REDUCING GHG EMISSIONS FROM MARINE ENGINES USING GreenMarine™ HYDROGEN FUEL ASSIST RETROFIT

DECARBONISATION WITH PROFIT

A practical, low-capex pathway to reduce diesel consumption and tCO_2e for every Marine Engine

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Marine Industry at a Turning Point

- **IMO's Ambitious 2050 Net-Zero Target**

The IMO has established a goal to achieve net-zero greenhouse gas emissions from international shipping by 2050,requiring immediate action.

- **Regulatory Compliance Pressure**

Stricter emission limits under MARPOL Annex VI and impending carbon pricing mechanisms are transforming operational requirements.

- **Legacy Fleet Challenge**

90% of vessels operate with legacy diesel engines that cannot be easily replaced,creating an urgent need for retrofit solutions.

- **Financial Imperative**

Fleet operators face mounting pressure to maintain profitability while investing in sustainability technologies.

- **Beyond CO_2 Concerns**

Regulations increasingly target multiple pollutants including NOx,SOx, and particulate matter,requiring comprehensive solutions.

Industry Status Quo

- 90% of Global Fleet: Operates with legacy engines
- Immediate Need: Retrofit Solutions for Decarbonization
- Key Challenge: Balancing Profitability with Sustainability

The Marine Sustainability Challenge

Emerald FuelSystems SGT

Regulatory Pressure

Stricter emission limits under MARPOL Annex VI, impending carbon pricing mechanisms,and complex global compliance requirements.

The Compliance Dilemma

Operators must balance immediate regulatory needs with long-term sustainability goals while maintaining commercial viability.

Commercial Pressure

Growing customer demand for green shipping, increased ESG scrutiny from investors,and brand reputation risks in sustainability performance.

Traditional Solutions Drawbacks

High capital expenditure,significant vessel modifications,and extended implementation timelines limit adoption of conventional approaches.

Operational Pressure

Volatile fuel costs directly impact profitability,aging fleets require retrofitting solutions,and limited options exist for immediate implementation.

Introducing SGT -GreenMarine ™

Emerald FuelSystems SGT

Revolutionary Hydrogen-Assisted Combustion

Precise hydrogen injection optimizes fuel burning for maximum efficiency and minimal emissions.

Immediate Performance Benefits

3-15%fuel savings,70%+particulate matter reduction, and significant NOx decrease across all engine loads.

Simple Retrofit Solution

Non-invasive installation requires no engine modifications,preserving warranty and classification.

Versatile Application

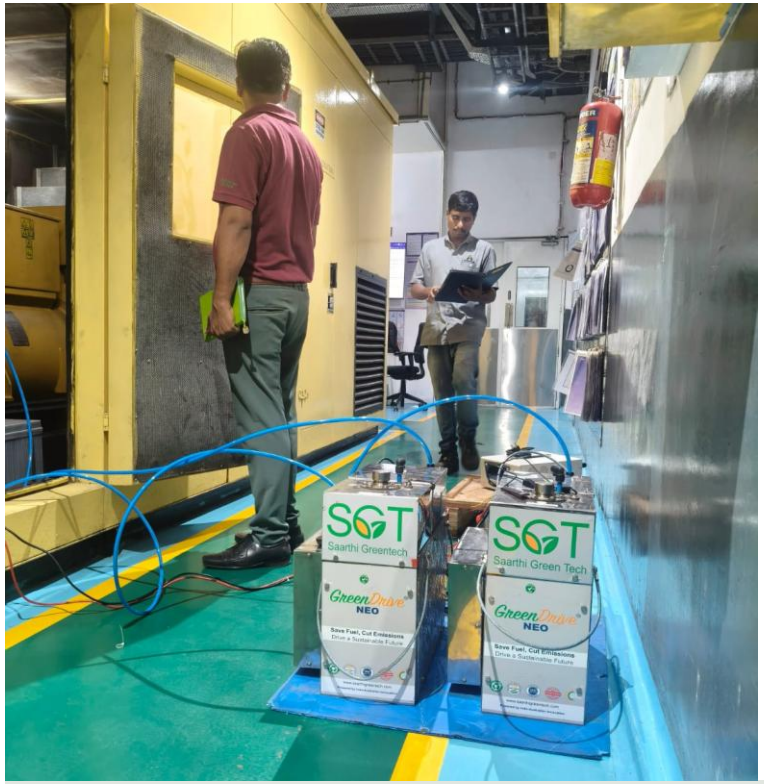
Compatible with auxiliary engines and high-speed propulsion systems across various vessel types.

