data-quality-aware methodologies
- Reduced probability of unexpected mooring or anchoring failures at commercial floating wind scale through improved integrity assessment reliability and uncertainty management



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.3 Data exploitation for O&M digitalisation



7.3.2 Digital workflows and tools for tow-to-port and on-site maintenance

Development and deployment of digital workflows and decision-support tools to plan, coordinate and execute tow-to-port and on-site maintenance operations for floating wind assets. These tools integrate asset condition data, metocean forecasts, port availability, vessel logistics and operational risks to optimise maintenance planning, support operational decision-making and minimise downtime during major maintenance activities.



Priority level



Current TRL



Technological Objective

To improve the planning, coordination and safety of tow-to-port and on-site maintenance operations through digital workflows and decision-support tools that optimise scheduling, operational execution and downtime management for major maintenance activities.



Specific Actions

- Definition of decision criteria and triggering thresholds for tow-to-port or on-site maintenance interventions based on asset condition, operational risk and site-specific spatial and regulatory constraints
- Integration of metocean data, logistics constraints, vessel availability and port capacity into digital maintenance planning environments
- Development of workflow management tools coordinating stakeholders (operators, ports, vessel providers and OEMs) during maintenance campaigns

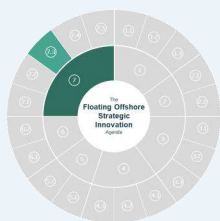
Validation and Trial Needs

- Application of digital tow-to-port workflows to representative floating wind maintenance scenarios
- Verification of downtime reduction, improved coordination and risk mitigation compared to ad hoc planning approaches
- Assessment of operational performance during real or simulated tow-to-port and offshore maintenance campaigns



Expected Results

- Reduced operational risk and downtime associated with major maintenance
- Improved coordination between offshore operations, port-based activities and maintenance logistics
- Increased predictability and cost control in major maintenance interventions



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.3 Data exploitation for O&M digitalisation



7.3.3 Digital workflows and tools for site-replacement maintenance

Development of digital workflows and decision-support tools to enable offshore, in-situ replacement of critical components in floating wind systems. These tools integrate asset condition data, metocean forecasts, vessel and lifting capacity, safety constraints and operational risk to support safe and efficient execution of site-based maintenance interventions.



Priority level



Current TRL



Technological Objective

To enable reliable, efficient and low-risk site-replacement operations by providing digital planning, simulation and decision-support tools adapted to floating wind O&M requirements.



Specific Actions

- Definition of operational envelopes and decision criteria for in-situ replacement of major components (for example, blades, dynamic cables, moorings)
- Integration of metocean forecasting, vessel motion limits and lifting constraints into digital planning environments
- Development of workflow tools coordinating multi-asset, multi-vessel offshore interventions under dynamic conditions



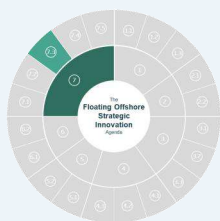
Validation and Trial Needs

- Application of digital site-replacement planning tools to representative offshore intervention scenarios
- Verification of operability windows, safety margins and logistical coordination through simulation or pilot offshore operations
- Comparison of intervention efficiency, risk profile and OPEX implications against conventional manual planning approaches



Expected Results

- Increased feasibility and safety of offshore component replacement
- Reduced planning uncertainty and improved execution efficiency
- Greater flexibility between tow-to-port and offshore intervention strategies



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.3 Data exploitation for O&M digitalisation



7.3.4 Digital tools for floating asset lifetime extension assessment

Development and deployment of digital tools to assess the technical and economic feasibility of extending the operational life of floating wind assets beyond their original design life, based on structural performance data, degradation trends fatigue accumulation and risk-informed residual life assessment methodologies.



Priority level



Current TRL



Technological Objective

To enable reliable, risk-informed and economically optimised life extension strategies for floating wind assets through integrated digital assessment methodologies incorporating uncertainty management, operational data integration and residual life evaluation capabilities.



Specific Actions

- Definition of life extension assessment frameworks incorporating structural integrity, mooring system performance, dynamic cable degradation and uncertainty evaluation methodologies
- Integration of operational monitoring and inspection data into digital models for residual life assessment and Remaining Useful Life (RUL) estimation
- Development of criteria and decision-support tools linking technical feasibility with economic performance, risk exposure and regulatory requirements



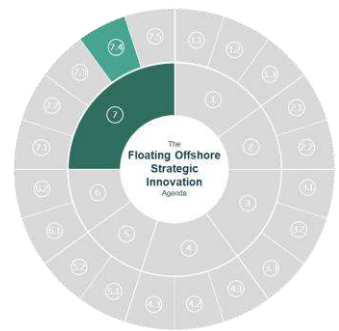
Validation and Trial Needs

- Application of life extension assessment tools to representative floating wind assets approaching mid-life operation
- Verification of degradation predictions and residual life estimations through inspection and monitoring data
- Review of assessment methodologies with certification bodies and regulatory stakeholders



Expected Results

- Increased confidence and reduced uncertainty in residual life and Remaining Useful Life (RUL) estimation for floating wind systems
- More robust and risk-informed decision-making regarding refurbishment, component replacement or decommissioning
- Quantified lifecycle value and OPEX impacts of life extension strategies, supporting improved return on investment for floating wind projects



