Methane Abatement in Maritime Innovation Initiative (MAMII)

Practical learnings and technology updates on methane emissions in maritime

IMO Technical Seminar on methane-based fuels

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MAMII at a glance

Methane is **28 times more potent** than CO2 on a 100-year scale and the second most significant Greenhouse Gas (GHG).

! Adopting a GWP20 approach means that methane's climate impact is 82.5 times more potent than CO2

MAMII Mission:

"An innovation initiative led by Safetytech Accelerator in collaboration with key maritime and LNG stakeholders, accelerating the adoption of technologies to monitor, measure and abate methane emissions."

Our Goal

To mitigate the environmental impact of LNG-fuelled ships

WtT

- ✓ LNG value chain ~4% of global CH_4; WtT much lower
- ✓ Monitoring tech enables global methane detection
- ✓ MAMII WtT transparency & certification (e.g. collaboration with MiQ)

TtW

- ✓ Methane slip is the main onboard methane emissions source, regardless of fuel origin.
- ✓ Methane abatement is a fast, high-impact shipping climate solution.
- ✓ Technology allowing for negligible methane emissions is already proven and available.

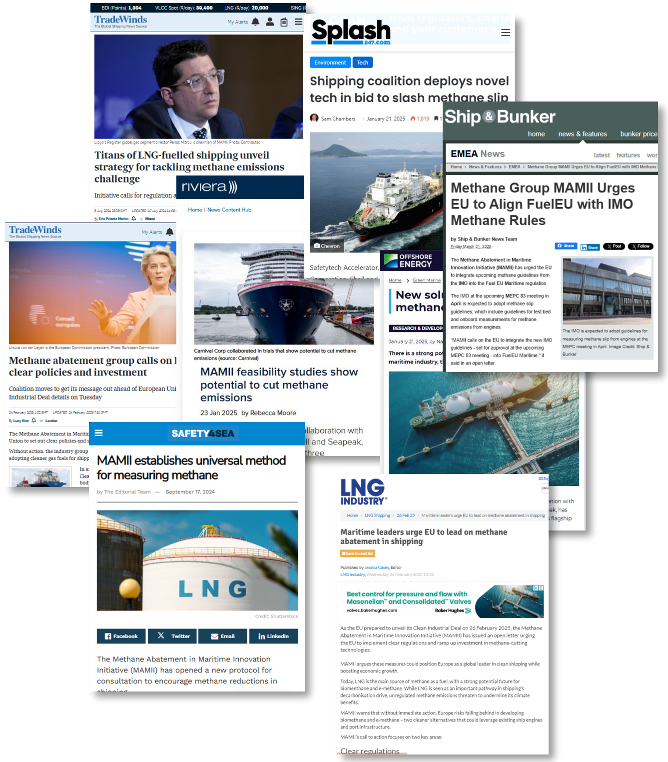
MAMII in a nutshell

40%

LNG powered vessels are part of MAMII

Industry-led initiative to measure and **reduce methane emissions** from LNG-fueled ships, launched by Safetytech Accelerator in 2022.

20 major shipping lines, energy firms, and technology providers to **accelerate methane abatement** technology adoption.



Focus on technology **trials, feasibilities, and advocacy**, for methane measurement and abatement.

MAMII Current Activities

Pillar 1: Technology Landscape

- Ongoing tech scouting & landscape analysis
- Structured evaluation of maturity, feasibility & performance
- Curated tech reports & targeted showcases
- Deep-dive sessions with selected providers
- MAMII events with demos & industry engagement

Pillar 2: Pilot & Feasibility Support

- Prioritize technologies for studies & pilots
- Bi-weekly feasibility calls with providers & partners
- Share feasibility results with partners
- Advance selected technologies to pilots
- Share pilot design & execution best practices

Pillar 3: Advocacy & Outreach

- Working group on EC guidelines for reporting and verification of actual TtW methane slip (Cslip) emission factors
- Coordinated responses to methane regulations & policy monitoring
- Ongoing Brussels engagement with MEPs & European Commission officials

Pillar 4: Protocol, Operations and Collaboration

- Exploring collaboration with SEA-LNG as technical partner at IMO.
- Participation in FUMES 2 Scientific Advisory Board
- Exploring collaboration with SIGTTO
- Engage on well-to-tank methane transparency & certification (e.g. MiQ)

MAMII Technology Highlights

240+
Companies identified (measurement, abatement and fugitive emissions detection)