Real-Time Performance Monitoring

IoT-enabled system provides continuous data on fuel savings and emissions reduction.

Extended Engine Life

Lower operating temperatures and reduced carbon deposits extend maintenance intervals.



System Benefits

- 3-15%reduction in diesel consumption based on load
- Significant reduction in PM,NOx,CO,and HC emissions
- Optimizes combustion without engine modification
- No need for high-pressure hydrogen storage-Inherently safe

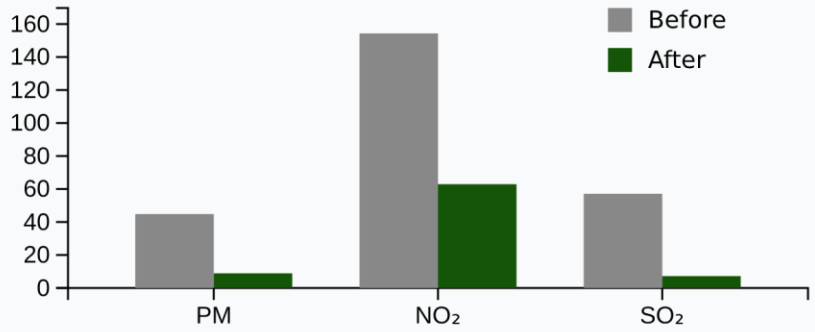
Proven Validation for Large DG Sets (Aux. Engines)

Two Sample Test Results

Independent NABL Testing

1500 kVA DG Results

Tested by NABL Accredited Lab



PM Reduction:
80%

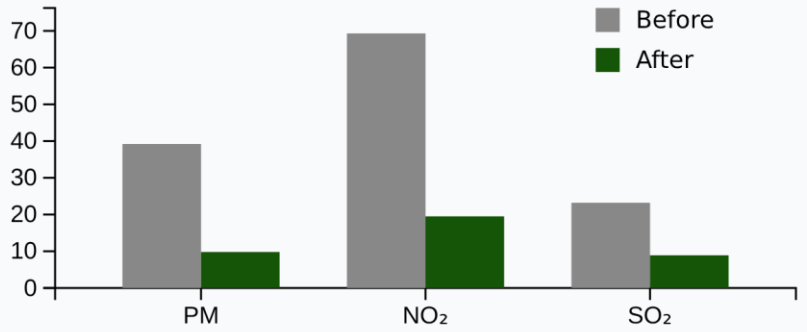
NO_2 Reduction:
59%

SO_2 Reduction:
87%

Fuel Efficiency:
8.5%

380 kVA DG Results

Tested by NABL Accredited Lab



PM Reduction:
75%

NO_2 Reduction:
72%

SO_2 Reduction:
62%

Fuel Saving:
3-12% (based on load)

