

HAZID and Qualitative Risk Analysis (QRA) of Gangway-Based Personnel Transfers to Offshore Wind Turbine Structures

S Idrees¹ and O T Gudmestad^{1,2,*}

¹ Department of Maritime Studies, Western Norway University of Applied Sciences (HVL), Haugesund, Norway

² Department of Mechanical and Structural Engineering and Materials Science, University of Stavanger, Stavanger, Norway

* E-mail: otgudmestad@gmail.com

Abstract. The safe transfer of personnel to offshore wind structures in order to carry out maintenance activities remains a critical operation, especially in regions with severe environmental conditions, such as the Southern North Sea. Several methods exist for accessing OWTs; gangway-based Walk-to-Work (W2W) systems are widely used. However, crew transfer operations pose various challenges and severe risks to personnel safety and equipment. This paper presents a qualitative risk analysis to identify, evaluate, and mitigate hazards associated with W2W gangway-based personnel transfer operations by using a well-structured risk assessment methodology. In this study, two systematic approaches were used for hazard identification (HAZID). The first involves a detailed review of meeting notes from discussions with industrial experts from different offshore sectors. The second consists of an in-person HAZID session conducted with a group of professional engineers. Through these methods, a total of 78 hazards were identified and classified into different categories, i.e., human factors, environmental factors, design & engineering, operations, and health, safety & emergency preparedness. Several high and critical risks that require urgent mitigation strategies, including the emergency retraction of gangways and the failure to recover technicians from OWTs during adverse weather conditions, have been identified.

1. Introduction

The offshore wind industry has become an essential sector in the growth of renewable energy due to the world's growing need for alternative energy sources. Figure 1 [1] shows the projected annual installation capacity in the European Union (EU) from 2018 to 2030, where the dark blue and light blue colors illustrate the onshore and offshore wind installations, respectively. Due to considerable wind resources and geographic advantages, the Southern North Sea is highly favorable for further deployments of Offshore Wind Tower (OWT) installations.

According to [2], Offshore wind operations are complicated and pose many safety challenges due to long project cycles, severe environments, and complex vessel traffic at sea. With the rapid growth of offshore wind farms, there has been a strong demand to consider efficient techniques for operation and maintenance (O&M). Among many operations, including the transit of equipment and heavy lifts, the safe and effective transfer of personnel to or from vessels to OWTs is one of the most critical operations [3].

According to [4], 854 incidents were reported in 2018. Among all, 37 work process categories were available for selection by the G+ members. Figure 2 illustrates the top 10 work processes with the proportion of high-potential incidents that were identified.

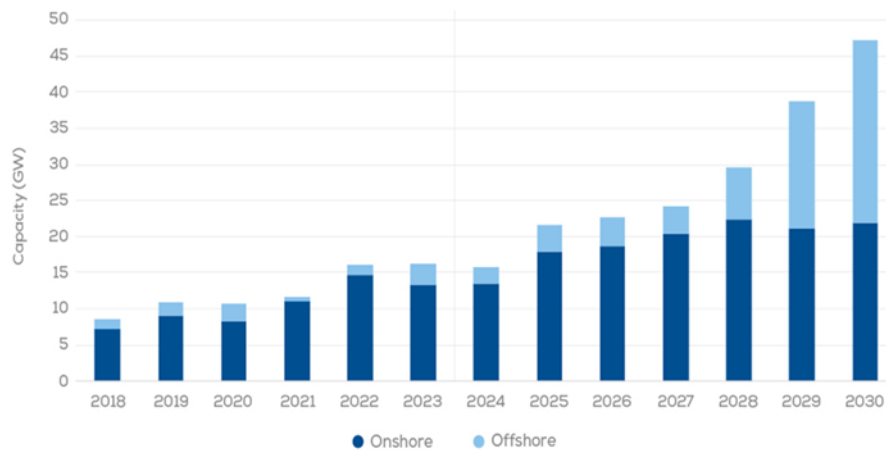


Figure 1. 2018-30 Annual onshore and offshore wind power installation capacity in the EU [1].