10+
Feasibility studies

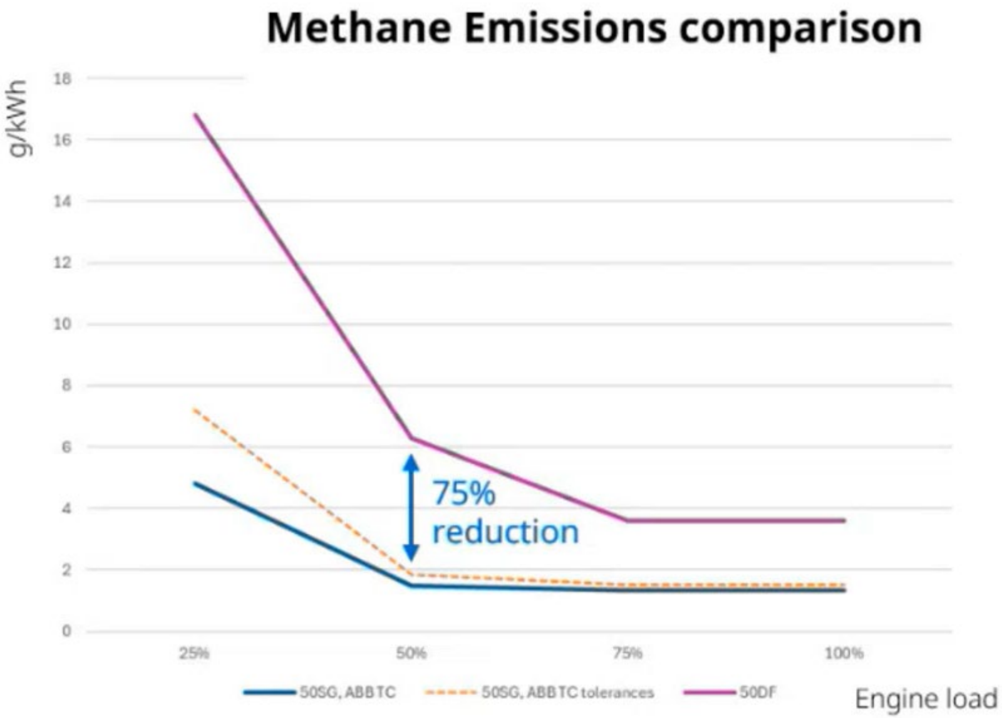
18+
Deep dive sessions

	Measurement	Abatement	Fugitive Emissions
Companies analysed:	72	98	76
Tech Categories:	Laser Spectroscopy, Standoff Cameras, IoT / Solid state sensors, Drones, Gas Chromatography, Satellites, Flow Meters	Catalyst, Scrubber (Wet/Dry), Plasma, Drones	Optical gas imaging, Sensor Networks & AI, Laser based system, Acoustic/Ultrasonic Imaging, Methane capture materials, Hyperspectral Imaging, others
Deep Dive Sessions:	Emsys, Yokogawa, Sailplan, SeaArctos, Servomex, Tunable, Kongsberg, Daphne Technology	Ecospray, CSSC, Sailplan, Hycamite, Johnson Matthey	Konica Minolta, Oiler, Emerson, Honeywell, Explicit
Feasibility Studies:	Green Instruments, Everimpact	RotoBoost, CDTi, Plenesys, Daphne Technology, Bennu	Xplorobot, Framergy, Sorama

Engine Developments – Cslip Improvements

4-Stroke Engines

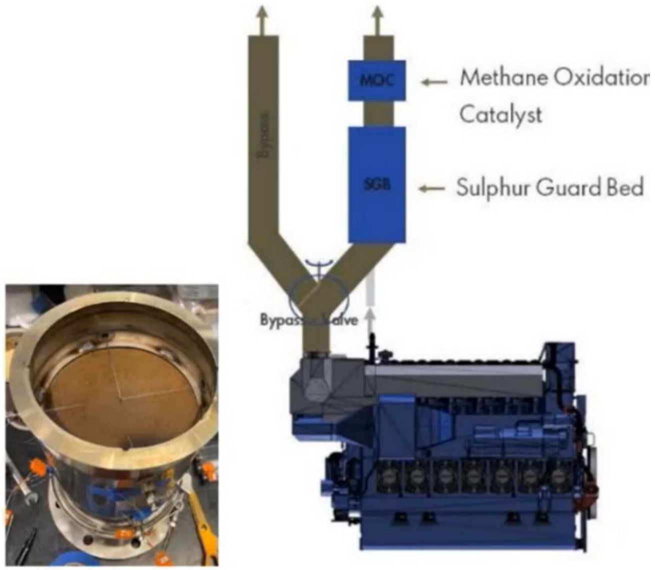
50DF Conversion to Spark Gas (SG)



- **Retrofit option** for 50DF engine
- The SG solution introduces an electrically controlled pre-combustion chamber valve for a more optimized combustion process
- Potential improvement in efficiency and **methane slip reduction up to 80%**

