BLUE ECONOMY
COOPERATIVE RESEARCH CENTRE

Australian Government
Department of Industry, Science, Energy and Resources

AusIndustry
Cooperative Research Centres Program

SHORT SUMMARY

1.20.004 Multi-Purpose Offshore/High Energy Platforms: Concepts and Applications

INTRODUCTION

This project focused on identifying potential opportunities and challenges between the energy and aquaculture sectors through reporting on novel multi-purpose offshore platform (MPOP) concepts and pilot projects recently developed worldwide to address the challenges of offshore seafood and energy production, and enable leveraging the benefits of co-location, vertical integration, infrastructure, and shared services.

This project also sought to shed light on the limitations structural reliability analysis methods employed for assessing the structural safety of novel MPOPs. It addressed the current status and future directions for structural reliability analysis of a novel MPOP considering Australia's unique environment.

KEY POINTS

- Current marine renewable energy and aquaculture practices would require large structures to be installed offshore.
- Included in these prospects for blue economy growth is the co-location and/or integration of both seafood and renewable energy production systems.
- MPOPs, whether they are integrated or co-located, can be a viable option for future developments in Australia. However, they must be cost-effective, reliable and have a minimal impact on the ecosystem.
- The offshore oil and gas industry provide lots of lessons to learn, data to use, and design engineering standards and tools to adapt for designing reliable MPOPs.

THE CHALLENGE

The realisation of MPOPs requires different actors to co-operate which could slow down the development and making implementation difficult. The different technologies and sectors are of differing maturity level, which could be a barrier for development. Likewise, the governance issues that arises when combining operations from different industrial sectors adds to uncertainty and could potentially slow down implementation.

THE OPPORTUNITY

Multi-purpose offshore platforms can decrease the impact on the environment compared to several single-use platforms by reducing the footprint of the operations and thereby optimising maritime spatial planning and by sharing infrastructure, resources and services which could offer significant benefits in terms of economic performance.

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OUR RESEARCH

Research Objectives

This scoping study project focused on identifying potential opportunities and challenges between the energy and aquaculture sectors, by reporting on novel MPOP concepts and pilot projects recently developed worldwide. All such initiatives seek to address the challenges of offshore seafood and energy production, and enable leveraging the benefits of co-location, vertical integration, infrastructure, and shared services. This study also aimed at shedding light on the limitations of structural reliability analysis methods employed for assessing the structural safety of novel MPOPs. It discussed the current status and future directions for structural reliability analysis of a novel MPOP, considering Australia's unique environment.

Our Approach

The project multidisciplinary research team specialised in offshore engineering, risk and reliability and marine biology conducted a systematic literature review of the state-of-the-art challenges and opportunities of offshore aquaculture farms and renewable energy systems to assess their feasibility in Australia as a case study.

A comprehensive review of the past and existing pilot projects of multi-use concepts was conducted to identify technological research gaps in terms of integrated/co-located marine renewable energy and aquaculture farming, and survey perspective of such offshore aquaculture platforms and their associate facilities and support systems, critical components and their potential failure modes.

Multi-Use Concepts

Multi-purpose offshore platforms can be defined as compatible applications combining multiple functions within the same infrastructure, share the same space, or occur at the same time. Multi-purpose offshore platforms can be realised via two approaches, namely co-location, and integration. Co-location mainly involves moving two or more platforms close together without physically connecting them to share benefits such as logistics, sea space, etc. Integration, on the other hand, is defined as hybrid use of a single structure for different purposes, e.g., aquaculture, wind, and wave.

Review of Multi Use Pilot Projects

Multi-use concepts with integrated energy and aquaculture have been studied by several EU projects such as TROPOS, MERMAID, H2Ocean, Aqua Wind Power and OOMU projects. The available experience and knowledge gained through these projects can be of significant help for developing MPOP concepts in Australia.

Risk and Reliability

An integrated system such as a MPOP would operate in an extremely uncertain offshore or nearshore environment. The uncertainty of the influencing parameters such as wave and wind models must be considered in deriving the stress distribution caused by the environmental forces over the structural components. As an example, Figure 1 shows some of the influencing random parameters in reliability assessment of offshore wind turbines and aquaculture structures.