Subarea 7.4 - Heavy offshore maintenance and major offshore interventions

Major offshore interventions represent some of the most complex, costly and weather-dependent activities throughout the operational life of floating offshore wind farms. This subarea **promotes the technologies, methodologies and decision-support tools required to execute these interventions more safely, efficiently and predictably.**

Innovation spans heavy lifting solutions, specialised maintenance assets, offshore replacement procedures, advanced planning and risk assessment tools, and methodologies for selecting the most appropriate maintenance strategy. Together, these developments seek to **reduce downtime, minimise operational risks and improve the overall efficiency of major maintenance campaigns.**

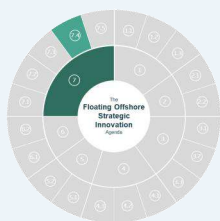
Innovation lines

- PL2 7.4.1 Heavy lifting and motion-compensated handling solutions:** for the offshore replacement of large components (blades, nacelle, tower sections, dynamic cables).
- PL3 7.4.2 Specialised offshore vessels and floating support platforms for FOW maintenance:** innovation in vessel concepts, semi-submersible barges, robotic solutions (USV,...) or auxiliary floating platforms specifically designed for major maintenance operations in floating wind.
- PL1 7.4.3 Procedures and tools for offshore replacement of critical components:** standardised methods, dedicated tools and qualification procedures for the at-sea replacement of moorings, dynamic cables, structural elements and electrical equipment, including on-demand additive manufacturing solutions (e.g. containerised 3D/4D printing platforms and smart adaptive materials) to produce certified spare parts offshore or in port, reducing downtime and logistics associated with spare-part transport.
- PL1 7.4.4 Advanced planning, risk modelling and decision-support systems for major interventions:** tools that integrate metocean data, asset condition, availability of resources, and operational risks to plan and execute large offshore operations with greater reliability.
- PL1 7.4.5 Maintenance strategy trade-off analysis (in situ vs. offshore):** comparative assessment of feasibility, cost, risk, logistics, and downtime impacts between maintaining assets in place versus executing offshore-oriented maintenance concepts.



Priority level





Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.4 Heavy offshore maintenance and major offshore interventions



7.4.1 Heavy lifting and motion-compensated handling solutions

Development and demonstration of heavy lifting and motion-compensated handling solutions for offshore replacement of large floating wind components. These systems incorporate advanced motion compensation technologies to enable safe lifting operations under dynamic vessel and platform motions.



Priority level



Current TRL



Technological Objective

To enable reliable and weather-resilient offshore heavy-maintenance activities by providing lifting systems capable of compensating for vessel and platform motions, reducing operational risk and expanding viable weather windows.



Specific Actions

- Assessment of motion characteristics and operational envelopes relevant to floating wind heavy lifting scenarios
- Adaptation and qualification of active motion compensation technologies for floating wind component geometries and load cases
- Development of operational procedures integrating compensated lifting systems with vessel and platform behaviour



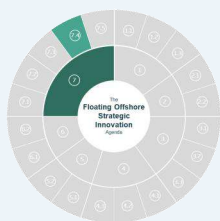
Validation and Trial Needs

- Full-scale or near-full-scale offshore trials to assess performance of motion-compensated lifting systems under representative metocean conditions
- Verification of lifting accuracy, load stability and operational safety during the handling of large components
- Evaluation of system reliability, energy consumption, maintainability and operational limits
- Assessment of compatibility with vessels, auxiliary platforms, deck layouts and at-sea replacement procedures



Expected Results

- Increased feasibility and safety of offshore replacement of blades, nacelles, tower sections and cable modules
- Expanded operational weather windows through advanced motion-compensation capabilities
- Greater flexibility between offshore replacement and tow-to-port maintenance strategies, with reduced reliance on tow-to-port where feasible



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.4 Heavy offshore maintenance and major offshore interventions



7.4.2 Specialised offshore vessels and floating support platforms for FOW maintenance

Development and adaptation of specialised offshore vessels and floating support platforms for major maintenance operations in floating offshore wind, including enhanced station-keeping, handling systems, robotic support capabilities and validated data-driven operational models where relevant. The focus is on enabling safe heavy interventions, component replacement and offshore repair under dynamic operational conditions.



Priority level



Current TRL



Technological Objective

To enable safe and efficient major offshore maintenance operations for floating wind farms through specialised offshore vessels and floating support platforms equipped with advanced station-keeping, handling, support and data-driven operational capabilities adapted to floating wind intervention needs.



Specific Actions

- Definition of functional and operational requirements for specialised offshore vessels and floating support platforms performing major maintenance operations in floating wind farms
- Development and adaptation of specialised vessel and floating support platform concepts incorporating enhanced station-keeping, motion reduction and optimised deck layouts for component replacement
- Integration and assessment of robotic and autonomous support systems (e.g. USV-assisted logistics or inspection support) to improve operational efficiency and safety
- Development and validation of data-driven and machine learning models supporting operability assessment, motion prediction and offshore intervention planning
- Assessment of compatibility between vessel/platform concepts, heavy lifting systems and floating wind component geometries and interfaces



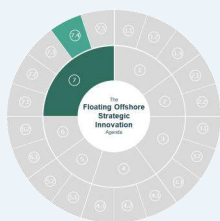
Validation and Trial Needs

- Representative trials of adapted offshore support concepts, robotic support systems and data-driven operational tools under relevant floating wind operational conditions
- Verification of station-keeping, motion mitigation, robotic support performance and operational safety during simulated or representative maintenance operations
- Assessment of operational limits, energy consumption, logistics efficiency and compatibility with motion-compensated lifting systems and robotic support solutions



