

White Paper

FROM ASSUMPTIONS TO ACCURACY

Unlocking the Value of Direct Emissions Monitoring in the Maritime Industry

August 2025

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Authors: Enrique Gallar, Dr William Ramsay, and Janne T Berglund

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Based on research and data from company pilot projects and collaborations with industry partners.

Executive Summary

This document critically addresses the validity of a direct CO₂ measurement approach that yields lower CO₂e mass emissions by approximately 7% ± 3%, compared to using the published GHG emission factor (Cf) for LNG in the IMO's Life Cycle Assessment (LCA) Guidelines.¹ The observed reduction is supported by accurate, real-time data recorded with installed equipment onboard multiple vessels and the correct application of internationally accepted calculation methodologies, including CDM Tool 8.

We present a defensible, evidence-based position demonstrating that the measured values reflect the actual performance of shipboard systems and should be accepted for LCA and GHG Factor Index (GFI) reporting.

By leveraging certified emissions monitoring equipment, which is one of the elements within the PureMetrics™ solution, operators eliminate reliance on assumptions, default factors, and manual data entry. This measurement approach increases data fidelity, reduces uncertainty in emissions accounting, and provides operational, financial, and regulatory advantages.

This paper also compares direct measurement (MRV Method D) to fuel-based quantification methods (e.g. MRV Method C), demonstrating significant differences in uncertainty and compliance readiness towards acceptance of Method D.

This paper is based on live data from PureMetrics™ deployments, validated through real-world operations, and supported by established regulatory frameworks and independent third-party studies.

[1] IMO. Lifecycle GHG and carbon intensity guidelines. International Maritime Organization, 2024. <https://www.imo.org/en/OurWork/Environment/Pages/Lifecycle-GHG---carbon-intensity-guidelines.aspx>

Introduction

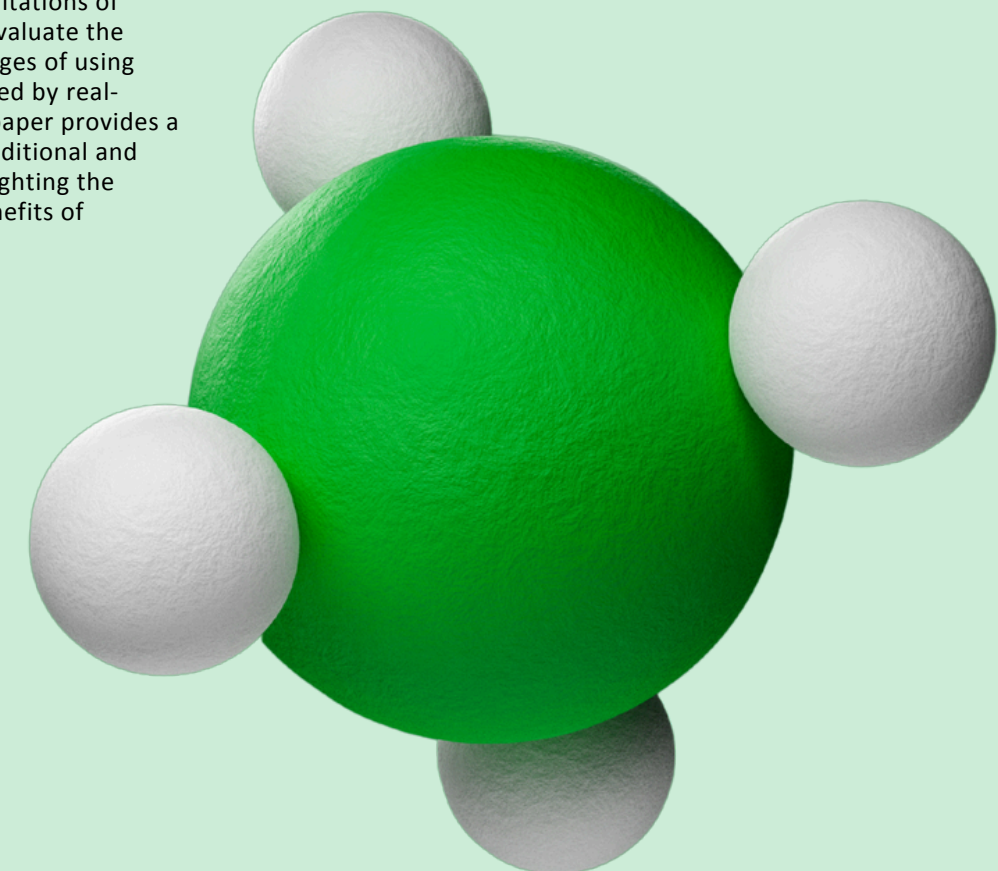
Accurately measuring greenhouse gas emissions is a critical challenge for maritime and land-based industries subject to tightening compliance requirements and emissions reporting obligations. With evolving regulations and pressure to align with environmental targets, the methodology chosen for emissions reporting plays a significant role in financial and operational exposure.

Current frameworks, including the EU MRV and IMO DCS, permit different measurement approaches, from periodic fuel consumption estimates (Methods A-C) to continuous emissions monitoring (Method D). These methodologies vary significantly in uncertainty levels. The method applied directly affects reported emission values and subsequently impacts regulatory compliance and exposure to carbon pricing mechanisms.

Traditional factor-based methods rely on static emissions factors combined with daily or periodic fuel readings. This introduces considerable variability, especially under real-world operating conditions. The uncertainty is amplified by manual data entry and by using assumptions that do not account for methane slip, which is frequently underestimated by as much as 30-60%, depending on engine type and load conditions.

Alternatively, direct emissions monitoring (Method D), such as with PureMetrics™, captures real-time exhaust gas data that provides accurate and traceable emissions profiles. Direct emissions monitoring, therefore, provides materially higher accuracy and data integrity compared to estimation-based approaches. By capturing real-time exhaust gas data, these systems also align with regulatory expectations and operational needs.

The following sections explore the limitations of current factor-based methods and evaluate the operational and compliance advantages of using direct emissions monitoring supported by real-world deployment data. This white paper provides a data-driven comparison between traditional and direct monitoring approaches, highlighting the tangible business and regulatory benefits of adopting PureMetrics™.



