Smart Ship HUB

THE MISSING LINK IN ENERGY SAVINGS

Why ESDs Need High-Frequency Data

INTRODUCTION

The shipping industry today is navigating uncharted waters. With the **International Maritime Organization (IMO)** setting ambitious decarbonization targets for 2050, ship owners and operators must adopt targeted **Energy Saving Devices (ESD)** technologies to deliver both operational efficiency and environmental responsibility.

Paving a practical pathway toward sustainability, ESDs are smart add-ons that help ships run leaner, cleaner, and faster. From propeller tweaks and hull coatings that cut through water with less resistance to trim optimizations and LED retrofits that quietly conserve energy, these technologies are transforming the way vessels perform. The benefits go beyond compliance. They lower fuel bills, enable smoother voyages, and facilitate progress towards net-zero goals, all of which add up to a strong competitive edge.

However, deploying ESDs isn't enough on its own. To unlock the full potential of these technologies, operators need accurate data and predictive insights that validate the actual outcome of their implementation across fleets. SmartShip© Hub has designed a data-centric solution to provide that support. We call it SmartShip©Hub Remote.

By combining continuous remote monitoring with **Artificial Intelligence (AI)** and **machine learning (ML)** powered analytics, the platform gives live visibility into a ship's performance, turning raw data into guidelines that show what's working and what needs improvement.

It supports compliance with C**arbon Intensity Indicator (CII)** and Energy **Efficiency Existing Ship Index (EEXI)** while turning efficiency initiatives into long-term operational advantages.

This paper explores key ESD systems, their role in reducing carbon intensity, and shows how **high-frequency data (HFD)** insights offered by SmartShip© Hub Remote help companies make them count. Together, these solutions propel the industry to a future wherein shipping balances profitability with sustainability.

THE NEED FOR ENERGY-SAVING MEASURES IN SHIPPING

The shipping industry is responsible for moving more than 80% of global trade[1], but this economic lifeline comes with a significant environmental cost. International shipping emissions have been rising. Between 2019 and 2024, they surged from 889 to 974 million tons of CO_2, representing a record 6% increase in 2024 alone, primarily driven by container and bulk carriers2.

With tightening regulations under EEXI, CII, and the EU Emissions Trading System (ETS), the message for ship owners and operators is clear: ships must burn less fuel and cut emissions. Non-compliance would result in financial penalties, operational restrictions, and reputational damage.

Traditional measures do not address today's decarbonization challenges. Rising fuel costs eat into margins, while customers, investors, and ports demand greater accountability.

Every drawback – be it excessive drag on a hull or outdated lighting on board – translates into higher costs and unnecessary carbon footprint.

ESDs bridge the gap between mediocrity and a new level of operational excellence in the shipping industry. By enhancing propulsion efficacy, optimizing vessel hydrodynamics, and reducing auxiliary power demand, ESD technologies help ships to function with less fuel and fewer emissions. When paired with accurate data tracking, their benefits also become visible and measurable.

In addition to keeping regulators satisfied, energy saving in shipping is about running lean, more competitive fleets that promote greener supply chains.

OVERVIEW OF KEY ESD TECHNOLOGIES

There is no shortage of ESDs and carbon footprint control techniques for the maritime sector today. Here's a quick look at the most widely used solutions:

Trim Optimization – By adjusting a ship's floating position to achieve the most hydrodynamic balance, trim optimization reduces drag and fuel burn.

LED Lighting – Replacing conventional bulbs with LEDs is a simple yet effective way to cut electrical load significantly, boosting overall vessel energy economy.

Variable Frequency Drives (VFDs) – The deployment of VFDs helps to regulate motor speeds in pumps and fans in a way that systems consume only the power actually drag and fuel burn.

Propeller Boss Cap Fins (PBCF) – By recovering energy from the swirling water flow behind the propeller, PBCFs minimize propeller hub vortex losses - this increases thrust efficiency and reduces fuel usage.

Propeller Cleaning – Routine cleaning of propellers prevents fouling and can dramatically reduce drag and fuel burn.

Data Auto-Logging – Regular data capture helps to monitor vessel performance, leading to meaningful analysis for energy management.

Main Engine Optimization – Regular data capture helps to monitor vessel performance, leading to meaningful analysis for energy management.

Auxiliary Engine Lube Oil (AE LO) Fine Filter - These filters improve lubrication quality to reduce friction and prolong engine life, resulting in lower energy consumption.

Flow Ducts – They smooth water flow into the propeller, reducing turbulence and helping vessels get more out of each unit of fuel.