Combined Results: Significant Emission Reductions & Fuel Efficiency Gains

8.5% Average Fuel Savings

Proven Validation Across DG Sizes

Comprehensive Testing & Validation

Range: Tested on diesel generators from **125 kVA to 1500 kVA**

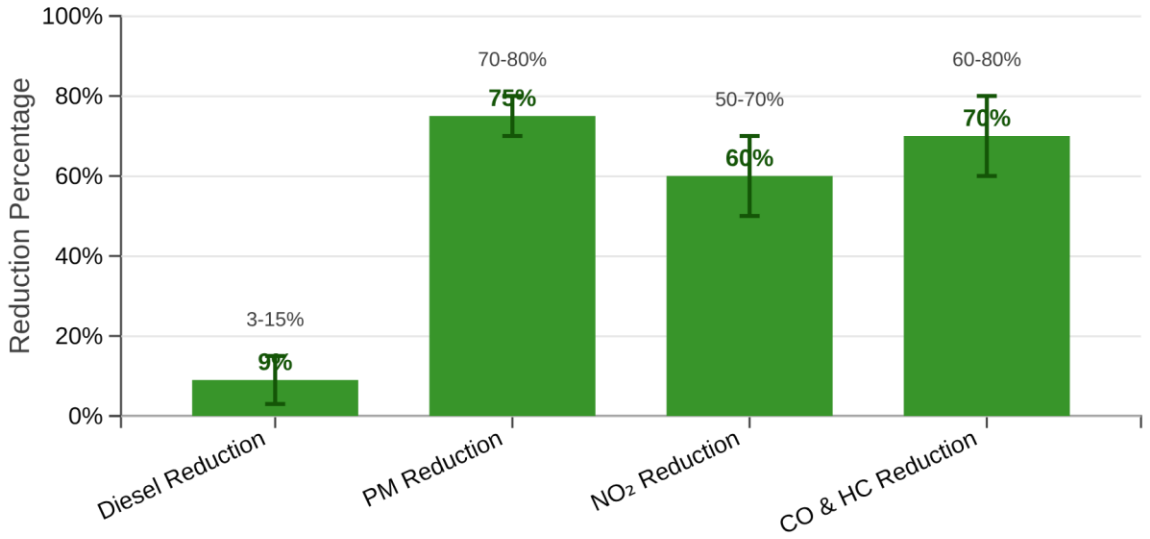
Fuel Reduction: Consistent **3% to 15%** reduction in diesel consumption

Particulate Matter: 70% to 80% reduction in PM emissions

NO_2 & Other Emissions: 50% to 70% reduction in NO_2 and **60% to 80%** reduction in CO & HC

Predictable Performance

GreenMarine™ demonstrates consistent and reliable performance across all DG sizes, making it a versatile solution for various decarbonization needs.



TRL 8-9 technology readiness level

Rapid installation in less than 4 hours

Compatible with **20-4000 kVA** DG sets

GreenMarine™ Performance on Marine Engines

Auxiliary Engine Applications

Immediate fuel savings of 3-15% for continuous hotel loads,significant port emission reductions,and enhanced engine reliability through cleaner combustion.

High-Speed Propulsion Applications

Optimized performance for vessels with 750-1800 RPM engines including workboats,ferries and offshore support vessels across variable duty cycles.

Operational Benefits

Improved throttle response,smoother engine operation,and compliance without complex exhaust after-treatment systems adding backpressure.

Retrofit Compatibility

Engineered specifically for marine environments with minimal installation footprint and seamless integration with existing systems.

Future Applications

Research underway for adaptation to slow-speed large engines (70-120 RPM)used in container ships and bulk carriers.

How GreenMarine™ Works

Water Electrolysis

System splits water (H_2O) into hydrogen (H_2) and oxygen (O_2) gas through electrolysis

Gas Infusion

Electronically metered Generated gas mixture blended into diesel engine's air intake manifold

Combustion Optimization

Metered Hydrogen improves combustion by increasing flame speed and reducing ignition delay

Key Benefits

- **Lower Diesel Consumption** - Optimized combustion leads to more efficient fuel usage & corresponding tCO2e reduction.
- **Reduced Emissions** - Decreased PM, NO_2, CO, and HC emissions
- **More Complete Burn** - Ensures thorough utilization of diesel fuel
- **Stable Power Generation** - Particularly under varying load conditions

Smart Control & Safety Architecture

Adaptive Hydrogen Dosing

Intelligently adjusts hydrogen dosage based on real-time engine conditions for optimal performance and safety

No Hydrogen Storage

Hydrogen produced on-demand and immediately consumed, eliminating risks associated with high-pressure storage

Built-in Safety Logic

Engineered for continuous remote operation with comprehensive safety protocols for demanding environments

Integrated Monitoring

Seamlessly integrated with SGT GreenVision™ for real-time monitoring of fuel usage, load profiles, and emission signatures

Multiple Shutdown Protections

Includes safeguards against overheating, backflow, and electrical anomalies to ensure system integrity

Proven Technology

SGT's Smart Control Architecture has been successfully tested & deployed across various industrial applications, ensuring reliable operation in offshore, 24/7 environments

