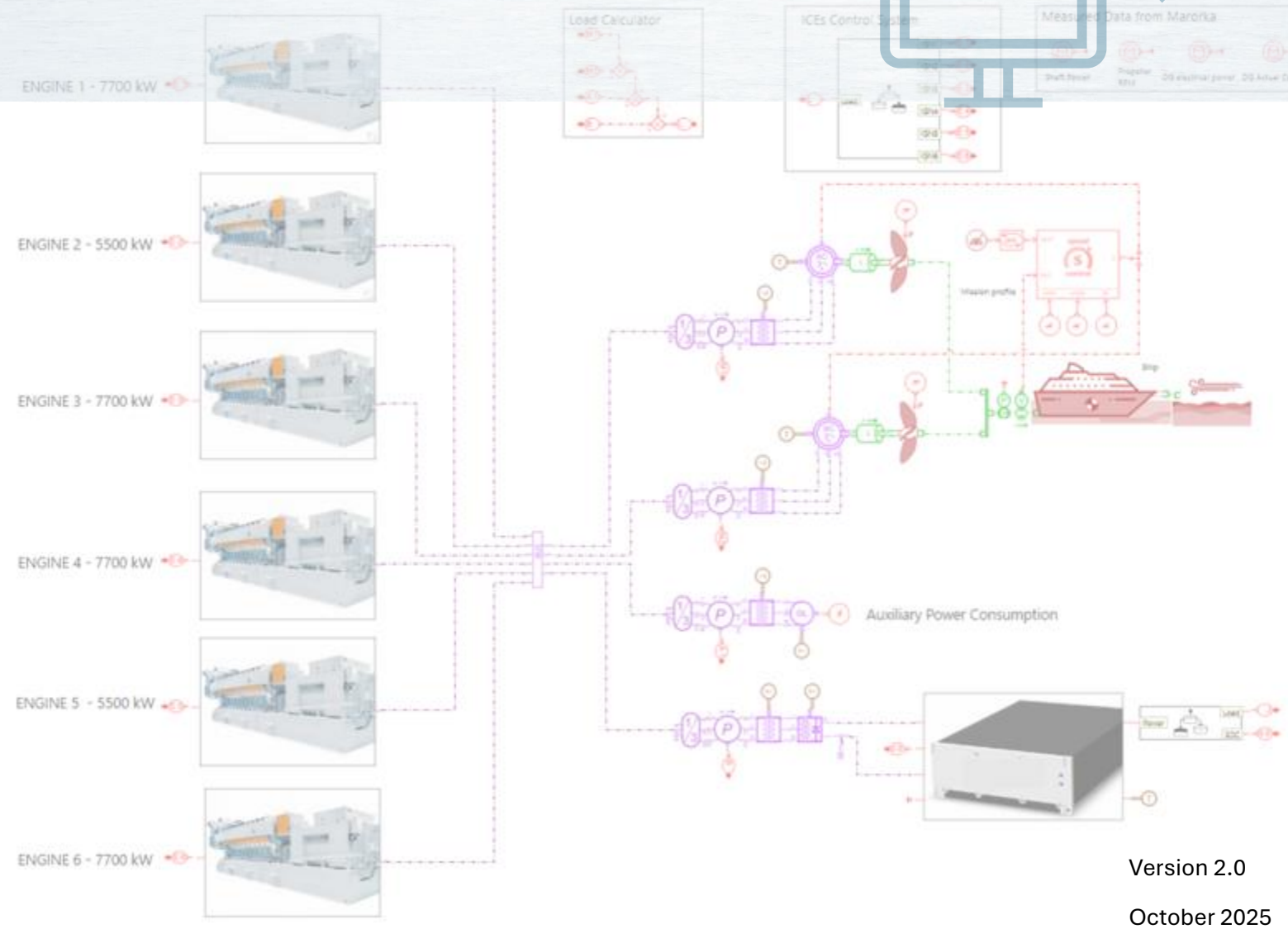
NEMOSHIP

DIGITAL PLATFORM USER MANUAL
LE COMMANDANT CHARCOT



Version 2.0

October 2025

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Acronyms

Abbreviations	
API	Application Programming Interface
BESS	Battery Energy Storage System
CO2	Carbon Dioxide
DG	Diesel Generator
ECDIS	Electronic Chart Display and Information System
GHG	Greenhouse Gas
GPS	Global Positioning System
HP	High Power
MP	Medium Power
IMO CII	International Maritime Organization Carbon Intensity Indicator
KPI	Key Performance Indicator
LNG	Liquefied Natural Gas
LNG CO_2eq WTT	Well-to-tank CO_2 equivalent emissions for LNG
MDO	Marine Diesel Oil
MDO CO_2eq WTT	Well-to-tank CO_2 equivalent emissions for MDO
PS	Peak Shaving
SOC	State of Charge
SOG	Speed Over Ground
SR	Spinning Reserve
UTC	Coordinated Universal Time
ZEO	Zero Emission Operation

1 Introduction

This guide provides comprehensive instructions for the **NEMOSHIP Digital Platform**, developed as part of the EU NEMOSHIP project. It is designed to assist maritime personnel—both onboard and ashore—in effectively utilizing the platform to optimize the performance and operational efficiency of the vessel *Le Commandant Charcot*.

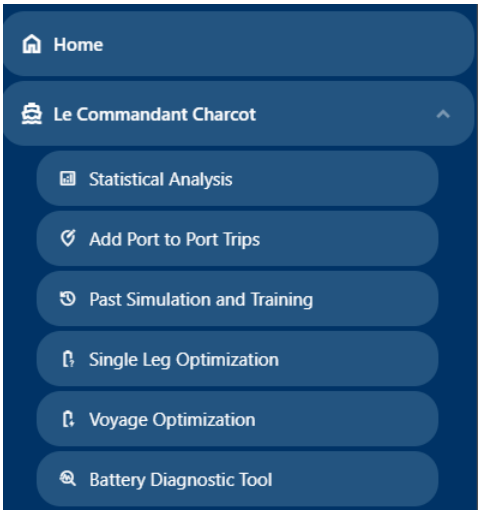


Figure 1 – Le Commandant Charcot Features

2 Platform Overview

The NEMOSHIP Digital Platform offers a comprehensive suite of tools and features designed to support maritime operations and analytics. The platform comprises the following key modules:

- **Statistical Analysis**: Delivers detailed performance metrics and trend analysis for vessel operations.
- **Add Port to Port Trips**: Provides the possibility to add new trips in the digital platform.
- **Past Simulation and Training**: Leverages historical voyage data to enable simulation scenarios and crew training exercises.
- **Single Leg Optimization**: Provides optimization tools for individual voyage segments or short-duration passages.
- **Voyage Optimization**: Offers comprehensive planning and optimization capabilities for complete voyages.

- **Battery Diagnostic Tool**: Delivers specialized functionality for real-time monitoring and diagnostic assessment of the vessel's battery systems.

3 Statistical Analysis Module

The **Statistical Analysis module** enables users to evaluate the impact of the vessel's **Battery Energy Storage System (BESS)** on fuel consumption and emissions. This module provides both a high-level overview of BESS performance across different operational modes and detailed analytical capabilities for in-depth assessment.

3.1 Operational Mode Analysis

The Statistical Analysis module evaluates BESS performance across three primary operational modes, each designed to optimize different aspects of vessel operations:

3.1.1 Zero Emission Operation (ZEO) Mode

- Purpose: This mode quantifies the environmental and fuel-saving benefits achieved when the BESS supplies electrical power during periods of zero-emission operation. These periods typically occur when the vessel is berthed in port without running the diesel generators. The analysis compares actual fuel consumption and emissions (with BESS providing power) against a simulated scenario where a Diesel Generator (DG) would have been solely responsible for meeting the electrical demand.
- Operational Concept: The platform identifies ZEO periods by detecting when Diesel Generators are shut down, while the battery actively discharges to meet the vessel's electrical requirements.
- Simulation Approach: During simulation, the actual "Net Production Power" recorded during the ZEO period serves as input to a hypothetical Diesel Generator configuration (matching the vessel's DG type and fuel specifications). The system then calculates the fuel consumption and emissions that would have occurred without the battery's contribution, enabling direct comparison.

3.1.2 Peak Shaving (PS) Mode

- **Purpose**: Peak Shaving mode evaluates the BESS's capability to reduce peak electrical loads on the Diesel Generators, enabling the crew to operate with fewer DGs or at more optimal loading levels. The analysis compares actual operations—where the BESS actively reduces peak loads—against a simulated scenario requiring an additional Diesel Generator to meet the same demand.
- **Operational Concept:** Peak Shaving is detected when the BESS actively contributes to the electrical grid, thereby reducing the load fluctuation on running DGs and mitigating excessive start cycles of DGs. This mode is particularly valuable during periods with transient power demand.

- **Simulation Approach:** The simulation configures an additional Diesel Generator (based on predefined logic related to DG types and capacities) to supply the power provided by the battery. This enables direct comparison of fuel consumption and emissions between BESS-enabled peak shaving and conventional DG-based operation.

3.1.3 Spinning Reserve (SR) Mode

- **Purpose**: Spinning Reserve mode analyzes the BESS's contribution to maintaining power redundancy and system stability during critical operations, particularly during maneuvering. With the BESS providing spinning reserve capacity, the vessel can often operate with a single DG during maneuvering, whereas conventional operation would typically require two DGs for safety and redundancy.
- **Operational Concept:** Spinning Reserve is identified during maneuvering periods requiring propulsion power and only one Diesel Generator is running, with the BESS standing ready to instantly supply additional power in the event of sudden load increases or DG failure. This configuration enables more efficient operation by eliminating the need to run an additional DG unnecessarily.
- **Simulation Approach:** The SR mode simulation distributes the "Net Production Power" between the actual running DG and a hypothetical additional medium power DG. The system calculates fuel consumption and emissions for this two-DG scenario and compares it against the actual single-DG operation enabled by the BESS.

3.2 Module Interface

The Statistical Analysis module features three primary views: **Overview**, **Details**, and **Saving for Period**.

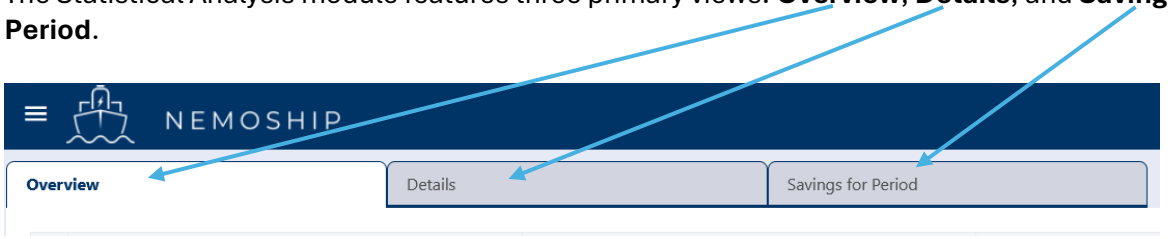


Figure 2 – Period Selection Interface

3.2.1 Overview

The **Overview** screen displays high-level operational statistics for the vessel, providing a comprehensive summary of BESS performance across all operational modes.

Displayed Information:

Operational Mode Summary:

- **Zero Emission Operation (ZEO)**
- **Peak Shaving (PS)**
- **Spinning Reserve (SR)**

For each operational mode, the following metrics are displayed:

- Start and end times of each operational period
- Percentage of total activity duration allocated to each mode

Key Performance Indicators (KPIs):

The following performance metrics are monitored from the start of the reporting period through the current time:

For Zero Emission Operation (ZEO) Mode:

- **Total Fuel Consumption** [t] – Metric tons of fuel consumed
- **Total Methane CO_2eq Emissions** [t] – Metric tons of methane emissions expressed as CO_2 equivalent
- **Total GHG Emissions** [t] – Metric tons of total greenhouse gas emissions (CO_2 equivalent)
- **Medium Power DGs Runtime** [h] – Operating hours of medium power Diesel Generators
- **High Power DGs Runtime** [h] – Operating hours of high-power Diesel Generators
- **Medium Power DGs Start Cycles** [-] – Number of start events for medium power Diesel Generators
- **High Power DGs Start Cycles** [-] – Number of start events for high-power Diesel Generators
- **EU Greenhouse Gas (GHG) | Baseline** – Compliance metric relative to EU regulatory baseline standards

For Peak Shaving (PS) and Spinning Reserve (SR) Modes:

In addition to all the KPIs listed above for ZEO mode, the following indicator is also included:

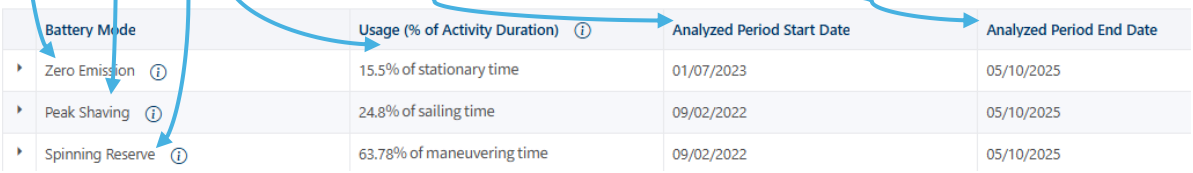
- **IMO CII | Class** – International Maritime Organization Carbon Intensity Indicator rating and classification class

Note: The performance metrics displayed in the Overview encompass the entire monitoring period, from the selected start date until the current time, providing a comprehensive view of vessel operations and the impact of different operational modes on fuel usage, emissions, and equipment utilization.

Operational Mode Detection Criteria:

Mode	Detection logic
Zero Emission Operation (ZEO)	Initiated when all Diesel Generators are stopped; terminates when battery State of Charge (SOC) remains steady for a continuous 30-minute interval.
Peak Shaving (PS)	Activated when battery power exceeds 400 kW. Terminates when battery power is less than 200 kW for at least 2.5 hours or the SOG is 0.
Spinning Reserve (SR)	Detected when a single DG is running during periods with propulsion power demand and Peak Shaving is not active. It ends when one of the detection condition is invalidated.

- Battery Operational modes
  - Zero Emission
  - Peak Shaving
  - Spinning Reserve
    - Percentage of total activity duration for each mode
    - Start and end times of analyzed period for each mode



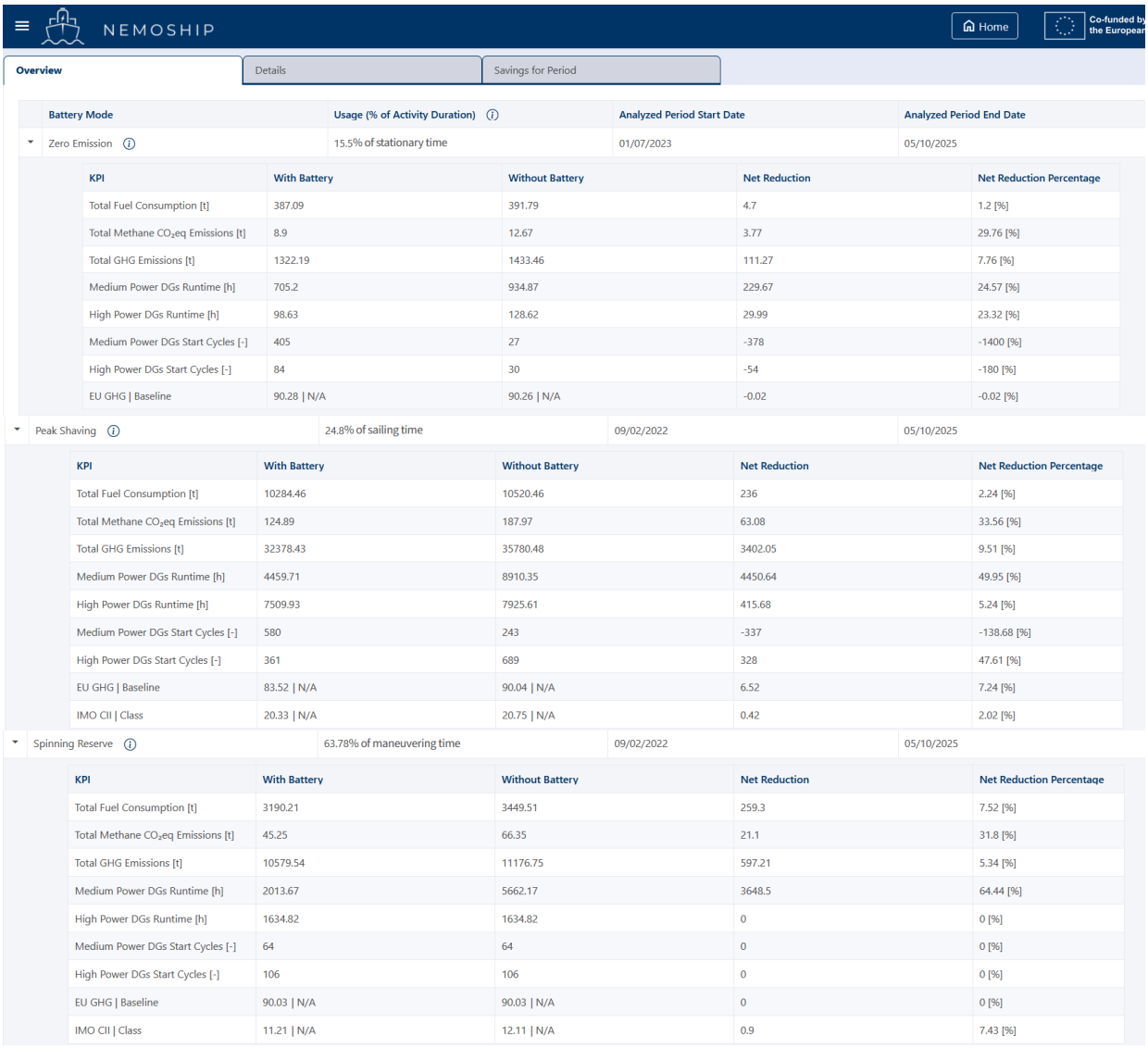
Battery Mode	Usage (% of Activity Duration)	Analyzed Period Start Date	Analyzed Period End Date
Zero Emission	15.5% of stationary time	01/07/2023	05/10/2025
Peak Shaving	24.8% of sailing time	09/02/2022	05/10/2025
Spinning Reserve	63.78% of maneuvering time	09/02/2022	05/10/2025

Figure 3 – Battery Operational Modes Selection

Comparative Analysis Scenarios:

All KPIs are plotted and analyzed across four distinct scenarios to quantify BESS impact:

1. **With Battery [T]:** Displays total values for each KPI with the vessel's battery system operational.
2. **Without Battery [T]:** Displays total values for each KPI in a simulated scenario without battery system operation.
3. **Net Reduction [T]:** Calculates the absolute difference (in metric tons or applicable units) between "With Battery" and "Without Battery" scenarios, demonstrating the net reduction achieved through battery system utilization.
4. **Net Reduction [%]:** Calculates the percentage reduction in each KPI achieved by using the battery system compared to conventional operation without it.



Battery Mode	Usage (% of Activity Duration)	Analyzed Period Start Date	Analyzed Period End Date
Zero Emission	15.5% of stationary time	01/07/2023	05/10/2025

KPI	With Battery	Without Battery	Net Reduction	Net Reduction Percentage
Total Fuel Consumption [t]	387.09	391.79	4.7	1.2 [%]
Total Methane CO_2eq Emissions [t]	8.9	12.67	3.77	29.76 [%]
Total GHG Emissions [t]	1322.19	1433.46	111.27	7.76 [%]
Medium Power DGs Runtime [h]	705.2	934.87	229.67	24.57 [%]
High Power DGs Runtime [h]	98.63	128.62	29.99	23.32 [%]
Medium Power DGs Start Cycles [-]	405	27	-378	-1400 [%]
High Power DGs Start Cycles [-]	84	30	-54	-180 [%]
EU GHG | Baseline	90.28 | N/A	90.26 | N/A	-0.02	-0.02 [%]

Peak Shaving	24.8% of sailing time	09/02/2022	05/10/2025

KPI	With Battery	Without Battery	Net Reduction	Net Reduction Percentage
Total Fuel Consumption [t]	10284.46	10520.46	236	2.24 [%]
Total Methane CO_2eq Emissions [t]	124.89	187.97	63.08	33.56 [%]
Total GHG Emissions [t]	32378.43	35780.48	3402.05	9.51 [%]
Medium Power DGs Runtime [h]	4459.71	8910.35	4450.64	49.95 [%]
High Power DGs Runtime [h]	7509.93	7925.61	415.68	5.24 [%]
Medium Power DGs Start Cycles [-]	580	243	-337	-138.68 [%]
High Power DGs Start Cycles [-]	361	689	328	47.61 [%]
EU GHG | Baseline	83.52 | N/A	90.04 | N/A	6.52	7.24 [%]
IMO CII | Class	20.33 | N/A	20.75 | N/A	0.42	2.02 [%]

Spinning Reserve	63.78% of maneuvering time	09/02/2022	05/10/2025

KPI	With Battery	Without Battery	Net Reduction	Net Reduction Percentage
Total Fuel Consumption [t]	3190.21	3449.51	259.3	7.52 [%]
Total Methane CO_2eq Emissions [t]	45.25	66.35	21.1	31.8 [%]
Total GHG Emissions [t]	10579.54	11176.75	597.21	5.34 [%]
Medium Power DGs Runtime [h]	2013.67	5662.17	3648.5	64.44 [%]
High Power DGs Runtime [h]	1634.82	1634.82	0	0 [%]
Medium Power DGs Start Cycles [-]	64	64	0	0 [%]
High Power DGs Start Cycles [-]	106	106	0	0 [%]
EU GHG | Baseline	90.03 | N/A	90.03 | N/A	0	0 [%]
IMO CII | Class	11.21 | N/A	12.11 | N/A	0.9	7.43 [%]

Figure 4 – Key Performance Indicators Display

Battery Mode Usage and Savings

In addition to the KPI analysis, the system provides comprehensive information about the **Total Fuel Saved** over the entire monitoring period. Interactive graphs track battery mode usage over time, along with corresponding fuel savings and greenhouse gas emission reductions achieved through BESS operation.

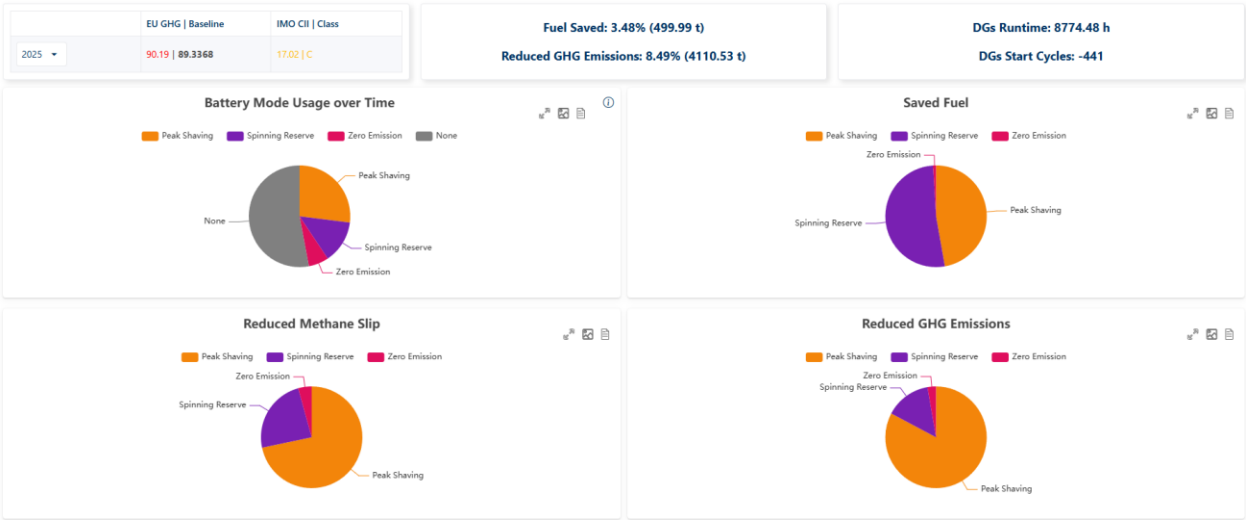


Figure 5 – Statistical Analysis Overview

Battery Mode Usage over Time

This graph illustrates the percentage of time the vessel operated in each battery mode (Zero Emission Operation, Peak Shaving, and Spinning Reserve) throughout the monitoring period. The visualization provides clear insight into battery system utilization patterns and the relative duration of each operational mode, enabling operators to understand how the BESS is being deployed across different operational scenarios.

