D3.11 Evaluation report electrification of inland cement carrier

Synergetics | Synergies for Green Transformation of Inland and Coastal Shipping

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AUTHOR	N. van Spronsen, MARIN n.v.spronsen@marin.nl

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Release Approval

1 | Release Approval

NAME	ROLE	REMARKS
K. Hoyer, DST	Reviewer	15-06-2026
B. Friedhoff, DST	Coordinator	26-06-2026

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Executive Summary

SYNERGETICS is an Innovation Action aiming at the green transformation of the existing inland and coastal fleet by creating synergies. On the one hand, synergies are sought with pilot and demonstration projects that are carried out outside of SYNERGETICS. Consortium partners are involved in many of these projects assessed within WP2, so that appropriate cross-linking is ensured. On the other hand, the findings from the project's own demonstrators (WP3) are compared and made available to the industry. WP3 comprises a total of eight demonstrations, which are listed below:

1) Full Scale:
    a. Demo_1: Hydrogen combustion engines and evaluation onboard a seagoing Crew Transfer Vessel
    b. Demo_2: Inland chemical tanker, methanol dual fuel
    c. Demo_3: Inland container vessel, swappable battery pack
    d. Demo_4: Inland cement carrier, electrification of main propulsion plant
2) Model Scale:
    a. Demo_5: Inland dry cargo vessel, aft-ship replacement
    b. Demo_6: Via Donau push boat
3) System:
    a. Demo_7: Methanol conversion
    b. Demo_8: Power management design

This deliverable outlines the work performed and lessons learned in the context of the Demo_4, the electrification of the main propulsion plant of an inland cement carrier operating in France. A systematic analysis to assess retrofitting options for this use case was conducted early in the project and is reported in the deliverable D3.1 SPEC analyses of full scale and model scale demonstrators. The analysis confirmed that the optimal retrofit strategy involved transitioning from a diesel-electric configuration to a battery-electric system supplied by shore-based charging infrastructure.

The deployment of this demonstrator, however, could not be realised primarily due to:

- Lack of properly dimensioned shore power. To charge the battery in a moderate time, dedicated supply with sufficient power is required. Charging the battery with 400 V three-phase 32 A would take about one week.
- In the proposal phase of SYNERGETICS there were strong ambitions to decarbonise ship operation and cargo handling on the Seine, also in preparation of the Olympic games. Accordingly, CFT committed to this demo despite the high own share of investment costs. However, only during the project execution it became obvious that neither the port nor the customer is willing to invest in the charging infrastructure.
- Even after intensive discussion of various approaches to overcome these hurdles, for example through the supplementary use of other funding programmes or electrification of a different ship, this demonstrator had to be given up.

After the in-depth analysis of the use case including the retrofitting concept, the required charging infrastructure and estimation of the costs, the implementation of this demonstrator could not be pursued any further. The full-scale demonstration was removed in an amendment by the end of 2025. As a consequence, this deliverable does not evaluate the experience made with the conversion and operation of the retrofitted vessel, but focuses on the analyses and lessons learned.

Generally, the electrification of small vessels on fixed routes with limited requirements for the range of autonomy is considered as a promising option for decarbonising inland waterway transport by electrification. Since the Sandre is already diesel-electric the conversion would have been less complex than starting with a diesel-direct driveline. Infrastructure development, however, is particularly crucial for all electrification projects in inland waterway transport. To ensure a reasonable charging time, a facility of appropriate dimensions must be constructed. And it was precisely at this point that the demonstrator could not be taken any further. The conversion was not carried out, as there will be no infrastructure development on the land side in the foreseeable future. This report describes what the conversion of the vessel might have looked like, as well as the details of why the demonstrator could not ultimately be implemented, and outlines the conclusions this will have for the electrification of inland waterway transport.

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1. | Introduction

This report provides an overview of the innovation actions related to the **demonstrator of the inland cement carrier *Le Sandre***, owned by CFT and operated by Sogestran, selected as **Demonstrator 4 (Demo 4)** within the **SYNERGETICS project**. The aim of this demonstrator was to present the **battery-electric retrofit of an inland waterway vessel** operating on a short route in France. The objective was to investigate and evaluate the most suitable retrofit solution for this cement carrier, as defined in **subtask 3.2.4 of SYNERGETICS**.

