JACK-UP RENEWABLE ENERGY GUIDELINES – EARLY DEVELOPMENTS

James N. Brekke
Brekke Offshore Consulting, LLC
Joost W. Janssen
GustoMSC
Alberto Morandi
GustoMSC

Abstract

With 20 years of experience and increasing activity in offshore wind, jack-up industry stakeholders have joined in a Joint Industry Program (JIP) on offshore wind farm (OWF) jack-ups. Under the administration of the Society of Naval Architects and Marine Engineers (SNAME), a group of over 30 organizations are participating in a two-year JIP named Jack-up Renewable Energy Guidelines (J-REG). The program is timely with the rapid scaling of offshore wind to meet ambitious worldwide targets by 2030 and beyond, with a growing number and size of wind turbines planned for installation and maintenance. Jack-ups have been the key building block to the successful installation and maintenance of those turbines.

This rapid scaling requires continued innovation underpinned by industry standards that mitigate the risks and contribute to a stable regulatory environment. The oil and gas (O&G) industry operates an extensive fleet of jack-up mobile offshore units (MOUs) with technologies and skills developed since the first such structures emerged in the 1950s and is a natural starting point in this process. Many features of these units have been successfully transferred to the OWF jack-ups used in the renewable energy space. The goal is to scale up renewable energies like offshore wind requiring aspects unique to OWF jack-ups to be addressed with this dedicated JIP effort. SNAME is in a privileged position to facilitate this process due to its long history supporting jack-up technology. Using this connection, this program will deliver a SNAME Technical and Research (T&R) Bulletin with guidelines that fill the "gaps". The broad objective is also to reduce non-productive time and to reduce risk in OWF jack-up operations.

The compelling case for development of OWF jack-up guidelines is highlighted by the differences in the functional requirements when compared to those for O&G. OWF jack-up operations are typically conducted over short periods of time at a site, typically 1-2 days per turbine location compared to 60-90 days for O&G jack-ups. These jack-ups also perform heavy lifts during turbine installation while O&G jack-ups conduct the different operations associated with drilling. The associated high frequency of rig moves and the heavy lift operations each significantly change the design and operational parameters of the jack-up. These and other requirements have caused the OWF jack-up to evolve into a 4-legged design that is self-propelled.

Key Words

Society of Naval Architects and Marine Engineers (SNAME), Offshore Wind Farm (OWF) Jack-up, Jack-up Renewable Energy Guidelines (J-REG), gaps, jack-up site-specific assessment (SSA), ISO standard, Jones Act, topic assessment, geohazards, metocean data, O&G jack-ups, mobile offshore units (MOUs)

Introduction

Considering Europe, USA and Asia, offshore wind capacity is expected to increase from 46 gigawatts (GW) by the end of 2021 to over 250 GW in 2030, with more than 23,000 turbines expected to be installed in that period, of which the majority will be bottom-fixed units. In addition, the offshore wind industry is in the early stages of globalization with major developers taking an interest in other countries. Brazil is in the initial stages of permitting over 3,400 offshore wind turbines to build 42 GW of capacity. Projects in Australia and other countries are under consideration.

The increased global demand for installation vessels will put pressure on the supply chain and the pipeline of projects is likely to tighten the supply of wind turbine installation vessel (WTIV) tonnage. In the US regulatory measures such as the Jones Act create space for alternative, feeder vessel solutions.

As a comparison the largest hydroelectric dam in operation (Three Gorges in China) has an installed capacity of 22 GW. In fact, it takes the 40 largest operating hydroelectric dams to match the installed capacity planned for offshore wind by 2050. The offshore wind industry is therefore aiming to scale up much faster than hydropower (and O&G) did. This will need to happen at a time when community and environmental expectations are vastly different and more stringent than in the early days of the hydropower and fossil fuel industries. Standards will play a key part in mitigating risk in this fast-paced development.

