

BUNKERSPOT

SHIPPING AT AN INTERSECTION

INSIDE:
EMISSIONS TRADING
CIRCULAR FUELS
ONSHORE POWER SUPPLY
TRAINING FOR
NEW FUELS

Plug in or pay up!

Vincent Doedee of Sustainable Ships, in collaboration with EOPSA, looks at the costs and benefits of onshore power supply

By 2030, containerships and passenger ships in Europe are required to use shore power under FuelEU Maritime (FEUM). In the same year, the Alternative Fuels Infrastructure Regulation (AFIR) mandates that 90% of port calls by ships above 5,000 GT at TEN-T ports must be electrified¹. Meeting these targets in just a few years demands enormous investments in both port infrastructure and ship retrofits. In fact, achieving this transition will take far more than money. It requires time, specialised knowledge and organisational capabilities that many actors in the maritime industry are still struggling to build. Certainly the screws are tightening for both port authorities and shipowners, but one pressing question remains unclear: 'what does it all cost?'

When does it make economic sense to 'plug in' and use an onshore power supply (OPS) instead of burning fuel onboard? Should shipowners commit to shore power today, or wait for new tides in the hope of a more cost-effective solution to comply with FEUM?

This article addresses these questions in three steps. First, it quantifies the scale of the problem (demand) and potential revenue streams for power providers (supply). Next,

it breaks down the main cost components of using shore power and identifies the conditions under which shore power becomes competitive from the shipowner's perspective, including the break-even electricity price. Finally, it examines a Feedermax container-ship on two realistic EU routes to show how these dynamics play out in practice.

THE SIZE AND VALUE OF SHORE POWER IN EUROPE²

Previous analysis by the [European Onshore Power Supply Association \(EOPSA\)](#) and [Sustainable Ships](#) on shore power demand in 2030 shows the Total Addressable Market (TAM) for shore power in EU ports is substantial: between 6 and 13 terawatt-hours (TWh) per year. To put this in perspective, only 51 ports across 15 coastal Member States currently provide shore power, with a combined capacity of just 309 MW, concentrated mainly in passenger and cruise terminals. In other words, the installed capacity is a fraction of what is needed to comply with upcoming regulations.

In practical terms, Europe must build the equivalent electricity demand of a small coun-

try, and deliver it directly into ports – essentially from scratch – within the next five years.

Achieving this will require extensive new shore-side infrastructure, as well as significant grid reinforcements. To comply with regulatory requirements, Europe will need to at least triple, and likely quadruple, its installed shore power base, with Italy, Spain, and France facing the steepest investments. At the same time, this enormous challenge also provides an enormous potential revenue stream for energy companies.

Assuming an electricity price of €0.35 per kWh, the annual revenue potential of supplying shore power to ships in EU ports lies between €2.1 and €4.5 billion. This represents a sizeable, recurring revenue stream for utilities and port operators, but one that depends entirely on timely uptake by shipowners.

The critical question, therefore, is not *whether* the demand exists – it clearly does – but *when* shipowners will decide to switch. If ports and power providers move too far ahead of shipowners, they risk underutilised infrastructure and stranded investments. If they wait too long, they face capacity shortages and congestion when demand