This report describes the **concept, challenges, and lessons learned** regarding Demo 4, with a focus on **analytical and design activities**. The scope was kept realistic to ensure the work continued to generate the **insights on energy demand, system configuration, and operational constraints** needed for SYNERGETICS' comparative assessment framework.

A key conclusion from this demonstrator is that **battery-electric propulsion charged via shore power** offers significant potential, particularly when powered by renewable energy, achieving up to **100% emission reductions for CO_2, NO_x, and particulate matter (PM)**. However, the **increased weight and volume of battery systems** must be considered, and **a suitable charging infrastructure on land is essential**—without it, the project is likely to fail. Additionally, **early stakeholder engagement, a clear business case for shipowners and operators, and streamlined regulatory procedures** are critical to overcoming hurdles and ensuring successful implementation.

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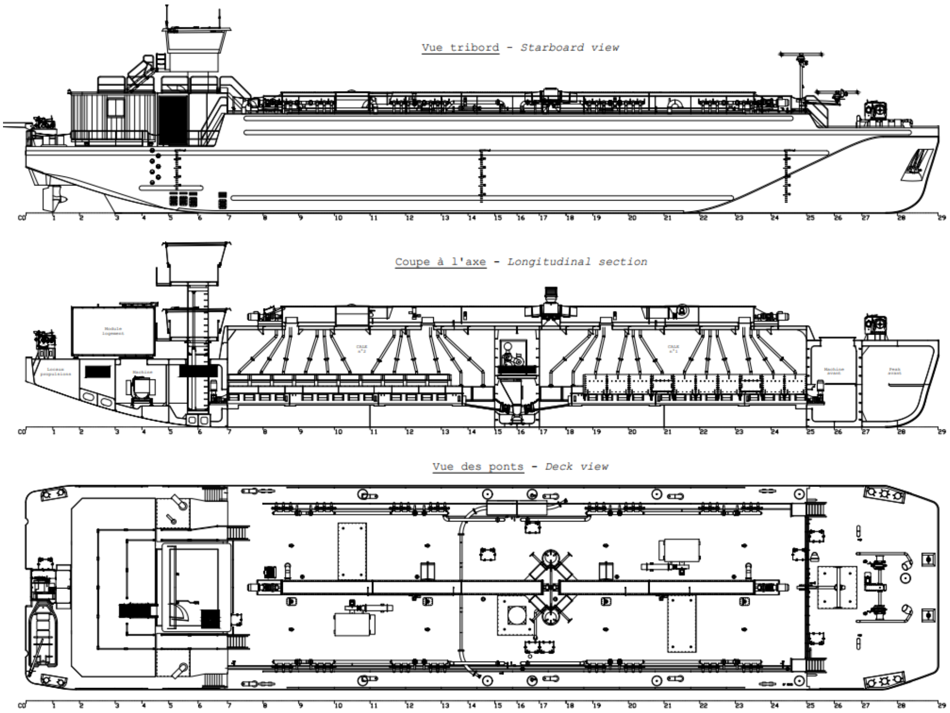
2. | Description of the vessel

Le Sandre is an inland cement carrier vessel dedicated to the transport of cement from Gennevilliers, located at the north of Paris, to Ivry sur Seine, located at the south of Paris. During the route along the Seine River, a densely populated area, the vessel calls at several ports, where cement is discharged. The main particulars and general arrangement of this vessel are shown in table 1 and figure 1 respectively. Figure **Fehler! Verweisquelle konnte nicht gefunden werden.** shows Le Sandre during operation.