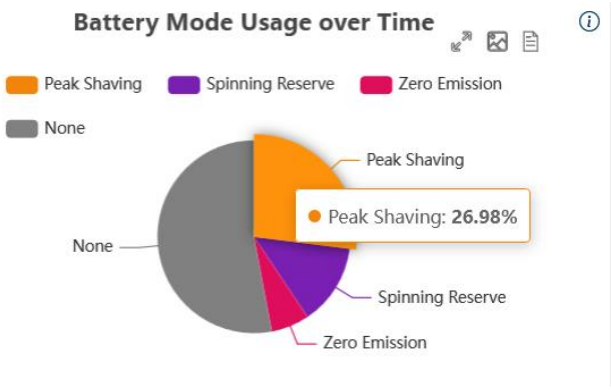


Figure 6 – Battery Mode Usage over Time

Fuel Saved (T)

The **Fuel Saved** graph displays the cumulative amount of fuel (in precentage and metric tons) conserved by operating the vessel with the battery system across different operational modes, compared to conventional operation without BESS. This metric directly quantifies the fuel efficiency gains achieved through battery system integration, providing tangible evidence of operational cost savings.

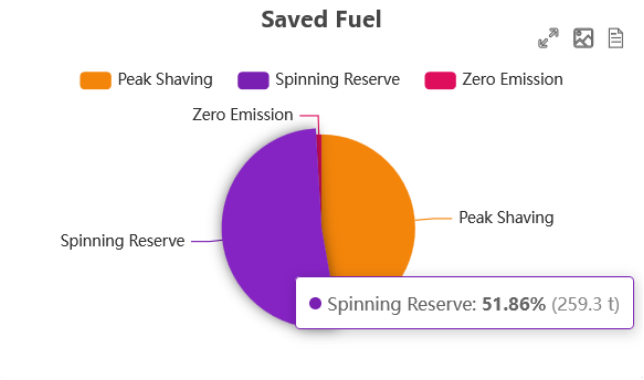


Figure 7 – Saved Fuel

Reduced GHG Emissions [t CO_2eq]

Complementing the fuel savings analysis, the platform tracks the reduction in **greenhouse gas (GHG) emissions** (measured in metric tons of CO_2 equivalent) resulting from battery system operation. This graph demonstrates the environmental benefits of the BESS in terms of reduced carbon footprint, supporting the vessel's sustainability objectives and regulatory compliance efforts.

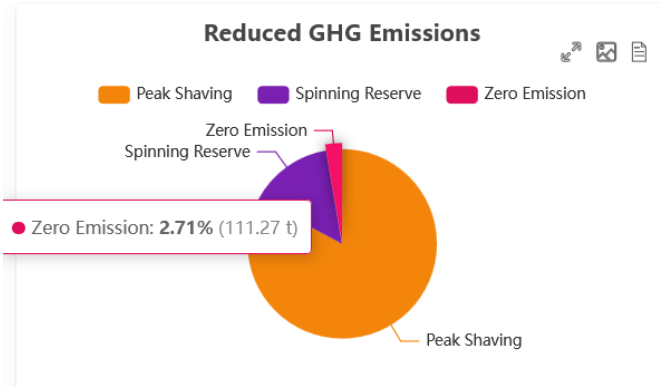


Figure 8 – Greenhouse Gas Emission Reductions

Reduced Methane Slip

The **Reduced Methane Slip** plot displays the amount of reduced methane slip in both tonnes and percentage across all 3 different operating modes: Zero Emission, Peak Shaving, and Spinning Reserve.

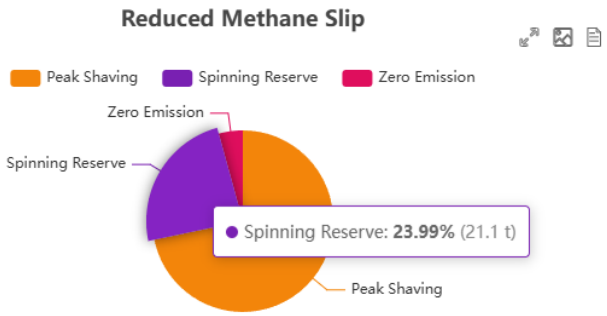


Figure 9 - Methane Slip Reductions

By providing these detailed analytical views, the **Statistical Analysis Module** delivers a comprehensive understanding of the battery system's operational performance, its impact on fuel consumption, and the associated environmental benefits. This information enables operators to:

- Optimize vessel operations and battery deployment strategies
- Maximize the economic and environmental benefits of the BESS
- Demonstrate compliance with environmental regulations and sustainability commitments
- Support data-driven decision-making for future voyage planning.

Monthly Statistical Overview

The platform provides a comprehensive monthly statistical overview of the vessel's operational modes. This analysis is presented through two complementary visualization approaches that enable detailed performance tracking and trend identification.

Operational Mode View

This graph displays the percentage breakdown of time allocated to each operational mode (Zero Emission Operation, Peak Shaving, and Spinning Reserve) on a monthly and annual basis. By visualizing the relative duration of each mode over time, operators can identify operational trends, seasonal variations, and opportunities to optimize vessel operations for maximum utilization of battery-powered modes.

Figure 10 – Monthly Operational Mode Distribution (Percentage View)

Time View

Complementing the percentage-based analysis, the platform also displays the absolute time (measured in hours) spent in each operational mode on a monthly basis. This view provides granular insight into actual battery system usage, enabling users to track the evolution of BESS deployment patterns over extended.

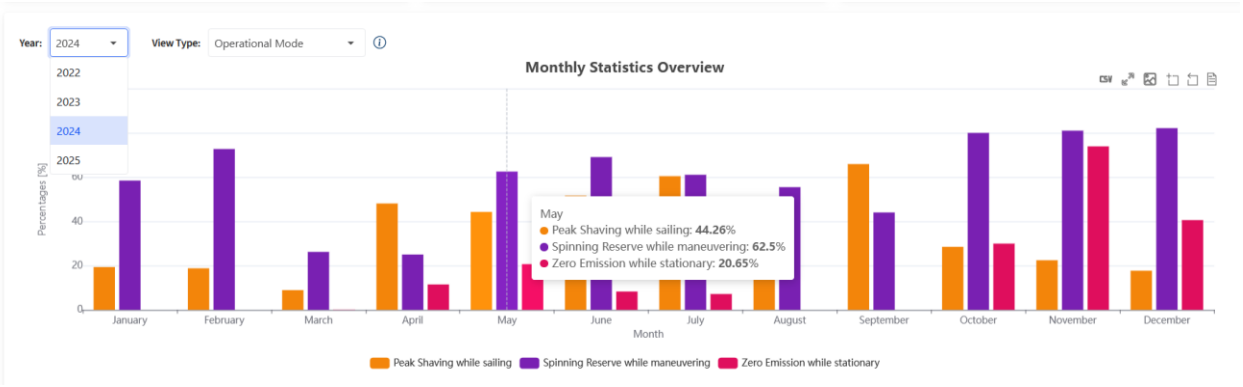


Figure 11 – Monthly Operational Mode Distribution (Time View)

By presenting the **Operational Mode View** and **Time View** side-by-side, the platform enables users to quickly compare and correlate percentage-based and absolute time metrics for each operational mode. This dual-perspective analysis facilitates:

- Comprehensive understanding of overall battery utilization patterns
- Identification of optimization opportunities
- Verification that the battery system is being deployed to its full potential
- Data-driven operational planning and decision-making

Monthly Fuel Consumption Savings

The platform provides detailed visualization of monthly fuel consumption savings achieved through battery system operation.

Comparative Analysis:

This graph compares actual fuel consumption data recorded by the vessel's monitoring platform against simulated fuel consumption that would have occurred without the battery system. The comparison is conducted on a monthly basis, revealing fluctuations in fuel savings over time and enabling identification of performance trends.

Display Configuration Options:

The fuel consumption savings graph can be configured to display data in two complementary formats:

Percentage View: This visualization presents monthly fuel consumption savings as a percentage, illustrating the relative reduction in fuel usage achieved through battery system operation. This metric is particularly useful for understanding efficiency improvements and comparing performance across different time periods.

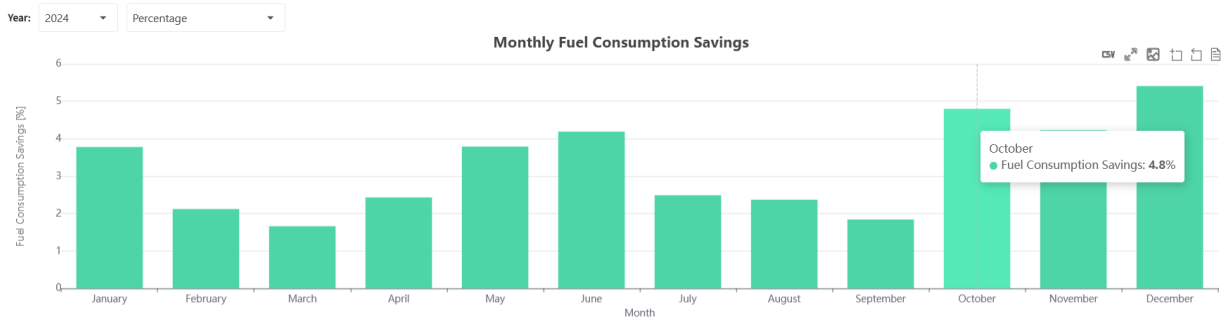


Figure 12 – Monthly Fuel Savings (Percentage)

Absolute Savings View [kg]: This visualization displays the actual quantity of fuel (measured in kilograms) saved each month, providing a tangible metric for understanding absolute fuel conservation. This view is valuable for calculating cost savings and quantifying environmental impact.

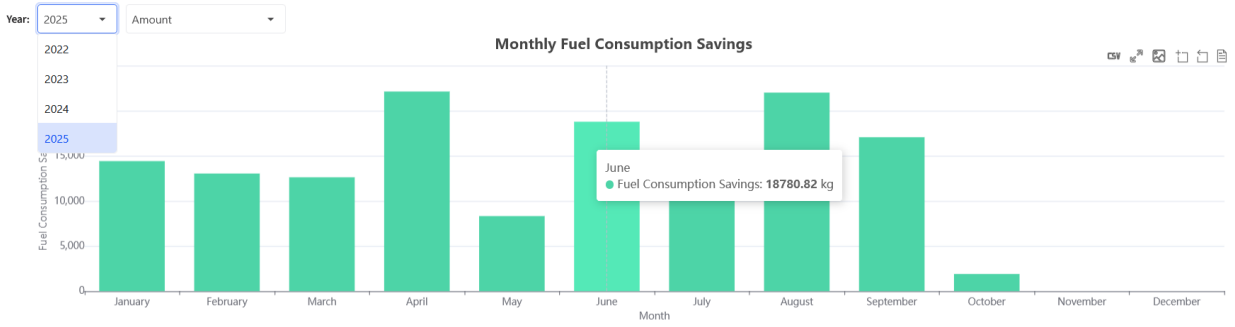


Figure 13 – Monthly Fuel Savings (Kilograms)

By offering both percentage-based and absolute quantity perspectives, users gain comprehensive understanding of battery system fuel consumption benefits. This dual approach supports:

- **Trend Identification:** Recognition of seasonal patterns and long-term performance trends
- **Operational Optimization:** Data-driven adjustments to maximize fuel efficiency
- **Environmental Impact Quantification:** Clear demonstration of sustainability benefits
- **Performance Benchmarking:** Comparison of results across different operational periods
- **Stakeholder Reporting:** Flexible presentation formats for different audiences

This detailed monthly analysis help the operators to continuously refine vessel operations, maximizing both the fuel efficiency gains and environmental benefits delivered by the battery system.

3.2.2 Details tab

The Details view enables users to conduct in-depth analysis and gain granular understanding of vessel performance and Battery Energy Storage System (BESS) impact. This view provides comprehensive tools for examining specific time periods, voyages, and operational characteristics.

Year and Voyage Selection

Users can select a specific year and individual voyage for detailed analysis, enabling focused examination of vessel operations and BESS performance during particular time periods or trips. This targeted approach supports precise performance evaluation and identification of optimization opportunities.

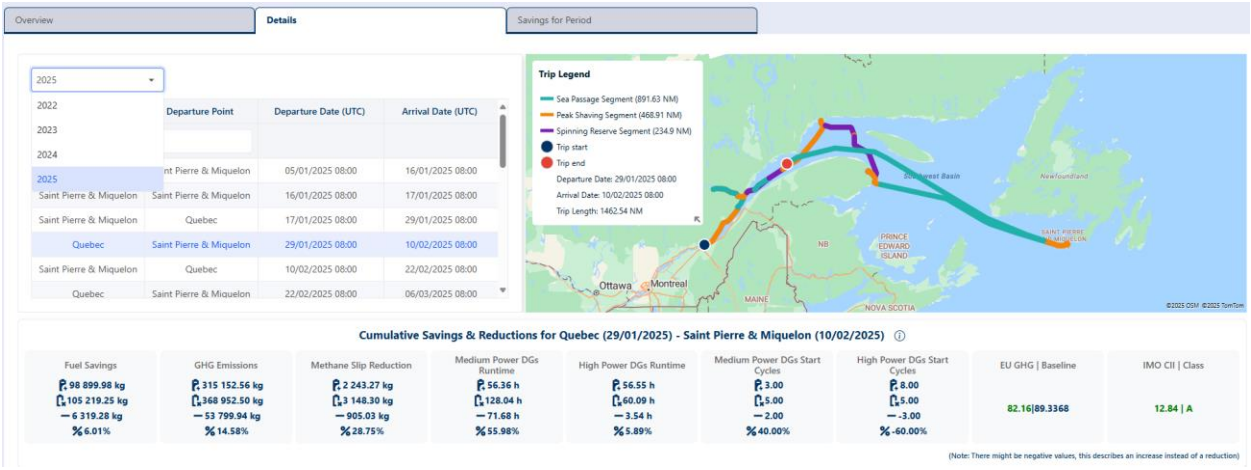


Figure 14 – Year and Voyage Selection Interface

Key Performance Metrics

Alongside operational mode analysis, the Details view presents comprehensive totals for the selected trip, including:

Metric	Unit	Description
Fuel Savings	kg / %	Quantity of fuel used with battery, without battery, fuel conserved and percentage reduction
GHG Emission Reductions	kg CO_2eq / %	Greenhouse gas emissions avoided (CO_2 equivalent)
Methane Slip Reduction	kg CO_2eq / %	Methane emissions avoided (CO_2 equivalent)
Medium Power DGs Runtime	h / %	Operating hours saved for medium power Diesel Generators
High Power DGs Runtime	h / %	Operating hours saved for high-power Diesel Generators
Medium Power DGs Start Cycles	count / %	Number of start events avoided for medium power DGs
High Power DGs Start Cycles	count / %	Number of start events avoided for high-power DGs
EU GHG | Baseline	gCO_2eq/MJ | gCO_2eq/MJ	Actual value compared to EU regulatory baseline
IMO CII | Class	gCO_2/tonne·NM | Rating	Carbon Intensity Indicator value and classification (A-E)

Cumulative Savings & Reductions - Example Voyage

Voyage: Quebec (29/01/2025) - Saint Pierre & Miquelon (10/02/2025)

Performance Metric	Absolute Value	Percentage Change
Methane Slip Reduction	905.03 kg CO_2eq	28.75% ↓
Medium Power DGs Start Cycles	2 cycles	40% ↓
Medium Power DGs Runtime	71.68 h	55.98% ↓
IMO CII | Class	12.84 | A	Superior rating
High Power DGs Start Cycles	-3 cycles	-60% (increase)
High Power DGs Runtime	3.54 h	5.89% ↓
GHG Emissions Reduction	53,799.94 kg CO_2eq	14.58% ↓
Fuel Savings	6,319.28 kg	6.01% ↓
EU GHG | Baseline	82.16 | 89.34 gCO_2eq/MJ	Below baseline

Figure 15 – Cumulative Savings and Reductions Summary

Benefits of Granular Analysis

This detailed view empowers users to:

- **Understand BESS Performance:** Evaluate battery system benefits at voyage or annual level rather than aggregated metrics only
- **Identify Improvement Areas:** Pinpoint specific operational scenarios requiring optimization
- **Optimize BESS Usage:** Make data-driven adjustments to battery deployment strategies
- **Maximize Benefits:** Enhance both environmental and financial advantages of the NEMOSHIP Digital Platform
- **Support Decision-Making:** Base operational decisions on comprehensive, voyage-specific data

The combination of specific year/voyage selection with detailed operational mode analysis and fuel/emissions savings provides a comprehensive and flexible tool for thorough BESS performance evaluation and data-driven efficiency enhancement.

Operational Mode Breakdown

Within the Details view, users can visualize the results for different KPIs across each operating mode (Zero Emission, Peak Shaving, and Spinning Reserve) during the selected trip. This breakdown provides insights into the impact of different operating modes for each specific time period when that mode was active, as well as comprehensive details for the entire duration that each mode was used throughout the trip.

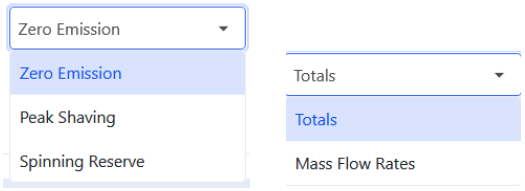


Figure 16 – Operational Mode Distribution for Selected Period

Peak Shaving Period Analysis

Users can examine specific Peak Shaving periods for the selected destination and time interval, enabling focused analysis of this critical operational mode.

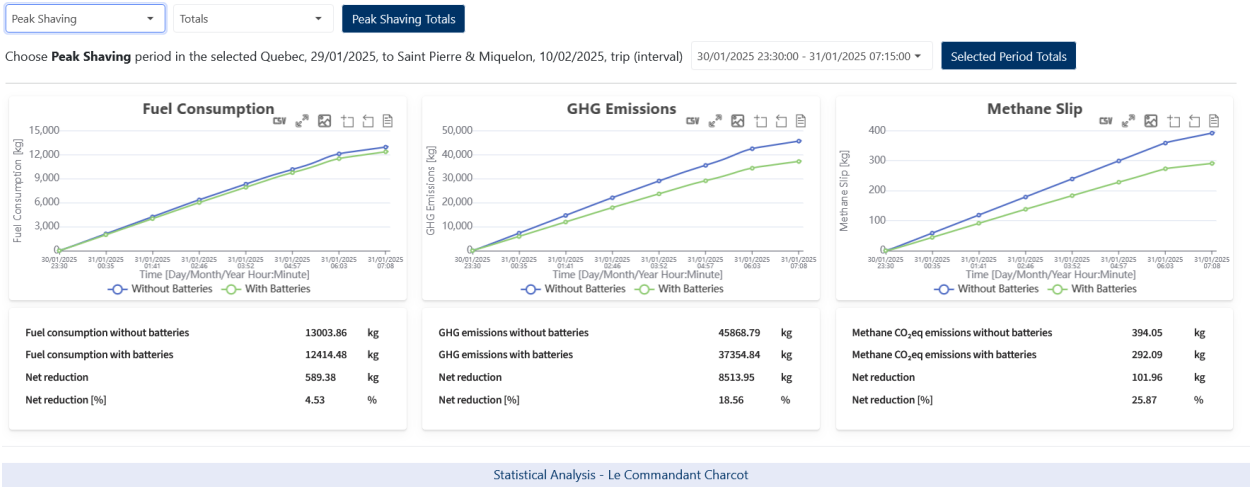


Figure 17 – Peak Shaving Period Detail View

Trip Interval Selection

For a specific mode (Zero Emission, Peak Shaving, or Spinning Reserve), the platform provides the ability to select a particular time interval during which that mode was active and analyze the results for that specific interval.

Figure 18 – Interval Selection Interface

Selected Period Performance Summary

For the chosen time period, the platform displays comprehensive totals for all key performance metrics:

- Fuel Savings [kg / %]
- GHG Emission Reductions [kg CO_2eq / %]
- Methane Slip Reduction [kg CO_2eq / %]
- Medium Power DGs Runtime [h / %]
- High Power DGs Runtime [h / %]
- Medium Power DGs Start Cycles [count / %]
- High Power DGs Start Cycles [count / %]
- EU GHG | Baseline [gCO_2eq/MJ]
- IMO CII | Class [gCO_2/tonne·NM | Rating]

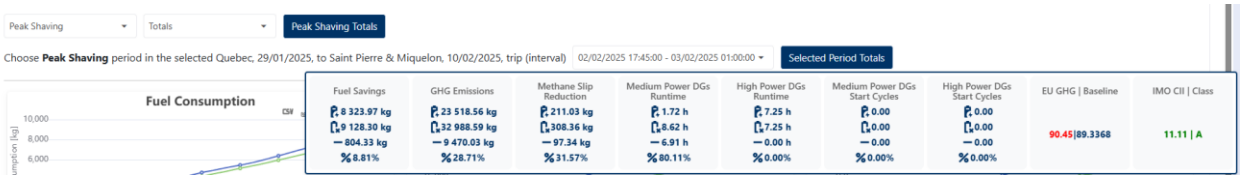


Figure 19 – Selected Period Total Performance Metrics

Mass Flow Rate Analysis

The Details view includes mass flow rate data for different operational modes during the selected trip, providing insight into fuel consumption patterns and system efficiency across various operating conditions.

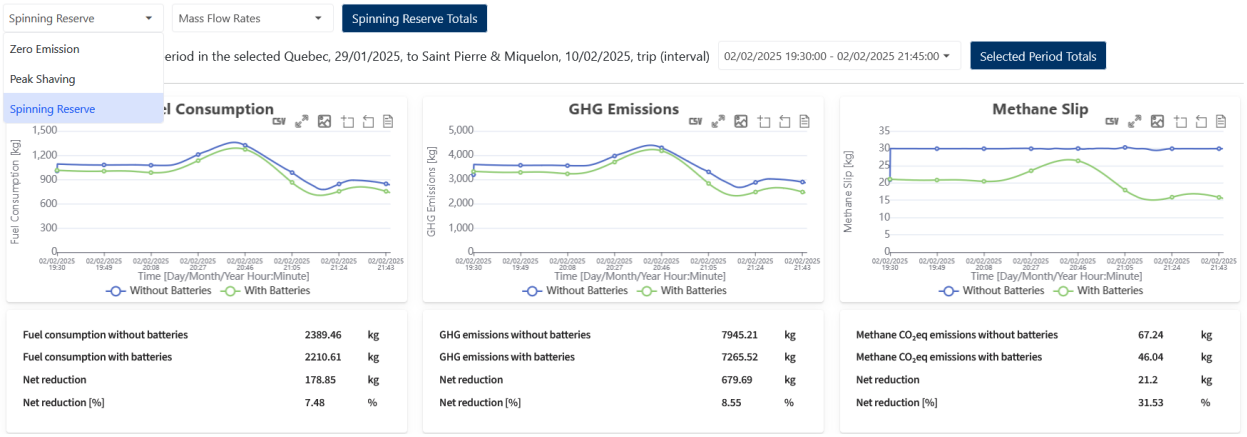


Figure 20 – Mass Flow Rate by Operational Mode

3.2.3 Savings for Period

The **Savings for Period** view provides flexible analysis capabilities, enabling users to select custom time periods that may encompass multiple voyages. This feature supports comprehensive performance evaluation across extended operational periods or specific route combinations.

Custom Period Selection

Users can define custom analysis periods to evaluate BESS performance across multiple trips and various operational scenarios. This flexibility enables:

- Analysis of seasonal performance patterns
- Comparison of different route combinations
- Evaluation of long-term operational trends

Date and Time Input:

The platform provides intuitive date and time selection fields:

- **Start Date/Time:** Define the beginning of the analysis period
- **End Date/Time:** Define the conclusion of the analysis period
- **Format:** dd/MM/yyyy hh:mm (UTC)

Example Period:

- Start: 01/08/2024 03:00
- End: 02/11/2024 11:00

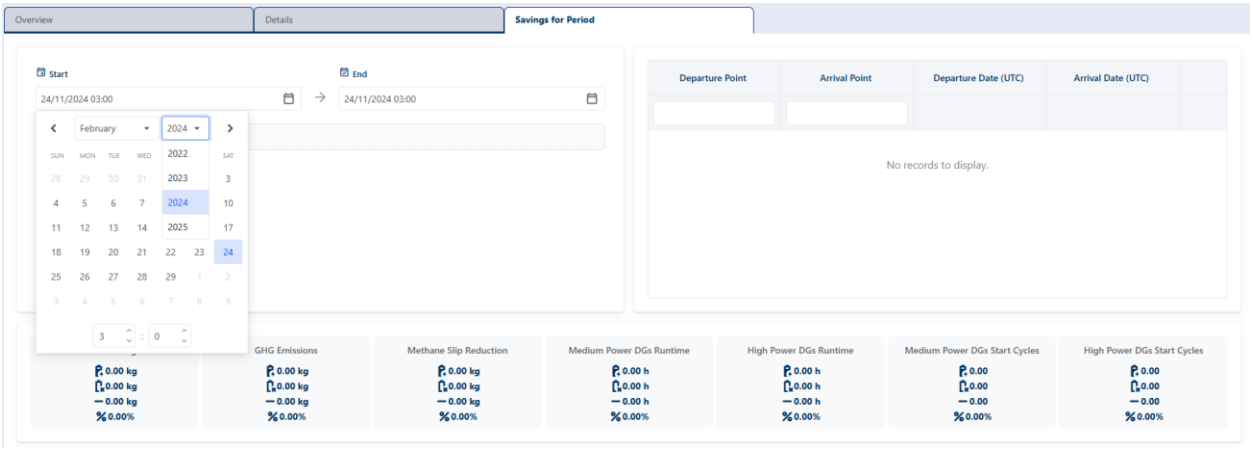


Figure 21 – Custom Period Selection Interface

Generating Analysis Results:

After defining the desired time period, users must click the **Get Totals** button to retrieve and calculate the performance data for the selected period. This action initiates the data processing and generates comprehensive performance metrics based on the specified timeframe.