Hull Paint – Specialized low-friction coatings keep hulls free of marine growth, allowing them to glide through water with less drag for smooth voyages.

Individually, these technologies deliver incremental benefits. However, their true potential is realized only when supported by reliable performance data collected constantly from different parts of a vessel.

Without real-time analysis of operations, it is difficult to gauge the impact of ESDs and adjust them to ensure compliance with decarbonization frameworks. This is where high-frequency HFD platforms provide value for a modernized, economical, and result-oriented maintenance approach.

THE ROLE OF HIGH-FREQUENCY DATA IN ENHANCING ESD EFFECTIVENESS

Although ESDs represent a necessary step forward in reducing vessel fuel consumption and emissions, their impact often falls short of expectations when they are deployed in isolation.

The reality is that the performance of ESD systems and solutions varies across loads, routes, and sea conditions – this makes it complex for operators to quantify real benefits, validate return on investments (ROI), and adapt operations for progressive improvement.

For example, while a trim optimization device promises fuel savings, the real economy fluctuates depending on cargo weight, hull condition, and weather. Likewise, a propeller cleaning schedule may enhance thrust output in theory but yield uncertain returns in the absence of actual operational verification.

Without high-frequency data, ESDs show potential. With it, they prove performance.

To redefine the role of ESDs, transforming them from static technologies into dynamic, performance-driven solutions, SmartShip©Hub offers SmartShip©Hub Remote. It is a 24*7 AI/ML-powered intelligent system for continuous capturing, analysis, and contextualization of ship data from an onshore center for live situational awareness during voyages to and from the port.

By integrating high-frequency sensor readings with noon reports, sea trial data, and manufacturer benchmarks, SmartShip©Hub Remote creates a single, secure source of operational truth. The data foundation thus built enables ship operators not just to implement ESDs but to optimize and validate them under real-world conditions.

INTEGRATED SITUATIONAL AWARENESS

The key benefit of SmartShip© Hub Remote lies in its ability to combine multiple streams of information into actionable insights. By ensuring a close interplay between ESD metrics and core ship systems via HFD, it enables shipping companies to get dynamic, verifiable outcomes for improved vessel efficiency.

Here's a table to illustrate how standard ESD technologies perform in isolation and what changes when they are supplemented by continuous data-driven monitoring and optimization offered by SmartShip© Hub Remote:

ESD TECHNOLOGY	PERFORMANCE IN ISOLATION	PERFORMANCE SUPPORTED BY SMARTSHIP© HUB REMOTE
Trim Optimization	Static guidance offered is based on vessel design and operator inputs that are not frequently adjusted.	Real-time optimization uses continuous HFD streams factoring in ship speed, draft (fore and aft), heel angle, engine performance, weather, wave height, and load conditions —leading to validated efficiency gains.
Data Auto-Logging	Data is either based on noon reports or comes from semi-automated logging, which includes time gaps and potential errors, making efficiency analysis unreliable.	Automatic, high-frequency logging is balanced with noon reports – it enables error-free, integrated performance insights.
LED Lighting	Energy savings come from reduced power consumption, but impact remains unmeasured.	Combined with HFD sensors, LED deployment is tracked within overall energy KPIs, quantifying decrease in carbon footprint.
Main Engine Optimization	Adjustments are made during dry dock or service intervals, and benefits may not last in changing conditions.	Continuous optimization powered by HFD analytics tunes combustion parameters dynamically and links results directly to fuel savings and CII scores.
Variable Frequency Drives	VFDs improve functioning of pumps/fans, but performance is based only on equipment specs.	HFD monitors real-time load variations and operational cycles, ensuring VFDs operate at optimal rate across varying conditions.
Auxiliary Engine Lube Oil Fine Filter	AELO filter reduces wear and improves engine reliability, but impact is recorded only during periodic inspections.	Continuous condition monitoring through HFD correlates filter performance with engine health and fuel use, predicting failures early and extending maintenance cycles.
Propeller Boss Cap Fins	Once installed, PBCFs improve hydrodynamics, but results are mere estimates or based on theoretical models.	The solution validates the actual performance impact of PBCF on each voyage by correlating propulsion data with operating conditions to ensure fins deliver maximum benefits beyond estimated values.
Flow Ducts	Ducts deliver incremental fuel savings by directing water flow, but benefits do not measured.	Real-time analysis quantifies savings dynamically under varying sea states for accurate ROI assessment and better route planning.
Propeller Cleaning	Impact depends on cleaning intervals, and performance drops are common between schedules.	HFD detects early signs of propeller fouling by analyzing engine power demand and shaft torque to trigger just-in-time cleaning for sustained performance.
Hull Paint	Paint makes the hull surface smoother and reduces drag post-application, but the benefits degrade over time.	The HFD platform correlates hull paint condition with drag coefficients to forecast when fouling will start affecting performance – it facilitates optimal re-application intervals.