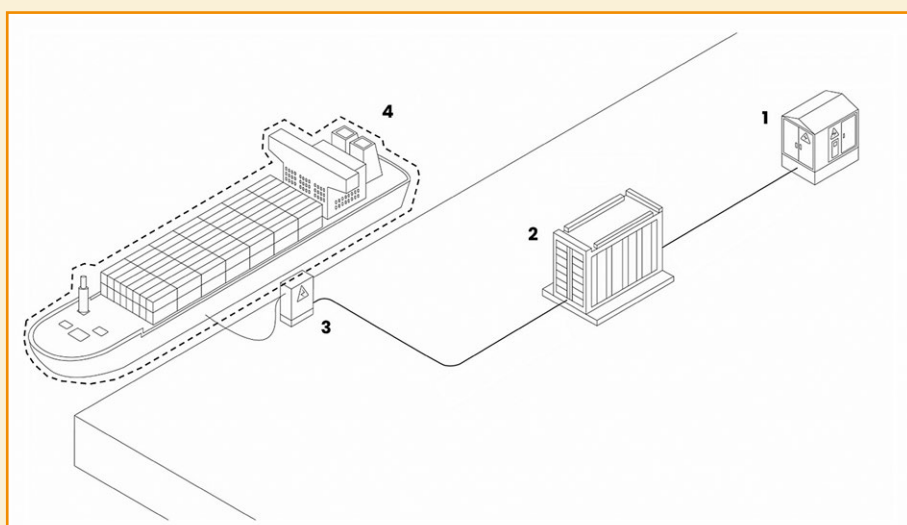


Figure 1: The illustration shows the main components of a typical shore power setup: (1) the grid connection (2) an e-house with transformer and converter if so required (3) the quayside connection point with cable management system (CMS) if required and (4) the vessel. This article examines the economics of shore power, focusing on the cost-benefit from the shipowner's perspective, and does not cover the detailed design of onshore infrastructure.

'In practical terms, Europe must build the equivalent electricity demand of a small country, and deliver it directly into ports – essentially from scratch – within the next five years'

finally surges. Timing will determine who captures this market.

BREAKING DOWN SHORE POWER COSTS FOR A SHIPOWNER

It is good for energy companies that shore power revenues in Europe alone can be billions of euros per year, but that does not help shipowners and operators answer their most pressing questions: when does it actually make sense to connect my ship? Do I do it now, or do I wait until 2030? And what will it cost? To answer these questions, the individual cost components of shore power must be determined and broken down in detail.

Analysis model

Sustainable Ships has developed an interactive techno-economic model to do exactly that, which has been used for this analysis. The [Shore Power Quickscan](#) compares the business-as-usual case (running auxiliary generators at berth) with the shore power case, where ships plug in while moored. Crucially, the model captures *all operational aspects*, both sailing *and* mooring, as well as CAPEX for a retrofit when needed. The model determines costs on a life-cycle basis, calculating the below stated costs components per year. Subsequent sections elaborate on the key cost components of using shore power from a shipowner's perspective.

Fuel vs. electricity

The main OPEX component for any ship is energy consumption, whether through fuel burned in auxiliary engines or electricity purchased from the grid. In this analysis, both sailing and port stays are considered, since using shore power affects a vessel's overall GHG intensity across the entire year, not only while moored. On a pure cost basis, electricity produced onboard by fuel combustion is generally cheaper: around €0.15 to €0.20 per kWh compared with €0.35 per kWh assumed for shore power throughout this article. This cost gap (using shore power is roughly twice as expensive when comparing fuel only) is precisely why additional policy instruments – ETS, FEUM, and IMO Net-Zero – are required to shift shipowners toward plugging in.

Maintenance and consumables

When plugged in, auxiliary engines are turned off, which slashes costs for engine maintenance (primarily crew man-hours) and consumables (lubricants, gaskets, filters, and other wear-and-tear items). Although this a minor component compared to fuel and com-

