Exploring the potential to establish a green shipping corridor between Santander and UK ports

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Final report

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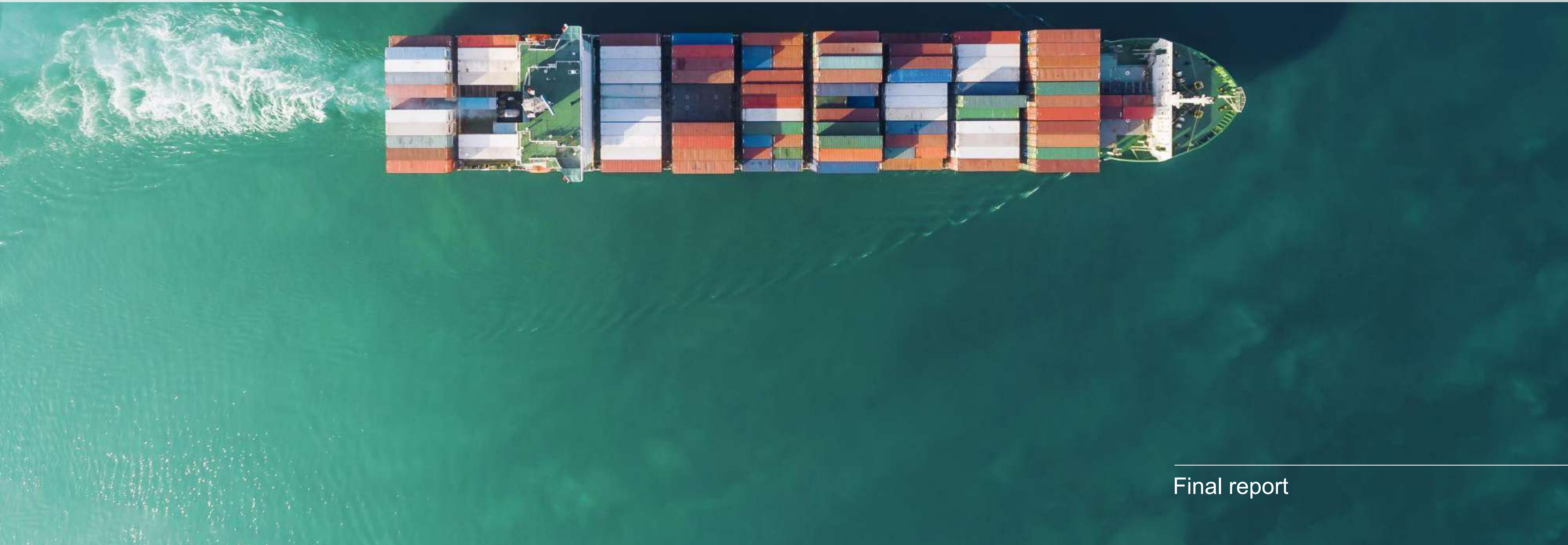

Final report

Index

01 Project context

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Unlocking green shipping corridors to strengthen UK–Spain maritime trade

CONTEXT

Port of Santander strengths

- Leading Ro-Ro / Short Sea Shipping port on Spain's north coast
- High rail share, significantly above other Spanish ports
- Active investment in LNG, bio-LNG, early onshore power supply, and exploration of green hydrogen

Relevance for the UK

- Long-standing, regular Ro-Ro, Ro-Pax and container services linking the UK and Northern Spain

Key barrier to further decarbonisation

- Limited visibility on UK ports' decarbonisation plans, making it difficult to identify viable Green Shipping Corridor partners

OPPORTUNITY

Enable a shared strategic understanding

- Build a high-level picture of the most important UK–Santander connections and their operational patterns

Identify decarbonisation opportunities and limits

- Highlight, at a strategic level, where decarbonisation is most feasible and where structural, technical or regulatory constraints remain

Inform future Santander-UK ports initiatives

- Provide a credible evidence base to shape future strategies, dialogue and the potential development of Green Shipping Corridors between Santander and UK ports

Defining a Green Shipping Corridor

Policy definition (Clydebank Declaration)

> *Green shipping corridors are routes between two or more ports where vessels deploy zero-emission technologies and fuels, and where the necessary infrastructure is in place to support this transition.*

Industry application

In practice, green shipping corridors are typically developed as phased transition pathways, reflecting:

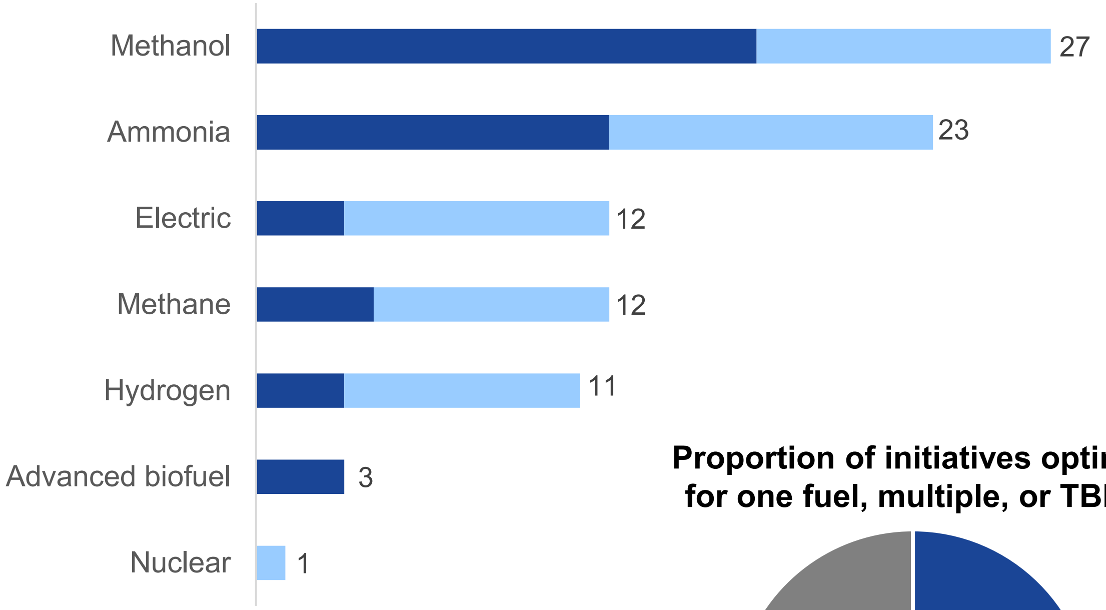
- Limited availability of zero-emission fuels
- Long vessel replacement cycles
- Evolving port and bunkering infrastructure

As a result, early-stage corridors often focus on low-emission fuels and incremental emissions reduction

Evidence from realisation-stage corridors (Global Maritime Forum, 2025)

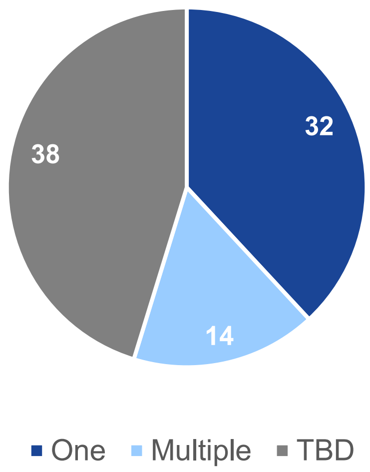
- Operational corridors are currently using drop-in biomethane (via LNG systems)
  - Stockholm-Turku
  - Vaasa-Umeå
- Zero-emission fuels such as ammonia and hydrogen are under development, with vessels and supply chains in construction
  - Australia-China iron ore route (Ammonia)
  - Oslo-Rotterdam (Hydrogen)
- No fully zero-emission green shipping corridors are currently in operation