Since the emergence of OWF jack-ups, OWF jack-up designs and operations have largely been based on experience and guidance from the offshore oil and gas (O&G) and construction sectors. As discussed further, the SNAME T&R 5-5A (Ref. 1) suite of documents (Guideline, Recommended Practice, Commentary and Gulf of Mexico Annex) represent a pioneering compilation of knowledge and experience to guide the jack-up SSA and formed the basis of ISO 19905-1 (Ref. 2). Although there are many similarities between O&G, construction and OWF jack-ups, there are important differences. Some of these differences have been recognized and some codes or guidelines have been established or adapted to address them. However, many aspects remain under-addressed, hence the need for this JIP.

Courtesy GustoMSC

To address the unique aspects of OWF jack-ups when compared to O&G jack-ups, the J-REG JIP has engaged participants from many sectors, including offshore wind energy developers, jack-up owners/contractors, designers, classification societies, marine warranty surveyors, turbine manufacturers, rig movers, universities, consultants, and regulatory bodies. Funds have been contributed by the major players in the JIP and are being used to execute priority studies, while other participants are contributing in-kind. The planned collaboration is expected to be useful in gaining consensus on current practices and documenting them as industry guidelines.

J-REG was undertaken by the SNAME Offshore Committee Panel OC-10, *Ocean Renewable Energy*, in the subcommittee for *Offshore Wind Farm (OWF) Jack-Ups* (Ref. 1). The activities were initiated by GustoMSC and have been coordinated by Brekke Offshore Consulting starting with Phase I in the summer of 2019. Phase I activities delivered a proposal for Phase II to develop worldwide guidelines for site-specific assessment (SSA) of OWF jack-ups. Phase II is underway now and is the primary topic of this paper.

The deliverable from the J-REG JIP Phase II will be a SNAME bulletin that documents guidelines generated from gap assessments of priority topics. This bulletin will refer to existing industry jack-up SSA standard ISO 19905-1 (Ref. 2) (elevated condition) and upcoming ISO 19905-4 (Ref. 3) (installation and removal) and may later form an Annex to such documents. The purpose of the bulletin would be to supplement the ISO standards by filling in gaps that exist between jack-up SSA guidelines for O&G and OWF. The guidelines are expected to apply across various regions (Americas, Europe, Asia) with guidance that is common to these regions whenever possible.

History of O&G Jack-up Site-Specific Assessment Standards

The development of guidelines for SSA of OWF jack-ups is closely tied to the history of O&G jack-up SSA standards. This began with a JIP started in the late 1980's with the objective of developing a consistent standard for conducting jack-up SSAs of O&G jack-ups. The resulting deliverable was published as SNAME Technical and Research (T&R) Bulletin 5-5 (Ref. 1) in 1994 when the SNAME Offshore Committee Panel OC-7 was formed to maintain and further the publication. Both phases drew on a wide range of companies who were the industry stakeholders including operators, drilling contractors, warranty surveyors, designers, Class societies, and consultants. SNAME T&R Bulletin 5-5 has been used extensively in the offshore O&G industry and was widely adopted as a contractual reference.

In the late 1990's, after SNAME Bulletin 5-5 had been published and updates were being developed, an initiative was begun by ISO Technical Committee 67 Sub Committee 7, Work Group 7 (ISO/TC 67/SC 7/WG 7) to enlist many of the same industry professionals to develop an ISO standard using SNAME T&R Bulletin 5-5 as the basis. This initiative was successful in delivering a publication called ISO 19905-1 which supersedes SNAME T&R Bulletin 5-5 and is now the oil and gas industry's site assessment standard for jack-ups elevated on site.

In addition to ISO 19905-1, written for SSAs of elevated jack-ups, a document has now been written for the SSA of O&G jack-ups being installed and removed from a site. This is draft ISO 19905-4, and it covers the operations of moving the jack-up on and off location, content that had not yet been covered in a SNAME or an ISO document. The draft of ISO 19905-4 is nearing completion and has been made available to this JIP.

To summarize, SNAME T&R Bulletin 5-5, ISO 19905-1 and Draft ISO 19905-4 are the primary standards that will be discussed here as to how they will be used to provide guidance for the SSA of OWF jack-ups. This is also timely as ISO/TC 67/SC 7/WG 7 is looking into expanding its mandate to support offshore renewable energy as well as O&G.