Source: Wartsila, 2025

Methane Oxidation Catalyst

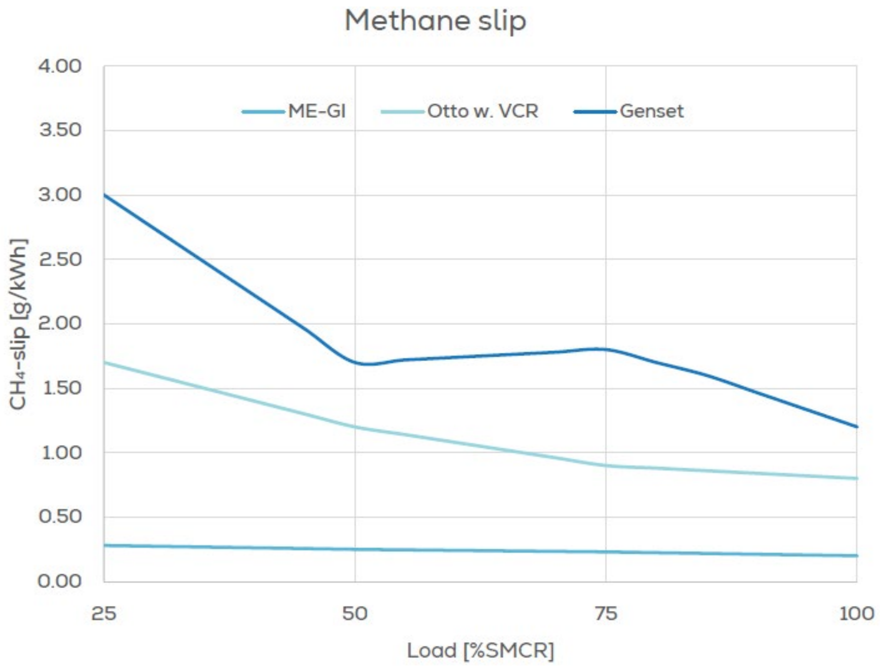


Key challenges – Under testing:
- Sulphur tolerance – sulphur guard bed, non-noble catalysts
- High temperature requirement – more active catalysts, pre-turbine installations
- Effect on engine operation – especially in the case of pre-turbine solutions
- Economic feasibility – size, cost, lifetime

Pilot project with SHELL currently in progress

High-Pressure 2-Stroke Engines

B&W G70ME-10.58 and 10.7-GI



- **Gas Injection Pressure**
- ME-10.58-GI: 325 bar
- ME10.7-GI: 380 bar
- Lower **fuel consumption** compared to the existing G70ME-C10.5
- **Tier III Abatement** with HPSCR, EGBP or EcoEGR

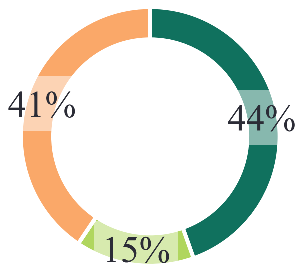
Source: Everllence, 2026

X82/92-DF-HP

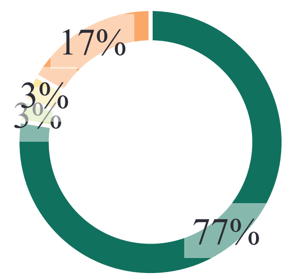
- **High-Pressure** DF LNG combustion system
- **First deliveries** expected in **2028**
- Available in X82 and X92 bore sizes
- **Tier III emissions compliance with SCR**
- Compatible with **LNG**, **bio-LNG**, and **e-LNG**.