The Measurement Problem

Single-Point Estimation vs. Direct Monitoring

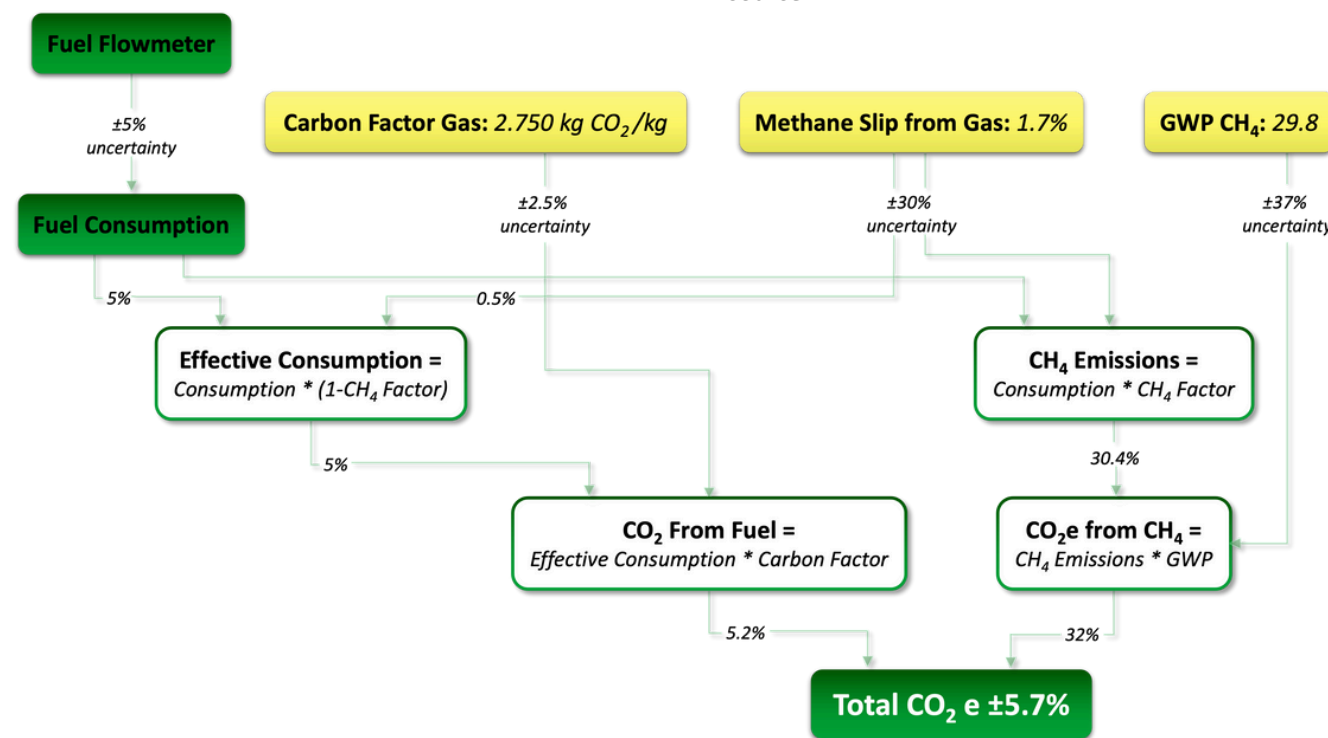
In maritime and land-based sectors, fuel-based emissions estimates remain a common industry practice. These are typically derived using either Bunker Delivery Notes (BDNs) or periodic fuel flowmeter readings. While these are sufficient for high-level tracking, these methods introduce considerable uncertainty when applied to compliance-grade emissions monitoring.

The EU Monitoring, Reporting and Verification (MRV) Regulation (2015/757) recognises four emissions monitoring methods: Method A (Bunker Delivery Notes), Method B (Fuel tank monitoring), Method C (Fuel flowmeters), and Method D (Direct CO₂ measurement via CEMS).² This white paper focuses on evaluating Method C and Method D in terms of their uncertainty, compliance readiness, and operational impact.

Traditional Single-Point Fuel Measurements

Periodic reporting methods such as BDNs (for Method A) or daily manual fuel recordings (Method B or C with totaliser) fail to capture the dynamic nature of engine performance. By relying on a single daily reading and applying emission factors retroactively, this approach is naive in understanding the real engine fuel usage. Additionally, fuel losses, onboard distribution variation, and operator input error can materially distort the emissions baseline. According to a study prepared for the IMO on uncertainty analysis in ship fuel consumption measurements over short periods of time, such errors can range between 15% and 20%.³

Figure 1a: Error Propagation in Fuel Flowmeter-Based Estimation: Illustrative example for a low-speed 2-stroke dual-fuel engine using MRV Method C. Assumes IPCC AR6 GWP for CH₄ (29.8 ±37%). Individual uncertainty ranges are based on typical values found in IMO and IPCC guidelines. Final CH₄ uncertainty can reach ±60% depending on the factor source.



Fuel Flowmeter Improvement

Fuel flowmeters (Method C) present an incremental improvement, offering continuous fuel consumption data. Typically, the flowmeter readings are subtracted from totalisers (which are used for ROB – remaining onboard fuel quantities). These daily differences in totaliser readings introduce significant uncertainty, as precision is reduced when readings are compared on a daily basis (illustrated in Figure 1a). Additionally, when paired with fixed emissions factors, they still fail to account for variations in combustion efficiency, methane slip, and varying engine operational points. The result is a reduction in uncertainty but continued reliance on indirect estimation, which highly underestimates the impact of methane slip on the GHG balance.

Impact on Data Accuracy

Uncertainty analysis shows that even improved flowmeter-based approaches using MRV Method C present a total emissions uncertainty of ±5.2% (this assumes no manual intervention and direct time series aggregation). In practice, however, manual workflows, such as comparing totaliser differences across timestamps, may introduce additional errors of up to 20%, as referenced above.³ In contrast, CEMS-based direct measurement (MRV Method D) reduces this to ±2.7 for CO₂ and ±5.7% for CH₄, enabling more repeatability and accuracy for emissions accounting. Visual inspection of scatter plots comparing daily snapshots with direct measurements confirms this: traditional methods show higher variance and outliers, while real-time monitoring reduces manual entry error and uncertainty (illustrated in Figure 1b).