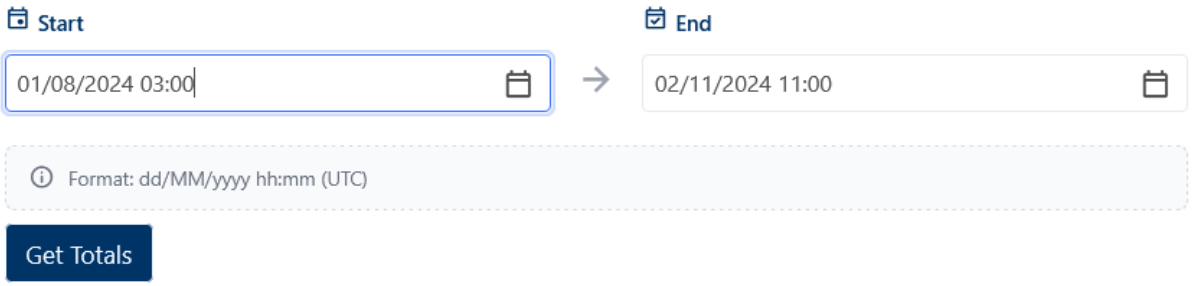


Figure 22 – Get Totals Button Interface

Trip Selection and Filtering

Departure-Arrival Port Selection:

After defining a period, individual trips can be selected based on departure and arrival port combinations, providing granular control over which voyages are included in the analysis. This port-based selection method enables users to:

- Focus on specific routes or trade patterns
- Compare performance across different geographical regions
- Analyze BESS effectiveness for particular voyage types

Trip Exclusion Capability:

Unwanted trips can be removed from the selection, ensuring that the analysis reflects only the relevant operational data. This filtering capability is valuable for:

- Excluding anomalous voyages or special circumstances
- Focusing on standard operational patterns
- Removing incomplete or compromised data sets
- Customizing analysis to specific research questions

Departure Point	Arrival Point	Departure Date (UTC)	Arrival Date (UTC)	
Punta Arenas	Ushuaia	03/11/2023 08:00	17/11/2023 08:00	
Ushuaia	Ushuaia	17/11/2023 08:00	29/11/2023 08:00	
Ushuaia	Ushuaia	29/11/2023 08:00	13/12/2023 08:00	
Ushuaia	Ushuaia	13/12/2023 08:00	27/12/2023 08:00	

Figure 23 – Trip Selection and Filtering Interface

Performance Data for Selected Period

For the custom-defined period, the platform provides comprehensive performance metrics:

Key Performance Indicators:

Metric	Unit	Description
Fuel Savings	kg / %	Total fuel conserved and percentage reduction
GHG Emissions Reduction	kg CO_2eq / %	Total greenhouse gas emissions avoided
Methane Slip Reduction	kg CO_2eq / %	Total methane emissions avoided

Medium Power DGs Runtime	h / %	Operating hours saved for medium power Diesel Generators
High Power DGs Runtime	h / %	Operating hours saved for high-power Diesel Generators
Medium Power DGs Start Cycles	count / %	Start events avoided for medium power DGs
High Power DGs Start Cycles	count / %	Start events avoided for high-power DGs

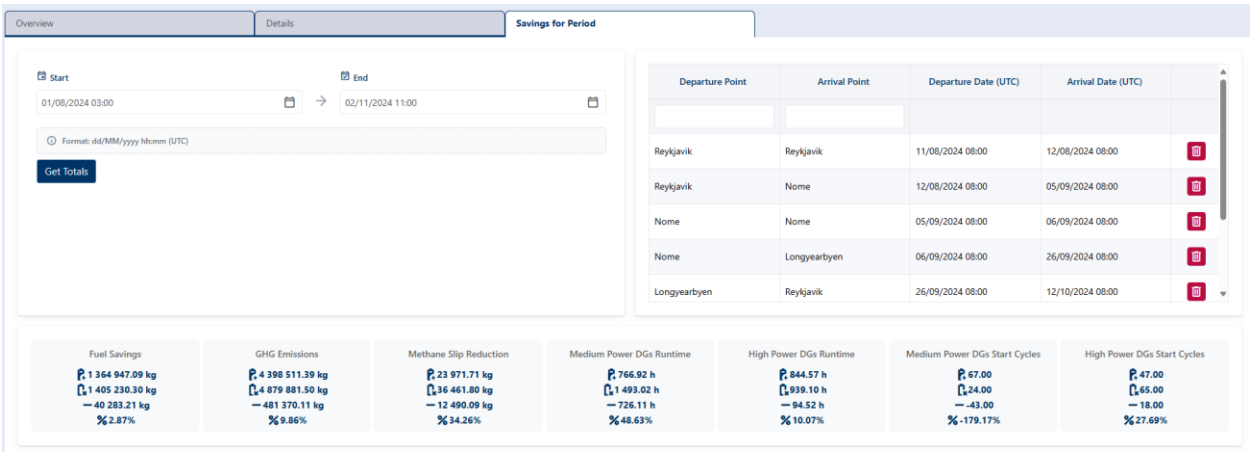


Figure 24 - Savings for Period Results

Benefits of Custom Period Analysis

The Savings for Period view empowers users to:

- **Flexible Reporting:** Generate performance reports for any desired time frame
- **Route Comparison:** Evaluate BESS effectiveness across different routes and operational patterns
- **Trend Analysis:** Identify long-term performance trends and seasonal variations
- **Stakeholder Communication:** Create customized reports for different audiences (management, regulatory bodies, investors)
- **Operational Planning:** Use historical multi-trip data to optimize future voyage planning
- **Performance Benchmarking:** Compare different operational periods to identify best practices

This comprehensive analysis tool provides the flexibility needed to extract meaningful insights from vessel operational data, supporting continuous improvement and data-driven decision-making.

4 Add Port to Port Trips

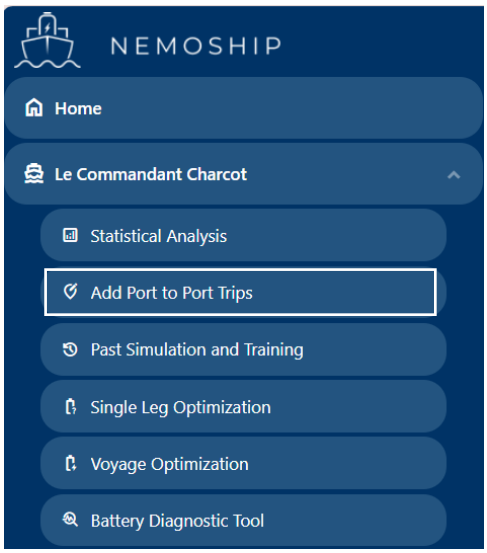


Figure 25 - Add Port to Port Trips Module

The **Add Port to Port Trips Module** has restricted access and is available only to specific users. The platform contains pre-loaded trips spanning from 2022 through 5th October 2025. These existing trips have been analyzed and cannot be modified. Analyzed trips are those included in the **Statistical Analysis Module** results, which encompass overall totals and results categorized by month, year, trip, and custom periods.

This module enables authorized users to introduce new trips into the system. New trip registration should occur at the completion of each voyage, as the system collects related data from Marorka during the registration process.

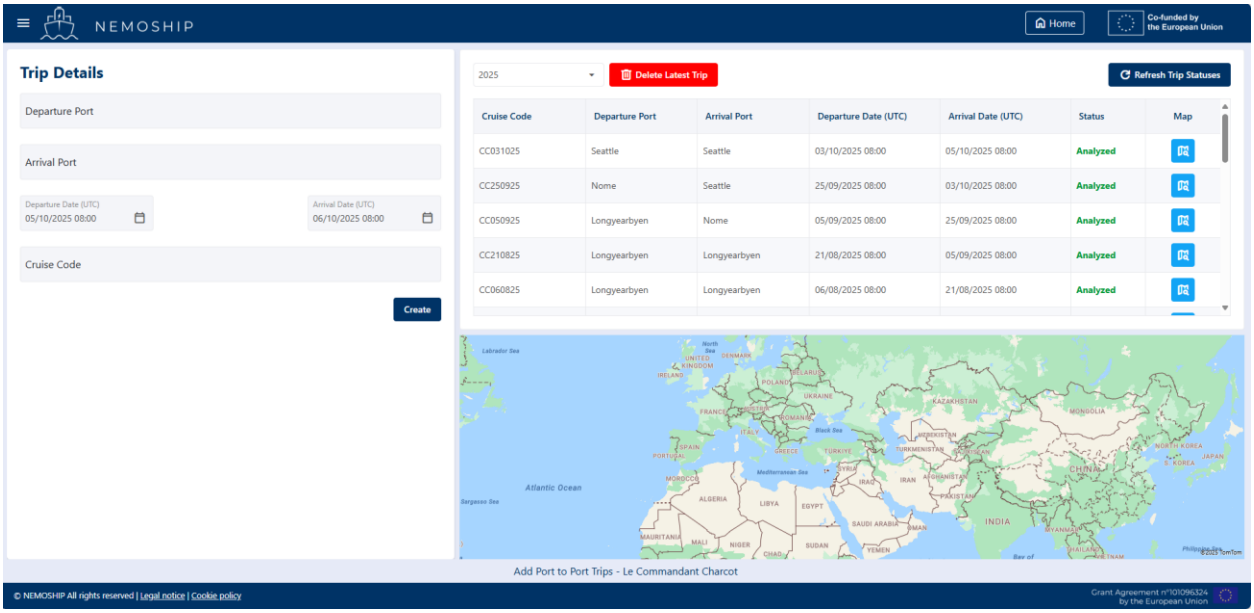


Figure 26 – Add Port to Port Trips Interface

4.1 Adding a New Trip

To register a new trip, five mandatory fields must be completed on the left side of the page:

- **Departure Port** - the voyage starting port
- **Arrival Port** - the voyage ending port
- **Departure Date** - departure date and time in UTC format
- **Arrival Date** - arrival date and time in UTC format
- **Cruise Code** - a unique identifier for the trip; if the entered code already exists for another trip, an error message will appear, and the trip registration will be rejected

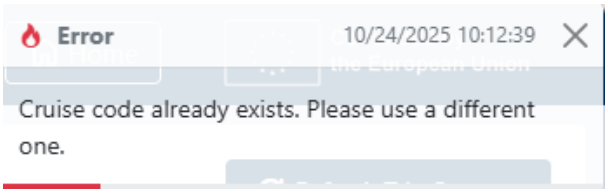


Figure 27 - Cruise Code Validation

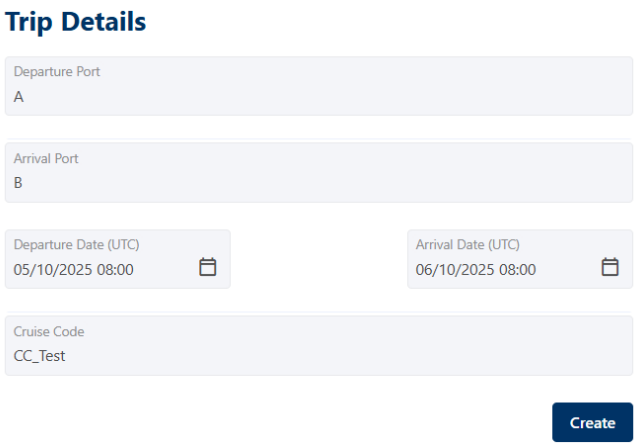


Figure 28 – New Trip Registration

New trip registration must comply with specific validation rules:

- The Arrival Date must occur after the Departure Date

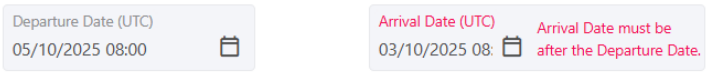


Figure 29 – Arrival Date Validation

- The Departure Date must occur after the Arrival Date of the most recent existing trip

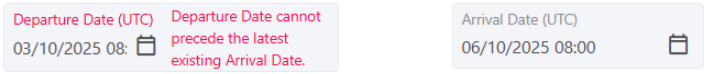


Figure 30 – Departure Date Validation

After completing all five field configurations, press the **Create** button to register the new trip.

4.2 Port to Port Trips Table

Following successful registration, a new entry will appear in the table on the right side of the page. This table displays all trips that have been analyzed and introduced into the platform. The trips are organized chronologically by year. To view trips from a different year, select the desired year from the dropdown menu located above the table.

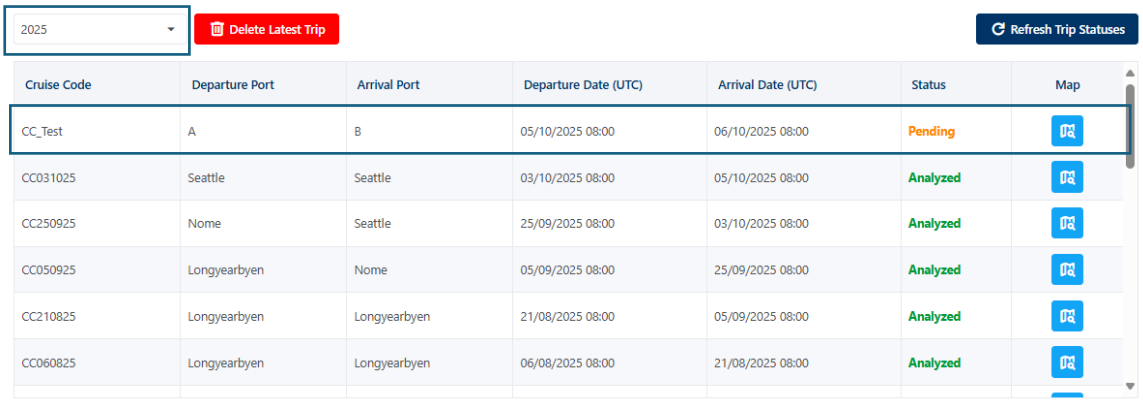


Figure 31 – Port to Port Trips Table – Pending Status

The table contains multiple columns with the following information:

- **Cruise Code**: the unique identifier of a trip
- **Departure Port**: the name of the starting port
- **Arrival Port**: the name of the arrival port
- **Departure Date**: the departure date in UTC format
- **Arrival Date**: the arrival date in UTC format
- **Status**: the current trip status, which displays one of three options:
  - ***Analyzed*** - the trip was successfully added and analyzed, with all related data included in the Statistical Analysis Module
  - ***Pending*** - the trip was recently added and is currently under analysis
  - ***Error*** - an error occurred during trip analysis, and the results could not be updated in the Statistical Analysis Module
- **Map** - a button that displays the trip route on the map below the table when pressed

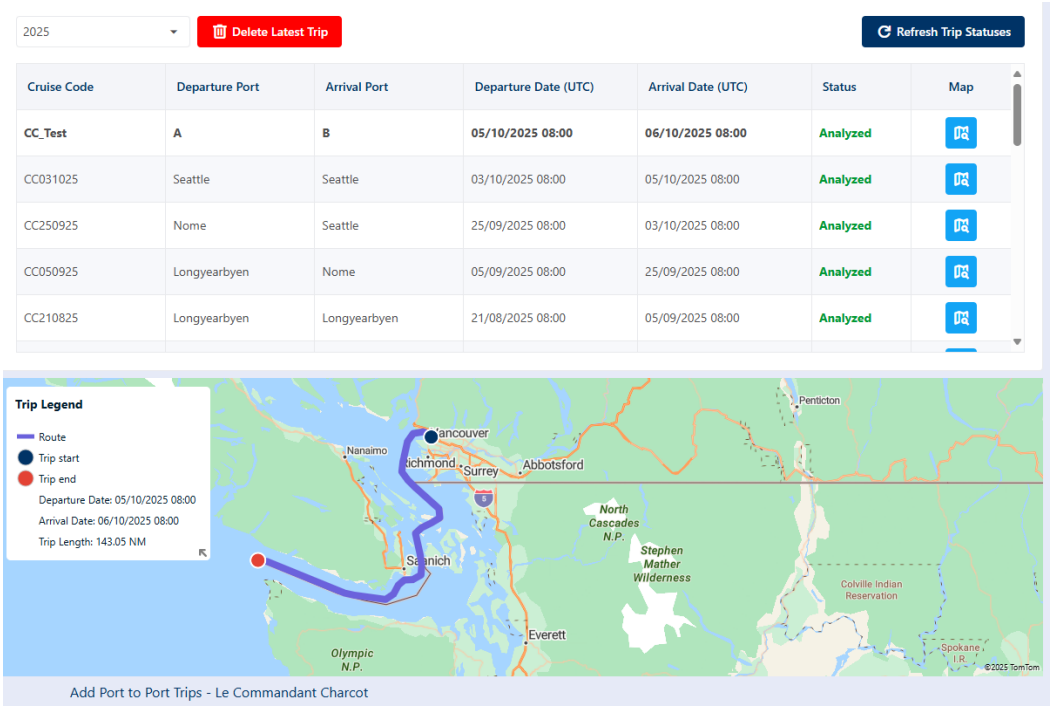


Figure 32 – Port to Port Trips Table – New Trip Added

Two additional buttons are located above the table:

- **Refresh Trip Statuses**: updates the status column to check whether the added trip has been completely analyzed (*Analyzed* status) or if an issue occurred (*Error* status)
- **Delete Latest Trip** - removes the most recent trip from the system. A confirmation popup appears to prevent accidental deletion and data loss.

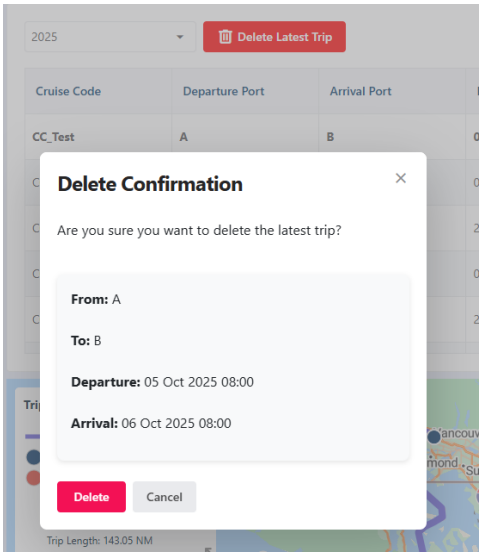


Figure 33 – Delete Trip Confirmation Dialog

Once a trip is deleted, all associated data is permanently removed from Statistical Analysis Module computations. Pre-loaded trips from 2022 through 5th October 2025 cannot be deleted. Attempting to delete these trips will generate an error message.

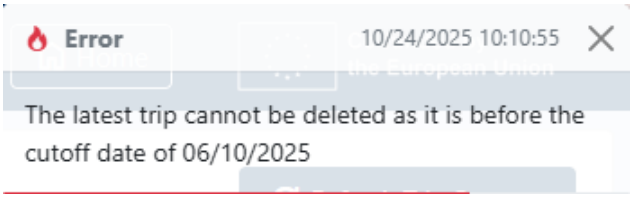


Figure 34 – Delete Trip Error

When a trip displays Pending status, no additional trips can be added until the current analysis operation completes.

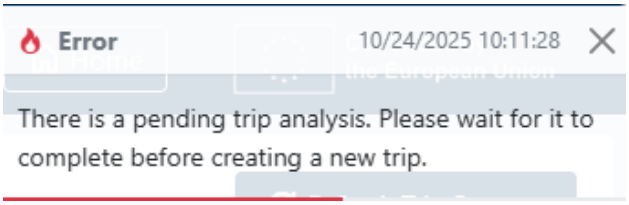


Figure 35 – Delete Trip Pending Error Message

5 Past Simulation and Training Module

5.1 Purpose

The **Past Simulation and Training Module** is designed to address "what-if" scenarios for historical voyage analysis. This module enables users to select a completed voyage or voyage segment, modify specific operational parameters, and analyze the resulting effects of these changes. This module consists of **three sequential steps**, plus an **archive section** where all completed simulations are stored for future reference and comparison.

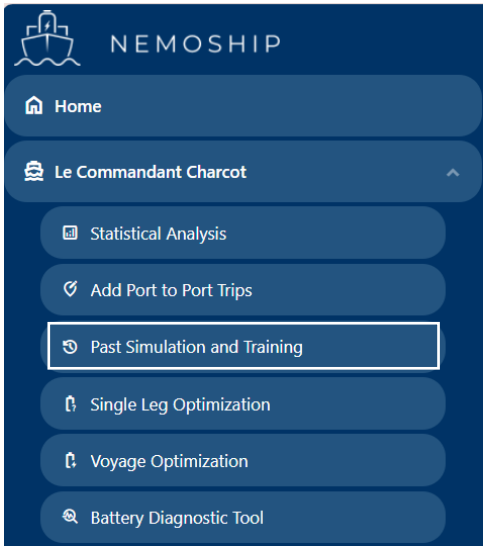


Figure 36 – Past Simulation and Training Module

5.2 Module Structure

5.2.1 Step 1: Select Route

The first step requires users to select a historical voyage for simulation. Two selection methods are available:

Port to port selection

Users can browse and select completed voyages from a comprehensive table displaying the following information:

- **Departure Point** - Origin port
- **Arrival Point** - Destination port
- **Departure Date (UTC)** - Voyage start date and time
- **Arrival Date (UTC)** - Voyage end date and time

This method is ideal when users know the specific ports involved in the voyage they wish to analyze.

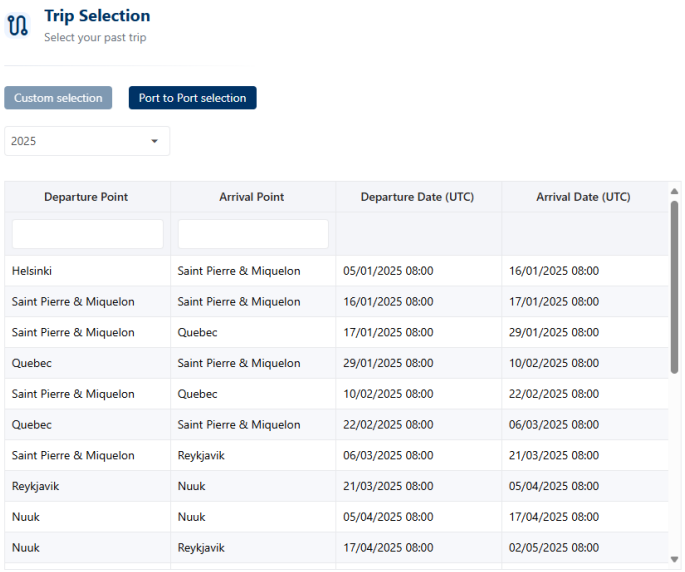


Figure 37 – Past Simulation and Training – Trip Selection

Custom selection

Users can define a specific period by selecting:

- **Start Date (UTC)** - Beginning of the desired voyage segment
- **End Date (UTC)** - End of the desired voyage segment

The system will retrieve the voyage or voyage segment that occurred within the specified timeframe. This method is particularly useful for analyzing partial voyages or specific operational periods.

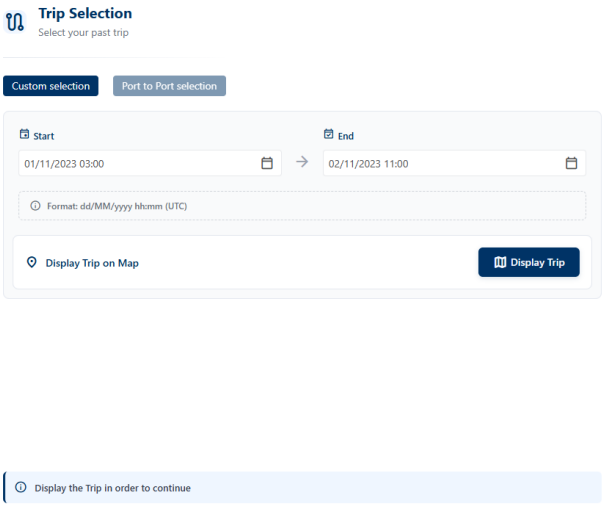


Figure 38 – Past Simulation and Training – Custom Selection

Archive Access

The **Archive** button, located in the upper right corner of the screen, provides access to all previously completed simulations.