Industry Guidance on OWF Jack-ups

During the initiation of the JIP Phase I and later during Phase II, the industry participants guided the JIP to deliver a SNAME bulletin within a two-year period. SNAME bulletins contain information only; that is, they contain no legal (Normative) requirements. This bulletin is to provide a supplement to ISO 19905-1 and the draft ISO 19905-4; therefore, it should refer to both the normative and the informative parts of the standards and provide guidance and recommendations to both parts. This SNAME bulletin is to be written in a way that is easily convertible to an ISO document in the future.

Additional guidance from the participants was as follows:

- Guidance will be developed using a joint-industry approach that affords expedited delivery when compared to a traditional all-volunteer approach. Besides expediting delivery, this should reduce the long-term burden on the participants.

- The bulletin will be applicable worldwide (Americas, Europe, Asia) so the bulletin will have guidance that is common to these regions wherever possible. The exception is that different site conditions in various regions will warrant emphasis on different topics. Examples are metocean data (and its availability), soil data (geohazards, problematic soils), and the presence of earthquakes in different regions of the world. During the process of developing the bulletin, if some issues arise that are specific to certain regions, regional annexes can be separately proposed to cover topics in greater detail in the future.

- This JIP covers jack-up SSA when elevated on location under operational and survival conditions and during installation and removal. As such, it would supplement the oil and gas standards ISO 19905-1 (elevated) and draft ISO 19905-4 (installation and removal). Gaining consensus among the participants on the aspects of SSAs would be important to align existing company assessment procedures. Although transit is not covered in any detail, it will be discussed briefly as part of the topic of moving to a safe location in preparation for a storm.

Early Developments from the JIP

Given the background above, the remainder of this paper describes early developments from the JIP as follows: 1) the JIP organization being used to deliver guidelines; 2) the aspects (gaps) identified for resolution; and 3) the early direction of the JIP's objectives and boundaries. As of this writing, 18 months remain in the JIP; thus, this paper is an interim report to the industry.

Evolution and Organization of JIP

Formation of J-REG JIP Phases I and II

To deliver the SNAME bulletin, the industry stakeholders showed a sufficient level of interest for a joint-industry program (JIP) approach to be selected by SNAME OC-10, the governing panel within the SNAME Offshore Technical and Research Committee.

A Phase I JIP was initiated in August of 2019 with eight participants electing to fund a work scope with fees covering coordination and administration fees only. Part way through this work scope, four additional participants joined to extend the work scope. The JIP Phase I funding participants included the mix of stakeholders as follows: developers (4), vessel contractors/owners (4), designers (2), Class societies (1), Class society/consultant/MWS (1). In addition to funding participants, 15-20 guest participants from universities (3), consulting firms, and marine warranty surveyors joined J-REG JIP Phase I. Late in Phase I, the name Jack-up Renewable Energy Guidelines (J-REG) was assigned to the JIP.

J-REG JIP Phase II initiated in April of 2021 and, as of this writing, has a roster of twelve funding participants and 21 guest participants. The mix of stakeholders includes a set of funding participants consisting of developers (5), vessel contractors/owners (4), designers (2), Class societies (1). In Phase II, the set of guest participants includes a broader cross-section of the industry including the sectors listed above and universities, marine consultants, geotechnical consultants, marine warranty surveyors, a rig mover, a turbine manufacturer, and a government agency.

Phase I Activities:

The J-REG JIP Phase I started with the objective of delivering a well-supported proposal for a Phase II JIP that would include proposals for outside studies (CTRs) and topic assessments conducted by discussion groups. The ultimate deliverable from Phase II would be supplemental guidelines in a SNAME bulletin. SNAME agreed to be the JIP administrator for both phases.

The activities in Phase I included general meetings of all participants and, part way through, smaller discussion group meetings on major categories identified by the participants. The discussion groups began "topic assessments" that set a blueprint for how to generate the supplementary guidelines. These topic assessments were set up to identify the need for outside studies, or CTRs. In Phase I, the work scope of the CTRs was agreed upon using participant questionnaires and review sessions. The funding participants then rated the CTRs to determine which would be initially funded in Phase II.

