



MAGpie

SMART GREEN PORTS

Report on pilot performance dashboard with surveillance possibility

contact@magpie.eu

+33 2 35 42 76 12

www.magpie-ports.eu



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REPORT ON PILOT PERFORMANCE DASHBOARD WITH SURVEILLANCE POSSIBILITY

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AUTHOR	Keulen, Hedzer Heerema Marine Contractors hkeulen@hmc-heerema.com

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André Lisboa	WP Leader	29-05-2026
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Maarten Flikkema	Scientific Coordinator	3/7/2026
Arne-Jan Polman	Project Coordinator	2-9-2026

Abbreviations

ABBREVIATION	FULL TERM	NOTES / CONTEXT
CAPEX	Capital Expenditure	Economic considerations
DC	Direct Current	ESS electrical system
DG	Diesel Generator	Onboard power generation
DP	Dynamic Positioning	Offshore operational mode
DP2	Dynamic Positioning Class 2	Redundancy with single failure
DP3	Dynamic Positioning Class 3	Redundancy incl. fire/flooding
ESS	Energy Storage System	Battery system under evaluation
kW	kilowatt	Power unit
kWh	kilowatt-hour	Energy unit
LNG	Liquefied Natural Gas	Fuel type
MCR	Maximum Continuous Rating	Engine load (% of rated power)
MW	megawatt	Power unit
NA	Not Applicable	Tables / results
SoC	State of Charge	Battery condition indicator
SSCV	Semi-Submersible Crane Vessel	Vessel type
SWB	Switchboard	Electrical power distribution
VP	Virtual Pilot	Simulation-based evaluation
WCF	Worst-Case Failure	DP failure scenario

1. Table of contents

Executive Summary	6
2. Introduction.....	7
3. Virtual pilot evaluation	8
3.1 Input and boundary conditions	8
3.2 Methodology.....	8
3.3 Results.....	9
4. Conclusions	12

Executive Summary

MAGPIE project is an international collaboration working on demonstrating technical, operational, and procedural energy supply and digital solutions in a living lab environment to stimulate green, smart and integrated multimodal transport and ensure roll-out through the European Green Port of the Future Master Plan and dissemination and exploitation activities. The consortium, coordinated by the Port of Rotterdam, consists of 3 other ports (DeltaPort, Sines and HAROPA), 9 research institutes and universities, 32 private companies, and 4 other organizations. The project is divided in 10 main work packages which include energy supply chains, digital tools, 10 demonstrators for maritime, inland water, road, and rail transport, non-technological innovations and the development of a Masterplan for European Green ports.

The MAGPIE project aims to accelerate the adoption of sustainable and energy-efficient solutions for ports and maritime transport through the demonstration and evaluation of innovative technologies. Within this context, Heerema Marine Contractors is assessing the application of battery energy storage systems on large offshore construction vessels to improve shore power utilization, reduce emissions, and enhance operational efficiency.

This deliverable presents the battery evaluation of the SSCV Sleipnir. The evaluation focuses on the operational performance and effectiveness of a proposed battery energy storage system in supporting shore power operation under constrained grid conditions and in smoothing power demand during vessel operations. The assessment is based on a virtual pilot evaluation, as the physical installation of the battery system falls outside the MAGPIE project implementation period.

High-resolution power demand data of the SSCV Sleipnir during inshore operations were used as input for a dynamic simulation model. The model evaluates the interaction between vessel electrical demand, shore power availability, and battery operation across a range of peak-shaving thresholds. Key parameters assessed include battery power output, energy throughput, state-of-charge variation and cycling frequency.

The results demonstrate that the battery system can effectively mitigate short-duration peak loads enabling continuous shore power operation within the imposed grid limitation. For appropriately selected power thresholds, the battery operates predominantly within a limited state-of-charge window, thereby minimizing deep discharges and reducing the risk of accelerated degradation. The evaluation also shows that flexible adjustment of peak-shaving thresholds can further optimize battery utilization depending on operational conditions.

Overall, the virtual pilot confirms that the proposed battery system provides a technically and operationally viable solution to increase shore power usage for the SSCV Sleipnir. The findings support the suitability of the battery concept and provide quantitative insight into its expected operational behavior, forming a solid basis for further decision-making and for the detailed battery design described in the complementary MAGPIE deliverable D3.16.