In supporting ESD deployments, SmartShip© Hub Remote amplifies their impact, giving operators the deep visibility, insights, and verifiable returns that directly contribute to their business goals.

SIMPLIFYING COMPLIANCE WITH CII, EEXI, & ETS

The IMO's **Carbon Intensity Indicator (CII)**, the Energy **Efficiency Existing Ship Index (EEXI)**, and the **EU Emissions Trading System (ETS)** mandate shipowners to demonstrate reductions in carbon intensity and emissions in measurable, verifiable terms.

The contribution of ESDs to decarbonization and related regulations cannot feasibly be proven without documented data. SmartShip© Hub Remote builds the compliance backbone by:

- Generating exact CO_2 intensity metrics for CII ratings.
- Collecting voyage data automatically, including fuel consumption, distance travelled, speed, and cargo carried.
- Simplifying reports for charterers, regulators, and auditors with harmonized datasets.
- Delivering advisory insights that help companies plan operational strategies aligned with regulatory thresholds.

In practice, this implies ESD investments get directly linked to regulatory performance, protecting operators from penalties and positioning them favorably with both customers and regulators.

A CONTINUOUS IMPROVEMENT CYCLE

The strength of SmartShip© Hub Remote's HFD and remote monitoring performance management platform lies in its ability to design an adaptive loop where performance is seamlessly examined, validated, and refined. Key benefits include:

REAL-TIME VALIDATION
Immediate feedback on how ESDs deliver expected savings

PREDICTIVE DIAGNOSTICS
Early detection of deviations before vessel operations are affected

REDUCED DOWNTIME
Proactive insights to minimize equipment failures and maintenance delays

OPERATIONAL DECISION SUPPORT
Recommendations for trim, engine load, or routing adjustments to maximize ESD impact

BENCHMARKING & ROI PROOF
Quantified evidence of asset utilization for ROI on tech investment and sustainability initiatives

SSH SUCCESS: HULL PERFORMANCE TRACKING ACROSS DRY DOCK AND HULL CLEANING

Observation:

This study pertains to SmartShip© Hub Remote's evaluation of hull performance for a vessel that was a crude oil tanker. The assessment was conducted across three distinct phases:

Figure 1 highlights rising fuel consumption at constant speeds before dry dock, pointing to hull resistance buildup.

Post-dry dock, consumption improved, but extended port stays in March–May and September–October 2024 accelerated deterioration.