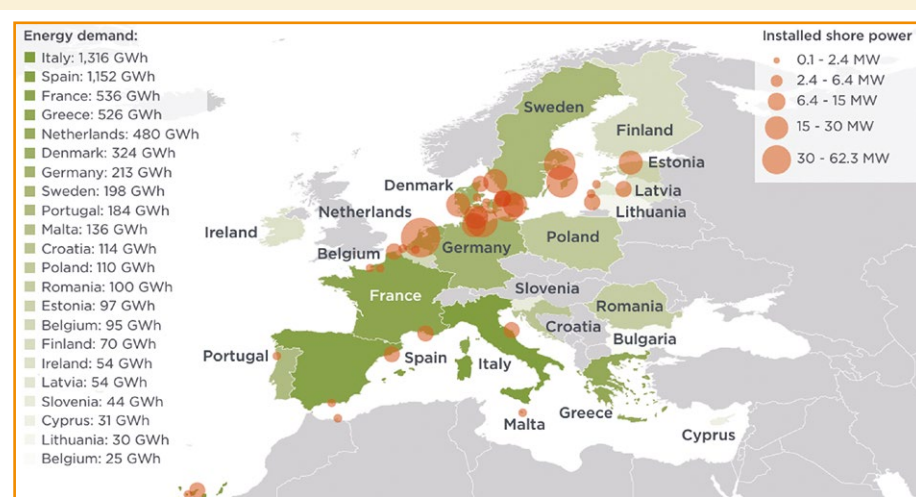


Figure 2: Energy demand of ships ≥400 GT at berth by EU Member State and available existing power installations in EU ports as per the International Council on Clean Transportation (ICCT). Energy demand from 2030 will initially be lower, as only ships of 5,000 GT and above are targeted by FuelEU Maritime and AFIR regulations.

Country	Energy Demand	Yearly Revenue
Italy	1,316 GWh	€ 460,600,000
Spain	1,152 GWh	€ 403,200,000
France	536 GWh	€ 187,600,000
Greece	526 GWh	€ 184,100,000
Netherlands	480 GWh	€ 168,000,000
Denmark	324 GWh	€ 113,400,000
Germany	213 GWh	€ 74,550,000
Sweden	198 GWh	€ 69,300,000
Portugal	148 GWh	€ 51,800,000
Malta	136 GWh	€ 47,600,000
Croatia	114 GWh	€ 39,900,000
Poland	110 GWh	€ 38,500,000
Romania	100 GWh	€ 35,000,000
Estonia	97 GWh	€ 33,950,000
Belgium	95 GWh	€ 33,250,000
Finland	70 GWh	€ 24,500,000
Ireland	54 GWh	€ 18,900,000
Latvia	54 GWh	€ 18,900,000
Slovenia	44 GWh	€ 15,400,000
Cyprus	31 GWh	€ 10,850,000
Lithuania	30 GWh	€ 10,500,000
Total	5,828 GWh	€ 2,039,800,000

Table 1. When the energy demand is transformed into revenue using an electricity price of €0.35 per kWh, the true value of shore power becomes apparent as the yearly recurring revenues are in the billions of euros. It should be noted that these numbers include ship types and sizes that are not covered by FuelEU or AFIR.

'EU regulations are expected to double the break-even price for shore-side electricity by 2030, and nearly triple it by 2040 when IMO Net-Zero penalties are layered on top'

pliance costs, these savings can become significant for larger auxiliary engines, particularly those above 2 MW, or when multiple units can be switched off simultaneously. In the case study used in this article, maintenance and consumables costs are negligible.

ETS

The EU and UK Emissions Trading Systems (EU ETS and UK ETS) are a de facto carbon tax for shipowners, as they directly penalise CO₂ emissions on a Tank-to-Wake basis. Switching to clean shore power avoids these emissions when at berth, saving approximately €300 per tonne of fuel consumed (assuming ~ €75 per allowance). ETS is a rather simple system when compared to FEUM or IMO Net-Zero, and for this analysis only the fuel (or rather emissions) saved *at berth* incur cost savings, as fuel consumed while sailing is unaffected by shore power.

FEUM

FEUM is a complicated regulation that has come into effect in 2025, with quite some incentives (and sticks) when it comes to shore power. Compliance costs are based on the vessel's annual Well-to-Wake GHG intensity, which includes energy use while sailing *and*

mooring. Because shore power improves this annual GHG intensity, savings will be incurred for the entire year and over all operational modes, including sailing. Because it is an EU regulation, only 50% of energy of voyages coming from and to the EU are taken into account. This means that the ship itinerary and port calls heavily affect the outcome of FEUM penalties. Of all the cost components, FEUM and IMO Net-Zero are typically the most significant ones.

