# Retrofitting for Realism: Establishing Dual-Fuel LNG as a Practical Decarbonisation Strategy

A Transitional Strategy for IMO Net-Zero Goals in Developing Nations

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# Abstract Overview

## Key Thesis

Dual-fuel LNG retrofitting reduces CO2 by 15-25% (post-methane slip), cuts SOx/PM near-zero, offers 2.7-year payback, and bridges to bio-LNG

### Challenges

Biofuels/ammonia face cost & scalability issues in developing nations

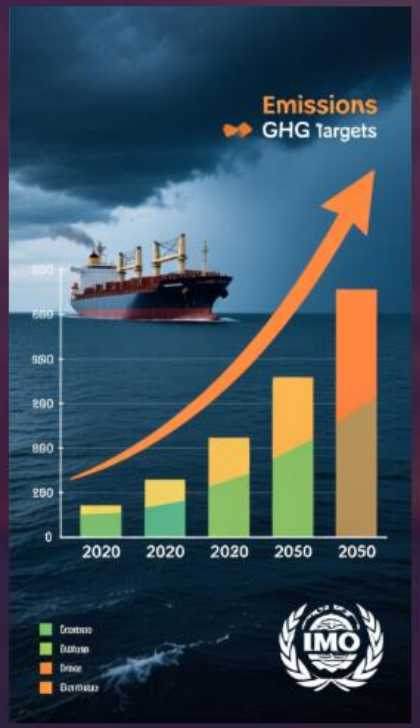
### India Focus

Survey of 50 Indian shipowners shows 70% cite cost barriers

### IMO Alignment

Supports 2030 interim targets and 2050 net-zero goals

# The Challenge: Navigating Maritime Decarbonization Uncertainty




## IMO 2050 Net-Zero Targets

20-30% reduction by 2030, 70-80% by 2040 - shipowners must act swiftly

## BP Energy Outlook 2024

Energy addition phase where low-carbon and fossil fuels coexist, increasing investment risks

## Survey Results

50 Indian shipowners surveyed - 70% cite cost as primary decarbonization barrier

# Novel Perspective: Reframing the Energy Trilemma

## Sustainability Challenges

Biofuels: $1,200-1,800/tonne, feedstock competition with food security

## Economic Barriers

Ammonia/hydrogen: $1,000+/tonne, specialized engines, toxicity risks

## Developing Nations Focus

Infrastructure and capital constraints demand practical, affordable solutions

## Flexibility Solution

Retrofitting vs. newbuilds: 20-30 year asset lifespans require transitional approach

# Methodology: Mixed-Method Approach for India's Coastal Shipping

## Literature Review

20+ sources including Lloyd's Register [1], SEA-LNG [4], IMO regulations, market analyses

## Financial Modeling

NPV/payback calculations with ±20% sensitivity on fuel costs ($500-700 VLSFO, $400-600 LNG)

## Case Study

SEA-LNG VLCC retrofit benchmark [7] for capital expenditure and fuel efficiency analysis

## LCA Assessment

GREET model analysis including methane slip (10-20% GWP increase) from ICCT 2023-25 [5,6]

# The Solution: Dual-Fuel LNG Retrofit - Immediate Impact & Adaptability

## Emissions Reduction

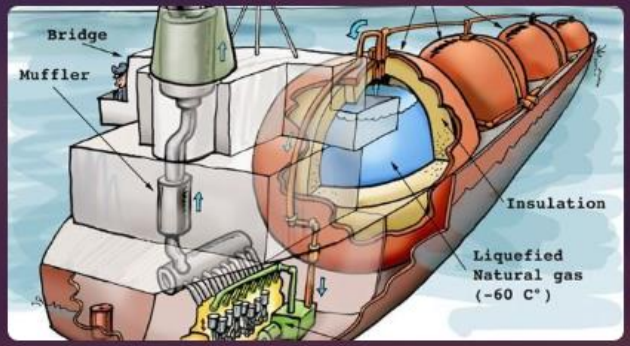
15-25% CO2 reduction (post-methane slip), near-zero SOx/PM, 85% NOx cut - aligns with IMO 2030 targets