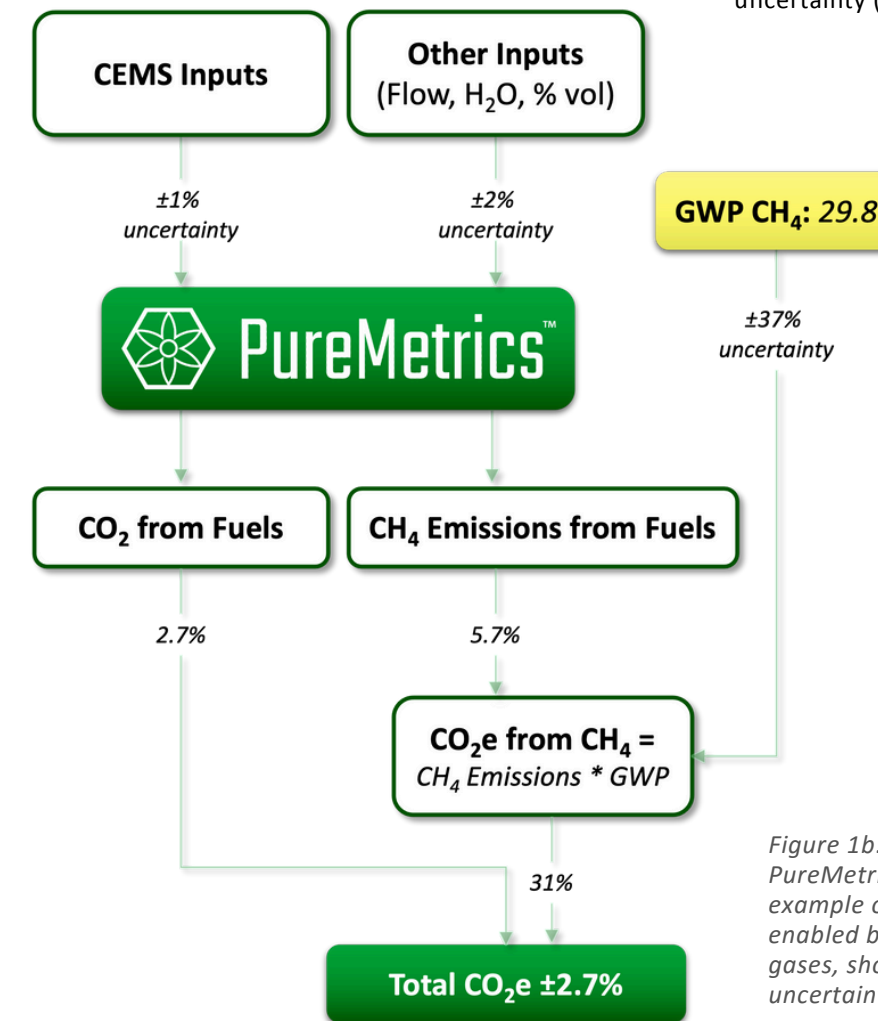


Figure 1b: Direct Measurement with PureMetrics™ (MRV Method D): Illustrative example of a simplified emissions pathway enabled by direct measurement of exhaust gases, showing reduced propagation of uncertainty.

[2] European Parliament and Council. Regulation (EU) 2015/757 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport. Official Journal of the European Union, 2015. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R0757>

[3] International Maritime Organization (IMO). (2017). Uncertainty Analysis of Methods Used to Measure Ship Fuel Oil Consumption. Shipwright LLC. Retrieved from https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Uncertainty_Analysis_in_Ship_Fuel_Oil_Consumption.pdf