The discussion group names are as follows:

- Seabed Characterization and Geohazard Mitigation (SCGM)
- Elevated Suitability
- Rig Move Preparation
- Installation and Removal Operations
- Jack-up Designs

Two special CTRs were proposed to support the discussion groups' efforts as follows:

- A guidance document would be written to guide the discussion groups' efforts.

- A core editing group would edit and compile the draft guidelines produced for the SNAME bulletin, in preparation for future conversion to an ISO document.

Separately, the Phase I scope included writing of the terms and conditions that were ultimately agreed upon by all Phase II funding participants going forward. Also, a non-disclosure agreement (NDA) was written for all participants (funding participants and guest participants) to agree upon.

Publicity resulting from Phase I is included in References 4, 5, and 6.

Phase II Activities

The discussion groups were re-established with the new set of Phase II participants to continue conducting topic assessments to resolve gaps between WTI jack-ups and O&G jack-ups. The activity includes generating guidelines using 1) topic assessments supported by funded CTR deliverables and 2) topic assessments done without the support of CTRs as necessary.

In conducting topic assessments, the following steps are undertaken by a discussion group:

- List and review technical references relevant to this topic.
- Describe a "first cut" at current practice for WTI jack-ups related to this topic.
- Describe gaps comparing current practice for O&G and WTI jack-ups.
- Carry out the committee work and CTRs needed to agree on current "industry" practice.
- Agree how clauses in the ISO documents should be edited to document guidelines.

The interaction with CTRs is described as follows:

- As indicated above, some topic assessments are supported by funded CTRs (outside studies).
- The CTR teams deliver results to the discussion groups to review within topic assessments.

The discussion groups work with the following mix of membership:

- Discussion group leaders who manage the work to achieve the objectives
- Stakeholders who influence the guidelines with practical knowledge in operations and business
- Technical experts who influence the guidelines with specialized knowledge of the topics

Gaps Identified for Resolution

The J-REG JIP is intended to identify, study, and reach industry consensus in resolving the "gaps" between OWF jack-ups used for installation and maintenance of wind turbines and ISO standards for O&G jack-ups used for drilling oil and gas wells. Gaps are in two categories: 1) aspects that are missing in the ISO standards or 2) aspects in the ISO standards that are inapplicable to OWF jack-ups and therefore need to be supplemented and replaced.

At the early stages of Phase I, the major categories of gaps are identified below. These categories have been maintained throughout the JIP, although their descriptions have evolved as detailed below.

- **Frequency of installation and removal**
  O&G drilling operations are typically conducted at the same location for about 2-3 months. The site assessment process for OWF jack-ups is more challenging since OWF jack-ups conduct wind turbine installation operations at a frequency of one turbine location every 1-2 days and for each decision to move the jack-up weather windows need to be within the allowable limits. If the entire

wind farm has 100 turbine locations, the full installation could take between 3-7 months. To conduct this full installation, extensive site assessment is needed for seabed characterization and geohazard mitigation. This assessment should include an understanding of the OWF jack-up's ability to safely pre-drive during installation and to extract the legs during removal.

- **Heavy crane lifts**
  The increasing size of wind turbines lead to differing requirements for the cranes used on the OWF jack-ups. These differences in the lifting requirements exist in loads, heights, and durations. These differences have implications on the hull form, leg structure, and jacking systems. Four leg configurations are common and these use "pre-driving" when the vessel is being installed, which is a different procedure than "pre-loading" as used on 3-legged O&G jack-ups. As a result of the heavy lifts the loads on the foundation of the jack-up can approach the preload limits on a frequent basis which is different from O&G jack-ups where preload limits are only approached in severe weather conditions which are rare events.

- **Dynamic positioning for installation and removal**
  For OWF jack-ups, dynamic positioning is used for installation and removal at the turbine location. This is different from the anchor-assisted approach typically used for O&G. This difference is a result of the frequency of the moves between locations. Dynamic positioning has aspects that are governed by other existing standards/guidelines. This category is included to understand the gaps as well as the differing risks the installation and removal poses to the adjacent structure (and all infrastructure).

- **Severe weather procedures**
  Due to the OWF jack-up spending shorter periods on location, being closer to safe havens near shore, and having the ability to move off location and transit faster, opportunities might exist for reduced return period in the site assessment. This assumes legs can be pulled reliably. These issues may lead to differences in guidelines between OWF jack-ups and O&G jack-ups.