1 | Main particulars of Le Sandre

Parameter	Value	Unit
Ship type	Cement carrier	
Year of construction		
Propulsion type	Diesel-Electric	
Length over all	51.2	m
Beam, moulded	11.4	m
Draught, maximum	3.25	m
Installed power (gensets)	940	kW



1 | General arrangement of Le Sandre

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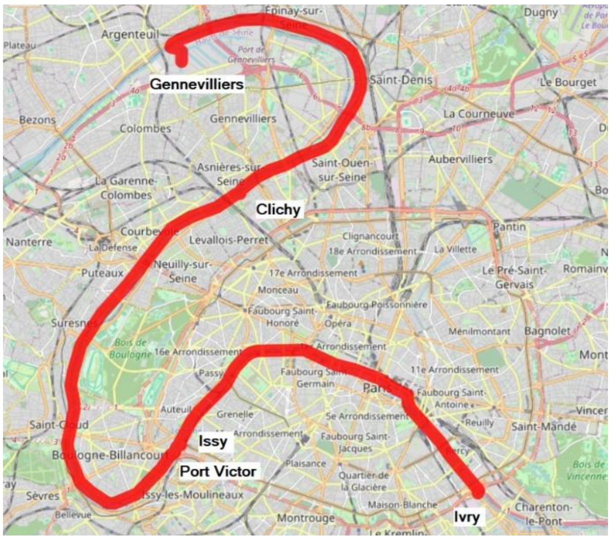
The cement is loaded at the port of Gennevilliers by gravity in combination with a screw conveyor located on deck. Unloading is conducted by liquifying cement using pressurized air and then discharged with flexible hoses. Discharge occurs typically at Issy les Moulineaux or Port-Victor.

Le Sandre has a diesel-electric propulsion system consisting of two main gensets plus one harbour generator. Propulsion is provided by two ducted thrusters each connected to an electric motor via a Z-drive.



2 | Route of Le Sandre shown on a map.

3 | Photo of vessel Le Sandre sailing on the Seine River

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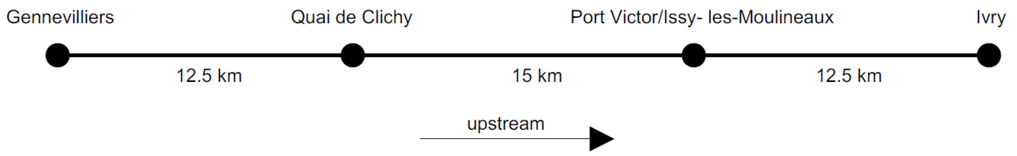
2.1 Sailing routes

As shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**, Le Sandre sails between ports located within or in the vicinity of Paris. The cement is loaded at Gennevilliers port, and afterward the vessel sails upstream to discharge in other ports. The typical routes of Le Sandre are the following:

1. **Gennevilliers** ↔ **Issy les Moulineaux/Port-Victor** (most preferred route). The ship departs fully loaded from Gennevilliers and then discharges at Issy-les-Moulineaux or Port Victor. Once the ship is unloaded, it sails back to Gennevilliers. The ship sails fully loaded upstream and empty downstream.
2. **Gennevilliers** → **Clichy** → **Issy les Moulineaux/Port-Victor** → **Ivry sur Seine** (longest route). The ship departs fully loaded from Gennevilliers and then discharges at Clichy, Issy-les-Moulineaux /Port Victor and Ivry. Then it returns to Issy les Moulineaux /Port Victor to discharge again, and then sails empty to Gennevilliers.



4 | Overview of the route of Le Sandre

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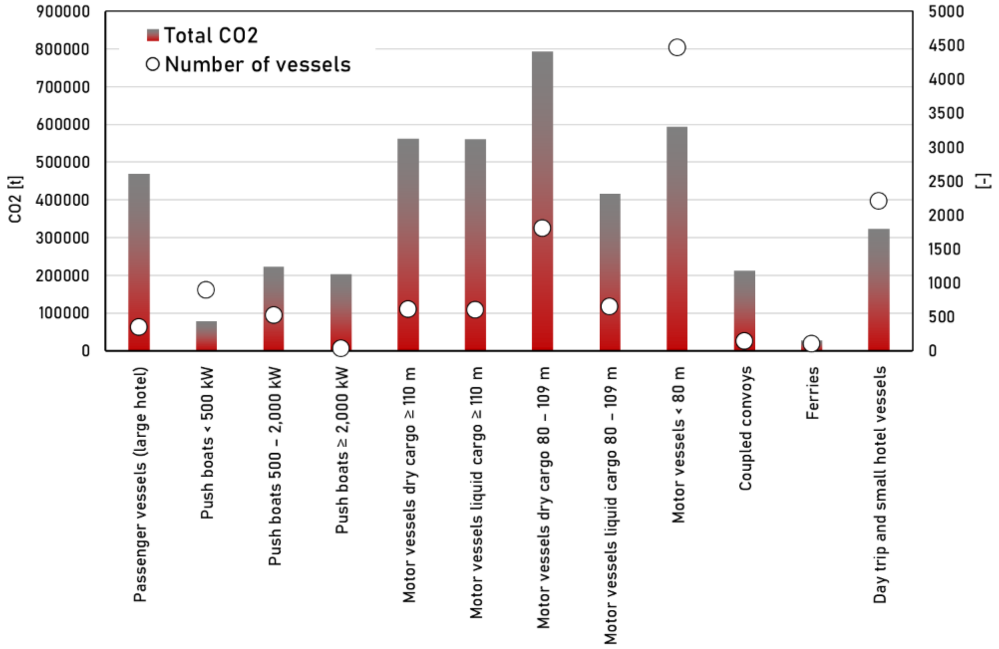
2.2 Impact

