Vard Design AS

Result report

PIEZO: Plug-In Electric Zero-emission Offshore-ship

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CONTENT

BACKGROUND AND OBJECTIVES

PIEZO is a research project funded by the Research Council of Norway (NFR pr.no. 309931) under the "Innovation Project for the Industrial Sector" scheme in the MAROFF2 program. The project commenced in 2020 and is scheduled to conclude in 2023. The project is led by Vard Design, the remaining consortium members are Vard Electro, Corvus Norway, Equinor, and SINTEF Ålesund. Furthermore, the project is supported by Solstad Offshore.

The project's primary objective is to develop a concept for a plug-in electric platform supply vessel (PSV), sailing emission free and charging offshore.

Secondary objectives:

1. Methods to capture the actual operating profile from an operational PSV and its relationship to environmental conditions (WP1)
2. Development of data-driven (surrogate) models of energy consumption for the ship sub-systems, based on onboard measurements (WP1)
3. Validation of digital twin simulation models (WP2)
4. Identify energy efficiency measures to incorporate into a plug-in electric PSV(WP2)
5. Methods to optimize operational capability, energy storage requirements and cost of a plugin electric PSV (WP2)
6. Development of smart energy management systems and operating strategies (WP3)
7. Evaluate solutions for safe offshore charging operations (WP4)
8. Development of a new hardware/plug solution for offshore charging (WP5)

ACHIEVED RESULTS AND EXECUTION OF CENTRAL R&D TASKS

The project has successfully demonstrated technical and economic feasibility of the primary objective, a plug-in electric platform supply vessel (PSV), sailing emission free and charging offshore.

The validation of the concept and development of a new PSV-design for battery electric operation is based on thorough studies of current PSV operations and energy consumption, validated numerical simulation models of the ship energy system and research on technical and operational solutions for offshore charging.

Notes on how we have met our secondary objectives in cooperation with partners and research environments:

1. In cooperation with Solstad Offshore we have collected logged data from the IAS system onboard Normand Sun. This data have been cleaned and combined with relevant hindcast weather data before further analysis by Vard Design and Sintef Ålesund.
2. Based on the data set described above Sintef Ålesund have developed a data-driven model for predicting the vessel's propulsion power in transit, given speed and environmental conditions. This model achieved a relative mean absolute error of approximately 1%. Additionally, a hybrid model for predicting the total resistance of the vessel given speed and environmental conditions is devised. The term "hybrid" indicates that, in contrast to the previously discussed data-driven model, pre-existing knowledge of the vessel and general hydrodynamics has been incorporated. More precisely, known relations derived from model tests, simulation results, standard propeller models etc. have been used. This approach has led to a model of lower overall precision (approx.

8% relative mean absolute error), but with the advantage of being able to more easily quantify the impact of certain phenomena on the vessel performance.

3. A digital simulation twin of Normand Sun vas built in the Siemens Amesim software by Vard Design. The simulation model was verified in respect of energy consumption in transit mode. Corrections and tuning of the model was done related to change in loading condition(CFD), wind force(CFD, change in water density and wave resistance. For the latter, data from sailing legs was categorized by weather conditions and matched with similar operation by the simulation model. Deviations was identified and model parameters tuned to improve the simulation accuracy.
4. Energy efficiency improvements has been incorporated with a top-down approach in the project. Firstly, by developing a method for hull-design optimalization where dimensions are evaluated in relation to cargo capacity, deck area, battery capacity and energy consumption. Secondly, when the optimal hull was found we designed a vessel with minimum accommodation area based on a lean manning philosophy. This resulted in minimum volume of space to heat, cool and ventilate. Further, an innovative HVAC system has been suggested for the final ship design with estimated energy consumption reductions of 15% compared to a conventional system. All studies performed by Vard Design.
5. A method has been developed for optimization of hull, main dimensions, cargo and battery spaces based on a parametrized hull model in CAESES, linked with Siemens Amesim for batched simulations of energy consumption. This has enabled optimalization of zero emission operation capabilities. A separate tool for estimation total cost of ownership has been developed in order to assess the economic feasibility and attractiveness. This assessment indicates a potential of 25% lower net present value for the PIEZO concept compared to a similar MGO vessel in a 20-year perspective. All studies performed by Vard Design.
6. Based on requirements from Vard Design and the system simulation model, Vard Electro have developed a functional energy management system, suitable for large batteries. The EMS was developed in Matlab and exported as FMU.
7. Based on own research and input from Solstad Offshore and Equinor, Vard Electro have assessed the safety aspects related to marine operation safety, electric installations, offshore charging system on rig, HVSC standards in high voltage charging and power availability- and restrictions on rigs.
8. Based on own research and input from Vard Design, Solstad Offshore and Equinor, Vard Electro have assessed technical aspects of offshore solutions. The study includes review of existing charging solutions, power system, charging scenarios, requirements for high voltage charging and implementation of onshore charging solutions to offshore installations.

Reports produced:
WP1 - Model development and validation
WP4 - Offshore Charging Solution Safety
WP5 - Offshore Charging Solutions

IMPLEMENTATION AND RESOURCE USE

The project has been running steadily throughout the project period. We encountered some covid-related delay but got back on track and finished with a very satisfactory result, slightly above budget.

SIGNIFICANCE/USEFUL VALUE THE RESULTS

We achieved our goal to verify the realism in our concept idea – battery-electric zero emission offshore vessels.
This proof of concept will be of high significance for the future development of zero emission offshore operations. The Norwegian Environmental Agency is briefed on our results.
In addition, the new simulation-based design methodology developed in this project will be highly valuable for VARD´s ability to optimize vessels for low energy consumption and minimum emissions. This is without doubt providing a competitive advantage.
For CORVUS the project has given new insight into the potential of large battery installations in offshore vessels and together with VARD we are now better positioned to capitalize on this.
Equinor has also gained new insight into the potential of battery-electric offshore service vessels and will utilize this knowledge when planning new tenders.
In addition to insight into future possibilities with battery-electric operation, Solstad Offshore now has better understanding of the energy consumption on their PSV and an extensive dataset of their operations for further research.

RESULTS EXPECTED TO BE COMPLETED AFTER THE END OF THE PROJECT

WP2 – Restricted report describing the new design methodology developed by Vard Design.