Resulting Uncertainty Distributions

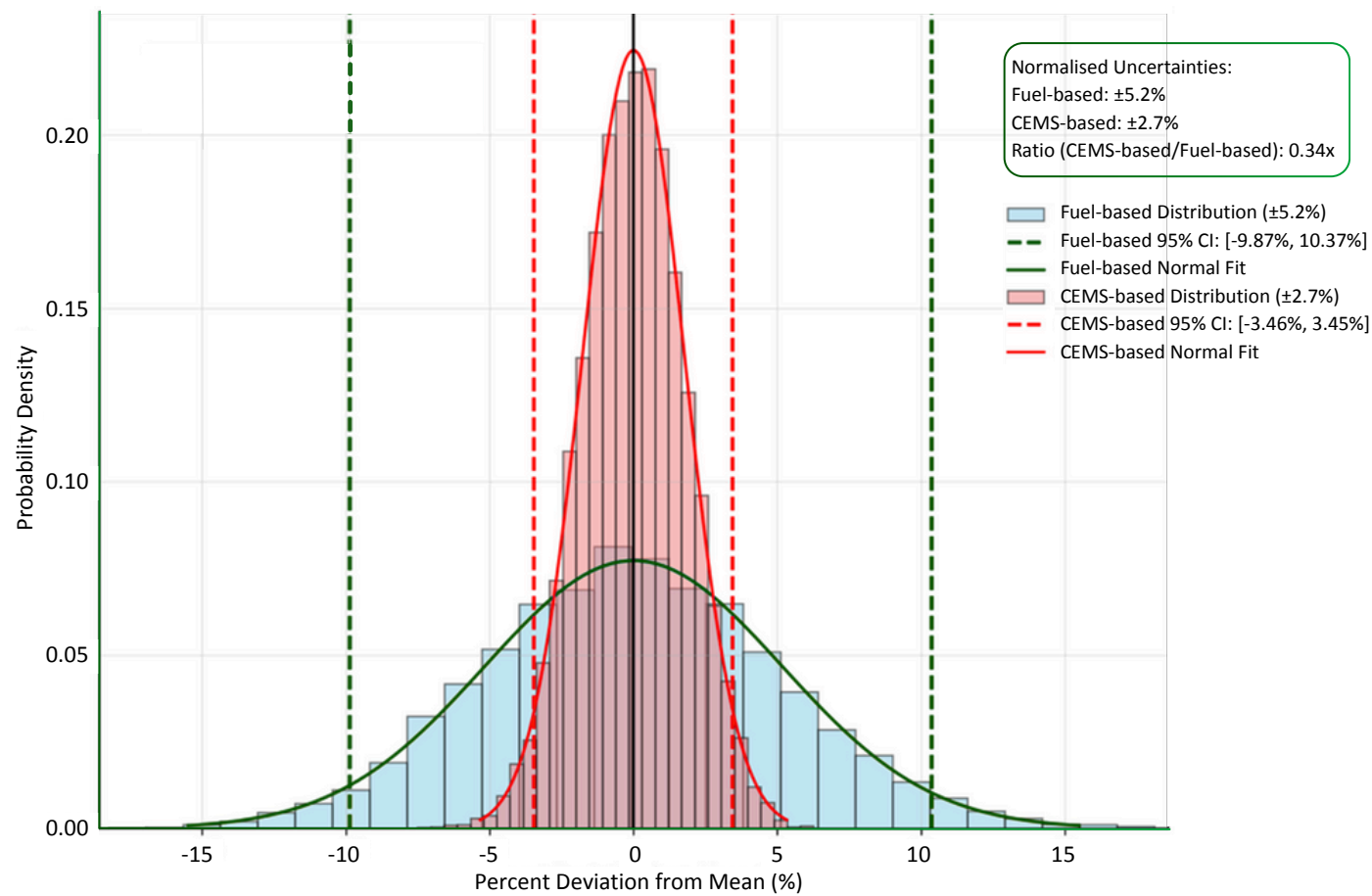


Figure 2: Comparison of CO₂e uncertainty distribution using fuel-based methods (Method C - blue) versus direct measurement using CEMS (Method D - red), showing the difference in total emissions uncertainty.

Figure 2 illustrates the significant difference in uncertainty between estimation and direct measurement for total CO₂e emissions. Emissions calculated from fuel consumption and emission factors (Method C) are inherently less precise, especially when manual data handling is involved. In contrast, direct measurement using CEMS (Method D) consistently shows narrower uncertainty bounds ($\pm 2.7\%$)⁴, offering better repeatability, transparency, and regulatory assurance.

Together, the results demonstrate that factor-based methods are no longer sufficient for compliance-grade reporting, particularly under frameworks like the EU ETS, which is increasing CH₄ inclusion rates from 40-70% to 100% in 2026.

In regulatory and commercial terms, the consequence of uncertainty is non-trivial.

Overreporting CO₂ due to estimator factors inflates taxation liabilities under schemes like the EU ETS. Underreporting CH₄, especially under variable engine loads, risks non-compliance with increasingly stringent methane regulations, as reflected by the rising inclusion rate in the EU ETS (from 40-70% today to 100% next year). This section demonstrates that estimation-based methodologies, even when enhanced with economical flowmeter readings, are no longer fit for purpose when precision, transparency, and accountability are required.

Progression of Emissions Measurement Methods

The maritime industry is undergoing a shift from manual, assumption-based reporting methods toward real-time, automated emissions monitoring. Each method, from Bunker Delivery Notes (BDNs) to direct measurement (Method D), offers a different level of accuracy and compliance readiness.

Manual logs and noon reports are still common but introduce high uncertainty and operator error. Fuel flowmeters (Method C) offer some improvement, but they still rely on static emission factors and indirect estimation. In contrast, direct measurement (Method D), such as PureMetrics™, captures real-world exhaust data across all engine loads, enabling a more accurate, traceable, and audit-ready emissions profile.

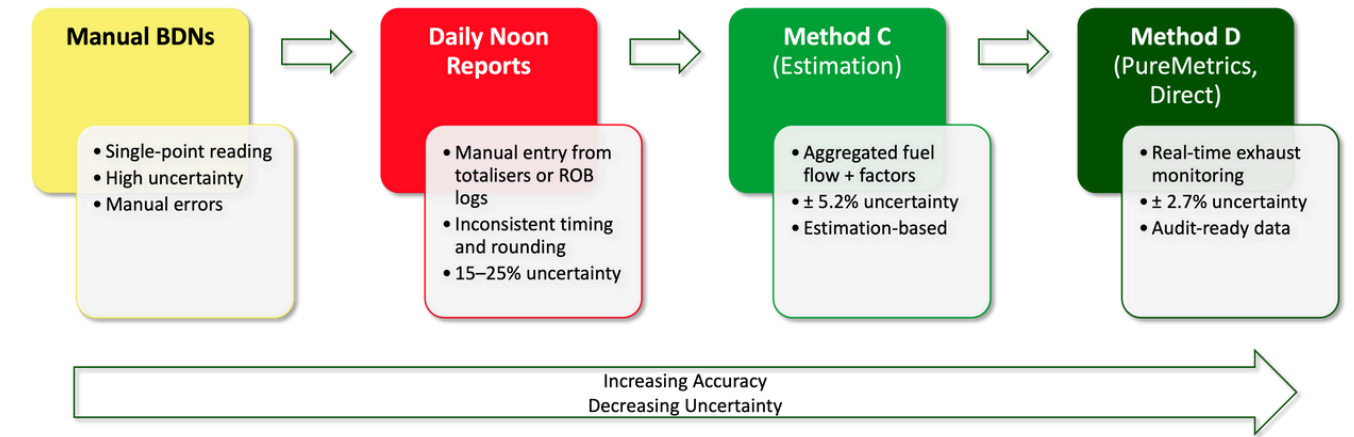


Figure 3: Emissions measurement methods are evolving from manual logs to real-time CEMS monitoring, with direct measurement offering the highest accuracy and traceability.

Comparison of Emissions Measurement Methods

Evaluating emissions monitoring approaches requires balancing implementation effort with data quality. While methods like manual logs and flowmeters may seem simple to deploy, their low accuracy and high uncertainty limit their usefulness under today's regulatory demands.

MRV Method D strikes a better balance. Though it requires a moderate installation effort, it delivers significantly higher data quality and lower uncertainty. This makes it the most robust option for operators who need compliance-grade emissions data and want to reduce exposure under schemes like the EU ETS.