When selecting the ships which will serve as the Demonstrators in SYNERGETICS, one of the factors considered was the possible impact of the retrofit. To estimate the magnitude of the impact, several aspects are taken into account: the absolute CO2, Nox and PM emissions of the ships of a certain type (i.e. the ships within a certain fleet family), the relative CO2, Nox and PM emissions of the ships within a certain fleet family (i.e. the absolute CO2, NOx and PM emissions of a fleet family normalized by the number of ships within the family), the operational area of a ship, etc.

The Sandre (fleet family: "Motor vessels < 80 m") belongs to the fleet family of inland vessels which ranks second with respect to the absolute CO2, NOx and PM emissions as shown in figure 5.



5 | Absolute CO2 emissions of the fleet families of the European inland fleet and number of vessels within the families in 2015 (similar ranking for NOx and PM emissions) data reported in the CCNR study on energy transition towards a zero-emission inland navigation sector.

Additionally, the ship operates in a densely populated area of Paris, making the impact of emission reduction particularly significant. This Demonstrator including lessons learned will provide vessel owners, operators and policy-makers in this fleet segment guidance on how to approach a similar case.

3. | Analyses

With the operational analysis the power and energy demand of the vessel are defined for the whole operation of the vessel. This is later used as input for the technology selection, they so called Ship Propulsion, Power and Energy Concepts (SPEC) analysis. The SPEC analysis gives an indication of what could be the most suitable power and energy concepts form a technology, investment, and operational point of view. In addition, from this analysis an indication of the main parameters (weight and volume of power and energy systems, equivalent CO2 emissions, etc.) of each concept is given, which allows to compare each concept and quickly evaluate its impact on the design of the ship. From this comparison the most suitable concepts can be selected for a further detailed study of their viability.

The purpose of this methodology allows an objective comparison of the different propulsion, power and energy concepts that could be used to reduce the CO2 and harmful emissions for inland and coastal vessels and thereby contributes to the objectives of SYNERGETICS.MARIN conducted an operational analysis and technology selection (SPEC analysis) of Le Sandre as well as of the other demonstrators within the SYNERGETICS project.

These can be found in deliverable D3.1[1] of SYNERGETICS. The definition of the terms used in the operational and SPEC analysis can be found in this deliverable as well.

A short summary of the operational and SPEC analysis carried out for this demonstrator is presented in section 3.1 and 0, respectively.

3.1 Operational analysis

During the operational analysis, the operation, user needs and requirements were defined, and they were used to create power profiles. The operational analysis of Le Sandre was built based primarily on data recordings, measured on the electrical busbar, taken during a period of 14 days, excluding the weekends where the ship was not operating, making a total of about 200 hours recorded. These data recordings, provided by Sogestran, detailed the type of operation and total energy consumed at a particular time when the ship was operating.

The data recordings included several voyages combining the routes presented in section 0. In order to dimension the PPE system, the bunkering independent operations (BIOs) were identified. This was done by grouping the recorded operations into bunkering intervals. As the vessel bunkers at Gennevilliers, the BIOs were defined by a sequence of operations between two consecutive calls at Gennevilliers.

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[1] “D3.1 SPEC analyses of full scale and model scale demonstrators”.