Overview of fuels used on global green corridor initiatives



Adapted from Global Maritime Forum Annual Green Corridor Report 2025

Proportion of initiatives opting for one fuel, multiple, or TBD



Policy context for study

Policy	Key requirements	Implication
EU ETS	• Applies to 100% of emissions for voyages within the EU and 50% for voyages between the EU and non-EU ports	Drives increasing cost of fossil fuel use on Santander–UK routes, strengthening the case for early fuel switching or compliance strategies
UK ETS	• Domestic maritime emissions covered in the UK ETS from July 2026 • Further expansion to international voyages involving UK ports under consideration, if global action proves insufficient	Could create dual carbon pricing on Santander–UK routes, increasing pressure for coordinated decarbonisation
FuelEU Maritime	• Requires progressive reduction in GHG intensity of marine fuels: 2% reduction by 2025 increasing to 80% by 2050 • Container and passenger ships >5,000 GT must connect to OPS at major EU ports, where available from 2030	Directly shapes fuel choices and OPS deployment, influencing both vessel investment and port infrastructure
AFIR	• Requires shore-side electricity for container and passenger vessels above 5,000 GT at TEN-T core ports by 2030	Requires OPS investment, creating both a compliance requirement and opportunity to reduce at-berth emissions
IMO NZF	• Targets net-zero GHG emissions from international shipping by or around 2050 • Indicative checkpoints: >20% emissions reduction by 2030, >70% reduction by 2040 • Ongoing development of global measures, including technical and economic measure	Sets long-term direction, reinforcing the need for scalable zero-emission fuels beyond transitional solutions

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Project scope and outputs: Route-level assessment of UK–Spain Green Shipping Corridors

What we will do

- Undertake a high-level route-level assessment of up to 2 UK–Spain corridors, jointly selected with the Port of Santander.
- Focus on predictable liner services, considering the wider end-to-end journey rather than a single port-to-port leg.
- For each corridor, assess:
  - Vessel and service characteristics
  - Potential alternative fuel pathways
  - OPS implications
  - High-level environmental and economic considerations.

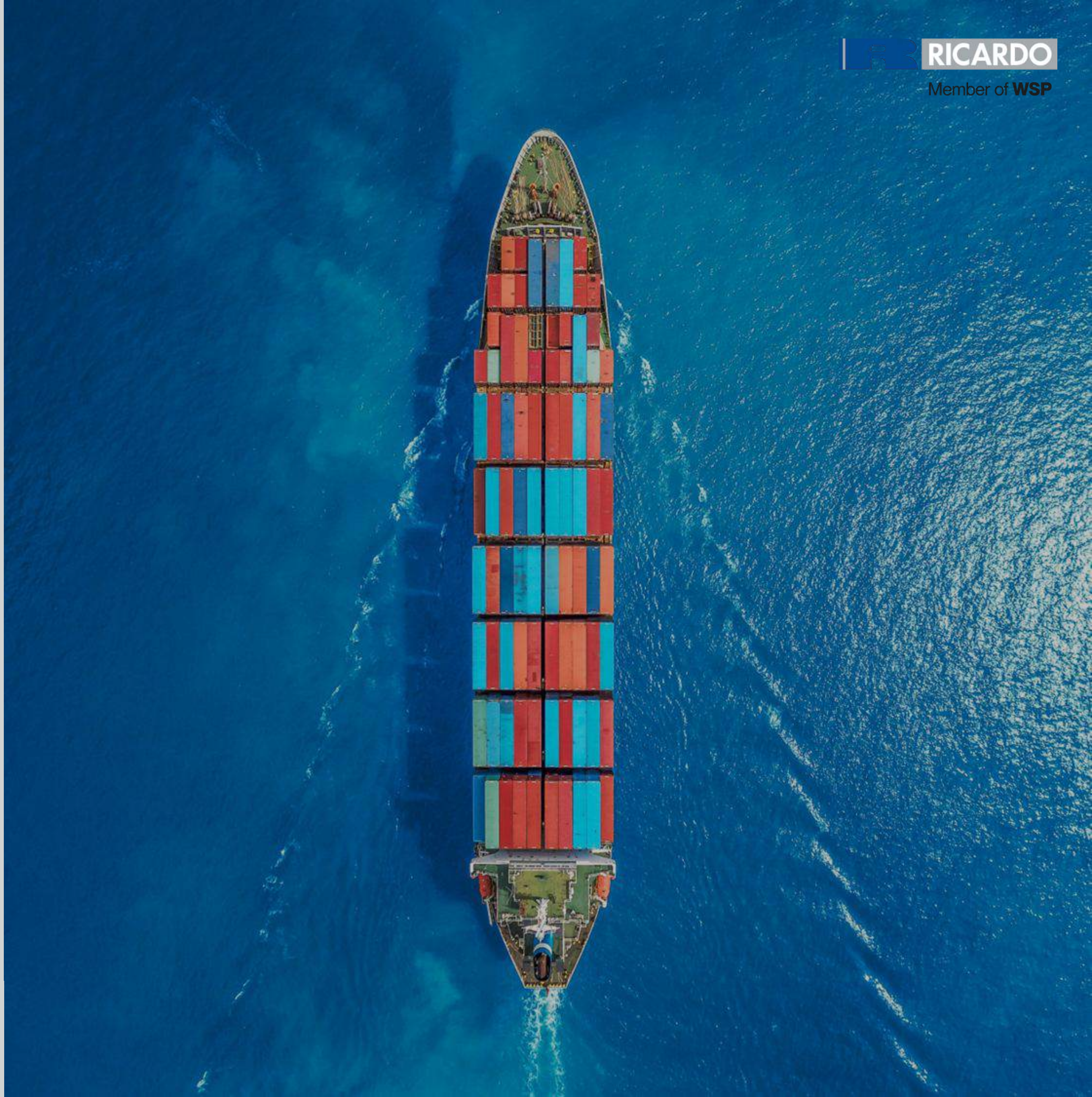
Outputs

- **Corridor snapshots** for up to 2 UK–Spain routes, covering:
  - Indicative decarbonisation pathways
  - Port and vessel implications
  - Key opportunities and constraints.
- A **comparative view of the two corridors** to support prioritisation.
- **Clear recommendations** on whether one or both corridors merit progression to a full Green Shipping Corridor feasibility study.

Data approach and scope

- Data sources: Publicly available information and stakeholder inputs.
- Nature of assessment: High-level, corridor-enabling, not a full feasibility study.

02 Route selection



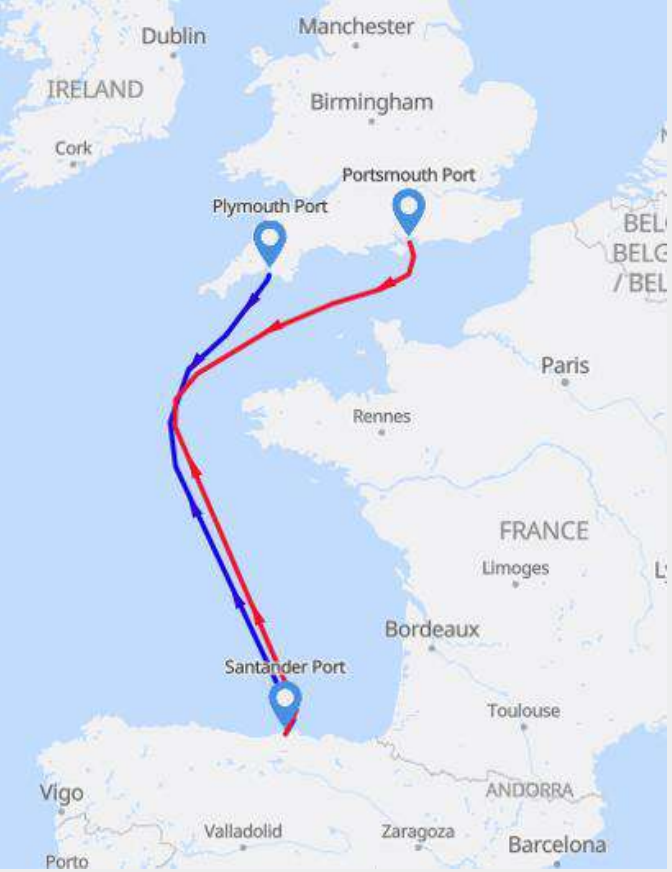
Corridors for analysis

- **Selection rationale**: Focus on Short Sea Shipping services connecting the Port of Santander with UK ports.
  - This captures routes to main trade partner (UK)
  - SSS vessels can accommodate multiple decarbonisation pathways to be explored
  - Ro-Ro/Ro-Pax corridors have synergies with "rolling highway" concept from Port of Santander, with low carbon transport services covering both maritime and land connections
- **Initial selection of routes**
  - *Britanny ferries RoPax route Santander – Plymouth/Portsmouth*: Benchmark route, already using LNG and bio-LNG
  - *UECC Ro-Ro route Santander – Avonmouth/Portbury/Southampton*: Fuel pathways to be defined and assessed
  - *Boluda Container route Santander –Dublin - Liverpool*: Fuel pathways to be defined and assessed