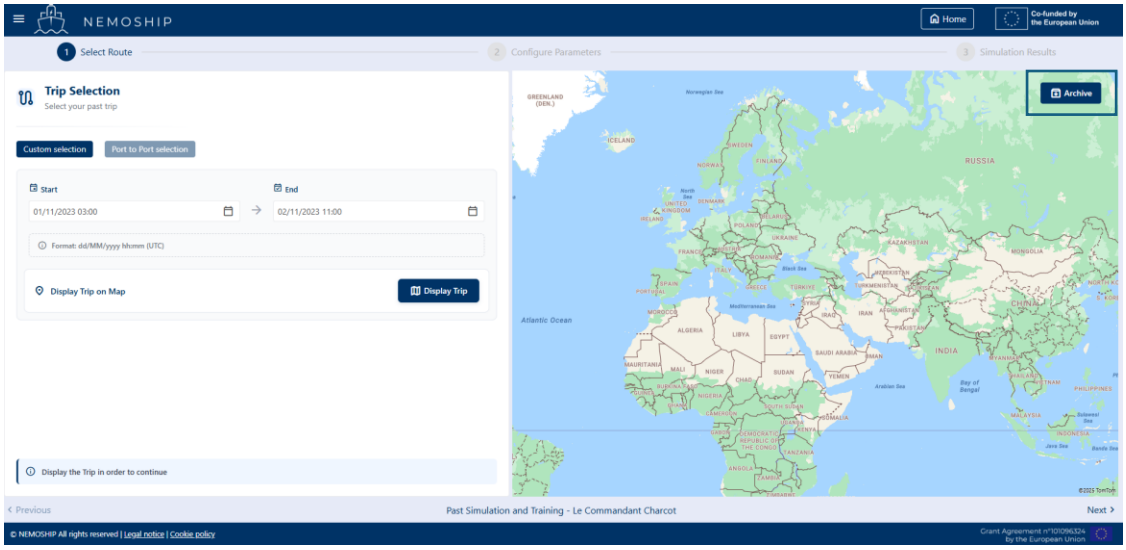


Figure 39 – Past Simulation and Training – Archive Button

5.2.2 Step 2: Configure Parameters

The **Configure Parameters** page features a dynamic configuration table that allows users to define multiple simulation scenarios simultaneously. The table is organized with **configurable parameters displayed in rows** and **individual configurations displayed in columns**. Users can create and manage **up to 5 configurations** within a single simulation, with a minimum requirement of **1 configuration**.

Each configuration represents a unique set of parameter values that will be tested independently. The selected parameters, combined with data retrieved from the Marorka API, are transmitted to the Simcenter Amesim simulation model.

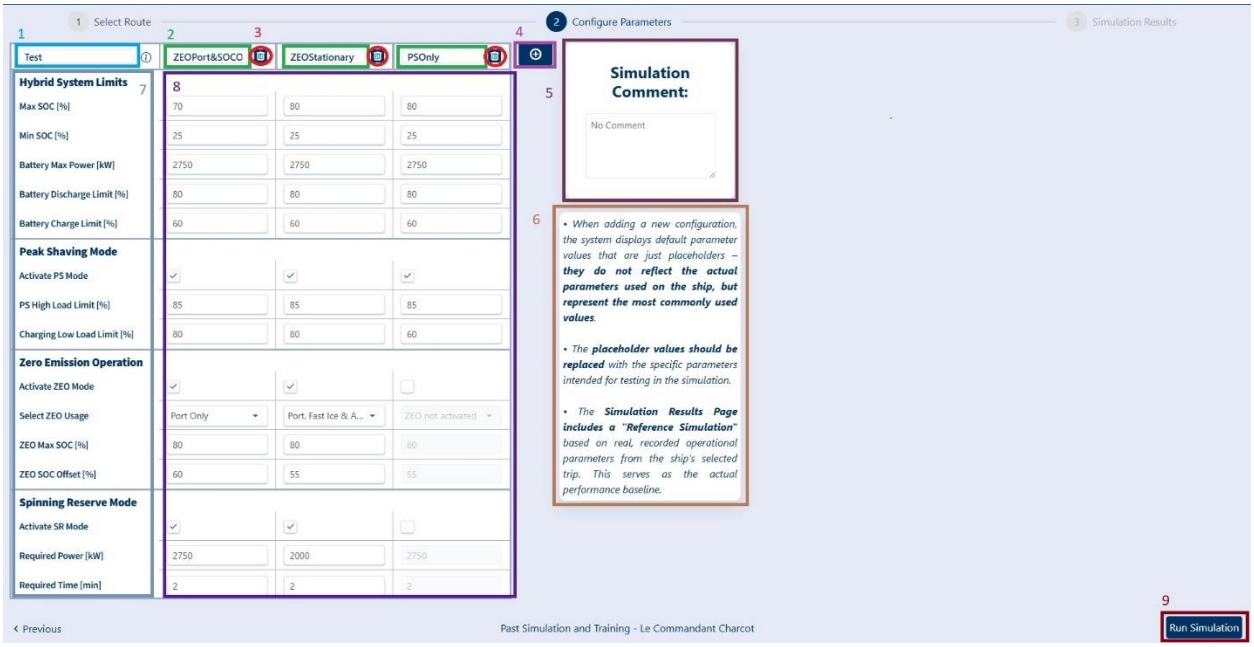


Figure 40 – Past Simulation and Training – Configure Parameters

Interface Elements

The following numbered elements correspond to the interface shown in the image above:

1. **Editable Simulation Name** - By default, displays the date and time when the user accessed this step. This can be customized for easier identification.
2. **Editable Configuration Name** - Automatically labeled as "Configuration X" (where X is a sequential number). Users can rename configurations for clarity.
3. **Delete Configuration Button** - Removes the selected configuration from the table.
4. **Add Configuration Button** - Creates a new configuration column in the table (up to the maximum of 5).
5. **Simulation Comment Text Area** - Allows users to add relevant notes or context for the simulation. These comments will be displayed in the Archive for future reference.
6. **Details Panel** - Provides contextual information and guidance about the current step.
7. **Parameter Labels** - Identifies each configurable parameter in the rows.
8. **Editable Parameter Values** - Input fields where users enter specific values for each configuration.
9. **Run Simulation Button** - Initiates the simulation process. A progress indicator will display while the simulation is running.

Configurable Parameters

The editable parameters are organized into distinct categories. These include general settings that apply across the entire system, followed by specific parameters for each Battery Energy Storage System (BESS) operational mode. Users can activate or deactivate individual modes and configure their specific settings.

Overall BESS Settings

These parameters define the general operation of the BESS and apply to all BESS modes unless overridden by mode-specific settings. They govern fundamental aspects such as:

- **State of Charge (SOC) Interval** - Defines the permissible SOC operating range for the BESS, establishing minimum and maximum charge levels.
- **Maximum Battery Power (kW)** - Specifies the maximum power(nominal) output for a single Energy Storage System (ESS) unit. The total maximum power across all BESS is twice this input value.
- **Charge/Discharge Power Limit (%)** - Sets the upper limit for BESS charge/discharge power in percentage of nominal BESS power(Maximum Battery Power [kW], the parameter above).
    - **100%**: The BESS will charge/discharge at its Maximum Battery Power.
    - **Less than 100%**: Power will be proportionally limited during charging/discharging intervals according to the formula:

$$\text{Maximum Charge/Discharge Power} = \text{Maximum Battery Power} \frac{\text{Charge/Discharge Limit}}{100}$$

Peak Shaving Mode

This mode is activated by default in the interface.

- **Deactivation:** If deactivated, the BESS will not supply power when the load exceeds the capacity of the running DGs, which will result in an additional DG starting.
- **Load Limits:** This mode utilizes two load limits for the DGs:
    - **PS High Load Limit:** Determines when the BESS should begin discharging to supply additional power, preventing DGs from exceeding their optimal load.
    - **Charging Low Load Limit:** Determines when the BESS should begin charging to absorb excess available power, keeping DGs above a minimum load.

Zero Emission Operation (ZEO) Mode

The ZEO mode is deactivated by default.

- **Activation:** When enabled the user can use the ZEO for various operational contexts:
    - **Port Only:** Ship SOG = 0 and propulsion power = 0

- **Port and Fast Ice:** Ship SOG = 0, and propulsion power >= 0
- **Port, Fast Ice & Adrift:** SOG is < 1 and propulsion power >= 0

This mode features its own operating SOC interval, which overrides the general SOC interval defined in the *Overall BESS Settings*. The key parameters for ZEO SOC management are:

- **ZEO Max SOC:** This is the maximum State of Charge. It determines the SOC level at which the Diesel Generator (DG) has sufficiently charged the BESS and can be disconnected from the grid.
- **ZEO SOC Offset:** This offset is used to calculate the minimum State of Charge. It defines the SOC level at which a DG is required to start to begin recharging the BESS.

Spinning Reserve (SR) Mode

The SR mode is activated by default.

- **Deactivation:** If deactivated, the minimum SOC will revert to the value defined in the 'Overall BESS Settings'. Furthermore, if the ship is maneuvering (propulsion power >= 0) with SR mode deactivated, an additional medium power Diesel Generators will start to provide the necessary redundancy that would otherwise be handled by the BESS.
  - **Impact on ZEO:** When SR mode is deactivated, the use of ZEO mode will be restricted to 'Port Only' (where propulsion power is 0).
- **Activation:** When SR mode is active, users must input:
  - **Required Power (kW):** The amount of reserve power needed.
  - **Required Time (minutes):** The duration for which the reserve power must be available.

    Based on these inputs, the system calculates the necessary backup energy. It then updates the minimum SOC, overriding the 'Overall BESS Settings' value, to ensure that the required backup energy is always available.

5.2.3 Step 3: Simulation Results

The batch simulation executes in the background and consists of multiple simulation runs:

- **Configuration Batches**: One batch for each user-defined configuration
- **Reference Batch**: An additional simulation that emulates the vessel's actual historical performance, validated against Marorka data

The reference batch does **not** represent a configuration with default parameters. Instead, it bypasses the configurable parameters entirely to accurately replicate real-world vessel operations as they occurred historically. This provides a baseline for comparison.

Upon completion, the simulation returns comprehensive data for each configuration batch and the reference batch. The application post-processes this data and presents the results through interactive tables and charts for analysis.

The Simulation Results page is organized into the following sections:

Measured Trip Performance Data Table

This table presents key performance metrics from the reference simulation, providing a comprehensive overview of actual vessel operations:

Diesel Generator (DG) Metrics

- DG Runtime - The cumulative time that each diesel generator has been running and producing power. This metric is shown only for the reference batch.
- High Power DGs Runtime – The total cumulative hours during which the high-power diesel generators have been actively running.
- Medium Power DGs Runtime - The total cumulative hours during which the medium power diesel generators have been actively running.
- High Power DGs Start Cycles – The total number of times a high-power generator was started.
- Medium Power DGs Start Cycles - The total number of times a medium power generator was started.

Battery Energy Storage System (BESS) Metrics

- BESS Equivalent Cycles - This metric quantifies the BESS usage, representing the number of equivalent full charge-discharge cycles. It is calculated by dividing the total energy discharged by the BESS by its rated energy capacity.

Fuel and Emissions Data:

- Total fuel consumption - The amount of fuel consumed by all generators over the simulation period.
- Emissions output - The total quantity of greenhouse gases released into the atmosphere

Environmental Compliance Indicators:

- IMO CII (International Maritime Organization Carbon Intensity Indicator) - A rating system (A to E) that measures how efficiently a ship transports goods or passengers in terms of CO_2 emissions per transport work (cargo carried × distance traveled). Ships must achieve at least a "C" rating to comply with international regulations, with penalties for poor performance.
- EU GHG (European Union Greenhouse Gas regulations) - Compliance metrics related to EU regulations requiring ships to monitor, report, and reduce greenhouse gas emissions. This includes tracking CO_2 emissions per unit of transport work and meeting reduction targets to operate in EU waters and ports. During ice navigation, correction factors are

not applied on EU GHG, which may result in inaccurate values when ice sailing represents a significant portion of the voyage.

Measured Trip Performance Data

DG Runtime [h]	DG1	DG2	DG3	DG4	DG5	DG6
	12.25	197.25	21	0	0	102.75
HP/MP Runtime [h]	High Power DGs			Medium Power DGs		
	136			197.25		
HP/MP Start Cycles	High Power DGs			Medium Power DGs		
	8			14		
BESS Equivalent Cycles ⓘ	4.42					
Fuel and Emissions Data [t]	Fuel Consumption			GHG Emissions		
	228.4			792.01		
Environment Compliance Indicators	IMO CII | Class			EU GHG | Baseline ⓘ		
	16.86 | C			90.36 | **89.3368**		

Figure 41 – Past Simulation and Training – Trip Performance Data

Map

On the right side of the screen the map displays the analyzed trip or segment.

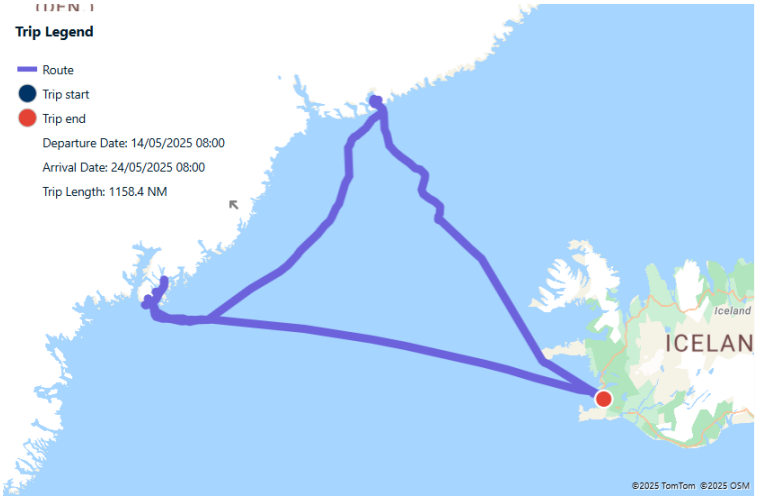


Figure 42 – Past Simulation and Training - Map

Parameters Impact Overview Panel

This panel provides a comprehensive comparison between configurations and the reference simulation:

- **Shaft Power Fidelity Index -** Indicates how accurately the simulation models match actual shaft power data
- **Metrics Comparison Table -** Displays the difference between each configuration's metric values and the reference simulation's values, enabling quick identification of performance improvements or degradations
- **Parameters Review Button -** Opens a pop-up window showing the parameters that were modified in Step 2 for each configuration, with changes highlighted for easy identification
- **Data Download Button -** Exports the complete batch simulation dataset, including data for all configuration batches and the reference batch, for external analysis

Figure 43 – Parameters Impact Overview

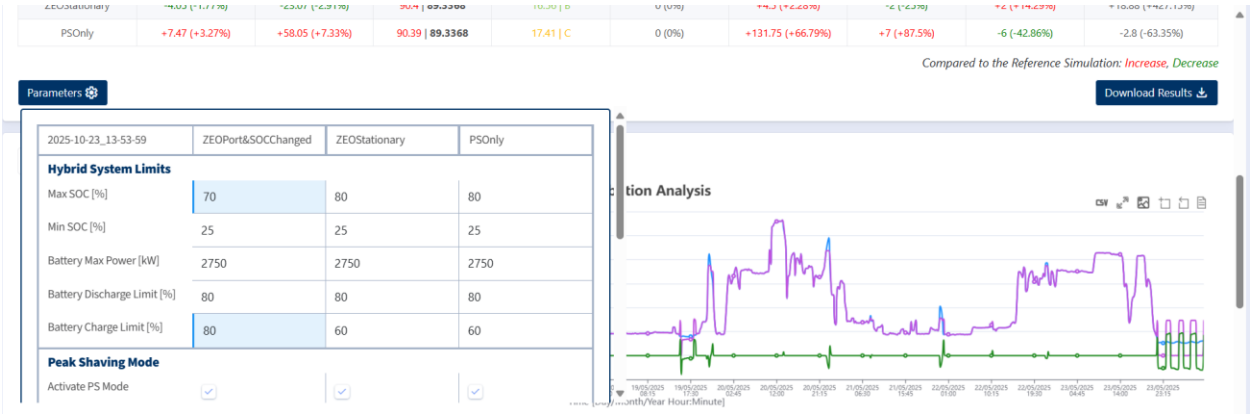


Figure 44 – Past Simulation and Training – Parameters

Power Distribution Chart

It is an interactive time-series chart that enables users to monitor and analyze the evolution of power distribution over time for each configuration (the reference batch is excluded to maintain focus on comparative analysis).

- **Total Power Demand** - Shows the overall electrical consumption trend throughout the selected voyage period
- **DG Electrical Power** - Represents the power supplied by the Diesel Generators, illustrating how they respond to changes in demand
- **Battery Power** - Illustrates the BESS contribution:
    - Positive values: Battery discharging (provides power to the system)
    - Negative values: Battery charging (absorbs excess power from the system)

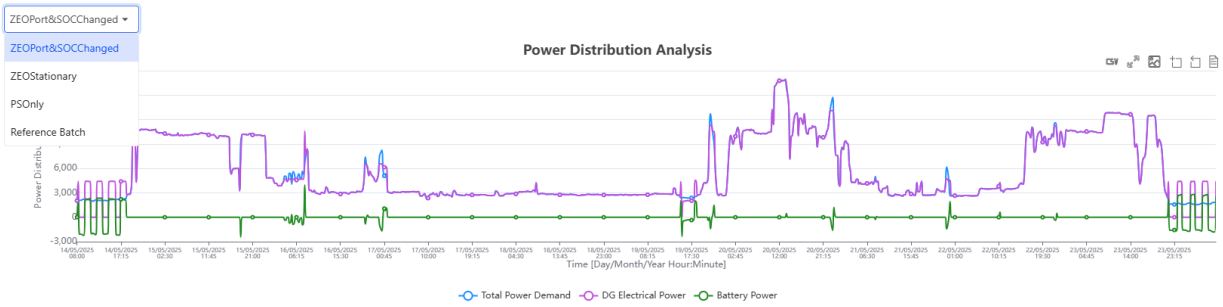


Figure 45 – Power Distribution Analysis

Left Multi-Chart Controller

This controller allows users to switch between different time-series performance charts using a dropdown menu. Users can quickly compare each configuration side-by-side and, for selected charts, access detailed breakdowns through pop-up windows. This functionality simplifies result analysis, highlights differences, and supports informed decision-making.

Fuel Mass Flow Rate Analysis

Quantifies the rate of fuel consumption by DGs, expressed in kilograms per hour (kg/h) for:

- Each configuration
- The reference batch
- The real data from Marorka

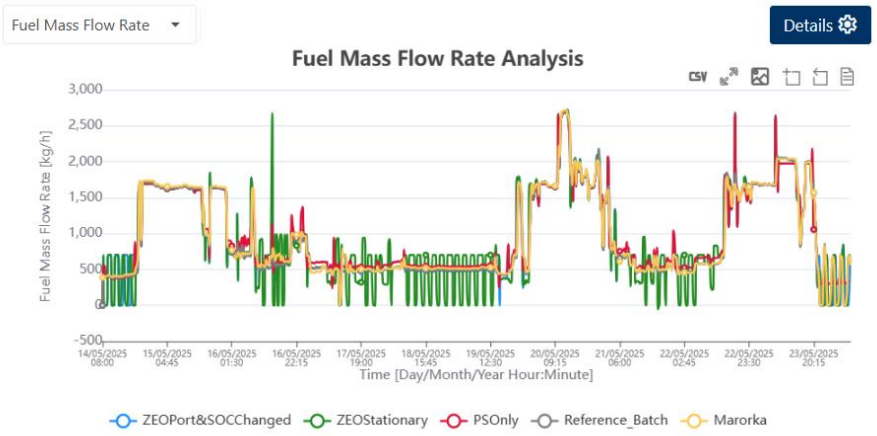


Figure 46 – Fuel Mass Flow Rate Analysis

Details Pop-up for Fuel Mass Flow Rate Analysis

Presents a **Fuel Consumption Summary** that includes:

- Total fuel consumed for each configuration and for the reference batch, expressed in metric tons
- Differences between the values obtained in the set configurations and the reference value
- Percentage differences indicating how much the configuration value varies from the reference value, expressed as a percentage of the reference

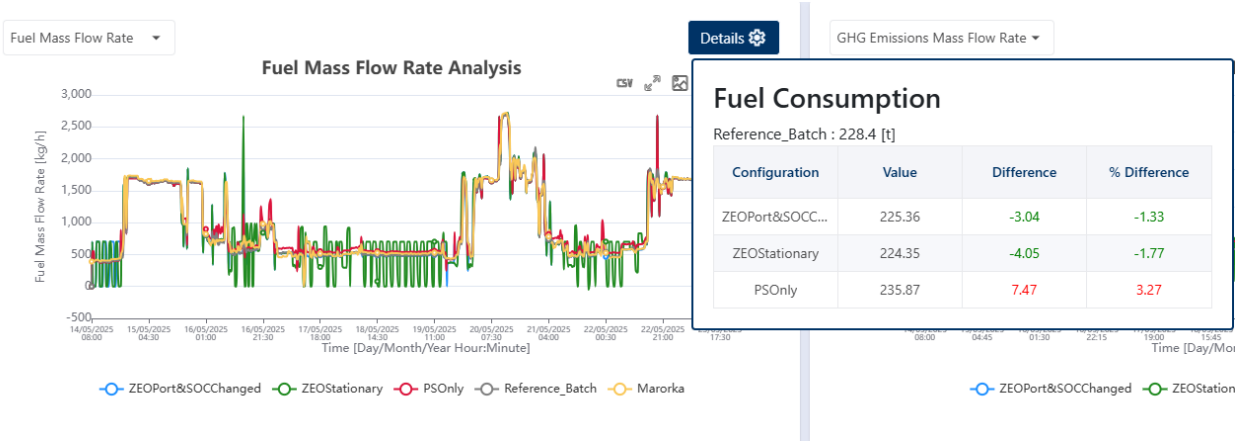


Figure 47 – Fuel Consumption Data

DG Electrical Power Analysis

Reveals the electrical output power delivered by the DGs over time for every configuration and the reference batch.

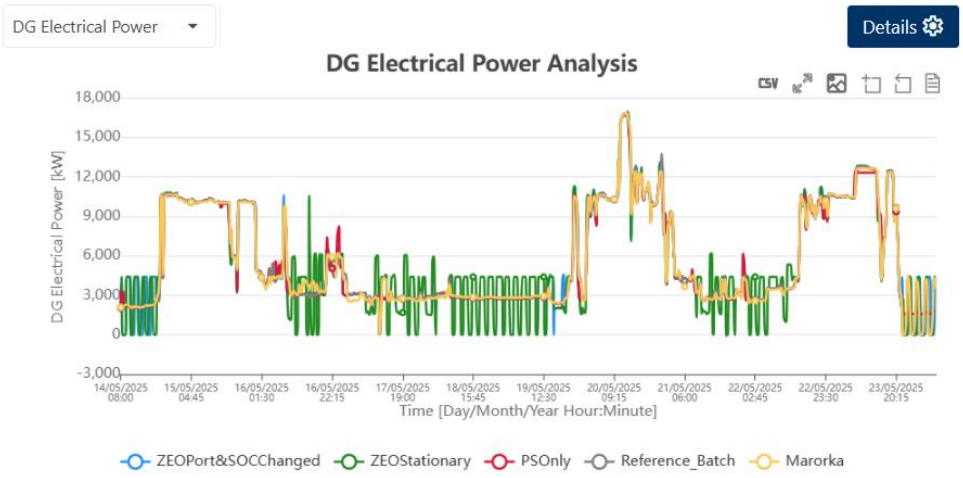


Figure 48 – DG Electrical Power Analysis

Details Pop-up for DG Electrical Power Analysis

Presents a **DG Electrical Energy Summary** with a comprehensive table showing:

- Total electrical energy for each configuration and for the reference batch, expressed in MWh
- Differences between the values obtained in the set configurations and the reference value
- Percentage differences indicating how much the configuration value varies from the reference value, expressed as a percentage of the reference

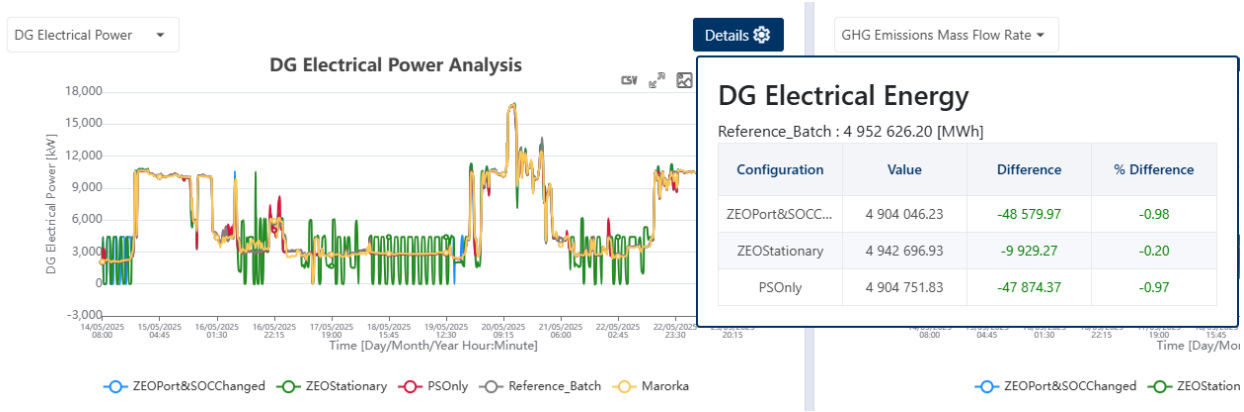


Figure 49 – DG Electrical Data

Battery SOC Analysis

Displays the State of Charge of the battery system over time for each configuration together with the real data from Marorka.