2. Introduction

In the context of increasing electrification and emission reduction ambitions within the offshore construction sector, battery energy storage systems are increasingly applied to large vessels to support both inshore and offshore operations. For the SSCV Sleipnir, the application of a battery system is considered as a means to improve the utilization of shore power, reduce generator running hours, and lower fuel consumption and emissions.

In 2021, shore power connections with an installed capacity of 10 MW were realized at both mooring locations of the SSCV Sleipnir and SSCV Thialf. Although the installed infrastructure provides a combined peak capacity of 20 MW, grid congestion has led to a substantially lower granted connection capacity. As a result, the available shore power is insufficient to continuously meet the vessel's peak electrical demand during certain operational modes, such as crane operations, requiring a fallback to onboard generators.

A battery energy storage system is proposed to address this limitation by providing peak shaving when the vessel's power demand exceeds the available shore power capacity. In addition, the battery can support offshore operations by smoothing generator load variations and enabling more efficient power plant operation (out of scope for this analysis). The extent to which these benefits can be realized depends on the interaction between vessel power demand, shore power limitations, and the operational behavior of the battery system.

This deliverable presents the battery evaluation of the SSCV Sleipnir within the MAGPIE project. The evaluation focuses on assessing the suitability and effectiveness of the proposed battery system from an operational perspective. Using high-resolution vessel power demand data and a virtual simulation approach, the study evaluates battery power and energy utilization, cycling behavior, and state-of-charge evolution under realistic operating conditions.

The results of this evaluation provide insight into the expected performance of the battery system in enabling continuous shore power operation and supporting offshore use, and form an essential input to the overall assessment of the system's operational value within the MAGPIE project. Furthermore, this approach illustrates how mobile energy storage solutions can complement immobile onshore infrastructure contributing to a broader vision of the smart green port of the future, as pursued within the MAGPIE project.

3. Virtual pilot evaluation

The implementation of the ESS is scheduled outside of MAGPIE schedule. A simulation is done to prove the design meets the expectations.

3.1 Input and boundary conditions

A 315 day - one-second resolution - dataset, distributed over 4 years, of the Sleipnir moored and connected to shore power was prepared.

The shore power limitation in which the ESS provides peak shaving is an arbitrary choice based on the grid- and/or operational limitations. The lower limit is defined by the power demand of the vessel, excluding peaks (approx. 6MW) and the upper limit is determined by the grid limitation of 8.5MW.

Further boundary conditions:

- 8MW | 3C battery capacity, approx. 2.67 MWh
- The round-trip (charge-discharge-charge) efficiency of the ESS is assumed at 90%.
- The initial State of Charge (SoC) is assumed at 90%
- For peak shaving 70-90% SoC is assumed to be acceptable (20%)
- Charging rate limited to a maximum of 1 MW

3.2 Methodology

When the power demand exceeds the chosen threshold, the ESS supplies power.

1. When active power demand is above the threshold, the ESS supplies power
2. The battery is to be charged by maximum 1,000 kW or less pending difference between actual power demand and threshold
3. Cycle definitions:
 - a. Single cycle starts and ends at initial SoC
 - b. Cycle energy is the sum of kWh within this single cycle
 - c. Cycle power is the maximum power occurred in this single cycle

3.3 Results

A small, indicative, time trace of the dataset with the power demand and battery use (light blue in top) is shown below:

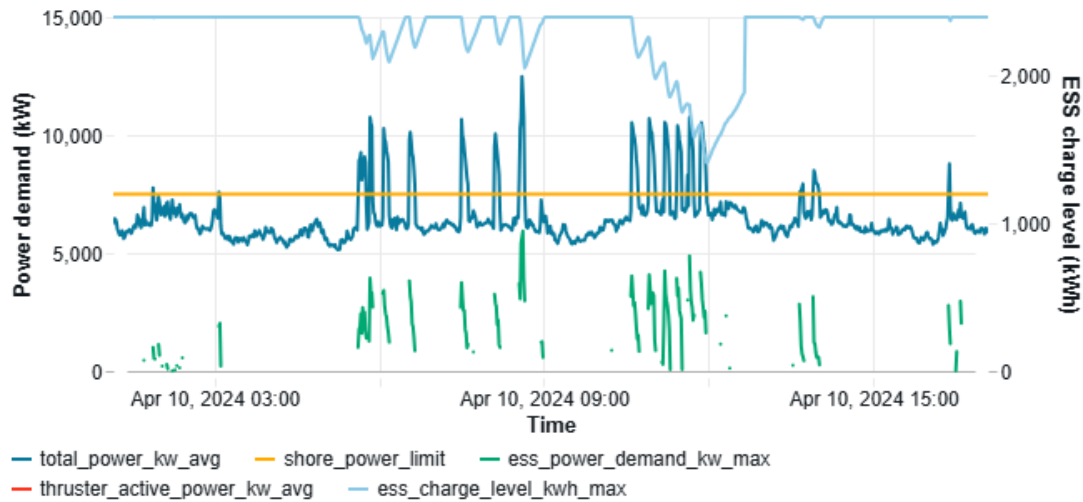


Figure 1: Active power with battery discharge > 7,500 kW

The battery discharge should be reasonably low to limit the degradation of the battery. Assuming a maximum discharge limit of 20% to limit the battery degradation, it is observed that a threshold $\geq 8,000$ kW is required operating the ESS continuously without exceeding the discharge limit too often. It is also noted that the battery occasionally is depleted using a 6,000 kW threshold.

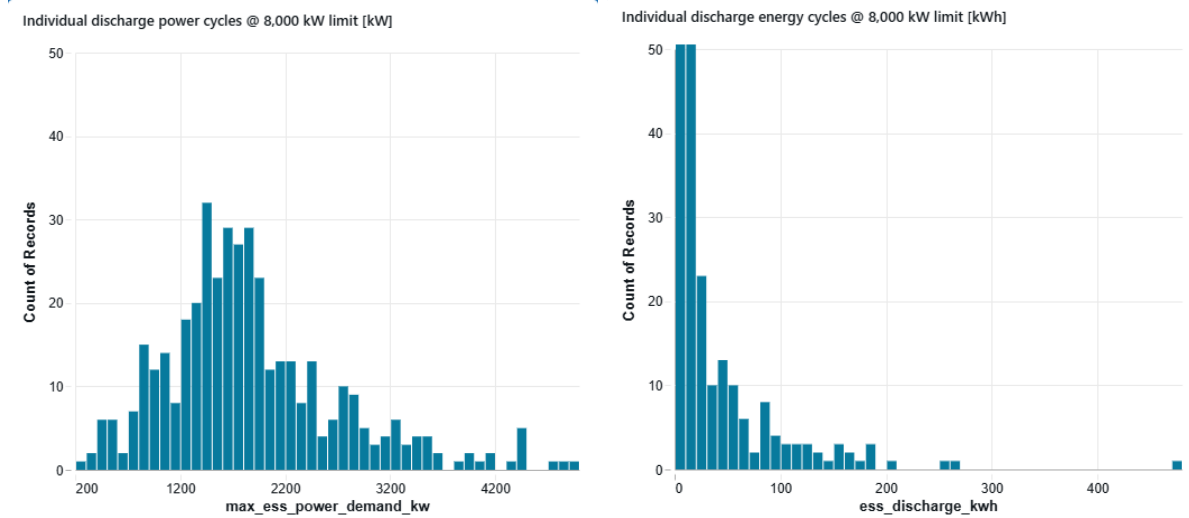


Figure 2: LEFT: power cycles RIGHT: Energy cycles [both with threshold 8,000 kW]

The higher the threshold limit, the higher the grid fee (based on on 15-minute peak values). Therefore, lowering the threshold lowers the overall grid cost. This does come at a higher utilization of the battery. It is recommended that this is evaluated in further detail during the operational phase.

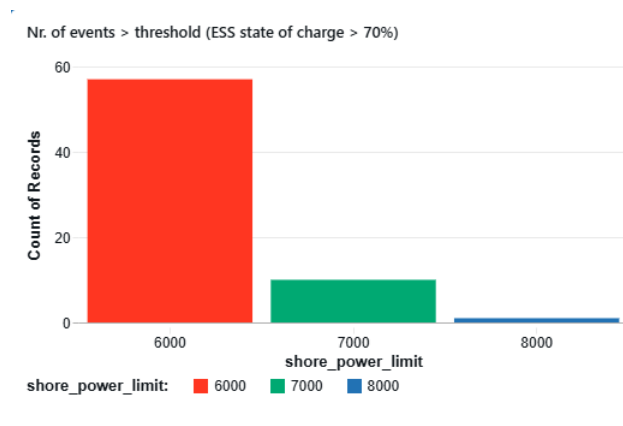


Figure 3: Number of events < 70% SoC for various thresholds

The threshold does not need to be fixed over time, meaning the threshold can be adjusted pending the operation. The trigger could be financial benefit by lowering the monthly fee for the 15-minute peak price. The upper limit of the threshold at 8,500 kW has zero events below 70% SoC., meaning the battery is never critically discharged at this setting.