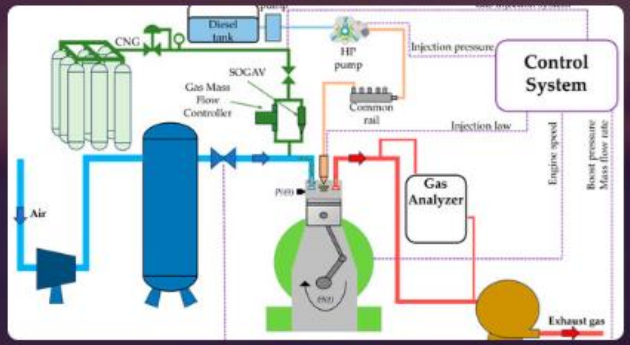
### Supply Security

Shell LNG Outlook: 50% global LNG trade growth by 2040

### Future Ready

Dual-fuel flexibility enables bio-LNG integration for carbon-neutral operations



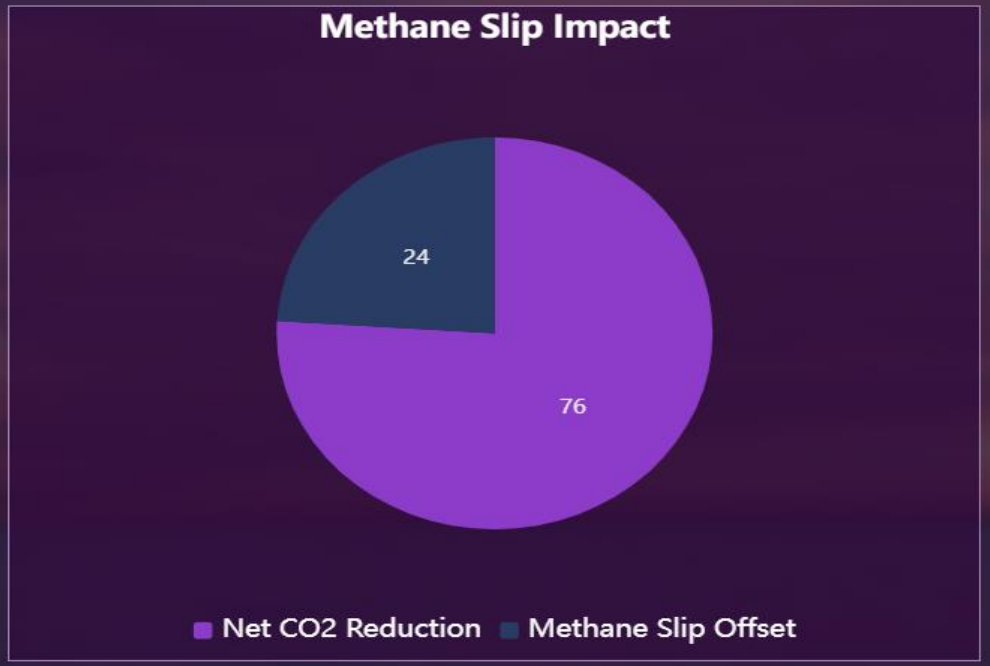



# Comparative Analysis: Why LNG Excels in Developing Nations

Retrofit focus reduces costs vs. newbuilds; 200+ global bunkering ports including emerging Mumbai hub

| Fuel | CO2eq Reduction | Cost ($/tonne) | Scalability Challenges | India Infrastructure |
|---|---|---|---|---|
| LNG (Dual-Fuel) | 10-25% (with slip) | $400-600 | Methane slip, growing supply | Emerging (Mundra, Kochi) |
| Biofuels | 50-80% | $800-1,200 | Feedstock shortage, food competition | Limited; high costs |
| Ammonia | 90-100% | $1,000+ | Toxicity, engine overhauls | Minimal; no ports yet |
| Methanol | 10-20% | $700-900 | Availability issues | Developing; Mumbai pilot |
| Hydrogen | 95-100% | $1,500+ | Storage density, high costs | Non-existent in India |

