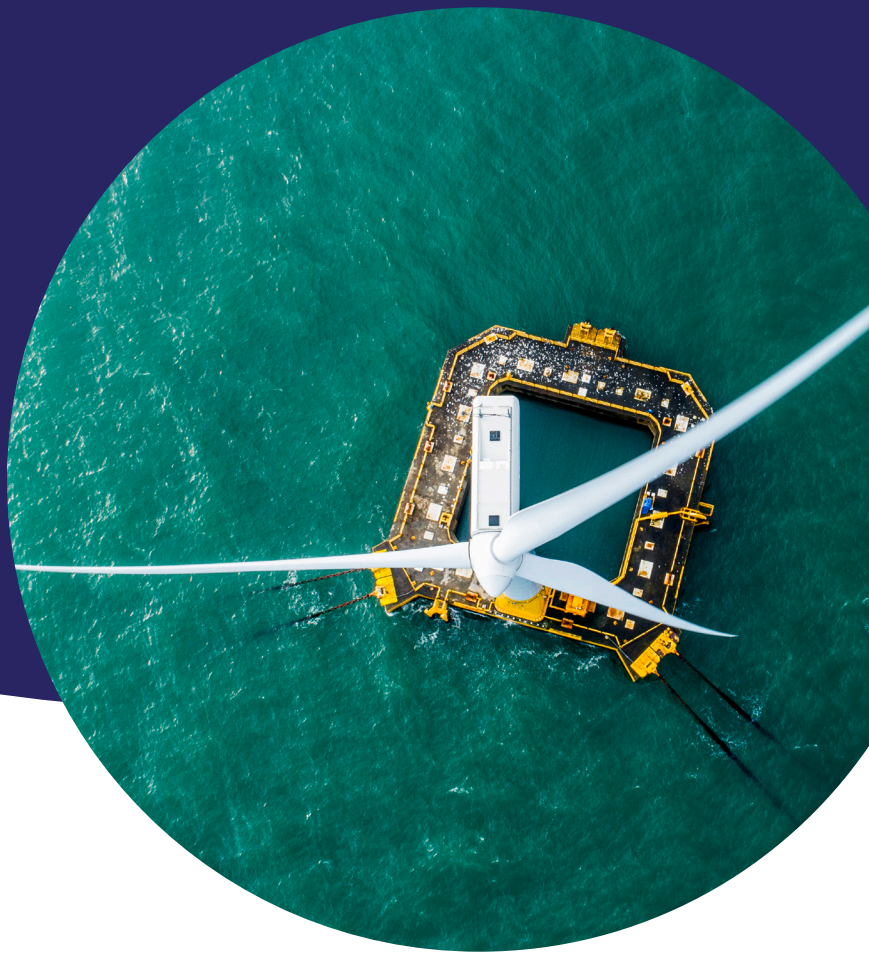
G+ Floating offshore wind hazard identification (HAZID)



G+ Global Offshore Wind
Health & Safety
Organisation

In partnership with
energy institute

G+ FLOATING OFFSHORE WIND HAZARD IDENTIFICATION (HAZID)

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1 EXECUTIVE SUMMARY

This G+ project was focused on the issues and risks associated with a typical floating offshore wind farm, across key operational periods during its lifecycle.

The project consisted of a literature review, to ascertain the relevance of existing guidance; (including offshore wind, oil and gas and marine activities), with the aim of ensuring a consideration of governance and legal issues, existing good practices and lessons learnt are identified and considered and any key issues are identified to consider when managing floating assets.

In addition, three HAZID workshops, comprising several data gathering and data analysis activities, held during October 2021. These were attended by G+ members and associates, IMCA members and the wider supply chain.

The workshop format was developed to:

- explore, understand and assess risks specific to floating developments,
- inform stakeholders of the key risks arising from the findings,
- ensure that risks are highlighted and managed at an early stage to avoid issues further down the development stages to ultimately improve the industry's safety performance even when developing new technology at a commercial scale.

The main purpose of the workstream was to identify the key health and safety hazards for floating wind

This report provides a summary of the key findings and recommendations from these activities.

1.1 RECOMMENDATIONS

1.1.1 Risk identification

The key outputs arising from the Safe by Design HAZID workshops highlight the pertinent risk items identified through high-level risk assessment for the three periods of operations during a typical FLOW project lifecycle. These are divided into onshore, offshore and O&M operation and are summarised in sections 5–17 of this report.

Each section provides It is recommended that a detailed risk assessment is undertaken on a specific project by project basis.

1.1.2 Literature review

The literature review concluded that there are a wide range of regulations, standards, guidance and other documents of varying degrees of relevance to the Health & Safety of commercial-scale FOW projects. Due to the maturity of the industry, FOW-specific requirements are not considered in most documents. Where there are FOW-specific requirements, they mostly consider design considerations, (such as structural requirements) rather than occupational H&S.

The key gaps in current FOW H&S guidance for commercial-scale projects, have been categorised into three groups;

- Gap 1 | Platform Motions during O&M
- Gap 2 | Platform Construction, Transport and Installation
- Gap 3 | New geographies

Platform motions during O&M

The motions of a floating wind platform derived from WTG operations, which are well known, but undertaken in a dynamic environment due to the motions from installation on a floating foundation. In Oil and Gas, there is less consideration of these motions due to the platforms being much larger (more stable) and topsides being relatively much smaller (little effect on motion characteristics).

FOW motion characteristics: floating platform motions, platform motions at hub heights, and platform motions with WTG locked.

Gaps in guidance: motion sickness, working in a dynamic environment, working at height, platform access (CTV and SOV), and platform access (helicopter).

Platform construction, transport and installation

There is good knowledge and track record on operations involving large floating structures from Oil and Gas, however gaps exist on the specific operations required when considering floating structures required for the installation of WTGs.

Gaps in guidance: quayside operations, towing, ballasting, mooring and cable installation, offshore heavy lifts, and decommissioning.

New geographies

As new markets emerge, there are opportunities for these markets to learn from the leaders and pick optimal approaches for developing FOW projects.

The following recommendations are made around the potential gaps in guidance and regulatory frameworks for these new and emerging markets:

- Understand the gaps in the above pillars for the specific market; regulatory frameworks, supply chain, training, etc.
- Develop H&S frameworks and guidance specific and appropriate to the market to ensure risk is managed on FOW projects and develop a sustainable industry. There is concern that without these frameworks in place, different stakeholders may not have the same H&S standards and increase the risk of harm to personnel.
- Industry knowledge gap; enable sharing of learnings from the lead markets to support the future FOW build out.
- New market players to partner with lead market players; mutual benefits in partnering across different markets and giving exposure of new developers to the requirements to safely develop FOW projects.

2 INTRODUCTION

G+ is the leading health and safety body for the global offshore wind industry and, as floating offshore wind matures to commercial-scale deployments, G+ is seeking to ensure the specific risks associated with floating developments are assessed, understood and managed through the development of good practice guidance and other safety management tools for use by its members and the wider industry.

The FOW HSE Workstream is being delivered by a Delivery Partnership (DP) composed of Renewable Consulting Group (RCG), Tadek, and European Marine Energy Centre (EMEC).

The Delivery Partnership worked together to carry out a high-level Risk Assessment for a typical commercial-scale Floating Wind farm. To facilitate the risk identification process, the base-case scenario assumes a farm of circa 50 semi-submersible platforms with 15 MW Wind Turbine Generators (WTG).

3 METHOD

A Risk Review was carried out by the Delivery Partners with the objective of developing a high-level Risk Assessment Matrix for a commercial-scale floating wind farm, to identify critical areas and potential bottlenecks to the development of the industry from a HSE perspective.

To facilitate the risk identification process, the base-case scenario assumes a farm of 100 semi-submersible 15MW wind turbines. However, special considerations and comments have been made to account for the wider range of foundation concepts.

The Risk Review was split into the following categories:

- FOW Onshore.
- FOW Offshore.
- FOW O&M.

The risk assessment for the three workshops were carried out following offshore industry good practice (considering ISO 17776, DNVGL-RP-N101).

The Onshore operations have been subdivided into four categories:

- Construction and logistics.
- Platform assembly.
- Platform launching.
- Quayside assembly and integration.

The Offshore operations have been subdivided into five categories:

- Tow-out.
- Mooring installation and hook-up.
- Array cable connection.
- Commissioning.
- Decommissioning.

The O&M operations have been subdivided into three categories:

- Unmanned Operation.
- On-site Maintenance.
- Onshore Maintenance.

For each category, specific activities have been identified and analysed to identify the potential risks and associated events.

3.1 GUIDANCE FOR RISK ASSESSMENT MATRIX

In this report, activities which may present some risk have been identified and assigned a probability, consequence and floating novelty factor score. These metrics have been used to evaluate the overall risk of the activity.

Specific activities were identified, analysed to identify the potential risks and associated events and were discussed at length by the DP partners to analyse the risks and provide a preliminary assessment specific to the context of the floating wind industry.

Risks associated with each activity were quantitatively evaluated according to three metrics: Probability, *P*, Consequence, *C*, and Floating novelty factor (relative risk to other sectors), *F*.

Table 1: Probability of risk

Probability, *P*	**Frequency**	**Key**
1 – Very unlikely to occur	Incident occurring once in Thirty Years or once every 10,000 operations	
2 – Unlikely to occur	Incident occurring once in Ten Years or once every 1,000 operations	
3 – Possibly could occur	Incident occurring once in Five Years or once every 100 operations	
4 – Likely known to occur	Incident occurring once in One Year or once every 50 operations	
5 – Potentially frequent occurrence	Incident occurring once Monthly or once every 10 operations	

Table 2: Consequence of risk

Consequence, *C*	**Impact**	**Key**
1 – Insignificant	Small Injuries / Damage < $100 k / Delay < 1 month	
2 – Minor	Severe Injuries and hospitalisation / Damage < $500 k / Delay < 2 month	
3 – Moderate	Life-changing injuries / Damage < $1 M / Delay < 6 month	
4 – Major	Fatality / Damage < $10 M / Delay < 1 year	
5 – Extreme	Multiple Fatalities / Damage > $10 M / Delay > 1 year	

Table 3: Floating novelty factor

Floating novelty factor, *F*	**Relative risk to other sectors**	**Key**
0,5 – Opportunity for risk mitigation	Operation may be performed more safely in FOW context	
1,0 – Similar level of risk	Operation is similar to other sectors	
1,5 – Potentially increased risk and/or fully novel risk	Operation is significantly more complex in FOW or completely novel	

The product of these figures (*P*, *C* and *F*) results in a total risk value, which has been used to rank the activities and highlight the most relevant ones, as outlined in later slides. The scoring was agreed between the partners upon discussion and independent evaluation.

Table 4: Overall risk

Overall risk	Total risk value, *P* x *C* x *F*	Conclusion	Key
Low	0,5 – 12,5	Operation does not present major risks and does not require additional review	
Medium	12,5 – 25,0	Operation should be considered for detailed risk assessment but does not represent significant concern	
High	25,0 – 37,5	Operation should be selected for further discussion and mitigation actions	

In this report, the activities have been grouped first by the Floating novelty factor, *F*, and then within that ranked by total risk value. Each activity has also been represented in subsequent slides within the risk matrix which is different for each value of *F*. The numbers in the matrix below indicate the total risk values. The user is advised to review the 'Comments' column for a better interpretation and understanding of the assessment of each activity.

F = 0.5		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1	0.5	1	1.5	2	2.5
	2	1	2	3	4	5
	3	1.5	3	4.5	6	7.5
	4	2	4	6	8	10
	5	2.5	5	7.5	10	12.5

F = 1.0		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

F = 1.5		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1	1.5	3	4.5	6	7.5
	2	3	6	9	12	15
	3	4.5	9	13.5	18	22.5
	4	6	12	18	24	30
	5	7.5	15	22.5	30	37.5

Figure 1: Overall risk matrix for F = 0,5, F = 1, F = 1,5

The tables in this report also contains further information on the applicability of each activity to other concepts (SPAR, BARGE and TLP), which differ from the base-case of the semisubmersible.

Table 5: Applicability to other concepts

Applicable to other concepts?	Key
Yes	
Limited	
No	

4 HAZID SUMMARIES

The following sections provides a summary of each high-level risk assessment for the three periods of operations during a typical FLOW project lifecycle. These are divided into onshore, offshore and O&M operations.

5 OFFSHORE OPERATIONS – ARRAY CABLE CONNECTION OPERATIONS

Of the 11 activities which have been identified for offshore array cable connection operations, 0 were considered as high overall risk and 4 were considered to be of medium overall risk.

Those 4 medium risk activities with the highest risk values were:

Risk ID no.1 **Personnel transfer on-board** risk value = 18 F = 15

- Conventional operation, most relevant HSE guidelines are applicable, may not be required for some platform types.
- Platform motions may render transfer more difficult.

Risk ID no.7 **Subsea operations (Diving)** risk value = 16 F = 1,0

- Diving should be kept to a minimum.
- ROV to be used to replace diving ops where feasible.

Risk ID no.2 **Cable preparation on-deck** risk value = 13,5 F = 1,5

- Existing vessel and associated guidelines largely applicable for most platform types. Required components mostly available in industry.
- Applicability of components should be reviewed depending on specificity of design.
- Ensure review and applicability of standard industry practices.

Risk ID no.3 **Installation of UTA/seabed connector** risk value = 13,5 F = 1,5

- Substantial pre-planning and surveys required as well as strong communication. Checks for updated protocols to be reviewed.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

The assessment performed by the DP indicated that most offshore operations would be very sensitive to the weather, due to the motions and dynamic effects on the FOW platform associated with wind and wave interaction. In some cases, the potentially different shape and mass distribution of the FOW platforms in comparison with other typical offshore structures may lead to a higher perceived risk for some operations that are quite common in the offshore industry (e.g. towing, hook-up). It was also noted that the presence of ballasting systems and their control may represent a relatively novel factor of risk in comparison with other sectors.

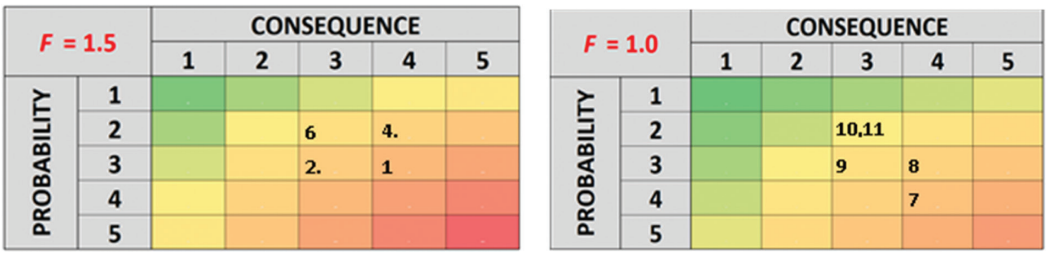

Figure 2: Risk matrix for F = 1,5 and F = 1,0

6 OFFSHORE OPERATIONS – COMMISSIONING

Of the 7 activities which have been identified for offshore commission operations, 0 were considered to be of high overall risk and 3 were considered to be of medium risk overall.

Those 3 medium risk activities with the highest risk values were:

Risk ID no.1 **Ballasting and loading conditions setting** risk value = 18 F = 1,5

- Duration and procedures are dependent on ballasting systems and must be taken note of prior to operation.

Risk ID no.2 **Personnel transfer on-board** risk value = 18 F = 1,5

- Conventional operation, most relevant HSE guidelines are applicable, may not be required for some platform types.
- Platform motions may render transfer more difficult.
- Mitigate using vessel-platform clamping or tether systems to keep on station.

Risk ID no.3 **Draft and stability survey** risk value = 13,5 F = 1,5

- Standards protocols and checklists to be followed.
- Checks to be made with classification societies for any potential updates and recommendations.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

The assessment performed by the DP indicated that most offshore operations would be very sensitive to the weather, due to the motions and dynamic effects on the FOW platform associated with wind and wave interaction. In some cases, the potentially different shape and mass distribution of the FOW platforms in comparison with other typical offshore structures may lead to a higher perceived risk for some operations that are quite common in the offshore industry (e.g. towing, hook-up).It was also noted that the presence of ballasting systems and their control may represent a relatively novel factor of risk in comparison with other sectors.

F = 1.5		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1					
	2					
	3			3	1,2	
	4					
	5					

F = 1.0		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1					
	2			7		
	3			5,6	4	
	4					
	5					

Figure 3: Risk matrix for F = 1,5 and F = 1,0

7 OFFSHORE OPERATIONS – DECOMMISSIONING

Of the 10 activities which have been identified for offshore decommissioning operations, 0 were considered to be of high overall risk and 5 were considered to be of medium risk overall.

Those 5 medium risk activities with the highest risk values were:

Risk ID no.1 **Mooring lines disconnection** risk value = 18 F = 1,5

- Largely dependent on platform type and design (location of pad-eyes, etc), existing guidelines usually applicable but likely updated for specific arrangements/procedures which may be required.
- Disconnection procedure similar to other procedures in oil and gas.

Risk ID no.2 **Platform transportation** risk value = 18 F = 1,5

- Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements.
- Contingencies usually considered, but delays may occur as a result of various unforeseen circumstances.

Risk ID no.6 **Diving operations** risk value = 16 F = 1,0

- Diving should be kept to a minimum.
- ROV to be used to replace diving ops where feasible.

Risk ID no.3 **Cable disconnection** risk value = 13,5 F = 1,5

- Procedure should be similar for different platform types.
- Standards and guidelines should be consulted to ensure safe disconnection.

Risk ID no.4 **Platform temporary station-keeping** risk value = 13,5 F = 1,5

- Largely dependent on platform type.
- Conventional station keeping tug based suited to semi sub concepts.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

The assessment performed by the DP indicated that most offshore operations would be very sensitive to the weather, due to the motions and dynamic effects on the FOW platform associated with wind and wave interaction. In some cases, the potentially different shape and mass distribution of the FOW platforms in comparison with other typical offshore structures may lead to a higher perceived risk for some operations that are quite common in the offshore industry (e.g. towing, hook-up). It was also noted that the presence of ballasting systems and their control may represent a relatively novel factor of risk in comparison with other sectors.

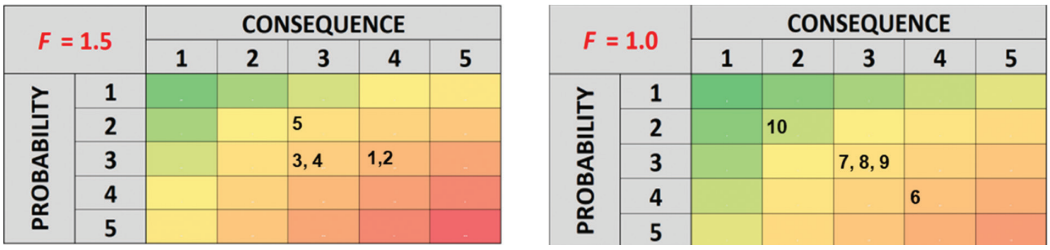

Figure 4: Risk matrix for F = 1,5 and F = 1,0

8 OFFSHORE OPERATIONS – MOORING INSTALLATION AND HOOK-UP

Of the 16 activities which have been identified for offshore mooring installation and hook-up operations, 0 were considered to be of high overall risk and 10 were considered to be of medium risk overall.

Those 10 medium risk activities with the highest risk values were:

Risk ID no.1 **Offshore heavy lift** risk value = 22,5 F = 1,5

- Generally considered within G+ as undesirable operation to perform.
- Requires large technological advancement to be safe.
- Could be driven by a bottleneck from limiting yard capacity for assembly.
- Requires cost benefit and feasibility study on a project specific basis due to limiting weather conditions.

Risk ID no.2 **Mooring line preparation on-deck** risk value = 18 F = 1,5

- Existing vessel and associated guidelines largely applicable for most platform types.
- Required components mostly available in industry.
- Applicability of components should be reviewed depending on specificity of design.
- Standard industry practice usually applies.

Risk ID no.3 **Platform temporary station-keeping** risk value = 18 F = 1,5

- Largely dependent on platform type. Conventional station keeping tug based suited to semi sub concepts.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

The assessment performed by the DP indicated that most offshore operations would be very sensitive to the weather, due to the motions and dynamic effects on the FOW platform associated with wind and wave interaction. In some cases, the potentially different shape and mass distribution of the FOW platforms in comparison with other typical offshore structures may lead to a higher perceived risk for some operations that are quite common in the offshore industry(e.g. towing, hook-up).It was also noted that the presence of ballasting systems and their control may represent a relatively novel factor of risk in comparison with other sectors.

