

# CL1 Fuel & Fertilizer: Marine-Grown Solution for Trade Resilience

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CL1 is a closed-loop marine fuel system based on commercial diesel. Designed for sustainability and strategic maritime advantage, CL1 enables onboard carbon capture and fertilizer production, operating beyond national borders.

This document has been prepared as a strategic outline for policymakers, maritime educators, and technology partners. It reflects Singaporean innovation built under limited conditions, intended to contribute to both climate resilience and trade independence in the face of global disruption.

This copy was submitted personally by the author to Dr. Wan Rizal for internal review.

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## Why CL1 Is Now Viable

### War in Ukraine:

- Major energy and fertilizer disruptions from the Ukraine-Russia conflict.
- Russia's former role as top urea, potash, and ammonia exporter is curtailed (FAO, 2022).

### Sanctions & Supply Chain Shocks:

- Fertilizer prices tripled in 2022 due to raw material scarcity (World Bank, 2023).
- Demand for renewable, local, and tariff-free alternatives surged.

## Carbon Taxation & Green Mandates:

- IMO GHG Strategy, EU ETS (2024), and Fit for 55 all price CO<sub>2</sub> emissions per ton.
- IMO DCS and CII ratings require emission intensity tracking and reduction.

CL1 offers a modular, scalable system to comply with these policies, particularly for smaller fleets unable to retrofit.

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## Tariff-Free Byproduct Export

- Marine-produced fertilizer is exempt from land-based tariffs (UNCLOS Article 91, WTO 2020).
- Flags of convenience allow untaxed, export-ready circulation.

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## Core Principle

### Diesel ? CO<sub>2</sub> ? Carbon Fertilizer

- Level 1 uses direct carbon capture.
- Level 2 adds algae (spirulina) to generate oil and biomass.
- Level 3 captures oxygen from algae and reinjects for combustion efficiency.

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## CL1 System Overview

### Level 1 ? Direct Carbon Capture:

- Weight: ~1.1 tons/m<sup>3</sup> (compressed fertilizer)
- Cost: \$0.70-\$2.00/L diesel
- Savings: Offsets carbon taxes and imported fertilizer
- Extra: Acts as a high-burn ignition additive

### Level 2 ? Algae Cultivation:

- Weight: ~0.85 tons/m<sup>3</sup> wet; ~0.20 tons/m<sup>3</sup> dry
- Cost: ~\$2.23/L at scale
- Savings: Replaces marine additives, extends diesel blend
- Extra: Blends into diesel up to B20 efficiently

### Level 3 ? Oxygen Recovery:

- Weight: ~0.0014 tons/m<sup>3</sup> (pure O<sub>2</sub> gas at STP)
- Cost: Moderate; requires tank, algae optimization
- Savings: Boosts burn efficiency and reduces soot
- Extra: Improves start/load performance of marine engines

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### Suggested Spirulina Blends (Cost and Burn Quality)

Diesel 100% ? ~\$0.70-\$1.00/L ? Standard burn ? Baseline fuel

Diesel 90% / Spirulina 10% ? ~\$0.95-\$1.15/L ? Cleaner burn

Diesel 80% / Spirulina 20% ? ~\$1.10-\$1.25/L ? Low NO<sub>x</sub>, better soot profile

Diesel 70% / Spirulina 30% ? ~\$1.25-\$1.40/L ? Very clean, cold flow concerns

Diesel 50% / Spirulina 50% ? ~\$1.40-\$1.60/L ? Ultra-low emissions, needs tuning

Recommended: B10-B20 for best cost/emission balance

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### Combustion Chemistry & Algae Feedback Loop

- Diesel burn emits ~2.68 kg CO<sub>2</sub> per liter
- Spirulina uses CO<sub>2</sub> and H<sub>2</sub>O to regrow biomass
- Excess O<sub>2</sub> harvested and reinjected boosts performance
- Loop stabilizes output while feeding future fuel cycles

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### Carbon Capture Costs

- CO<sub>2</sub> from 1,000L diesel = ~2.68 tons (US EPA)
- Capture energy: 268-670 kWh
- Capture cost: \$40-\$200 per 1,000L

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### Carbon Credits & PR Value

- Spirulina donations can support humanitarian food aid
- PR value and tax benefits via ESG alignment

- ~2.68 carbon credits per 1,000L; \$30-\$80 per credit
- Supplements sell for ~\$0.03-\$0.08/tablet retail

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## Accident & Environmental Safety

- Spirulina spills are non-toxic
- Not self-sustaining in seawater
- Breakup and dilution minimize marine life impact

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## Infrastructure Caveat

- Spirulina oil requires additive compatibility testing
- Does not replace refinery or fuel cert procedures
- Ship layout, tanks, and biohandling must be engineered
- Marine design input is essential for load management

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## Deployment Roadmap

Phase 0 ? Barrel-scale test

Phase 1 ? Algae tank + B10 pilot

Phase 2 ? Engine oxygen loop trial

Phase 3 ? Small ship demonstrator

Phase 4 ? Full retrofitted commercial ship

Goal: Floating green ship ecosystem using closed-loop emissions

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End Statement

CL1 is not a patent ? it?s an open-source call to build smarter ships, cleaner oceans, and decentralized food/fuel networks. Built by hand, tested in theory, now ready to validate.

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