Expected Results

- Expanded capability for offshore execution of major maintenance operations
- Increased operational weather windows through improved vessel and platform stability
- Reduced reliance on tow-to-port strategies for major component replacement
- Lower maintenance costs and improved availability of floating wind assets



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.4 Heavy offshore maintenance and major offshore interventions



7.4.3 Procedures and tools for offshore replacement of critical components

Development and validation of standardised procedures, dedicated tools and qualification frameworks enabling the offshore replacement of critical floating wind components, including mooring lines, dynamic cables, structural elements, electrical equipment and major turbine components. The line focuses on increasing repeatability, safety and operational robustness of at-sea replacement activities while enabling emerging solutions for on-demand manufacturing of certified spare parts offshore and ensuring personnel readiness for complex intervention operations.



Priority level



Current TRL



Technological Objective

To enable reliable and repeatable offshore replacement of critical floating wind components through validated procedures, dedicated intervention tools and qualification frameworks that reduce operational risk, minimise reliance on tow-to-port maintenance strategies and support safe execution by trained and certified offshore personnel.



Specific Actions

- Identification of component interfaces, operational constraints and operability envelopes associated with offshore replacement of moorings, dynamic cables, structural elements, electrical equipment and major turbine components
- Development of standardised offshore replacement procedures incorporating safety margins, motion constraints and operational sequencing for floating wind interventions
- Development and qualification of specialised tools and fixtures for manipulation, disconnection and installation of large offshore components
- Development of qualification, certification and simulation-based training approaches for offshore personnel involved in major intervention operations
- Assessment of emerging solutions for on-demand manufacturing and certification of spare parts to support offshore maintenance logistics



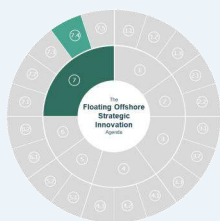
Validation and Trial Needs

- Offshore trials demonstrating reliability of replacement procedures under representative metocean and motion conditions
- Verification of tool performance, operational limits and compatibility with component interfaces and vessel/platform configurations
- Assessment of procedure repeatability and operational efficiency across different floating wind turbine configurations
- Validation of certification and quality assurance approaches for spare parts produced through distributed or on-demand manufacturing solutions
- Use of simulation environments, onshore testing and scaled validation approaches where appropriate prior to full offshore demonstration



Expected Results

- Standardised, safer and more efficient offshore replacement methods for critical components
- Increased repeatability and predictability of major offshore maintenance operations
- Expanded capability for at-sea maintenance interventions, reducing reliance on tow-to-port strategies
- Improved personnel readiness and operational safety through validated qualification and simulation-based training approaches
- Improved logistics flexibility through emerging on-demand manufacturing approaches for certified spare parts



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.4 Heavy offshore maintenance and major offshore interventions



7.4.4 Advanced planning, risk modelling and decision-support systems for major interventions

Development of advanced planning tools and decision-support systems to optimise the preparation and execution of major offshore interventions in floating wind farms. These systems integrate metocean data, asset condition information, vessel and equipment availability, logistical constraints, SIMOPS management, motion-related operational limits and human-factor considerations to support safe, reliable and efficient offshore operations.



Priority level



Current TRL



Technological Objective

To provide robust data-driven planning and risk modelling capabilities that improve the safety, predictability and effectiveness of major offshore interventions, while supporting human-centred operational decision-making, dynamic risk management and safe execution under complex offshore conditions.



Specific Actions

- Definition of multi-parameter decision frameworks combining asset health indicators, metocean limits, operational resource constraints and dynamic go/no-go criteria
- Development of user-oriented planning platforms and digital dashboards integrating role-based operational support, decision traceability and coordination between operators, contractors and vessel providers
- Development and integration of simulation and digital modelling tools to evaluate intervention sequences, lifting operations, weather operability windows and SIMOPS scenarios
- Integration of training-ready capabilities enabling operational rehearsal, scenario simulation and competency validation for offshore teams



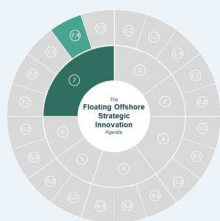
Validation and Trial Needs

- Application of planning and decision-support systems to representative major intervention scenarios, including procedure rehearsal and operational simulation
- Verification of system accuracy in predicting operational windows, task duration, resource needs and human-factor-related operational constraints
- Assessment of intervention efficiency gains and reduction of unplanned delays using simulated or historical maintenance campaigns



Expected Results

- Improved predictability, coordination and operational reliability of complex offshore maintenance operations
- Reduced intervention risk, operational delays, cost uncertainty and human-error-related incidents at wind farm scale
- Expanded operability windows through improved forecasting, integrated planning tools and enhanced offshore decision-support capabilities
- Accelerated industrialisation of offshore maintenance campaigns through standardised planning, decision-support and training frameworks



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.4 Heavy offshore maintenance and major offshore interventions



7.4.5 Maintenance strategy trade-offs analysis (in situ vs. offshore)

Development of methodologies and decision-support tools to compare heavy maintenance strategies for floating wind assets, assessing in situ maintenance versus offshore-oriented concepts (tow-to-port, offshore exchange, specialist vessels). The line targets structured evaluation of technical feasibility, cost, logistics, HSE risk and downtime impacts under site-specific constraints, enabling robust maintenance planning and selection of optimal intervention concepts.