F = 1.5		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1					
	2					9
	3			10	2,3,4,5,6,7	1
	4			8		
	5					

F = 1.0		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1					
	2			13,14,15		
	3		16	12		
	4				11	
	5					

Figure 5: Risk matrix for F = 1,5 and F = 1,0

9 OFFSHORE OPERATIONS – TOW-OUT

Of the 12 activities which have been identified for offshore two-out operations, 0 were considered to be of high overall risk and 4 were considered to be of medium risk overall.

Those 4 medium risk activities with the highest risk values were:

Risk ID no.1 **Quayside disconnection and release** risk value = 18 F = 1,5

- Operation quite conventional, detailed understanding of procedures required to avoid severe stability issues.

Risk ID no.2 **Second ballasting operation (open ocean)** risk value = 18 F = 1,5

- Duration and procedures are dependent on ballasting systems and must be taken note of prior to operation.

Risk ID no.3 **Transportation of platform to pre-installed mooring site** risk value = 18 F = 1,5

- Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements.
- Contingencies usually considered, but delays may occur as a result of various unforeseen circumstances.
- Unexpected weather conditions mitigated by using two independent long-range weather forecasts.

Risk ID no.4 **Connection of towing lines to platform** risk value = 13,5 F = 1,5

- Platform and design dependent (location of pad-eyes, etc.), existing guidelines usually applicable but likely updated for specific arrangements/procedures which may be required.
- Detailed design should consider towing configuration although at project stage this is already done and validated.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

The assessment performed by the DP indicated that most offshore operations would be very sensitive to the weather, due to the motions and dynamic effects on the FOW platform associated with wind and wave interaction. In some cases, the potentially different shape and mass distribution of the FOW platforms in comparison with other typical offshore structures may lead to a higher perceived risk for some operations that are quite common in the offshore industry(e.g. towing, hook-up).It was also noted that the presence of ballasting systems and their control may represent a relatively novel factor of risk in comparison with other sectors.

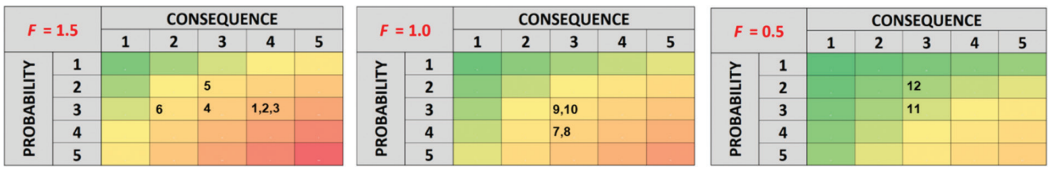

Figure 6: Risk matrix for F = 1,5, F = 1,0 and F = 0,5

10 ONSHORE OPERATIONS – CONSTRUCTION AND LOGISTICS

Of the 21 activities which have been identified for onshore construction and logistic operations, 0 were considered to be of high overall risk and 3 were considered to be of medium risk overall.

Those 3 medium risk activities with the highest risk values were:

Risk ID no.1 **Inexperience with local concrete construction contractors** risk value = 18 F = 1,5

- Close cooperation with experienced engineers required to mitigate.

Risk ID no.4 **Limiting yard capacity for commercial scale number of units** risk value = 15 F = 1,0

- Detailed logistics plan prior and throughout onshore works / realistic assessment of yard capacity and space / all onshore contractors aware of works going on nearby.

Risk ID no.3 **Foundation concrete structural sub-assemblies transportation** risk value = 13,5 F = 1,5

- Examples from O&G/civil/coastal engineering for bigger structure.
- Large yards/facilities required.
- Local HSE and staff competence to be verified work rules issues.
- Quality/HSE issues using multiple facilities.
- Working outdoor limited depending on local weather, staff competence to be verified.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

Whilst some of these operations may be relatively known in the industry, the DP felt that the specificity and size of the foundation parts and the difficulties associated with performing some of the assembly on a floating configuration would lead to perceived higher risks. It should also be noted that the assessment included the consideration of logistical challenges due to the size of a commercial farm.

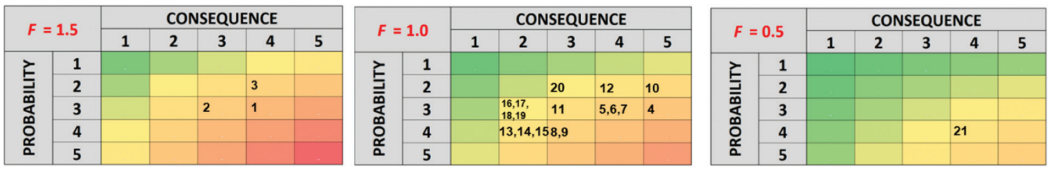

Figure 7: Risk matrix for F = 1,5, F = 1,0 and F = 0,5

11 ONSHORE OPERATIONS – PLATFORM ASSEMBLY

Of the 10 activities which have been identified for onshore platform assembly operations, 1 was considered to be of high overall risk and 3 were considered to be of medium risk overall.

The activity considered to be of high overall risk was:

Risk ID no.1 **Sheltered waters platform assembly required** risk value = 30 F = 1,5

- Has been successfully performed before, with Hywind in sheltered waters.
- Remains one of the most critical activities.
- Technology will need advancement to perform this offshore.
- Raised as significant concern by G+ group.

This operation should be selected for further discussion and mitigation actions.

The 3 medium risk activities with the highest risk values were:

Risk ID no.2 **Foundation sub-assemblies mobilisation** risk value = 18 F = 1,5

- Need for a large separate area (foundation separate from WTG).
- Impact on logistics and production planning.
- Potential optimisation for reducing number of lifts.

Risk ID no.3 **Foundation welding / connection** risk value = 18 F = 1,5

- Welding of large structures common in offshore yard but for smaller volumes.
- Account for load-bearing mechanisms/strategies.
- Alternatives type of connection being used (grouting, bolted, concrete reinforcement framing).

Risk ID no.4 **Insufficient quayside depth** risk value = 15 F = 1,5

- Very little ports with current quayside depths that would accommodate quayside assembly, especially for spars.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

Whilst some of these operations may be relatively known in the industry, the DP felt that the specificity and size of the foundation parts and the difficulties associated with performing some of the assembly on a floating configuration would lead to perceived higher risks. It should also be noted that the assessment included the consideration of logistical challenges due to the size of a commercial farm.

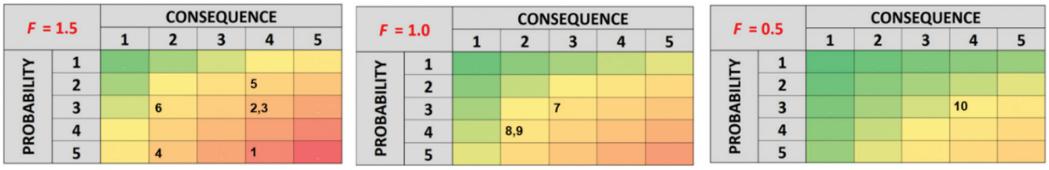

Figure 8: Risk matrix for F = 1,5, F = 1,0 and F = 0,5

12 ONSHORE OPERATIONS – PLATFORM LAUNCHING

Of the 8 activities which have been identified for onshore platform launching operations, 0 were considered to be of high overall risk and 2 were considered to be of medium risk overall.

Those 2 medium risk activities with the highest risk vales were:

Risk ID no.1 **Personnel on board during launching phase** risk value = 18 F = 1,5

- Dependent on temporary arrangements in place for access / egress and for working at height.

Risk ID no.2 **Platform Heavy Lifting to water** risk value = 13,5 F = 1,5

- Requires huge cranes and infrastructure and adequate space at quayside for mobilisation.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

Whilst some of these operations may be relatively known in the industry, the DP felt that the specificity and size of the foundation parts and the difficulties associated with performing some of the assembly on a floating configuration would lead to perceived higher risks. It should also be noted that the assessment included the consideration of logistical challenges due to the size of a commercial farm.

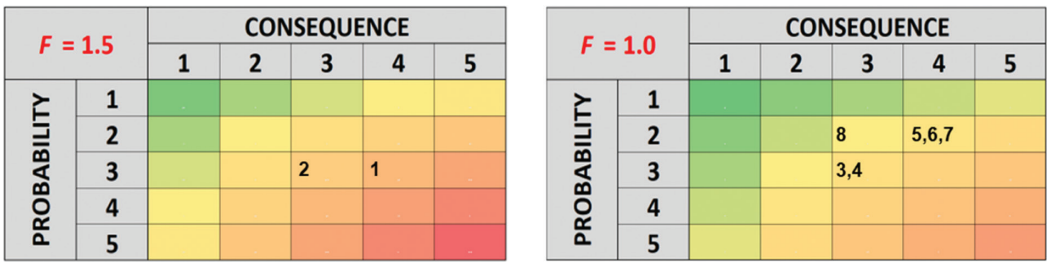

Figure 9: Risk matrix for F = 1,5 and F = 1,0

13 ONSHORE OPERATIONS – QUAYSIDE ASSEMBLY AND INTEGRATION

Of the 11 activities which have been identified for onshore quayside assembly and integration operations, 0 were considered to be of high overall risk and 1 was considered to be of medium risk overall.

The activity considered to be of medium overall risk was:

Risk ID no.1 **Stability/Inclining Checks and Ballasting** risk value = 13,5 F = 1,5

- May be not required or performed on site for some concepts (e.g. spar).
- Standard guidance for inclining tests to be adapted for floating wind.
- Active ballasting system increase complexity and risk.

This activity therefore should be considered for a detailed risk assessment but should not represent significant concern.

Whilst some of these operations may be relatively known in the industry, the DP felt that the specificity and size of the foundation parts and the difficulties associated with performing some of the assembly on a floating configuration would lead to perceived higher risks. It should also be noted that the assessment included the consideration of logistical challenges due to the size of a commercial farm.

Figure 10: Risk matrix for F = 1,5, F = 1,0 and F = 0,5

14 O&M – ONSHORE MAINTENANCE

Of the 11 activities which have been identified for O&M onshore maintenance operations, 0 were considered to be of high overall risk and 6 were considered to be of medium risk overall.

Those 6 medium risk activities with the highest risk values were:

Risk ID no.1 **Mooring lines disconnection** risk value = 18 F = 1,5

- Largely dependent on platform type and design (location of pad-eyes, etc), existing guidelines usually applicable but likely updated for specific arrangements/procedures which may be required.
- Connection procedure similar to other procedures in oil and gas.

Risk ID no.2 **Platform transportation** risk value = 18 F = 1,5

- Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements.
- Contingencies usually considered, but delays may occur as a result of various unforeseen circumstances.

Risk ID no.3 **Foundation structural repairs** risk value = 18 F = 1,5

- Minor (temporary) repairs usually done on site when possible.
- Limited structural works to be done on quayside.
- Major repairs (hull breach, etc) would require lifting of platform but may not be feasible.
- Potential to replace foundation completely rather than take on major repairs on damaged foundation.

Risk ID no.4 **Cable disconnection** risk value = 13,5 F = 1,5

- Procedure should be similar for different platform types.
- Standards and guidelines should be consulted to ensure safe disconnection.
- Motions of the platform may render the operation difficult.

Risk ID no.5 **Platform temporary station-keeping** risk value = 13,5 F = 1,5

- Largely dependent on platform type.
- Conventional station keeping tug based suited to semi sub concepts.

Risk ID no.6 **Quayside connection** risk value = 13,5 F = 1,5

- Operation quite conventional, detailed understanding of procedures required to avoid severe stability issues.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

Most large maintenance tasks are perceived as relatively less risky since they are performed onshore in a relatively controlled environment, however the structural repairs on the foundation may require the execution of high-risk operations.

Figure 11: Risk matrix for F = 1,5, F = 1,0 and F = 0,5

15 O&M – ON-SITE MAINTENANCE

Of the 17 activities which have been identified for O&M on-site maintenance operations, 0 were considered to be of high overall risk and 9 were considered to be of medium risk overall.

Those 9 medium risk activities with the highest risk values were:

Risk ID no.1 **Offshore heavy lifts for major component exchange** risk value = 22,5 F = 1,5

- Generally considered within G+ as undesirable operation to perform.
- Requires large technological advancement to be safe.
- Requires cost benefit and feasibility study on a project specific basis due to limiting weather conditions.

Risk ID no.2 **Helicopter towering** risk value = 18 F = 1,5

- Mostly required for evacuations and minor interventions.
- Variable risk due to relative motions between aircraft and platform to be considered.

Risk ID no.3 **Personnel transfer** risk value = 18 F = 1,5

- Conventional procedures largely applicable.
- Variable risk due to relative motions between vessel and platform to be considered.
- Method of transfer to be considered as different risks may apply.
- Draught of both vessel and platform to be considered when transferring on/off.
- In general there is higher risk transferring from platform due to vessel (mostly CTV) due to ergonomics.
- Lower risk compared to fixed types due to tidal variations working in favour of floating platform.
- Lower risk for SOV with heave compensation.
- Access point risks can be mitigated significantly in design stages with SOV AHC bridges and multiple access points if commercially viable.

Risk ID no.4 **Emergency evacuation** risk value = 18 F = 1,5

- Evacuation more difficult on FOW due to added risk due to platform motions.
- Casualty evacuation requirements can drive some secondary steel re/design.

Risk ID no.5 **CTV access to platform** risk value = 18 F = 1,5

- Procedures similar for different platform types.
- Likelihood and severity of consequences largely dependent on weather conditions.

Risk ID no.6 **SOV approach and maneuvering** risk value = 13,5 F = 1,5

- Similar procedures to fixed bottom.
- Dynamic positioning will need to track motions.
- Motion of vessel due to weather conditions to be considered due to no transit zones.

Risk ID no.7 **SOV access to platform** risk value = 13,5 F = 1,5

- Procedures similar for different platform types.
- Likelihood and severity of consequences largely dependent on weather conditions.
- Two week window for transit decreases risk of travelling in unfavourable weather conditions + more time for planning.

Risk ID no.8 **Loading and lifting of replacement items and tools** risk value = 13,5 F = 1,5

- Mostly similar risks to fixed bottom but slightly higher risk for turbines with potentially larger hub heights.
- Motions of floating turbines may increase risk of falling objects.

Risk ID no.9 **Working onboard platform and turbine** risk value = 13,5 F = 1,5

- Can be mitigated by stating that all personnel require both GOW and BOSIET, or recommendations to improve GOW training.

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

For the on-site maintenance, activities associated with transfer of personnel and access are highlighted as potentially risky due to the influence of the dynamics of the platform. Most large maintenance tasks are perceived as relatively less risky since they are performed onshore in a relatively controlled environment, however the structural repairs on the foundation may require the execution of high-risk operations.

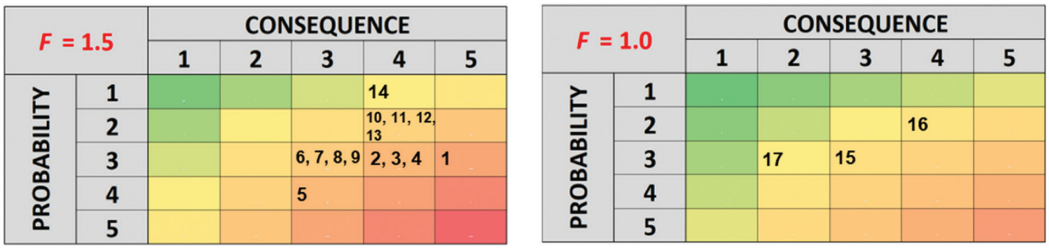

Figure 12: Risk matrix for F = 1,5 and F = 1,0

16 O&M – UNMANNED OPERATION

Of the 11 activities which have been identified for O&M unmanned operations, 0 were considered to be of high overall risk and 6 were considered to be of medium risk overall.

Those 6 medium risk activities with the highest risk values were:

Risk ID no.1	**Loading conditions control (ballast management)**	risk value = 18	F = 1,5
	– Increased risk in case of failure due to more difficult intervention required since unmanned.		
Risk ID no.2	**Moorings integrity and functionality**	risk value = 18	F = 1,5
	– Consequence of mooring failure may be more severe due to poor redundancy considerations. – Loss of position and disconnected mooring lines may cause larger issues in farms consisting of several turbines.		
Risk ID no.3	**Foundation integrity**	risk value = 15	F = 1,5
	– Potential increase to foundation fatigue due to increased motions and thus maintenance.		
Risk ID no.4	**WTG Nacelle yawing**	risk value = 13,5	F = 1,5
	– Operation of nacelle yawing may be sensitive to platform dynamics. – Considerations for nacelle yawing to be included for all concepts. – Weather vaning / mooring may allow for modification. – Review wind / wave / current impacts.		
Risk ID no.5	**Subsea connections**	risk value = 13,5	F = 1,5
	– Frequency/likelihood dependent on method of connection and workmanship and surrounding environment.		
Risk ID no.6	**Cable integrity and functionality**	risk value = 13,5	F = 1,5
	– Behaviour of dynamic cable as well as water depth (touchdown point for shallow waters) may have impact on frequency of failure. – Considerations for turbulent behaviour, VIV on cable.		

These activities therefore should be considered for a detailed risk assessment but should not represent significant concern.

The DP identified the ballast management and the moorings integrity as the two main risk factors during unmanned operation, due to the relative novelty of these components applied to the FOW industry. Most large maintenance tasks are perceived as relatively less risky since they are performed onshore in a relatively controlled environment, however the structural repairs on the foundation may require the execution of high-risk operations.