This chart does not include a details pop-up.

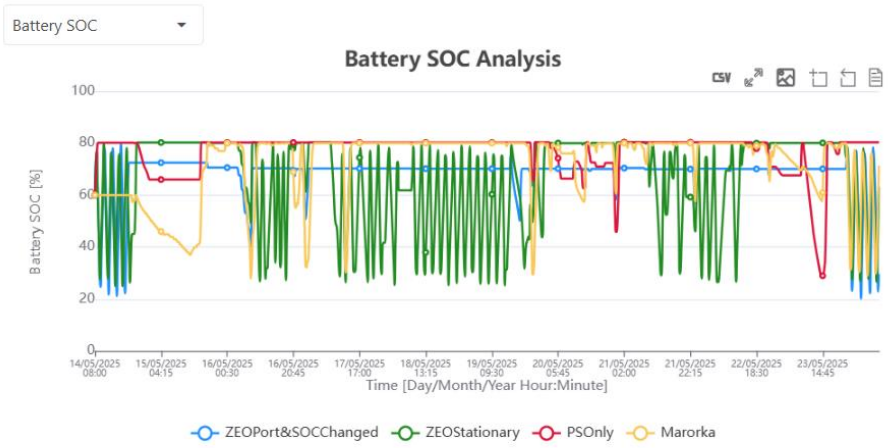


Figure 50 – Battery SOC Analysis

Right GHG Emissions & GPS Speed Charts

Similar to the left-side controller, this section allows users to switch between different performance metrics using a dropdown menu.

GHG Emissions Chart

Compares greenhouse gas emissions over time for each system configuration and the reference batch.

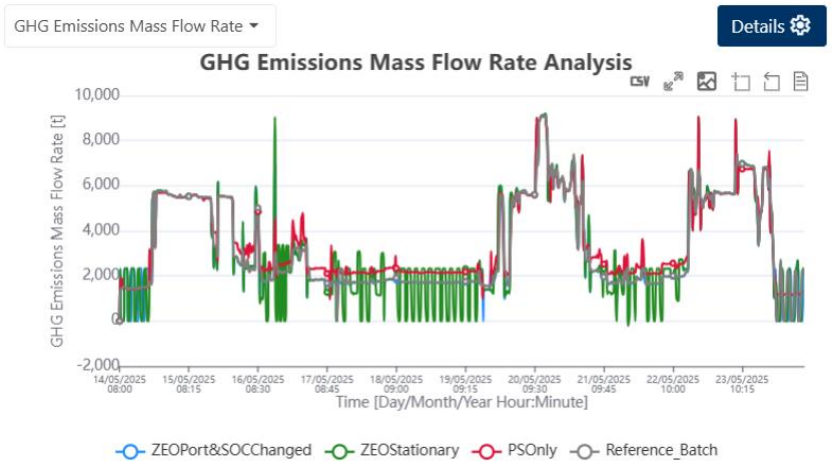


Figure 51 – GHG Emissions Chart

Details Pop-up for GHG Emissions Chart

Displays a **GHG Emissions Summary** table showing:

- Total emissions for each configuration and for the reference batch, expressed in metric tons
- Differences between the values obtained in the set configurations and the reference value
- Percentage differences indicating how much the configuration value varies from the reference value, expressed as a percentage of the reference

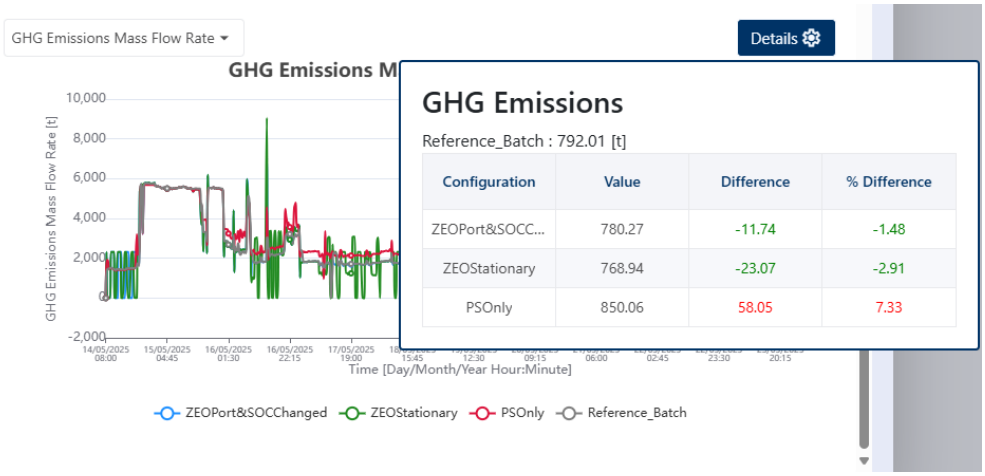


Figure 52 – GHG Emissions Data

GPS Speed Chart

Visualizes the vessel's speed over ground throughout the voyage period.

This chart does not include a details pop-up.

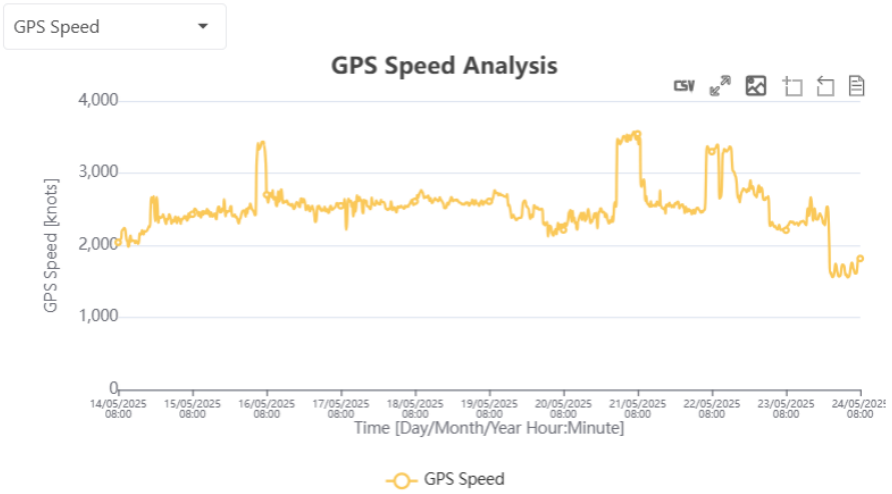


Figure 53 – GPS Speed Analysis

5.3 Archive

The **Simulation Archive** provides users with centralized access to all previously executed batch simulations. Each user can view only their own simulations, ensuring data privacy and personalized workflow management.

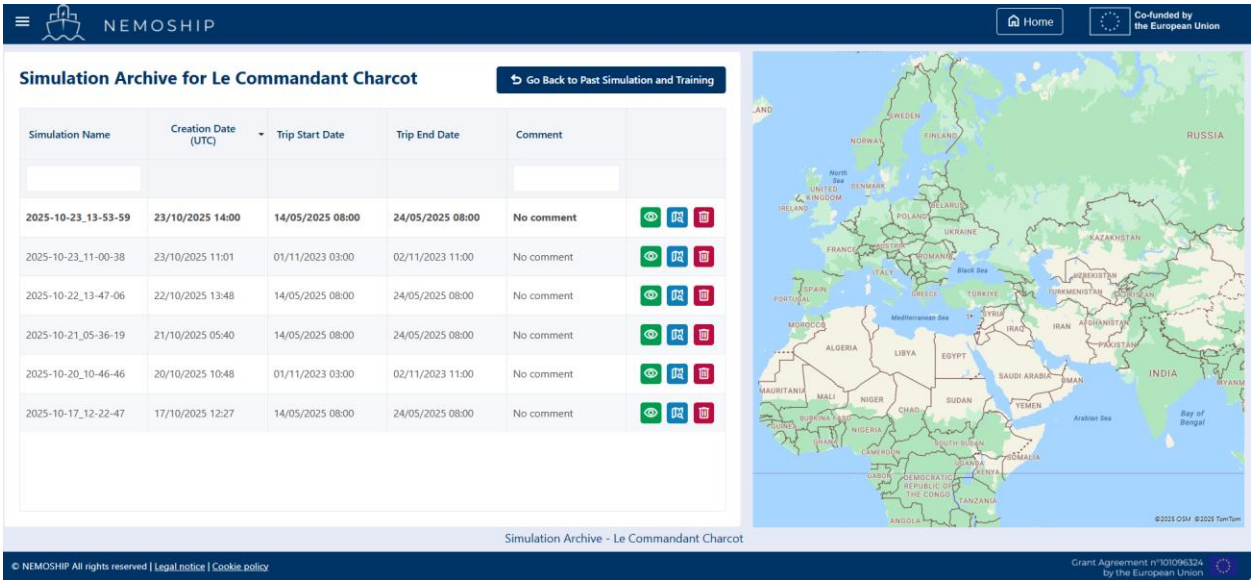


Figure 54 – Simulation Archive Page

The archive displays a comprehensive table containing key information about each simulation, making it easy to identify and retrieve specific analyses:

5.3.1 Table Columns

- **Simulation name** - the default or modified name of the simulation
- **Creation date** - the date on which the simulation was created
- **Trip start date** - the starting date of the analyzed period
- **Trip end date** - the end date of the analyzed period
- **Comment** - the comment added by the user
- **Actions** - a column containing 3 action buttons for managing each simulation that are detailed in the next section

5.3.2 Action Buttons

See Results

Opens a dialog window displaying the complete **Step 3: Simulation Results** content for the selected batch simulation.

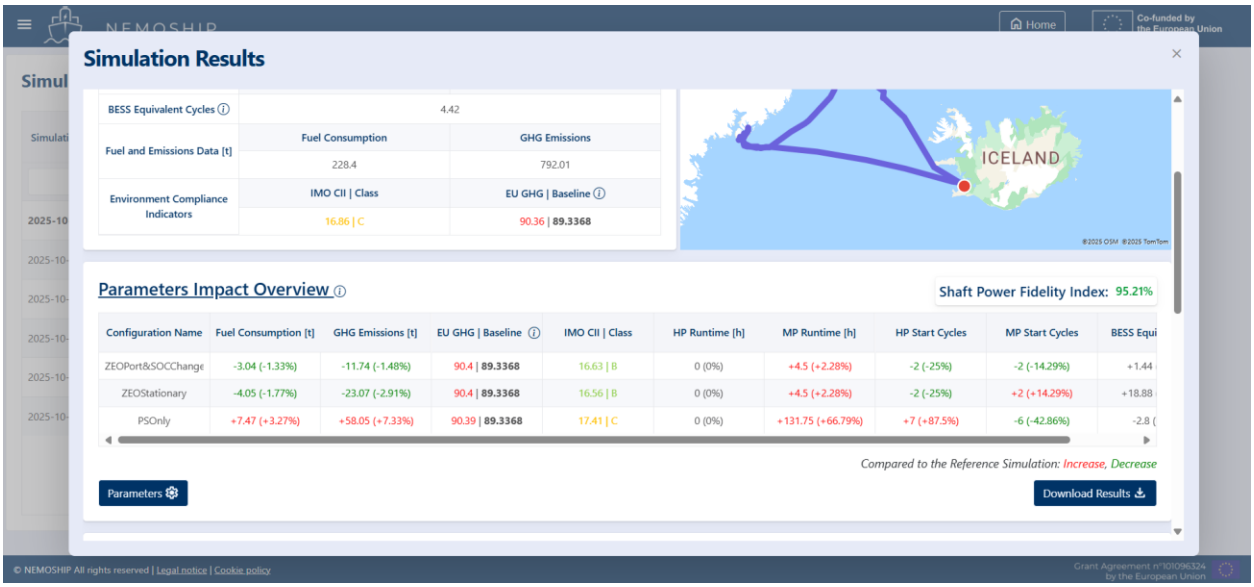


Figure 55 – Simulation Results

See Trip on Map

Displays the voyage or voyage segment on the interactive map located on the right side of the screen

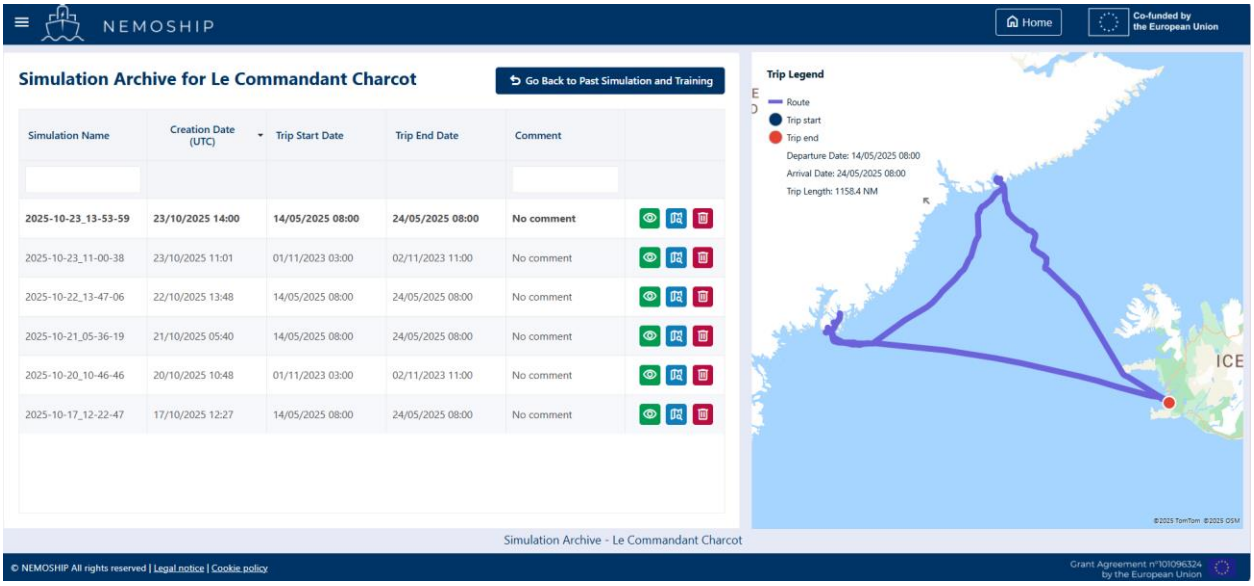


Figure 56 – Trip Visualization on the Map

Delete Simulation

Permanently removes the selected simulation from the archive.

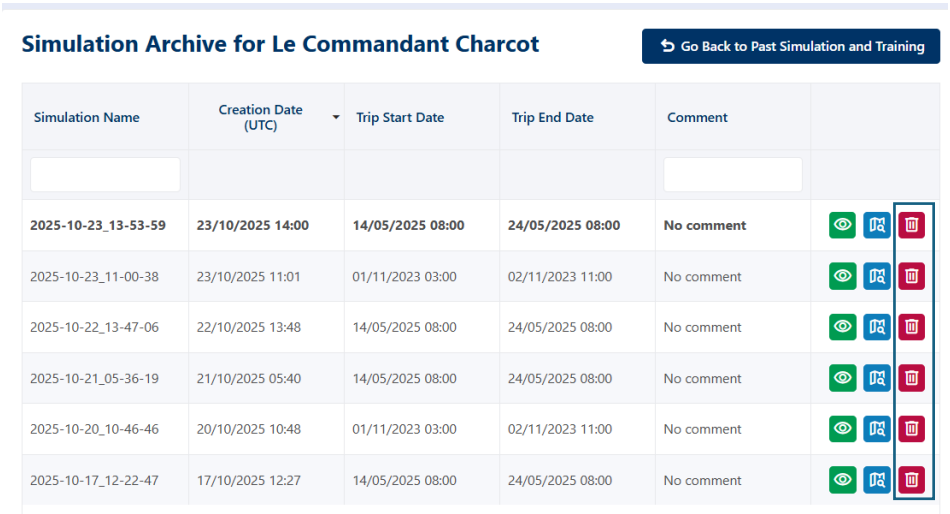


Figure 57 – Delete Simulation Data

6 Single Leg Optimization Module

6.1 Purpose

The **Single Leg Optimization Module** optimizes a specific portion (called a "leg") of a vessel's voyage. This optimization can focus on reducing costs, minimizing emissions, or achieving a balanced combination of both objectives according to specified priorities.

The module is specifically designed for real-time application during current voyages, providing immediate insights and recommendations on how to efficiently utilize the vessel's power management system. Rather than serving as a planning tool for future trips, this module delivers actionable guidance for ongoing operations, enabling crew members and operators to make informed decisions about power distribution, generator usage, and battery management while the vessel is actively navigating its route.

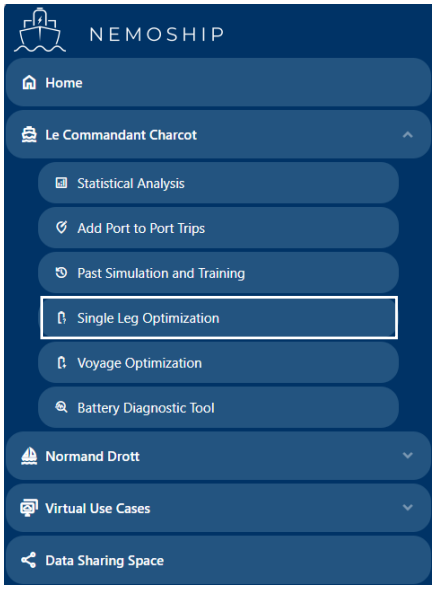


Figure 58 – Single Leg Opimization Module

6.2 How It Works

For a given route segment (limited to a single leg with a maximum duration of 2-3 hours to ensure accurate results), the platform analyzes the specified ice conditions and predicts the required power profile for the vessel.

Using this determined power profile along with optimization constraints, the platform provides intelligent insights on how to efficiently manage battery and generator systems to achieve the most cost-effective and/or emission-efficient operation.

6.3 Module Structure

The module consists of **4 sequential steps**. Each step depends on the completion of the previous one, meaning that until all required actions in the current step are completed, the next steps remain blocked (appear greyed out).

Users can navigate through the module in two ways:

- **Step names** - Click on the step names displayed at the top of the screen (this option is not always available, depending on the type of action that will be done)
- **Navigation buttons** - Use the *Previous* and *Next* buttons located at the bottom of the screen

Figure 59 – Single Leg Optimization Steps

6.3.1 Step 1: Define Route

This step allows users to import a route for the voyage leg where optimization will be performed. The route file must be an Excel file generated from an ECDIS exported .xps file and follow the required format.

	A	B	C	D	E	F	G	H	I	J	K
1	NACOS Platinum										
2	####										
3	Commandant Charcot										
4	Passage Plan for Route 6.1.1 Nansen Fjord - Reykjavik										
5	Signed at										
6	No.	Name	Latitude	Longitude	BWW [°]	Radius [NM]	Distance [NM]	Sail	Speed [kn]	Scheduled	
7	1	Nansen Fjord	68°18.686' N	029°48.150' W		1.00				22 Jul 2025 14:00 UTC	
8	2		68°17.222' N	029°48.309' W	182.3	1.50	0.56	RL	5.0	22 Jul 2025 14:06 UTC	
9	3		68°15.781' N	029°42.617' W	124.3	1.00	3.23	RL	5.0	22 Jul 2025 14:45 UTC	
10	4		68°14.522' N	029°38.362' W	128.6	1.00	1.81	RL	5.0	22 Jul 2025 15:07 UTC	
11	5		68°12.749' N	029°36.157' W	155.2	1.00	1.95	RL	5.0	22 Jul 2025 15:30 UTC	
12	6		68°11.385' N	029°31.609' W	128.9	1.00	2.08	RL	5.0	22 Jul 2025 15:55 UTC	
13	7	Exit 5kn	68°08.490' N	029°29.492' W	164.8	1.00	3.28	RL	5.0	22 Jul 2025 16:34 UTC	
14	8	Pack ice exit	67°41.200' N	029°17.900' W	170.9	1.00	27.38	RL	6.0	22 Jul 2025 21:09 UTC	
15	9		67°17.000' N	027°55.000' W	127.3	1.00	39.99	RL	12.2	23 Jul 2025 00:30 UTC	
16	10	Ice belt	67°00.000' N	027°52.800' W	177.1	1.00	17.06	RL	12.2	23 Jul 2025 01:54 UTC	
17	11		66°36.000' N	026°42.000' W	130.7	1.00	37.17	RL	12.2	23 Jul 2025 04:57 UTC	
18	12		64°42.843' N	023°58.279' W	149.2	1.00	132.13	RL	12.2	23 Jul 2025 15:47 UTC	
19	13		64°11.850' N	021°56.930' W	120.6	1.00	61.18	RL	12.2	23 Jul 2025 20:48 UTC	
20	14	Pilot	64°10.310' N	021°53.490' W	135.8	1.50	2.33	RL	12.2	23 Jul 2025 21:00 UTC	
21	15		64°09.450' N	021°51.500' W	134.7	0.10	1.18	RL	3.1	23 Jul 2025 21:22 UTC	
22	16	Quay Skarfabak...	64°09.170' N	021°51.430' W	173.8	1.00	0.37	RL	3.1	23 Jul 2025 21:30 UTC	
23	Distance Enroute 332 NM			ETE 0:00							
24	Page 1 of 1										

Figure 60 – ECDIS Route Planing File Format

Uploading the Route

To upload the passage plan file, use the *Drag and Drop or Click to Choose Passage Plan* button located at the top right of the map. When the file is uploaded correctly and loads successfully into the platform, the route will be displayed on the map. A confirmation message will appear indicating successful file processing.

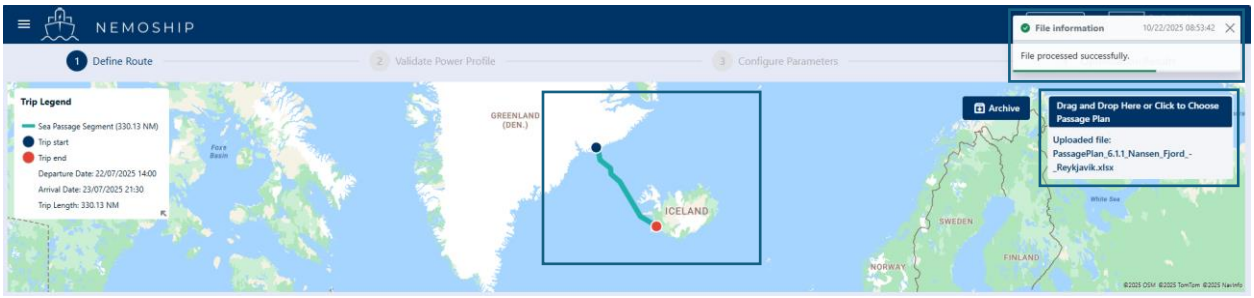


Figure 61 – Upload ECDIS File

If the file format is invalid, an error message will alert the user, and progression to the next step will not be possible.

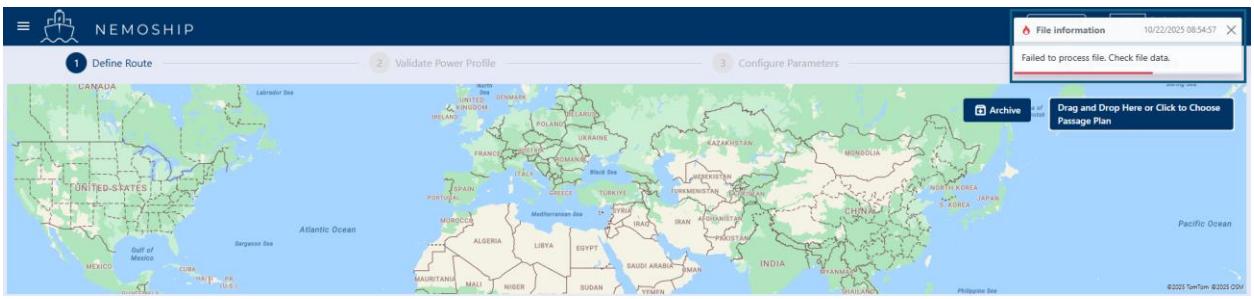


Figure 62 – Error Message on File Uploading

Defining Ice Conditions

After successful file upload, two additional buttons become available: **Add Entry** and **Remove Last Entry**. These buttons allow users to define ice conditions along the imported route.