Priority level



Current TRL



Technological Objective

To enable selection of the most cost-effective and risk-robust heavy maintenance strategy by providing standardised trade-off analysis methods that quantify feasibility, logistics, downtime and total cost impacts for in situ versus offshore-oriented intervention concepts.



Specific Actions

- Develop comparative assessment frameworks combining technical feasibility, metocean operability, logistics (vessels/ports) and HSE risk into consistent KPIs and decision criteria
- Build cost and downtime models capturing mobilisation, weather windows, resource constraints, spares strategy and schedule impacts for each maintenance concept
- Define standardised scenario sets, input assumptions and uncertainty ranges (asset types, distances, port capability, grid constraints) to enable repeatable, auditable and risk-informed comparisons at FEED/O&M planning stages



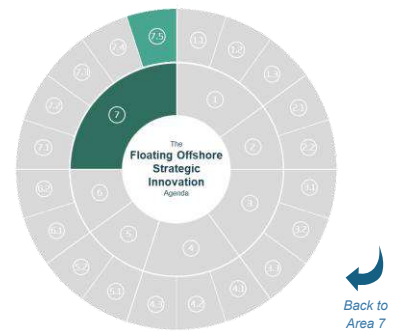
Validation and Trial Needs

- Application to representative project case studies to benchmark outcomes against operator experience and historical intervention data
- Sensitivity and uncertainty analysis to test robustness to metocean variability, failure rates, vessel availability and cost assumptions
- Demonstration of tool integration into O&M planning processes (maintenance scheduling, spares, contracting strategy) with documented decision traceability



Expected Results

- Decision-support methodology delivering transparent comparisons of in situ against offshore-oriented heavy maintenance concepts
- Optimised intervention strategies reducing downtime and total O&M cost while improving HSE performance
- More bankable O&M plans through auditable assumptions, clearer risk allocation and improved logistics planning



Subarea 7.5 - Decommissioning, repowering and end-of-life strategies of the floating system

Planning for the end of the asset lifecycle is becoming an increasingly important aspect of floating offshore wind development. This subarea explores the technologies and methodologies required to **ensure that decommissioning and repowering activities can be carried out safely, efficiently and with minimum environmental impact.**

Innovation covers disconnection technologies, platform removal strategies, modular dismantling solutions that facilitate component reuse, dedicated planning and risk assessment tools, and environmental management approaches for decommissioning operations. Together, these innovation areas **support more circular, responsible and cost-effective end-of-life management for floating offshore wind assets.**

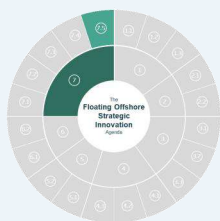
Innovation lines

- PL3 7.5.1 Technologies for safe disconnection of moorings, anchors, cables, and electrical systems:** development of methods and tools for hook-down operations, electrical disconnection, and controlled release of moorings and dynamic cables under offshore conditions.
- PL1 7.5.2 Optimised strategies for removal and tow-back of floating platforms:** innovation in manoeuvres, configurations, and tools for towing complete or partially dismantled floating units back to port.
- PL3 7.5.3 Modular dismantling technologies enabling circular reuse of floating wind components offshore and in port:** methods and technologies enabling progressive dismantling of turbine, tower, substructure and auxiliary systems, incorporating modular construction and upcycling frameworks that facilitate component replacement, refurbishment, reuse and repurposing of modules (e.g. blades, tower sections, mooring connectors, dynamic cable segments and electrical housings), supporting lifecycle extension and improved traceability of floating wind assets.
- PL5 7.5.4 Planning, risk modelling and simulation tools specific to decommissioning operations:** digital platforms that allow simulation of uninstallation sequences, risks, loads, and logistical requirements, reusing models developed for installation and heavy maintenance.
- PL5 7.5.5 Environmental impact assessment and disposal strategies for floating wind decommissioning:** assessment of environmental impacts, regulatory gaps and end-of-life options including reuse, recycling and final disposal of offshore infrastructure.



Priority level





Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.5 Decommissioning, repowering and end-of-life strategies of the floating system



7.5.1 Technologies for safe disconnection of moorings, anchors, cables, and electrical systems

Development of procedures, tools and technologies to safely execute the disconnection of mooring systems, dynamic cables and electrical interfaces during floating wind decommissioning operations. The focus is on enabling controlled hook-down operations, minimising offshore risks and ensuring predictable, low-impact asset removal under variable metocean conditions.



Priority level



Current TRL



Technological Objective

To enable reliable, standardised and safe offshore disconnection of floating wind systems through controlled release of moorings, dynamic cables and electrical interfaces while reducing risks to personnel, vessels and the environment.