F = 1.5		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1					
	2			7		3
	3		8,9	4, 5, 6	1, 2	
	4					
	5					

F = 1.0		CONSEQUENCE				
		1	2	3	4	5
PROBABILITY	1					
	2					
	3		10, 11			
	4					
	5					

Figure 13: Risk matrix for F = 1,5 and F = 1,0

ANNEX A
ABBREVIATIONS AND ACRONYMS

EI	Energy Institute
DP	delivery partnership
G+	G+ Global Offshore Wind Health and Safety Organisation
HAZID	hazard identification study
H&S	health and safety
HSE	Health and Safety Executive
OEM	original equipment manufacturer
O&M	operation and maintenance
SbD	safe by design
TP	transition piece
WTG	wind turbine generator

ANNEX B
HAZID RECORD (OFFSHORE)

Operation	Offshore Operations
Author	
Checked	
Approved	
Date	03-11-2022
Attendance	
Abbreviations	PD = Project Developer, CON = Construction Contractor, MWS = Marine Warranty Surveyor, CMN = Component Manufacturer, TMN = Turbine Manufacturer, TRL = On-land Transportation Contractor, TRM = Sea Transportation Contractor, POR = Port Authority, MOP = Marine Operator Contractor, OWN = Wind Farm Owner, MNT = O&M Contractor

EMEC THE EUROPEAN MARINE ENERGY CENTRE LTD

TADEK Naval Architects, Project Managers, Offshore & Subsea Engineers

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OFFSHORE OPERATIONS HAZID RECORD

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
Tow-Out													
1	Personnel offloading and onboarding	Man overboard/Falling/improper harness and other safety equipment/ defective gangways	MOP	2	3	0.5	**3**	Operation does not present major risks and does not require additional review	Conventional operation, most relevant HSE guidelines are applicable, may not be required for some platform types. Floater configuration (draft, ballasting, phase of assembly) may affect transfer risk		Yes	Yes	Yes
2	Set-up and preparation for towing (ballast, loading, securing the equipment)	Excessive motions and excursions/ unstable behaviour/ballast management failure/falling objects/ working at height/confined spaces	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Care must be taken to ensure turbine rotor is locked during towing (dependant on tow duration), rotations may be required, potentially automated. Sea fastening approach is approved and complied prior to leaving from quayside. Floater configuration (draft, ballasting, phase of assembly) may affect operations. Nighttime operating, particularly for 24h operation, would need additional consideration	SPAR transportation may be more challenging due to tall hull. Sometimes HLV may be required. The platform type will affect the different ballasting procedures and floater configuration	Limited	Yes	Limited
3	Quayside disconnection and release	Line failure/excessive motions and excursions/unstable behaviour/ unfavourable weather conditions/ Collision or impact/General and transfer loads may cause instability/ Lack of operation space	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Operation quite conventional, detailed understanding of procedures required to avoid severe stability issues		Yes	Yes	Yes
4	Approaching/ Manoeuvring of tugboats and workboats	Unstable behaviour/collisions with other craft/ entangling of towing lines/ falling/man overboard/unfavourable weather conditions/ breakdown in communications	MOP	4	3	1	**12**	Operation does not present major risks and does not require additional review	Potential restrictions in operation and manoeuvring space but dependent on facility, strong communication required		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
5	Connection of towing lines to platform	Incorrect connection/Platform not secured properly/Faulty connection points/Incorrect or inaccurate modelling during analysis stage	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Platform and design dependent (location of pad-eyes,etc), existing guidelines usually applicable but likely updated for specific arrangements/ procedures which may be required. Detailed design should consider towing configuration although at project stage this is already done and validated		Limited	Yes	Yes
6	Tugboats and anchor handlers positioning turbine and in port manoeuvring	Insufficient pull provided/ Incorrect positioning/Human error/ unfavourable weather conditions/ collisions/ Inaccurate routing/ Aviation interference/breakdown in communications/Obstructions/Lack of communication with third parties/ Insufficient training	MOP	4	3	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Potential restrictions in operation and manoeuvring space but dependent on facility, strong communications, surveys and preparations required		Yes	Yes	Yes
7	Lengthening of towing lines when in open ocean	Lines lengthened too early/Lines not long enough when lengthened/Lines lengthened without control/Entangling of lines/Line failure/winch failure	MOP	2	3	1.5	**9**	Operation does not present major risks and does not require additional review	Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements		Yes	Yes	Yes
8	Second ballasting operation (open ocean)	Incorrect or insufficient ballasting/ Loss of stability or unstable behaviour/ unfavourable weather conditions	OWN/MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Duration and procedures are dependent on ballasting systems and must be taken note of prior to operation		Yes	Yes	Limited
9	Port navigation and communications	Miscommunication/Lack of communication between crew and port/Marine traffic/insufficiently dredged areas	MOP/POR	4	3	1	**12**	Operation does not present major risks and does not require additional review	Standard port protocols and guidelines usually applicable but possibility of unforeseen circumstances, reviews of protocols to be carried out		Yes	Yes	Yes
10	Tug and workboat management	Insufficient BP capacity/Interference with shipping routes/Staff shortage/ breakdown in communications/ collisions /unfavourable weather conditions/Insufficient training	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Vessels provided usually sufficient and organisation of vessels is pre-planned to avoid shortages. Provided training usually enough to avoid issues but shortages may be possible depending on geographies and demand from other oil and gas sectors		Yes	Yes	Yes
11	Transportation of platform to pre-installed mooring site	Loss of stability/Human error during transportation/Unfavourable weather conditions/ Delayed arrival at mooring site	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements. Contingencies usually considered, but delays may occur as a result of various unforeseen circumstances. Unexpected weather conditions mitigated by using two independent long range weather forecasts	SPAR transportation may be more challenging due to tall hull. Sometimes HLV may be required. SPAR types usually installed in deeper waters	Limited	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
12	Non project-related marine traffic	Unrelated vessel in close proximity losing station keeping/position control/ fishing vessel equipment fouling turbine moorings or other subsea infrastructure	OWN	3	3	1	**9**	Operation does not present major risks and does not require additional review	Only FOW novelty will come from the consequence of corrective actions in maintenance. Standard mitigating actions apply from O&G and fixed bottom offshore wind. Exclusion zones and monitoring during work installation phases to be considered as well as temporary navigational aids		Yes	Yes	Yes
Mooring Installation & Hook-Up													
13	Moorings components offloading to barge/ AHV	Dropped objects/excessive oscillations/ crane failure/unstable vessel behaviour/ Failure of winch or tensioned lines	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Mooring components mostly standard and applicable for most platform types, number of mooring lines may vary which may reduce required resources overall		Yes	Yes	Yes
14	Moorings transportation to site	Rigging failure/equipment movement or missing equipment/excessive vessel motions/unstable vessel behaviour	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Procedures mostly standard and applicable for most platform types, number of mooring lines/ equipment may vary which may reduce required resources overall		Yes	Yes	Yes
15	Installation vessels mobilisation	Excessive motions/unstable arrangement/water ingress and slamming	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Existing vessel and associated guidelines largely applicable for most platform types, large number of mooring lines will be required for various installations in large farms/multi-platformed farms. Potential to optimise resources and transportation		Yes	Yes	Yes
16	Mooring line preparation on-deck	Improper machinery handling/ Mechanical failure/Inaccurate assembly/ high loads and torques/Insufficient training/Poor planning	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing vessel and associated guidelines largely applicable for most platform types. Required components mostly available in industry. Applicability of components should be reviewed depending on specificity of design. Standard industry practice usually applies		Yes	Yes	Yes
17	Mooring line and Anchor Installation	Dropped objects/clashing and interference with other subsea equipment/incorrect positioning/ insufficient penetration-dragging/ inexperience with new synthetic moorings/Insufficient preparation of the seabed/Time to drive pile larger than expected	MOP	4	3	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing vessel and associated guidelines largely applicable for most platform types. Required components mostly available in industry. Applicability of components should be reviewed depending on specificity of design . Consideration to be given for pre-installation subsea surveys and Unexploded Ordinance (UXO) studies/ clearing		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
18	Proof loading and marking	Pull-line failure/seabed obstacles/high-load mechanical failure/insufficient buoyancy/Poor quality of preliminar numerical analysis/Tensioner failure/ Reaction anchor not stabilized	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing standards applicable for definition of proof loads. Potential updates to be reviewed and agreement with classification society. Consideration of development of novel techniques		Yes	Yes	Yes
19	Support vessels mobilisation (ISV)	Pull-line failure/seabed obstacles/high-load mechanical failure/insufficient buoyancy		3	3	1	**9**	Operation does not present major risks and does not require additional review	Typical ISVs available from O&G industry. The need for specialised equipment may be reduced in comparison to bottom-fixed offshore wind		Yes	Yes	Yes
20	Platform temporary station-keeping	Line failure/excessive motions and excursions/unstable behaviour/ Unfavourable weather conditions/ Collisions/Obstacles/Tug engine failure or drifting/Tug loss of control and positioning	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform type. Conventional station keeping tug based suited to semi sub concepts. SIMOPS reviews may be required prior to execution of the operation	SPAR and TLP type may require different operations and considerations for stability	Yes	Yes	Yes
21	Mooring pull-in and connection	Line failure/high-load mechanical failure/poor securing of the connection/Winch failure/Collisions/ Incorrect tensioning applied	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform type and design (location of pad-eyes,etc), existing guidelines usually applicable but likely updated for specific arrangements/procedures which may be required. Connection procedure similar to other procedures in oil and gas. Mitigated by load monitoring system and checked throughout O&M. SIMOPS reviews may be required prior to execution of the operation	SPAR and TLP type may require different operations and considerations for stability	Yes	Yes	Yes
22	Subsea operations (ROV)	Breakdown in communication or connection/Poor control/Insufficient training/Entanglement/Insufficient specs/Accessibility or visibility issues/ Collision	MOP	3	2	1	**6**	Operation does not present major risks and does not require additional review	ROV to be considered for use for majority of subsea operations. Sufficient technology and expertise usually available. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
23	Subsea operations (Diving)	Swinging objects/Entanglement/ Exposure to dangerous substances/Loss of air/Decompression sickness	MOP	4	4	1	**16**	Operation should be considered for detailed risk assessment but does not represent significant concern	Diving should be kept to a minimum. ROV to be used to replace diving ops where feasible. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
24	Personnel transfer on-board	Man overboard/Falling/improper harness and other safety equipment/ defective gangways	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Conventional operation, most relevant HSE guidelines are applicable, may not be required for some platform types. Floater configuration (draft, ballasting, phase of assembly) may affect transfer risk. Nighttime operating, particularly for 24h operation, would need additional consideration	The platform type, state of ballast and floater configuration will affect transfer risk	Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
25	Mooring tensioning and set-up	Line failure/high-load mechanical failure/loss of position/excessive platform motions and excursions/ collisions/Winch-Fairlead-Chainstopper failure	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Standard components and procedures usually available from industry however pretensioning requirement may be specific to platform type and should be considered. Catenary moorings operation usually standard, semi taut will have higher loads and will likely require specific considerations. SIMOPS reviews may be required prior to execution of the operation	Different operations for TLP, for example deballasting to increase buoyancy and tension	Yes	Yes	Yes
26	Platform ballasting/de-ballasting	Excessive motions and excursions/ unstable behaviour or loss of stability/ ballast management or system failure/ human error/collisions	OWN/MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform concept. Existing procedures not directly applicable and are specific to other industries. Potential updates in procedures to be reviewed. SIMOPS reviews may be required prior to execution of the operation	Different ballasting operations for SPAR/ TLP	Yes	Yes	Yes
27	Offshore heavy lift	Excessive motions and excursions/ unstable behaviour or loss of stability/dropped objects/damage to components/working at height while offshore/human error/collisions/man overboard/improper harness safety/ breakdown in comms/inexperience	TRM/MOP/ OWN	3	5	1.5	**22.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Generally considered within G+ as undesirable operation to perform. Requires large technological advancement to be safe. Could be driven by a bottleneck from limiting yard capacity for assembly. Requires cost benefit and feasability study on a project specific basis due to limiting weather conditions. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
28	Vessel operations	Vessel contractor general inexperience or inexperience with FOW/unsitable and insufficient processes/insufficient time for crew familiarisation	MOP	2	5	1.5	**15**	Operation should be considered for detailed risk assessment but does not represent significant concern	High novely rating from the unique FOW operations to install and hook up a turbine platform. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
Array Cable Connection													
29	Umbilical components offloading to barge/ AHV	Dropped objects/excessive oscillations/ crane failure/unstable vessel behaviour/ Failure of winch or tensioned lines/ MBR infringement	MOP	2	3	1.5	**9**	Operation does not present major risks and does not require additional review	Dynamic/array cable designs to be reviewed with existing procedures		Yes	Yes	Yes
30	Umbilical and UTA/connectors transportation to site	Rigging failure/equipment movement/ excessive vessel motions/unstable vessel behaviour/MBR infringement	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Components mostly standard and applicable for most platform types, potential to optimise transportation and reduce required resources overall		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
31	Installation vessel mobilisation	Excessive motions/unstable arrangement/water ingress and slamming	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Existing vessel and associated guidelines largely applicable for most platform types. Potential to optimise resources and transportation		Yes	Yes	Yes
32	Cable preparation on-deck	Machinery handling/Mechanical failure/ Inaccurate assembly/high loads and torques/MBR infringement	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing vessel and associated guidelines largely applicable for most platform types. Required components mostly available in industry. Applicability of components should be reviewed depending on specificity of design. Standard industry practice usually applies . SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
33	Installation of UTA/ seabed connector	Dropped objects/clashing and interference with other subsea equipment/incorrect positioning	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Substantial pre-planning and surveys required as well as strong communication. Checks for updated protocols to be reviewed. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
34	Laying of cable	Dropped objects/excessive swinging oscillations/incorrect buoyancy module/interference with seabed obstacles/twisting and loading/MBR infringement/buoyant component failure	MOP	2	4	1.5	**12**	Operation does not present major risks and does not require additional review	Standard procedures widely applicable with conventional operations for cable laying. Applicable to most platform types. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
35	Pull-in and connection to platform	Wrong position or length/incorrect stiffener arrangement/high-load mechanical failure/poor securing of the connection/MBR infringement	MOP	2	4	1.5	**12**	Operation does not present major risks and does not require additional review	Largely dependent on platform type and design (location of pad-eyes,etc), existing guidelines usually applicable but likely updated for specific arrangements/procedures which may be required. Connection procedure similar to other procedures in oil and gas. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
36	Subsea operations (ROV)	Breakdown in communication or connection/Poor control/Insufficient training/Entanglement/Insufficient specs/Accessibility or visibility issues	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	ROV to be considered for use for majority of subsea operations. Sufficient technology and expertise usually available. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
37	Subsea Operations (Diving)	Swinging objects/Entanglement/ Exposure to dangerous substances/Loss of air/Decompression sickness	MOP	4	4	1	**16**	Operation should be considered for detailed risk assessment but does not represent significant concern	Diving should be kept to a minimum. ROV to be used to replace diving ops where feasible. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
38	Personnel transfer on-board	Falling injuries/improper harness/ defective gangways	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Conventional operation, most relevant HSE guidelines are applicable, may not be required for some platform types, platform motions may render transfer more difficult		Yes	Yes	Yes
39	Connection and latching of electrical connection on board	Mechanical failure/Handling hazards/ sharp terminations	MOP	3	4	1	**12**	Operation does not present major risks and does not require additional review	Conventional operation, standards should be applicable to all platform types, sensitivity to platform motions		Yes	Yes	Yes
Commissioning													
40	Ballasting and loading conditions setting	Components failure/machinery injuries/ Mechanical hazards/Exposure to noise and vibration	OWN/MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Duration and procedures are dependent on ballasting systems and must be taken note of prior to operation. SIMOPS reviews may be required prior to execution of the operation	Spar and TLP may require different ballasting procedures	Limited	Yes	Limited
41	Draft and stability survey	Falling injuries/exposure to water loads/ boat stability	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Standards protocols and checklists to be followed. Checks to be made with classification societies for any potential updates and recommendations		Yes	Yes	Yes
42	Personnel transfer and use of davit crane	Falling injuries/improper harness/ defective gangways/falling objects	MOP/OWN	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Conventional operation, most relevant HSE guidelines are applicable, may not be required for some platform types, platform motions may render transfer more difficult. Mitigate using vessel-platform clamping or tether systems to keep on station. Morions and limiting criteria for use of davit crane to be considerd		Yes	Yes	Yes
43	System checks and setting	Tripping hazard/dropped objects/ mechanical failure/handling hazards/ Confined spaces	OWN	3	3	1	**9**	Operation does not present major risks and does not require additional review	Standards protocols and checklists to be followed. Checks to be made with classification societies for any potential updates and recommendations. Strong communication, training and competency required to ensure reliability		Yes	Yes	Yes
44	Electrical Testing and functionality checks	Short-circuit and electric shocks/Fire	OWN	3	4	1	**12**	Operation does not present major risks and does not require additional review	Standard procedures to be followed. Applicable to most platform types		Yes	Yes	Yes
45	Final testing and commissioning	Mechanical and electrical failures/ Exposure to noise and vibration/ Dropped objects	OWN	3	3	1	**9**	Operation does not present major risks and does not require additional review	Procedures and checklists may vary depending on platform type		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
46	Vessels mobilisation	Excessive motions/unstable arrangement/water ingress and slamming	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Existing vessel and associated guidelines largely applicable for most platform types		Yes	Yes	Yes
Decommissioning													
47	Systems shut-down and securing of equipment	Tripping hazard/dropped objects/ mechanical failure/handling hazards	OWN	2	2	1	**4**	Operation does not present major risks and does not require additional review	Strong communication and competency to ensure that all systems have been shut down prior to the decommissioning process begins. Procedure for this may vary depending on platform type		Yes	Yes	Yes
48	Cable disconnection	High-load mechanical failure/poor securing of the connection	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Procedure should be similar for different platform types. Standards and guidelines should be consulted to ensure safe disconnection. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
49	Cable laying and marking	Dropped objects/excessive swinging oscillations/interference with seabed obstacles	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Procedure should be similar for different platform types. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
50	Platform temporary station-keeping	Line failure/excessive motions and excursions/unstable behaviour/ Unfavorable weather conditions/ Collisions/Obstacles/Tug engine failure or drifting/Tug loss of control and positioning	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform type. Conventional station keeping tug based suited to semi sub concepts. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
51	Mooring lines disconnection	Line failure/high-load mechanical failure/Transient motions and accelerations	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform type and design (location of pad-eyes, etc), existing guidelines usually applicable but likely updated for specific arrangements/procedures which may be required. Disconnection procedure similar to other procedures in oil and gas. SIMOPS reviews may be required prior to execution of the operation	Similar procedures for TLP but tendon system is in general more complex	Limited	Yes	Limited
52	Mooring lines laying and marking	Seabed obstacles/dropped objects/ insufficient buoyancy	MOP	2	3	1.5	**9**	Operation does not present major risks and does not require additional review	Procedure should be similar for different platform types. SIMOPS reviews may be required prior to execution of the operation	TLP mooring system may require direct retrieval	Yes	Yes	Limited
53	Platform transportation	Loss of stability/Human error during transportation/Unfavourable weather conditions	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements. Contingencies usually considered, but delays may occur as a result of various unforeseen circumstances. Sea fastening strategy to be assessed prior to transportation	SPAR transportation may be more challenging due to tall hull. Sometimes HLV may be required. Towing of TLP would be dependent on capability of changing loading conditions	Limited	Yes	Limited

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/ Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
54	Cable retrieval	Dropped objects/high-load mechanical failure/unstable behaviour of loaded vessel	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Standard procedure and protocols to be followed. Strong communication and sufficient competency required to ensure avoidance of interference with any other subsea structures/ cables. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
55	Mooring line retrieval	Dropped objects/high-load mechanical failure/unstable behaviour of loaded vessel	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Standard procedure and protocols to be followed. Strong communication and sufficient competency required to ensure avoidance of interference with any other subsea structures/ cables. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
56	Diving operations	Swinging objects/Entanglement/ Exposure to dangerous substances/Loss of air/Decompression sickness	MOP	4	4	1	**16**	Operation should be considered for detailed risk assessment but does not represent significant concern	Diving should be kept to a minimum. ROV to be used to replace diving ops where feasible. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes

ANNEX C
HAZID RECORD (ONSHORE)

Project Number	D100
Document Number	TDK-D100-HAZ1
Operation	Onshore Operations
Author	
Checked	
Approved	
Date	03-11-22
Attendance	
Abbreviations	PD = Project Developer, CON = Construction Contractor, MWS = Marine Warranty Surveyor, CMN = Component Manufacturer, TMN = Turbine Manufacturer, TRL = On-land Transportation Contractor, TRM = Sea Transportation Contractor, POR = Port Authority, MOP = Marine Operator Contractor, OWN = Wind Farm Owner, MNT = O&M Contractor

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ONSHORE OPERATIONS HAZID RECORD