Dual-Pathway CO_2 Reduction

Emerald FuelSystems SGT

Direct Fuel Savings & N_2O Avoidance

Direct Fuel Savings

3-15%fuel efficiency improvement

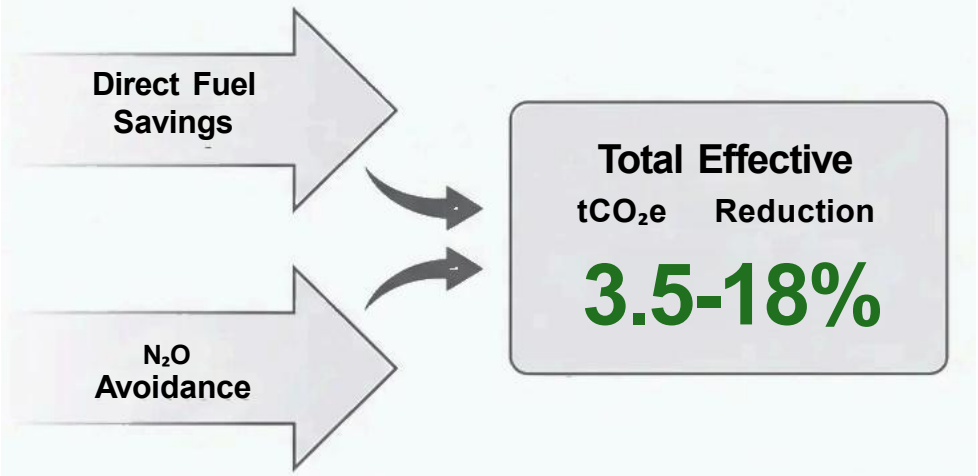
GreenMarineTM delivers 3-15% fuel efficiency improvement through optimized combustion,directly reducing CO_2 emissions and operational costs.

N_2O Emission Avoidance

Avoids SCR N_2O emissions

By eliminating the need for SCR systems that produce N_2O (a potent greenhouse gas),GreenMarineTM prevents additional climate impact.

Combined tCO_2e Impact



No Fuel Switching Required

Achieve meaningful carbon reductions while continuing to use conventional marine fuels,avoiding costly alternative fuel infrastructure.

Measurable Climate Benefits

All emission reductions are quantifiable and reportable for regulatory compliance and ESG reporting requirements.

Stack Emission Data from Real Engines

Emerald FuelSystems SGT

3-12% fuel efficiency improvement

Avoids N_2O emissions

1500 KVA GENERATOR – STACK EMISSION DATA

Sr No	Measuring Parameter	Units	Testing Standard / Protocol	Limit (mg/Nm3)	Without Hydrogen	With Oxy-Hydrogen	Improvement %
1	PM	mg/Nm3	IS:11255 (Part 1) RA 2019	75	44.8	8.9	80.13
2	SO2	mg/Nm3	IS:11255 (Part 2) RA 2019	NA	31.4	7.8	75.16
3	NO2	mg/Nm3	IS:11255 (Part 7) RA 2017	710	154.3	62.8	59.3
4	CO2	%	IS:13270 RA 2019	NA	5.6	3.2	**42.86**
5	CO	%	IS:13270 RA 2019	NA	0	0	NA
6	O2	%	IS:13270 RA 2019	NA	12	15.8	-31.67

380 KVA GENERATOR – STACK EMISSION DATA

Sr No	Measuring Parameter	Units	Testing Standard / Protocol	Limit (mg/Nm3)	Without Hydrogen	With Oxy Hydrogen	Improvement %
1	PM	mg/Nm3	IS:11255 (Part 1) RA 2019	75	39.2	9.8	75
2	SO2	mg/Nm3	IS:11255 (Part 2) RA 2019	NA	23.2	8.6	62.93
3	NO2	mg/Nm3	IS:11255 (Part 7) RA 2017	710	69.3	19.5	71.86
4	CO2	%	IS:13270 RA 2019	NA	4.6	3.3	**28.26**
5	CO	%	IS:13270 RA 2019	NA	0	0	NA
6	O2	%	IS:13270 RA 2019	NA	12.8	14.3	-11.72

Impact on IMO CII &EEXI Compliance

EEXI Compliance Enhancement

GreenMarine reduces specific fuel consumption by 3-15%,improving EEXI ratings without costly engine power limitations,ensuring vessels meet the required energy efficiency standards.