When the **Add Entry** button is pressed, a new entry appears in the table. To define an ice interval, four variables must be specified:

- ***Start Date and Hour***- Beginning of the ice condition period
- ***End Date and Hour*** - End of the ice condition period
- ***Ice Condition*** - Select from the following options the appropriate ice concentration:
  - *Very Open Drift (1/10 to 3/10 concentration)*
  - *Open Drift (4/10 to 6/10 concentration)*
  - *Close Pack/Drift (7/10 to 8/10 concentration)*
  - *Very Close Pack/Drift (9/10 to less than 10/10 concentration)*
  - *Compact Ice (10/10 concentration, no water visible)*
  - *Consolidated Ice (10/10 concentration, floes frozen together)*
- ***Ice Thickness*** - Thickness measured in meters

Once the ice interval was correctly defined, it will also be visible on the map. By pressing on that specific portion on ice, additional information will be available (start time and end time).

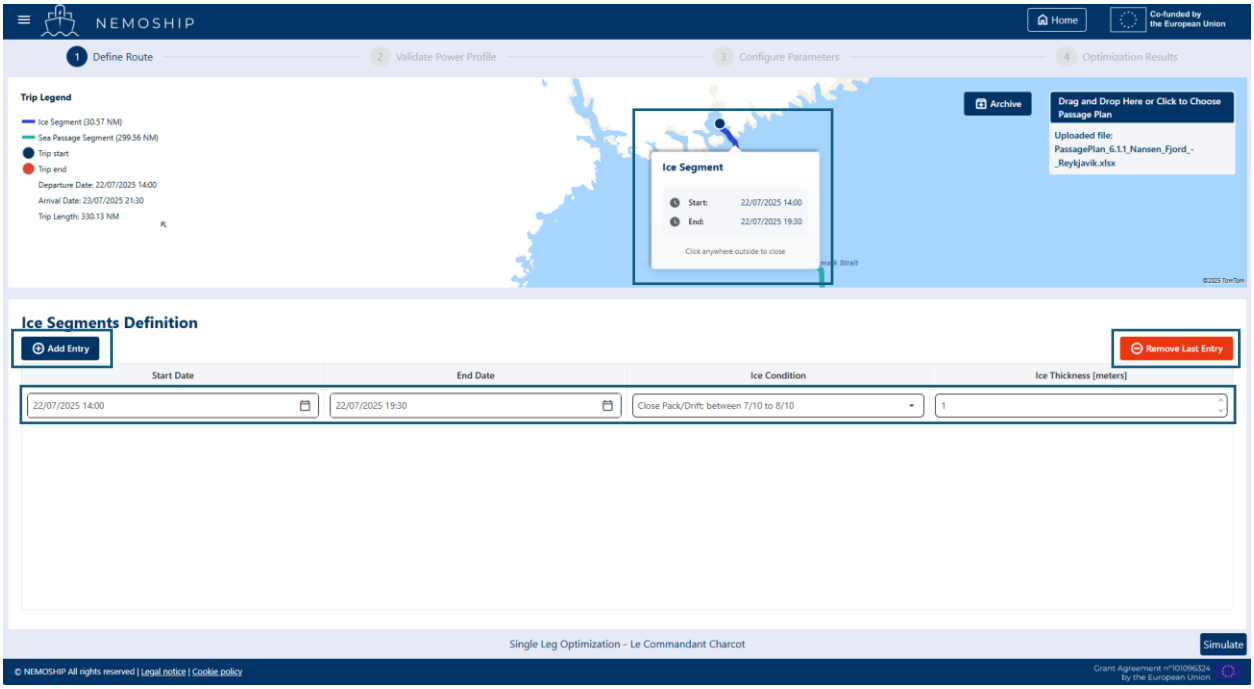


Figure 63 – Ice Segments Definition

The **Remove Last Entry** button removes the most recent table row.

Multiple rows can be added as needed, but the following requirements must be followed:

- Start Date must always be earlier than End Date for each row
- Start Date of each new entry must be after the previous entry's End Date

If these conditions are not met, error messages will appear in the table or at the top right of the page when the Simulate button is pressed.

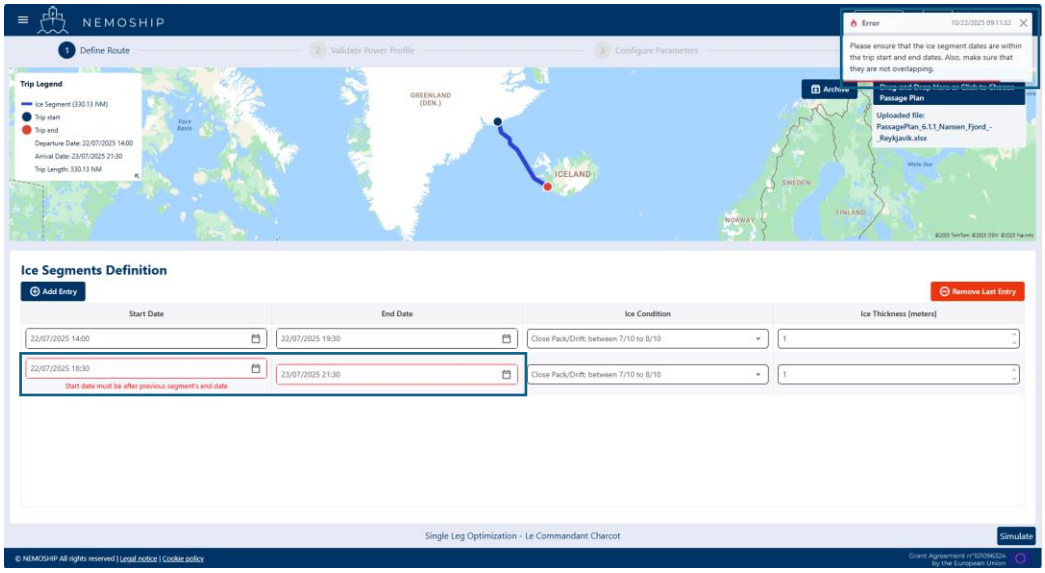


Figure 64 – Remove Ice Entry

To proceed to the next step, press the **Simulate** button located at the bottom right of the screen.

Simulation Process

When the button is pressed, two main processes occur. First, the platform retrieves weather conditions for the imported route using a weather provider (Open Meteo) and associates these conditions to each waypoint. Second, the platform uses a digital model to predict the power profile required by the vessel for the specified conditions, including ice conditions and weather details.

During these processes, a loading page displays all steps in detail and shows the current execution point of the background processes.

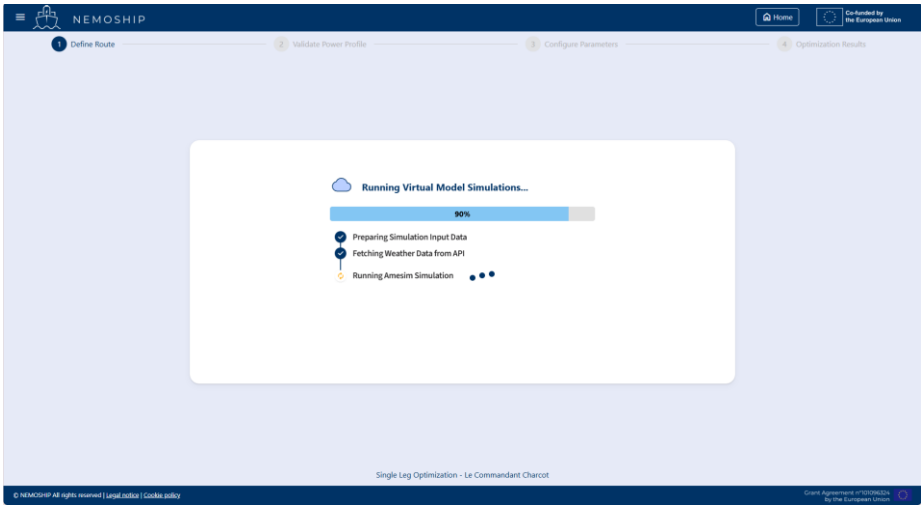


Figure 65 – Simulation Status

6.3.2 Step 2: Validate Power Profile

Once the power profile prediction is complete, the results will be visible on a plot in the second step of the module. Because ice thickness significantly impacts the predicted power profile, the platform creates variations on the ice thickness values entered by the user. Based on the original values, the system generates variations by adding 0.1, 0.2, and 0.3 meters and subtracting 0.1, 0.2, and 0.3 meters from the original values.

These new values are incorporated into the simulation process, resulting in multiple power profiles. Users can analyze these profiles on the plot and select the power profile that best fits actual conditions. To select a different power profile, choose the preferred variation from the "Select your preferred Power Profile" card. When selected, the chosen profile will be highlighted on the plot and used when pressing the Next button.

On the right side of the screen, the entire process of varying the shaft power is explained in detail.

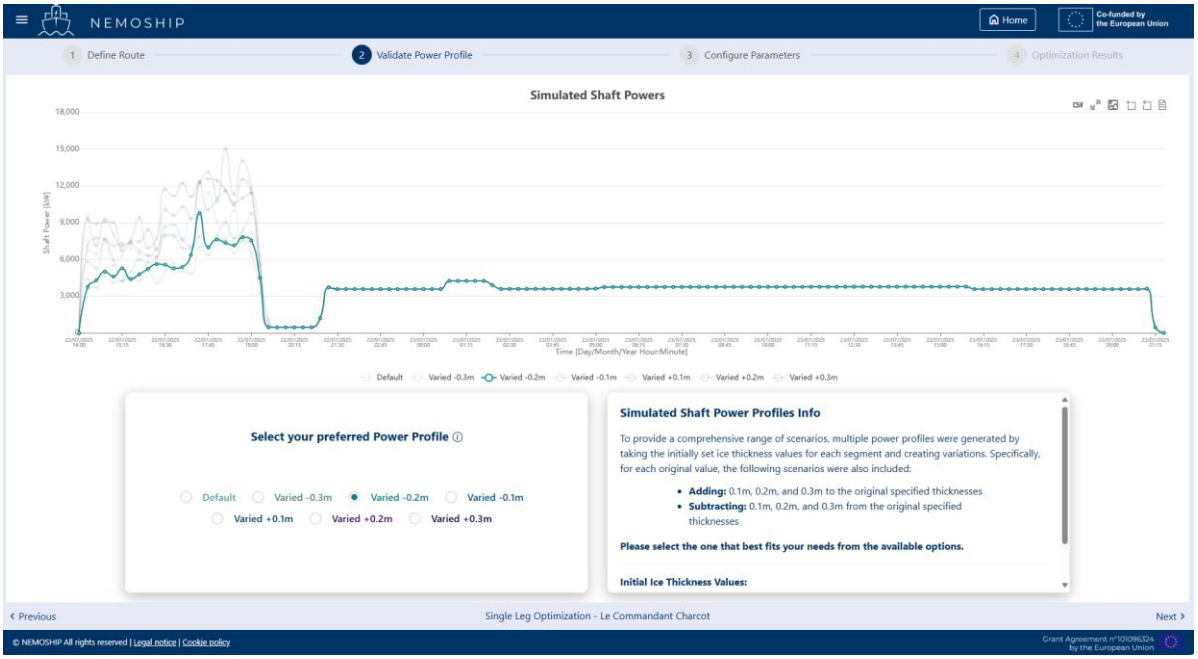


Figure 66 – Simulated Shaft Power Validation

6.3.3 Step 3: Configure Parameters

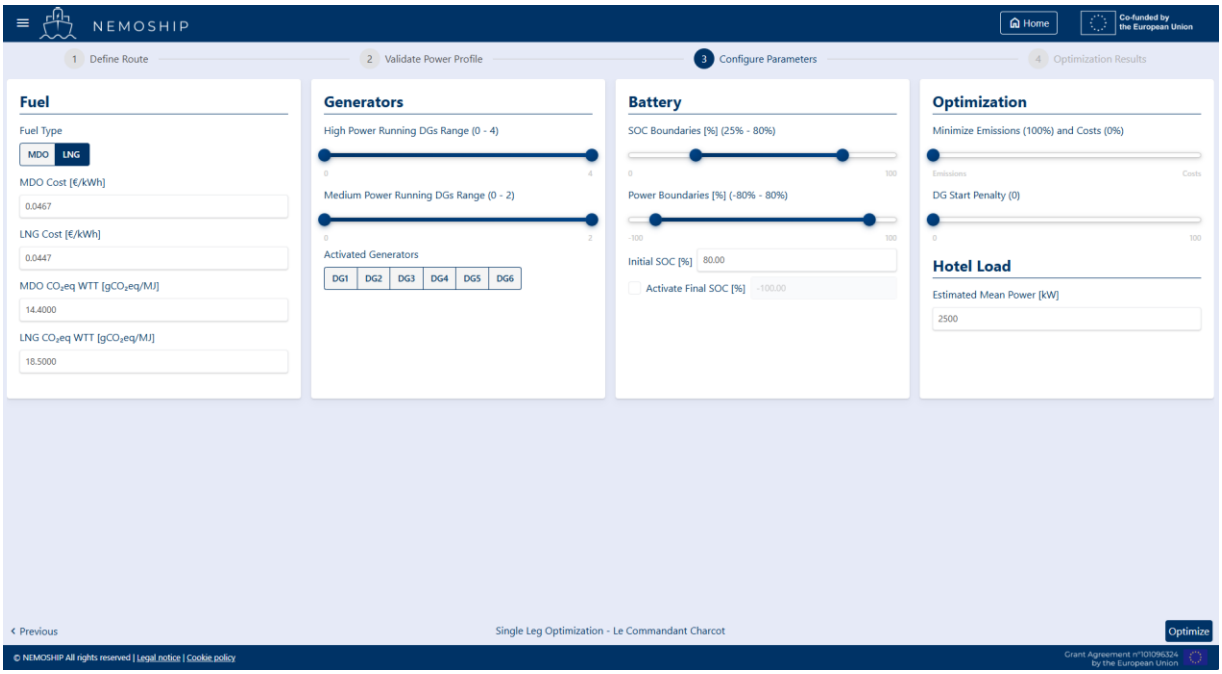


Figure 67 – Optimization Parameters

The third step consists of a set of parameters that can be configured before performing the optimization. All parameters have default values but can be changed based on user preferences. The parameters are divided into 5 categories:

Fuel

- **Fuel Type**: Select from LNG or MDO *(default: LNG)*
- **MDO Cost [€/kWh]**: Cost per kilowatt-hour for Marine Diesel Oil *(default: 0.0467)*
- **LNG Cost [€/kWh]**: Cost per kilowatt-hour for Liquefied Natural Gas *(default: 0.0447)*
- **MDO CO_2eq WTT [gCO_2eq/MJ]**: Well-to-tank CO_2 equivalent emissions for MDO *(default: 14.4000)*
- **LNG CO_2eq WTT [gCO_2eq/MJ]**: Well-to-tank CO_2 equivalent emissions for LNG *(default: 18.5000)*

Generators

- **High Power Running DGs Range**: Range for high power diesel generators operation *(default: 0 – 4)*
- **Medium Power Running DGs Range**: Range for medium power diesel generators operation *(default: 0 – 2)*
- **Activated Generators**: Selection of active generator units (DG1 through DG6 available) *(default: no generators activated)*

Battery

- **SOC Boundaries [%]**: State of Charge operational boundaries for the battery system *(default: 25% - 80%)*
- **Power Boundaries [%]**: Power limits for battery charging and discharging *(default: -80% - 80%)*
- **Initial SOC [%]**: Starting State of Charge level *(default: 80%)*
- **Activate Final SOC [%]**: Target State of Charge at voyage completion *(default: 80%)*

Optimization

- **Minimize Emissions and Costs:** Weighting factor for optimization objectives *(default: minimize emissions)*
- **DG Start Penalty**: Penalty applied for diesel generator startup events *(default: 0)*

Hotel Load

- **Estimated Mean Power [kW]**: Average hotel load power consumption *(default: 2500 kW)*

Once the optimization parameters have been defined, the next step is pressing the Optimize button. A loading screen will appear while the optimization runs in the background. Depending on the length of the voyage leg and the configured parameters, the optimization process may take anywhere from 1-2 minutes to 10-30 minutes to complete.

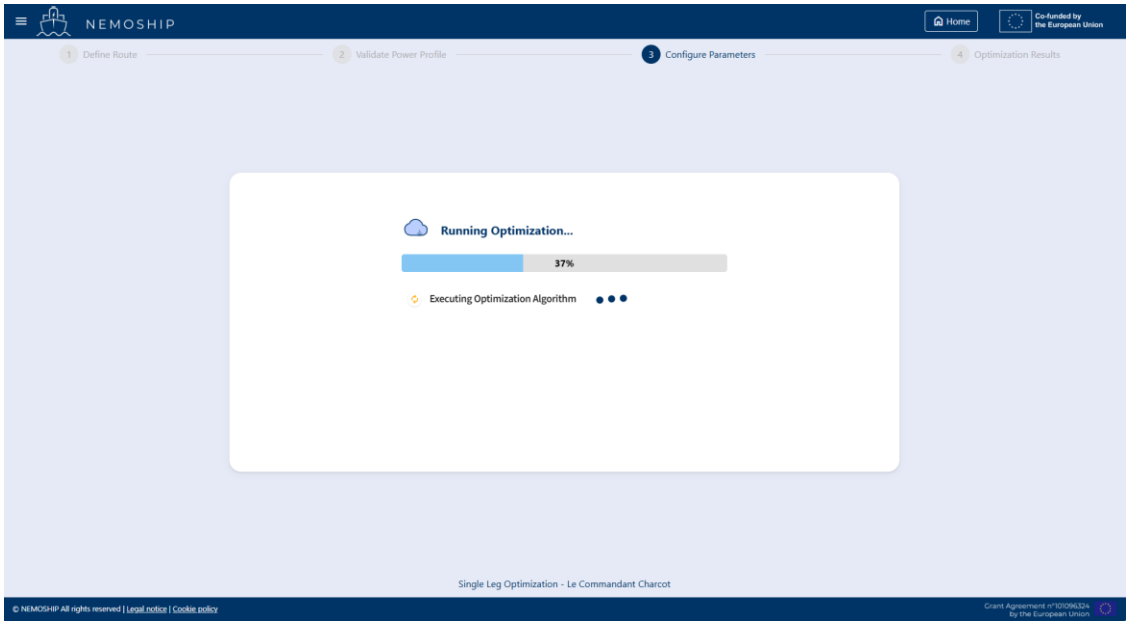


Figure 68 – Optimization Running

6.3.4 Step 4: Optimization Results

After the optimization algorithm completes its run, users are automatically redirected to the 4th step where optimization results are available.

Key Performance Indicators

On the top left corner, multiple key performance indicators are displayed, describing costs, emissions, and other relevant information for the configured trip and parameters. The available metrics are:

Environmental Metrics:

- **Total CO_2eq emissions [kgCO_2eq]**: Total carbon dioxide equivalent emissions for the entire voyage
- **Total CO_2eq emissions from methane slip [kgCO_2eq]**: Specific emissions from methane slip during LNG combustion

Cost and Fuel Consumption:

- **Total fuels costs [euros]**: Combined cost of all fuel types consumed during the voyage
- **Mass of MDO consumed [t]**: Total Marine Diesel Oil consumption
- **Mass of LNG consumed [t]**: Total Liquefied Natural Gas consumption

Efficiency Metrics:

- **Global efficiency [-]**: Overall system efficiency across all power sources
- **BESS efficiency [-]**: Battery Energy Storage System efficiency

- **HP DGs efficiency [-]**: High Power Diesel Generators efficiency
- **MP DGs efficiency [-]**: Medium Power Diesel Generators efficiency

Operational Statistics

- **BESS equivalent cycles [-]**: Number of complete battery charge/discharge cycles
- **Number of HP DGs running hours [h]**: Total operating time for High Power generators
- **Number of MP DGs running hours [h]**: Total operating time for Medium Power
- **Number of HP DGs starts [-]**: Total startup events for High Power generators
- **Number of MP DGs starts [-]**: Total startup events for Medium Power generators

These indicators provide a comprehensive overview of the optimization results, allowing users to evaluate the performance of the recommended power management strategy across economic, environmental, and operational dimensions.

Below the KPI table, there is a **Parameters** button that allows users to review the values of all parameters configured in *Step 3: Configure Parameters* page. This feature provides a convenient way to verify the settings used for the current optimization run without navigating back to the configuration step.

When viewing the parameters summary, all parameter values from the four categories (Fuel, Generators, Battery, and Optimization) are displayed. Parameters that were modified from their default values are highlighted with blue underlined text, providing visual indication to help users quickly identify which settings they customized for the current optimization. Default parameter values remain in standard text format.

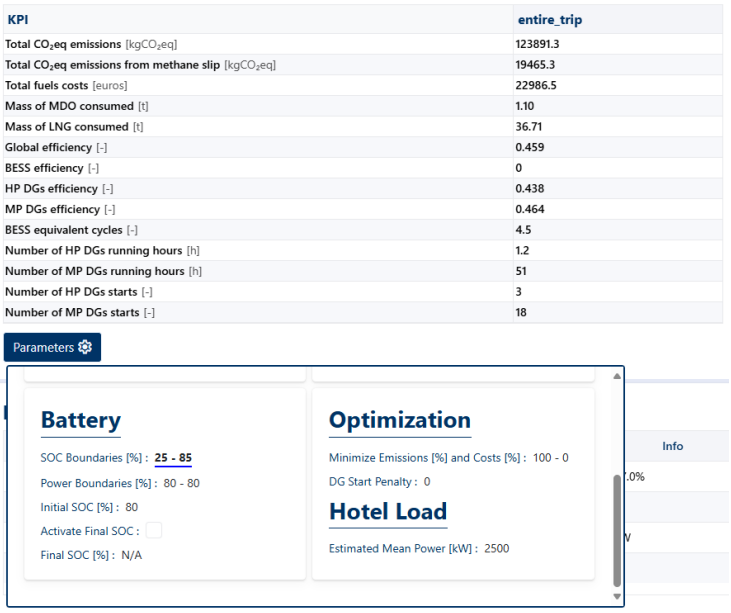


Figure 69 – Optimization Results – KPIs and Parameters

Map

On the right side of this table there is a map present in which the trip can be seen together with the ice segments. Moreover, information such as departure date, arrival date and trip length in nautical miles with the length in which the vessel will be in ice and the length in which the vessel will operate in open sea are present in the legend.

Figure 70 – Trip Displayed on Map

PMS Advices

The Power Management System (PMS) Advices table displays critical operational recommendations generated by the optimization algorithm. This section presents key battery management parameters that have been optimized for the specific voyage conditions. In the provided example, the table shows four main battery-related advisories including peak shaving high load limit set at 87.0%, charging load limit at 57.4%, discharging maximum power at 3399kW, and charging maximum power at 3399kW.

PMS Advices

Item	Info	Note
PMS/Battery	peak shaving high load limit = 87.0%	optimisation variable
PMS/Battery	charging load limit = 57.4%	optimisation variable
PMS/Battery	discharging max power = 3399kW	optimisation variable
PMS/Battery	charging max power = 3399kW	optimisation variable

Figure 71 – Optimization Results – PMS Advices

Power Distribution Analysis

Below the advisories, a comprehensive Power Distribution Analysis chart visualizes the optimized power allocation strategy throughout the entire voyage leg timeline. The chart displays power output in kilowatts on the vertical axis against the voyage timeline on the horizontal axis. Multiple colored bars represent different power sources including DG1 through DG6 power outputs, battery discharge power, battery charge power, and the overall output power demand line. This visualization allows maritime operators to understand how the optimization algorithm distributes power generation across different sources at various points during the voyage, showing when batteries

should charge or discharge and which generators should operate to achieve optimal efficiency, cost, and emissions performance.

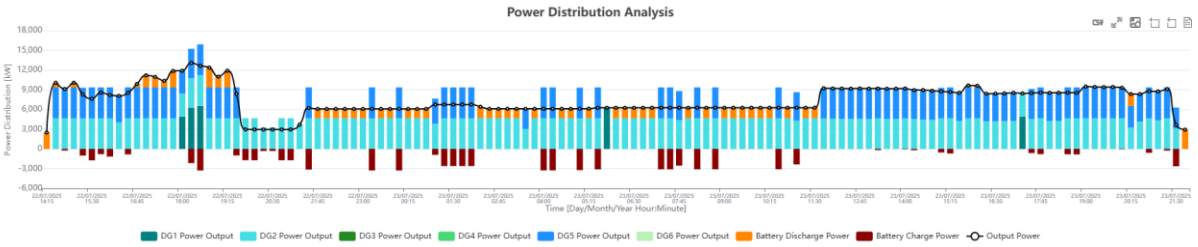


Figure 72 – Optimization Results – Power Distribution Analysis

Other plots

In the bottom section of the results page, two additional visualization areas provide detailed analysis of the optimization outcomes. The left side features a dropdown menu with four selectable items that dynamically change the plot content based on the user's selection, while the right side offers a choice between two items that similarly update the displayed plot according to the selection.