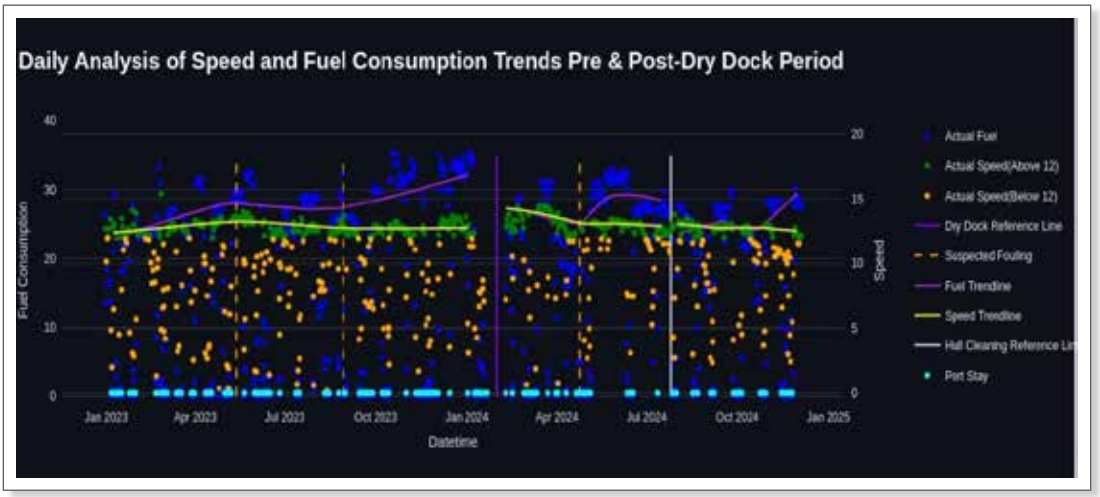

Image 1: Speed (12knots) & Fuel Consumption trends – Pre-& Post Dry Dock period

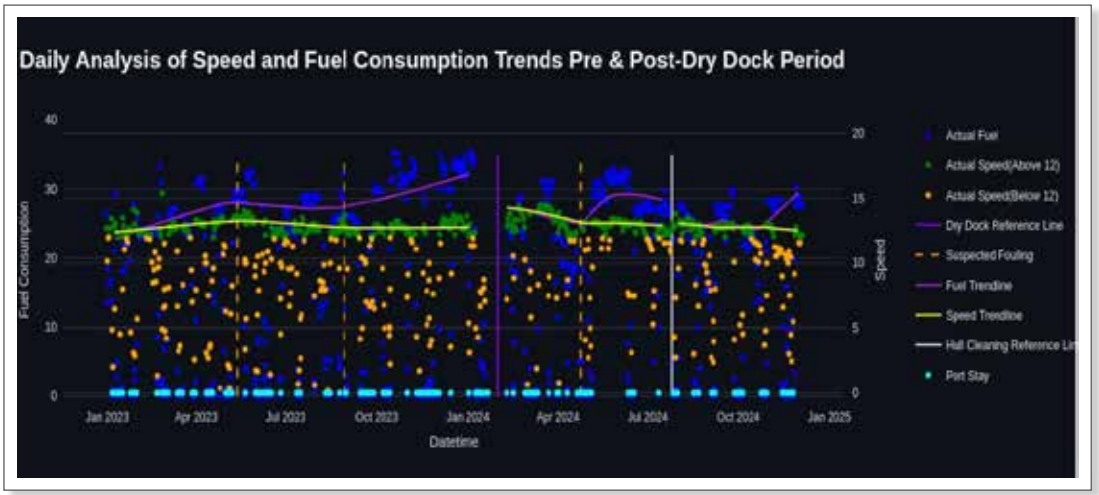

Image 2: Speed (12 knots) & Fuel Consumption trends – Post-Dry Dock period

Following hull cleaning, fuel use decreased significantly. However, warranty breaches persisted due to low operating speeds and high seawater temperatures. (Images 3 and 4)

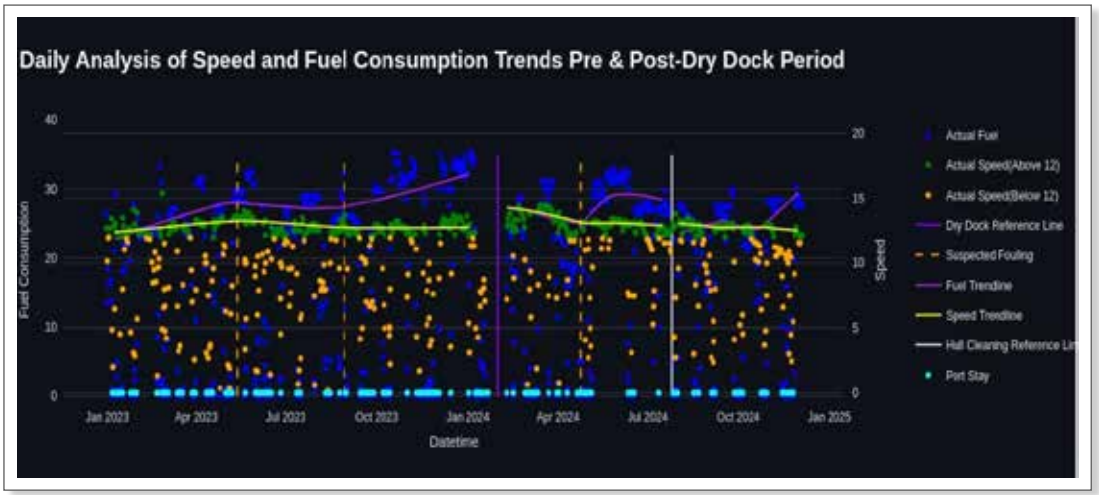

Image 3: Warranty breach graph (290C & 12kts)

