Environmental Engineering and Management Journal

March 2026, Vol. 25, No. 3, 695-707
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu
http://doi.org/10.30638/eemj.2026.055

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ENVIRONMENTAL AND ECONOMIC ASSESSMENT OF RETROFITTING CONTAINERSHIPS WITH LOW-EMISSION ALTERNATIVE FUELS UNDER EU ETS POLICY

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Abstract

Reducing air pollutant emissions from maritime transport is essential for achieving global climate and environmental quality targets. This study evaluates the environmental and economic feasibility of retrofitting a 20,000 twenty-foot equivalent unit (TEU) containership operating on the Asia–Europe route to use three alternative fuels, as liquefied natural gas (LNG), methanol, and ammonia—under the regulatory framework of the European Union Emissions Trading System (EU ETS). A comprehensive cost–benefit analysis integrating fuel consumption modelling, pollutant emission inventories, monetized environmental impacts, and projected EUA (European Union Allowances) prices is employed to assess both ship owner and societal perspectives. Results show that all three fuels substantially reduce SO_x, NO_x, PM, and CO_2 emissions compared with Very Low Sulphur Fuel Oil (VLSFO), with ammonia exhibiting the highest environmental performance and LNG providing the most balanced reductions. Despite these environmental benefits, only LNG yields a positive Net Present Value for ship owners due to its lower fuel consumption and significant EUA savings. Methanol and ammonia remain economically unattractive under current market conditions, though sensitivity analysis reveals that ammonia becomes viable at substantially higher carbon prices or reduced fuel costs. From a societal standpoint, all alternatives deliver strong positive welfare gains, indicating misalignment between private incentives and environmental benefits. The study concludes that current market mechanisms are insufficient to stimulate adoption of zero-carbon marine fuels and highlights the need for strengthened carbon pricing instruments, targeted subsidies, and technology-support policies to facilitate a sustainable maritime energy transition.

Key words: alternative fuels, containership, cost-benefit analysis, European Union allowances, maritime decarbonization

Received: December, 2025; Revised final: January, 2026; Accepted: February, 2026; Published in final edited form: March, 2026

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