Specific Actions

- Definition of operational requirements and safety constraints for disconnection of mooring lines, anchors, dynamic cables and electrical interfaces
- Development of specialised tools and systems for controlled hook-down, line tension management, cutting, securing and lifting operations
- Identification of key operational risks, operational envelopes and contingency procedures for disconnection operations under variable metocean conditions



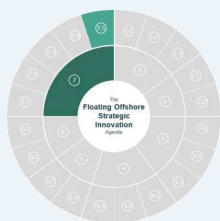
Validation and Trial Needs

- Demonstration of disconnection procedures during pilot decommissioning operations or controlled offshore trials
- Verification of controlled tension release, handling stability and safe recovery of moorings and dynamic cables
- Assessment of procedural reliability, operational limits and required vessel capabilities



Expected Results

- Safer and more predictable disconnection of mooring, cable and electrical systems during floating wind decommissioning
- Reduced risk of uncontrolled line release, equipment damage or environmental impact
- More efficient decommissioning workflows with reduced offshore exposure
- Lower operational costs and improved planning reliability for end-of-life operations



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.5 Decommissioning, repowering and end-of-life strategies of the floating system



7.5.2 Optimised strategies for removal and tow-back of floating platforms

Development of optimised strategies, operational procedures and dedicated tools for the safe and efficient removal of floating wind platforms and their tow-back to port during decommissioning. The focus is on minimising offshore risks, operational time and environmental impacts while optimising single-unit and wind-farm-scale tow-back campaigns under variable metocean conditions.



Priority level



Current TRL



Technological Objective

To enable predictable, low-risk and cost-effective removal operations with minimum environmental impact by improving tow-back planning, platform handling, towing configurations and offshore-to-port logistical coordination.



Specific Actions

- Definition of removal architectures considering platform configuration, residual loads, mooring disconnection sequence and location-specific operational constraints
- Assessment of towing strategies, platform stability and vessel support requirements for intact and partially dismantled floating units under representative metocean conditions and tow-back scenarios, including ballast and de-ballast management considerations
- Integration of port logistics, towing distances, vessel availability and dismantling strategies into removal planning frameworks
- Assessment of ballast water handling, treatment and disposal requirements associated with floating platform decommissioning and tow-back operations



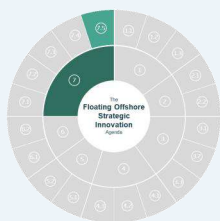
Validation and Trial Needs

- Application of optimised removal and tow-back strategies to representative floating wind decommissioning scenarios
- Verification of platform stability, towing line loads, dynamic behaviour and fuel/energy requirements during tow-back
- Assessment of operational limits, towing speeds, vessel requirements and coordination with port infrastructure
- Evaluation of port capabilities for ballast water handling and treatment, as well as management of decommissioning-related waste streams



Expected Results

- Reduced operational risk during removal and tow-back phases
- Improved coordination between offshore removal and onshore dismantling activities
- Increased predictability and cost optimisation in end-of-life floating wind campaigns



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.5 Decommissioning, repowering and end-of-life strategies of the floating system



7.5.3 Modular dismantling technologies enabling circular reuse of floating wind components offshore and in port

Development of modular dismantling technologies and engineered methods to enable progressive deconstruction of floating wind turbines, platforms and auxiliary systems both offshore and in port. These approaches support safe and efficient dismantling operations while enabling refurbishment, reuse and recycling of modular components, contributing to circular lifecycle management of floating wind assets and leveraging validated lifecycle operational datasets generated during design and operation phases.



Priority level



Current TRL



Technological Objective

To enable safe, efficient and repeatable dismantling solutions that minimise offshore risk exposure, reduce logistical complexity and support circular end-of-life strategies through modular, step-by-step deconstruction processes and traceable lifecycle information.



Specific Actions

- Definition of dismantling sequences and modular break-down strategies suitable for different floating wind system architectures
- Development of dedicated dismantling tools and handling frames enabling safe progressive disassembly offshore and in port
- Integration of lifecycle asset data, configuration traceability and operational constraints into dismantling planning and execution methodologies
- Integration of dismantling strategies with recycling and material recovery processes to maximise reuse, recyclability and traceability of components



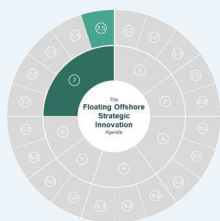
Validation and Trial Needs

- Application of modular dismantling approaches to representative floating wind decommissioning scenarios
- Validation of dismantling tool performance through controlled trials and representative offshore and onshore dismantling scenarios, including assessment of operational limits, safety margins, precision and repeatability
- Assessment of dismantling efficiency, waste minimisation, material recovery rates and reuse potential of recovered components



Expected Results

- Safer and more predictable dismantling operations with reduced offshore personnel exposure
- More efficient decommissioning workflows through modular, stepwise deconstruction strategies
- Increased reuse, refurbishment and recycling potential of floating wind components and materials
- Improved traceability and repeatability of end-of-life operations through lifecycle-informed dismantling methodologies



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.5 Decommissioning, repowering and end-of-life strategies of the floating system



7.5.4 Planning, risk modelling and simulation tools specific to decommissioning operations

Development of digital planning and simulation tools to support floating wind decommissioning operations. These tools model uninstallation sequences, vessel logistics, metocean constraints, component behaviour, operational risks and environmental footprint implications, enabling scenario-based optimisation of removal strategies. The line also includes the adaptation of installation and heavy-maintenance simulation models, supported by structured lifecycle datasets to improve operational predictability, decision-support capabilities and risk-informed planning.



Priority level



Current TRL



Technological Objective

To enable accurate, efficient and risk-informed planning of floating wind decommissioning campaigns through advanced simulation environments, structured operational datasets and decision-support capabilities that improve predictability, optimise removal sequences, reduce operational uncertainty and support environmentally informed decommissioning strategies.