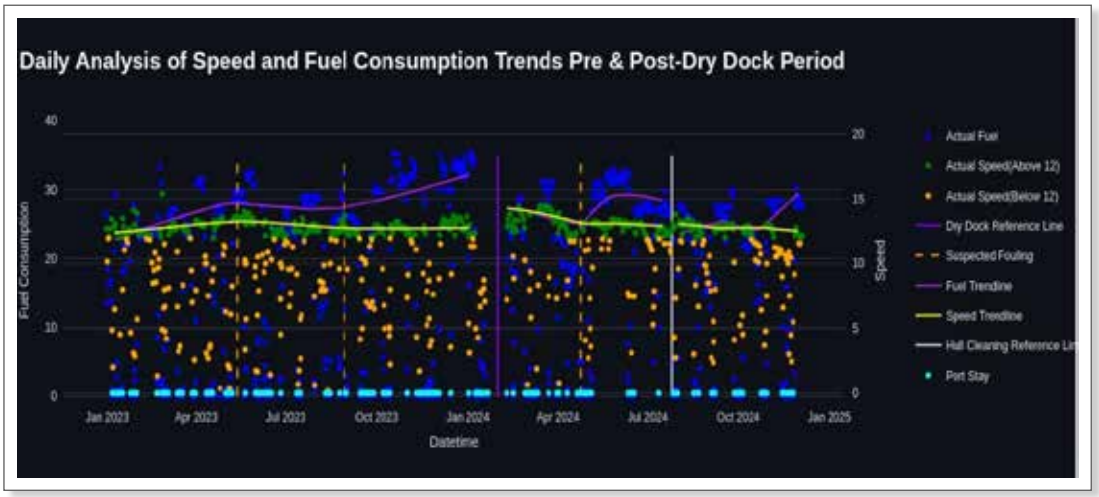

Image 4: Warranty breach graph (290C & 13kts)

ANALYSIS

With SmartShip© Hub Remote, we continuously tracked the vessel's performance and provided timely recommendations to maintain efficiency. Our monitoring revealed:

PRE-DRY DOCK
Consumption dropped to **24.07 MT,** validating the effectiveness of the intervention. It later crept up to **26.16 MT,** signaling renewed fouling and necessitating targeted cleaning

POST-DRY DOCK
Consumption improved to **25.34 MT** after owners carried out hull painting

ON SUSPECTED FOULING
Consumption rose to **28.97 MT,** prompting alerts about hull fouling and scheduling cleaning.

AFTER HULL CLEANING
Consumption dropped to **24.07 MT,** validating the effectiveness of the intervention. It later crept up to **26.16 MT,** signaling renewed fouling and necessitating targeted cleaning.

Our warranty monitoring flagged operational thresholds in real-time – speeds below 12–13 knots and seawater temperatures exceeding 29°C – allowing for timely advisories to avoid efficiency loss. We also analyzed the impact of extended port stays, particularly after September 2024, and recommended operational adjustments Through continuous tracking and sea trial comparisons, we ensured the vessel stayed close to benchmark efficiency under both ballast and laden conditions, enabling proactive measures rather than reactive fixes.

This continuous oversight ensured that performance issues were not only detected early but also acted upon with timely recommendations.

IMPACT

The case demonstrates how SmartShip© Hub Remote's high-frequency data and steady stream of real-time insights make it feasible to link operational practices with coating performance and fouling onset. Although dry dock and hull cleaning interventions temporarily restored efficiency, sustained gains were undermined by operational factors.

With its continuous performance monitoring, SmartShip© Hub Remote provided owners with a transparent view of hull condition, pinpointing how extended port stays, sub-optimal speeds, and environmental factors accelerate drag build-up. The details help operators to anticipate fouling cycles, validate coating solutions, and schedule proactive maintenance.

The study shows how high-frequency tracking is not just about ESG compliance: it is an essential operational tool to optimize efficiency, ensure warranty alignment, and improve long-term fuel economy.

A FEW FINAL WORDS

The shipping industry today faces the pressures of rising fuel costs and tightening decarbonization regulations. It is further challenged by supply chain disruptions, geopolitical tensions, trade uncertainties, cybersecurity needs due to increased digitalization, rising customer and charterer expectations, market volatility, and high insurance costs.

While ESDs are being deployed to make operations safer, more compliant, and future-ready, they can deliver on their promise only with reliable, real-time performance validation.

As an HFD platform, SmartShip© Hub converts real-time data into insights that enable ship owners and operators to boost performance stability, authenticate ROI, and ensure regulatory compliance. It enables users to track how ESD investments translate into tangible profitability and sustainability outcomes. And that's because in the years ahead, leveraging data-centric solutions will mean more than adhering to compliance rules – it will define who sets the pace in the global transition to cleaner, more innovative, and more resilient shipping.

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