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In addition, the following tasks/operations were identified:

1. **Sailing upstream:** Ship sailing against the current i.e., in the direction Gennevilliers → Ivry
2. **Sailing downstream:** Ship sailing with the current i.e., in the direction Ivry → Gennevilliers
3. **Loading:** Cement is loaded on board. Main power consumers are the screw conveyors on deck and other auxiliary equipment.
4. **Unloading:** Cement is unloaded from the ship. Main power consumers are the air compressor units used to liquify the cargo, and the pumps to blow the cement.
5. **Waiting:** Ship is waiting in harbour. Main consumers are auxiliary systems which are part of the hotel load.
6. **Economic waiting:** Ship is waiting in harbour with a minimum power consumption, e.g., at night.

After analysing the recorded data, the tasks carried out by Le Sandre were identified as well as their corresponding power consumption. These tasks were arranged sequentially to describe the current operation of the vessel defining a number of Bunker Independent Operations. A Bunker Independent Operation is a sequence of the operations the ship needs to carry out without intermediate bunkering. The energy required for the BIO defines the amount of energy carrier (fuel, batteries, etc.) that needs to be carried on board to complete all the operations within the BIO.Once the tasks and the route of each BIO were defined, power-time charts were constructed by establishing a sequence of tasks that describe the operation of the vessel. This was done based on the recorded data in combination with the input from Sogestran. By doing so, it was possible to determine the power demand as a function of time for each BIO, resulting in the power-time charts.

Next, from the power-time charts the energy demand of each BIO was calculated, and then compared with the recorded data. It was observed that the energy demand calculated from the power-time charts matched very well (within 2%) the energy consumption from the recorded data, which proved that the defined tasks were a realistic representation of the power demand to be expected during the operation of Le Sandre.

It was intended that after the retrofit Le Sandre would be equipped with batteries that will be charged at a shore power connection located at Port Victor. Thus, new BIOs were defined assuming Port Victor as the new “bunkering” location. For these new BIOs power-time charts were defined based on a new sequence of tasks withing these BIOs. From the power-time charts information about the power and energy demand was derived, which was used as input for the technology selection in the SPEC analysis.

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3.2 SPEC analysis

The SPEC analysis in deliverable D3.1 identified fixed batteries charged via a shore power connection as the most suitable retrofit solution for Le Sandre.

Given the circumstances, Le Sandre appears to be ideally suited for electrification: The vessel spends most of its time in harbour for waiting, loading, or unloading. Shore power can directly supply the high energy demand of cargo unloading, which is one of the most power-intensive activities. Additionally, shore power can charge the on-board batteries to be installed during the retrofit, ensuring energy availability for other operations. The current unloading harbour, Port Victor, is located in an industrial zone, making the installation of a shore connection technically and logistically most feasible.

Table 2 lists once again all the options that were examined. The calculated values of the operational analysis serve as input parameters for the SPEC analysis. A preselection of the most suitable technologies was made using the combination of ship- and client-related inputs. Subsequent, the relevance of technology-, investment- and operations-related parameters were weighted and subsequently ranked

Another important factor in the decision-making process was, of course, the shipowner's preferences and capabilities. And here, too, the focus was clearly on the electrification of operations.

2 | Results of the SPEC concept ranking for the preselection of a system for Demo 4. Base concept is a high-speed combustion engine with Diesel (EN590).

System	**Ranking**		
	Overall	**Technology & Investment**	**Operations**
#16 = Diesel (EN590) CI ICE (hi-speed)	4.1	2.5	5.6
#9 = e-CH3OH (CO2 PTS)/Dsl 95/5%vol CI ICE	5	4	5.9
#19 = e-LNG (CO2 PTS) SI ICE	5.8	5.1	6.5
#21 = Battery-electric (renewable)	8.9	9	8.8
#36 = e-H2 300b ISO LT PEMFC	5.4	3.5	7.4
#48 = Battery-electric (fossil)	8.3	7.6	9

For the vessel Le Sandre, operating as described in the operational analysis, the following conclusions summarise the findings of the SPEC analysis:

CO_2 Emission Reduction

The battery-electric PPE system (concept #21) and the renewable hydrogen concept (concept #36) achieve the largest reduction in CO_2 emissions when electricity is generated from renewable sources. However, if fossil fuels are used to generate electricity for the batteries (concept #48), other concepts such as #9 (e-methanol) and #19 (e-LNG) become more attractive in terms of CO_2 emission reduction.