03 Benchmark case

Benchmark route (Santander <-> Portsmouth)

Map of route



Route information

Operator: *Brittany Ferries*

Frequency: W*eekly*

Vessels operating: *Pont-Aven, Salamanca, Santona**

Round trips per week: 2

Consumption per round trip: ~*150 tonnes (LNG & MGO)*

**In substitution of Salamanca if needed*

Vessel information

	Pont-Aven	Salamanca	Santona
Age	22 years	5 years	4 years
Type of vessel	Ro-Ro cargo ship	Ro-Ro cargo ship	Ro-Ro cargo ship
Size	186 m (40.914 GT)	214 m (41.716 GT)	214 m (41.716 GT)
Fuel used	HFO, MGO	LNG, MGO	LNG, MGO
Deadweight Tonnage	4.803 t	8.013 t	7.205 t

Pont-Aven

Salamanca

Santoña

Benchmark route (Santander ←→ Portsmouth)

What has been implemented	Key enabling factors
LNG-capable RoPax vessels deployed on Santander–UK routes **LNG bunkering infrastructure** established in Santander Progressive use of **bio-LNG as a drop-in fuel** **Commercial operations maintained** under alternative fuel use	**Early operator commitment** to alternative fuel vessels **Port infrastructure readiness** aligned with deployment **Reliable fuel supply chains** (LNG → bio-LNG transition) **Coordination across port, operator and fuel supplier**

This case demonstrates that successful deployment is driven by alignment across stakeholders, infrastructure and timing, rather than reliance on a single fuel solution.

04 Route 1 - UECC

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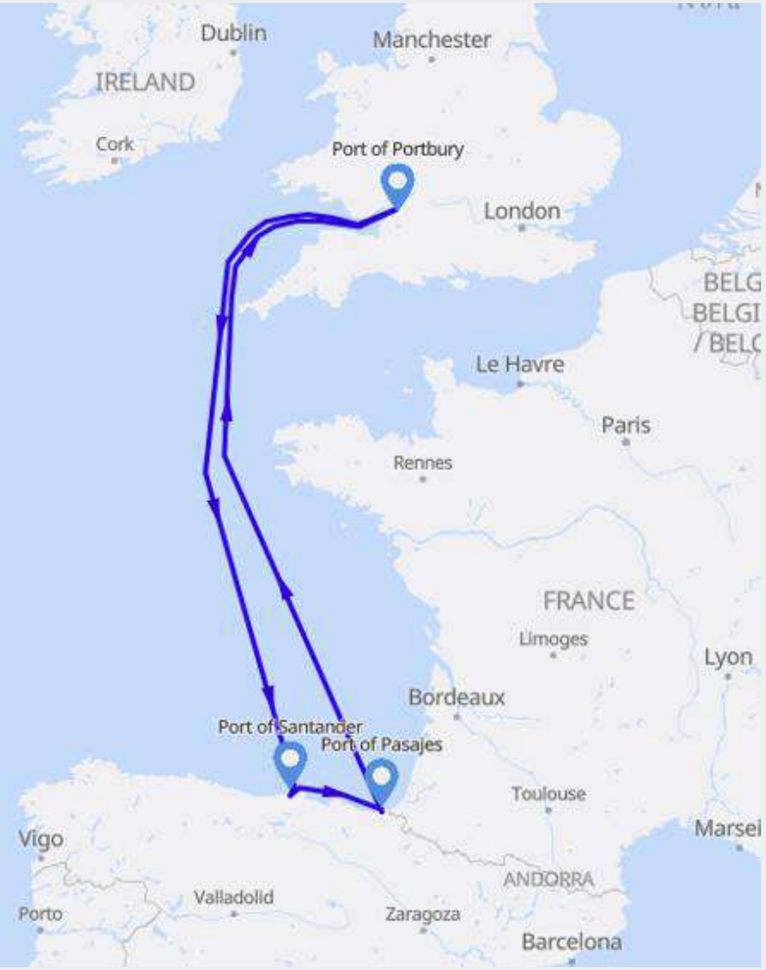
Route snapshot

Map of route



Route information

- Operator: *UECC*
- Frequency: *Twice per week*
- Vessels operating: *AutoSun*
- Time at sea/time at berth: *360 h / 90 h*
- Consumption per round trip: *100 tonnes (VLSFO & MGO)*

Vessel information

- Age: *26 years*
- Type of vessel: *Ro- Ro Cargo Ship*
- Size: *146 m (21.094 GT)*
- Fuel used: *VLSFO, MGO*
- Deadweight Tonnage: *6.670 t*

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Fuel assessment

Assessment Criteria	BAU (MGO/VLSFO)	HVO / Advanced Bio-diesel (Drop-in)	Methanol bio-/e-	LNG bio-/e-	Ammonia	Battery + OPS
GHG reduction potential (WTW)	-	High	High	Medium	High	High
	0	~83 % reduction	~82 % reduction	~74 % reduction	100% reduction	100% reduction
FuelEU / ETS exposure impact	-	Low	Medium	Low	Low	Low
	Highest compliance exposure	Meaningfully lowers FuelEU / ETS costs	Reduces compliance costs but fuel remains expensive	Strong complaince benefit for low-GHG LNG pathways	Very low compliance exposure for green ammonia	Eliminates compliance costs
Technical suitability	-	High	Medium	Medium	Low	Low
	Currently used on existing vessels	Drop-in use in existing diesel engines	Metahnol dual fuel engines already exist. Retrofit possible but requires engine and fuel systems change	Suitable for LNG-capable vessels; major conversion otherwise	Technically feasible, but complex and immature for RoRo retrofit	Generally unsuitable for retrofit on these routes
Onboard impact	-	Low	Medium	Medium	High	High
	No changes to tank volume, weight, or vessel layout; existing fuel system remains unchanged	Negligible impact on tank volume, weight, or cargo space; vessel keeps its original fuel footprint	Requires larger dedicated methanol tanks and safety spaces, increasing volume and structural weight and reducing available cargo area	Requires large insulated LNG tanks and gas-handling systems, adding weight and affecting stability; significant cargo space loss for RoRo vessels	Requires much larger tanks and extensive safety systems, adding weight and technical complexity; moderate impact on stability and internal space	Large battery systems occupy significant space and add weight, reducing cargo capacity and affecting stability; requires dedicated rooms and cooling, limiting layout flexibility
Port & bunkering implications	-	Low	Medium	Low	High	High
	No new port infrastructure or bunkering systems required; existing facilities fully support conventional fuels	No additional port infrastructure needed; existing tanks and bunkering systems can be used without modification	Requires larger fuel volumes and more frequent bunkering; methanol bunkering is simple with only moderate adaptations to existing liquid-fuel infrastructure	Requires new cryogenic LNG tanks and specialized bunkering systems with strict safety zones; ports need dedicated infrastructure and procedures	Requires entirely new or heavily upgraded infrastructure, specialized ammonia-rated storage and transfer systems, and expanded safety and permitting measures	Requires high-capacity OPS with substations, HV shore connections and grid reinforcement; standardized interfaces and defined safety zones are needed
Operational impact	-	Low	Low	Low	Medium	High
	High-energy-density fuels enable long range and infrequent, predictable bunkering aligned with normal port calls	Drop-in fuel with similar energy density to diesel; no change in range or bunkering frequency, standard handling, and high operational flexibility	Lower energy density reduces range and may require more frequent bunkering; safety-critical handling can slightly increase turnaround time but remains manageable	Same energy density and range as LNG; drop-in use maintains full operational flexibility and keeps bunkering procedures and turnaround times unchanged	Much lower energy density reduces range and may require more frequent bunkering; complex, safety-intensive handling can extend turnaround times and limits routing to ports with ammonia capability	Severely limited range and frequent charging needs; long recharge times impact turnaround, and dependence on OPS reduces routing flexibility and can affect schedule reliability
Order-of-magnitude cost impact	-	Low	Medium	Low	High	High
	No capex for vessels or ports	No vessel or port capex; higher fuel OPEX due to premium price, but fully drop-in with no operational cost impacts	Moderate vessel capex for dual-fuel engines and dedicated systems; low port capex using existing liquid-fuel infrastructure; major cost driver is high OPEX, as bio/e-methanol is far more expensive than fossil fuels	No vessel or port capex for LNG-ready ships and ports; higher OPEX as bio/e-LNG is more expensive than fossil LNG	High vessel capex due to large tanks, safety systems and complex fuel handling; high port capex for dedicated ammonia infrastructure; fuel OPEX remains high as green ammonia is still costly and immature	Very high vessel capex due to large battery systems; high port capex for MW-scale charging and grid upgrades; OPEX depends on electricity prices
Technology & market maturity	-	High	Medium	Medium	Low	Medium
	Fully mature, widely used fuels with universal engine compatibility and global availability	Commercially proven in short-sea ferry and RoPax operations; fully drop-in and compatible with existing marine diesel engines	Rapidly advancing toward commercial maturity with proven dual-fuel engines and growing fleet; compatible with existing liquid-fuel infrastructure and already in short-sea commercial service	Fully mature drop-in fuels for LNG-capable ships; widespread port availability and established dual-fuel engine technology already proven in RoRo operations	Early-stage technology with limited operational experience; engines and class rules still maturing	Mature and widely deployed for short-sea ferries; fully electric systems proven but not scalable to larger RoRo vessels due to battery weight/volume limits
Overall corridor suitability	-	High	Medium	High	Low	Low
	Highly feasible and low-risk due to full maturity, universal availability and no vessel or port modifications, but only a short-term transitional option as it does not meet long-term decarbonisation goals	Highly feasible, fully drop-in option requiring no vessel or port modifications; commercially mature and operationally straightforward for corridor deployment	Near-term deployable with mature engine technology and adaptable port infrastructure, but feasibility depends on route supply and is constrained by high fuel cost and limited low-GHG methanol availability	Highly viable near-term option: fully drop-in for LNG-ready vessels, widely available at many ports, and already proven in RoRo operations	Pre-commercial for RoRo: no vessels in service and only pilot projects; bunkering has early demonstrations but infrastructure remains nascent	Commercially proven for short-sea ferries; suitability for RoRo is limited by battery size and OPS deployment