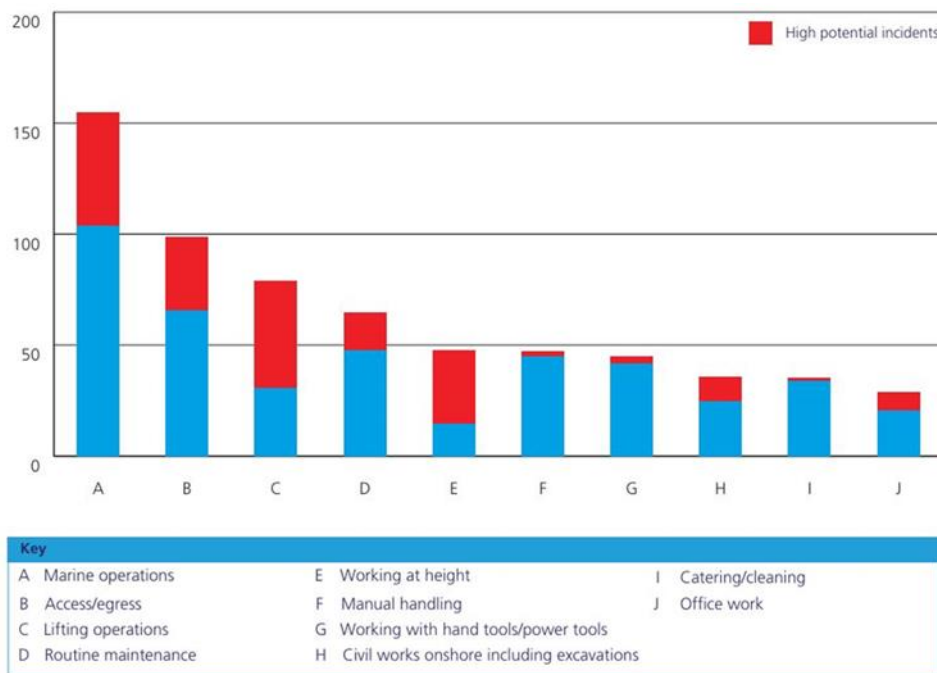


Figure 2. Top 10 work processes with the highest number of incidents reported [4].

It has been noted that out of 854 reported incidents, 99 were of access or egress (B) of personnel to or from the offshore structures. Out of these, 33% were considered high-potential incidents as they caused the highest chances of crew fatalities. However, several marine operations (A) may consist of diving operations, transfer and transit by vessels, and different vessel operations that are also involved in the transfer of personnel.

Advanced gangway systems are mounted on Service Operation Vessels (SOVs) and are used for personnel transfers to OWTs (Figure 3). These systems, especially the motion-compensated gangways, have been designed and developed to be used in harsh offshore environmental conditions as they compensate for the vessel motions caused by strong wind and high waves. Although these modern access systems can reduce the risks of falling and drowning as compared to the existing methods, due to technological innovations and advanced access systems, the transfer of personnel is still a high-risk and complicated operation.



Figure 3. Illustration of an SOV [5].

Furthermore, despite having significant wind resources, the Southern North Sea presents additional challenges due to the harsh weather conditions, such as rough seas and strong winds, which make a significant impact on transfer operations. These factors minimize the capabilities of gangway systems and increase the risks faced by operators during the transfer operation. Human factors such as a lack of operator training, making decisions under pressure, and poor communication on board further complicate this operation.

Due to the relationship between human factors, severe environmental challenges, and advanced systems, this requires a thorough understanding and investigation of the risks that are associated with this operation. Therefore, it is necessary to minimize risks and accidents to improve operational efficiency and ensure the safety of personnel involved in these critical activities.

A recent study carried out at Western Norway University of Applied Sciences, Haugesund [6], has evaluated the risks associated with the use of offshore gangway systems by:

- Conducting HAZID analysis for personnel transfer to offshore wind turbine operations.
- Emphasizing the subjectiveness of a HAZID.
- Identifying, summarizing, and categorizing the associated risks for personnel transfer operations.
- Applying Qualitative Risk Analysis (QRA) to evaluate the identified hazards.
- Proposing risk mitigation actions for identified hazards and their associated risk levels.

Highlights from the study are reported in the present paper.