Weight and Volume Requirements

The battery-electric concepts (#21 and #48) require a significantly greater amount of weight and volume for the energy carrier compared to other concepts.

E-Methanol and E-LNG Concepts (#9 and #19)

These concepts require only a relatively small increase in volume and weight due to the lower energy density of methanol compared to diesel. Their CO_2 emissions are comparable.

Compressed Hydrogen Concept (#36)

This concept represents an intermediate solution in terms of volume and weight, positioned between the methanol/LNG options and fully battery-powered systems.

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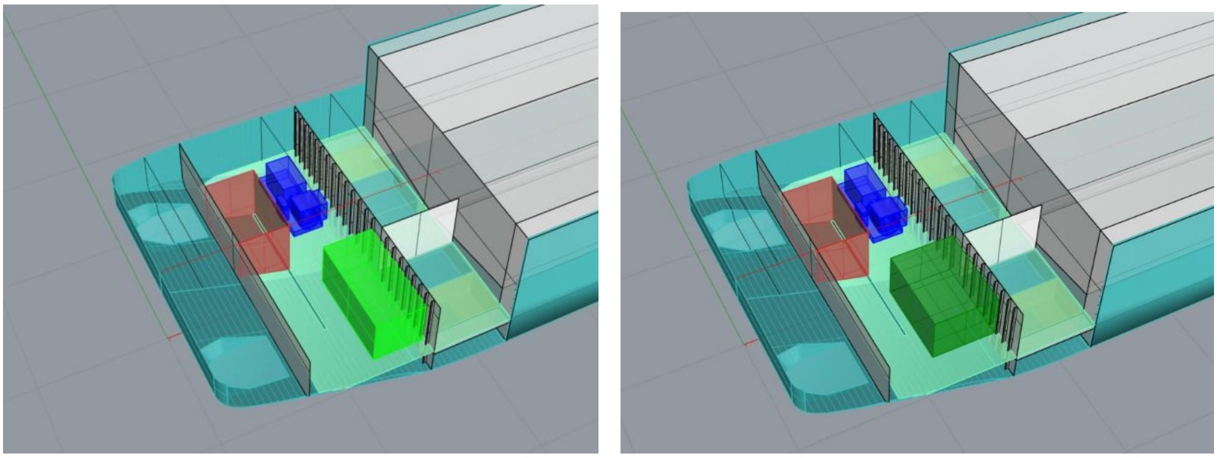
3.3 Design

Based on the results of the SPEC analysis, a preliminary conceptual design of the power and energy system was started for this demonstrator. For such, the total required energy from the most energy demanding BIO was used as input, taking into consideration the power losses in the power distribution system and the depth of discharge of the batteries. Using battery information from manufacturers, the two battery arrangements shown in figure 6 were proposed.



6 | 3D model of the two alternative arrangements of the battery packs for the retrofit of Le Sandre. Battery packs are in light and dark green, genset in blue and diesel tank in brown.

As next step it was planned to continue with a more detailed arrangement of the power system and a single line diagram of the retrofitted vessel, but it was notified the full-scale retrofit would not go forward, the conceptual design of the power and energy system came to a halt.

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4. | Challenges

CFT's cement carrier Le Sandre is already equipped with a Diesel-electric propulsion system and operates on a short stretch on the Seine in Paris. The operational analysis and technology selection performed for this vessel indicated that the ship is suited to integrate a battery for propulsion and loading/unloading equipment, though a loss of cargo space/capacity has to be accepted according to the outcome of deliverable D3.1. In principle, no major changes would need to be carried out to install batteries to the vessel.

However, a battery-powered vessel always requires a charging station on land to complement it. Without this, operation is obviously not possible. And it was precisely this point that caused the problem which ultimately led to the failure of the demonstrator: the plan was for the onshore charging infrastructure to form part of a French infrastructure programme in the run-up to the Olympic Games in Paris.