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Implications of most credible fuel candidates on vessel design (RoRo)

This assessment focuses on fuels that are technically and commercially credible for near-term deployment on the corridor, namely HVO, methanol, and LNG.

HVO (drop-in)	(bio/e-) LNG	(bio/e-) Methanol
Pathway: Use in existing fleet	**Pathway:** Newbuild or retrofit (complex)	**Pathway:** Newbuild or retrofit
• No engine or fuel system modifications required • Immediately deployable across entire fleet, independent of vessel age • Equivalent to conventional marine fuels; existing procedures and training apply • No impact on tank size, vessel layout, or cargo/passenger capacity	• LNG dual-fuel engines, cryogenic tanks, and gas handling systems required • Low impact if vessel is LNG-ready; otherwise requires major conversion or newbuild • Cryogenic temperatures and gas risks require specialised containment, monitoring, and controlled bunkering procedures • Large insulated tanks increase weight and reduce available cargo or lane space	• Dual-fuel engines and dedicated fuel systems required • Retrofit feasible for newer vessels, but more typically implemented via newbuild or methanol-ready designs • Low flashpoint and toxicity require enhanced bunkering procedures, detection systems, and crew training • Larger fuel tanks required due to lower energy density, reducing available cargo or lane capacity
Retrofit complexity 1 2 3 4 5	**Retrofit complexity** 1 2 3 4 5	**Retrofit complexity** 1 2 3 4 5

RoRo vessels are more adaptable to fuel transitions, but alternative fuels can still reduce lane capacity and require alignment with retrofit or newbuild cycles.

SANTANDER PORT – FUEL SUPPLY & BUNKERING OVERVIEW

Available fuels

LFO MGO LNG / Bio-LNG

Bunkering Infrastructure

- Conventional fuels are supplied by truck
- Existing LNG Terminal (Repsol)

Bunkering Readiness

- **HVO:** Can be bunkered at any time. It is a drop-in fuel.
- **Bio-LNG:** Can be bunkered without additional changes. The port has been supplying Bio-LNG/LNG since 2024, using existing LNG bunkering procedures.
- **Bio-Methanol / Methanol:** Not ready for supply.

Infrastructure implications

Safety Considerations

Methanol is a low-flashpoint and toxic fuel, requiring designated safety zones, vapor detection, alcohol-resistant firefighting systems, and strict access control

New Infrastructure Needs

Requires methanol-compatible bunkering equipment (hoses, couplings, ERC), vapor-return systems, emergency shutdown capabilities, and dedicated storage/transfer areas

Quayside Space Considerations

Establishment of methanol-specific hazard zones, restricted SIMOPS areas, and secure equipment staging space would be necessary

Training for Port Workers

Personnel would require training for low-flashpoint fuel handling, toxic exposure management, HAZID/HAZOP practices, emergency shutdown procedures, and methanol-specific firefighting

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PORT OF PASAJES – FUEL SUPPLY & BUNKERING OVERVIEW

Available fuels

HFO MGO MDO

Bunkering Infrastructure

Bunkering is carried out via container or truck (CEPSA)

Bunkering Readiness

- **HVO:** Can be bunkered at any time. It is a drop-in fuel.
- **Bio-LNG:** The port has no LNG terminal.
- **Bio-Methanol / Methanol:** The port lacks the required safety systems and methanol-specific infrastructure.

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PORT OF PORTBURY – FUEL SUPPLY & BUNKERING OVERVIEW

Available fuels

HFO MGO LFO

Bunkering Infrastructure

Marine fuels are available at the port, but the port does not have LNG bunkering infrastructure

Bunkering Readiness

- **HVO:** Can be bunkered at any time. It is a drop-in fuel.
- **Bio-LNG:** The port has no LNG terminal.
- **Bio-Methanol / Methanol:** The port lacks the required safety systems and methanol-specific infrastructure.

Infrastructure implications

Safety Considerations

Both LNG and methanol are low-flashpoint fuels, requiring controlled safety zones, gas/vapor detection systems, alcohol-resistant or cryogenic-compatible firefighting equipment, and strict access control.

New Infrastructure Needs

The port currently has no LNG terminal and no methanol infrastructure; bunkering would require compatible transfer equipment (cryogenic hoses, methanol-grade hoses, couplings, ERC), vapor-return capability, and emergency-shutdown systems.

Quayside Space Considerations

Methanol and LNG bunkering would require establishing fuel-specific hazard zones and restricted SIMOPS areas.

Training for Port Workers

Personnel would need training in low-flashpoint fuel handling, cryogenic safety (LNG), methanol toxicity management, HAZID/HAZOP practices, emergency-shutdown procedures, and specialized firefighting.

Environmental assessment

Discussion

For this Ro-Ro corridor, the analysis assumes fleet replacement rather than retrofit, since retrofitting Ro-Ro cargo vessels is technically complex, costly, and results in a loss of lane-metres and cargo capacity, making it operationally unattractive.

