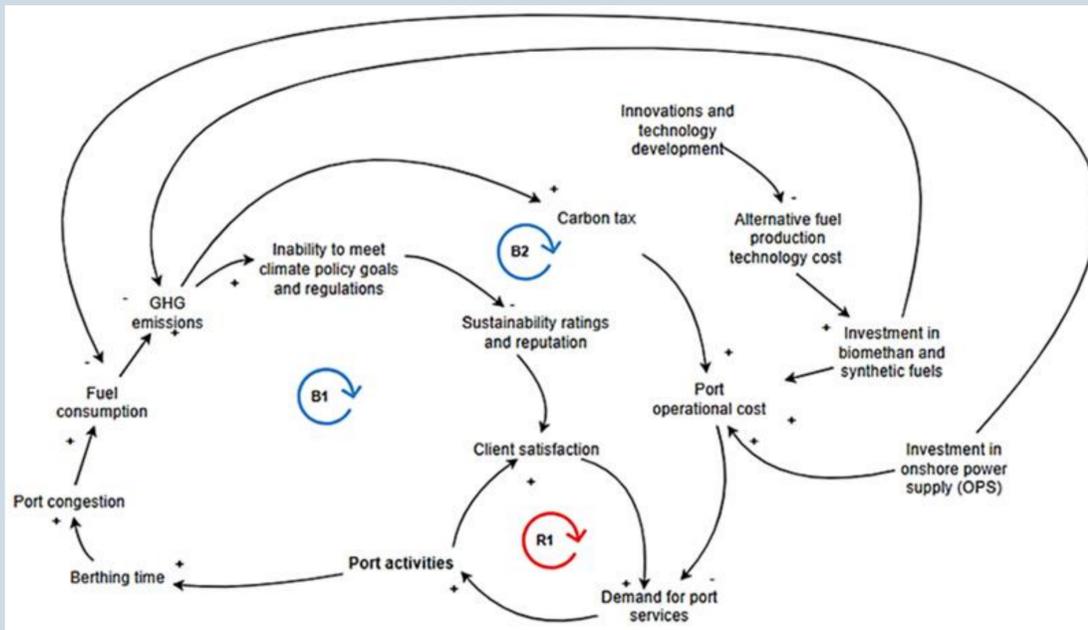


Ports will not be able to provide climate neutral ship service unless the port infrastructure itself is thoughtful and developed to meet the objectives of climate neutrality.

The study provides concrete, operational steps for ports – especially ones like Port of Riga – to transition to climate neutrality. Using best practices from Rotterdam and Hamburg ports. Adopting renewable energy, improving efficiency, thus achieving EU, ESPO, IMO and UN climate neutrality and sustainability goals while maintaining economic competitiveness.

Emissions make it difficult for the port to comply with national or international climate policy goals and regulations, leading to an inability to meet sustainability criteria.

An important consideration in this transition is the timing of investment decisions.



Casual loop diagram for decarbonisation and technological innovation dynamics in port operations

Introduction

With global transport responsible for approximately 24% of all carbon dioxide (CO₂) emissions and shipping accounting for 10% of total transport emissions, it will be imperative for ports to help facilitate the transition of shipping vessels to clean energy.

The International Maritime Organization (IMO) transformed the UN SDGs objectives to focus directly and on the development of the marine environment and infrastructure.

As the country's most important trade and development hub, ports should be endeavoured to improve as quickly and qualitatively as possible in order to comply with all the above-mentioned sustainable development plans and adopted laws.

Countries' ports' implementation of GHG emission reduction measures

Country	Ports	Measures implemented/proposed
Belgium	Antwerp	Solar energy, wind energy, geothermal energy, energy saving measures, energy management plans, digitalisation, port city integration, modal shift/split, OPS
Denmark	Copenhagen, Aalborg	Hybridisation, solar energy, energy saving measures, energy management plans, OPS, automated mooring systems
Finland	Finnish ports	Energy saving measures, automated mooring system
Germany	Hamburg	Alternative cleaner fuels (hydrogen), hybridisation, electrification, wind energy, geothermal energy, energy management plans, digitalisation, port city integration, truck emissions reduction, Modal shift/split
Italy	Genoa	Information measures, solar energy, energy management plans, OPS
Netherlands	Rotterdam, Amsterdam	Information measures, alternative cleaner fuels, wind energy, solar energy, energy saving measures, energy management plans, digitalisation, container terminal automation and operation system, port city integration, truck emissions reduction, modal shift/split, OPS, alternative fuels bunkering, automated mooring systems, solar energy, wind energy, smart grid, port city integration
Sweden	Gothenburg, Helsingborg, Stockholm	Information measures, energy management plans, modal shift/split, OPS, alternative fuels bunkering, hybridisation, Alternative fuels bunkering, OPS
UK	Felixstowe, Dover, Abardeen	Information measures, solar energy, energy saving measures, energy management plans, smart load management, land transport, measures, OPS

Methodology

The author uses a **systems thinking approach** to holistically assess the multifaceted interactions between environmental, economic, and operational factors influencing port sustainability. A **causal loop diagram (CLD)** was developed to visualize the feedback loops and leverage points within port systems.

Results and conclusions

Both the literature review and the results confirm that the production and use of **alternative** and **renewable fuels** in port is **inevitable over time**. Currently it is economically unprofitable, especially for smaller ports.

1) The literature review showed different decarbonisation strategies implemented at benchmark ports both globally and in Europe for broader vision and their contribution to UN SDGs.

2) Three scenarios were developed (baseline scenario, moderate and ambitious) for decarbonising Latvian ports, using systems thinking approach to balance environmental, economic and operational factors, representing these scenarios in two CLDs.

3) The CLDs show how complicated port activity really is. It can be said that the port, as a public infrastructure, need to be **developed** to climate neutrality from **several points of view** at the same time to get the best results.

4) CLDs were made so in future research it could be explored in depth how much investment is needed and how to allocate it to technological improvements in port infrastructure so that the CO₂ reduction is worth the investment.

5) An in-depth examination of other countries' best practices suggests **three recommendations** for implementation on **medium-sized ports**:

- Short-term – port authorities focus on quick wins like LED lightings, OPS and Automated Mooring Systems (AMS).
- Mid-term – invest in renewable energy (solar panels and offshore wind farms) and hybrid CHE.
- Long-term – develop hydrogen/ammonia production, bunkering and circular economy initiatives.