D3.8 Demonstration of battery pack application on an inland vessel

Synergetics | Synergies for Green Transformation of Inland and Coastal Shipping

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AUTHOR	Lucas Haag Zero Emission Services lucas.haag@zeroemissionservices.nl
CO-AUTHORS	Karola van der Meij k.v.d.meij@marin.nl Nicole van Spronsen n.v.spronsen@marin.nl Pablo Garcia Barrena p.garcia@marin.nl

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Release Approval

1-1 | Release Approval

NAME	ROLE	DATE
P. Garcia Barrena	WP-Leader, Reviewer	19-06-2025
B. Friedhoff	Coordinator	26-06-2025

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Executive Summary

Battery-electric propulsion is one of the options to decarbonise inland shipping. Sailing with battery-electric propulsion reduces locally the impact on the climate, improves air quality, and reduces noise pollution. Due to its high Technology Readiness Level (TRL), this technology poses the advantage of allowing a fast implementation onboard, compared to other technologies which are still under development.

ZESpacks are 20ft containers containing batteries, which can be loaded onboard of a vessel. The ZESpack connects to ships or charging stations through a multipole quick power connector (MQPC), enabling automated transfer of DC power, auxiliary systems and data. To facilitate the usage and robustness of the system so that it can be expanded to other ships, ZES is improving their current system the next-generation ZESpack.

This system has been working very well since its first use in 2021 on the inland container vessel the Alphenaar. This task is part of Work Package 3 Demonstration (WP3) of the SYNERGETICS project. Some adjustments have been made with regards to the shape of the container to reduce risk of damage. Nevertheless, next-gen ZESpacks have moved from the MQPC system to the Megawatt Charging System (MCS), which is proving to be the worldwide standard.

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1. | Introduction

For the EU-funded Innovation Action SYNERGETICS, Zero Emission Services (ZES) is demonstrating that retrofitting can be a successful method to make an inland or coastal ship 'greener'. Since 2021, the vessel Alphenaar transports emission-free cargo between the Dutch cities Alphen aan den Rijn and Moerdijk. This vessel serves as a demonstrator (Demo 3) within SYNERGETICS. Here, Zero Emission Services is demonstrating the extension of their ZESpack battery pack services on inland vessels. Electric sailing locally reduces the impact on the climate, improves air quality, and reduces noise pollution. The system uses ZESpacks: swappable energy containers that can be deployed flexibly on a pay-per-use basis.

This document provides an overview of the demonstrator vessel and the ZESpack system, focusing on the improvements carried out for the next generation of ZESpacks. Improving the ZESpack system would facilitate the use of swappable battery packs, allowing a faster growth of the battery-electric technology and therefore a faster decarbonisation of inland shipping.

2. | Description of the vessel

The Alphenaar is an inland container vessel that transports containerised cargo between the Dutch towns of Alphen aan den Rijn and Moerdijk. In Table 2-1 the main particulars of the vessel are presented, and in Figure 2-1 a photo of the ship is shown.

Table 2-1: Main particulars of the Alphenaar.

Ship type:	Inland container vessel	
Year of construction	2019	
Propulsion type	Diesel-Electric/Battery-electric	
Length over all	90	m
Beam, moulded	10.5	m
Draught, design	3.6	m
Deadweight, at design draught	1883	t
Container capacity	104	TEU
Service speed (approx.)	14	km/h

The ship has a diesel-electric propulsion system with an aft and a forward engine room, which is where the main gensets are located.