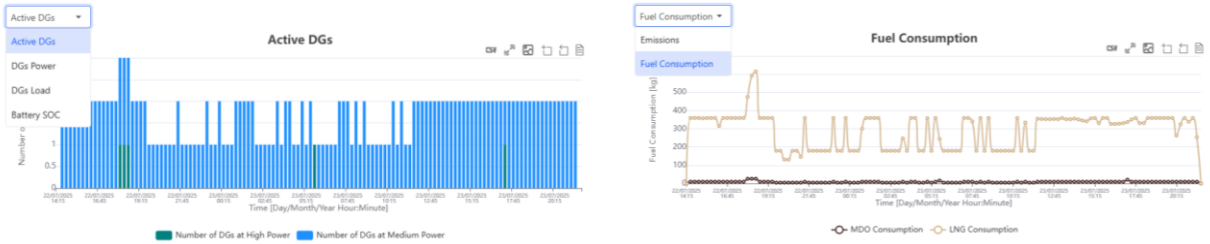


Figure 73 – Optimization Results Plots

Active DGs *Fuel Consumption*

Left Side Plot Selection

The dropdown menu on the left allows users to analyze four different aspects of the power management strategy.

The **Active DGs plot** shows the number of generators that should be operational at each 15-minute interval throughout the voyage, with blue bars representing the count of medium power generators and a green line indicating the number of high power generators that should be active.

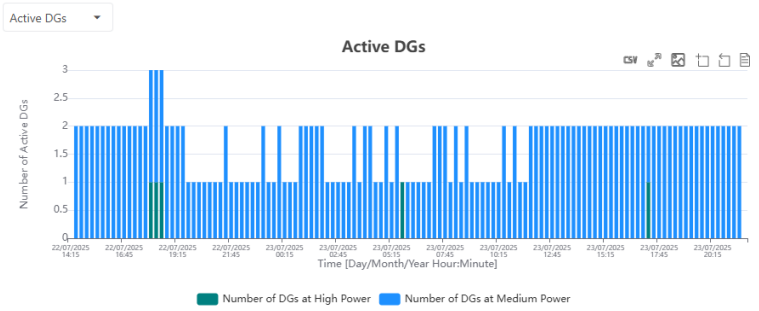


Figure 74 – Optimization Results – Active DGs

The **DGs Power plot** displays the actual power output generated by both high power and medium power generators over time, maintaining the same 15-minute timestep resolution.

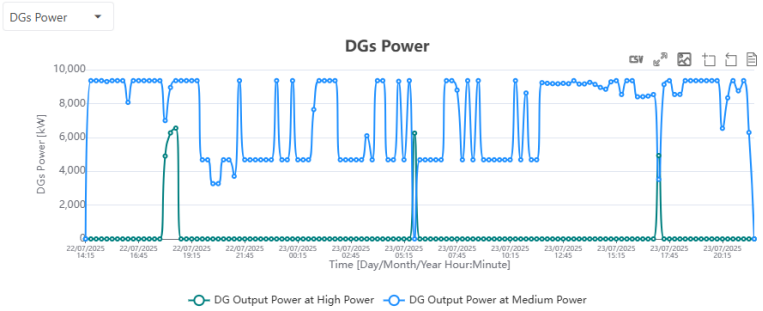


Figure 75 – Optimization Results – DGs Power

The **DGs Load plot** presents the individual load percentage for each of the six generators, allowing operators to see how the optimization distributes workload across the available generating units.

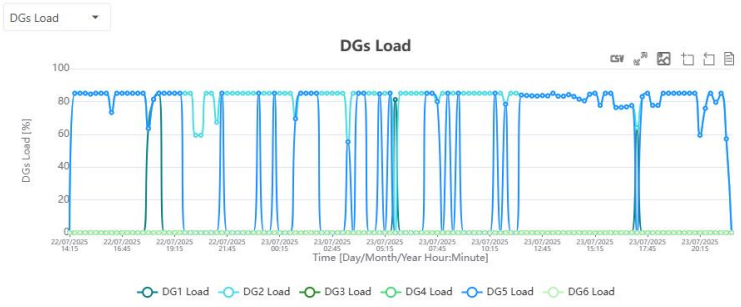


Figure 76 – Optimization Results – DGs Load

The **Battery SOC plot** illustrates the evolution of the battery's state of charge over time based on the configured parameters and optimization strategy.

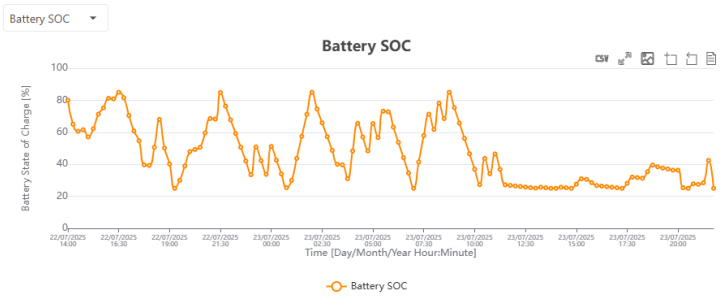


Figure 77 – Optimization Results – Battery SOC

Right Side KPI Visualization

The right side of the interface provides users with a choice between two critical performance metrics.

The **Emissions plot** tracks the evolution of CO_2 equivalent emissions and CO_2 equivalent methane emissions throughout the voyage, helping operators understand the environmental impact of the optimized power management strategy.

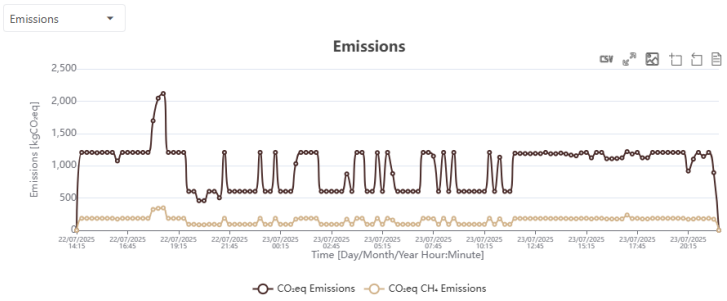


Figure 78 – Emissions

Alternatively, the **Fuel Consumption plot** displays the projected quantities of Marine Diesel Oil (MDO) and Liquefied Natural Gas (LNG) that will be consumed during the trip, providing essential information for fuel planning and cost analysis.

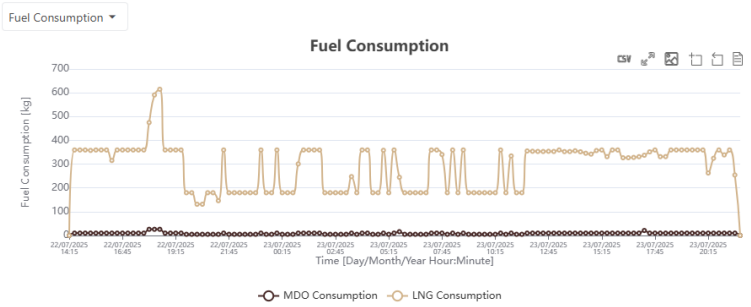


Figure 79 – Optimization Results – Fuel Consumption

6.3.5 Archive

On the first step of the Single Leg Optimization process, near the upload button, there is an Archive button that provides users with convenient access to their optimization history. This feature allows users to easily return to previous optimizations without having to repeat the entire four-step process from beginning to end.

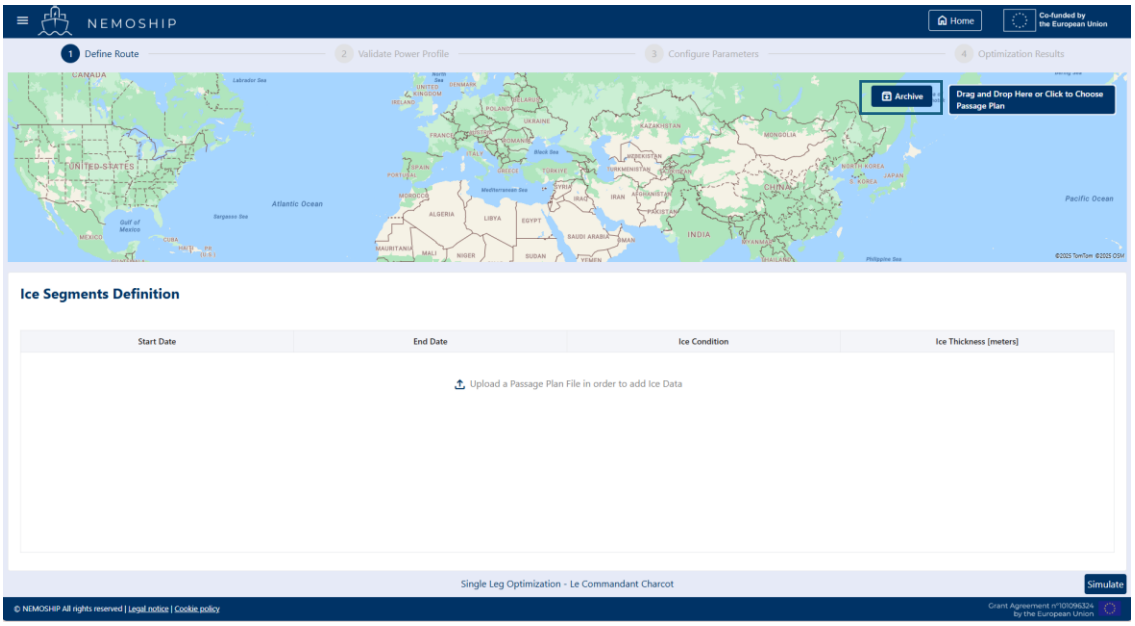


Figure 80 – Single Leg Optimization – Archive Button

The archive page contains a "Go Back to Single Leg Optimization" button at the top that redirects users directly to Step 1 of the Single Leg Optimization workflow. The main content area features a comprehensive table on the left side with four distinct columns that organize the optimization history and a map on the right side.

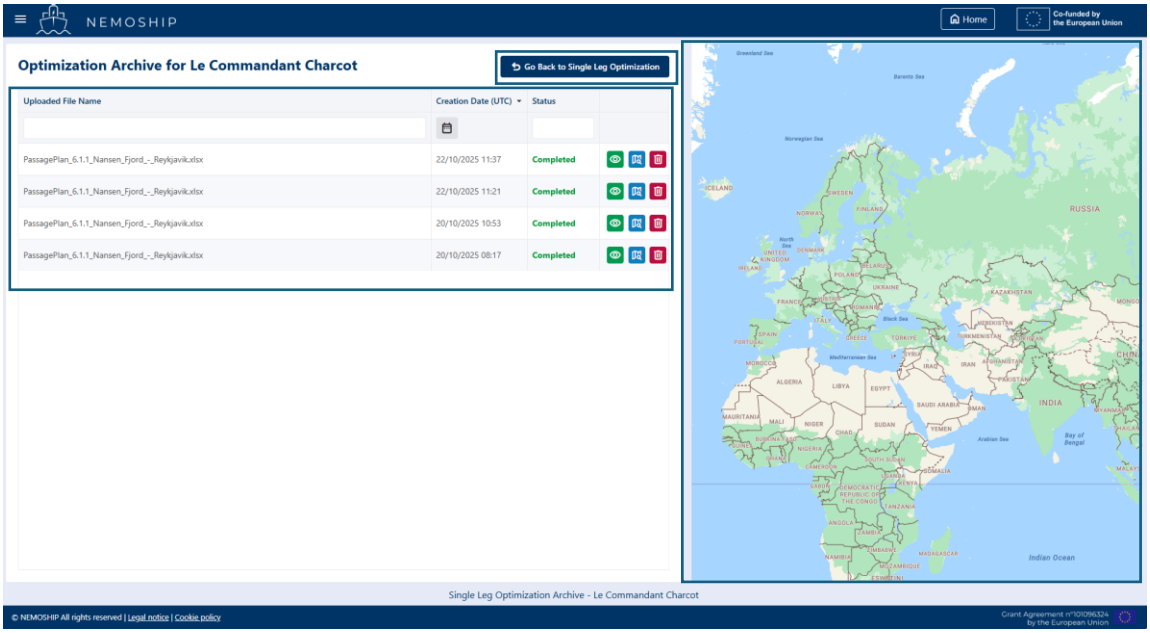


Figure 81 – Single Leg Optimization – Archive Window

Archive Table Columns

- The first column displays the name of the file that was used for importing the trip data on which the optimization was performed
- The second column shows the date when the optimization was executed, presented in UTC format
- The third column indicates the current status of each optimization process, which can display several states:
  - **Completed** for optimizations that finished successfully
  - **Failed** when errors occurred during the optimization process (such as conflicting constraints or infeasible solutions)
  - **Error** for issues related to digital platform processes
  - **In Progress** for optimization processes that are still running
- The fourth column contains three action buttons for each optimization entry
  - The first button opens a new window displaying the complete optimization results, which presents an identical interface to the Step 4 results page previously described

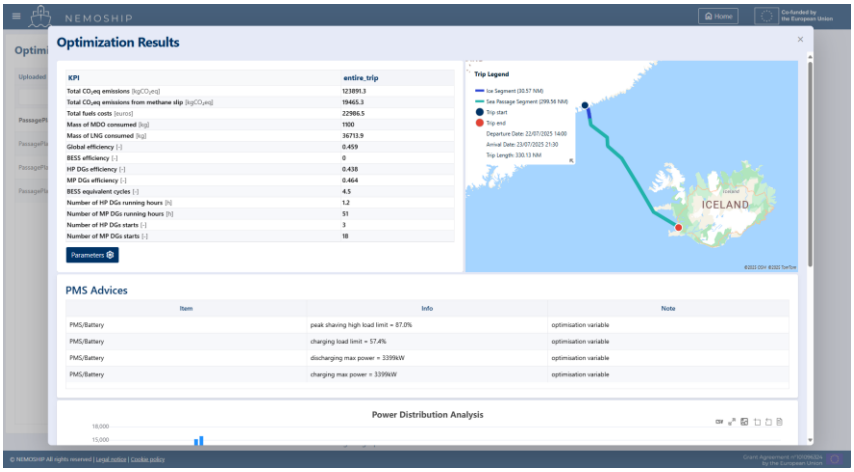


Figure 82 – Single Leg Optimization – Archive Results

- The second button visualizes the trip route on the map display on the right side

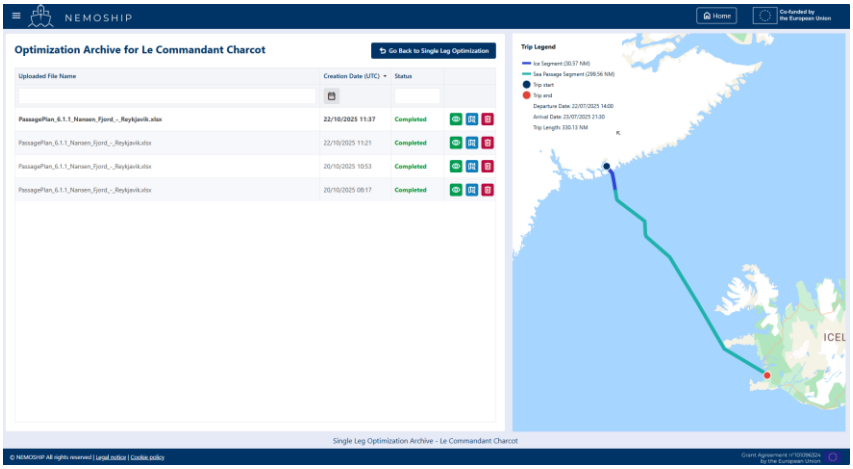


Figure 83 – Single Leg Optimization – Archive Trip Visualization

- The third button allows users to permanently delete the optimization results from their archive

7 Voyage Optimization Module

7.1 Purpose

The **Voyage Optimization Module** operates similarly to the **Single Leg Optimization Module** but serves a different primary function. This module optimizes an entire voyage by providing insights on how to operate each individual leg within the trip. Optimization can be performed based on costs, emissions, or both parameters in varying proportions.

Unlike single leg optimization, which performs real-time optimization for the next 2-3 hours to deliver accurate real-time guidance, this module optimizes complete voyages that may span from several days to a month. This module should be used before the trip begins to gain an overview of the configurations that should be implemented throughout the voyage.

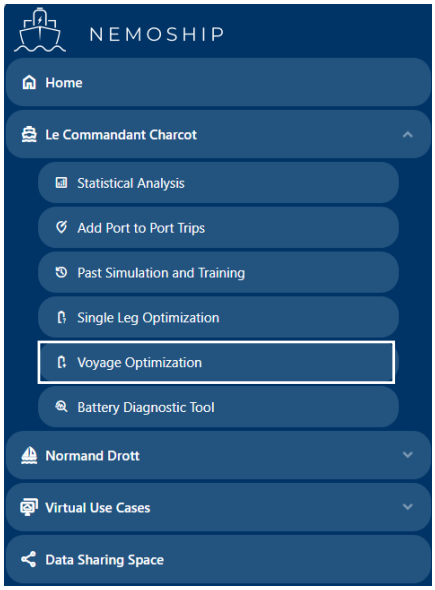


Figure 84 – Voyage Optimization Module

7.2 How It Works

The module follows a workflow similar to the **Single Leg Optimization Module**. For a specified route with defined ice conditions, the platform predicts the required power profile. Based on the determined power profile and optimization constraints, the platform provides insights for efficient battery and generator usage. The system delivers the most cost-effective and emission-efficient results.

7.3 Module Structure

The **Voyage Optimization Module** contains the same four steps as the **Single Leg Optimization Module**. Each step depends on the completion of the previous step, meaning subsequent steps remain blocked (greyed out) until the current step's required actions are completed. Navigation through the module can be accomplished by clicking on step names located at the top of the screen or by using the **Previous** and **Next** buttons positioned at the bottom of the interface.

7.3.1 Step 1: Define Route

This step enables importing the route for the future voyage that will undergo optimization. The route file must be imported as a Nautique file exported in Excel format. The format is fixed and contains mandatory columns that must be present to process the file and extract important information. An example of a valid file is displayed in the image below.

1-Production
2-Armement
3-Production
4-Prod Mgr

Le Commandant Charcot

from	Reykjavik	to	Reykjavik
from	5/14/2025	to	5/24/2025

CC140525 V2

10 NIGHTS

SHIP : Le Commandant Charcot

Date	Port of call / Country	Latitude	Longitude	Port Costs	Distance	Situation	Full sea spe	FSS duration (h)	Total duration (h	Departur Man.(min)	Arrival Man.(min)	anchor/ Along	GMT	ETA	ETD
Wed 14-May-25	Reykjavik	64°09.2'N	021°51.4'W			Along side							0.00		19.00
Thu 15-May-25	At Sea	65°30'N	034°00'W			At sea							0.00		
Fri 16-May-25	Ice entry	65°22.0'N	036°45.0'W		389	At sea	12.55	31.00	31.00				-1.00	1.00	1.00
Fri 16-May-25	Tasiilaq	65°37.1'N	037°36.5'W		29	Adrift	4.14	7.00	7.00			11.00	-1.00	8.00	19.00
Sat 17-May-25	Kungmit	65°51.7'N	037°01.1'W		28	Adrift	2.33	12.00	12.00			11.00	-1.00	7.00	18.00
Sat 17-May-25	Qernertivartivit	65°43.1'N	037°20.4'W		15	Fast Ice	7.50	2.00	2.00				-1.00	20.00	
Sun 18-May-25	Qernertivartivit	65°43.1'N	037°20.4'W			Fast Ice							-1.00		
Mon 19-May-25	Qernertivartivit	65°43.1'N	037°20.4'W			Fast Ice							-1.00		16.00
Mon 19-May-25	Ice exit	65°21.0'N	036°53.0'W		58	At sea	8.29	7.00	7.00				-1.00	23.00	23.00
Tue 20-May-25	Ice entry	66°00.0'N	034°00.0'W		100	At sea	11.11	9.00	9.00				-1.00	8.00	8.00
Tue 20-May-25	Similaq	66°33.5'N	034°24.2'W		18	Fast Ice	4.50	4.00	4.00				-1.00	12.00	
Wed 21-May-25	Similaq	66°33.5'N	034°24.2'W			Fast Ice						25.00	-1.00		13.00
Wed 21-May-25	Ice exit	66°20'N	033°00'W		18	At sea	6.00	3.00	3.00				-1.00	16.00	16.00
Thu 22-May-25	Ice entry	66°15'N	032°30'W		144	At sea	13.09	11.00	11.00				-1.00	3.00	3.00
Thu 22-May-25	Blosseville	66°40'N	030°00'W		56	Adrift	6.22	9.00	9.00			05.00	-1.00	12.00	17.00
Fri 23-May-25	Ice exit	65°00'N	025°00'W		56	At sea	7.00	8.00	8.00				-1.00	1.00	1.00
Fri 23-May-25	Reykjavik pilot	64°10.3'N	021°53.5'W		265	At sea	13.95	19.00	19.00			44.00	0.00	21.00	21.00
Fri 23-May-25	Reykjavik	64°09.2'N	021°51.4'W		2	Along side	2.00	1.00	1.00				0.00	22.00	
Sat 24-May-25	Reykjavik	64°09.2'N	021°51.4'W			Along side							0.00		19.00
Sat 24-May-25	Reykjavik	64°09.2'N	021°51.4'W			Along side									

Figure 85 – Excel Nautique File Format

All cells in the Excel file must contain values for all columns. Otherwise, an error will occur. To resolve this issue, the Excel file must be completed with all required information.

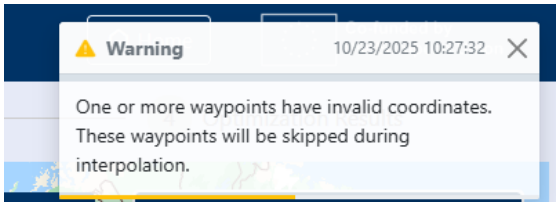


Figure 86 – Warning Message on File Upload

Uploading the Route

To upload a Nautique file, use the *Drag and Drop or Click to Choose a Route Planning File* button located at the top right of the map. When the file uploads correctly and loads successfully into the platform, the route will be displayed on the map. A confirmation message will appear indicating successful file processing.

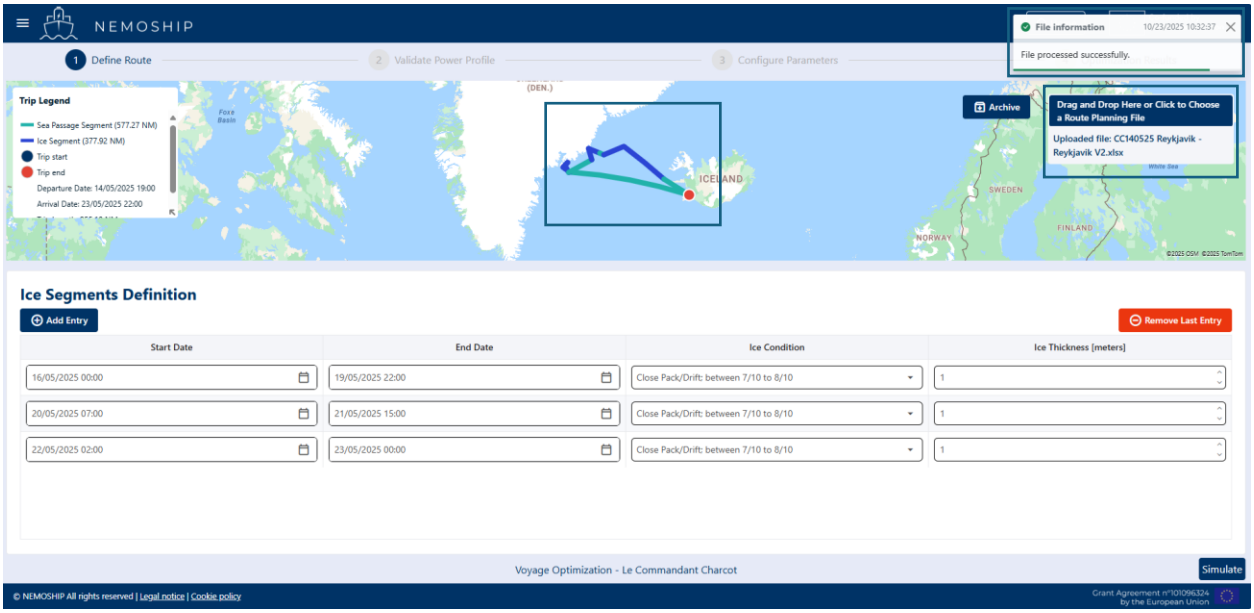


Figure 87 – New Route Uploading

If the file format is invalid, an error message will alert the user, and progression to the next step will not be possible.