IMO Net-Zero

The IMO's global Net-Zero Framework is expected to come into force in 2028, pending approval in late 2025. Similar to FEUM, it calculates GHG intensity on an annual basis and penalises shipowners above defined thresholds. In this analysis, IMO Net-Zero costs are assumed to stack on top of FEUM, although discussions are ongoing about harmonisation between the two regulations. Until these are fixed or more about them is known, IMO Net-Zero is considered a significant cost component when it comes to shore power.

CAPEX

Beyond OPEX, capital expenditure is often required to retrofit ships for shore power

use. Typical items required onboard include onboard transformers (to adapt to the correct voltage and ensure galvanic protection), switchboard modifications, high-voltage connection interfaces, and related engineering and integration costs. CAPEX costs are highly ship-specific and vary significantly, although on a life-cycle basis the CAPEX costs are typically negligible. For some vessels, retrofits may already be in place, in which case OPEX alone determines the decision.

Key Findings

The breakdown of shore power costs highlights several important insights.

1. CAPEX and maintenance are negligible on a lifecycle basis. Retrofit expenses are one-off, often marginal when spread across 15 years, and savings from reduced engine wear are small compared to the main operational cost drivers.
2. Compliance costs dominate the equation. Of these, FEUM typically has the largest financial impact, followed by the upcoming IMO Net-Zero framework. Both measure full-year GHG intensity, so even partial use of shore power improves compliance across an entire voyage profile, not just at berth.
3. Electricity price is decisive in the next years. At the assumed benchmark of €0.35 per kWh, shore power can already provide cost savings from 2025 onwards in certain scenarios, particularly for vessels with itineraries fully inside the EU. The savings become most pronounced after 2030 however, when FEUM penalties escalate and IMO Net-Zero costs are added on top. From that point, the financial case for shore power strengthens significantly, making it the cheaper option in nearly all realistic conditions, also outside the EU.

BREAK-EVEN ELECTRICITY PRICE

Considering that electricity prices are a decisive factor in the cost balance, especially in the period until 2030, the next question is clear: at what price does shore power actually become cost-effective compared to burning fuel? This is the critical benchmark for shipowners and ports alike: the price point below which plugging in saves money, above which costs are incurred. Understanding this price point gives shipowners a clear reference when negotiating electricity tariffs in port or with terminal operators.

As stated previously, the break-even point has historically been around €200 per MWh

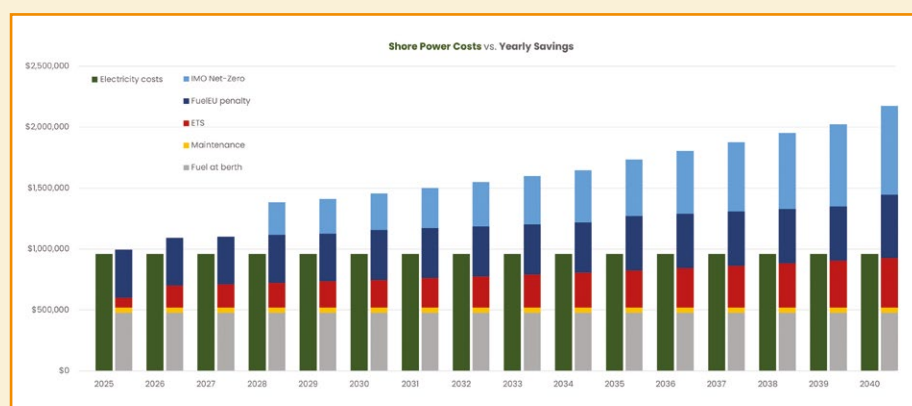


Figure 3: This graph shows the costs of shore power (green) versus all savings, broken down per cost component. When savings are higher than costs, shore power is more cost-effective. Historically, only fuel price versus electricity costs are considered. The graph shows that combustion of fuel on board is typically cheaper than electricity from the grid, unless a very low price is used (€0.20 per kWh or less). When regulatory costs such as EU and UK ETS, FuelEU and IMO Net-Zero are added, the savings outweigh the costs of electricity starting already in 2025. CAPEX is excluded however.