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
Constructions and Logistics													
1	Blade Manufacturing	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	TMN	3	2	1	**6**	Operation does not present major risks and does not require additional review	Assume blade length the same as offshore wind. Similar processes for construction and manufacturing		Yes	Yes	Yes
2	Nacelle Manufacturing	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	TMN	3	2	1	**6**	Operation does not present major risks and does not require additional review	Assume standard nacelle construction for most concepts. Similar processes for construction and manufacturing		Yes	Yes	Yes
3	Tower Manufacturing	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	TMN	2	3	1	**6**	Operation does not present major risks and does not require additional review	Stiffer towers needed. Few concepts involving novel structures		Yes	Yes	Yes
4	WTG Components Road Transportation	Impact on circulation/Crash injuries/ Breakage of components due to vibrations/Road capability/Driver Fatigue	TRL/PD	3	4	1	**12**	Operation does not present major risks and does not require additional review	Difficult due to large sizes, extensive planning and logistics. Assume similar requirements as per bottom-fixed, interface with new supply chain		Yes	Yes	Yes
5	WTG Components Sea Transportation	Navigational collisions/traffic, Loading operations, stability loss, dropped objects, clashes with other cargo	TRM/PD	2	4	1	**8**	Operation does not present major risks and does not require additional review	Likely to face similar challenges to bottom-fixed, New navigational risks (port-to-port), different loading/ offloading reqs		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
6	WTG Component Handling and Storage	Obstruction to other operations/ Damage to components/Clashes with other port users/Falling objects/ Mobilisation incidents/component damage due to theft/vandalism	CON	3	3	1	**9**	Operation does not present major risks and does not require additional review	Security Risk, especially in new jobs/locations, subject to local HSE Rules		Yes	Yes	Yes
7	WTG Components Heavy Lift for mobilisation	Dropped objects (injuries, damages), Rigging failure, wind-loading related falls/motions	CON	2	5	1	**10**	Operation does not present major risks and does not require additional review	Similarities with offshore wind, involvement of contractor with larger capacity		Yes	Yes	Yes
8	Moorings Fabrication	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	CMN	3	2	1	**6**	Operation does not present major risks and does not require additional review	Standard from offshore industry, special conventional components/designs (ropes, connectors) may result in production challenges, production logistics and ramp-up to be considered, novel components delays for qualification/production	Fabrication process likely similar but differnet materials may be required for TLP for stiffness considerations	Yes	Yes	Limited
9	Anchors Fabrication	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	CMN	3	2	1	**6**	Operation does not present major risks and does not require additional review	Standard from offshore industry, production logistics and ramp-up to be considered, advanced types including suction gravity anchors require consideration	TLP Anchor system usually more expensive/ sophisiticated. TLP experience high tendon loads	Yes	Yes	Limited
10	Subsea Cable and ancillaries Fabrication	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	CMN	4	2	1	**8**	Operation does not present major risks and does not require additional review	Similar construction to bottom-fixed but dynamic requires added armouring, handling may be more challenging		Yes	Yes	Yes
11	Foundation steel sub-assemblies (pontoons, columns etc.) fabrication	High temperature steel handling risks/ Material contamination/Handling injuries/machinery injuries/falling objects	CON	3	4	1	**12**	Operation does not present major risks and does not require additional review	Examples from O&G for bigger structure, large yards/facilities required, local HSE and work rules issues, quality/HSE issues using multiple facilities, working outdoor limited depending on local weather, staff competence to be verified		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
12	Foundation concrete structural sub-assemblies fabrication	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	CON	2	4	1.5	**12**	Operation does not present major risks and does not require additional review	Examples from O&G/ civil/coastal engineering for bigger structure, large yards/facilities required, local HSE an, staff competence to be verifiedd work rules issues, quality/ HSE issues using multiple facilities, working outdoor limited depending on local weather, staff competence to be verified		Yes	Yes	Yes
13	Foundation steel sub-assemblies (pontoons, columns etc.) transportation	Navigational collisions/traffic, Loading operations, stability loss, dropped objects, clashes with other cargo	TRM	3	4	1	**12**	Operation does not present major risks and does not require additional review	Fabrication may be close to port, navigational risks (port-to-port), different loading/offloading reqs, merge?		Yes	Yes	Yes
14	Foundation concrete structural sub-assemblies transportation	Navigational collisions/traffic, Loading operations, stability loss, dropped objects, clashes with other cargo	TRM	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Fabrication may be close to port, especially for concrete, navigational risks (port-to-port), different loading/offloading reqs, may need to produce strict ballast plan for all stages		Yes	Yes	Yes
15	Foundation sub-assemblies Handling and Storage	Obstruction to other operations/ Damage to components/Clashes with other port users/Falling objects/ Mobilisation incidents/component damage due to theft/vandalism	CON	4	2	1	**8**	Operation does not present major risks and does not require additional review	Security Risk, especially in new jobs/locations, subject to local HSE Rules		Yes	Yes	Yes
16	Foundation sub-assemblies Heavy Lift for mobilisation	Dropped objects (injuries, damages), Rigging failure, wind-loading related falls/motions	CON	3	4	1	**12**	Operation does not present major risks and does not require additional review	Similarities with offshore wind, involvement of contractor with larger capacity		Yes	Yes	Yes
17	Logistics and construction coordination	Language barriers at construction site/ local perception of HSE guidelines	PD/CON	4	3	1	**12**	Operation does not present major risks and does not require additional review	Floating wind projects likely to have a large international base and potentially being built at locations with different culture		Yes	Yes	Yes
18	Construction and transportation working practices	Poor HSE culture and understanding of standard HSE guidelines	PD/CON	4	3	1	**12**	Operation does not present major risks and does not require additional review	Floating wind projects likely to have a large international base and potentially being built at locations with different culture		Yes	Yes	Yes
19	On-site fabrication and construction work	COVID-related restrictions	PD/CON	4	2	1	**8**	Operation does not present major risks and does not require additional review	The effect of COVID pandemic may be protracted for a longer time		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
20	Limitiing yard capacity for commercial scale number of units	Crowded yard with simultaneous operations, works on multiple turbines at once/injuries or fatalities due to lots of machinery and personnel in close proximity/logistics bottlenecks	CON/TRL/ POR	3	5	1	**15**	Operation should be considered for detailed risk assessment but does not represent significant concern	Detailed logistics plan prior and throughout onshore works/realistic assessment of yard capacity and space/ all onshore contractors aware of works going on nearby		Yes	Yes	Yes
21	Inexperience with local concrete construction contractors	Incidents due to contractor inexperience with concrete FOW structures/damage to components/inaccurate construction	CON	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Close cooperation with experienced engineers required to mitigate		No	Yes	Limited
Platform Assembly													
22	Foundation sub-assemblies mobilisation	Obstruction to other operations/ Damage to components/Clashes with other port users/Falling objects/ Mobilisation incidents	CON	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Need for a large separate area (foundation separate from WTG), impact on logistics and production planning, potential optimisation for reducing number of lifts	SPAR installed offshore	No	Yes	Yes
23	Foundation securing and stabilisation	Falling objects/Damage to components/ Inaccurate assembly/welding/weather-wind loads and motions/working at height	CON	4	2	1	**8**	Operation does not present major risks and does not require additional review	Requirement for special tools and supports to secure sub-assemblies, account for load-bearing mechanisms/ strategies, impact on logistics and production planning	SPAR installed offshore	No	Yes	Yes
24	Foundation welding/ connection	Hot works/Incident due to poor training/ Working at height/HV equipment shocks/High load failure/confined spaces	CON	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Welding of large structures common in offshore yard but for smaller volumes, account for load-bearing mechanisms/ strategies, alternatives type of connection being used (grouting, bolted, concrete reinforcement framing)	SPAR installed offshore	No	Yes	Yes
25	Secondary structures assembly (handrails etc.)	Falling objects/Damage to components/ Inaccurate assembly/welding/weather-wind loads and motions/working at height/confined spaces	CON	3	3	1	**9**	Operation does not present major risks and does not require additional review	Standard procedures/ tools/materials available at yards, Potentially specific depending on platform type, not likely to be significant structures		Yes	Yes	Yes
26	Coating, Corrosion Protection and Painting	Chemical exposure/working at height/ dropped objects/confined spaces	CON	3	2	1.5	**9**	Operation does not present major risks and does not require additional review	Most marine and offshore practice applicable		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
27	Hull outfitting	Falling objects/Damage to components/ Inaccurate assembly/welding/working at height/confined spaces	CON/PD	4	2	1	**8**	Operation does not present major risks and does not require additional review	Most marine and offshore practice applicable, dependent on concept functional specification and equipment for operation (e.g. semisub with active ballast control)		Yes	Yes	Yes
28	Working at height (general)	Falling objects/Falling injuries/ Injuries and damage due to improper scaffolding and harness	CON	2	4	1.5	**12**	Operation does not present major risks and does not require additional review	As generally unmanned, floating wind platforms may have fewer points of support than other structures and may require further reinforcements and ad-hoc harnessing		Yes	Yes	Yes
30	Insufficient quayside depth	Platform grounding/requires risker activities such as offshore or sheltered waters assembly/excessive motions	TRM/OWN	5	2	1.5	**15**	Operation should be considered for detailed risk assessment but does not represent significant concern	Very little ports with current quayside depths that would accommodate quayside assembly, especially for spars. Could include dredge when possible, to make provision of depth for inclined floating asset (incorrect ballast, side wind)	Relevant to all, but much more severe for SPAR type. Would currently require to be horizontally towed to deeper waters for upending and turbine assembly	Yes	Yes	Yes
31	Sheltered waters platform assembly required	Combined complexity of floating crane, DAF of lift itself and lifting onto another floating structure/damage to components and or vessels/falling objects/injury to personnel	TRM/OWN	5	4	1.5	**30**	Operation should be selected for further discussion and mitigation actions	Has been successfully performed before with Hywind in sheltered waters. Remains one of the most critical activities. Technology will need advancement to perform this offshore. Raised as significant concern by G+ group		Yes	Yes	Yes
32	Dry or wet storage of components/ structure(s)	corrosion/pitting/damage to components/moorings failure in extreme weather	POR/OWN	3	4	0.5	**6**	Operation does not present major risks and does not require additional review	May require tens of turbines/platorms to be in storage at a time. Low novelty compared to O&G		Yes	Yes	Yes
Platform Launching													
33	Platform Heavy Lifting to water	Falling objects/unsafe oscillations/ collisions and damage to adiacent structures/rigging failure	MOP/CON	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Requires huge cranes and infrastructure and adequate space at quayside for mobilisation		Yes	Yes	Yes
34	Load-out from barge	Excessive motions and excursions/ unstable arrangement/water ingress and slamming/collisions and damage to adiacent structures/rigging failure/injury due to water splashes	MOP/CON	2	4	1	**8**	Operation does not present major risks and does not require additional review	Depends on platform type and dimensions. Likely to be applicable for semisubs, barge and TLPs in towing condition. Potential lack of training/experience from barge contractor and operators	SPAR type usually installed offshore	No	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
35	Drydock launch	Support not secured/wrong mass distribution and stability issues/water ingress/injury due to water splashes	CON	2	4	1	**8**	Operation does not present major risks and does not require additional review	Theoretically possible only in yards with sufficient capacity and platforms of limited size. Rigging and securing potentially risky due to uncovnentional non-ship geometry	SPAR type usually installed offshore	No	Yes	Yes
36	Construction on barge and sinking	Excessive motions and excursions/ unstable arrangement/water ingress and slamming/collisions and damage to adiacent structures/rigging failure	MOP/CON	2	4	1	**8**	Operation does not present major risks and does not require additional review	Assumes availability of deck barges to perform construction on top. Additional risks associated with station-keeping and staff access and mobilisation	SPAR type usually installed offshore	No	Yes	Yes
37	In-water mobilisation and station-keeping	Excessive motions and excursions/ unstable performance/drifting-off due to line damage/tugs failure/limitations to navigations or to other concurrent port operations	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Constrained on the space and water depth in port, very specific depending on platform type		Limited	Yes	Yes
38	Personnel on board during launching phase	Working at height/temporary arragements/blockages for emergency evacuation/risks during access and egress	MOP/CON	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Dependent on temporary arrangements in place for access/egress and for working at height		Yes	Yes	Yes
39	Tugs manoeuvring and arrangement	Engine failure/Human error/Poor communication	MOP	2	3	1	**6**	Operation does not present major risks and does not require additional review	Multiple support vessels may be required with large added risks associated with coordination and management		Yes	Yes	Yes
40	Platform rigging and mooring for integration	Line failure/excessive motions and excursions/unstable behaviour	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Dependent on platform type and configuration. Only required for concepts involving assembly at quayside		Yes	Yes	Yes
Quayside Assembly & Integration													
41	Stability/ Inclining Checks and Ballasting	Excessive motions and excursions/ unstable behaviour/ballast management failure/human error	MOP/PD	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	May be not required or performed on site for some concepts (e.g. spar). Standard guidance for inclining tests to be adapted for floating wind. Active ballasting system increase complexity and risk	Ballasting procedures may be different for TLP type platforms. Usually done on site for spar type, ballasting procedure is much more simple	Limited	Yes	Limited
42	Final Preps/ Checks (e.g. transition piece, bolting)	Excessive motions and excursions/ unstable behaviour/ballast management failure/falling objects/working at height	CON	4	2	1.5	**12**	Operation does not present major risks and does not require additional review	Assumes typical transition piece between horizontal axis turbine and platform. Complications due to small accelerations/ motions to be considered		Yes	Yes	Yes

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	BARGE	TLP
43	Tower Heavy lifting	Falling objects/unsafe oscillations/ collisions and damage to adiacent structures/rigging failure	CON	3	5	0.5	**7.5**	Operation does not present major risks and does not require additional review	Assumes assembly at quayside, not feasible for some concepts. Lifting and installation of the tower safer in comparison to offshore		Yes	Yes	Yes
44	Nacelle Assembly	Falling objects/unsafe oscillations/ collisions and damage to adiacent structures/rigging failure/working at height	CON	3	5	0.5	**7.5**	Operation does not present major risks and does not require additional review	Assumes assembly at quayside, not feasible for some concepts. Lifting and installation of the nacelle safer in comparison to offshore		Yes	Yes	Yes
45	Blade Assembly	Falling objects/unsafe oscillations/ collisions and damage to adiacent structures/rigging failure	CON	3	5	0.5	**7.5**	Operation does not present major risks and does not require additional review	Assumes assembly at quayside, not feasible for some concepts. Lifting and installation of the blades safer in comparison to offshore		Yes	Yes	Yes
46	Working at height (during WTG assembly)	Falling objects/Falling injuries/ Injuries and damage due to improper scaffolding and harness	CON/PD	2	4	0.5	**4**	Operation does not present major risks and does not require additional review	As generally unmanned, floating wind platforms may have fewer points of support than other structures and may require further reinforcements and ad-hoc harnessing		Yes	Yes	Yes
47	Pre-commissioning and final testing	Components failure/machinery injuries/ Mechanical hazards/Exposure to noise and vibration/falling objects/falling injuries	PD	5	2	0.5	**5**	Operation does not present major risks and does not require additional review	All testing and commissioning performed in more controlled environment onshore, hence safer		Yes	Yes	Yes
48	Electrical Testing and functionality checks	Short-circuit and electric shocks/Fire	PD	3	4	0.5	**6**	Operation does not present major risks and does not require additional review	All testing and commissioning performed in more controlled environment onshore, with better availability of fire safety equipment		Yes	Yes	Yes
49	Weather limitations to assembly/ testing	Excessive motions/Sudden loads and accelerations	PD/MOP	4	2	0.5	**4**	Operation does not present major risks and does not require additional review	Weather may constrain the assembly in the final stages, quayside moorings to be secured		Yes	Yes	Yes
50	Quayside assembly in water (lifting onto floating structure)	Component damange/dropped objects/ working at height/excessive motions	MOP	3	3	0.5	**4.5**	Operation does not present major risks and does not require additional review	Required if there is insufficient quayside capacity for numerous turbines and structures to be assembled onshore at quayside		Yes	Yes	Yes
51	Double handling	Potential injuries/falling objects/damage to components	TRL	4	3	1	**12**	Operation does not present major risks and does not require additional review	Novelty is from the required logistical planning challenges specific to FOW		Yes	Yes	Yes

ANNEX D
HAZID RECORD (O&M)

Operation	O&M Operations
Author	
Checked	
Approved	
Date	03-11-22
Attendance	
Abbreviations	PD = Project Developer, CON = Construction Contractor, MWS = Marine Warranty Surveyor, CMN = Component Manufacturer, TMN = Turbine Manufacturer, TRL = On-land Transportation Contractor, TRM = Sea Transportation Contractor, POR = Port Authority, MOP = Marine Operator Contractor, OWN = Wind Farm Owner, MNT = O&M Contractor

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OPERATIONS AND MAINTENANCE HAZID RECORD

No.	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
Unmanned Operation													
1	Start-up	Generator not starting/Electrical failure/ Mechanical failure/Fire/Structure cracks	OWN	3	2	1	**6**	Operation does not present major risks and does not require additional review	Assume same operations as fixed bottom. However more specific considerations may be required for FOW platforms to avoid resonant frequencies. Potential increase to turbine component fatigue due to increased motions and thus maintenance. Definition of WTG controller will require platform motion considerations		Yes	Yes	Yes
2	Power production	Generator not starting/Electrical failure/ Mechanical failure/Fire/Structure cracks	OWN	3	2	1	**6**	Operation does not present major risks and does not require additional review			Yes	Yes	Yes
3	Normal shutdown	Generator not starting/Electrical failure/ Mechanical failure/Fire/Structure cracks	OWN	2	3	1.5	**9**	Operation does not present major risks and does not require additional review			Yes	Yes	Yes
4	Emergency stop	Generator not starting/Electrical failure/ Mechanical failure/Fire/Structure cracks	OWN	3	2	1.5	**9**	Operation does not present major risks and does not require additional review			Yes	Yes	Yes
5	Parking	Generator not starting/Electrical failure/ Mechanical failure/Fire/Structure cracks	OWN	3	2	1.5	**9**	Operation does not present major risks and does not require additional review			Yes	Yes	Yes
6	Loading conditions control (ballast management)	Unstable behaviour/Ballast management failure/Components failure/machinery injuries/Mechanical hazards/Exposure to noise and vibration	OWN	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Increased risk in case of failure due to more difficult intervention required since unmanned	Dependent on platform type; concepts may have different ballasting types and may not need to be ballasted, such as with solid ballast solutions	Limited	Yes	Limited

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
7	WTG Nacelle yawing	Mechanical failure/Loss of control/Excessive loading/Motions interference on platform	OWN	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Operation of nacelle yawing may be sensitive to platform dynamics. Considerations for nacelle yawing to be included for all concepts. Weather vaning/mooring may allow for modification. Drivers are wind/wave/current	More yaw motion required to overcome mooring stiffness in TLP type platforms	Yes	Yes	Yes
8	WTG and Foundation integrity	Fatigue cracks/Structural failure/blade damage/blade failure/tower deformation/ Hull integrity and flooding	OWN	2	5	1.5	**15**	Operation should be considered for detailed risk assessment but does not represent significant concern	Potential increase to foundation and WTG fatigue due to increased motions and thus maintenance. Consequence of blade failure expected to be similar, though falling objects may cause damage to the floating platform	Likelihood of occurrence of hazards and resulting consequence largely dependent on platform type	Yes	Yes	Yes
9	Moorings integrity and functionality	Line failure/high-load mechanical failure/loss of position/excessive platform motions and excursions/ collisions/loss of stability	OWN	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Consequence of mooring failure may be more severe due to poor redundancy considerations. Loss of position and disconnected mooring lines may cause larger issues in farms consisting of several turbines	Line failure in TLP may be more severe relative to other platform types dependent on redundancy	Yes	Yes	Yes
10	Subsea connections	Cable failure/Joint failure/Incorrect or insufficient assembly/Moisture in connections/Factory defect/Insufficient training/Unfavourable environment conditions	OWN	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Frequency/likelihood dependent on method of connection and workmanship and surrounding environment	Less likely to have subsea connections in TLP	Yes	Yes	Yes
11	Cable integrity and functionality	Cable failure/high-load mechanical failure/ short-circuiting/excessive stretching-overtension/buoyancy failure/seabed friction/dropped objects/vortex induced vibrations (VIV)/Mooring failure/Fibre optics failure/Factory defect	OWN	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Behaviour of dynamic cable as well as water depth (touchdown point for shallow waters) may have impact on frequency of failure. Considerations for turbulent behaviour, VIV on cable	Motions of dynamic cable dependent on platform type and thus motions. Influence of hang-off with consideration for platform motions	Yes	Yes	Yes
NEW	Non project-related marine traffic	Unrelated vessel in close proximity losing station keeping/position control/fishing vessel equipment fouling turbine moorings or other subsea infrastructure	OWN	3	3	1	**9**	Operation does not present major risks and does not require additional review	Only FOW novelty will come from the consequence of corrective actions in maintenance. Standard mitigating actions apply from O&G and fixed bottom offshore wind. Monitoring to be considered as well as temporary navigational aids when platforms are removed for maintenance		Yes	Yes	Yes
On-site Maintenance													
12	CTV Transit	Falling/Man overboard/Lack of safety equipment/Excessive motions/Motion sickness/Unfavourable weather conditions	MNT	2	4	1	**8**	Operation does not present major risks and does not require additional review	Likelihood of motion sickness more apparent in CTV		Yes	Yes	Yes

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
13	SOV Transit and standby	Falling/Man overboard/Lack of safety equipment/Excessive motions/Motion sickness/Unfavourable weather conditions	MNT	3	2	1	**6**	Operation does not present major risks and does not require additional review	Advantage over CTV due to less motions. 2 week window for transit decreases risk of travelling in unfavourable weather conditions + more time for planning		Yes	Yes	Yes
14	CTV approach and manoeuvring	Unfavourable weather conditions/Collisions/ Insufficient training or manoeuvring	MNT	2	4	1.5	**12**	Operation does not present major risks and does not require additional review	Similar procedures to fixed bottom, however platform size and motions may cause challenges. The platform type will effect the risk in manoeuvring near the platform due to the location of the access points and the relative motions. Interaction between CTV push on and mooring set up to be considered. Motion of vessel due to weather conditions to be considered due to no transit zones		Yes	Yes	Yes
15	SOV approach and manoeuvring	Unfavourable weather conditions/Collisions/ Insufficient training or manoeuvring	MNT	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Similar procedures to fixed bottom. Dynamic positioning will need to track motions. The platform type will effect the risk in manoeuvring near the platform due to the location of the access points and the relative motions Motion of vessel due to weather conditions to be considered due to no transit zones		Yes	Yes	Yes
16	CTV access to platform	Unfavourable weather conditions/ Insufficient training/collisions/Breakdown in communications/Vessel unable to reach platform (consequence?)	MNT	4	3	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Procedures similar for different platform types but perceived risk may be different for other concepts. Likelihood and severity of consequences largely dependent on weather conditions		Yes	Yes	Yes
17	SOV access to platform	Unfavourable weather conditions/ Insufficient training/collisions/Breakdown in communications/Vessel unable to reach platform (consequence?)	MNT	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Procedures similar for different platform types. Likelihood and severity of consequences largely dependent on weather conditions. 2 week window for transit decreases risk of travelling in unfavourable weather conditions + more time for planning		Yes	Yes	Yes