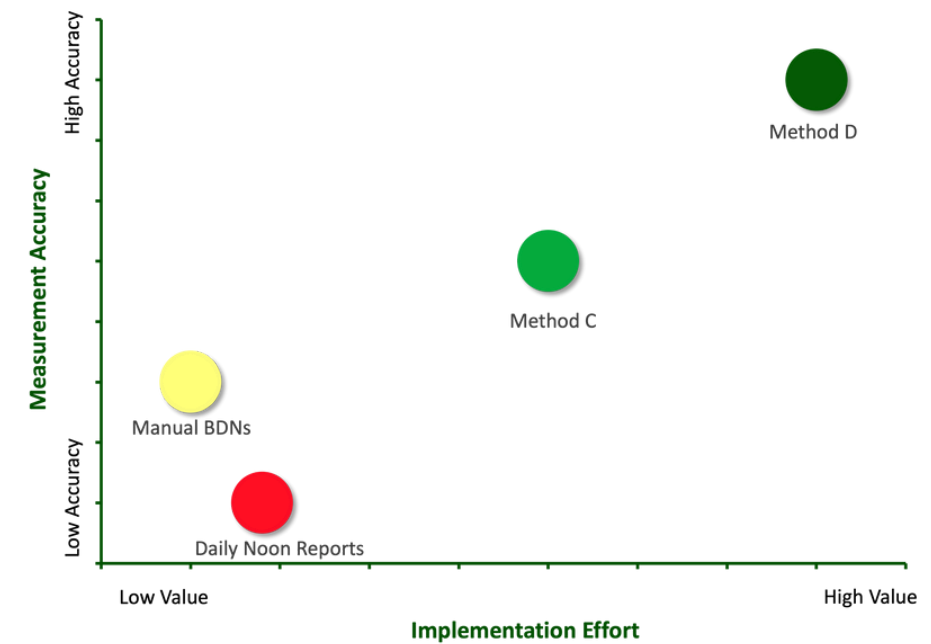


Figure 4: MRV Method D outperforms others in both accuracy and compliance suitability, while traditional methods fall short despite their lower implementation effort.

As the industry evolves, MRV Methods C and D are increasingly seen as the only viable paths for compliant reporting. This shift is explored further in the following chapters.

[4] Based on live emissions data collected through PureMetrics™ on dual-fuel commercial vessels. Results illustrate differences between direct measurement (MRV Method D) and estimation-based approaches. The $\pm 2.7\%$ uncertainty figure reflects aggregated results from certified CEMS measurements under MRV Method D, benchmarked against standard estimation methods.

Factor-Based Fuel Calculation Limitations

Factor-based emissions calculations rely on static emission factors applied to fuel consumption data. These factors, while standardised, are broad approximations that cannot account for real-world variations in engine performance, combustion dynamics, or fuel quality. This introduces significant uncertainty, particularly in maritime operations where loads fluctuate and operational profiles are inconsistent.

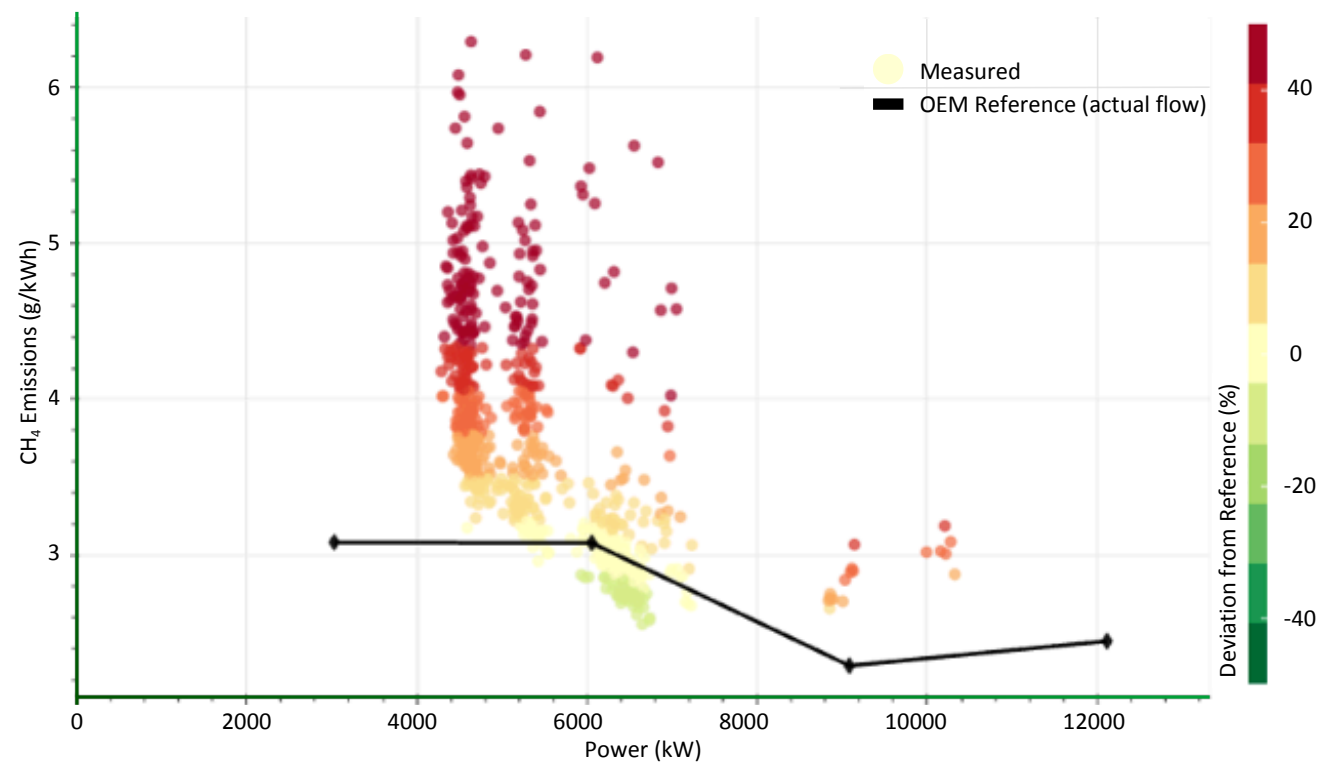
The uncertainty is compounded by the instruments used to measure fuel—BDNs, tank level soundings, and flowmeters, which themselves introduce errors. For example, emissions calculated from BDNs often deviate due to unrecorded fuel losses, transfer inconsistencies, fuel quality reports, or timing mismatches. When these measurements are combined with generalised emissions factors, the resulting data do not reflect actual emissions. With increasing compliance scrutiny, additional precision brings benefits to reporting.