2. Literature review

2.1 Overview of offshore wind operations and maintenance

The first OWT was commissioned in Sweden in 1990 [7]. The offshore wind industry has grown significantly since the start of the 21st century, and it continues to develop and shift further towards deep-sea water. Although significant numbers of OWTs are remotely operated from shore-based centres, regular inspections and repair work must be carried out for efficient wind operation. Offshore wind farms require regular inspection, maintenance, and repair work, which consists of many complex and expensive operations. According to [8], carrying out such activities, it could cost between 5 and 10 times more than similar work would have to be done onshore. The transfer of crew is a critical operation, as the maintenance crew has to walk to work (W2W) from one floating unit to another fixed or floating structure using a bridge access system [9].

2.2 Access methods to OWTs

Overall, there are three typical points to access OWTs to carry out inspection, maintenance, and repair work [10].

- A boat landing point, from where the crew members climb a ladder from sea level to reach the platform.
- An access platform, which is located on the top of a transition piece (TP) between the foundation and the wind turbine tower, from where the technicians can directly enter the tower by using the gangways mounted on the vessel.
- A helipad (basket) located on the top of the nacelle of the turbine. This will normally involve hoisting the personnel onto the helipad.

2.3 Personnel transfer methods

The transfer of equipment along with technicians is a critical operation because the downtime of a wind turbine maintenance and repair period is highly dependent on the efficient mode of transfer. The maintenance of OWTs requires several types of vessels to carry out work on-site. Over the years, crew transfer vessels (CTVs) and service operation vessels (SOVs), along with conventional or motion-compensated gangways and helicopters, have been used for transfer operations between the vessels and offshore structures [2]. Maintenance of OWTs must ensure the safe transit and transfer of equipment and crew from shore to the offshore wind farm, as well as lifting operations of equipment such as blades and the generator that need to be replaced. Access through gangways would be more challenging when connecting with Floating Offshore Wind Towers (FOWTs) compared to access to fixed structures.

Transfers through Crew Transfer Vessels (CTVs) are the most common solution for personnel transfer. This works simply by maintaining the frictional contact between the bow of the vessel and a fender mounted on the bow and the OWT boat landing location. The technicians climb onto the wind turbine from a ladder. Usually, these vessels are only certified to take a maximum of 12 technicians along with small spares and equipment [11]. However, the performance of CTVs is also highly affected by environmental conditions such as high waves. The transfer operation would be suspended when the wave height exceeds a certain threshold, e.g., a significant wave height of 2.0 meters.

SOVs are usually equipped with motion-compensated gangways for efficient and safe transfer operations to or from the OWTs. Currently, the majority of the SOVs used in the offshore wind sector are retrofitted vessels from the oil & gas industry, with permanently or temporarily installed motion-compensated gangways. Other systems, which are hydraulic gangways or active motion-compensated access devices, can also be installed on SOVs. These installed types of equipment help to counteract the relative motion of the vessel within the limits of the hydraulic system and have a higher working limit than fenders [12]. However, this equipment costs more than fenders that are used in Crew Transfer Vessel (CTVs) transfers.

2.3.1 Gangway types

In 2007, the first active motion compensation test was conducted near Hook of Holland, North Sea, which counteracts the six degrees of freedom motions by using hydraulic cylinders [13]. This first-type Lloyd-certified and DNV-approved gangway can transfer up to 20 people in less than five minutes from a vessel to fixed or floating OWTs [14]. According to [15], Barge Master introduced their first motion-compensated gangway in 2015, which could be mounted directly on the deck of a vessel.

Telescopic gangways consist of extendable sections that can adjust the length of the walkway to maintain a connection between vessels and OWTs. Telescopic gangways are often configured with motion compensation (active & passive) systems and provide additional flexibility for different heights. It can be attached through a gripper that maintains the gangway in its position with the boat landing point [11].

2.4 Challenges related to offshore personnel transfer

One of the most critical challenges to carrying out a safe transfer of personnel to or from the OWT structure is harsh weather conditions. This includes significant wave heights (H_s), strong currents, high wind speeds, and limited visibility, etc., which can affect the transfer operations. Due to these environmental factors, a higher possibility of delays in the maintenance activity may occur. Due to a longer period of waiting time to access and the loss of power generation of OWTs, the maintenance cost

may increase significantly. Furthermore, in case of emergencies, such as fire or sudden weather changes during equipment replacement, safe evacuation of technicians from the offshore wind structure is critical. OWTs that are installed far from onshore, rescue services may be delayed due to the long distance and limited accessibility to the site.