CII Rating Improvement

Direct fuel efficiency gains translate to better annual carbon intensity scores,helping vessels maintain favorable A-C ratings and avoid falling into lower,non-compliant categories.

Avoiding Operational Penalties

Prevents vessels from falling into D-E ratings that require corrective action plans and face potential commercial restrictions and market devaluation.

Cost-Effective Compliance

Achieves regulatory compliance with positive ROI through significant fuel savings,unlike other solutions that increase operational costs or require expensive retrofits.

No Operational Compromise

Maintains full vessel performance and schedule flexibility while improving environmental ratings,allowing operators to meet goals without sacrificing efficiency or capacity.

GreenMarine™ vs.Traditional Solutions

Feature	GreenMarine TM	Scrubber (SOx)	SCR(NOx)
CAPEX Model	Zero(DaaS)-Immediate ROI	High-Major Investment	Medium/High-Significant Investment
OPEX Impact	Reduced with Fuel Savings	Increased with Power &Consumables	Increased with Urea &Catalyst
Emissions Reduced	All emissions reduced including CO_2 ,PM(>70%),NOx	SOx,PM	NOx only
Fuel Efficiency	+3-15%Improvement	Reduced (Backpressure)	Reduced (Backpressure)
Installation Footprint	Minimal-Simple Retrofit	Large-Structural Mods	Significant-Space Claim
Financial Model	Decarbonisation-as-a-Service (DaaS gives Positive Cash Flow)	Traditional Purchase-Long Payback	Traditional Purchase-Long Payback

Direct Cost Comparison: GreenMarine™ reduces overall operational costs,unlike scrubbers and SCR which increase expenses through power demands and consumables.

Multiple Emissions Reduction: Simultaneously targets CO_2,PM,and NOx,offering a comprehensive solution compared to single-pollutant technologies.

Installation &Space Requirements:Offers a minimal footprint and simple retrofit process,avoiding major structural modifications.

Financial Model Advantage: Unique DaaS model provides zero upfront CAPEX, guaranteed performance,and immediate positive cash flow.

Operational Impact: Improves fuelefficiency by 3-15%, avoiding the engine backpressure issues associated with traditional exhaust treatment systems.

Decarbonisation-as-a-Service(DaaS)

Zero-CapEx Solution

Eliminate upfront investment through subscription model that preserves capital for core business needs

Immediate Positive Cash Flow

Monthly service fee structured to be less than fuel savings, ensuring day-one profitability

Performance Guarantee

No performance risk-if the system doesn't deliver promised savings,you don't pay

Performance Guarantee

No performance risk-if the system doesn't deliver promised savings,you don't pay

Hassle-Free Operations

SGT manages all maintenance,monitoring and repairs without burdening your crew

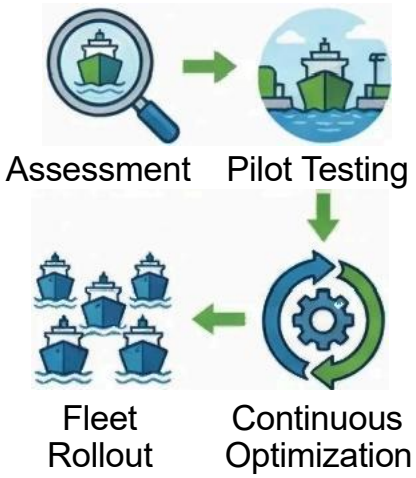
Verified Emissions Reporting

Automated data collection supports ESG goals and regulatory compliance reporting requirements

Addressing Key Concerns

Ensuring a Seamless and Effective Transition

Phased Implementation Approach



Our 4-phase strategy includes assessment,pilot testing,fleet rollout,and continuous optimization.

Zero Disruption Installation

Systems are installed during scheduled maintenance periods with minimal operational impact.

Comprehensive Training Support

Crew training ensures proper operation and maintenance with 24/7 technical assistance.

Continuous Performance Monitoring

IoT sensors and cloud analytics provide real-time efficiency data and optimization.