Within the major categories above, a set of gaps (topics) was identified between O&G and OWF jack-ups. The higher priority gaps are indicated in bold.

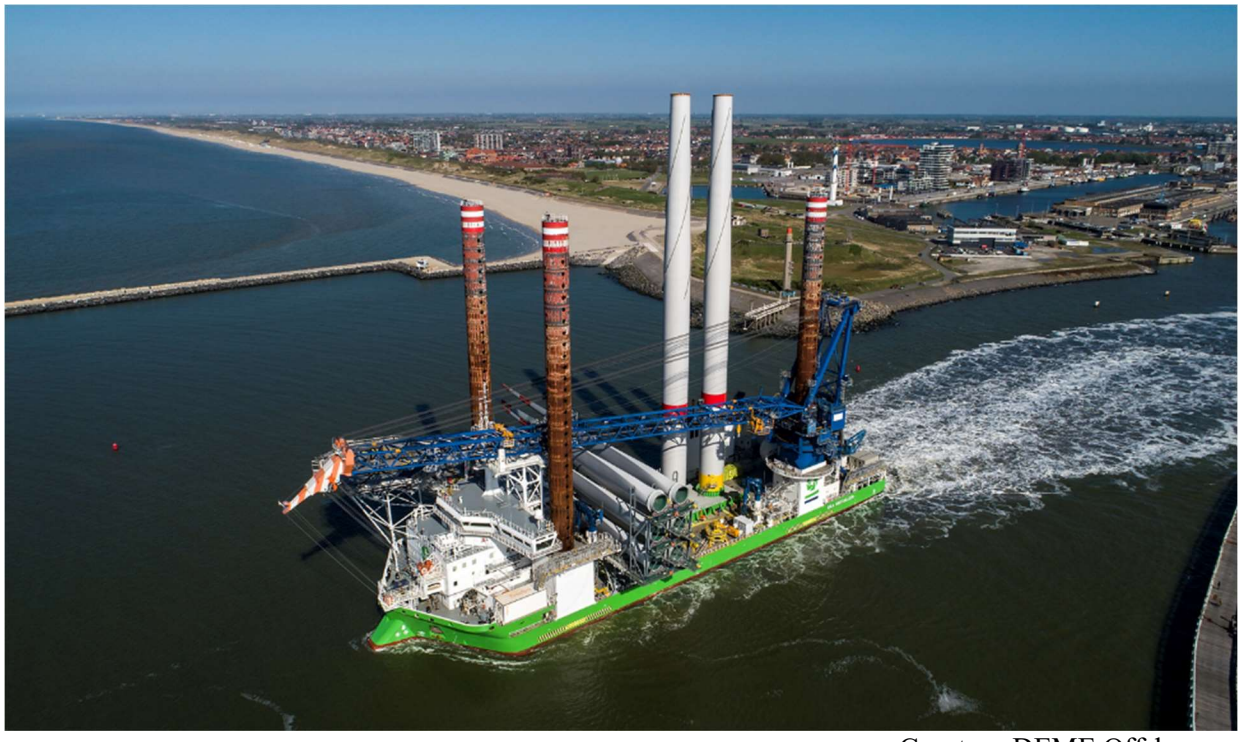
1. Data on past incidents, lessons learned and best practices
2. **Guidance on soil assessment data requirements making use of existing data gathering/modelling techniques used in the wind industry and recognizing the number of turbine sites for installation and maintenance**
3. **Guidance on geohazards such as shallow gas, buried channels, faults, fluid escape features, buried slopes, buried boulders, clearance requirements to cables, scour protection, and UXO**
4. **Information on the effect of seabed slope and boulders**
5. **Information on cyclic degradation for short term operations, like piling activities**
6. **Improvements in penetration predictions and establishment of a standard jacking log sheet to record spudcan installations and leg extraction performance for use throughout the industry**
7. Agreement between parties to share information on jack-up data and site data (metocean, soils, geohazards, infrastructure), that documents roles of each stakeholder
8. Maintenance of jacking data in a format that is practical and useful to share
9. **Guidance on a proper required survival return period for short, elevated operations typical for WTI jack-ups**