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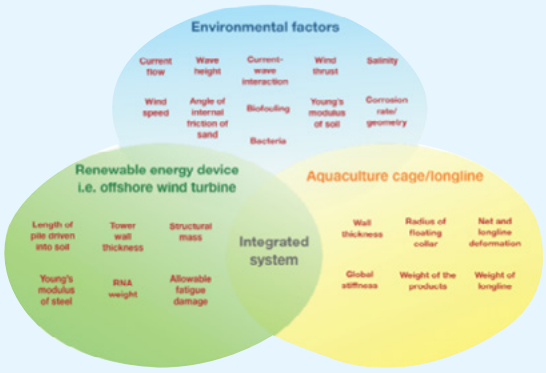

Figure 1. Examples of random parameters affecting reliability of an integrated floating aqua-wind system.

OUTCOMES

Innovative integration methods on a commercial basis for marine renewable and aquaculture sectors are still in their infancy, as there are many unknown aspects and limitations regarding the operational and technical issues which may threaten human safety, the environment, and assets.

Even though site selections of a multi-use ocean space have been extensively studied in the literature, only a few studies have focused on different frameworks for integrating the structural limitations of specific design concepts into the geographic information system (GIS)-based site selection tools.

It should also be considered that the transition of aquaculture systems from sheltered to more exposed culture environments is in a relatively nascent stage of development – much is still to be learned about how animal welfare and system suitability are affected by these increasingly challenging environments, and novel approaches are continuously being developed e.g., a submersible aquaculture system.

Accurate reliability assessment of MPOPs would not be possible without dealing with challenges regarding flexibility of structural components, unique structural features of renewable energy and aquaculture systems, high level of non-linearity, multi-scale features, etc. that make load analysis of the intended system difficult.

NEXT STEPS

Failure modes specific to the novel design of MPOPs must be identified, formulated, and studied considering the dependencies among the corresponding failure mechanisms. Uncertainties which exist within the models, environmental and design parameters, deterioration processes, and geometries must be quantified and incorporated into the reliability assessment accurately.

By incorporating the reliability analysis results into a decision-making framework, asset managers would be provided with a powerful, accurate and easy-to-interpret tool to decide on the maintenance planning of their assets in both the short and the long-term.

The current design standards being used for the design of marine structures should be revised to include a system-based reliability approach based on the specific requirements of aquaculture and offshore renewable energy industries. The revised standards would be adapted from the conventional offshore oil and gas industry standards in terms of construction materials, structural features, failure modes, health monitoring requirements and reliability targets of the MPOPs.

Finally, it is recommended to conduct a workshop for the selection of the best concept of potential MPOPs identified in this project for further R&D projects considering site-specific conditions. Prospective projects by the CRC will involve several stakeholders across various disciplines and perspectives, each with unique sets of criteria for feasibilities of future projects.

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PROJECT REPORTS/PUBLICATIONS

ARYAI, V., ABBASSI, R., ABDUSSAMIE, N., SALEHI, F., GARANIYA, V., ASADNIA, M., BAKSH, A.-A., PENESIS, I., KARAMPOUR, H., DRAPER, S., MAGEE, A., KENG, A. K., SHEARER, C., SIVANDRAN, S., YEW, L. K., COOK, D., UNDERWOOD, M., MARTINI, A., HEASMAN, K., ABRAHAMS, J. & WANG, C.-M. 2021. Reliability of multi-purpose offshore-facilities: Present status and future direction in Australia. Process Safety and Environmental Protection, 148, 437-461.

ARYAI, V., BAKSH, A., ABDUSSAMIE, N., ABBASSI, R., SALEHI, F., GARANIYA, V., WANG, C.M., HAN, M. (2020). Multi-Purpose Offshore/High Energy Platforms: Concepts and Applications, P.1.20.004 – Final Project Report. Launceston: Blue Economy Cooperative Research Centre.

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