CO₂ overestimation is a systemic issue in factor-based models. Emission factors are a generalisation of characteristics of all engine states, operating conditions, and fuel quality, resulting in disparate CO₂ outputs that could be avoided through

reporting. However, this leads to unnecessary financial burden under carbon pricing mechanisms. Case studies show that emissions calculated from fuel data exceed those derived from direct measurement.⁴

Methane (CH₄), with factors ranging from 0.2% to 1.7% for low-speed 2-stroke engines and up to 3.1% for medium-speed 4-stroke engines, has shown a clear underestimation and is an equally critical concern. CH₄ slip varies significantly with engine type, load, and maintenance status—factors not accounted for in static models. Real-world measurements indicate that actual slip can be 2 to 3 times higher than industry default factors. Published values often assume average conditions and underreport true slip rates by 30-60%, particularly in four-stroke dual-fuel engines.⁵ The EU FUMES study found similar results, reinforcing the risk of underestimating methane emissions in current reporting practices.⁶ This misrepresentation carries regulatory risk and obscures the true environmental impact of operations.

Figure 5: CH₄ g/kWh vs power for a low-speed dual-fuel engine (n=962 datapoints). Comparison between PureMetrics™ measured data (coloured circles) and OEM reference curve (black circles and line) from NO_x technical file series.

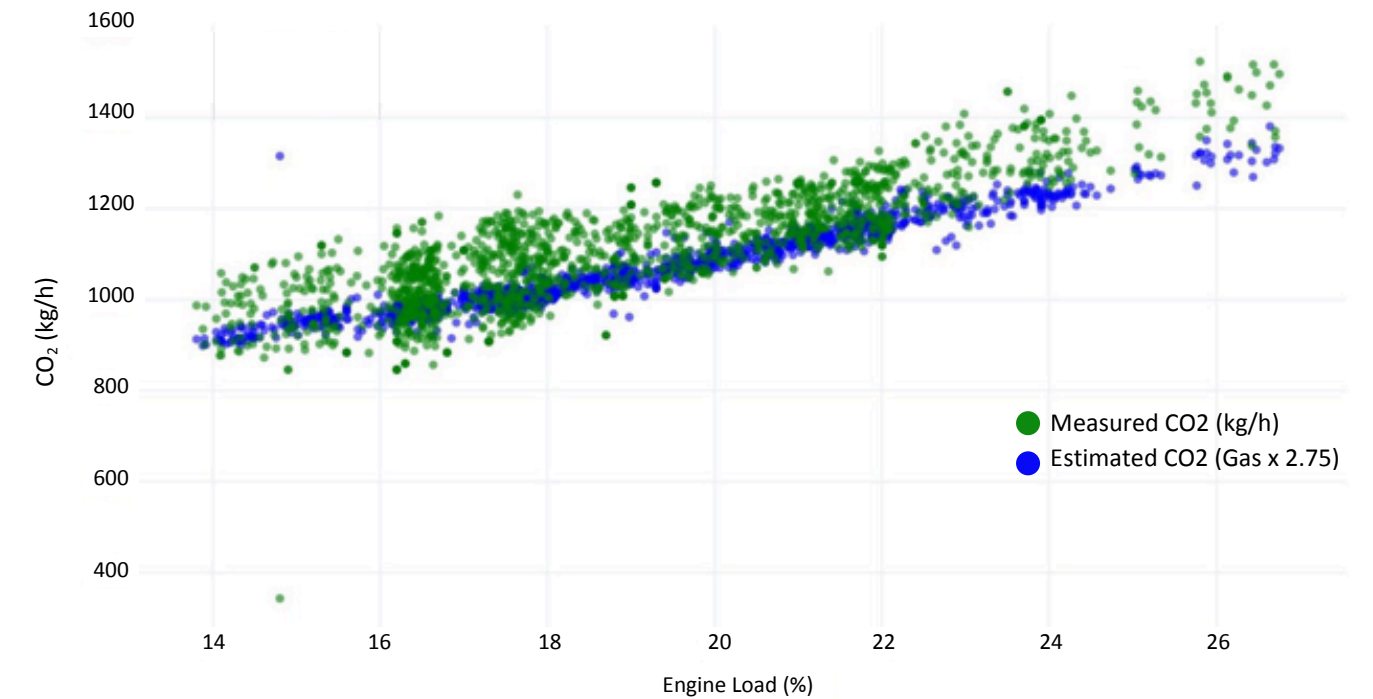


Comparative data between factor-based and direct measurement methods reveal consistent discrepancies. Statistical analyses highlight wider uncertainty bands around factor-based estimates, particularly for CH₄. This reinforces the conclusion that these methods, while convenient, are not suitable for operators seeking verifiable, audit-ready emissions data.

Figure 5 presents a sample dataset from a Low-Speed 2-stroke Dual-Fuel engine, where the engine OEM has published reference data for the engine or a parent engine in its NO_x technical file based on bench test conditions. The scatter plot shows measured CH₄ concentrations using PureMetrics™ across varying power loads. Reference data, based on the engine's NO_x technical file, is plotted for comparison. The visual disparity illustrates the limitations of default assumptions and emphasises the value of direct, engine-specific sensing for accurately capturing real-world methane slip quantification.

Figure 6 extends this comparison, highlighting discrepancies in CO₂ values. Measured data with lower variance diverge from Method C estimates, where calibration factors and flowmeter dispersion introduce additional uncertainty.

Figure 6: Comparison of CO₂ mass rates measured by PureMetrics™ (exhibiting lower variance and dispersion) versus Method C (flowmeter derived CO₂ mass rate). The chart highlights the lower uncertainty for direct measurements compared to calculated CO₂ rates.



[5]Independent studies from T&E, CE Delft, ICCT, SINTEF, and NTNU (2020-2024).