Source: WinGD

LNG DF Fleet (excl. LNGCs) | Existing



LNG DF Fleet (excl. LNGCs) | Orderbook

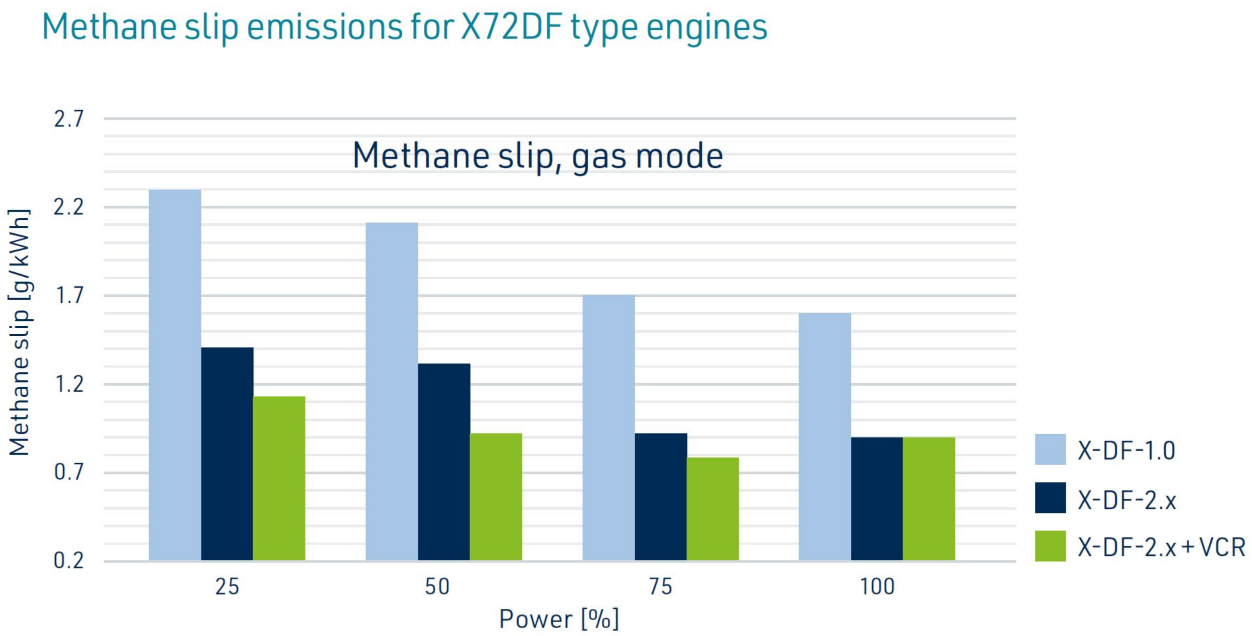


■ HP2S ■ LP2S
■ LP2S + EGR ■ LP4S

Source: IHS Database (Dec. 2025)

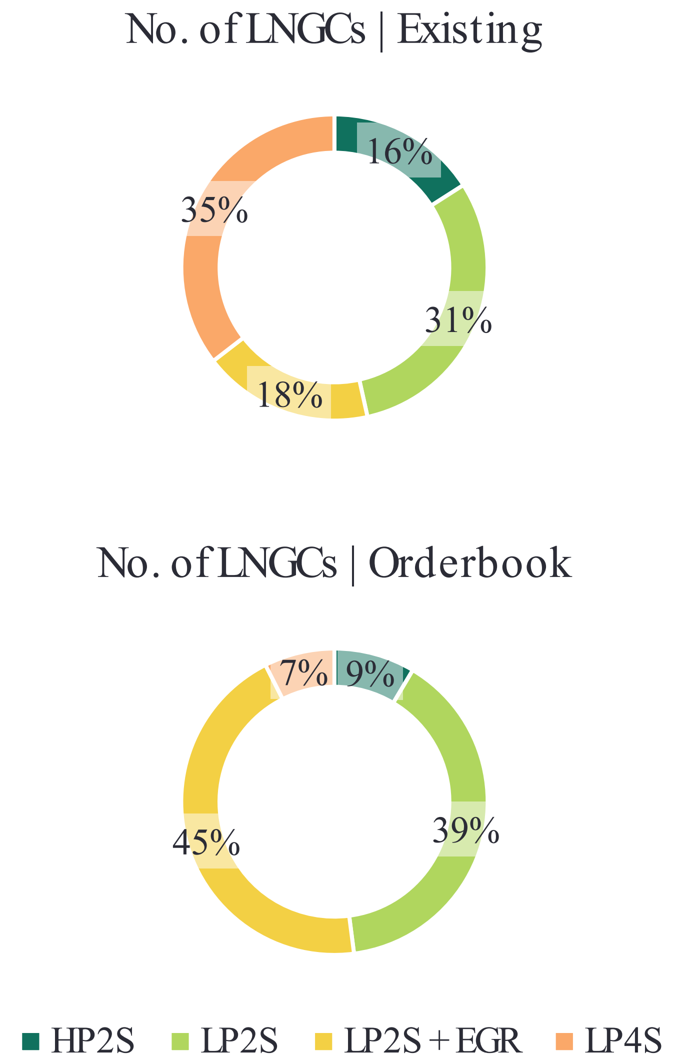
Low-Pressure 2-Stroke Engines

X-DF2.2/2.x



- With iCER or VCR technology, methane emissions expected to be lower than these of first-generation X-DF engines
- **iCER** technology is available for **X72DF-2.1/2.2**
- Variable Compression Ratio (**VCR**) technology available for **X62DF-2.1, X62DF-S2.0 and X72DF-2.1/2.2**
- VCR offers **fuel consumption reduction by up to 3.1%** in gas mode.

Source: WinGD



Source: IHS Database (Dec. 2025)

Methane Oxidation Catalysis (MOC)

What is a MOC?

Passive solution for methane slip reduction.

$$CH_4 + 2O_2 \xrightarrow{\text{Methane Oxidation Catalysis}} CO_2 + 2H_2O$$

Critical Parameters:

- Exhaust Gas Impurities
- Temperature Range – methane conversion increases when temperature rises
- Exhaust flow – lower exhaust flow, increased conversion rate

Main Challenge:

Catalyst stability – Brief exposure to trace of sulfur (ppm level) may result in irreversible catalyst loss (sulfur poisoning).

Solution:

Sulfur (SOx) guard that traps sulfur before reaching the catalyst.

Without sulfur guard, MOC lifetime is very limited.