OWTs require regular inspection and maintenance activities to carry out continuous operations. According to [9], preventive maintenance for OWTs is reported to be 2 to 4 times per year. Additionally, to carry out regular inspections and repair work, technicians have to spend a long time on the structures in harsh weather conditions. Due to this, the offshore crew can feel physical fatigue, seasickness, and mental stress, which may lead to a delay in response and cause accidents during transfer operations.

Furthermore, human errors are one of the most common causes of accidents in offshore wind farms. This includes a lack of training, mistakes in judgment, and poor communication [16]. According to [17], several environmental factors, such as cold temperature and low visibility, may also affect human performance during offshore operations (Table 1).

Table 1. General cold environmental factors affecting human performance (HP)

Stressors	Details
Cold Temperature	Breathing difficulty, muscular stiffness, frostbite, lowered metabolism, hypothermia, bulky clothing
Ice ad-freeze	Stiffness of suits impairing movement, incapacitating mechanisms, slippery surfaces, adds weight/mass
Combined weather effects	Wind, snow, and waves impair human performance
Marine Ice	Precludes rapid descent to sea level, unstable for personnel movements
Low visibility	Ice, fog, lack of solar illumination, frost on windows, visor, glasses
Stress	Fear of disorientation

Offshore transfer operations are not only affected by harsh weather or human errors, but they can also be affected due to equipment failures, such as DP system failure, engine failure, and hydraulic or pneumatic failures in motion compensation gangways, etc. During the safe transfer operations, vessels need to maintain their position near the offshore structure. Failure in DP systems can cause severe accidents, including collision with the structure, emergency disconnection of the W2W vessel, and risk to the life of the maintenance crew [18].

2.5 Regulatory framework and industry standards

Personnel transfer operations to offshore wind structures are carried out under several international conventions, regulations, codes, and standards. These frameworks provide detailed guidelines for DP operators, gangway operators, transferees, and safe transfer systems such as gangways and operational vessels, etc., to ensure compliance with design, operational, and maintenance requirements.

The following EU directives have been established to ensure operational safety and competency:

- Directive 2014/90/EU and Regulation (EU) 2024/1975 [19], providing safe design, construction, performance, and testing.
- Directive 2012/35/EU, providing requirements of minimum training requirements and competency standards for seafarers [20].

The following international regulations and conventions aim to enhance the safety of personnel, service vessels, and gangway equipment:

- SOLAS, an international agreement established by the IMO to improve the safety of life at sea [21].
- IP-Code 2022. This IP code focuses on the safe transfer of industrial personnel and provides the minimum safety requirements for the vessels that are used to transport them to or from offshore structures [22].

- STCW – 1978, The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers was adopted by IMO in 1978. It provides minimum training and certification requirements for seafarers according to their role on board [23].

Classification society standards represent important documents providing operational and safety requirements for offshore gangways, used for personnel transfer operations.

- An example is DNV-ST-0358 [24].
- Industry Best Practices documents represent the state of best practice:
- IMCA M254 provides guidelines for safe walk-to-work (W2W) operations between vessels and offshore structures using gangways [25].
- The Global Wind Organization (GWO) has developed a standardized safety training for wind industry professionals to minimize the risks due to the remote location of work and the higher possibility of risks. [26].

3. Risk assessment for offshore personnel transfers

3.1 Definitions used

According to the International Organization for Standardization (ISO), a risk is simply defined as the combination of the probability of an event and its negative consequences [27]. It can also be represented in the form of an equation:

$\text{Risk} = \text{Probability} * \text{Consequences}$

A hazard can be defined as a potential source of harm. These potential harms may be related to the loss of life or damage to health, the environment, or assets, or a combination of these [28]. In offshore W2W transfers, hazards such as a lack of operator training, language barriers, limited transfer locations on OWTs, and severe weather conditions, etc., can pose risks to life and cause fatalities during transfer operations.

An accident can be defined as a sudden, unwanted, and unplanned event or a sequence of events that leads to harm to people, the environment, or other tangible assets [29].

According to [28], a risk evaluation is a judgment, on the basis of risk analysis and risk acceptance criteria, of whether a risk is tolerable or not. In this step, the degree of risk is assessed by using a risk matrix for associated hazards to prioritize and mitigate them.

3.2 Identified hazards in offshore W2W transfers

Relevant key hazards for offshore W2W transfers are listed in Tables 2 to 6 below.