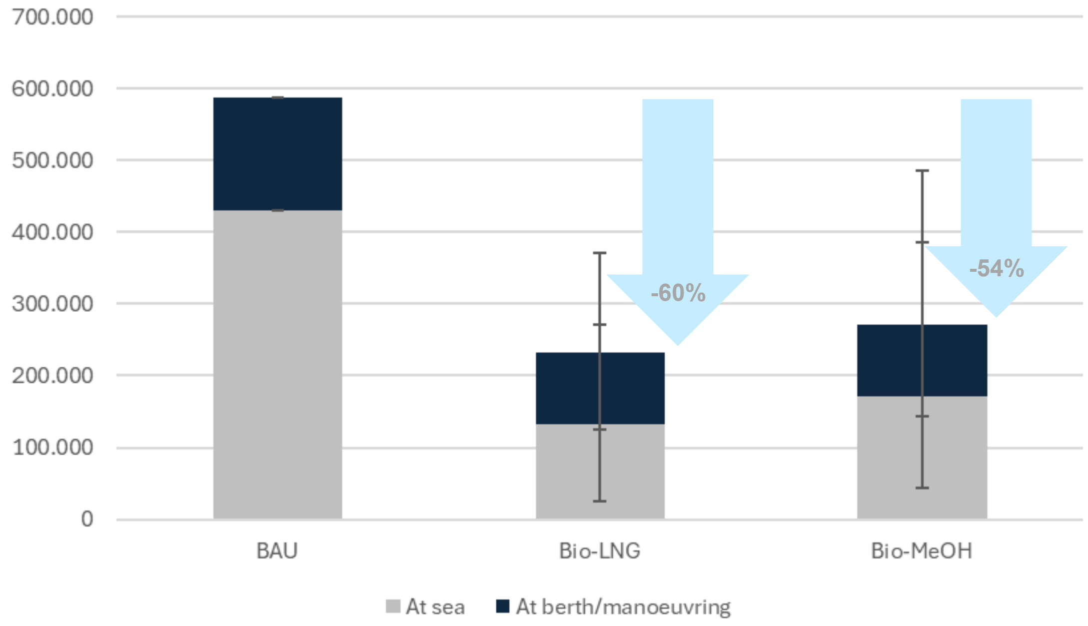
The transition pathway begins with HVO as a transitional fuel until 2030, after which the Ro-Ro vessel is replaced by a newbuild operating on Bio-LNG or Bio-Methanol.

Bio-LNG delivers a 60% WtW CO_2e reduction and represents a viable decarbonisation pathway for short-sea Ro-Ro operations. If this option is selected, bunkering would take place in Santander, as it is the only port within the corridor currently supplying Bio-LNG.

Bio-Methanol provides a 54% WtW reduction; however, none of the three ports analysed (Santander, Pasajes, Portbury) currently supply methanol as a marine fuel. Selecting this scenario would therefore require modifications to port-side bunkering systems and associated safety infrastructure to enable methanol handling and delivery.

The accompanying figure shows the cumulative GHG emissions from 2025 to 2050, illustrating how both alternative-fuel newbuilds deliver substantial long-term reductions compared with the current VLSFO-fuelled Ro-Ro baseline.

Graph showing emission reduction



Economic assessment

Discussion

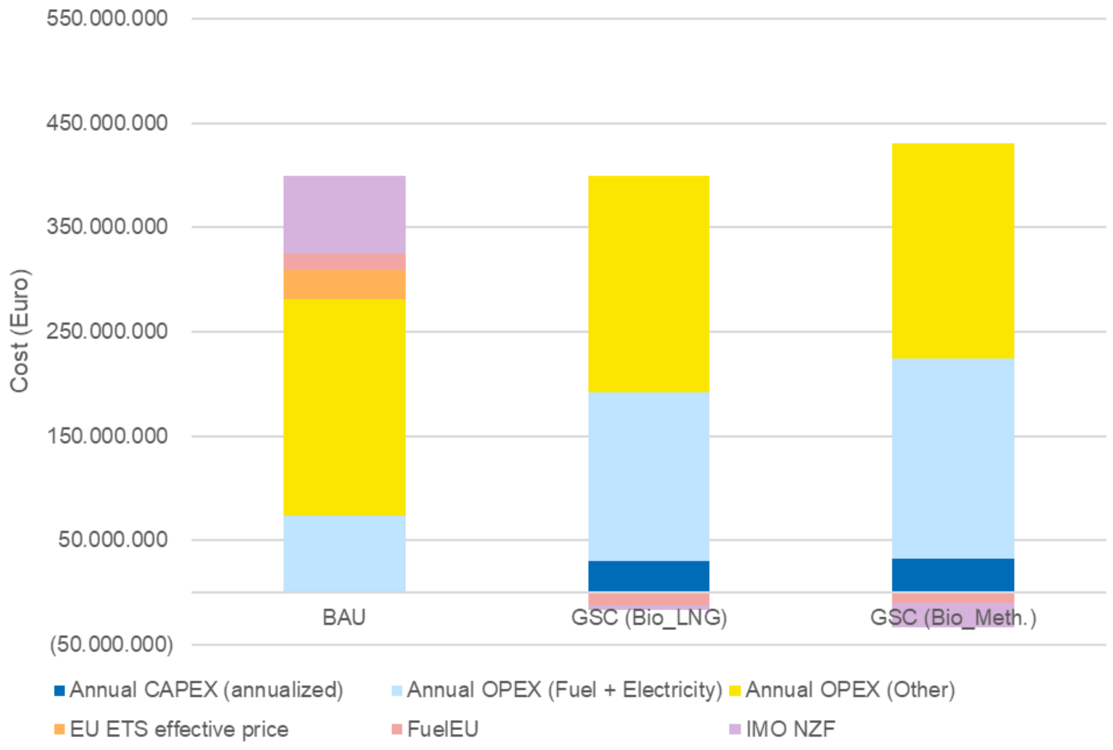
This chart shows the cumulative estimated cost from 2025 to 2050 for the BAU and GSC scenarios on the Santander–Pasajes–Portbury Ro-Ro corridor, combining annualised CAPEX, fuel and electricity OPEX, other operational costs, and projected regulatory penalties under the EU ETS, FuelEU Maritime, and IMO NZF frameworks.

The GSC scenario was the option delivering the highest emissions reduction among the alternatives assessed. (GSC Bio-Methanol 397 M€)

Although adopting the GSC (382 M€) pathway **requires a significant upfront investment to purchase a new Ro-Ro vessel**, the chart illustrates that continuing to absorb decarbonisation-related penalties through 2050 in the **BAU scenario** (400 M€) ultimately results in **higher total costs**, meaning that the long-term savings from avoided regulatory charges outweigh the initial fleet-renewal expenditure.

Note: *The UK ETS price has not been considered in this analysis, since it will come into effect in July and will apply only to domestic maritime routes and at-berth emissions. For the corridor assessed, this has a negligible impact on the economic case, as there are no domestic legs and emissions at berth in UK ports represent a very small share of total emissions. Furthermore, extension of the UK ETS to international shipping is expected only if global measures prove to be insufficient. Given that the analysis already incorporates the IMO Net Zero Framework, it is not necessary to also include the UK ETS in the assessment.*

Graph showing cost difference



VLSFO: 514 €/t (2025) - 590 €/t (2050) -- MGO: 763 €/t (2025) - 876 €/t (2050)
Bio-LNG: 1.183 €/t (2025) - 1.613 €/t (2050)
Bio-Methanol: 1.112 €/t (2025) - 556 €/t (2050)
New vessel estimated prices: Bio-LNG (28.620.000 €) Bio-Methanol (31.560.029 €)

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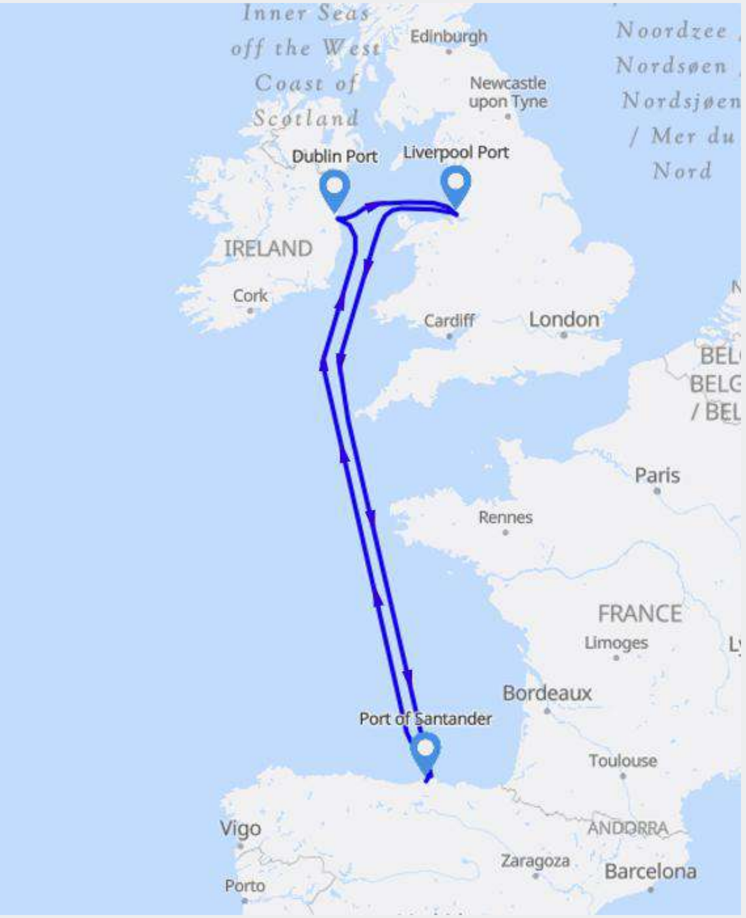
05 Route 2 - Boluda