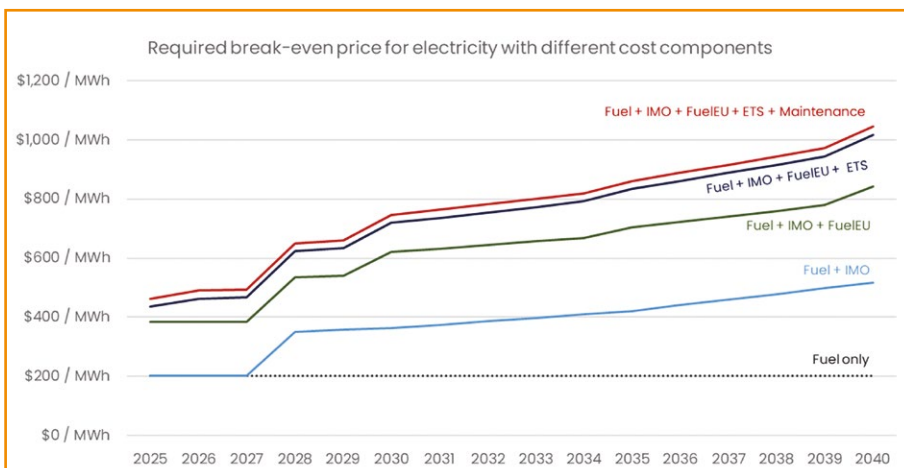


Figure 4: This graph shows the break-even price of onshore electricity under different scenarios, or in other words the price required to have the same costs using shore power as business as usual. Each curve shows how additional cost components (ETS, FuelEU, IMO Net-Zero) progressively raise the threshold, making shore power competitive even at high electricity prices.

(or €0.20 per kWh), the typical cost of producing electricity with auxiliary engines burning marine fuel. Maintenance and consumables costs are typically not significant when compared to this price point (~ €0.03 per kWh). The decisive shift comes with upcoming regulations that introduce compliance penalties, i.e. ETS (EU or UK), FEUM and IMO Net-Zero.

As a rule of thumb, EU regulations are expected to double the break-even price for shore-side electricity by 2030, and nearly triple it by 2040 when IMO Net-Zero penalties are layered on top. This means that even if the cost of electricity in port approaches €1,000 per MWh (close to €1 per kWh), shore power remains the cheaper option compared to burning conventional fuels.

CASE STUDY: 2,500 TEU CONTAINERSHIP WITH DIFFERENT ROUTES

The above-described principles and break-even price points are useful to analysts and shore power geeks, but very abstract for the average shipowner. To make the impact of shore power usage more tangible, two practical case studies are examined: a 2,500 TEU Feedermax containership deployed on two different European routes. Each case compares the cost of running auxiliary engines against plugging into shore power at each port from 2025 until 2040.

Ship and voyage properties

The ship considered is a typical 2,500 TEU Feedermax built before 2010 and its lifetime has just been extended until 2040. It has a single Wärtsilä engine with 21,560 kW for propulsion purposes and three Wärtsilä 9L20 diesel generators for auxiliary use, each capable of providing 1,880 kVA. Average power demand while in port is assumed to be ~600 kW (average for containerships). The ship is operational for 350 days per year, sailing between different ports at a cruising speed of 22 knots. The main fuel when sailing is LFO, and the fuel used for auxiliary engines when at berth is marine diesel oil (MDO).