[6] International Council on Clean Transportation (ICCT). Fugitive and Unburned Methane Emissions from Ships (FUMES): Characterizing methane emissions from LNG-fueled ships using drones, helicopters, and onboard measurements. January 2024. <https://theicct.org/publication/fumes-characterizing-methane-emissions-from-lng-fueled-ships-using-drones-helicopters-and-on-board-measurements-jan24/>

The PureMetrics™ Solution

Direct Emissions Monitoring

Comparative Evaluation: MRV Method C vs. MRV Method D

To fully appreciate the operational and compliance benefits of direct emissions monitoring, it is useful to compare MRV Method C and MRV Method D side by side (Figure 7). These two approaches represent the most advanced measurement frameworks permitted under the EU MRV regulation and are the only viable options for operators pursuing verification-grade emissions data.

While Method C relies on fuel flow data and standard emission factors, Method D is based on real-time exhaust gas data, including concentration, flow, temperature, pressure, water content, and engine operational parameters. Method D offers improved uncertainty margins ($\pm 2.7\%$), based on validated CEMS data collected during live vessel operations, includes methane slip in its scope, and provides full traceability for auditing and verification purposes, making it better aligned with EU MRV and IMO DCS expectations.

This comparison demonstrates that while Method C provides a structured estimation framework, it falls short in areas critical to regulatory compliance, methane transparency, and operational insight. In practice, many reporters claim to use Method C but rely on differential readings entered manually, effectively applying Method B workflows. This introduces significant additional uncertainty, with error rates of 10% to 20%. Method D, as implemented through PureMetrics™, delivers a step-change in data quality, enabling more accurate reporting, financial optimisation, and environmental accountability.

Figure 7: Key differences between MRV Method C (fuel-based estimation) and MRV Method D (direct measurement), including data input, uncertainty levels, methane treatment, CO₂ handling, and traceability.

	MRV Method C (Emission Factors)	MRV Method D (via PureMetrics™)
Data Input	Fuel flowmeter readings + emissions factors	Real-time exhaust gas data (concentration, flow, temperature, pressure, water, engine data)
Accuracy (uncertainty)	$\pm 5.2\%$	$\pm 2.7\%$
Methane Slip	Based on published factors	Direct; actual CH ₄ levels measured
CO₂ Emissions	Based on conservative default values	Direct emissions data
Data Resolution	Aggregate monthly or voyage-level data	Audit-ready, real-time data
Traceability	Limited: Based on assumptions, flowmeter readings, and manual logs	Full: Stack gas measurements with CDM Tool 8 methodology and Class appraisal

Addressing Concerns About Direct Measurement

It is common for direct measurement data to differ from emissions calculated using fuel-based factors, particularly when CO₂ appears lower than expected. These differences do not reflect measurement error, but rather accurate accounting of unburned fuel and methane slip. PureMetrics™ uses CDM Tool 8 methodology, follows MRV Method D, and has been reviewed by classification societies. Unlike fuel proxies, it captures actual combustion outcomes, offering traceable, verifiable results based on real-world exhaust analysis.

PureMetrics™ leverages CEMS to perform direct emissions measurement across multiple exhaust stacks, delivering real-time emissions data. This method eliminates reliance on assumptions or theoretical estimates and provides high-resolution data across all engine loads and operating conditions.

The accuracy of PureMetrics™ is anchored in its direct sensing capability. While global warming potential (GWP-100y) factors—such as CO₂ (1), CH₄ (29.8 \pm 11) for fossil origin, and N₂O (273 \pm 130)⁷—still carry significant inherent uncertainties (typically $\pm 40\%$ and 47% respectively), which still apply to GHG calculations, PureMetrics™ minimises additional measurement error through the use of calibrated sensors and validated data capture protocols. In live installations, PureMetrics™ has demonstrated measurement uncertainty as low as $\pm 2.7\%$, significantly outperforming the $\pm 5.2\%$ uncertainty typical of a factor-based approach.

When comparing direct measurement to calculation-based methodologies, the differences are not only technical but operational. Direct sensing captures real variations in emissions due to combustion efficiency, load changes, and engine dynamics. This enables operators to move from assumptions to facts, essential for compliance, reporting, and performance optimisation.

The benefits extend beyond accuracy. PureMetrics™ enables direct emissions profiling, identifying trends and anomalies that would otherwise go unnoticed in periodic (daily fuel samples) reporting. Aggregated over time, this data supports fleet-wide benchmarking and operational improvements. It also facilitates dynamic reporting, producing compliance-ready outputs for EU MRV, IMO DCS, and other frameworks.

Real-world deployments of PureMetrics™ have demonstrated substantial financial value. Operators equipped with direct monitoring avoid CO₂ overpayment, reduce CH₄ underreporting risks, and unlock insights that contribute to fuel savings and optimised maintenance, based on more precise emissions accounting. Reports generated from PureMetrics™ data can be customised for verifiers, regulators, and internal stakeholders.

Key Takeaways

- Direct measurement (MRV D) reduces CO₂ emissions uncertainty to $\pm 2.7\%$.
- Methane slip underestimation may reach $\pm 60\%$ depending on the factor source.
- EU ETS CH₄ inclusion at 100% from 2026 makes estimation methods non-viable.
- PureMetrics provides compliance-grade data, supports audit-ready reporting, and can reduce exposure to emissions costs.

[7] IPCC AR6 – Global Warming Potential factors for CO₂, CH₄, and N₂O. <https://www.ipcc.ch/report/ar6/wg1/>

Business and Environmental Impact

Transitioning from estimation to direct measurement has material implications for compliance, cost, and competitiveness.

From a regulatory perspective, direct measurement supports regulatory readiness under EU MRV and IMO DCS frameworks. Unlike factor-based methods, PureMetrics™ provides traceable, auditable data that can meet the expectations of verification bodies and regulatory authorities. This reduces the risk of penalties and ensures transparent reporting across jurisdictions. The system is also compatible with SEEMP Change Plan requirements, further future-proofing compliance strategies.

Financially, accurate measurement translates to measurable savings. By avoiding overestimated CO₂ outputs and unaccounted CH₄ slip, operators reduce exposure to emissions trading costs and potential taxes. More precise, real-time emissions data also contribute to more efficient engine tuning, reduced fuel consumption, and targeted maintenance.