Route snapshot

Map of route



Route information

Operator: *Boluda*

Frequency: *Weekly*

Vessels operating: *Lucia B*

Time at sea/time at berth: *168 h / 63 h*

Consumption per round trip: *100 (tonnes HFO) /*

5 (tonnes MGO)

Vessel information

Age: *19 years*

Type of vessel: *Container Ship*

Size: *140,64 m (7.852 GT)*

Fuel used: *HFO + MGO*

Deadweight Tonnage: *9.340 t*

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Fuel assessment

Assessment Criteria	BAU (MGO/VLSFO)	HVO / Advanced Bio-diesel (Drop-in)	Methanol bio-/e-	LNG bio-/e-	Ammonia	Battery + OPS
GHG reduction potential (WTW)	- 0	High ~83 % reduction	High ~82 % reduction	Medium ~74 % reduction	High 100% reduction	High 100% reduction
FuelEU / ETS exposure impact	- Highest compliance exposure	Low Meaningfully lowers FuelEU / ETS costs	Medium Reduces compliance costs but fuel remains expensive	Low Strong complaince benefit for low-GHG LNG pathways	Low Very low compliance exposure for green ammonia	Low Eliminates compliance costs
Technical suitability	- Currently used on existing vessels	High Fully compatible drop-in fuel; usable on all vessels without engine modifications or retrofits	Medium Usable via dual-fuel engine retrofits or methanol-ready designs	Medium Drop-in for LNG-capable vessels; retrofits only feasible for ships already equipped with LNG systems	Low Technically feasible but complex and costly; requires major vessel modifications due to ammonia's toxicity and handling characteristics	Low Not suitable as a retrofit due to battery weight/volume and integration complexity; feasible mainly for newbuilds designed for short-sea, high-frequency operations with OPS
Onboard impact	- No impact	Low Negligible impact on space or weight	Medium Increased tank volume and system complexity	Medium Larger tanks required with additional weight	High Significant tak volume needed and additional safety systems	High Major weight and space penalties due to bettery energy density
Port & bunkering implications	- No port infrastructure changes required; existing storage and bunkering systems fully support conventional fuels	Low No infrastructure changes required; existing diesel storage and bunkering systems can be used without modification	Low Requires larger fuel volumes and more frequent bunkering; methanol bunkering is straightforward, needing only moderate adaptations for low-flashpoint handling	Low Requires new cryogenic LNG storage and specialised bunkering systems with vapour-return and safety measures; ports without LNG capability need significant infrastructure additions	High Requires entirely new or heavily upgraded infrastructure, specialised ammonia storage and transfer systems, and extensive safety and permitting measures	High Requires high-capacity OPS with substations, HV shore connections and grid reinforcement, along with defined safety zones and protected connection systems
Operational impact	- High-energy-density fuels enable long range and infrequent, predictable bunkering aligned with regular port calls	Low Drop-in fuel with diesel-like energy density; no change in range or bunkering frequency, standard handling, and high operational flexibility	Low Lower energy density reduces range and may require more frequent bunkering; safety-critical handling can slightly increase turnaround times but remains manageable	Low Same energy density and range as LNG; fully drop-in for existing dual-fuel engines, keeping routing flexibility and stable turnaround times	Medium Much lower energy density reduces range and may require more frequent bunkering; complex safety-critical handling can extend turnaround times and limits routing to ports with ammonia capability	High Severely limited range and frequent charging needs; long recharge times impact turnaround, and dependence on OPS restricts routing to ports with sufficient grid capacity
Order-of-magnitude cost impact	- No vessel or port capex, as conventional fuels use existing tanks, piping and handling systems already in place	Low No vessel or port capex; higher fuel OPEX due to premium price, but fully drop-in with no operational cost impacts	Medium Moderate vessel capex for dual-fuel engines and dedicated systems; low port capex using existing liquid-fuel infrastructure; major cost driver is high OPEX, as bio/e-methanol is far more expensive than fossil fuels	Low No vessel or port capex for LNG-ready ships and ports; higher fuel OPEX as bio/e-LNG remains more expensive than fossil LNG	High High vessel capex due to large tanks, safety systems and complex handling requirements; high port capex for dedicated ammonia infrastructure; fuel OPEX remains high as green ammonia is still costly and immature	High Very high vessel capex due to large battery systems; high port capex for MW-scale charging and grid upgrades; OPEX depends on electricity prices
Technology & market maturity	- MGO and VLSFO remain the dominant and fully mature fuels, widely used across European and global fleets. Both fuels benefit from universal engine compatibility and require no additional class approvals	High Fully mature, universally used fuels with complete engine compatibility and no additional class approval requirements	Medium Rapidly advancing toward commercial maturity, supported by growing newbuild orders, proven dual-fuel engines and expanding bunkering; a credible near-term option, though not yet as mature as conventional fuels	Medium Fully mature drop-in option for LNG-capable vessels, with wide port availability and established dual-fuel engine technology already deployed in the container segment	Low Entering early deployment with the first ammonia-powered containership under construction; still limited operational experience, but engines, safety frameworks and bunkering are progressing toward initial commercialization	Low Technically mature for short-sea container feeders, demonstrated by early electric vessels; scalability to larger ships remains limited by battery weight/volume, and OPS feasibility
Overall corridor suitability	- Highly feasible and low-risk due to full maturity, universal availability and no vessel or port modifications, enabling immediate deployment	High Highly feasible as a fully drop-in fuel requiring no vessel or port modifications; commercially mature and easy to deploy	High Near-term deployable with mature engine technology and adaptable port infrastructure, but feasibility is limited by high fuel cost, stricter safety procedures and constrained bio/e-methanol supply	Medium Highly viable near-term option as a fully drop-in fuel for LNG-capable vessels, already proven at scale in the container segment and supported by mature infrastructure	Low Pre-commercial for container operations; bunkering has early demonstrations, but infrastructure and supply chains remain nascent	Low Feasible only for very short, fixed-schedule feeder routes; large battery volume limits payload and range, OPS availability is uneven, and the lack of OPS in Santander prevents charging at one end of the corridor

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Implications of most credible fuel candidates on vessel design (Container)

This assessment focuses on fuels that are technically and commercially credible for near-term deployment on the corridor, namely HVO, methanol, and LNG.

HVO (drop-in)

Pathway: Use in existing fleet

- No engine or fuel system modifications required
- Immediately deployable across entire fleet, independent of vessel age
- Equivalent to conventional fuels; no additional handling or regulatory requirements
- No impact on TEU capacity or vessel layout

Retrofit complexity

1 2 3 4 5

(bio/e-) LNG

Pathway: Newbuild or retrofit (complex)

- LNG dual-fuel engines, cryogenic tanks, and gas handling systems required
- Well-suited to LNG-designed vessels, but retrofit is typically uneconomic for large container ships
- Cryogenic temperatures and gas risks require specialised containment, monitoring, and controlled bunkering procedures
- Large insulated tanks reduce cargo capacity and introduce layout constraints

Retrofit complexity

1 2 3 4 5

(bio/e-) Methanol

Pathway: Newbuild or retrofit

- Dual-fuel engines and dedicated fuel systems required
- Retrofit technically feasible but commercially limited; primarily a newbuild pathway
- Toxicity and low flashpoint require additional safety systems, crew training, and controlled bunkering
- Lower energy density requires larger tanks, reducing TEU capacity

Retrofit complexity

1 2 3 4 5

Compared to RoRo vessels, container ships face stronger constraints from fuel storage due to direct impacts on cargo capacity and voyage economics

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SANTANDER PORT – FUEL SUPPLY & BUNKERING OVERVIEW

Available fuels

LFO MGO LNG / Bio-LNG

Bunkering Infrastructure

- Conventional fuels are supplied by truck
- Existing LNG Terminal (Repsol)

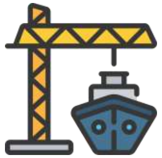
Bunkering Readiness

- **HVO:** Can be bunkered at any time. It is a drop-in fuel.
- **Bio-LNG:** Can be bunkered without additional changes. The port has been supplying Bio-LNG/LNG since 2024, using existing LNG bunkering procedures.
- **Bio-Methanol / Methanol:** Not ready for supply.