# Addressing Methane Slip for Credible Savings




## Slip Rate

6.4% in low-pressure engines (ICCT 2024) vs IMO 3.5% assumption

## Mitigation Solutions

Wärtsilä high-pressure engines: 1.7% slip rate

## Bio-LNG Bridge

Minimizes risk while supporting transitional role

# Financial Case: Robust ROI - 2.7-Year Payback

| Scenario | VLSFO Price | LNG Price | Payback Years |
|---|---|---|---|
| Base Case | $600/tonne | $450/tonne | 2.7 years |
| High Volatility (+20%) | $720/tonne | $540/tonne | 2.3 years |
| Low Volatility (-20%) | $480/tonne | $360/tonne | 3.4 years |

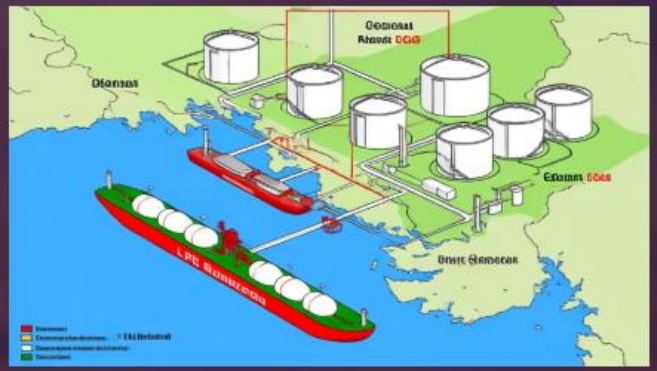
**$3.67M**

Annual Fuel Savings

**2.7**

Year Payback Period

# Technical Feasibility: Engineering Essentials



## Cryogenic Storage

LNG stored at -162°C in specialized tanks requiring structural analysis

## Vaporizer System

Converts liquid LNG to gas before injection into dual-fuel engines

## Safety Systems

Double-walled piping and Gas Valve Unit (GVU) for leak containment

# Case Study: VLCC Retrofit Benchmark & India Extension

## SEA-LNG 2024 Results

Demonstrates proven financial and environmental benefits for large vessel retrofits, providing benchmark for Indian coastal shipping applications

**12**

Grade CII Improvement

# Benefits & Challenges: Value Chain Wins & Infrastructure Solutions

## Benefits Across Value Chain

Creates positive impacts for shipowners, charterers, and ports through financial savings and regulatory compliance

- Shipowners: ROI, fuel savings, CII improvement
- Charterers: Sustainability goals, efficiency gains
- Ports: New revenue streams, competitive advantage

## Infrastructure Challenges

Bunkering development faces chicken-egg problem requiring coordinated solutions

- High upfront costs and demand uncertainty
- Fragmented regulatory framework
- PPPs, subsidies, mobile bunkering solutions

# Conclusion: The Smart Path Forward


## Balances the Trilemma

Technically sound, financially viable, environmentally compliant solution

## Enables Participation

Allows India and developing nations to meaningfully contribute to IMO goals

## Call to Action

Adopt LNG retrofits today for tomorrow's green fleet

# References

## Key Sources

Top references supporting this research and analysis

### [1] Lloyd's Register

LNG Retrofits Surge Report (2025)

### [3] IMO

2023 GHG Strategy MEPC.377(80)

### [4] SEA-LNG

LNG Pathway Mid-Year Review (2025)