1

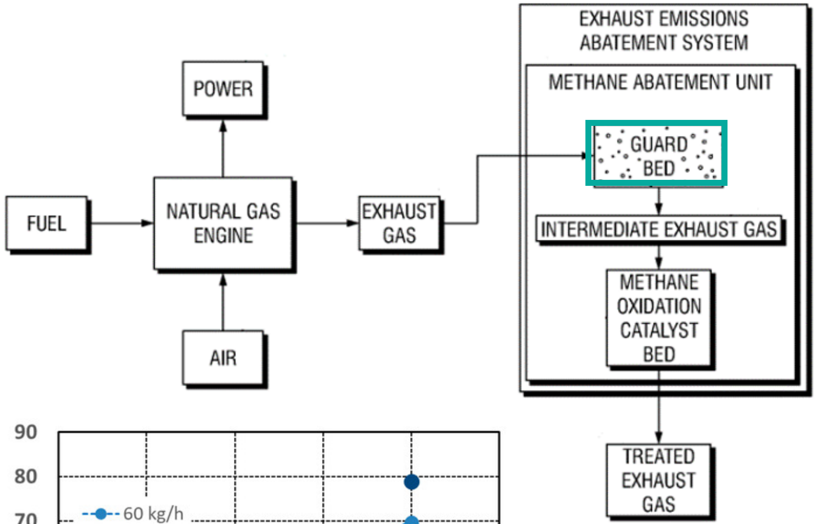
Sulfur Trap

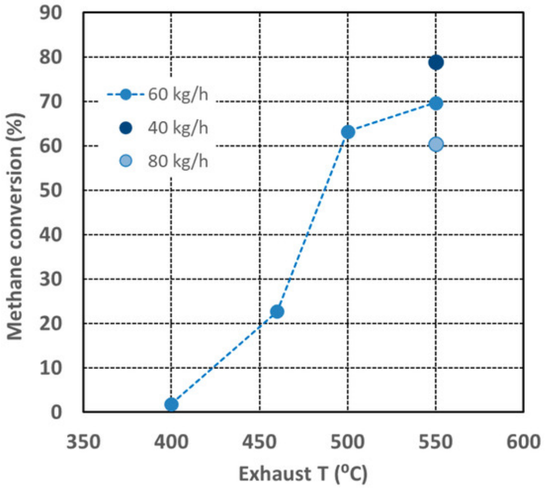
Cleaned exhaust first passes through CDTi's sulfur adsorber, where sulfur compounds are captured and contained.

2

Methane Oxidation Catalyst

Exhaust passes through an oxidation catalyst, converting methane into water and carbon dioxide.