Infrastructure implications

Safety Considerations

Methanol is a low-flashpoint and toxic fuel, requiring designated safety zones, vapor detection, alcohol-resistant firefighting systems, and strict access control



New Infrastructure Needs

Requires methanol-compatible bunkering equipment (hoses, couplings, ERC), vapor-return systems, emergency shutdown capabilities, and dedicated storage/transfer areas

Quayside Space Considerations

Establishment of methanol-specific hazard zones, restricted SIMOPS areas, and secure equipment staging space would be necessary

Training for Port Workers

Personnel would require training for low-flashpoint fuel handling, toxic exposure management, HAZID/HAZOP practices, emergency shutdown procedures, and methanol-specific firefighting

DUBLIN PORT – FUEL SUPPLY & BUNKERING OVERVIEW

Available fuels

LFO

MGO

Bunkering Infrastructure

There is a large fossil fuels terminal within the port

Bunkering Readiness

- **HVO:** Can be bunkered at any time. It is a drop-in fuel.
- **Bio-LNG:** Not currently available.
- **Bio-Methanol / Methanol:** Not ready for supply.

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LIVERPOOL PORT – FUEL SUPPLY & BUNKERING OVERVIEW

Available fuels

HFO MGO

LFO MGO

Bunkering Infrastructure

Liverpool currently carries out bunkering via barge and truck to ship

Bunkering Readiness

- **HVO:** Can be bunkered at any time. It is a drop-in fuel.
- **Bio-LNG:** Not currently available.
- **Bio-Methanol / Methanol:** Not ready for supply.

Infrastructure implications

Safety Considerations

Both LNG and methanol are low-flashpoint fuels, requiring controlled safety zones, gas/vapor detection systems, alcohol-resistant or cryogenic-compatible firefighting equipment, and strict access control.

New Infrastructure Needs

The port currently has no LNG terminal and no methanol infrastructure; bunkering would require compatible transfer equipment (cryogenic hoses, methanol-grade hoses, couplings, ERC), vapor-return capability, and emergency-shutdown systems.

Quayside Space Considerations

Methanol and LNG bunkering would require establishing fuel-specific hazard zones and restricted SIMOPS areas.

Training for Port Workers

Personnel would need training in low-flashpoint fuel handling, cryogenic safety (LNG), methanol toxicity management, HAZID/HAZOP practices, emergency-shutdown procedures, and specialized firefighting.

Environmental assessment

Discussion

For this container-ship corridor, the analysis assumes fleet replacement rather than retrofit, since retrofitting container vessels is technically complex, costly, and typically leads to significant losses in cargo capacity, stowage flexibility, and vessel stability margins, making it an operationally unattractive option.

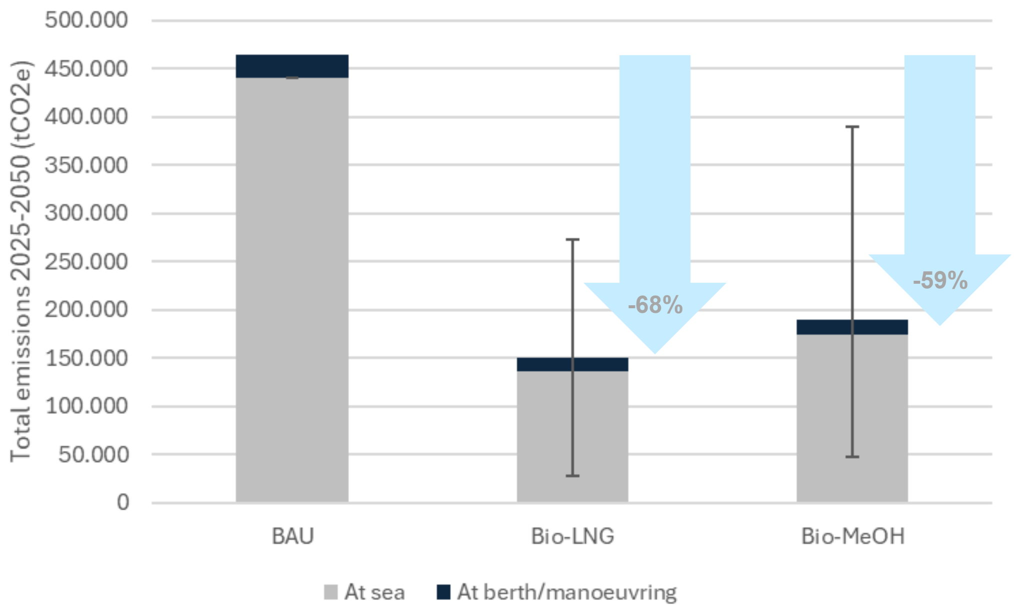
The transition pathway begins with HVO as a transitional fuel until 2030, after which the vessel is replaced by newbuild container ships operating on Bio-LNG or Bio-Methanol.

Bio-LNG delivers a 68% WtW CO_2e reduction and represents an alternative decarbonisation pathway for short-sea container operations on the Santander–Dublin–Liverpool route. If this option is selected, bunkering would take place in Santander, as it is the only port in the corridor currently supplying Bio-LNG.

Bio-Methanol, also technically deployable through commercially available dual-fuel engines and compatible with existing liquid-fuel infrastructure, offers a 59% WtW CO_2e reduction. If this scenario is selected, port-side bunkering systems would require modification, since none of the three ports analysed currently supply methanol as a marine fuel.

The accompanying figure shows the cumulative GHG emissions from 2025 to 2050, illustrating how both alternative-fuel newbuilds deliver substantial long-term reductions compared with the current VLSFO-fuelled container-ship baseline.

Graph showing emission reduction



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Economic assessment

Discussion

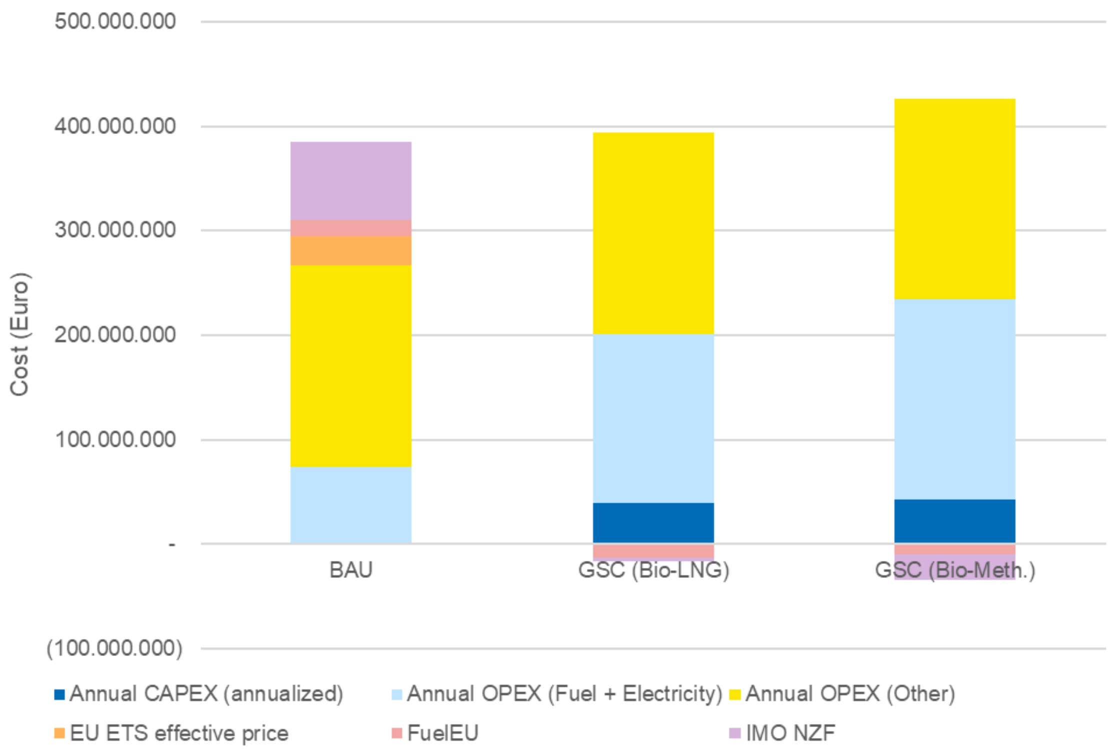
The chart illustrates the cumulative estimated cost from 2025 to 2050 for the Santander–Dublin–Liverpool container-ship corridor, comparing the Business-as-Usual (BAU) scenario with the Green Shipping Corridor (GSC) scenarios based on Bio-LNG (377 M€) and Bio-Methanol (392 M€). Since the Bio-LNG GSC scenario delivers the best overall results, both in terms of total cost and emissions reduction, it is selected as the preferred option.