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
18	Helicopter transit	Unfavourable weather conditions/Pilot error/ Mechanical failure/Difficulty in manoeuvring and evacuating to due motions/Collisions	MNT	1	4	1.5	**6**	Operation does not present major risks and does not require additional review	Mostly required for evacuations and minor interventions. Transit relatively standard		Yes	Yes	Yes
19	Helicopter lowering to nacelle and floater	Unfavourable weather conditions/Pilot error/Mechanical failure/Collisions during winching	MNT	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Mostly required for evacuations and minor interventions. Variable risk due to relative motions between aircraft and platform to be considered		Yes	Yes	Yes
20	Personnel transfer	Falling/Man overboard/lack of safety equipment/working at heights/single access point unsuitable in certain weather directions/excessive vessel motions for personnel transfer/collision if access point is too far inboard of structure	MNT	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Conventional procedures largely applicable. Variable risk due to relative motions between vessel and platform to be considered. Method of transfer to be considered as different risks may apply. Draught of both vessel and platform to be considered when transferring on/off. In general there is higher risk transferring from platform due to vessel (mostly CTV) due to ergonomics. Lower risk compared to fixed types due to tidal variations working in favour of floating platform. Lower risk for SOV with heave compensation. Access poimt risks Can be mitigated significantly in design stages with SOV AHC bridges and multiple access points if commercially viable		Yes	Yes	Yes
21	Emergency evacuation	Worker panic/Blockages and obstructions/ Motions/Difficulty finding safety path/Falling objects/Lack of awareness/Breakdown in communications/Entanglement/entrapment during descent	MNT	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Evacuation more difficult on FOW due to added risk due to platform motions. Casualty evacuation requirements can drive some secondary steel re/design		Yes	Yes	Yes

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
22	Loading and lifting of replacement items and tools	Falling (and loss) of tools or items/Working at heights	MNT	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Mostly similar risks to fixed bottom but slightly higher risk for turbines with potentially larger hub heights. Motions of floating turbines may increase risk of falling objects. Transfer (either manual or by use of a transport system/tool) of tools/parts from a pontoon to the WTG on a floating (moving) foundation may cause an additional risk, this will be dependent on the platform layout. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
23	Electrical maintenance and repairs	Electrocution/Working confined spaces/ Insufficient training/Insufficient instruction or repairs/Motion sickness/Working at heights/Worker fatigue	MNT	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Repairs and instructions applicable to most platform types. Slightly increased risk in FOW due to motions and more confined spaces due to substructure. Weather dependent operation - worker efficiency (i.e. time for operation to be completed and quality) dependent on platform motions and location of operation within platform (i.e. operations at nacelle more difficult than at base). SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
24	Mechanical and structural maintenance and repairs, including blades	Mechanical failure/Lack of safety equipment during repairs/Working in confined spaces/ Working with heavy objects/Worker fatigue/ working at heights/injuries from rope access in dynamic envrionment	MNT	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern			Yes	Yes	Yes
25	Subsea inspections and operations	Swinging objects/Entanglement/Exposure to dangerous substances/Loss of air/ Decompression sickness/Lack of visibility	MNT	2	4	1.5	**12**	Operation does not present major risks and does not require additional review	ROV should be used where feasible, diving operations kept to minimum and only when absolutely necessary. Continuous monitoring may be required. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
26	Offshore heavy lifts for major component exchange	Heavy dynamic lifts from floating crane to floating structure/damage to components/ dropped objects/working from height/ unfavourable weather conditions/injury to personnel	MOP	3	5	1.5	**22.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Generally considered within G+ as undesirable operation to perform. Requires large technological advancement to be safe. Requires cost benefit and feasability study on a project specific basis due to limiting weather conditions. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
27	Ballast management system repair/ inspection	Working in confined spaces/personnel transfer/mechanical failure/access issues/ emergency or casualty evacuation requirements	OWN/MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Can draw similarities with O&M, but access and space will be much more restrictive. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
28	Working onboard platform and turbine	Insufficient training (BOSIET tailored to O&G and not offshore wind). GWO training covers offshore wind but can be better taking some learning objectives from BOSIET	MOP	3	3	1.5	**9**	Operation does not present major risks and does not require additional review	Can be mitigated by stating that all personnel require both GWO and BOSIET, or recommendations ro improve GWO training. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
Onshore Maintenance													
29	Systems shut-down and securing of equipment	Tripping hazard/dropped objects/mechanical failure/handling hazards/access issues	OWN/MNT	3	2	1	**6**	Operation does not present major risks and does not require additional review	Strong communication and competency to ensure that all systems have been shut down prior to the decommissioning process begins. Procedure for this may vary depending on platform type. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
30	Cable disconnection	High-load mechanical failure/poor securing of the connection	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Procedure should be similar for different platform types. Standards and guidelines should be consulted to ensure safe disconnection. Motions of the platform may render the operation difficult. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
31	Cable laying and marking	Dropped objects/excessive swinging oscillations/interference with seabed obstacles	MOP	3	3	1	**9**	Operation does not present major risks and does not require additional review	Procedure should be similar for different platform types. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes
32	Platform temporary station-keeping	Line failure/excessive motions and excursions/unstable behaviour	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform type. Conventional station keeping tug based suited to semi sub concepts. SIMOPS reviews may be required prior to execution of the operation		Yes	Yes	Yes

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
33	Mooring lines disconnection	Line failure/high-load mechanical failure	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Largely dependent on platform type and design (location of pad-eyes, etc), existing guidelines usually applicable but likely updated for specific arrangements/ procedures which may be required. Connection procedure similar to other procedures in oil and gas. SIMOPS reviews may be required prior to execution of the operation	Similar procedures for TLP but tendon system is in general more complex	Limited	Yes	Limited
34	Mooring lines laying and marking	Seabed obstacles/dropped objects/ insufficient buoyancy	MOP	2	3	1.5	**9**	Operation does not present major risks and does not require additional review	Procedure should be similar for different platform types. SIMOPS reviews may be required prior to execution of the operation	Further consideration may be required for SPAR/TLP	Limited	Yes	Limited
35	Platform transportation	Loss of stability/Human error during transportation/Unfavourable weather conditions	MOP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Existing towing guidelines widely applicable but may need to be updated to consider specific arrangements. Contingencies usually considered, but delays may occur as a result of various unforeseen circumstances		Limited	Yes	Yes
36	Foundation structural repairs	Hot works/Incorrect or insufficient use of materials/Insufficient training/Working in confined spaces/Difficulty accessing/ Working with heavy objects	OWN/COP	3	4	1.5	**18**	Operation should be considered for detailed risk assessment but does not represent significant concern	Minor (temporary) repairs usually done on site when possible. Limited structural works to be done on quayside. Major repairs (hull breach, etc) would require lifting of platform but may not be feasible. Potential to replace foundation completely rather than take on major repairs on damaged foundation	SPAR type less likely to have major or strenuous repairs	Limited	Yes	Limited
37	Blade/Nacelle repairs and replacement	Heavy lifts/Incorrect assembly/Working at heights/Missing components/Unfavourable weather conditions (causing collision)/ Operator error/injuries from rope access in dynamic envrionment	OWN/COP	3	4	0.5	**6**	Operation does not present major risks and does not require additional review	Major replacements to take place onshore dependent on availability of port facilities. Alternatively potential for replacements/repairs to be done at sheltered bay thus may have some slight motions during operation	Disassembly of turbine may be required for SPAR. Ideally works for SPAR done completely on site. Quayside maintenance for TLP platforms may require specific considerations	Limited	Yes	Limited

No	Activity	Potential Risk/Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (P x C x F)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Operations/Procedures applicable to other concepts? (Yes/No/Limited)		
											SPAR	Barge	TLP
38	General checks	Insufficient training/Incomplete checklists/ Incorrect check or reading	OWN	4	2	1	**8**	Operation does not present major risks and does not require additional review	Typical checks applicable to standard offshore wind turbines. Likely to be easier to be performed at quayside. Port HSE guidelines should be applicable	Different checks may apply depending on platform	Yes	Yes	Yes
39	Quayside connection	Line failure/excessive motions and excursions/unstable behaviour/unfavourable weather conditions/Collision or impact/ General and transfer loads may cause instability/Lack of operation space	MOP	3	3	1.5	**13.5**	Operation should be considered for detailed risk assessment but does not represent significant concern	Operation quite conventional, detailed understanding of procedures required to avoid severe stability issues		Limited	Yes	Yes

ANNEX E
G+ FLOATING OFFSHORE WIND HEALTH & SAFETY
TASK 1B: LITERATURE REVIEW

Contents

1 INTRODUCTION

Floating Offshore Wind (FOW) technology is expected to mature significantly over the coming decade as an increasing number and size of projects are constructed and operated. This project is considering Health and Safety risks for personnel involved in the construction and operation of commercial scale FOW projects (>200MW) and how to consider mitigating actions at an early stage of the industry.

The current state of the FOW industry:

- Track record of single WTGs and small arrays of (up to five) WTGs
- Small number of markets, mostly developed by those with existing Fixed-Bottom Offshore Wind (FBOW) projects.

Expected market development:

- Projects are increasing in scale, which will drive cost reductions and accelerate further deployment.
- Project activity spread across markets with a varying track record of offshore wind and other offshore structure projects.

From a Health and Safety perspective, these market developments are important to consider due to the projects being developed in some new jurisdictions requiring potentially new supply chains as well as development of new skills and training. The markets with existing offshore experience from offshore wind and Oil and Gas construction and operation will be able to leverage on this experience.

This literature review will consider relevant existing guidance; including offshore wind, oil and gas and marine activities. The search has focussed on comparative applications; such as other unmanned platforms to have a complete list of topics and references. The aim has been to ensure existing good practices and lessons learnt are identified and considered for the future commercial-scale FOW projects. The purpose of the reviews has been to determine the relevance and applicability of the guidance to commercial-scale floating offshore wind.

Floating Offshore Wind (FOW) is at early stage of project development with 124 MW of capacity deployed to date, installed on 27 floating substructures. FOW is projected to grow significantly over the next 10 years and there is an opportunity now to ensure Health and Safety risks are minimised at this early stage of the industry.

FOW will be de-risked through reliance of the experience and track record in Fixed-Bottom Offshore Wind (FBOW), as well as Oil and Gas, however there are novel aspects to be considered. In addition to these novel aspects, FOW will be deployed in new jurisdictions with limited familiarity with offshore construction and operations.

This report considers the following:

- Summary of existing guidance relevant to FOW
- Risk assessment methodology
- Key differences between fixed and floating
- Governance and legal considerations
- Navigational and aviation
- Safety margins

The FOW background report gives further information on the following:

- FOW technology substructures
- FOW technology subcomponents
- FOW market overview

2 OVERVIEW OF EXISTING GUIDANCE RELEVANT TO FOW

2.1 OVERVIEW

The purpose of this section is to provide an overview of relevant guidance, including in fixed-bottom offshore wind projects (FBOW) and Oil and Gas projects, and are expected to be relevant to future commercial-scale FOW projects.

There is a hierarchy of frameworks providing guidance and enforcement mechanisms that may be required across the lifecycle of a FOW project. These frameworks, summarised in Exhibit 2, give the context of the regulations, standards and other guidance and documents that have been reviewed.

The documents have been listed and categorised based on their relevance to FOW Health and Safety as well as the phase of the project life cycle they relate to, following the categories shown in Exhibit 1.

Exhibit 1: Lifecycle of an offshore wind project

Source: RCG

- Design (D) Review of the preliminary design and the design bases
- Manufacturing and Fabrication (M&F) Evaluation of the construction procedures, documentation related with the implementation planning and the planning of the construction
- Transport and Installation (T&I) Documentation linked to the production, transport, assembly, installation and commissioning of offshore structures
- Operation and Maintenance (O&M) Evaluation of O&M procedures,
- Decommissioning (DEC) Documentation linked to the dismantling/deconstruction of offshore wind structures

Exhibit 2: Health and safety frameworks for relevant documents

Intervention	Subtype(s)	Purpose	H&S Example(s)
International law	– International conventions – EC Treaties	Agreements on common objectives, principles and rules. Assist in facility transboundary movement of goods and services to enable interoperability. Enable development of common baseline product and performance standards	– UN – Global Harmonized System of Classification and Labelling of Chemicals (GHS)
Legislation	– EU Directives – EU Regulations – National/ federal regulations	Impose requirements, restrictions or conditions in relation to a specified activity. May be supported by mechanisms to secure compliance via enforcement actions	– Directive 2006/42/EC of the European Parliament and of The Council on machinery – UK Health and Safety at Work etc (HSWA). 1974
Standards (harmonized)	– Transposed harmonized standards (EN standards)	Define state of the art for either a product or safety feature. Referenced when making a Declaration of Conformity. Can apply to common products (Type C), safety features (Type B) or general safety principles (Type A). Published in Official Journal	– EN ISO 19353:2016. Safety of machinery. Fire prevention and fire protection – EN 13852-1:2013. Cranes. Offshore cranes. General-purpose offshore cranes
Standards (other)	– Standards and technical specifications	Rules, guidelines or characteristics for activities or for their results, aimed at achieving the optimum degree of order in a given context. Examples include product standards, test methods, codes of practice, guideline standards, management systems standards. Technical Specifications address work still under technical development	– EN 50308:2004. Wind turbines. Protective measures. Requirements for design, operation and maintenance – ISO 45001:2018. Occupational health and safety management systems
Codes of practice	– Codes of practice – Common rules	Agreed common approaches defining standards or recommended 'rules' for controlling risks to meet health and safety obligations or to address specified risks. May be written/endorsed by range of actor such as regulators, standards bodies or industry associations. Typically apply only at a national/sector level	– Wind Turbine Safety Rules (WTSR) (UK)

Exhibit 2: Health and safety frameworks for relevant documents (continued)

Intervention	Subtype(s)	Purpose	H&S Example(s)
Industry guidance	– Sector guidance	Sector or activity specific good practice setting out recommended health and safety practices	– G+ Good practice guideline – Working at height in the offshore wind industry – VDMA Safety Culture
Status quo	– 'Self-regulation'	Businesses operate under applicable national H&S rules in addition to any self-imposed 'in-house' standards or safety programs. No direct oversight by regulators or industry associations. Duty holders determine which laws, standards or good practice apply to the risks they create	– Group or company H&S management systems
Research and development	– Collaborative research – Academic studies – Sector led initiatives	R&D activities to generate evidence to assist in the recognition, evaluation and control of known and emerging health and safety risks. Often initiated as a result of data/statistics and horizon scanning activities	– A detailed ergonomic assessment of ladder climbing: Key risks (short- and long-term) to technicians in the offshore wind industry (G+, 2018)
Data and statistics	– Health and safety performance statistics	Sector, activity or role specific health and safety performance statistics. Primarily record lagging (post incident/exposure) data (e.g. injuries). May also record leading indicators (e.g. training metrics). Aim to produced normalized data sets to identify key risks and monitor trends	– G+ Health and Safety Statistics – AEE report on accidents in Spanish wind sector (2007–2017)
Horizon scanning	– Knowledge creation and sharing forums	Networks, forums and knowledge exchanges to anticipate future health and risks and challenges	– European Risk Observatory – HSE Foresight Centre (www.hse.gov.uk/horizons)

To provide more structure and clarity, the findings will be further split following distinct activities, providing the required granularity to identify gaps in existing guidance.

The regulations, standards and guidance documents expected to be of relevance for FOW projects have been identified. The UK is covered in more detail considering there is three times more capacity operational than the next biggest market. However, other relevant jurisdictions and international regulatory frameworks have been included also considering the expected future developments in these regions. The following approach has been taken:

- Relevant regulations to FOW Health and Safety listed with an assessment of their relevance specifically for both FOW and H&S;
- Overview of the key authorities producing and enforcing (if applicable) their requirements;
- Overview of the regulations, standards and guidance documents that will be most applicable to commercial-scale FOW projects.

FOW H&S relevance: Regulations, standards and guidance documents have been assessed on their relevance to commercial-scale FOW projects based on the following scale:

High

- Highly relevant to the considerations of occupational Health and Safety of FOW, or;
- Prescribes Health and Safety requirements for FOW projects.

Medium

- Relevant to FOW, such as structural requirements but limited occupational Health and Safety considerations
- Relevant to Health and Safety occupational considerations but limited considerations of FOW specific requirements (e.g. Oil and Gas)

Low

- Little or no relevance to occupational Health and Safety and FOW requirements

2.2 REGULATIONS

Exhibit 3 presents the primary international and regional health and safety regulations that are of relevance or are expected to be of benefit for commercial scale FOW projects.

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
	✓	✓	✓	✓	Health and Safety Executive	**Health and Safety at Work etc (HSWA). 1974**	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	**HSWA (Application outside Great Britain) Order (AOGBO) 2013**	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	**Management of Health and Safety at Work Regulations (MHSWR) 1999**	Regulation	Offshore and Onshore	High	UK
	✓	✓			Health and Safety Executive	Construction Design and Management Regulations (CDM) 2015	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	Provision of Use of Work Equipment Regulations (PUWER) 1998	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	The Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015	Regulation	Offshore Oil and gas	Med	UK Continental Shelf

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW) (continued)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
	✓	✓	✓	✓	Health and Safety Executive	**Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)**	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	The Confined Space Regulations 1997	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	Work at Height Regulations 2005	Regulation	Offshore and Onshore	High	UK
	✓	✓	✓	✓	Health and Safety Executive	Offshore Installations (Prevention of Fire and Explosion, and Emer. Response) 1995 (PFEER)	Regulation	Offshore Oil and gas	Medium	UK
		✓	✓	✓	Maritime and Coastguard Agency (MCA)	UK Merchant Shipping Regulations	Regulation	Maritime	High	UK
		✓	✓	✓	MCA	MGN 372 Guidance to mariners operating in vicinity of UK OREIs	Marine Guidance Notes	Offshore Renewable Energy Installations (OREI)	Medium	UK

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW) (continued)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
	✓	✓	✓	✓	MCA	MGN 654 OREIs safety response	Marine Guidance Notes	OREI	High	UK
		✓	✓	✓	MCA	OREIs: Requirements, guidance and operational considerations for SAR and Emergency Response	Regulatory guidance (Annex 5 of MGN 654)	OREI	High	UK
		✓	✓	✓	MCA	OREIs, Emergency Response Co-operation Plans (ERCoP)	Regulatory guidance	OREI	High	UK
	✓	✓	✓	✓	Arbejdstilsynet (Danish Working Environment Authority)	Working Environment Act no. 674 of 25 May 2020	Regulation	Offshore and Onshore	High	Denmark
	✓	✓	✓	✓	Søfartsstyrelsen (Danish Maritime Authority)	**Offshore Safety Act no. 125 of 6 February 2018**	Regulation	Offshore Wind and Oil and gas	High	Denmark
	✓	✓	✓	✓	Bundesministerium für Arbeit und Soziales (BMAS)	**German Labor Protection Act**	Regulation	Offshore and Onshore	High	Germany

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW) (continued)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
		✓	✓	✓	Bundesministerium für Verkehr und digitale Infrastruktur (BMVI)	Seeanlagengesetz (SeeAnlG)	Regulation	Maritime	Medium	Germany
		✓	✓	✓	Bundesministerium für Verkehr und digitale Infrastruktur (BMVI)	Safety on the Water – Sicherheit auf dem Wasser	Regulation	Maritime	Low	Germany
✓	✓	✓			Bundesamt für Seeschifffahrt und Hydrographie (BSH)	Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)	Standard	Offshore Wind	Medium	Germany
		✓	✓	✓	Wasser- und Schifffahrtsverwaltung des Bundes (WSV)	Sea Tasks Act (SeeAufgG)	Regulation	Maritime	Medium	Germany
		✓	✓	✓	Wasser- und Schifffahrtsverwaltung des Bundes (WSV)	Federal Waterways Act (WaStrG)	Regulation	Maritime	Low	Germany
	✓	✓			Health and Safety Authority (HSA)	Safety, Health and Welfare (Offshore Installations) (Installation Managers)	Regulation	Offshore	Medium	Ireland

