WP7 - Semi-virtual demonstration and improvement for full-electric vessels

D7.1: Report on modular electrical architecture for DC electrical network - Public Summary:

The ambition of the NEMOSHIP project is to develop, test and demonstrate innovative technologies, methodologies and guidelines to accelerate large Battery Energy Storage System (BESS) deployment and optimal exploitation toward 2030 on both hybrid and fully electric configurations. To help achieve this ambition, NEMOSHIP has developed a 1 MWh modular and standardised battery energy storage solution that is able to exploit heterogeneous storage units and a cloud-based digital platform to enable data-driven, optimised and safe exploitation. The project will demonstrate the maturity of these innovations at TRL 7 for hybrid ships as well as their adaptability towards fully electric ships.

This deliverable focuses on the development and evaluation of a modular DC electrical architecture that enables the effective integration and exploitation of large BESS in shipboard power networks. The work presented in this report investigates how the modular BESS concept developed in NEMOSHIP can be translated into a robust, scalable and safe DC electrical network suitable for both retrofitted vessels and newly designed ships.

The report introduces a detailed modelling framework for high-fidelity power electronic converters that interface BESS with both AC and DC shipboard grids. These models go beyond simplified representations and accurately capture switching behaviour, control interactions, voltage dynamics and loss mechanisms under realistic vessel operating conditions. This approach enables a realistic evaluation of how converters behave under fast load transients, mission-dependent power variations and different operational modes typical of marine applications.

In addition, the work builds upon previously defined project use cases to further refine and improve the DC shipboard architecture under realistic operational scenarios. The first use case represents a fully electric vessel supplied exclusively by large-scale BESS, while the second considers a hybrid configuration combining fuel cells and batteries for extended autonomy. Rather than introducing new concepts, these use cases are used as validated reference scenarios to optimise DC network topology, power source sizing, protection concepts and operational energy flows.

Furthermore, studies on the DC reconfiguration of two real vessels, Normand Drott and Le Commandant Charcot, provide a practical comparison between existing AC architectures and the improved DC alternatives, highlighting operational and architectural benefits of transitioning to DC distribution.

A key aspect of the work is the investigation of scalability and modularity, including the hybridisation of HE and HP battery technologies. This approach demonstrates how dynamic stress on energy batteries can be reduced, system robustness can be improved, and electrical architecture can be adapted to varying operational requirements without compromising safety or redundancy principles such as Safe Return to Port (SRTP).

Overall, the results demonstrate how a modular DC electrical architecture, supported by high-fidelity modelling and system-level analysis, can significantly enhance the integration, performance and flexibility of large battery systems in ships. These developments support the NEMOSHIP objective of accelerating maritime electrification and enabling more efficient, scalable and future-proof shipboard power systems in line with European and international climate targets.

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