Scalable Fleet-wide Deployment

Proven methodology allows rapid scaling from single vessel to entire fleet operations.

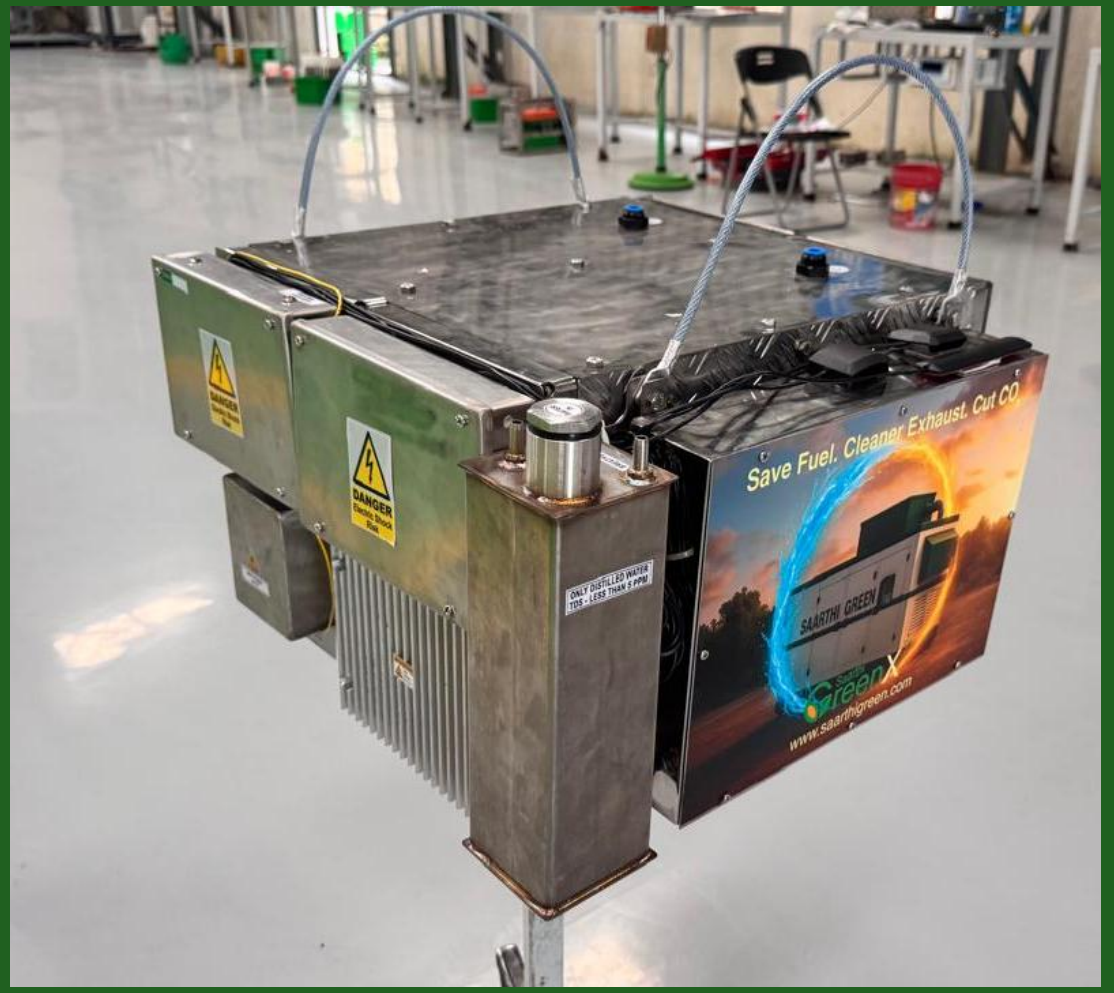
Contact & Next Steps

Get in Touch

Partner with Emerald Fuel Systems to become a decarbonization leader. Our GreenMarine™ Hydrogen Fuel Assist Retrofit offers a practical, high-ROI solution for immediate emission reduction on any marine auxillary engine without requiring significant capital investment or operational disruption.

Take the first step with our 3-60 day Proof of Concept to validate performance on your existing diesel generators and develop a tailored implementation roadmap.

Emerald FuelSystems



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