Specific Actions

- Adaptation of installation and heavy-maintenance simulation models to end-of-life scenarios, including alternative load paths and dismantling configurations
- Integration of logistical, port, vessel and environmental footprint considerations into digital planning environments for decommissioning campaigns
- Development of decommissioning-specific risk assessment and operability evaluation frameworks
- Development and integration of structured operational datasets and data-driven decision-support tools for optimisation of removal planning and execution strategies



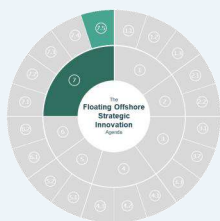
Validation and Trial Needs

- Application of decommissioning planning and simulation tools to representative floating wind end-of-life scenarios
- Verification of prediction accuracy for operation duration, vessel logistics, weather windows, dismantling constraints and environmental impact estimation
- Assessment of usability, robustness and decision-support capability under variable operational conditions



Expected Results

- Improved coordination and predictability of complex decommissioning operations
- Reduced operational risk and uncertainty during end-of-life campaigns
- More efficient integration between offshore removal, tow-back and onshore dismantling or recycling phases
- Improved decision-support capability through validated lifecycle datasets and enhanced operational planning tools
- Increased ability to compare and optimise decommissioning scenarios considering operational, logistical and environmental footprint criteria



Lifecycle Stage O&M and decommissioning

Area 7 Operation, Maintenance and Decommissioning

Subarea 7.5 Decommissioning, repowering and end-of-life strategies of the floating system



7.5.5 Environmental impact assessment and disposal strategies for floating wind decommissioning

Development of applied methodologies to assess and minimise environmental impacts during floating wind decommissioning, addressing regulatory requirements and gaps while defining practical end-of-life pathways. The line covers removal operations, seabed disturbance, waste streams and treatment routes, as well as decision frameworks for reuse, repowering, recycling and final disposal of offshore infrastructure, aligned with industrial feasibility, permitting needs and lifecycle sustainability considerations.



Priority level



Current TRL



Technological Objective

To enable environmentally robust and regulator-ready decommissioning by providing standardised impact assessment approaches and implementable end-of-life strategies that minimise seabed disturbance, reduce ecosystem impacts and support feasible reuse, recycling and disposal pathways while considering lifecycle operational and environmental performance.



Specific Actions

- Develop decommissioning impact assessment methodologies covering removal scenarios, seabed disturbance, emissions / noise and waste streams, including cumulative aspects where relevant
- Map regulatory requirements, permitting expectations and compliance pathways across relevant jurisdictions for floating wind assets interventions
- Define end-of-life option frameworks and logistics for reuse, repowering, recycling and disposal routes, including lifecycle environmental and operational assessment criteria
- Assessment of the economic viability and cost implications of alternative end-of-life pathways, including reuse, repowering, recycling and disposal routes
- Development of lifecycle-informed design recommendations to improve future reuse, recyclability, life extension and environmentally efficient decommissioning of floating wind components and substructures



Validation and Trial Needs

- Case study application on representative floating wind projects to benchmark impacts and validate decision frameworks against permitting expectations
- Validation of waste and material flows (including hazardous materials) and feasibility of recycling/reuse routes with industry and supply-chain stakeholders
- Pilot demonstrations of selected end-of-life operations (component removal, segregation, transport, recycling trials) to confirm practicality and environmental performance



Expected Results

- Standardised but adaptable methodologies and templates for environmental assessment and end-of-life planning aligned with different regulatory and permitting contexts
- Reduced consenting risk and improved environmental performance through traceable, best-practice decommissioning plans supported by lifecycle-based assessment approaches
- Clear, implementable end-of-life pathways increasing reuse/recycling rates and reducing final disposal volumes
- Improved consideration of end-of-life and environmental constraints in future floating wind component and substructure design

Annexes



Annex I – Methodological framework

Purpose of the prioritisation methodology

The prioritisation methodology has been developed to identify the innovation lines with the greatest potential to accelerate the industrial deployment of floating offshore wind in Europe. Given the large number and diversity of innovation lines included in the **Strategic Innovation Agenda**, a structured **assessment framework** has been established to enable a consistent and transparent comparison across all proposed innovations.

Rather than evaluating technological maturity alone, the **methodology** combines **two complementary perspectives**: the **viability** of implementing each innovation within the European industrial ecosystem and its **expected contribution to reducing the cost** of floating offshore wind. This approach makes it possible to distinguish innovations that are not only technically achievable but also capable of delivering a significant impact on the competitiveness of the sector.

Stakeholder assessment process

The development of the Strategic Innovation Agenda has followed a three-stage participatory process involving organisations from across the European floating offshore wind ecosystem.

The first stage has involved the **identification of the innovation lines**, drawing on a review of relevant literature and existing sectoral agendas, complemented by regional stakeholder workshops to identify and validate key innovation needs.

The second stage, corresponding to **Phase 1 of the online participatory process**, has focused on the **characterisation of the innovation lines**. Stakeholders have reviewed and refined the innovation fact sheets, validating key elements such as the innovation description, expected results, technological maturity and other relevant technical information. This collaborative process has ensured that the innovation lines accurately reflect the current needs and priorities of the sector.

The third stage, corresponding to **Phase 2 of the online participatory process**, has focused on the **prioritisation of the innovation lines**. During this stage, stakeholders have assessed only those innovation lines for which they considered themselves sufficiently knowledgeable, assigning scores to the assessment criteria described below.

Assessment criteria for innovation lines prioritisation

Each innovation line has been assessed against two complementary criteria, both evaluated on a five-point scale ranging from 1 (lowest) to 5 (highest).