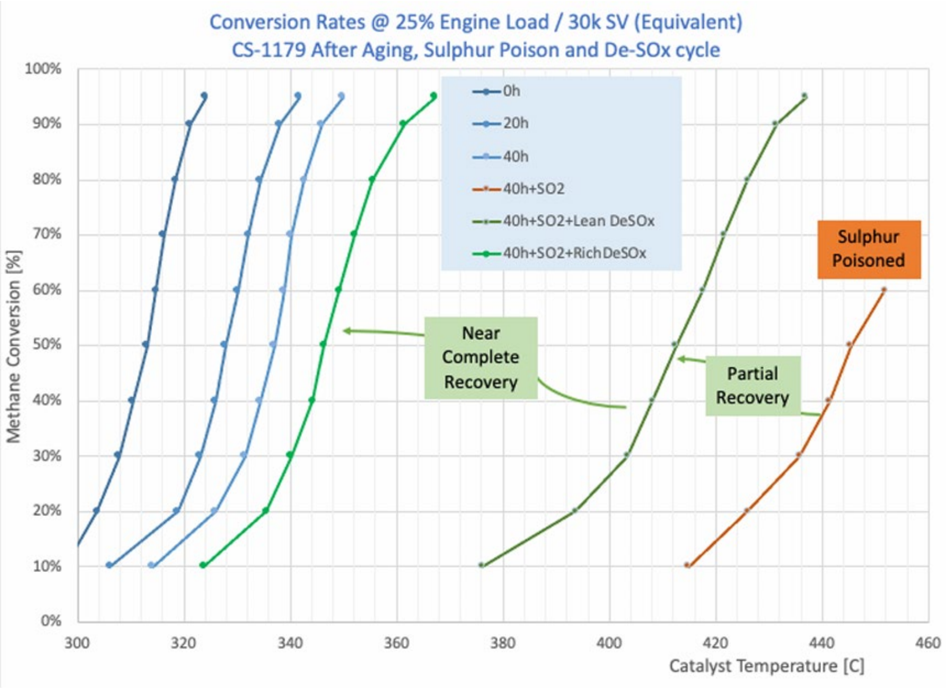




Source: VTT - Dinex, Green Ray Project, CDTi

CDTi: Methane Oxidation Catalyst

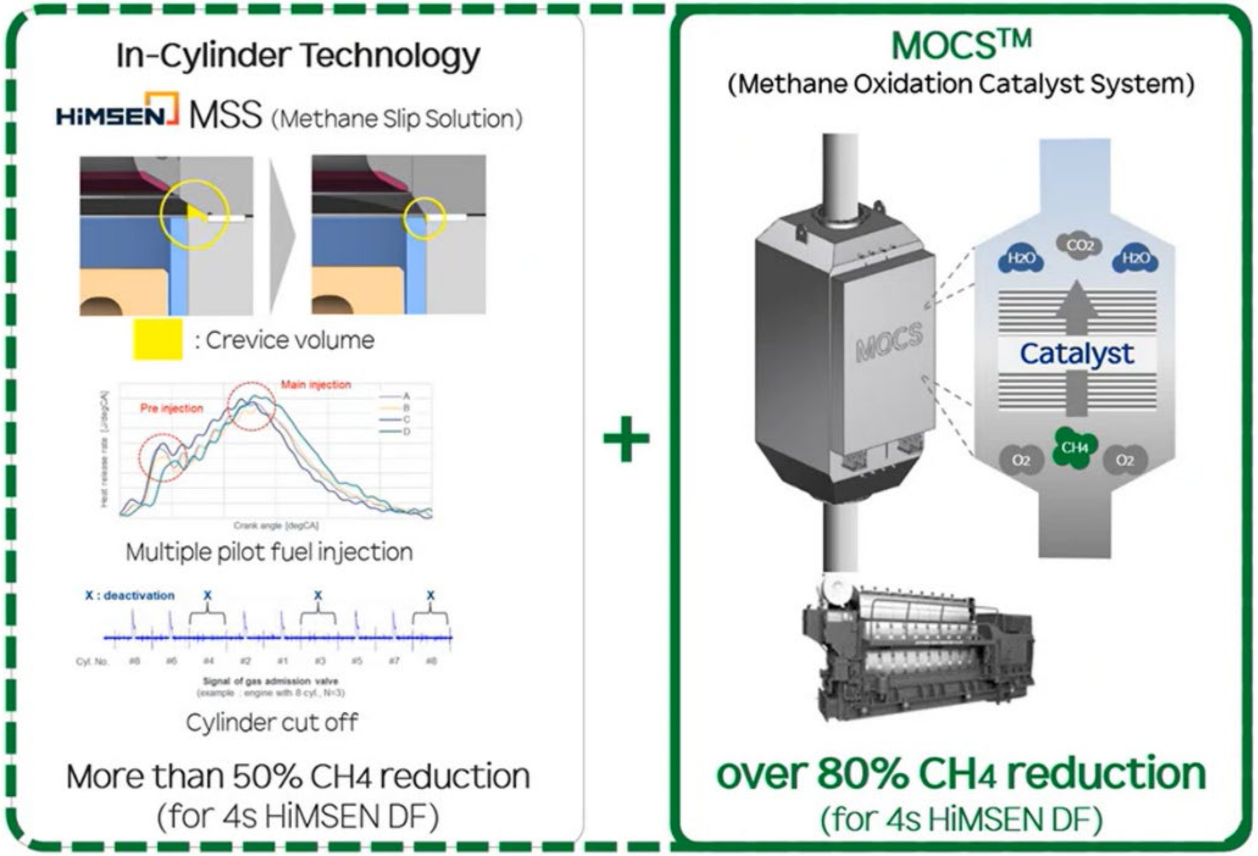
- **Oxidises CH_4 into CO_2 and H_2O**
- Two-stage system:
  - **Sulfur adsorber** to protect the catalyst from poisoning
  - **Methane oxidation catalyst**
- Operates effectively across **variable engine loads and temperatures**
- Reduction: Up to **80% methane conversion**
- Maintenance: **every 3,000 hours**
- MOC expected lifetime: **20,000 hours**
- **Lab-based validation**: *Testing conducted in simulated exhaust conditions using synthetic gas, including catalyst performance mapping, aging simulations and sulfur poisoning/recovery studies.*
- No public pilot demonstrated



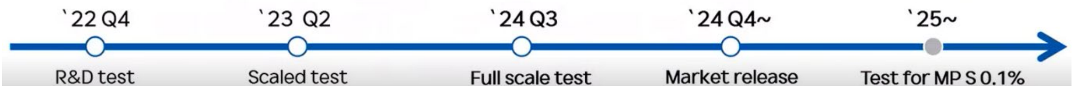
Source: CDTi, 2026

Other MOC examples

In-cylinder technology and software updates could reduce methane slip up to 50%; MOCS under development



MOC tested for 800 hours, with full-scale engine tests in 2025;
sulphur resistance up to 0.1% under development