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW) (continued)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
			✓		Health and Safety Authority (HAS)	Safety, Health and Welfare (Offshore Installations) (Operations)	Regulation	Offshore	Medium	Ireland
	✓	✓	✓	✓	Ministry of Health, Labour and Welfare	Industrial Safety and Health Act	Regulation	All sectors, occupational	High	Japan
	✓	✓	✓	✓	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Act on Prevention of Marine Pollution and Maritime Disaster	Regulation	Maritime/ ship	High	Japan
		✓	✓	✓	MLIT	Ship Safety Act Enforcement Regulations	Regulation	Maritime/ ship	High	Japan
	✓	✓			MLIT	Technical guidelines for offshore wind facilities in ports and harbours	Recommended Practices	Offshore wind	Medium – High	Japan
✓	✓	✓	✓	✓	New Energy and Industrial Technology Development Organisation (NEDO)	Guidebook for fixed bottom offshore wind development	Regulation	Offshore wind	Medium – High	Japan
✓	✓	✓	✓	✓	MLIT	Technical standards for floating offshore wind turbine	Regulation	Floating wind	High	Japan

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW) (continued)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
	✓	✓	✓	✓	Occupational Safety and Health Administration (OSHA)	**Occupational Safety and Health Act of 1970**	Regulation	All sectors, occupational	Medium – High	USA
	✓	✓	✓	✓	Occupational Safety and Health Administration (OSHA)	29 CFR – 1910 – General Industry; 1915, 1917, 1918 and 1919 – Maritime; 1926 – Construction	Regulation	All sectors, occupational	Medium – High	USA
	✓	✓	✓	✓	Department of the Interior (DOI)	30 CFR 250	Regulation	Oil and Gas	Medium	USA
	✓	✓	✓	✓	Department of the Interior (DOI)	30 CFR 585 – Renewable Energy and Alternate Uses of Existing Facilities on the OCS	Regulation	Renewable energy	Medium	USA
	✓	✓	✓	✓	American Wind Energy Association (AWEA)	**AWEA Offshore Compliance Recommended Practice (OCRP) 2012**	Recommended Practices	Offshore wind	Medium	USA
	✓	✓	✓	✓	American Clean Power (ACP) Association standards Committee	**ACP Offshore Compliance Recommended Practices (OCRP) Edition 2**	Recommended Practices	Offshore wind	High	USA

Exhibit 3: Regulations relevant for health and safety and their applicability to commercial-scale Floating Offshore Wind (FOW) (continued)

Lifecycle Phase					Regulatory Body	Document (Key document)	Document Type	Sector	FOW H&S relevance	Jurisdiction
D	MF	TI	OM	DEC						
		✓	✓	✓	International Maritime Organization (IMO)	International Convention for the Safety of Life at Sea (SOLAS)	Convention (not ratified by all members)	Merchant ships	Medium – High	International
		✓	✓	✓	International Maritime Organization (IMO)	Convention on the International Regulations for Preventing Collisions at Sea (COLREGs)	Convention (not ratified by all members)	Shipping	Medium	International
		✓	✓	✓	International Maritime Organization (IMO)	International Convention for the Prevention of Pollution from Ships (MARPOL)	Convention (not ratified by all members)	Shipping	Medium	International
	✓	✓	✓	✓	International Labour Organization (ILO)	Maritime Labour Convention, 2006	Convention (not ratified by all members)	Maritime	Medium	International

2.2.1 United kingdom

In the UK, the following three regulators each have a role in offshore (floating) wind health and safety regulation.

- Health and Safety Executive (HSE UK): Non-departmental statutory body corporate sponsored by the Department for Work and Pensions (DWP). Its main function is to make arrangements to secure the health, safety and welfare of people at work and to protect the public from dangers arising from work activities.
- Maritime and Coastguard Agency (MCA): Executive Agency of the Department for Transport (DfT). Its main functions are to develop, promote and enforce high standards of marine safety, to minimise loss of life amongst seafarers and coastal users, and to minimise pollution from ships to the sea and coastline.
- Marine Accident Investigation Branch (MAIB): Not a regulator but responsible for investigating accidents related to ships and crew in the territorial sea and to UK registered vessels worldwide, to determine their circumstances and causes in order to prevent similar accidents recurring.

The scope of jurisdiction of these three bodies can overlap, hence a Memorandum of Understanding (MOU) is in place (last updated in May 2021[1]) to ensure effective collaboration between the bodies where their duties for H&S enforcement and accident investigation overlap at the water margin, offshore and on inland waterways in and around the UK. An Operational Working Agreement (OWA) was also established to outline the key and supporting principles to be adopted when selecting the lead organisation for H&S enforcement and accident investigation.

In general, HSE UK is in charge of work activities covered by Health and Safety at Work etc Act 1974 and its relevant statutory provisions, such as docks, jetties, leading/cargo operation, ship repair, offshore installations energy structure. MCA's jurisdiction covers UK ships and crew safety anywhere globally, and foreign flag ships and crew in UK waters and inland areas (ports). MAIB jurisdiction generally covers all marine incidents investigations in the territorial sea and on inland waterways, and incidents involving UK ships anyway globally.

For floating wind assets in territorial sea and UK continental shelf, FOW platforms are considered a 'non-mobile installation'. HSE UK will lead on enforcement (including incident investigation) during the design, construction, operational and decommissioning phase, while permanently anchored. MCA (or MAIB in the case of an accident) are responsible for enforcement during towing operations. However, during the construction phase in port, where there are varied activities, there is potential for overlap in the roles and responsibilities of HSE, MCA and MAIB.

[1] Guidance overview: Memorandum of understanding between HSE, MCA and MAIB, May 2021. https://www.gov.uk/government/publications/memorandum-of-understanding-between-hse-mca-and-maib

Health and Safety at Work etc Act (HSWA) 1974 and its Application outside Great Britain Order (AOGBO) 2013	
	The fundamental principle of the HSWA is to make those who create risks, in the course of work activity, responsible for protecting workers and the public from the consequences of their activities, by clearly define each parties' duties. The HSWA was extended in 2013 with an Application outside Great Britain Order (AOGBO) to apply H&S legislation to workers involved in offshore work activities on wind farms in and beyond the territorial sea. Although not specified in the regulation, it is understood this regulation is appliable to FOW.

Lifting Operations and Lifting Equipment Regulations 1998	
	This regulation provides technical information for those involved in the supply, operation and control of lifting equipment in the offshore environment and is aimed primarily at duty holders involved in the operation and safe use of lifting equipment offshore. It applies to all installation, including both fixed-bottom wind farm and FOW, operating within the UK continental shelf.

Source: Health and Safety Executive (HSE)

2.2.2 Germany

In Germany, offshore wind developers are responsible for the establishment and implementation of the health and safety guidelines. The applicable regulatory framework is based on the German Labour Protection Act – Arbeitsschutzgesetz (ArbSchG) which has been issued by the Federal Ministry for Labour and Social Affairs – Bundesministerium für Arbeit und Soziales (BMAS). The BMAS is supported by advisory committees on occupational health to regularly review and update the German Labour Protection Act if needed. The Federal Institute for Occupational Safety and Health – Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) is BMAS' most important advisory body operating directly under BMAS. In addition to the Labour Protection Act, offshore wind developers should also comply with regulations implement by the German Social Accident Insurance Institution for the energy, textile, electrical and media products sectors – Berufsgenossenschaft Energie Textil Elektro Medienerzeugnisse (BGETEM).

Notably, some elements of health and safety procedure must be described in a health and safety plan (Schutz- und Sicherheitskonzept) which is prepared under the standard terms of the Federal Waterways and Shipping Administration – Bundesamt für Seeschifffahrt und Hydrographie (BSH) permit. BSH is responsible for spatial planning and for the testing and approval of power generation plants (offshore wind turbines), cables or other plants within the scope of federal responsibility.

Occupational Safety and Health Act (ArbSchG), 1996	
	The Act is the German law for the implementation of EU Directives (EC Directive 89/391/EEC, 12 June 1989) on occupational safety. The Occupational Safety and Health Act aims to ensure and improve the health of all employees through occupational health and safety measures. Section 3 of the ArbschG requires employers to guarantee the safety and the protection of the health of personnel with relevant organisational and technical measures. As of Section 3, all employers are obligated to conduct risk assessments taking into consideration the particularities of the offshore working environment.

Source: Federal Ministry for Labour and Social Affairs (BMAS)

For maritime issues in Germany, the Federal Waterways and Shipping Administration – Wasser-und Schifffahrtsverwaltung des Bundes (WSW) and BSH are the responsible authoritative bodies. More specifically, WSW is responsible for the maintenance of the shipping waterways, and examines all hazards related to ship navigation. It should be noted that WSW controls territorial shipping (up to 12 nautical miles from coast), while BSH has the overall responsibility for offshore wind projects.

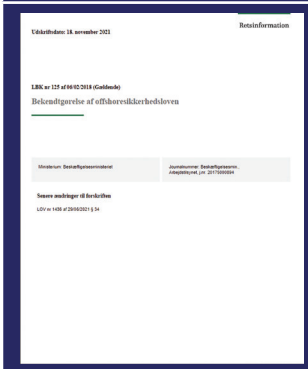
2.2.3 Denmark

In Denmark, the Danish Working Environment Authority – Arbejdstilsynet (DWEA) is responsible for ensuring a safe, healthy and constantly improving working environment through effective supervision and appropriate implementation of the health and safety measures. More specifically, the DWEA is responsible for implementing the Offshore Safety Act, 1992 and establishing procedures to ensure coordination with the tasks concerning both offshore wind and offshore oil and gas activities.

The WEA operates under the Danish Ministry of Employment, and cooperates with the following authorities for offshore wind installations:

- The Danish Energy Agency – Energistyrelsen (DEA): DEA is the competent authority that oversees all offshore installations, oil and gas and offshore wind farm, within the Danish EEZ.
- The Danish Maritime Authority – Søfartsstyrelsen (DMA): DMA is responsible for supervision of navigational shipping, including safely transfers from shore to offshore wind farm sites.

Although DMA is the responsible authority for most of the maritime activities, marine access to offshore wind farms, all maritime activities that lays within the coastal territory of the Danish waters are regulated by the Danish Coastal Authority – Kystdirketoratet (DCA). Port facilities and operations for loading and offloading are supervised by DCA, including port security.

The Offshore Safety Act, 1992x R	
 Retsinformation Udskriftsdato: 18. november 2021 LBK nr 125 af 06/02/2018 (Gældende) Bekendtgørelse af offshoresikkerhedsloven Ministerium: Beskæftigelsesministeriet Journalnummer: Beskæftigelsesmin. Arbejdstilsynet, jnr. 2017/000504 Senere ændringer til forskriften LOV nr 1408 af 28/06/2021 § 34	The main purpose of the Offshore Safety Act is to promote a high level of health and safety standards for workers involved in all offshore activities, offshore wind and offshore oil and gas, creating a framework that allows employers to shape their own health and safety framework addressing their offshore issues. Under the Section 5 of the Act, employers must ensure that health and safety risks associated with offshore activities are identified, assessed and reduced as much as reasonably possible. As per Sections 58 and 59, an Offshore Safety Council and a Preparedness Committee should be formed to assist in the preparation and enforcement of regulations.

Source: DWEA

2.2.4 Japan

Due to the lack of shallow water between the coast and continental shelf and the country's seismic activity, Japan is promoting floating wind. There are however extreme conditions to be considered where due to the seasonal occurrence of typhoons. The primary H&S regulators for floating wind are the Safety Policy Division and the Ocean and Environmental Policy Division under the Bureau of Maritime, an executive agency of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). They enforce the H&S standards for transportation and port facility. They also establish a technical standard for FOW equipment requirements including safety guidelines to promote rational and efficient FOW design. It regulates the procedures that the FOW developers shall follow during design, manufacture and construction phases.

In addition, the Electric Power Safety Division and the Industrial Safety Committee under the Ministry of Economy, Trade and Industry (METI), and the Labour Standards Inspection Office under the Ministry of Health, Labour and Welfare (MHLW) are also relevant regulators, who enforce H&S regulations of WTG, electrical infrastructure and workers.

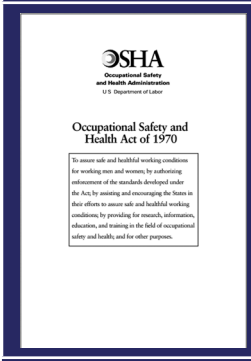
No specific FOW H&S regulation is established in Japan, and the FOW developers are requested to comply with general H&S procedures in different regulations related to the development of FOW, including but not limited to: Electricity Business Act, Port and Harbour Act, Ship Safety Act, Industrial Safety and Health Act.

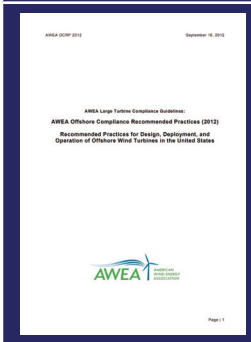
2.2.5 United States of America

In general, the primary regulator for health and safety in the US is the Occupational Safety and Health Administration (OSHA), within the Department of Labor (DoL), who provide health and safety regulation on a federal level and approve specific state level H&S plans. For renewable energy activities H&S on Outer Continental Shelf (OCS), the Department of the Interior (DOI) is acting as the principal regulator and enforcement agency and collaborating with OSHA and the US Coast Guard to share relevant safety and training information and promote safety on the OCS.

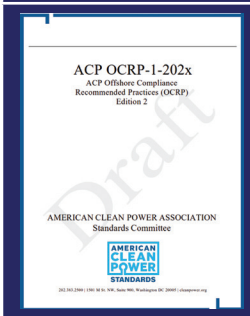
DOI has delegated its responsibility to two major bodies regulate offshore energy sources, Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental

Enforcement (BSEE). A memorandum of agreement was established in December 2020 to clarify each bureau's roles and responsibilities. BOEM has authority over environmental compliance, oil spill preparedness, inspections, enforcement, and investigations for outer continental shelf (OCS) renewable energy activities, and BSEE will assist BOEM with these aspects from a health and safety perspective. At present, for renewable energy sector, BSEE is developing strategies to oversee safety and environmental requirements for facility's entire lifecycle, promote the safety of operations through regulatory requirements and programmes and enforce compliance with all applicable safety, environmental, and conservation laws and regulations. DOI will consider the standards used in OSHA regulations as a baseline but can allow alternate standards to achieve the same level of safety.

Occupational Safety and Health Act of 1970 and 29 CFR	
 OSHA Occupational Safety and Health Administration U.S. Department of Labor Occupational Safety and Health Act of 1970 To assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health; and for other purposes.	The OSH Act includes similar requirements for the employer and employee to the HSWA and ArbSchG, to prevent workers from being harmed at workplace. The OSH Act led to the formation of OHSA. Further OHSA regulations cover the procedures employers are required to follow to protect their workers from hazards. The more applicable standards for FOW related activities can be found in 29 CFR, parts 1910 (general industry); 1915, 1917, 1918 and 1919 (maritime), and 1926 (construction).

AWEA Offshore Compliance Recommended Practice (OCRP) 2012	
 AWEA OCRP 2012 September 16, 2012 AWEA Large Turbine Compliance Guidelines: AWEA Offshore Compliance Recommended Practices (2012) Recommended Practices for Design, Deployment, and Operation of Offshore Wind Turbines in the United States AWEA	AWEA OCRP 2012 was developed by the Department of Energy, the National Renewable Energy Laboratory (NREL), BOEM, BESS and the American Wind Energy Association (AWEA), to cover all aspects of fixed -bottom offshore wind facility throughout its entire lifecycle. It was used as informative frame for regulators, developers and certified verification agents. Section nine of the AWEA OCRP 2012 includes a list of some of the safety and navigational regulatory documents that should be considered for offshore wind design and installation phases in USA OCS waters. It does not address FOW technology.

ACP Floating Wind Compliance Recommended Practices – Draft



In 2017 an initiative was approved to address the AWEA OCRP 2012 shortfalls. AWEA was later renamed the American Clean Power Association (ACP). Five groups have been formed for the programme, covering offshore compliance, US floating wind systems, US offshore wind metocean conditions characterisation, geotechnical and geophysical investigations and design and submarine cables.

The ACP OCRP-1-202x ACP Offshore Compliance Recommended Practices (OCRP) Edition 2 draft standard is now available in draft. ACP OCRP-2 'U.S. Floating Wind Systems Recommended Practices' is in development, although no publication date has been confirmed.

2.3 STANDARDS

Exhibit 4 presents the standards that are of relevance or are expected to be of benefit for commercial scale FOW projects. Whilst not all of these standards are FOW orientated they do consider the requirements for offshore environments and demonstrate what is required for compliance according to currently accepted standards. The overview is not meant to be an exhaustive list due to the nature of the variety of international countries and waters of which an installation will be installed.

Exhibit 4: Standards relevant for HSE for floating offshore wind projects

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
✓	✓				American Bureau of Shipping (ABS)	N/A	Generic Rules for Conditions of Classification – Offshore Units and Structures	Offshore/ O&G	Medium	2021
✓	✓	✓	✓		ABS	N/A	**Guide for Building and Classing Floating Offshore Wind Turbine Installations**	Floating Offshore Wind	Medium to High	2020
✓	✓				Bureau Veritas (BV)	NR445 DT Amd 002 E	Rules for the Classification of Offshore Units	Offshore	Low to Medium	2019
✓	✓	✓	✓		BV	NI 572 DT R02 E	**Classification and Certification of Floating Offshore Wind Turbines**	Offshore Wind	Medium	2019
✓	✓	✓	✓		BV	NI 631 DT R00 E	Certification Scheme for Marine Renewable Energy Technologies	Offshore	Low to Medium	2016
✓	✓	✓	✓		BV	NR494 R04	Classification and certification of mooring systems for permanent and mobile offshore wind turbines	Offshore Wind	Medium	2021

Exhibit 4: Standards relevant for HSE for floating offshore wind projects (continued)

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
✓	✓	✓	✓		ClassNK	N/A	Guidelines for Offshore Floating Wind Turbine Structures	Offshore Wind	Medium	2012
✓	✓	✓	✓		Det Norske Veritas (DNV)	DNV-OS-J126	Design of Offshore Wind Turbine Structures	Offshore Wind	Low to Medium	2016
✓	✓	✓	✓		DNV	DNVGL-ST-0145	Offshore Substations for Wind Farms	Offshore Wind	Low to Medium	2016
✓	✓	✓	✓		DNV	DNVGL-ST-0119	**Floating wind turbine structures**	Offshore Wind	Medium to High	2018
		✓	✓		DNV	DNVGL-ST-N001	Marine Operations, General	Offshore Wind	Medium	2016
✓	✓	✓	✓		Lloyd's Register	-	Rules and Regulations for the classification of Floating Offshore installations at a fixed location	Offshore/ O&G	Low to Medium	2013
✓	✓				International Electrotechnical Commission (IEC)	IEC 61400-1:2019	Wind energy generation systems – Part 1: Design requirements	Wind Turbine Generator	Medium	2019, current
✓	✓				IEC	IEC TS 61400-3-2:2019	**Wind energy generation systems – Part 3-2: Design requirements for floating offshore wind turbines**	FOW	High	Standard to be published mid-2022.