### [5,6] ICCT/DNV

Methane Slip Studies (2023-2025)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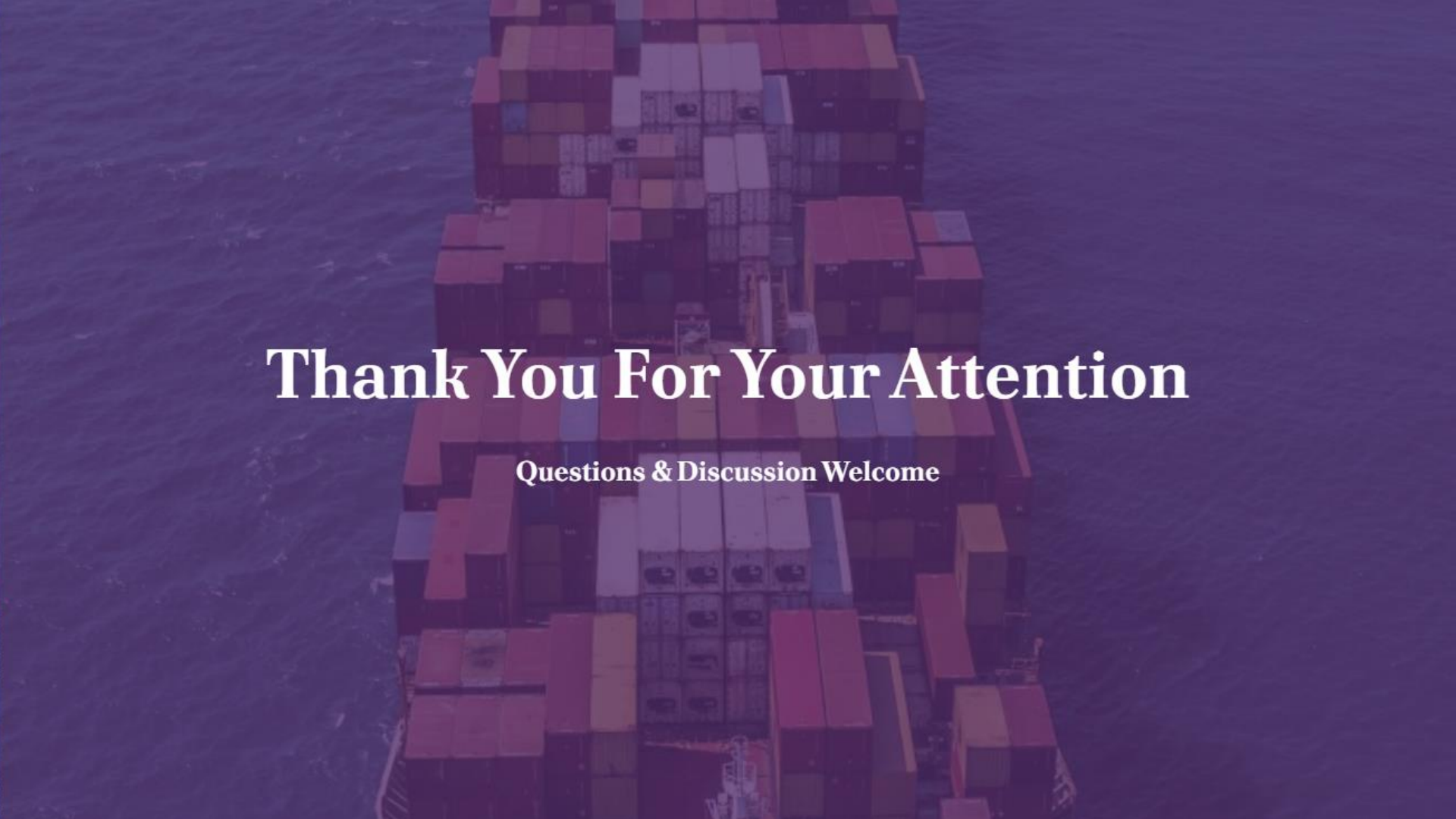
INDIA
My spirit soars with thanks to the Indian Maritime University (IMU) and Institute of Marine Engineers (India) (IMEI) for their dynamic support, alongside my Parents united, we triumph!
DMET's visionary legacy, upheld by IMEI, fueled my ascent here at the conclave.



# Thank You For Your Attention

Questions & Discussion Welcome