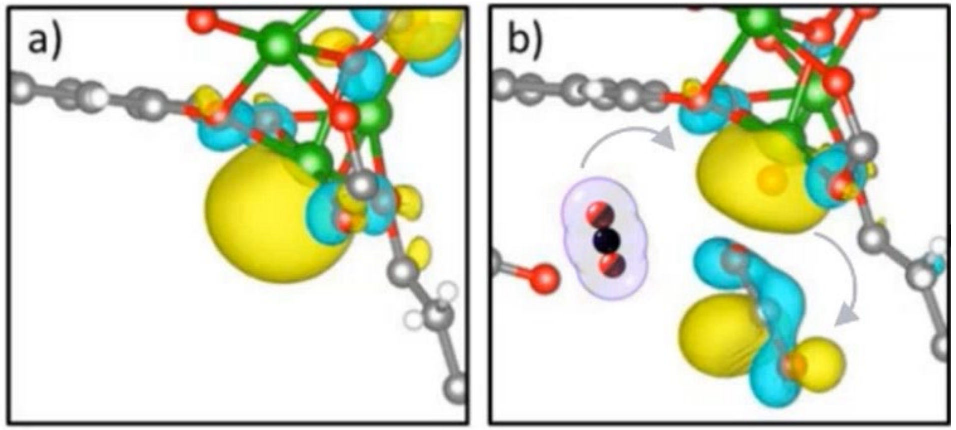
Source: Himsen, 2025

Emerging technology: Metal Organic frameworks (MOFs)

Already applied to land facilities| Ongoing research for ship installation feasibility

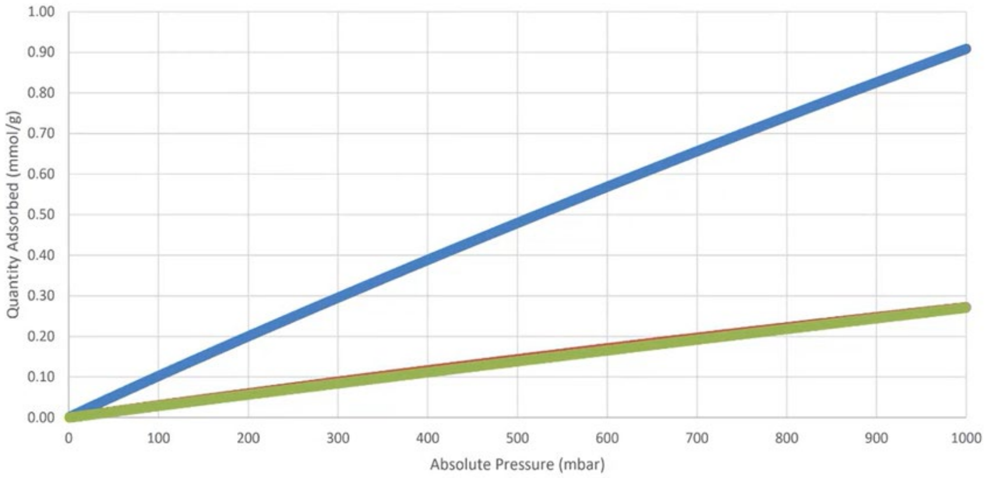
Applications include:

- Gas treatment
  - Air treatment – capture of GWP pollutants (CO_2, Methane, Nox, HFC etc.), atmospheric water harvesting
  - Gas storage
  - Gas separations including cyclic H_2S capture
  - Catalytic treatment applications
  - Temperature