Table 2. Hazards caused by human factors.

Hazardous Event	Consequences
Lack of operator training	Higher possibility of an accident during gangway operation.
Language barrier on board	Miscommunication leads to potential collisions and risks to life.
Crew fatigue and health issues	Human errors may increase, or alertness may decrease.
Gangway operator certification	Safety standards compromised.
Lack of seasickness awareness / or training	Physical discomfort increases and affects operational efficiency.

Table 3. Key hazards involving environmental factors.

Hazardous Event	Consequences
Adverse weather conditions (e.g., strong wind, high waves, fog)	Impact DP capacity and gangway stability. Serious risk of injury or falls during the transfer operation. Unable to attach the gangway to recover technicians on OWT.
Turbine movement (FOWTs)	Severe access challenges and difficulty in tracking the DP vessel to FOWTs.

Table 4. Key hazards involving design & engineering factors.

Hazardous Event	Consequences
Complex gangway design	Difficult transfer operation due to stairs and the complex layouts of the gangway.
Gangway stability issues	Poor gangway locking systems cause serious personnel safety concerns.
Failure of the gangway control system	Loss of control due to the system failure of the gangway.
Collapse due to mechanical/hydraulic or structural failure	Risk due to falls, drowning, or trauma from height during transfer operations.

Table 5. Key hazards associated with transferring operations.

Hazardous Event	Consequences
Sudden vessels roll and pitch	Risk of falling on the gangway during transfer.
Uncontrolled movement of the load being transferred	Major injury or fatality risk if the load swings or drops onto personnel during transfer operations.
Mis-landing or gangway connection errors	Risk of fall from height due to incorrect gangway positioning.
Emergency retraction of the gangway during transfer	Personnel may fall if the gangway retracts during motion, especially when the DP system fails.
Incorrect placement of the gangway operator	High risk of collision.

Table 6. Key hazards affecting health, safety & emergency preparedness.

Hazardous Event	Consequences
Entrapment between the moving parts of the gangway	Severe injury (e.g., loss of fingers) may occur if hands are placed mistakenly during gangway retraction.
Overhead equipment dropping onto personnel	Higher risk of major injury or fatality from falling objects.
Unauthorized personnel near the moving parts of a gangway	Severe injury or risks from crushing by moving gangway components.
Lack of an emergency response system	Delays in evacuation or medical assistance can cause severe injury or sudden illness.
Insufficient medical care on the vessel	Delays in treatment for sick or injured personnel can cause fatalities.

HAZID data were obtained from a summary of meetings that were discussed among technical experts from different types of offshore companies. These professionals shared their concerns, including the operational challenges and safety observations related to W2W gangway-based personnel transfer operations based on their practical experience and knowledge. Furthermore, a HAZID session was conducted to identify the hazards, possible threats, existing barriers, initial & residual risks, and mitigating actions that could minimize the likelihood and consequences.

Each hazard was, thereafter, assessed in four impact areas to provide detailed information on hazards and their impact (Table 7).

Table 7. Hazard consequence areas.

Impact Area	Definition
People	Risks that can directly affect the safety of the personnel that is involved in the operation.
Asset	Risks that can affect the equipment, such as vessels, gangways, and offshore structures.
Environmental	Risks that can impact the natural environment, including the ecosystems.
Reputation	Risks that can impact the public perception and trust in the organization.

A 5x5 risk assessment matrix was used to evaluate the associated risks (Table 8). The matrix includes:

1. Likelihood levels: 1 (extremely rare) to 5 (very frequent).
2. Consequence severity: 1 (no injury or minor impact) to 5 (fatality or severe impact).

Table 8. Risk matrix used for hazard evaluation in this study.

Severity	Consequences				Increasing likelihood				
	People	Asset	Environment	Reputation	1	2	3	4	5
					Extremely rare occurrence (never reported in the offshore wind industry)	Rare occurrence (reported but highly unlikely)	Occasional occurrence (has happened in offshore wind transfers)	Frequent occurrences (have happened multiple times in a specific location)	Very frequent (happens regularly in offshore wind personnel transfers)
1	No injury or health effect	No damage	No effect	No impact					
2	Minor injury (e.g., small cuts, bruises)	Slight damage	Slight effect (oil spill, less disturbance)	Slight impact (managed internally, no media attention)					
3	Minor injury or health effects (e.g., fractures)	Moderate damage	Moderate effect (disruption to marine life, minor fuel spill)	Moderate impact					
4	Major injury or health effects (e.g., serious fractures,	Significant damage	Significant impact	Significant impact (public & regulatory attention)					
5	Fatality or permanent total disability	Major damage	Major effect (long-term contamination, disruption in the ecosystem)	Severe impact (shutdown risk, legal actions)					

The combined likelihood and consequence ratings of each hazard define the overall risk level, which is described along with colour grades in Table 9.