CASE 1

The first case study considers the Feedermax sailing a classic North Sea loop between Rotterdam, Antwerp, Hamburg, and Bremerhaven. Each port call lasts around 18 hours (average between 12 and 24 hours), with a full roundtrip taking approximately 4.8 days. With 350 operational days per year, the vessel completes roughly 74 roundtrips, or nearly 300 individual port calls annually.



	Case 1	Case 2
Ship	2,500 TEU Feedermax	2,500 TEU Feedermax
Fuel	LFO / MDO / electricity from OPS	LFO / MDO / electricity from OPS
Propulsion	1x Main Engine 21,560 kW	1x Main Engine 21,560 kW
Auxiliary	3x Wärtsilä 9L20 1,880 kVA each	3x Wärtsilä 9L20 1,880 kVA each
Consumption	75 mT/day sailing and 3.8 mT/day moored	75 mT/day sailing and 14.5 MWh/day moored
Route	Rotterdam – Antwerp – Hamburg – Bremerhaven	Rotterdam – Felixstowe – Dublin
Port call	18 hours	18 hours
Trip length	4.8 days	4.7 days
Roundtrips	~ 74 per year	~ 74 per year
Savings*	\$16.7 M	\$8.6 M

Table 2. Voyage properties of the ship for the two different case studies, with an illustrative example. Savings are cumulative from 2025 until 2040. Fuel and electricity consumption are assumed constant for this analysis. No retrofit costs, hookup time or different electricity prices for different ports have been taken into account.

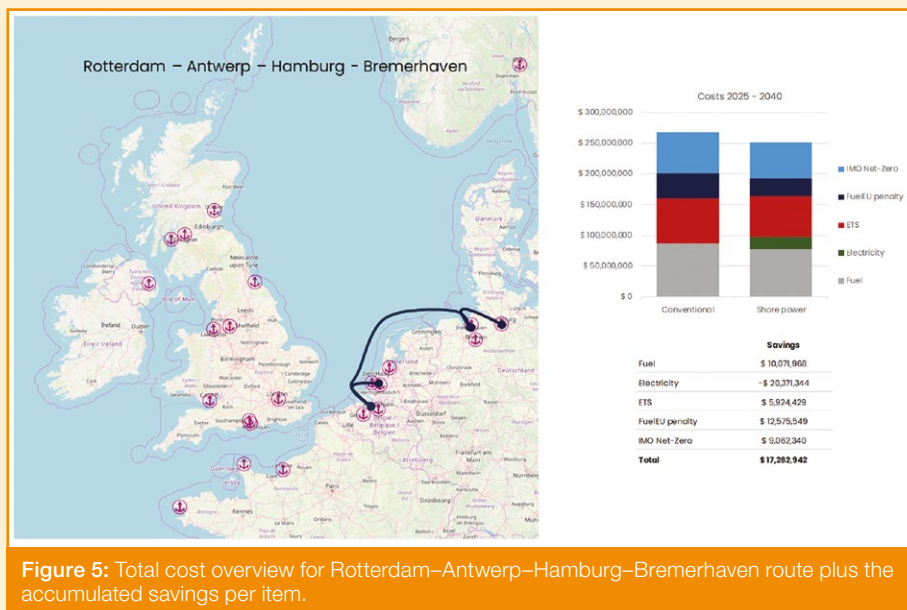


Figure 5: Total cost overview for Rotterdam–Antwerp–Hamburg–Bremerhaven route plus the accumulated savings per item.

WHEN DOES SHORE POWER MAKE ECONOMIC SENSE? _____

For ports and energy providers, the picture is clear. The Total Addressable Market (TAM) represents a multi-billion-euro opportunity, with recurring revenues of around €2 billion per year across the EU. The main challenge is building the required infrastructure in time, a formidable task but not unsurmountable.