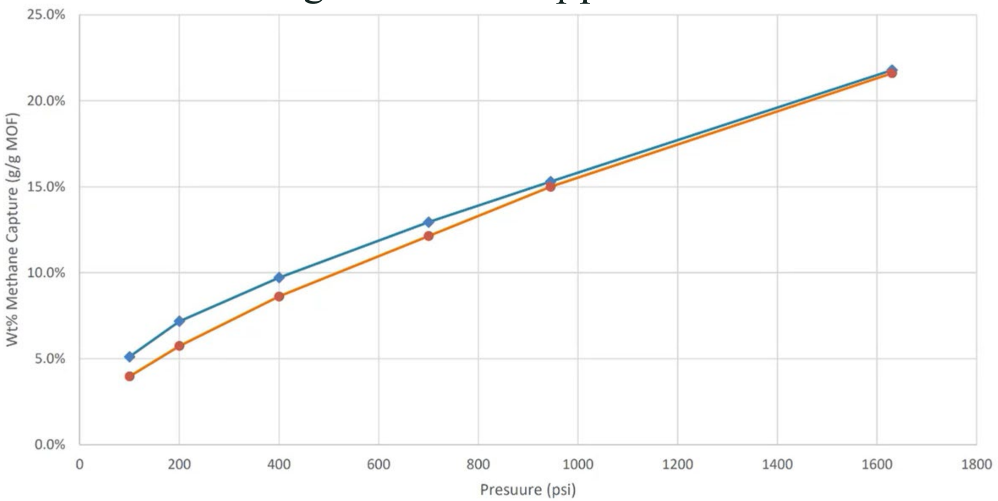


Source: Framergy, 2025

Low- Pressure Application



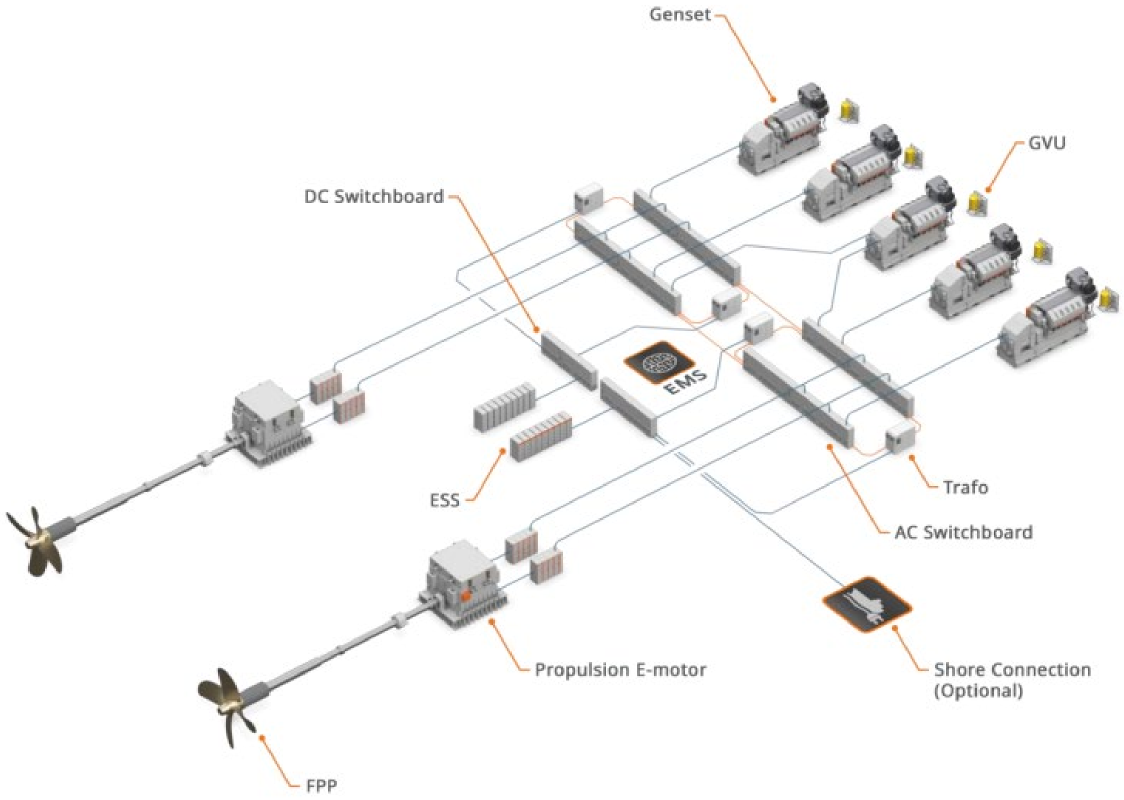
High- Pressure Application



SHELL – Wartsila – Hanwha Ocean Hybrid Concept

Hybrid electric system overview

- Fully electrified & modular power system
- Mix of Wärtsilä 31 Spark Gas and Dual Fuel GENSETS
- Wärtsilä 690VAC, Low-Loss Concept electrical distribution - minimum electrical losses and maximum redundancy´& highly proven in service
- 2MWh, 3C Battery Energy Storage combined with DC Hub & Smart Energy Management Software:
  - Spinning Reserve -> enables optimal load factors to greatly improve performance and reduce running hours
  - Peak shaving -> enables steady state load on generating sets & eliminates dynamic load losses
  - Capability to operate in zero emissions mode with either battery or shore connection
- Efficient and compact permanent magnet e-motors driving large and efficient low speed FPPs
- 30% lower installed power and 40% lower weight vs current 2-stroke designs



Source: Shell – Wartsila – Hanwha Ocean, 2025

Concluding Remarks

- **Technology** which can ensure WtW methane emissions mitigation is **available** as we speak

- **Methane slip has been reduced by 60-70%** across all engine technologies in the last 3 years. MOCs and other abatement solutions can deliver up to total extinction of methane slip.

- We are not yet there, the integration of methane in **more regulatory schemes** in the future could have a **detrimental impact** to many engines in service. We need to look back and develop retrofit solutions.

- With the introduction of **methane measurement guidelines**, we have taken a huge step in addressing the problem. There are still though a number of questions stemming from their application and more work to be done in rationalizing them.

- As more energy is now invested on methane slip, we should take a closer look to operational or fugitive leaks , develop operational guidelines and uptake feasible technology towards the **methane proof ship**

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