All together the modelled power and energy cycles prove the ESS system enables the shore power system to be used fulltime, thereby avoiding running on-board engines. This directly reduces both fuel consumption and emissions.

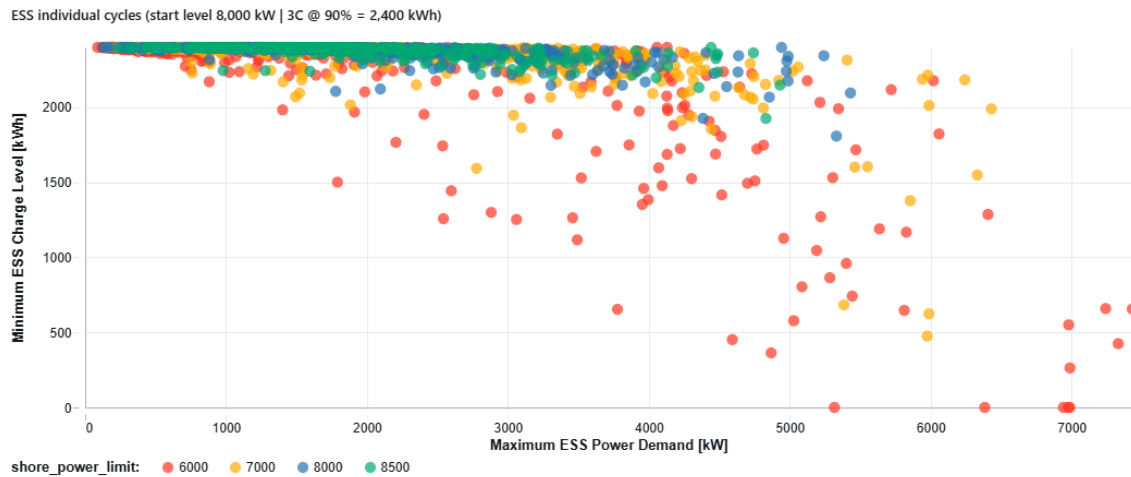


Figure 4: Scatterplot power / energy discharge per cycle

4. Conclusions

This deliverable has presented the battery evaluation of the SSCV Sleipnir within the MAGPIE project, focusing on the operational performance of a proposed battery energy storage system under realistic inshore operating conditions. Using a virtual pilot approach based on high-resolution vessel power demand data, the interaction between shore power limitations, vessel demand, and battery operation was assessed.

The results demonstrate that the battery system can effectively mitigate short-duration power peaks that exceed the available shore power capacity. By supplying power during these peak events, the battery enables continuous shore power operation despite grid-imposed limitations. This significantly increases the utilization of the already installed shore power infrastructure and reduces the need for fallback to onboard generators.

The evaluation shows that battery operation is highly dependent on the chosen peak-shaving threshold. For appropriately selected thresholds, the battery predominantly operates within a limited state-of-charge window, resulting in relatively low energy discharge per cycle. This operational behavior limits deep discharges and excessive cycling, which is important for controlling battery degradation and ensuring long-term system viability.

Furthermore, the analysis indicates that a fixed peak-shaving threshold is not strictly required. Allowing flexibility in threshold selection depending on operational conditions provides additional optimization potential, balancing shore power utilization, battery loading, and state-of-charge management.

Overall, the virtual pilot evaluation confirms that the proposed battery system constitutes a technically viable and operationally effective solution for the SSCV Sleipnir. The results provide quantitative insight into expected battery utilization, cycling behavior, and state-of-charge evolution, and demonstrate that the system can meet its intended operational objectives. These findings support further implementation considerations and complement the detailed battery design activities presented in MAGPIE deliverable D3.16.