Table 9. Risk ratings and colour gradings as used for the risk evaluation.

Color grading	Score	Description
Low Risk	1 to 4	Acceptable risk, managed through standard procedures.
Moderate Risk	5 to 9	Requires monitoring and minor mitigations.
High Risk	10 to 17	Requires significant control measures.
Critical Risk	18 to 25	Unacceptable risk, immediate action required.

Moderate and high-risk situations require risk reduction to As Low As Reasonably Practicable, according to the ALARP principle in risk analysis. Once the identified hazards were evaluated using the risk matrix approach, appropriate mitigation actions were suggested to reduce the risk levels of high and critical hazards. The mitigation measures were concluded from both the notes of meetings with industrial experts and the in-person HAZID session, conducted with professional engineers.

4. Analysis and mitigation of high and critical hazards

This section presents hazards that were identified as high or critical risk based on the risk acceptance criteria using a risk matrix. This includes a brief description of hazards and mitigation actions that were proposed to reduce the risk level by considering the ALARP principle.

4.1 Turbine blade movement during transfer (critical)

Movement of turbine blades during the personnel transfer operations may lead to the collapse of the attached gangway. There is a higher possibility that the transferring personnel may fall from a height. This hazardous event was ranked as a critical risk (red), which needs to be reduced as low as reasonably practicable.

The following risk mitigation strategies were proposed:

- Ensure that permit-to-work (PTW) and lock-out/tag-out (LOTO) procedures are strictly followed before starting the transferring operations to OWTs.
- A turbine blade strike analysis shall be performed for each specific type of vessel before entering the wind farm area.

4.2 Failure to recover personnel due to severe weather (critical)

In severe weather conditions, connecting the gangway to the offshore wind structure may be difficult. There is a higher possibility that the technicians may be stranded on OWTs. This hazardous event was ranked as a critical risk (red). The following risk mitigation strategies were proposed:

- Review the metocean data, including at least a three-day forecast, before the W2W vessel leaves port to ensure that the weather conditions are within safe operational limits.
- Man-overboard drills must be regularly conducted to train the transferring personnel to deal with emergency scenarios effectively.

4.3 Emergency retraction of gangway (critical)

Due to DP system failure or severe motion of the W2W vessel, an emergency retraction of the gangway may lead to the falling of the transferring crew from a height. During the HAZID session, this hazardous event was ranked as a critical risk (red). The following risk mitigation strategies were proposed:

- Offshore technicians, DP, and gangway operators must be trained continuously to handle emergencies, including detachment from offshore structures.
- Transferring personnel should avoid using earplugs or ear defenders when moving through W2W gangways to ensure awareness of alarms and emergency signals.

4.4 Environmental impact on DP and gangway stability (high)

High waves, strong winds, and low visibility may impact the DP system capacity and the stability of the gangway, which may have a high probability of collisions with the offshore wind structures. This hazardous scenario was ranked as a high-risk (orange) event. The following risk mitigation actions were suggested:

- W2W gangways should be designed according to DNVGL-ST-0358 or an equivalent standard, and criteria for significant wave height and wave periods must be considered.
- Ensure that the IMCA guidelines are strictly followed during transfer operations.
- Personnel transfer operations should be performed within the defined operational limits.

4.5 Lack of system redundancy (high)

The failure of a single system component, including the DP system, may lead to operational failures and present severe risks to personnel's lives. This hazardous event was ranked as a high risk (orange). The following risk mitigation actions were proposed during the HAZID session:

- Implement full system redundancy in all gangway-related systems.
- W2W vessels used for personnel transfer operations should be at least DP2 class.

- Regular maintenance and testing of backup systems should be performed before carrying out transfer operations.