10. **Guidance on weather restricted operations for cases where the survival return period is not met**
11. **Guidance on assessment of elevated crane operational condition including foundation safety**
12. **Guidance on earthquake assessment and resilience requirement.**
13. **Guidance on installation/removal conditions, metocean conditions, and alpha factors**
14. **Guidance on preloading procedures, required preload time, measurement of the actual achieved preload, settlement rates, how to manage risk**
15. Whether and how to include liftboats in annex
16. Guidance on the assessment and operations of the DP system
17. Guidance for cylindrical legs or legs with no spudcans
18. Guidance for risk assessment to avoid of infrastructure with cables in place of pipelines
19. Guidance on rig move procedures
20. Guidance for running from large storms

Some of the gaps (topics) above have been addressed as CTRs during Phase II and are now funded for execution. Others are being assessed as topics in the discussion groups. The above list of gaps is not exhaustive. Other topics could be added to the list during Phase II as further gap identification takes place during review of ISO 19905-1 and 19905-4 together with industry experience.

Discussion of Objectives and Boundaries

As the J-REG JIP Phase II kicked-off, participants began a structured discussion to narrow the objectives and boundaries of the JIP going forward. This discussion has been used to engaged participants and establish a forum for communicating industry knowledge and experience. This section shows the early developments of the JIP based on this discussion.



Courtesy DEME Offshore

Objectives

As noted above, this JIP will provide guidelines for the site-specific assessment of jack-ups and associated operating procedures focusing on the differences between OWF jack-ups and O&G jack-ups. The objectives are as follows:

- Using gap analysis, identify, keep record of, and address the gaps in guidance between site-specific assessments and related operations of OWF and O&G jack-ups. The gap identification should focus on areas with potential improvements in safety or productivity.

- Reduce non-productive time and risk of OWF jack-up operations. This is achieved by gaining industry consensus on current practice for site assessments and related operational procedures to promote safety and practicality. Two examples are listed below.

    - Safely increase the operability of OWF jack-ups by establishing target reliabilities for certain operations and introducing the corresponding safety factors. Not all operations are amenable to this, but two potential examples are crane operations and pre-driving.

    - Assess the uncertainties and risk involved in the planning and execution of jack-up installation and removal at a site, with particular emphasis on pre-driving and leg extraction. Risk assessments would include the jack-up itself and the surrounding infrastructure.

Scope: Jack-up Types

The primary focus of the JIP should be on the jack-ups most critical to offshore wind farms. First would be the 4-legged jack-ups commonly used for installation and maintenance of offshore wind turbines and / or their foundations (see Reference 7, DNV-OS-C104 sec 8). A second jack-up of primary focus would be the feeder jack-ups that support the installation operations. These are listed below in bold as a) and b).

All jack-ups and liftboats in the wind energy developments could be included in this bulletin; however, the JIP work scope has boundaries. The vessels shown below as c) through f) can be addressed to an extent that depends on the interest of the participants and the ease of gathering guidance.

a) Jack-ups with 4 legs that install and maintain wind turbines and their foundations (those that pre-drive)
b) Feeder jack-ups supporting offshore wind farms
c) Jack-ups with more than 4 legs that install and maintain wind turbines (those that pre-drive)
d) Jack-ups with 3 independent legs supporting offshore wind farms (those that pre-load)
e) Liftboats supporting offshore wind farms
f) Jack-ups of all types used in harbor areas for construction of fixed and floating wind farms

Conclusions

This paper shows the early developments in a joint-industry program (JIP) entitled Jack-up Renewable Energy Guidelines (J-REG). This JIP follows a long history of industry work developing SNAME bulletins and ISO standards on oil and gas (O&G) jack-up SSAs. With the emergence of the offshore wind energy industry over the past 20 years the need has arisen for industry standards to supplement those in the O&G industry. To meet this need, a group of over 30 companies has come together in a JIP to address the industry need by contributing knowledge and experience from their individual companies. This paper reports on early developments from this program showing the JIP organization, the gaps to be addressed between OWF jack-ups and O&G jack-ups, and the group's early direction on their objectives and boundaries going forward.

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