Exhibit 4: Standards relevant for HSE for floating offshore wind projects (continued)

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
✓	✓				IEC	IEC 61400-4:2012	Wind turbines – Part 4: Design requirement for wind turbine gearboxes	Wind Turbines	Medium	2012, current
✓	✓				IEC	IEC 61400-5:2020	Wind energy generation systems – Part 5: Wind turbine blades	Wind Turbines	Medium	2020, current
✓	✓				IEC	IEC 61400-6:2020	Wind energy generation systems – Part 6: Tower and foundation design requirements	Wind Turbines	Medium	2020, current
✓	✓				IEC	IEC 61400-11:2012	Wind turbines – Part 11: Acoustic noise measurement techniques	Wind Turbines	Medium	2012
✓	✓	✓	✓	✓	IEC	IEC TS 61400-30	Safety of WTGs – General principles for design (Technical Specficiation)	Wind Turbines	Medium	Awaiting publication
✓	✓				IEC	IEC 61400-12-1:2017	Wind energy generation systems – Part 12-1: Power performance measurements of electricity producing wind turbines	Wind Turbines	Medium	2017

Exhibit 4: Standards relevant for HSE for floating offshore wind projects (continued)

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
✓	✓				IEC	IEC TS 61400-14:2005	Wind turbines – Part 14: Declaration of apparent sound power level and tonality values	Wind Turbines	Low	2005
✓	✓				IEC	IEC 61400-25-1:2017	Wind energy generation systems – Part 25-1: Communications for monitoring and control of wind power plants – Overall description of principles and models	Wind Turbines	Low	2017
✓	✓	✓	✓		American Petroleum Institute (API)	API RP 2SM	Design, Manufacture, Installation, and Maintenance of Synthetic Fibber Ropes for Offshore Mooring	Offshore/ O&G	Medium	2014
✓	✓	✓	✓		API	API RP 2FPS	Recommended Practice for Planning, Designing, and Constructing Floating Production Systems	Offshore/ O&G	Medium	2011

Exhibit 4: Standards relevant for HSE for floating offshore wind projects (continued)

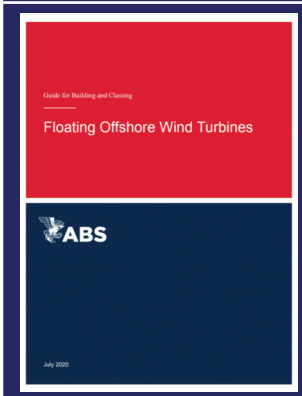
Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
✓	✓	✓	✓		API	API RP 2T	Recommended Practice for Planning, Designing, and Constructing Tension Leg Platforms (TLP)	Offshore/ O&G	Medium (TLP only)	2010 (R2015)
✓	✓	✓	✓		International Organisation of Standardisation (ISO)	ISO 19901 series	**Petroleum and natural gas industries — Specific requirements for offshore structures**	Offshore, O&G (fixed and floating)	Medium to High	Various
✓	✓				ISO	19904-1:2019	Petroleum and natural gas industries – Floating offshore structures – Part 1: Ship-shaped, semi-submersible, spar and shallow-draught cylindrical structures	Offshore, O&G	Medium	2019
	✓				ISO	29400:2020	Ships and marine technology – Offshore wind energy – Port and marine operations	Offshore Wind	Low to Medium	2020
✓	✓				ISO	45001:2018	Occupational health and safety management systems.	All	Medium	2018

Exhibit 4: Standards relevant for HSE for floating offshore wind projects (continued)

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
✓	✓	✓	✓	✓	ISO	ISO 31000	Risk management	All	Medium	2018
		✓	✓		NORSOK	S-001	Technical Safety	Offshore, O&G	Medium	2020
✓		✓	✓		NORSOK	S-002	Working Environment	Offshore, O&G	Medium	2018

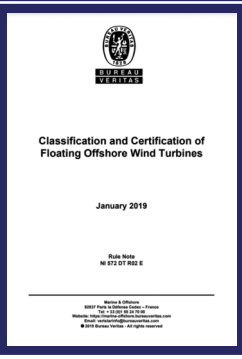
2.3.1 Classification society: American Bureau of Shipping (ABS)

ABS is a US maritime classification society established in 1862. ABS has a strong track record in O&G and has been increasing their involvement in offshore wind, both for fixed and floating projects. Notably ABS provided classification for the largest operational floating wind farm Kincardine, at a capacity of 48MW.

American Bureau of Shipping's Guide for Building and Classing Floating Offshore Wind Turbine Installations (ABS 195) | 2020	
	The document describes requirements specific to FOW for classification and cross-references relevant existing rules, guidance and standards. The focus is from a design and engineering perspective but there are several relevant references to safety. ABS 195 includes references to various other ABS rules, guides and guidance notes. The design criteria specified in the Guide are intended for the unmanned Floating Offshore Wind Turbine Installation having a safety level equivalent to the medium (L2) exposure level as defined in ISO 19904-1 for unmanned floating offshore structures. Reference is made to the ABS Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries, which contains an overview of risk assessment techniques and additional information.

2.3.2 Classification society: Bureau Veritas (BV)

Bureau Veritas provide testing, inspection and certification services across various industries. BV have a track record in marine and offshore, but more limited in offshore wind to date. However, have been more active in the initial FOW projects which takes advantage of their Oil and Gas and maritime expertise.

Classification and Certification of Floating Offshore Wind Turbines (NI 572) | 2019	
	The BV guidance note provided specific guidance and recommendations for the classification and certification of FOW platforms. The focus is of the note is on design and engineering perspectives, with cross-reference to IEC 61400 series of standards. There is little occupational health and safety focus, but does consider safety factors for the key components for FOW projects; including structural strength, mooring systems, tendon legs and turbine mechanical components.

2.3.3 Classification society: DNV

DNV is a Norwegian classification society, are the independent expert in assurance and risk management and are the world's leading classification society and a recognized advisor for the maritime industry. DNV deliver world-renowned testing, certification and technical advisory services to the energy value chain including renewables, oil and gas, and energy management.

Design of Floating Wind Turbine Structures (DNVGL-ST-0119) | 2018


DNV·GL

STANDARD

DNVGL-ST-0119 Edition July 2018

Floating wind turbine structures

DNV GL AS

The DNV offshore standard provides principles, technical requirements and guidance for design, construction and in-service inspection of FOW turbine structures, defined as the support structures and station keeping systems. This document supersedes DNV-OS-J103.

The standard covers structural design of FOW structures. The standard gives provisions for the floater motion control system and the control system for the wind turbine – whether these systems are separate or combined – to the extent necessary in the context of structural design. The standard also gives provisions for transportation, installation and inspection to the extent necessary in the context of structural design. The design principles and overall technical requirements are specified in the standard.

2.3.4 Classification society: Lloyd's Register (LR)

Lloyd's Register (LR) is a UK classification society established in 1760 with extensive experience in compliance for the marine and offshore industries. LR have a strong track record in Oil and Gas, including in floating offshore assets. However, LR have not focussed on the development of guidance or standards for fixed-bottom offshore wind or floating offshore wind.

2.3.5 International standards bodies: IEC

IEC is an international standards organisation and recognised as the main body for onshore and offshore wind energy, most recently including FOW. The IEC standards are developed and updated through consensus with industry experts to

Wind energy generation systems – Part 3-2: Design requirements for floating offshore wind turbines | 2019 (Part of TC 88 standards)	
	IEC 61400-3-1:2019 outlines the minimum design requirements for fixed offshore wind turbines, including design loads, load safety factors and control system. IEC TS 61400-3-2:2019 specifies the additional requirements for assessment of the external conditions at a floating offshore wind turbine (FOWT) site and specifies essential design requirements to ensure the engineering integrity of FOWTs. Its purpose is to provide an appropriate level of protection against damage from all hazards during the planned lifetime. Considers the design safety but limited consideration of occupational health and safety. Currently a Technical Standard (TS) which is being developed into a standard, currently in draft format. The standard is expected to be published in mid 2022, when the TS suffix will be removed.

2.3.6 The International Organization for Standardization (ISO)

ISO is a worldwide federation of national standards bodies, of which there are 165 national standards bodies. The work of preparing International Standards is normally carried out through ISO technical committees. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization. ISO standards are cross-referenced across various standards.

Petroleum and natural gas industries – Specific requirements for offshore structures (ISO 19901)	
	The ISO 19901 series of standards gives general requirements for the design, construction and operation of offshore structures used in the petroleum and natural gas industries; this includes floating structures but doesn't consider offshore wind and therefore gaps exist specific to FOW requirements. Part 1: Metocean design and operating considerations Part 2: Seismic design procedures and criteria Part 3: Topsides structure Part 4: Geotechnical and foundation design considerations Part 5: Weight control during engineering and construction Part 6: Marine operations Part 7: Stationkeeping systems for floating offshore Part 8: Marine

2.3.7 American Petroleum Institute (API)

API was formed in 1919 as a standards-setting organization and is the global leader (particularly in the US) in convening subject matter experts across segments to establish, maintain, and distribute consensus standards for the oil and gas industry. API has developed more than 700 standards to enhance operational safety, environmental protection and sustainability across the industry, especially through these standards being adopted globally. Although standards developed for the oil and gas industry, provides standards, recommended practices and risk assessments applicable across offshore practices.

2.3.8 Oil and gas standards; NORSOK

NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are as far as possible intended to replace oil company specifications and serve as references in the authorities' regulations. As for API, standard and guidance is developed for oil and gas but fundamental approaches can be applied across.

2.4 GUIDANCE AND OTHER DOCUMENTS

Exhibit 5 presents the guidance and other documents that are of relevance or are expected to be of benefit for commercial scale FOW projects. Whilst not all of these documents are FOW orientated they do consider the guidance and recommendations according to current industry practice. The overview is not meant to be an exhaustive list due to the nature of the variety of guidance available.

Exhibit 5: Guidance and regulations relevant for HSE for offshore wind projects

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
			✓		G+	**Safe helicopter operations in support of global offshore wind industry (Section A+B)**	Good practice guidelines	Offshore Renewable Energy	Medium	2021
		✓	✓	✓	G+	G+ Integrated Offshore Emergency Response	Good practice guidelines	Offshore Renewable Energy	Medium	2019
		✓	✓	✓	G+	**G+ Offshore wind farm transfer**	Good practice guidelines	Offshore Renewable Energy	Medium to High	2020
	✓	✓	✓	✓	G+	G+/DROPS Reliable securing booklet for offshore wind	Good practice guidelines	Offshore Renewable Energy	Low to medium	2019
	✓	✓	✓	✓	G+	Working at height in the offshore wind industry	Good practice guidelines	Offshore Renewable Energy	Low to medium	2018
	✓	✓	✓	✓	Health and Safety Executive	**Guidance on Risk Assessment for Offshore Installations**	Offshore Information Sheet No. 3/2006	Offshore/ O&G	Medium to High	2006

Exhibit 5: Guidance and regulations relevant for HSE for offshore wind projects (continued)

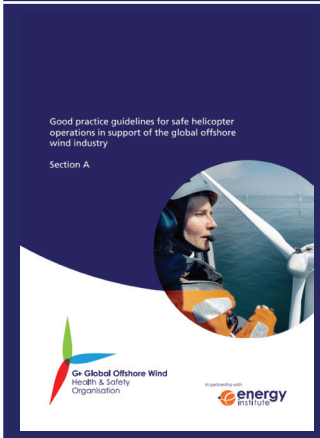
Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
		✓	✓	✓	Health and Safety Executive/ MCA	**Regulatory expectations for emergency response arrangements for the offshore renewable energy industry**	Offshore Information sheet 02/2019	Offshore Renewable Energy	Medium to High	2019
✓		✓	✓		Maritime and Coastguard Authority (MCA)	Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response	Regulatory guidance	Offshore Renewable Energy	Medium to High	2021
✓	✓	✓	✓	✓	RenewableUK	Offshore Wind and Marine Energy Health and Safety Guidelines	H&S industry guidance	Offshore Renewable Energy	Medium	2014
✓					Floatgen	**Report on the requirements of the floating structure – Deliverable No 3.1**	Project deliverable	FOW	Medium to High	2013

Exhibit 5: Guidance and regulations relevant for HSE for offshore wind projects (continued)

Lifecycle Phase					Regulatory Body	Standard Number	Description	Sector	H&S relevance	Revised date – status
D	MF	TI	OM	DEC						
		✓	✓		IMCA	IMCA SEL 025/M 202 – Guidance on the transfer of personnel to and from offshore structures	Industry guidance	Offshore Wind	Low	2014
		✓	✓		DNV GL	Gangway Access to Offshore Facilities – Walk-to-Work (W2W) Industry Guidance	Industry guidance	Offshore	Low to medium	2015
✓	✓	✓	✓	✓		Worker health and Safety Offshore Wind Farms	Report	Offshore Renewable Energy	Medium	2012
		✓	✓		World Forum Offshore Wind (WFO)	Insurability of Floating Offshore Wind	White Paper	FOW	Medium	2021
✓	✓				ORE Catapult	Floating offshore wind – Application of standards, regulations, project certification and classification – risks and opportunities	Mapping report (Deliverable D1)	FOW	Medium to High	
		✓			Official Norwegian Reports (NOU)	**The Loss of the 'Bourbon Dolphin' on 12 April 2007**	Accident report following fatality	Offshore/ O&G	Medium to High	2008
✓	✓	✓	✓	✓	HSE	Marine risk assessment	Offshore Technology Report 2001/063	Offshore	Medium	2001

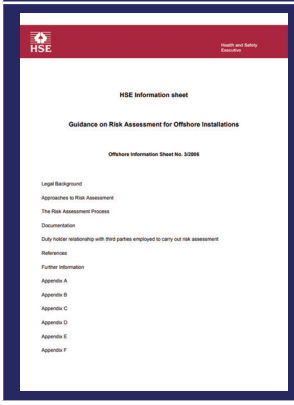
2.4.1 G+

G+ is the global health and safety organisation, bringing together the offshore wind industry to pursue shared goals and outcomes. It is run in partnership with the Energy Institute, which provides the secretariat and supports its work.

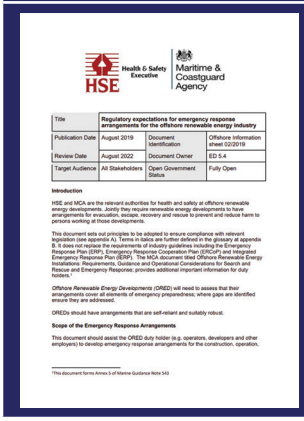
G+ Safe helicopter operations in support of global offshore wind industry (Section A and Section B) | 2021	
	The G+ published good practice guidelines on the use of helicopters in offshore wind, considering routine operations as well as abnormal events and emergencies. The overall purpose of these guidelines is to support continuous improvement in managing health and safety risks to and from helicopter operations, enabling safe development of the global offshore wind industry. They aim to help the industry integrate helicopter operations safely into projects, taking an approach appropriate and proportionate to the operational context and its risk profile. Section A of the guidelines provides a non-technical summary of the use of helicopters in offshore wind. Section B contains the more detailed, formal guidelines. The guidelines are detailed in the consideration of H&S risk for offshore wind. FOW aspects are considered, however the gaps are highlighted rather than being covered; such as the special design considerations for hoist platforms on floating WTGs and determining if movement is acceptable, or not.

G+ Offshore wind farm transfer | 2020	
	Provides a framework for safe transfers in an offshore wind farm, primarily focussed on fixed-bottom projects. The goal is to provide consistency and good practice regarding transfer across the wind industry and allow operators and vessel owners to produce or to verify their transfer procedure up against a set of industry standard guidelines. The guidelines mention the hazard and protective measures can be applied also for FOW, however does not elaborate on further details.

2.4.2 Health and Safety Executive (HSE)

Health and Safety Executive's Guidance on Risk Assessment for Offshore Installations (Offshore Information Sheet No. 3/2006)	
 HSE Health and Safety Executive HSE Information sheet Guidance on Risk Assessment for Offshore Installations Offshore Information Sheet No. 3/2006 Legal Background Approaches to Risk Assessment The Risk Assessment Process Documentation Duty holder relationship with third parties employed to carry out risk assessment References Further Information Appendix A Appendix B Appendix C Appendix D Appendix E Appendix F	Provides guidance for Asset Managers, Safety Managers and Safety Engineers in the offshore industry on suitable and sufficient risk assessment. The guidance has been produced in the context of Oil and Gas but the framework is very relevant and useful for considering FOW risk assessment. The guidance is further considered in the Risk Assessment Methodology section.

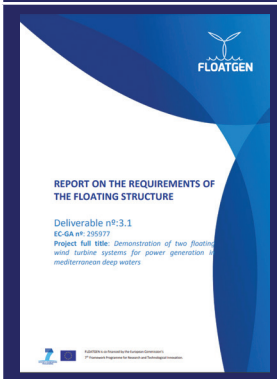
2.4.3 HSE and MCA

Regulatory expectations for emergency response arrangements for the offshore renewable energy industry (Offshore Information sheet 02/2019)	
 HSE Health & Safety Executive / Maritime & Coastguard Agency Title: Regulatory expectations for emergency response arrangements for the offshore renewable energy industry Publication Date: August 2019 — Document Identification: Offshore Information sheet 02/2019 Review Date: August 2022 — Document Owner: ED 5.4 Target Audience: All Stakeholders — Open Government Status: Fully Open Introduction HSE and MCA are the relevant authorities for health and safety at offshore renewable energy developments. Jointly they require renewable energy developments to have arrangements for evacuation, escape, recovery and rescue to prevent and reduce harm to persons working at those developments. This document sets out principles to be adopted to ensure compliance with relevant legislation (see appendix A). Terms in italics are further defined in the glossary at appendix B. It does not replace the requirements of industry guidelines including the Emergency Response Plan (ERP), Emergency Response Cooperation Plan (ERCoP) and Integrated Emergency Response Plan (IERP). The MCA document titled Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response, provides additional important information for duty holders.[1] Offshore *Renewable Energy Developments (ORED)* will need to assess that their arrangements cover all elements of emergency preparedness; where gaps are identified ensure they are addressed. OREDs should have arrangements that are self-reliant and suitably robust. Scope of the Emergency Response Arrangements This document should assist the ORED duty holder (e.g. operators, developers and other employers) to develop emergency response arrangements for the construction, operation, [1]This document forms Annex 5 of Marine Guidance Note 543	Sets out principles for Offshore Renewable Energy Development (ORED) to ensure compliance with relevant legislation (including HSWA, MHSWR, CDM) for emergency response. This document assists duty holders in developing emergency response arrangements for the construction, operation maintenance and decommissioning of a renewable energy installation. Outlines principles and regulatory expectations for ORED development, including approach to risk assessment. There are no specific considerations included for FOW but does specify FOW is within scope of the guidance.

2.4.4 Floatgen

Floatgen is a 2 MW floating wind turbine demonstrator installed in South Britany, France (Sem-Rev test site). The project was commissioned in 2018 and features Ideol's barge floating platform. The project has been a proof of concept for the specific technology but also more general FOW design requirements and practices.

Floatgen's Report on the requirements of the floating structure (Deliverable 3.1)

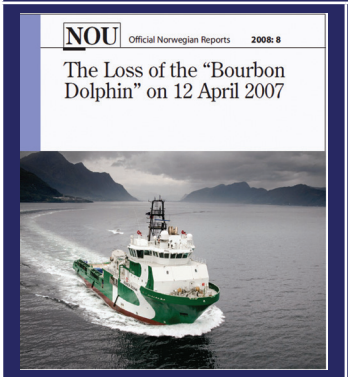


The report describes the specific requirements for the Floatgen demonstrator project, however provides useful general FOW design philosophy and references to safety, environment and management of accidental cases. The document was published in 2013 and noting the subsequent further development of the relevant standards, discussed in above section.

The report is specific to a FOW design (Ideol's Damping Pool), however the H&S considerations are applicable more widely to FOW. The report considers both design and occupational H&S, however it is a relatively concise document.

2.4.5 Loss of bourbon dolphin

Eight fatalities from the Loss of the 'Bourbon Dolphin' | 2007



On 12 April 2007, the Anchor Handling Tug Supply (AHTS) vessel 'Bourbon Dolphin' was engaged in anchor handling operations for a semi-submersible drilling rig to the west of the Shetland Islands. The vessel capsized rapidly during anchor handling operations. Of the fifteen people on board, only seven were rescued.

The report provides a detailed account of the accident, details of the event, the causes and outlines numerous recommendations, including highlighting the following:

- Stability of anchor-handling vessels; ensuring vessel-specific stability calculations and limiting mooring load based on stability (GZ).
- Requirements for the company's safety management; including vessel-specific anchor-handling procedures, familiarisation during master handover and identifying requirement for experienced personnel
- Planning and preparedness, including risk assessments

2.5 GAP IDENTIFICATION

As demonstrated in the literature review, there are a wide range of regulations, standards, guidance and other documents of varying degrees of relevance to the Health and Safety of commercial-scale FOW projects. Due to the maturity of the industry, FOW-specific requirements are not considered in most documents. Where there are FOW-specific requirements, they mostly consider design considerations, (such as structural requirements) rather than occupational H&S. This is not surprising considering the number of projects in operation is small compared to offshore wind, renewables and Oil and Gas. In addition, most of the focus has been on design optimisation to reduce costs and scale up projects. The documents that are relating to occupational H&S for Offshore Wind do not have specific FOW considerations, but do in certain cases outline potential gaps in understanding (such as helicopter access).

