



# Continuous Emission Monitoring Systems for maritime applications

Green Deal Validation



### Summary

This validation study investigates the practical feasibility and usability of Continuous Emission Monitoring Systems (CEMS) for monitoring NO<sub>x</sub>-emissions on sea-going vessels within the context of the Dutch Green Deal. While CEMS does not directly reduce (NO<sub>x</sub>)-emissions, it can provide critical insight into real-world emission behaviour, enabling informed decisions for compliance, maintenance, and policy development.

To determine whether CEMS is a suitable technology for the goals under the Dutch Green Deal, this study focuses on:

- What is the practical feasibility of CEMS on the different ship types as defined for the Dutch Green Deal Programme.
- What are the technical aspects governing the usability of CEMS based emission results. What are the main uncertainties of CEMS results.
- What are the standards and regulations governing the use of CEMS in maritime applications?

To do this, a small literature study is combined with data analysis on a provided CEMS dataset and a measurement campaign onboard a vessel equipped with a sensor based CEMS.

The key findings of this study are outline below:

CEMS can reliably monitor NO<sub>x</sub>-emissions under real-world conditions but cannot replace certification measurements due to inherent uncertainties. For electrochemical sensor-based systems, overall uncertainty found in literature is typically  $\pm 20\%$ . During testing on standard engine test cycles, the deviations of CEMS measurements were found to be lower with  $-8.6\%$  on the D2 cycle. Higher deviations can however occur during real world conditions, influenced by factors such as NO/NO<sub>2</sub> ratio, SCR operation, and engine power estimation. Furthermore, installation errors can significantly increase inaccuracies—deviations of up to 140% were observed when sensors were placed too close to SCR units or stack walls. Proper sensor positioning ( $\geq 5$ –10 pipe diameters downstream of obstructions and away from walls) and homogeneity checks upon installation are essential to avoid these errors.

Currently, no maritime-specific standards exist for CEMS monitoring. IMO MARPOL Annex VI governs NO<sub>x</sub>-limits but does not mandate real-world monitoring. However, discussions within IMO and parallels with automotive regulations (e.g., Euro 7 OBM) suggest that onboard monitoring could become part of future compliance strategies, making CEMS a critical technology.

CEMS is technically feasible for most vessel types in the Dutch reference fleet. Its near-term relevance is highest for vessels under public procurement contracts, where Environmental Cost Indicators (ECI/MKI) are increasingly considered. For other vessels, adoption will depend on regulatory developments.

Sensor-based CEMS offers low-cost maintenance (annual sensor replacement by crew), while analyser-based systems require frequent calibration and specialized personnel. CEMS operation does not affect the general vessel propulsion safety and operation.

Initial investment costs of CEMS range between €5,000 to €15,000 for sensor-based systems. Annual operational costs are found to be between €3,700 and €7,000. Costs are modest relative to vessel budgets but require regulatory or contractual incentives for widespread adoption.

Based on these findings, the study concludes that CEMS can be a valuable technology to provide insights into NO<sub>x</sub>-emissions and SCR performance onboard sea-going vessels, both for supporting vessel maintenance crews and informing policy makers. While uncertainties and installation sensitivity limit its use for certification purposes, CEMS is well-suited for monitoring emission trends and compliance under real-world conditions.