- **Technical-industrial viability:** Technical-industrial viability assesses the extent to which an innovation can be realistically developed, integrated and deployed within the European floating offshore wind industry. The assessment considers aspects such as technological validation, implementation complexity, integration with existing systems, industrial readiness and the main technical or industrial risks associated with large-scale deployment.
- **Expected impact on cost reduction:** Expected impact on cost reduction evaluates the potential contribution of each innovation to reducing the Levelised Cost of Energy (LCOE) through improvements in manufacturing, installation, operation, maintenance or overall system performance. The assessment focuses on the expected long-term impact of each innovation on the competitiveness of floating offshore wind rather than on short-term economic benefits.

Together, these two criteria provide a balanced assessment of both the technical-industrial viability and the strategic value of each innovation line.

Once the consultation process has been completed, the answers have been aggregated by calculating the average score obtained by each innovation line for each assessment criterion. These average scores constitute the basis for the prioritisation framework presented in the following sections.

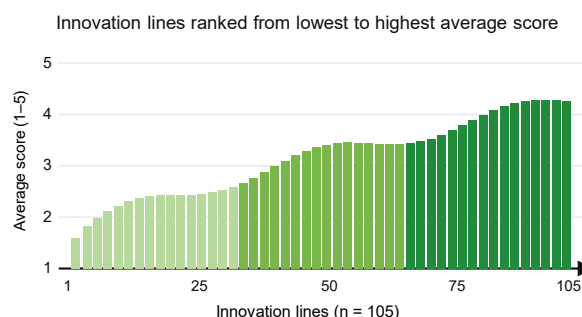
Transformation of the assessment results

In order to preserve the information contained in the average scores and improve the model's discriminatory power, the average scores obtained for each assessment criterion have been converted into standardised assessment levels.



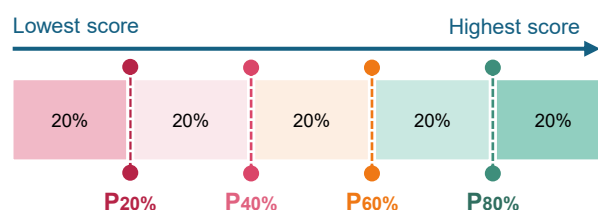
1 Ranking of the innovation lines

For **both** technical-industrial viability and expected impact on cost reduction, the **innovation lines have first been ranked according to their average scores**, from the lowest to the highest value.



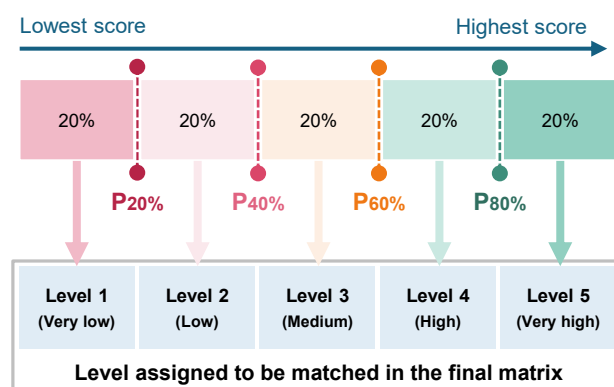
2 Percentile-based classification

The **resulting distributions** have then been **divided into five groups using the P20, P40, P60 and P80 percentiles** as threshold values. This allows each innovation line to be classified according to its relative position within the distribution of scores for each assessment criterion.



3 Assignment of levels (1 to 5)

Based on their position within each distribution, **every innovation line** has been assigned **a level from 1 to 5** for each assessment criterion. As a result, each innovation line has been characterised by a pair of standardised assessment levels representing its relative performance in terms of technical-industrial viability and expected impact on cost reduction.



4 Resulting standardised levels

After this transformation, every innovation line obtains **two standardised levels** (from 1 to 5):

- One for technical-industrial viability
- One for impact on cost reduction

These levels constitute the **input for the subsequent 5x5 prioritisation matrix**.

Illustrative example of resulting levels for an innovation line

Innovation line X.Y.Z.	Technical-industrial viability	Impact on cost reduction
	Level 3 (Medium)	Level 2 (Low)



The resulting levels are combined in the 5x5 prioritisation matrix to determine the final Priority Level (PL1 to PL5) for each innovation line

Priority classification framework

The standardised assessment levels assigned to each innovation line have been combined through a **5×5 prioritisation matrix**, where technical-industrial viability and expected impact on cost reduction constitute the two assessment dimensions.

The **interaction** between both dimensions has determined the final **Priority Level (PL)** assigned to each innovation line. This approach has enabled innovations with different combinations of viability and impact to be consistently classified, while giving greater strategic relevance to innovation lines with a stronger expected contribution to cost reduction.

The resulting prioritisation matrix is presented below:

		Impact on cost reduction				
		1 - Very low	2 - Low	3 - Medium	4 - High	5 - Very high
Technical-industrial viability	5 - Very high	PL4	PL3	PL2	PL1	PL1
	4 - High	PL4	PL3	PL2	PL1	PL1
	3 - Medium	PL5	PL4	PL3	PL2	PL2
	2 - Low	PL5	PL5	PL4	PL3	PL2
	1 - Very low	PL5	PL5	PL5	PL4	PL3

Five Priority Levels have been defined:

- **PL1 – Highest strategic priority:** Innovation lines combining the strongest expected impact on cost reduction with a high level of technical-industrial viability.
- **PL2 – High strategic priority:** Innovation lines with a significant strategic contribution and favourable implementation prospects.
- **PL3 – Medium strategic priority:** Innovation lines with moderate strategic relevance or implementation potential.
- **PL4 – Moderate strategic priority:** Innovation lines requiring further technological or industrial development before achieving higher strategic relevance.
- **PL5 – Lower strategic priority:** Innovation lines with currently limited strategic priority, although they may become more relevant as technologies and market conditions evolve.