For shipowners, the decision is a more complicated choice: pay escalating compliance costs or plug into shore power. The exact economics for any single vessel depend on the voyage or route, i.e. the share of energy falling under EU regulation. FEUM and EU ETS exposure are decisive; they are what turn shore power from a cost into a saving. IMO Net-Zero is the icing on the cake. For those shipowners operating mainly in EU, break-even can already be achieved by 2025, while after 2030 – when FEUM penalties increase and IMO Net-Zero is introduced – the financial case becomes overwhelming. The compliance clock is ticking, however.

With retrofit and infrastructure lead times of two to three years, those who delay risk being caught out when FEUM and AFIR enforcement begins.

During the last round of environmental regulation roughly 10 years ago, when sulphur limits were introduced by the IMO, a ‘scrubber rush’ was triggered that created bottlenecks, long waits, and inflated costs. This time, a ‘shore power rush’ is inevitable. The winners will be those who move first, securing capacity, funding, and partnerships ahead of the crowd.

The question is no longer *if* shore power makes economic sense, but *how quickly* companies can act to seize the opportunity.

1. TEN-T ports are part of the EU's Trans-European Transport Network, serving as key hubs for passenger and freight transport, connecting sea with other modes, and playing an increasing role in the energy transition and alternative fuels deployment. Exact classification and scope of ships targeted by FuelEU are defined in Regulation 2023/1805 Article (3) definitions.
2. This paper focuses on shore power usage in Europe only. Other regions, such as California and China are not considered in this article even though current subsidised electricity prices in China make it extremely profitable.

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When plugging into shore power instead of running auxiliary generators, the cumulative savings between 2025 and 2040 amount to an estimated \$16.7 million.

This route is a textbook example of a high-frequency feeder loop in the ARA region, where shore power availability is expected to be rolled out earliest under AFIR. With short voyages, consistent port calls, and major hub ports involved, the commercial and compliance case for shore power is particularly strong. Shipowners on such itineraries face limited excuses for delay, as the operational profile aligns almost perfectly with the regulatory targets.

CASE 2 _____

The second case study considers the same ship deployed on a different North Sea service, linking Rotterdam to Felixstowe and Dublin.

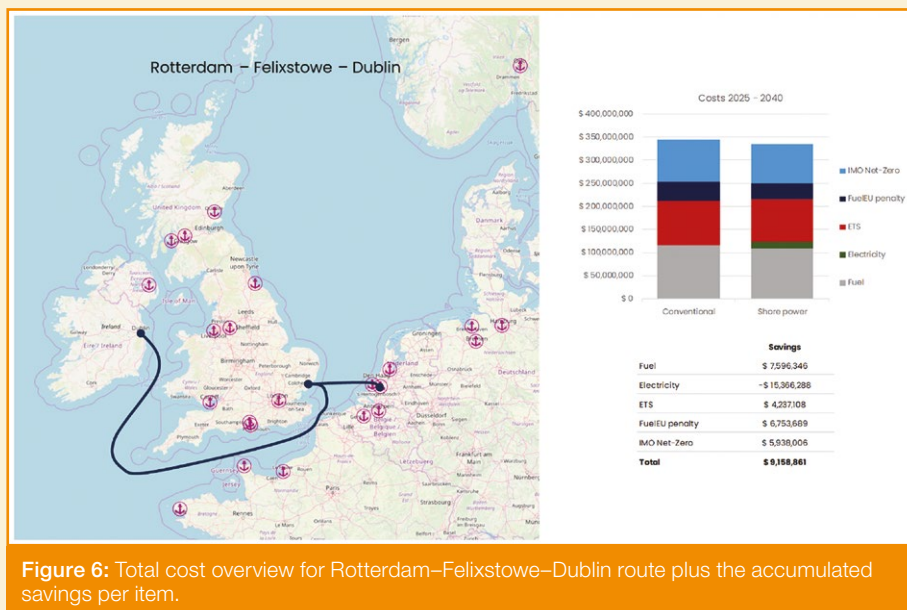


Figure 6: Total cost overview for Rotterdam–Felixstowe–Dublin route plus the accumulated savings per item.