Strategically, direct monitoring offers a competitive edge. Charterers and cargo owners increasingly assess emissions performance in procurement decisions. Asset owners using PureMetrics™ can provide certified, high-resolution emissions data, enhancing transparency and meeting the growing demand for ESG-aligned operations. Early adopters have demonstrated not only compliance assurance but also reputational and commercial benefits.

The shift to direct emissions monitoring is not just a technological upgrade—it is a business enabler in a regulatory environment that demands precision, accountability, and operational insight.

Conclusion

Accurate emissions measurement is not only a technical improvement, it is a regulatory and financial imperative. As maritime regulations evolve under frameworks such as the EU Monitoring, Reporting and Verification (MRV) Regulation, the IMO Data Collection System (DCS), and the inclusion of shipping in the EU Emissions Trading System (EU ETS), operators are increasingly exposed to direct cost implications tied to the quality of their emissions data.

Estimation-based approaches, such as those relying on fuel consumption and conservative emissions factors, carry a substantial uncertainty margin—typically $\pm 5.2\%$ —and are prone to overreporting carbon dioxide and underestimating methane slip. This inflates carbon liabilities under emissions pricing schemes and risks non-compliance with methane-specific regulatory thresholds. Furthermore, these methods lack the transparency and traceability required for third-party verification, audit readiness, and defensible reporting.

PureMetrics™ addresses these challenges by performing direct emissions measurement using certified CEMS, delivering real-time emissions data. In a recent customer pilot conducted over 3 months of normal operations and on an LNG tanker with DF engines for propulsion and auxiliary power, PureMetrics™ resulted in 4% on fuel equivalent savings (compared to Method C), while actual methane slip was measured at 3.4% for the entire vessel. With an uncertainty margin as low as $\pm 2.7\%$, these results demonstrate that PureMetrics™ delivers a significantly higher degree of measurement accuracy and integrity while lowering reported CO₂ emissions. This enables operators to optimise their emissions reporting, reduce exposure under the EU ETS, and avoid costly discrepancies during third-party audits or regulatory reviews.

Regulatory Momentum Toward Direct Measurement

Recent developments at the IMO reflect growing institutional support for onboard measurement approaches. At MEPC 83, the committee encouraged the use of real-world test-bed and direct emissions monitoring as a credible alternative to factor-based estimation. This signals a future regulatory landscape increasingly aligned with the core capabilities of systems like PureMetrics™.⁸ The proposed Gas Fuel Intensity (GFI) framework, combined with Regulatory Units (RUs), which function as penalties, and Support Units (SUs), which serve as incentives, further reinforces the need for accurate, verifiable emissions data as both a compliance and commercial lever.

While Method D is not yet universally accepted as a primary method by classification societies, Daphne Technology advocates for its recognition as the principal standard, given its significantly lower uncertainty and higher transparency. Today, it remains a complementary option, but its value proposition is evident and increasingly urgent.

In an environment where carbon pricing and environmental disclosure are increasingly linked to business performance, the shift from estimation to verification is no longer optional. Direct emissions measurement with PureMetrics™, supported by real-time data, empowers shipowners, fleet managers, and compliance officers to meet regulatory obligations, reduce financial risk, and build operational strategies on accurate, defensible data.

[8] IMO. IMO approves net-zero regulations for global shipping. April 2024. <https://www.imo.org/en/MediaCentre/PressBriefings/pages/IMO-approves-netzero-regulations.aspx>

References & Regulatory Alignment

PureMetrics™ Operational Data

Based on field deployment data and emissions readings collected using certified CEMS equipment on commercial dual-fuel vessels. These data have been benchmarked against industry default factors and used to compare estimation and direct measurement methodologies.

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- UNFCCC. CDM Tool 8: Tool to Determine Emissions from Fossil Fuel Combustion. <https://cdm.unfccc.int/methodologies/PAMethodologies/tools/am-tool-08-v3.0.pdf>

Glossary

CEMS – Continuous Emissions Monitoring System

A system that uses sensors to directly measure exhaust gas composition onboard. Under MRV Method D, CEMS is used to quantify CO₂ emissions based on actual combustion output.

CO₂ – Carbon Dioxide

A greenhouse gas produced from the combustion of fossil fuels. It is the primary focus of most maritime emissions regulations.

CH₄ – Methane

A potent greenhouse gas often released through methane slip in gas-fueled engines. Its global warming potential (GWP) is 29.8 times higher than that of CO₂ (IPCC AR6).

GHG – Greenhouse Gas

Gases that trap heat in the atmosphere. In this paper, the focus is on CO₂, CH₄, and N₂O.

GWP – Global Warming Potential

A metric used to compare the impact of different greenhouse gases over a set time horizon. Values are established by the IPCC.

MRV – Monitoring, Reporting and Verification

A European regulation requiring ships to monitor and report annual CO₂ emissions. It defines four methods (A-D) for how emissions can be calculated or measured.

MRV Method C

An estimation-based method using fuel flowmeter data combined with standard emission factors.

MRV Method D

A direct measurement method using certified CEMS to measure CO₂ emissions from exhaust gases.

NO_x – Nitrogen Oxides

Pollutants formed during combustion, referenced here in relation to engine technical files used for CH₄ comparison plots.

EU ETS – European Union Emissions Trading System

A carbon pricing mechanism that includes maritime transport. Reported emissions are subject to carbon cost under this framework.

IMO – International Maritime Organization

A UN agency responsible for regulating shipping. Sets guidelines for GHG reporting and lifecycle assessment.

DCS – Data Collection System

IMO's framework for collecting fuel consumption and distance data from ships.

CDM Tool 8 – Clean Development Mechanism Tool 8

A UN methodology for determining emissions from fossil fuel combustion. Used for calculation protocols and traceability.

GFI – Gas Fuel Intensity

A proposed IMO metric for measuring emissions intensity from gas-fueled vessels.

RUs – Regulatory Units

Potential penalty instruments used under future GHG frameworks for emissions performance below target thresholds.

SUs – Support Units

Potential incentive instruments used to reward vessels for emissions performance above regulatory expectations.