4.6 Subjectivity of the HAZID methodology

Although the HAZID approach provides valuable insights into operational risks, it is necessary to recognize its inherent limitations and variability, specifically because of its reliance on expert judgment. It is important to understand that the HAZID methodology is subjective because it mainly depends on expert opinions to identify the hazards and assess the associated risks. In this study, the participants were industrial professionals and experienced engineers from different offshore sectors with a background in engineering, technical safety, and offshore operations.

To carry out an effective hazard identification and risk assessment process, the group of participants shall be competent professionals. However, their background and expertise can make an impact on the results of the study. While the same group of participants evaluates different types of offshore projects, their background and approach may lead to similar safety recommendations within different project types. For instance, a group of engineers may prioritize technical safety issues, while a group of economists may focus on the financial risks of the project.

5. Conclusions

This paper has presented the main findings from HAZID and risk assessment approaches conducted for offshore W2W personnel transfer operations. Several key hazards pose high or critical risks. These have been described in detail, along with their mitigation measures based on the ALARP (as low as reasonably practicable) principle. Additionally, the subjectivity of the HAZID methodology has also been discussed. Hazard identification sessions before executing offshore W2W operations are, however, recommended to ensure safe access to offshore wind turbines for repair and maintenance. The information presented in the paper would hopefully provide support to the hazard identification sessions.

References

- [1] WindEurope. (2024). Wind energy in Europe: 2023 Statistics and the outlook for 2024-2030. <https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2023-statistics-and-the-outlook-for-2024-2030/>
- [2] Mou, J., Jia, X., Chen, P., & Chen, L. (2021). Research on the Operation Safety of Offshore Wind Farms. *Journal of Marine Science and Engineering*, 9, 881. <https://doi.org/10.3390/jmse9080881>
- [3] Ren, Z., Verma, A. S., Li, Y., Teuwen, J. J. E., & Jiang, Z. (2021). Offshore wind turbine operations and maintenance: A state-of-the-art review. *Renewable and Sustainable Energy Reviews*, 144, 110886. <https://doi.org/10.1016/j.rser.2021.110886>
- [4] G+ Global Offshore Wind Health & Safety Organisation. (2019). 2018 incident data report. Published by Energy Institute, London. https://www.gplusoffshorewind.com/_data/assets/pdf_file/0005/638861/PDF-G-2018-incident-report.pdf
- [5] ABB. (2018, May 30). ABB to equip high-spec service operations vessel for the world's largest offshore wind farm. News. <https://new.abb.com/news/detail/51620/abb-to-equip-high-spec-service-operations-vessel-for-the-worlds-largest-offshore-wind-farm>
- [6] Idrees, S. (2025). HAZID and Qualitative Risk Analysis (QRA) of Gangway-Based Personnel Transfers to Offshore Wind Turbines in the Southern North Sea. M.Sc. Maritime Operations, Western Norway University of Applied Sciences
- [7] Sun, X., Huang, D., & Wu, G. (2012). The current state of offshore wind energy technology development. *Energy*, 41(1), 298–312. <https://doi.org/10.1016/j.energy.2012.02.054>
- [8] van Bussel, G., & Zaaier, M. (2001). Reliability, Availability, and Maintenance aspects of large-scale offshore wind farms: A concept study. *Proceedings of MAREC*, 113. https://www.researchgate.net/publication/239589238_Reliability_Availability_and_Maintenance_aspects_of_large-scale_offshore_wind_farms_a_concepts_study