However, with the expected ramp-up in project activity the G+ are proactively looking to understand the H&S gaps. We have summarised the below key gaps in current FOW H&S guidance for commercial-scale projects. The gaps have been categorised into three groups;

- Gap 1 | Platform motions
- Gap 2 | Platform Construction, Transport and Installation
- Gap 3 | New geographies

2.5.1 Gap 1 | Platform motions during O&M

The motions of a floating wind platform derived from WTG operations, which are well known, but undertaken in a dynamic environment due to the motions from installation on a floating foundation. In Oil and Gas, there is less consideration of these motions due to the platforms being much larger (more stable) and topsides being relatively much smaller (little effect on motion characteristics).

FOW motion characteristics:

- Floating platform motions vary based on foundation type and local MetOcean conditions (including wave height and periods, current and wind speeds) and are particularly sensitive when the period approaches its natural frequency. FOW platforms are normally unmanned platforms and technicians will only access when conditions are benign compared to the foundation design conditions. The motions and forces are therefore much lower compared when technicians are accessing and maintaining the WTGs, but are important to understand and assess the impact on O&M and H&S.
- Platform motions at hub heights; considering future hub heights for commercial scale FOW projects of over 140 metres (above sea level), a small inclination of the platform will create a large resulting motion. At 140 metres hub height +/-1 degree of inclination equates to +/- 2.5 metres at hub height, or an amplitude of 5 metres of lateral motion in the WTG hub.
- Platform motions with WTG locked; the WTG acts as a damper for platform motions when operational to reduce pitch motions. When the WTG is not operational (downtime or maintenance) or low wind speeds (while there is still wave activity) there will be periods with no WTG damping and may still have residual sea states.

Gaps in guidance:

- Motion sickness; the effect of the platform motions on the ability of technicians to undertake their tasks safely. The effect of exposure of technicians to FOW motions is not well known considering the small number of projects in operation. At this stage, only anecdotal information has shown there are cases of motion sickness on FOW projects, however it's not clear how much is caused by the transit to the projects versus working on the floating WTG. There is also anecdotal evidence of motion sickness in FBOW with larger WTGs in deeper waters. There is a significant amount of research on motion sickness but very little has been applied to FOW, and more strongly weighted to accelerations in the vertical axis, such as from vessels at speed and/or in rough weather (ISO 2631 and BS 6841 both consider human exposure to whole-body vibration, however not suitable for determining likelihood of motion sickness in FOW).
- Working in a dynamic environment; motions may affect the ability to undertake manual tasks and increase the H&S risk for technicians; this would need to be

- considered for all work within the WTG. The lateral motions increase with height so WTG hub being a key area of consideration. In addition, most platforms have a static pitch in operation, which can be up to ~6degrees and may exacerbate the dynamic risks. O&G regulations There is a lack of guidance on working in such dynamic environments for FOW projects, and the effect on H&S risk.
- Working at height; the H&S risk for operations at height (internal and external) increases in a dynamic environment. In FOW there is an additional risk consideration as motions increase with height, this is an area for potential consideration within the existing G+ guidance.
- Platform access (CTV and SOV); access performance is well known in FBOW. In FOW there are operational sites and lessons are being learnt, however there are new foundation types being deployed and each have their own characteristics. For CTVs and SOVs, it's important to understand the relative motion characteristics based on the MetOcean conditions to understand accessibility, and to consider the effect of the mooring systems. There is a knowledge gap on the H&S risks of transferring between different vessel types to different FOW platform types. The Carbon Trust are currently undertaking such study which is hoped will help with this understanding and reduce the knowledge gap.
- Platform access (helicopter); helicopter access for FBOW is relatively well known, however experience in FOW operations is very limited. It is not known whether the platform motions relative to the helicopter during approach and hoisting operations are acceptable. Considering the WTG rotor will be locked, the above motion characteristics may also play a factor, assuming helicopter access will be undertaken with blades locked and in 'bunny ear' position. The G+ guidance provides guidance on FBOW helicopter access; this includes mention of FOW access, but no specific guidance included and therefore recommended these be extended to consider FOW operations and to define the acceptable criteria for undertaking these operations.

2.5.2 Gap 2|Platform construction, transport and installation

There is good knowledge and track record on operations involving large floating structures from Oil and Gas, however gaps exist on the specific operations required when considering floating structures required for the installation of WTGs.

<u>Gaps in guidance:</u>

- Quayside operations; the WTG integration is well know from fixed-bottom, however these operations are currently all undertaken offshore with Jack-Up Vessels. Undertaking these operations inshore or at the quayside has H&S advantages in being in a more controlled environment, however there are also novel factors not considered in the guidance documents. These novel factors include the level of protection provided from waves within harbour, bottoming out of platform on seabed for stability and high volume of onshore logistics/heavy lifts. In addition, there will be a large workforce in the construction area, making the enforcement of H&S practices more difficult. The 'factory' approach to the production and assembly of platforms is novel and guidelines are recommended to capture the gaps from existing guidelines.
- Towing; there is experience in O&G of towing operations for large floating structures. There have however been several incidents involving towing operations and it's important that similar incidents are not repeated in FOW. Towing operations are similar, however FOW platforms have larger relative topsides (WTG) and different

wave responses based on platform design. It's recommended to highlight the O&G experience, share incidents to prevent future occurrences and outline where different approaches are required.

- Ballasting; operations are well known from O&G and mostly can follow existing guidance. However, specific requirements for FOW should be considered; e.g. FOW platforms have less relative stability so ensuring required stability across full phase of operations, from quayside to operations to decommissioning.
- Mooring and cable installation; significant guidance and learnings can be taken from O&G, however FOW novelties should be considered; including new materials, quick connectors, handling of larger dynamic export/array cables.
- Offshore heavy lifts; heavy lifts for FOW are novel due to the lift requirements. Although WTG components are not considered heavy compared to O&G, they are complex due to the height (to the hub), reach (dependent on WTG position on platform) and relative motions (between the crane vessel and FOW platform) required to replace or install components. The high reach also provides challenges for motion compensated cranes to safely lift components. There are a very small number of times these heavy lifts have been undertaken with FOW platforms, so the industry needs to build experience and understand the limiting criteria.
- Decommissioning; there is little guidance provided specific to decommissioning and often there is little or no consideration for decommissioning in the design phase. The operations tend to be specific and not optimised for efficiency and H&S risk, however there is an opportunity with FOW to consider this matter early in the design phase to reduce H&S risk for these operations.

General gaps compared to existing guidance:

- In general, existing guidance for offshore structures considers a small number of high-value assets, rather than the industrialised approach required for FOW developments. The physics of offshore structures are constant between O&G and FOW, however a different operational approach is expected to be required for FOW construction and hence H&S risks should be considered in this context.
- The current guidance is not tailored to the requirements for FOW platforms, especially considering the larger relative topside (WTG) relative to platform size for FOW and how this effects H&S considerations throughout construction activities.
- Currently the main focus of guidance is on structural design, rather than occupational H&S. At this stage, the onus is placed on duty-holders to risk assess their FOW developments and there is little industry guidance available as reference. There is an opportunity to provide industry guidance to support this understanding of H&S risks and ensure the industry adopts good practice from the outset.
- There are 27 platforms in operation, therefore developers' and suppliers' direct experience and involvement in FOW projects is limited. It is recommended to have a mechanism of sharing H&S risks from these early projects to key stakeholders to ensure these risks are mitigated in the design phase of future larger scale developments.

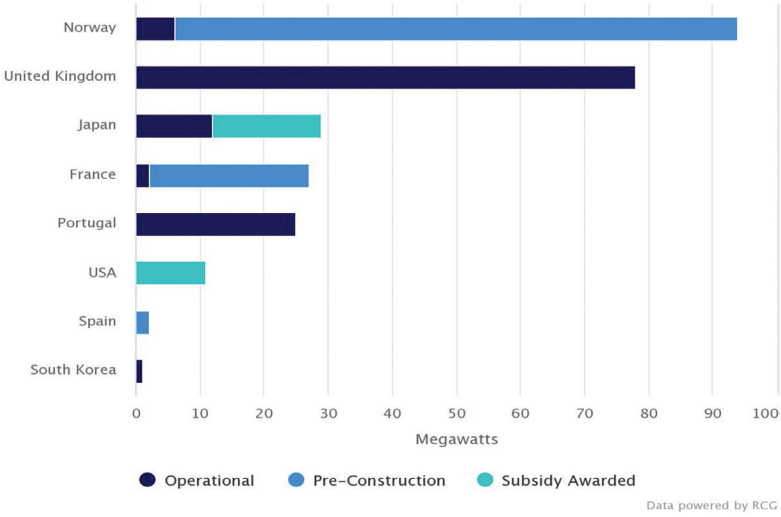
2.5.3 Gap 3|New geographies

The jurisdictions with offshore industries (Oil and Gas and more recently offshore wind) have provided the experience for the FOW industry to leverage and not have to start from scratch. These markets' experience includes the following pillars:

- Regulatory frameworks (including H&S but also leasing, consenting and offtake mechanisms);
- Policy mechanisms and forums for industry and policymakers to engage;
- Supply chain capability (ports, fabrication yards, vessels, WTGs, mooring systems, offshore engineering);
- Industry knowledge and experience;
- Training frameworks and providers;
- Skilled workforce.

The existing markets with offshore track records have a benefit in being able to capitalise on this experience for the development of FOW projects. Exhibit 6 shows the breakdown of the FOW projects operational (124 MW), under construction (115 MW) and route to market secured/subsidy awarded (28 MW).

Exhibit 6: FOW market overview by country



The UK and Norway (outside of China) can be seen as clear leaders in the development of FOW. There are also countries such as Japan, France and South Korea who are rapidly learning and developing their experience in order to develop their pilot and future commercial scale projects. As of 2021, beyond these countries there is no further FOW development with route to market secured. However, the expectation is for development of FOW projects in new markets up to 2030.

As new markets emerge, there are opportunities for these markets to learn from the leaders and pick optimal approaches for developing FOW projects. The following recommendations are made around the potential gaps in guidance and regulatory frameworks for these new and emerging markets:

- Understand the gaps in the above pillars for the specific market; regulatory frameworks, supply chain, training, etc.
- Develop H&S frameworks and guidance specific and appropriate to the market to ensure risk is managed on FOW projects and develop a sustainable industry. There is concern that without these frameworks in place, different stakeholders may not have the same H&S standards and increase the risk of harm to personnel.

- Industry knowledge gap; enable sharing of learnings from the lead markets to support the future FOW build out.
- New market players partner with lead market players; mutual benefits in partnering across different markets and giving exposure of new developers to the requirements to safely develop FOW projects.

3 RISK ASSESSMENT METHODOLOGY

3.1 RISK REVIEW APPROACH

A Risk Review was carried out by the Delivery Partners with the objective of developing a high-level Risk Assessment Matrix for a commercial-scale floating wind farm, to identify critical areas and potential bottlenecks to the development of the industry from a HSE perspective. To facilitate the risk identification process, the base-case scenario assumes a farm of 100 semi-submersible 15MW wind turbines. However, special considerations and comments have been made to account for the wider range of foundation concepts.

The Risk Review was split into the following categories:

- FOW Onshore
- FOW Offshore
- FOW O&M

The risk assessment for the three workshops analysed have been carried out following offshore industry good practice (considering ISO 17776, DNVGL-RP-N101).

The **Onshore** operations have been subdivided into four categories:

- Construction and Logistics
- Platform Assembly
- Platform Launching
- Quayside Assembly and Integration

The **Offshore** operations have been subdivided into five categories:

- Tow-out
- Mooring Installation and Hook-Up
- Array Cable Connection
- Commissioning
- Decommissioning

The **O&M** operations have been subdivided into three categories:

- Unmanned Operation
- On-site Maintenance
- Onshore Maintenance

For each category, specific activities have been identified and analysed to identify the potential risks and associated events. This has been demonstrated in three workshops, one for each main category and discussed by all partners to produce a comprehensive risk assessment.

Exhibit 7: Example of FOW risk assessment

No.	Activity	Potential Risk/ Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (PxCxF)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Opera ions/Procedures applicable to other concepts?		
											SPAR	BARGE	TLP
Constructions and Logistics													
1	Blade Manufacturing	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	TMN	3	2	1	6	Operation does not present major risks and does not require additional review	Assume blade length the same as offshore wind. Similar processes for construction and manufacturing	None	Yes	Yes	Yes
2	Nacelle Manufacturing	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	TMN	3	2	1	6	Operation does not present major risks and does not require additional review	Assume standard nacelle construction for most concepts. Similar processes for construction andmanufacturing	None	Yes	Yes	Yes
3	Tower Manufacturing	Exposure to chemicals and dangerous substances/Falling objects/Handling injuries/machinery injuries/Mechanical hazards/Exposure to noise and vibration	TMN	2	3	1	6	Operation does not present major risks and does not require additional review	Stiffer towers needed. Few concepts involving novel structures	None	Yes	Yes	Yes

Exhibit 7: Example of FOW risk assessment (continued)

No.	Activity	Potential Risk/ Event	Responsible Stakeholder	Probability (P)	Consequence Rating (C)	Floating Wind Novelty Risk (F)	Risk Value (PxCxF)	Conclusion	Comments	Considerations for other platform concepts (if applicable)	Opera ions/Procedures applicable to other concepts?		
											SPAR	BARGE	TLP
4	WTG Components Road Transportation	Impact on circulation/ Crash injuries/ Breakage of components due to vibrations/Road capability/Driver Fatigue	TRL/PD	4	4	0.5	8	Operation does not present major risks and does not require additional review	Difficult due to large sizes extensive planning and logistics. Assume similar requirements as per bottom- fixed, interface with new	None	Yes	Yes	Yes
5	WTG Components Sea Transportation	Navigational collisions/traffic, Loading operations, stability loss, dropped objects, clashes with other cargo	TRM/PD	2	4	1	8	Operation does not present major risks and does not require additional review	Likely to face similar challenges to bottom-fixed, New navigational risks (port-to- port), different		Yes	Yes	Yes

3.2 RISK ASSESSMENT SCORING

Each of the three workshops and corresponding risk assessments used the scoring matrix shown below in Exhibit 8.

In line with common industry practice for risk assessments and guidance from 'DNVGL RP-N101' and ISO 17776, a quantitative score was applied for the consequence and likelihood of the occurrence of an undesirable activity.

A FOW novelty factor was then applied to each activity to capture the additional risk in this comparatively immature market, where most individuals and organisations are inexperienced. The highest FOW novelty factor of 1.5 was applied to those activities that become significantly riskier with FOW compared to FBOW or oil and gas.

Exhibit 8: Risk assessment scoring matrix

LIKELIHOOD	PROBABILITY
1 – Very Unlikely to occur	Incident occurring once in **Thirty Years** or once every **10,000 operations**
2 – Unlikely to occur	Incident occurring once in **Ten Years** or once every **1,000 operations**
3 – Possibly could occur	Incident occurring once in **Five Years** or once every **100 operations**
4 – Likely known to occur	Incident occurring once in **One Year** or once every **50 operations**
5 – Potentially frequent occurrence	Incident occurring once **Monthly** or once every **10 operations**

IMPACT SCORE	CONSEQUENCE
1 – Insignificant	Small Injuries/Damage < $100k/Delay < 1 month
2 – Minor	Severe Injuries and hospitalisation/Damage < $500k/Delay < 2 month
3 – Moderate	Life-changing injuries/Damage < $1M/Delay < 6 month
4 – Major	Fatality/Damage < $10M/Delay < 1 year
5 – Extreme	Multiple Fatalities/Damage > $10M/Delay > 1 year

RELATIVE RISK TO OTHER SECTORS	FLOATING WIND NOVELTY RISK
0.5 – Opportunity for risk mitigation	Operation may be performed more safely in FOW context
1.0 – Similar level of risk	Operation is similar to other sectors
1.5 – Potentially increased risk and/or fully novel risk	Operation is significantly more complex in FOW or completely nove

TASK RISK ASSESSMENT MATRIX						
LIKELIHOOD		CONSEQUENCE				
		Insignificant	**Minor**	**Moderate**	**Major**	**Extreme**
FOW Novelty	**0.5**	**1**	**2**	**3**	**4**	**5**
Very unlikely to occur	**1**	**0.5**	**1**	**1.5**	**2**	**2.5**
Unlikely to occur	**2**	**1**	**2**	**3**	**4**	**5**
Possibly could occur	**3**	**1.5**	**3**	**4.5**	**6**	**7.5**
Likely known to occur	**4**	**2**	**4**	**6**	**8**	**10**
Potentially frequent occurrence	**5**	**2.5**	**5**	**7.5**	**10**	**12.5**
FOW Novelty	**1.0**	**1**	**2**	**3**	**4**	**5**
Very unlikely to occur	**1**	**1**	**2**	**3**	**4**	**5**
Unlikely to occur	**2**	**2**	**4**	**6**	**8**	**10**
Possibly could occur	**3**	**3**	**6**	**9**	**12**	**15**
Likely known to occur	**4**	**4**	**8**	**12**	**16**	**20**
Potentially frequent occurrence	**5**	**5**	**10**	**15**	**20**	**25**
FOW Novelty	**1.5**	**1**	**2**	**3**	**4**	**5**
Very unlikely to occur	**1**	**1.5**	**3**	**4.5**	**6**	**7.5**
Unlikely to occur	**2**	**3**	**6**	**9**	**12**	**15**
Possibly could occur	**3**	**4.5**	**9**	**13.5**	**18**	**22.5**
Likely known to occur	**4**	**6**	**12**	**18**	**24**	**30**
Potentially frequent occurrence	**5**	**7.5**	**15**	**22.5**	**30**	**37.5**

CONSEQUENCE RATING	
HIGH 25.0–37.5	Operation should be selected for further discussion and mitigation actions
MEDIUM 12.5–25.0	Operation should be considered for detailed risk assessment but does not represent significant concern
LOW 0.5–12.5	Operation does not present major risks and does not require additional review

3.3 RISK ASSESSMENT ASSUMPTIONS

The most developed FOW concepts are based on horizontal axis turbines, coupled with components and processes very similar to those used in FBOW. The moorings, and export cable systems, although their application is novel in the context of the offshore wind industry, can partially rely on the experience gained from the offshore oil and gas industry.

3.3.1 Offshore activities

The installation methodology of a 15MW turbine installed at a quayside on a semisubmersible foundation was assumed, along with a wet-tow to site and connection to pre-installed moorings. This installation philosophy is largely applicable to many concepts but may require modifications depending on the type of foundation analysed (e.g. TLP, spar). Operations that were deemed to be specific to the concept of a semisubmersible foundation were commented separately for other concepts.

The areas and activities identified in the risk identification workshops are detailed in separate documents, as well as any suggestions for mitigating actions and required development.

3.3.2 O&M activities

The risk assessment for operations and maintenance was conducted under the assumption that a commercial scale floating offshore wind farm would be largely unmanned and controlled remotely. Therefore, the risks associated with failures and/or damages of the structure and the WTG components during operation would normally result in significant financial consequences but a small effect from a HSE perspective.

With the same base case as the onshore and offshore risk assessments of a semi-submersible turbine substructure, it was assumed that minor maintenance and repairs would be performed offshore with the platform being accessed by either vessels (CTVs and SOVs) or helicopters. Major interventions on the foundation structure and/or replacement of WTG blades and tower would be undertaken onshore upon disconnection and towing of the platform to the port.

4 CONCLUSION

This literature review provides an overview of the relevant Health and Safety (H&S) guidance, including from fixed-bottom offshore wind projects (FBOW) and Oil and Gas projects, and are expected to be relevant to future commercial-scale FOW projects. As demonstrated, there are a significant number of frameworks that commercial-scale FOW will be able to utilise, however most have not been developed considering the specificities of FOW.

The relatively small scale FOW deployment to date has meant that, where there are FOW-specific requirements, they mostly consider design considerations (such as structural requirements) rather than occupational H&S. There is therefore an opportunity to proactively develop guidelines that also consider occupational H&S and ensure these considerations as early as possible in the design phase.

This report has outlined where there are considered to be gaps in these frameworks, and have been categorised into three proposed groups:

- Platform motions during O&M
- Platform construction, transport and installation
- New geographies

It expected that the gaps can be covered through adapting existing frameworks, research and development, lessons learnt from early developments and working group initiatives to ensure commercial scale FOW projects are built with a H&S mindset.

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