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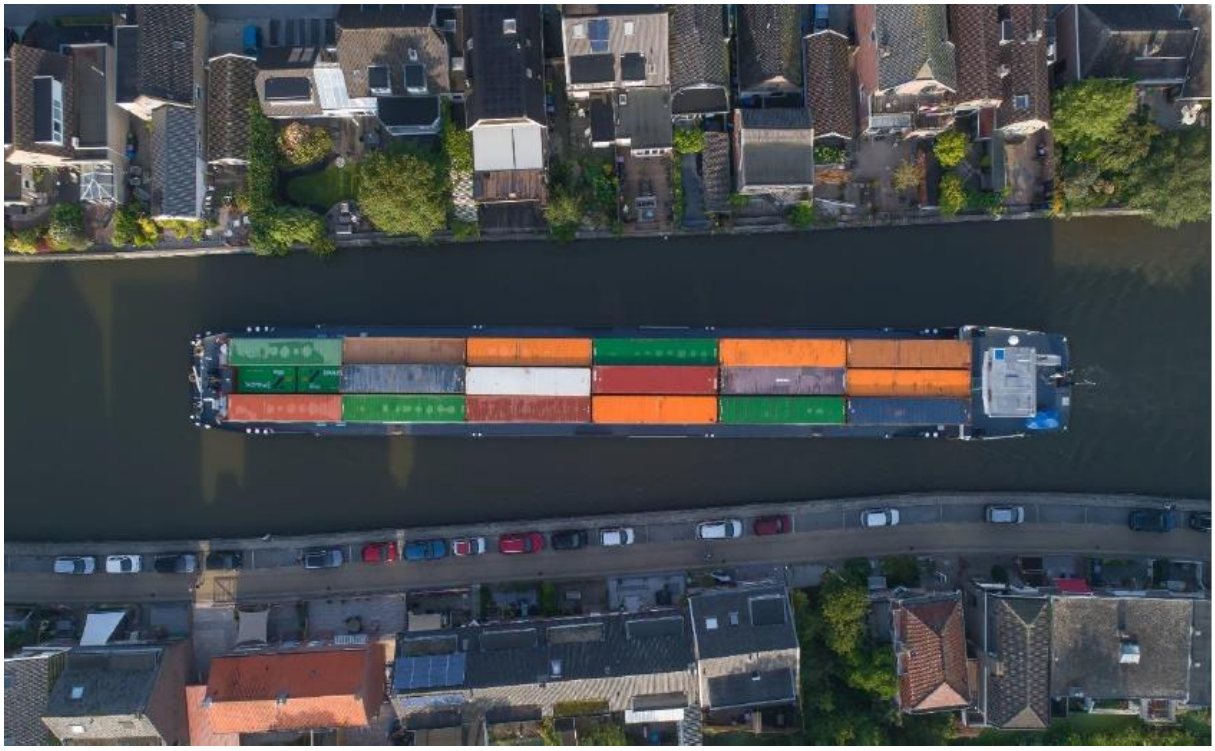

Figure 2-1: Photo of the vessel Alphenaar sailing through a canal near a residential area.

The vessel was retrofitted in 2021 to allow the use of the ZESpack system. The ZESpacks are connected to the ship's grid by means of an onboard connection located at the forward end of the cargo hold. Two ZESpacks are placed on two 20ft container slots at the forward end of the hold, as shown in Figure 2-2. These two packs are sufficient to provide the energy required for a round trip between Alphen aan de Rijn and Moerdijk.

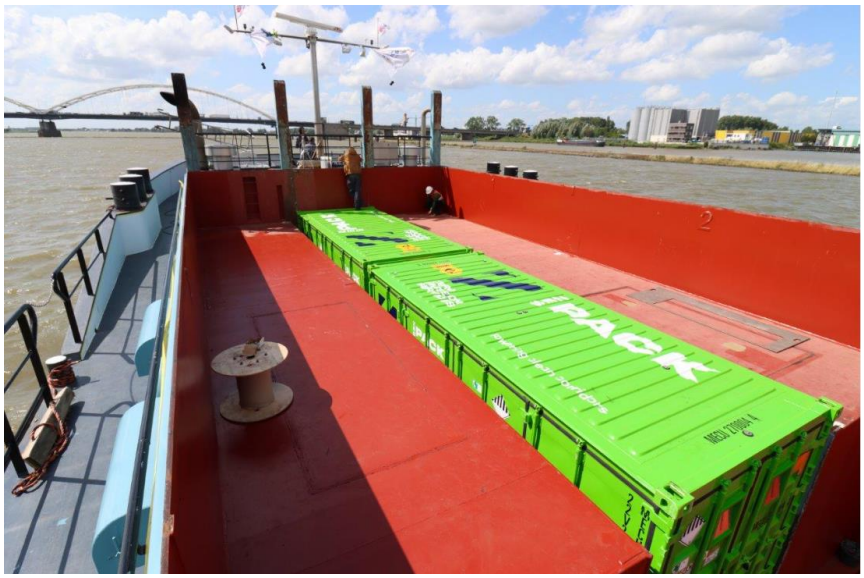

Figure 2-2: ZESpacks placed on the Alphenaar.