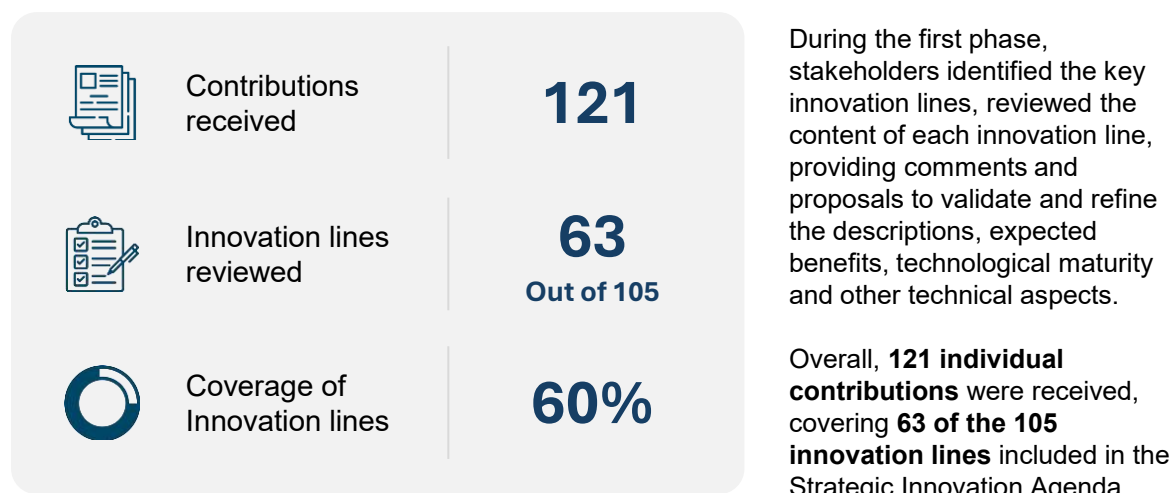
The resulting Priority Levels provide a common framework for comparing innovation lines across all strategic areas and for identifying those with the greatest potential to support the future deployment of floating offshore wind.

Annex II – Stakeholders participation

The development of the Strategic Innovation Agenda has been supported by a **broad participatory process involving organisations from across the European floating offshore wind ecosystem**. Stakeholders have contributed at different stages of the process, **first identifying key innovation needs and lines** through regional workshops, then **validating and refining** the innovation lines and subsequently assessing their **strategic priority**. This collaborative approach has ensured that the Agenda reflects both the technical expertise and the industrial perspectives of the European sector.

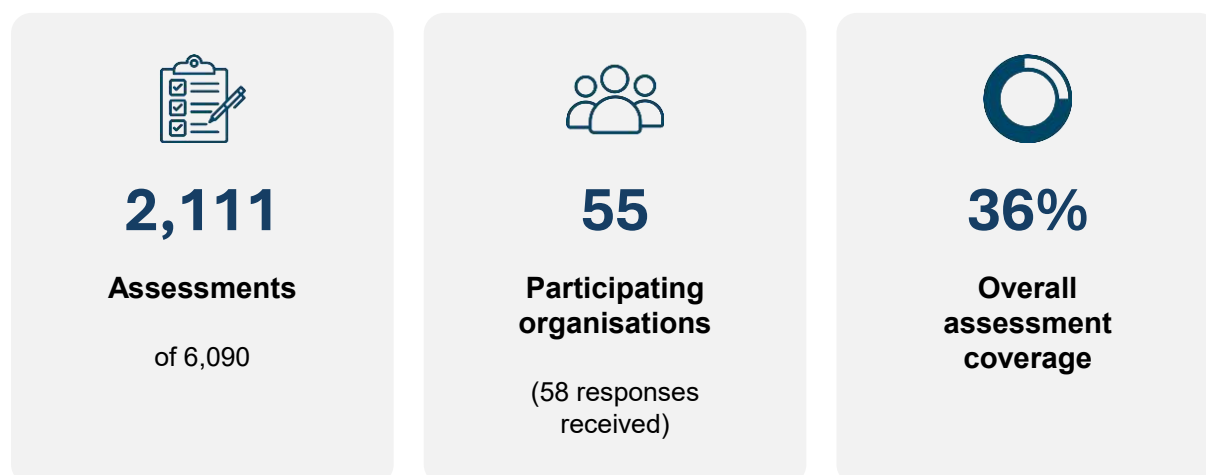
Phase 1 – Characterisation and refinement of innovation lines

Validation and refinement of the innovation fact sheets



Phase 2 – Prioritisation of innovation lines

Assessment of technical-industrial viability and expected impact on cost reduction



During the prioritisation phase, participating organisations assessed the innovation lines according to their areas of expertise using the two assessment criteria defined in the methodology. The consultation generated **2,111 complete assessments**, corresponding to an **overall participation rate of 36%** of the maximum possible assessments (6,090). A total of **55 organisations submitted 58 responses**, providing a robust evidence base for the prioritisation exercise.



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