- [9] Gudmestad, O. T., & Viddal, S. (2022). Personnel transfer from vessel to offshore floating wind turbine. In Book: Trends in Renewable Energies Offshore (pp. 517–523). CRC Press. <https://doi.org/10.1201/9781003360773-59>
- [10] Savenije, L. B., & Katsouris, G. (2016). Offshore Wind Access 2017. Prepared by TNO. Published by ECN, ECN-E-16-013. <https://resolver.tno.nl/uuid:547fcb60-2a93-489b-9db0-7fbf2aef404b>
- [11] Hu, B., Stumpf, P., & van der Deijl, W. (2019). Offshore Wind Access, TNO 2019 R10633. Report 2019. <https://publications.tno.nl/publication/34634066/MqvM2m/TNO-2019-R10633.pdf>
- [12] Guanche, R., Martini, M., Jurado, A., & Losada, I. J. (2016). Walk-to-work accessibility assessment for floating offshore wind turbines. Ocean Engineering, 116, 216–225. <https://doi.org/10.1016/j.oceaneng.2016.03.013>
- [13] Cerda Salzmänn, D. J. (2010). Ampelmann—Development of the Access System for Offshore Wind Turbines [PhD Thesis, Delft University of Technology]. <https://repository.tudelft.nl/record/uuid:28576ef7-dee4-4ab4-a824-36f7b94ab21f>
- [14] Ampelmann A-type. (2007). <https://www.ampelmann.nl/systems/a-type>
- [15] Dighe, V. V., Pergod, L., & Yung, C. (2022). Offshore Wind Access, TNO 2022 R12419. Report 2022. <https://publications.tno.nl/publication/34640428/gNMAGS/TNO-2022-R12419.pdf>
- [16] Wozniakowski-Zehenter, M. (2023). Offshore wind farm safety—Approaching and leaving the wind turbine. <https://www.identecsolutions.com/news/offshore-wind-farm-safety-approaching-and-leaving-the-wind-turbine>
- [17] Abaei, M., Arzaghi, E., Abbassi, R., & Garaniya, V. (2017). Human Error Risk Assessment Model for Shipping Maintenance Procedures in Harsh Environments. 3rd Workshop and Symposium on Safety and Integrity Management of Operations in Harsh Environments (C-RISE3). <https://www.researchgate.net/publication/320780725>
- [18] DNV. (2019). Safe Termination of DP Operations using Battery Hybrid DP Systems, Report prepared and published by DNVGL [Det Norske Veritas DNVGL-2019-1240, Rev. 0]. https://www.havtil.no/contentassets/a55a1f92db42492ebadc33757a3b528b/dnv-gl-report-no.-2019-1240_rev-00_safe-termination-of-dp-operations-using-battery-hybrid-dp-systems.pdf
- [19] European Commission. (2024). Commission Implementing Regulation (EU) 2024/1975 of 19 July 2024, laying down rules for the application of Directive 2014/90/EU on marine equipment and repealing Regulation (EU) 2023/1667. Official Journal of the European Union, L 1975. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401975
- [20] European Parliament & Council. (2022). Directive (EU) 2022/993, Minimum level of training of seafarers (codification). Official Journal of the European Union, L 169, 45–88. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022L0993>
- [21] SOLAS. (1974). International Convention for the Safety of Life at Sea (SOLAS) 1974. <https://treaties.un.org/doc/Publication/UNTS/Volume%201184/volume-1184-I-18961-English.pdf>
- [22] IMO. (2022). Resolution MSC.527(106): International Code of Safety for Ships Carrying Industrial Personnel (IP Code), Adopted on 10 November 2022. [https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MSCResolutions/MSC.527\(106\).pdf](https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MSCResolutions/MSC.527(106).pdf)
- [23] IMO. (1995). International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, 1978, as amended in 1995. <https://www.samgongustofa.is/media/english/STCW-Convention-1995.pdf>
- [24] DNV. (2022). Det Norske Veritas DNV-ST-0358 Offshore gangways, Edition September 2017, Amended July 2022. <https://www.dnv.com/news/bridging-the-gap-dnv-gl-launches-first-standard-for-classification-of-offshore-gangways-49236/>
- [25] IMCA. (2020). International Marine Contractors Association: Guidelines for walk-to-work operations, Rev 0.1. <https://beta.imca-int.com/resources/technical-library/document/8bc53e5f-c55b-ee11-8def-6045bdd0ef2e/>
- [26] GWO. (2024). Global Wind Organization: Basic Safety Training Standard (BST), Version 18. <https://cdn.prod.website->

files.com/5ce6247122f44f06d8edebbb/667974cdeac78a9c777318f0_BST%20V18%20240624%20Final.pdf

- [27] Council of Europe. (2025). Concept of Risk—European and Mediterranean Major Hazards Agreement. European and Mediterranean Major Hazards Agreement. <https://www.coe.int/en/web/europarisks/concept-of-risk>
- [28] NORSOK Z-013. (2010). NORSOK Standard: Risk and emergency preparedness assessment. Standards Norway, Oslo, Norway.
- [29] Rausand, M. (2013). In the book: Risk assessment: Theory, Methods, and Applications (Vol. 115). John Wiley & Sons.