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3. | Description ZESpack system

3.1 | Description ZESpack containers

A ZESpack consists of a battery pack installed inside a 20ft container. The batteries have a total capacity of 2 100 kWh at full load and have a maximum output voltage of 936 V. With a C-rate of circa 0.5C, the batteries are able to be charged in 2 h and to deliver a maximum power of 1000 kW.

Thanks to its modular system, vessels can easily swap ZESpacks and travel longer distances without being limited by long charging times. Several charging and swapping stations are now available in the Netherlands, but ZES expects to expand coverage throughout the entire country with a projected network of 14 charging stations in 2028, along with the corridors to Antwerp and Duisburg.

In addition to the usage of the ZESpacks onboard, the battery packs can be used to support terminal electrification, addressing grid congestion and peakshaving. When no vessels have a container swap planned, ZESpacks can be used for grid balancing.

Finally, the ZES system is a pay-per-use system, which means that the containers are owned and managed by ZES, and the customer only pays for the consumed energy.

3.2 | Charging stations ashore

ZESpacks are changed by an onshore charging station similar to the one showed in Figure 3-1. The charging station consists of a steel frame with an electrical connection that converts the AC current of the grid into DC at the voltage required by the ZESpack.

Figure 3-1: ZESpacks stored next to a charging station ashore.

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3.3 | Connection onboard

To connect a ZESpack to a ship or charging station, a standardized system is used involving a Multipole Quick Power Connector (MQPC), a mechanical docking frame, and electrical/data connections. The MQPC system enables automated coupling of power, auxiliary systems, and data through a male/female connector interface—where the female connector is fixed in the ZESpack, and the male connector, with a self-aligning scissor lift mechanism, is part of the docking station or vessel.

The Connector Box System includes three main connections: primary DC power, auxiliary systems (e.g. climate control, PLC), and communication lines. The system integrates components such as a control box, junction box, and connector box, all designed to ensure reliable and safe operation. The container aligns using corner pins, allowing tolerances of ±10 mm for final MQPC positioning.

Figure 3-2: Connector Box System (exposed)

Electrical connections include high-current DC cables, grounding, AC auxiliary power, and communication lines (Ethernet and I/O). Data exchange uses the Modbus protocol and includes real-time battery status, safety indicators, energy metrics, and subsystem health, supporting cloud integration and system monitoring.

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4. | Modifications

4.1 | Objectives

The primary goal for this demonstrator is to improve the overall design, reliability, and operability of the ZESpacks, making the system more robust, scalable, and easier to handle. Some objectives could be met with modifications to the existing ZESpacks, whilst other have been met with a next-gen design of ZESpacks.

Key objectives include:

- **Reduce risk of damages**
- **Increase interoperability**

4.2 | Engineering and implementation

Damages risk reduction

First-gen containers have been modified by flattening the shapes such that they are less prone to get stuck. Also, a guiding frame has been implemented to guide the ZESpack onto the right location during loading. For next-gen assets, ZESpacks are placed on the highest level of the vessel. This makes correct placement easier for the container crane, reducing risk of damage.

Terminal handling safety will be improved with the use of screens (indicating what to do), manuals and a lighting system which will indicate if it is safe to remove ZESpack or not. On top of that, ZES is developing a system that triggers an alarm signal for when ZESpacks are being removed whilst still connected to the vessel/charging station.

Interoperability increase

The new generation of ZESpacks are equipped with a Megawatt Charging System (MCS) connector. This is a newly standardized connector with high interoperability, potentially allowing ZESpacks to be charged at third-party charging stations and vice versa. This flexibility increases network coverage, supports terminal electrification goals and enhances the feasibility of intermodal transport.

Since the MCS connector is hand-operated, chances that a ZESpack cannot charge due to incorrect placement of the connector is much lower.

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