Although the GSC Bio-LNG (377 M€) pathway requires a **significant upfront investment** to acquire a new container vessel, the analysis shows that **this capital expenditure is ultimately compensated by the substantial long-term savings resulting from avoided payments under the EU ETS, FuelEU Maritime, and IMO NZF frameworks**, which grow considerably in the BAU scenario (385 M€).

As in the Ro-Ro case, the chart demonstrates that the cost of continuing to operate a conventional HFO-fuelled fleet becomes progressively more expensive, making Bio-LNG the most cost-effective and environmentally impactful solution over the 2025–2050 period.

Note: *The UK ETS price has not been considered in this analysis, since it will come into effect in July and will apply only to domestic maritime routes and at-berth emissions. For the corridor assessed, this has a negligible impact on the economic case, as there are no domestic legs and emissions at berth in UK ports represent a very small share of total emissions. Furthermore, extension of the UK ETS to international shipping is expected only if global measures prove to be insufficient. Given that the analysis already incorporates the IMO Net Zero Framework, it is not necessary to also include the UK ETS in the assessment.*

Graph showing cost difference



HFO: 472 €/t (2025) - 541 €/t (2050) -- MGO: 763 €/t (2025) - 876 €/t (2050)
Bio-LNG: 1.183 €/t (2025) - 1.613 €/t (2050)
Bio-Methanol: 1.112 €/t (2025) - 556 €/t (2050)
New vessel estimated prices: Bio-LNG (37.100.000 €) Bio-Methanol (40.911.148,74 €)

06 Benefits and constraints

Benefits and opportunities for ports

Managing carbon and regulatory risk

Structured pathway to manage exposure to tightening IMO and regional regulation

Strengthening market position and revenue

Attract new business, retain customers, and enhance long-term competitiveness

Enabling investment and scalable transition

Unlock financing and concentrate demand to enable infrastructure and fleet transition

- Prepare for IMO, EU ETS and FuelEU Maritime requirements
- Reduce risk of stranded port and vessel assets
- Create controlled testbeds before wider rollout
- Future-proof against rising carbon pricing

- Attract premium cargo and ESG-aligned customers
- Strengthen position in emerging fuel supply chains
- Enable long-term contracts and differentiation in tenders
- Support customers in meeting ESG and decarbonisation targets

- Improve access to green and blended finance
- Aggregate demand to support fuel supply development
- Enable targeted infrastructure investment (e.g. OPS, bunkering)
- Create local jobs and build regional capability
- Deliver co-benefits: cleaner air, reduced noise, water quality improvements

Green shipping corridors position ports as early movers in the energy transition while unlocking commercial, financial, and environmental value.

Key constraints

Fuel supply

- Limited availability of scalable sustainable fuels
- Uncertainty around dominant fuel pathways
- Competition for fuels from other sectors

Infrastructure & Investment

- High CAPEX for bunkering and energy infrastructure
- Uncertain utilisation of early fuel infrastructure
- Grid capacity and energy supply limitations
- Long asset lifetimes creating investment risk

Coordination & Governance

- Need for alignment across ports, operators and fuel suppliers
- Difficulty securing long-term demand commitments
- Regulatory and safety framework uncertainty

07 Conclusions and next steps

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Corridor conclusions: Santander-UK

	Common across both corridors	RoRo (Pasajes–Portbury)	Container (Dublin–Liverpool)
Fuel choice	• **HVO:** near-term compliance solution • **Bio-LNG / methanol:** primary transition fuels • **Long-term:** dependent on scalable low/zero-carbon fuels	Bio-LNG most practical pathway given existing use in similar RoRo operations	Greater sensitivity to fuel choice due to cargo capacity impacts
Infrastructure	• **Santander:** LNG-ready with existing capability **UK /** • **Irish ports:** lack LNG and methanol infrastructure • **Corridor viability:** dependent on alignment across all ports	More flexible bunkering logistics	Greater reliance on coordinated multi-port infrastructure development
Cost (CapEx & OpEx)	• **CapEx:** high upfront investment for newbuild vessels • **OpEx:** fuel cost premium vs fossil fuels • **Cost parity:** achievable by 2050 via ETS and FuelEU savings • **Uncertainty:** highly sensitive to fuel and carbon price assumptions	Slightly lower operational risk	Higher exposure to fuel cost and utilisation uncertainty
Emissions	• **Reductions:** significant vs VLSFO baseline • **HVO:** transitional only, not sufficient long-term • **Alternative fuels:** deliver substantial cumulative reductions to 2050	Bio-LNG ~60%, Methanol ~54%	Bio-LNG ~68%, Methanol ~59%
Overall conclusion	• **Feasibility:** both corridors technically viable • **Constraints:** fuel availability, infrastructure alignment, fleet renewal timing • **Delivery:** dependent on coordinated action across stakeholders	**More immediately actionable** given operational flexibility and precedent	**Feasible but more complex delivery**, dependent on coordinated investment

Both corridors face common structural challenges.
Corridor selection is driven less by technical feasibility and more by stakeholder alignment, investment timing, and risk appetite.

✶ **Priority action**

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Recommended next steps for Santander–UK Green Shipping Corridor development

Short term (0-2 years) — Establish the corridor foundation

- ✶**Progress to Santander-led green corridor feasibility study.** Quantify fuel pathways, infrastructure gaps between Santander and UK ports, and identify a single pilot route and operator
- ✶**Secure engagement with specific UK ports linked to existing services.** Prioritise Bristol (Portbury/Avonmouth), Portsmouth and Liverpool based on current traffic, and test willingness to participate in a pilot corridor
- **Position Santander as the primary fuel supply location for the corridor.** Build on existing LNG capability to support early deployment while engaging UK ports on complementary infrastructure
- **Develop a shared corridor roadmap with committed partners.** Move from broad engagement to a formalised collaboration via MoU or working group with operators, ports and fuel suppliers

Medium term (2-5 years) — Enable transition

- ✶**Support operator fleet transition decisions on priority routes.** Engage UECC and Boluda to align vessel replacement cycles with viable fuel pathways identified in the feasibility study
- **Develop a Santander-specific bunkering scale-up plan**. Define required capacity, storage and operational procedures to support increased LNG/bio-LNG demand and future fuels
- **Work with UK ports to define minimum viable infrastructure**. Focus on *what is actually needed to enable operations*, rather than full-scale deployment (e.g. truck-to-ship, temporary solutions)
- **Launch a pilot corridor on a selected route.** Demonstrate emissions reduction and operational feasibility using a defined vessel–fuel–port combination
- **Develop bankable project cases for funding.** Use pilot and feasibility outputs to access EU funding, green finance and bilateral UK–Spain collaboration mechanisms

Long term (5+ years) — Scale and future proof

- **Scale corridor operations and expand to additional routes.** Move from pilot to full deployment across Santander–UK routes and wider international connections
- **Position Santander as a regional alternative fuel hub for Atlantic routes.** Extend supply capability to serve wider UK, Ireland and Atlantic traffic

Brittany Ferries' LNG and bio-LNG deployment on Santander–UK routes shows that early progress is enabled by operator-led investment, Santander-based fuel supply and phased infrastructure development, rather than requiring full corridor readiness from the outset.

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