In the proposal phase the customer of Le Sandre was ambitious and asked for greening of the ship operation and cargo handling. Thus, the SYNERGETICS proposal was based on the actual request of the customer. However, even though the retrofitting with batteries was initially driven by the customer, who is also operating the handling facilities with a concession from the port authorities, only during the project execution it became obvious that neither the port nor the customer was willing to invest in the charging infrastructure.

In addition, as the project progressed, it became clear that the French construction sector is in crisis[2] and that, as a result, investment in charging infrastructure along the route for Le Sandre is not feasible. This lack of properly dimensioned shore power results in disproportionately long charging times. To charge the battery in a moderate time, dedicated supply with sufficient power is required. Charging the battery with 400 V three-phase 32 A would take about one week. SOG/CFT cannot invest into the infrastructure since they are not owning or operating the shoreside. As a result, the retrofit and operational testing of the cement carrier at full scale could not be carried out.

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[2] https://eurometal.net/ffb-recession-hits-french-construction-outlook-remains-gloomy/

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5. | Lessons learned

The following points summarise the lessons learned from this demonstrator:

1. **Inform and convince key stakeholders to cooperate:** The Le Sandre Demo serves as an exemplary case of an inland vessel operating within a reduced area over short distances. Since her route goes through a densely populated area, the potential benefits, particularly in terms of reduced CO_2 emissions, are significant for a large population, resulting thus in a high positive impact. Beyond the operator and shipowner, key stakeholders in decision-making positions include the port authority, energy providers and relevant policy makers. A lesson learned is to inform them adequately as early as possible to enable effective collaboration and to eliminate hurdles. This aligns with the objectives of SYNERGETICS, which aim to engage policy makers and other stakeholders by providing insights into updated Transition Pathways Task 5.2 and scenarios for policy makers Task 5.3.

2. **Provide insights in total business case:** A closed business case for ship owner and operator in a sustainable retrofit solution of electrification needs attention. To provide clear insights in the whole picture of the type of vessel and the sailing profile in order to make an informed decision, SYNERGETICS is provided a Decision Support Tool for Vessel Owners (Task 5.1). This includes impact on operational profiles, energy and emission savings and changes to business cases (CAPEX, OPEX, financing options).

3. **Provide clarity of regulatory procedures:** Clarity and streamlining of the regulatory procedures for greening retrofit solutions on board helps to define major bottlenecks that hinder the accelerated adoption of greening retrofit solutions. In the Demo of Le Sandre, Class requirements may also require additional space to divide the main source of power, the space for ventilation of the battery room, etc. Clarity in these rules helps to deal with the assessment and acceptance procedures. During the SYNERGETICS project this is addressed in Task 4.5; Outlines the overview of the existing and near future legal framework.

6. | Conclusions and recommendations

The work conducted for this demonstrator led to several key conclusions regarding the feasibility and implementation of battery-electric propulsion and retrofit projects in inland waterway transport.

Firstly, the potential of battery-electric propulsion charged via a shore power connection should be seriously considered for vessels with a similar operational profile to this case, particularly when renewable energy sources are used to generate the electricity. Under these conditions, the emission reduction potential for CO_2, NO_x, and particulate matter (PM) can reach up to 100%, making it a highly effective solution for decarbonisation. However, it is essential to also account for the drawbacks of this concept, such as the increased weight and volume of the battery systems, which may impact vessel design and operational efficiency. Crucially, a battery-powered vessel always requires a corresponding and suitable charging infrastructure on land. Without this infrastructure in place, the project is likely to fail as it could be seen in the Le Sandre case.

Secondly, early engagement with a wide range of stakeholders is critical to the success of similar retrofit projects. Informing and convincing stakeholders at an early stage fosters effective collaboration and helps to eliminate potential hurdles, such as resistance to change or misaligned expectations.

Additionally, the business case for shipowners and operators must be carefully evaluated. Understanding the economic implications, including capital expenditures (CAPEX), operational expenditures (OPEX), and potential revenue streams, is vital to ensure the financial viability of the project.

Finally, clarity and streamlining of regulatory procedures at an early stage of the process can significantly reduce obstacles during the design phase. Proactively addressing regulatory requirements and ensuring compliance with applicable standards helps to avoid delays and ensures a smoother project execution.

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