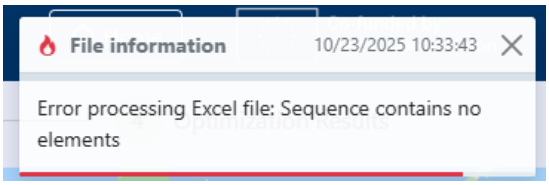


Figure 88 – Error Processing Excel File

Defining Ice Conditions

After successful file upload, the **Ice Segments Definition** table will be automatically completed based on data from the Nautique file. By default, all entries will have *Close Pack/Drift (7/10 to 8/10 concentration)* as the ice condition and *1 meter* for ice thickness. All auto-completed data can be modified, entries can be deleted, and new entries can be added using the two available buttons: **Remove Last Entry** and **Add Entry**.

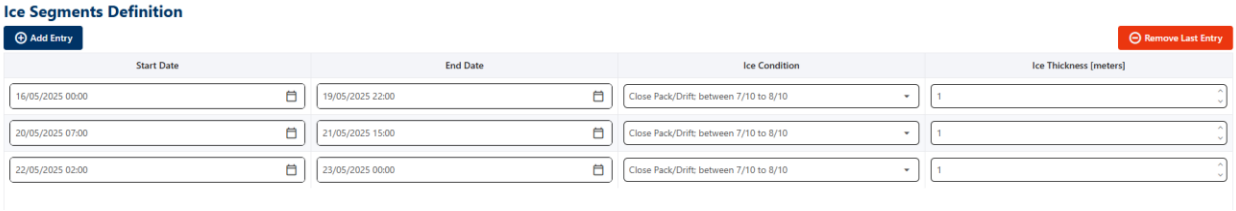


Figure 89 – Ice Segments Definition

Similar to the **Single Leg Optimization Module**, all data is visible on the map with teal representing sea passage segments and dark blue representing ice portions. Clicking on a specific segment displays additional details about that segment in a popup on the map.

Figure 90 – Ice Segment Visualization on Map

The same two conditions apply as in the other optimization module when adding ice entries. Start Date must always be earlier than End Date for each row. Start Date of each new entry must be after the previous entry's End Date. If these conditions are not met, error messages will appear in the interface.

To proceed to the next step, press the **Simulate** button located at the bottom right of the screen.

Simulation Process

When the button is pressed, two main processes occur. First, the platform retrieves weather conditions for the imported route using a weather provider (Open Meteo) and associates these conditions to each waypoint. Depending on the timing of the optimization relative to the actual trip, weather data might or might not be available. If the voyage optimization is performed more than 15 days before the real date of the trip, future weather data will not be available and calm weather conditions will be used instead, considering ideal navigation conditions.

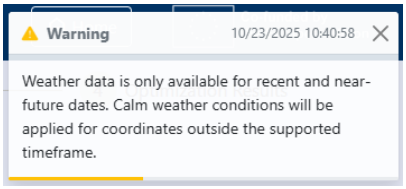


Figure 91 – Weather Data Warning

Second, the platform uses a digital model to predict the power profile required by the vessel for the specified conditions, including ice conditions and weather details.

During these processes, a loading page displays all steps in detail and shows the current execution point of the background processes.

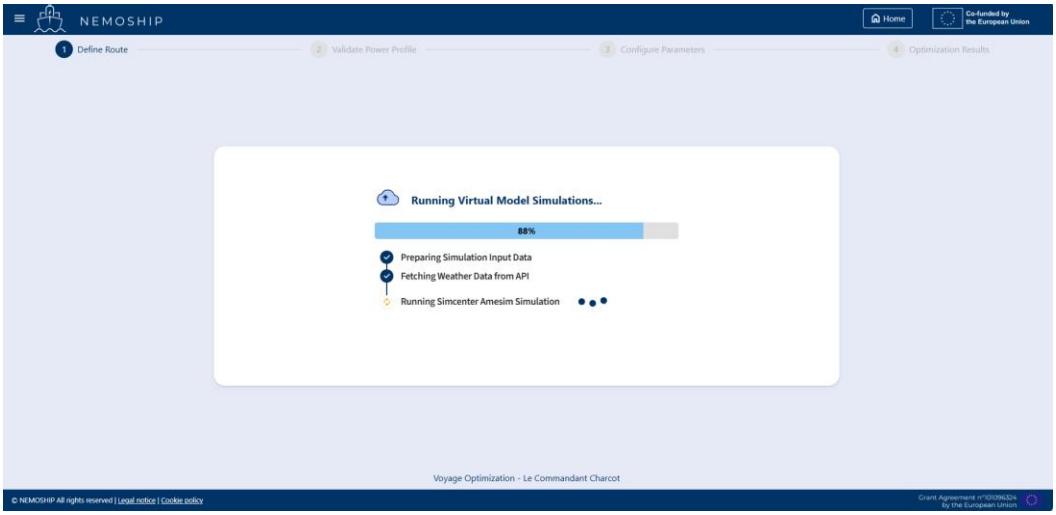


Figure 92 – Simulation Progress

7.3.2 Step 2: Validate Power Profile

Identically to the second step of **Single Leg Optimization Module**, once the power profile prediction is complete, the results will be visible on a plot in the second step of the module. The same variations with adding 0.1, 0.2 and 0.3 meters and subtracting 0.1, 0.2, and 0.3 meters from the original set ice thickness values are performed and the most appropriate power profile can be chosen using the control from the interface under *Select your preferred Power Profile*.

Figure 93 – Simulated Shaft Power Validation

After selecting it, the *Next* button on the bottom part of the page can be pressed or the **Configure Parameters** step on the top part of the page can be selected.

7.3.3 Step 3: Configure Parameters

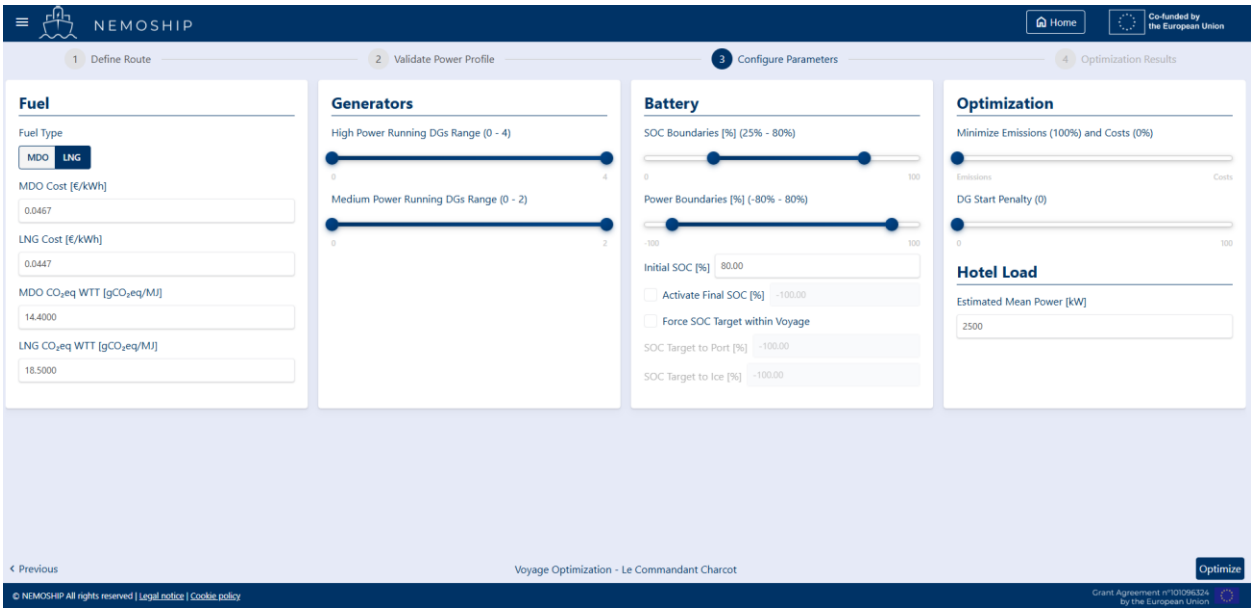


Figure 94 – Optimization Parameters

The third step consists of a set of parameters that can be configured before performing the optimization. All parameters have default values but can be changed based on user preferences. The parameters are divided into 5 categories including the same parameters that were detailed in *Step 3: Configure Parameters* in the **Single Leg Optimization Module**. There are only 2 differences.

In this module, the *Activated Generators* field is no longer required since the assumption is that the vessel starts from the port and all generators will be turned off. The second difference is that in the battery section a new field called Force SOC Target within Voyage appears. When activating it, 2 additional fields can be completed by the user:

- **SOC Target to Port [%]:** the state of charge that the vessel must have when being in port *(default: 80%)*
- **SOC Target to Ice [%]:** the state of charge of the battery that the vessel must have when arriving at an ice segment *(default: 80%)*

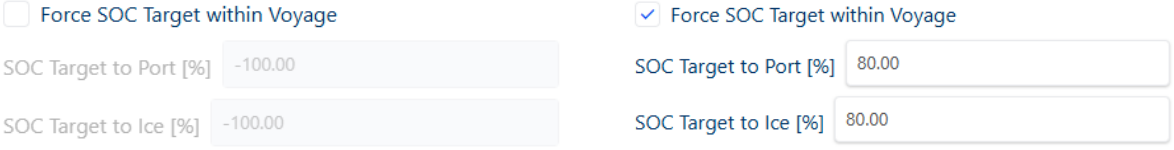


Figure 95 – Voyage Optimization - Configuration Parameters

Once the optimization parameters have been defined, the next step is pressing the **Optimize** button. Instead of a loading screen appearing as was the case for **Single Leg Optimization Module**, in the 4th step the Archive page will be opened. This happens because of having a long trip for which the optimization may take a while (from a few minutes to hours depending on the trip length and the set optimization parameters). In this way the user can continue navigating within the digital platform and come back to the archive after a time to check if the results are ready. In order to refresh the status of the optimization, the **Refresh** button must be pressed. The status of the optimization can be seen in the Status column:

- **Completed** for optimizations that finished successfully and for which the results can be seen
- **Failed** when errors occurred during the optimization process (such as conflicting constraints or infeasible solutions)
- **Error** for issues related to digital platform processes
- **In Progress** for optimization processes that are still running

All other information is the same as in the **Archive** for **Single Leg Optimization Module**.

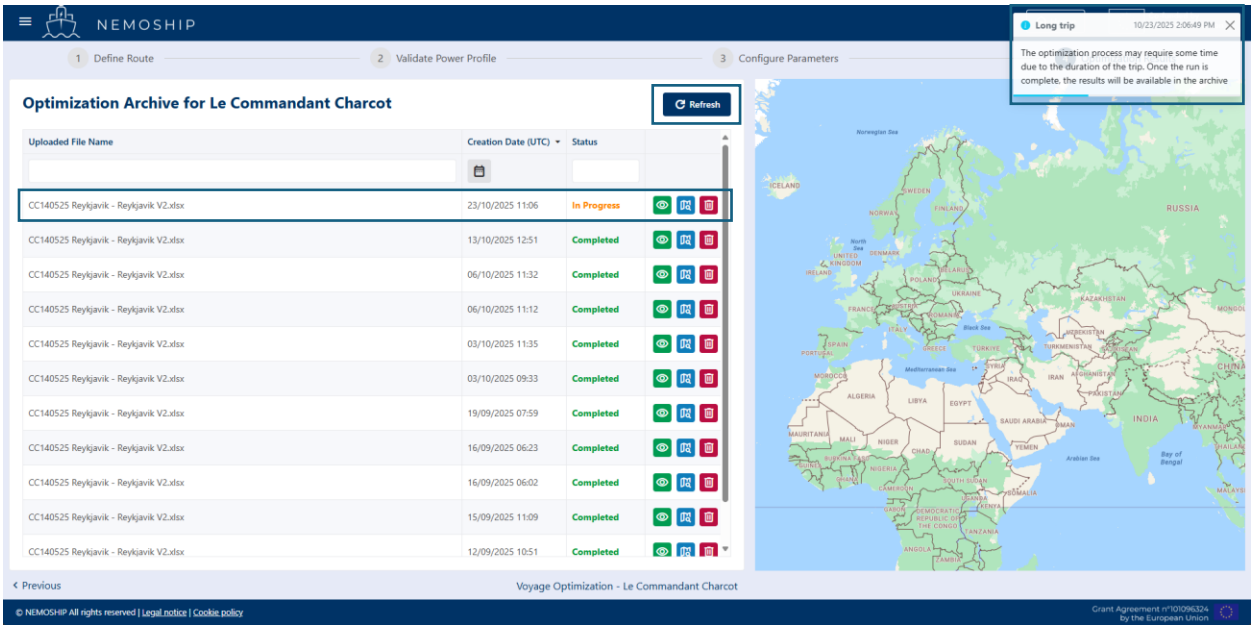


Figure 96 – Voyage Optimization Archive

7.3.4 Step 4: Optimization Results

After the optimization algorithm completes its run, the user will see the status **Completed** and the results page can be opened by pressing the first button in the 4th column (the eye button).

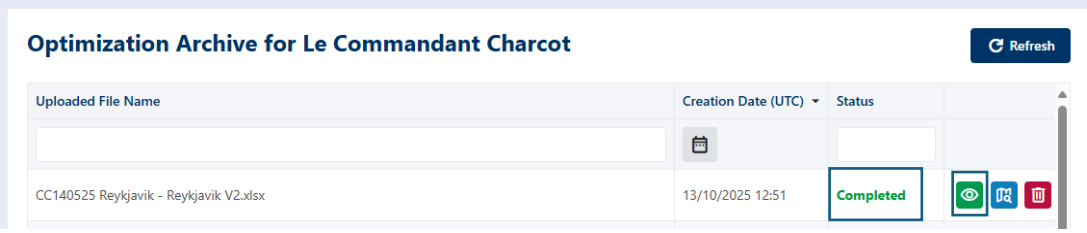


Figure 97 – Optimization Completed

The results page looks exactly the same as the one in the **Single Leg Optimization Module** providing the same kind of indications. The only difference is that the guidance and KPI measurements are done for both each individual leg and for the whole trip.

The first table from the left top corner contains the 14 indicator values for each individual leg and for the whole trip as well.

KPI	lID_19	LegID_20	LegID_21	LegID_22	LegID_23	LegID_24	entire_trip
Total CO_2eq emissions [$kgCO_2eq$]	5.6	745.5	12421.7	55849.9	91748.6	387.1	844949.9
Total CO_2eq emissions from methane slip [$kgCO_2eq$]	.4	151.6	1926.5	9085	14695.5	86.2	134669.8
Total fuels costs [euros]	.9	131.5	2309.5	10280.8	16928	68.1	156263.3
Mass of MDO consumed [kg]		16	105	646	847	5	8290
Mass of LNG consumed [kg]	8.3	201.2	3693.7	16280.8	27003.9	107.2	248846.7
Global efficiency [-]	6	0.423	0.457	0.454	0.455	0.411	0.455
BESS efficiency [-]		0	0	0	0	0	0
HP DGs efficiency [-]	3	0.429	N/A	0.445	0.422	N/A	0.441
MP DGs efficiency [-]	5	N/A	0.464	0.465	0.459	0.422	0.464
BESS equivalent cycles [-]		0	0.3	1.8	0.7	0	25.6
Number of HP DGs running hours [h]		0.2	0	5.2	0.5	0	31.2
Number of MP DGs running hours [h]		0	5.2	15.5	40.8	0.2	314.5
Number of HP DGs starts [-]		1	0	14	1	0	72
Number of MP DGs starts [-]		0	3	2	3	0	119

Figure 98 – Voyage Optimization – KPIs

Also, on the map, the user can see which leg is selected and the results are available for. If the vessel is moving on the selected leg, it will appear in red on the map. If it is stationary, an image with a ship will show up on the map representing the place where the vessel is located.

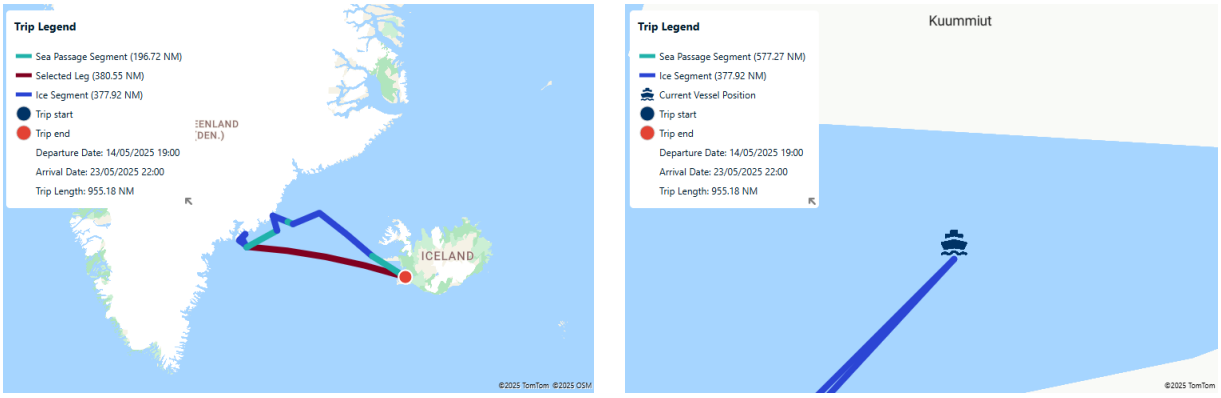


Figure 99 – Voyage Optimization - Map Visualization

This selection is done by using the dropdown below the KPI table. The user can either choose a leg or the entire trip to see the guidance.

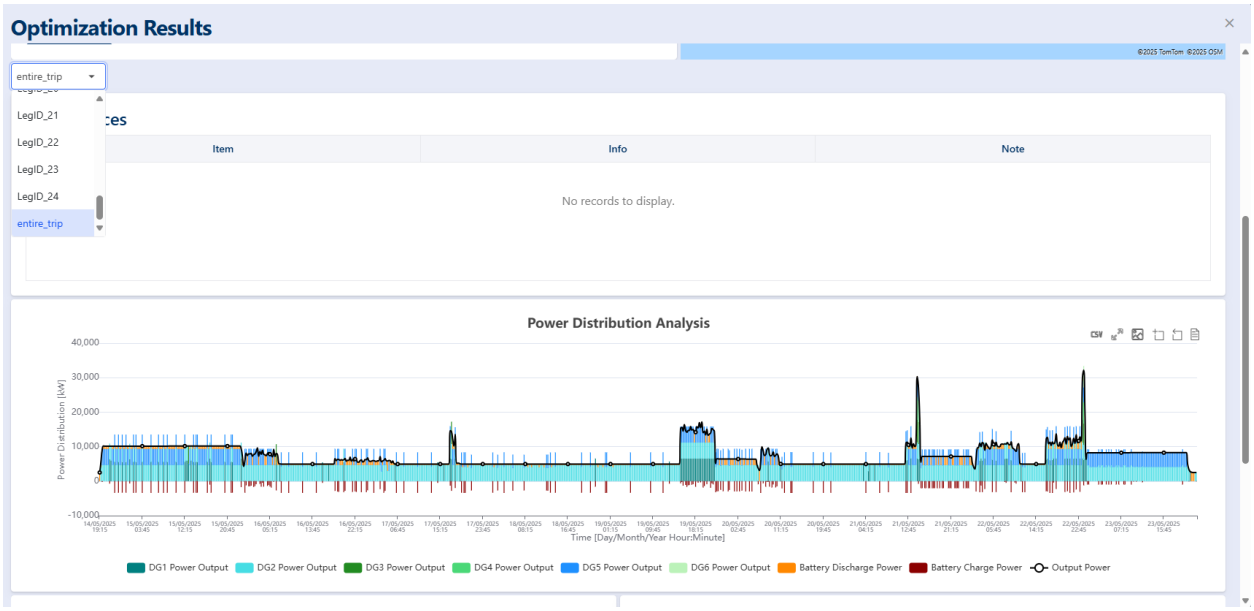


Figure 100 – Voyage Optimization Results per Leg

For better understanding of the page structure and the interpretation of the plots, you can access the *Step 4: Optimization Results* section from **Single Leg Optimization Module**.

7.3.5 Archive

On the first step of the **Voyage Optimization Module**, near the upload button, there is an Archive button that provides users with convenient access to their optimization history. This feature allows users to easily return to previous optimizations without having to repeat the entire four-step process from beginning to end.

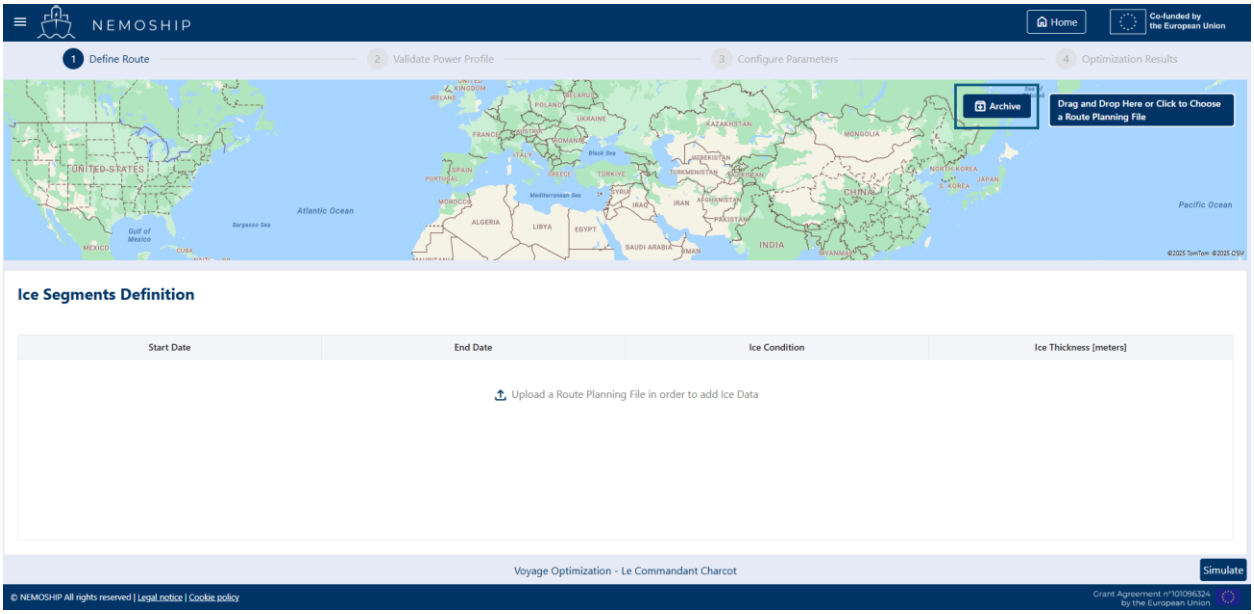


Figure 101 – Voyage Optimization - Archive

The content of the archive is identical to the one described in both the **Single Leg Optimization Module** and *Step 4: Optimization Results* in the **Voyage Optimization Module**.

8 Conclusion

The NEMOSHIP Digital Platform provides vessel operators with powerful tools to monitor, analyze, and optimize Battery Energy Storage System (BESS) performance. Throughout this manual, we have explored the platform's key features, from real-time monitoring and interactive dashboards to detailed voyage analysis and performance reporting. By using these tools effectively, operators can achieve significant fuel savings, reduce greenhouse gas emissions, and improve overall operational efficiency.

The platform transforms complex operational data into clear, actionable insights. Users can track critical metrics such as State of Charge, power flow, and operational modes in real-time, while also accessing historical data to identify trends and optimization opportunities. The interactive map features allow operators to visualize voyage routes and correlate geographical factors with performance data, providing a complete picture of vessel operations.

Environmental and economic benefits go hand in hand with the NEMOSHIP platform. Reduced diesel generator runtime leads to lower fuel consumption and maintenance costs, while simultaneously decreasing emissions and methane slip. The platform's comprehensive reporting capabilities support regulatory compliance with EU GHG and IMO CII requirements, helping vessels meet increasingly stringent environmental standards. Every optimization identified and implemented contributes to both cost savings and environmental stewardship.

To maximize the value of the NEMOSHIP Digital Platform, the recommendation is to establish regular monitoring routines, analyzing voyage data systematically, and sharing insights across operational teams. Use the platform's comparative analysis features to identify best practices and interpret historical data to plan future voyages more efficiently.

The platform continuously evolves with new features and capabilities. For technical support, or to provide feedback, please contact the NEMOSHIP support team:

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