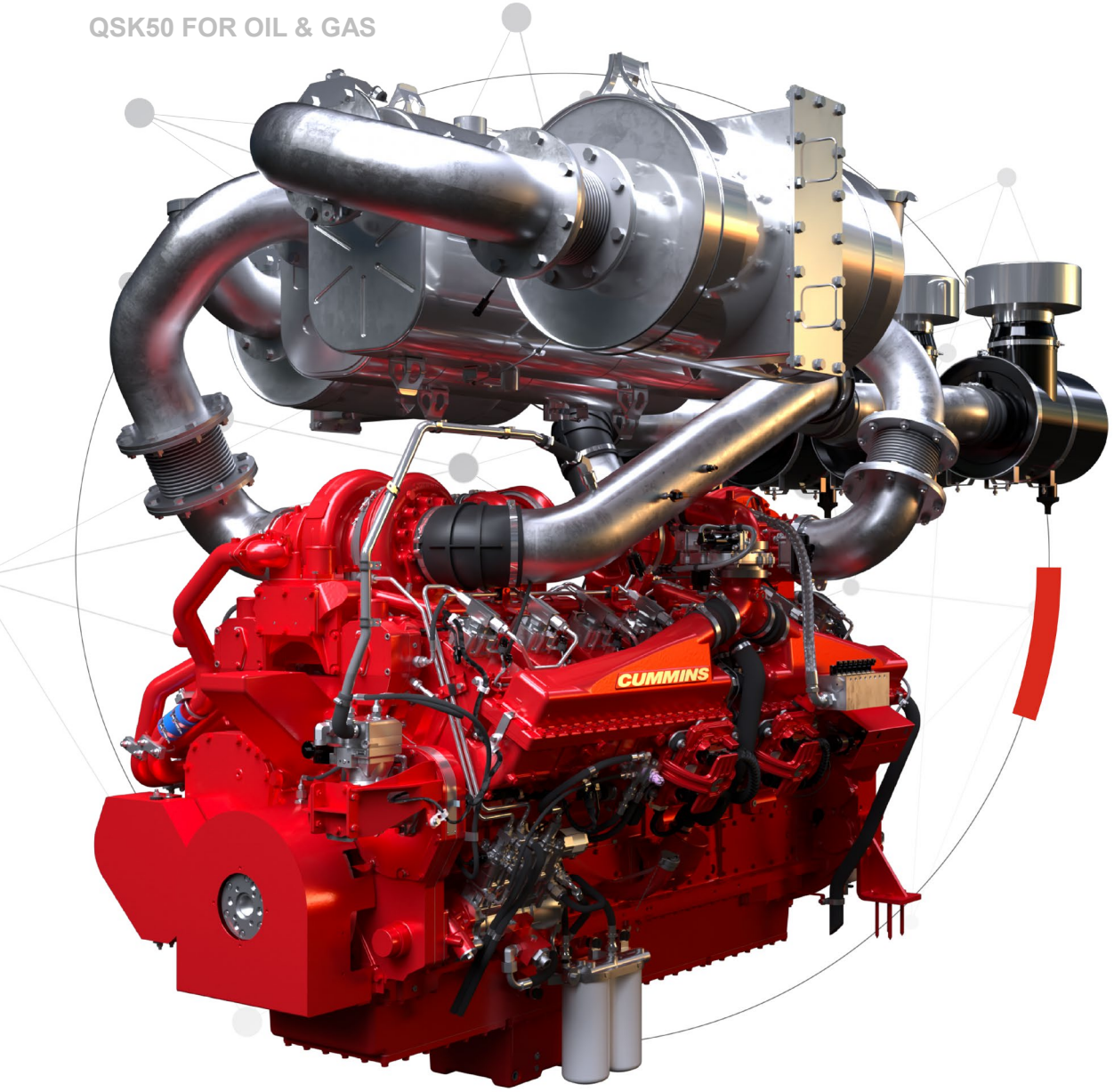
QSK50 FOR OIL & GAS




Power Systems

# Perspective on Decarbonization of High Horsepower Applications

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# CUSTOMER DRIVERS & MARKET EXPECTATIONS

TRANSITION CHALLENGES AND DRIVERS OF PROGRESSIVE DECARBONIZATION

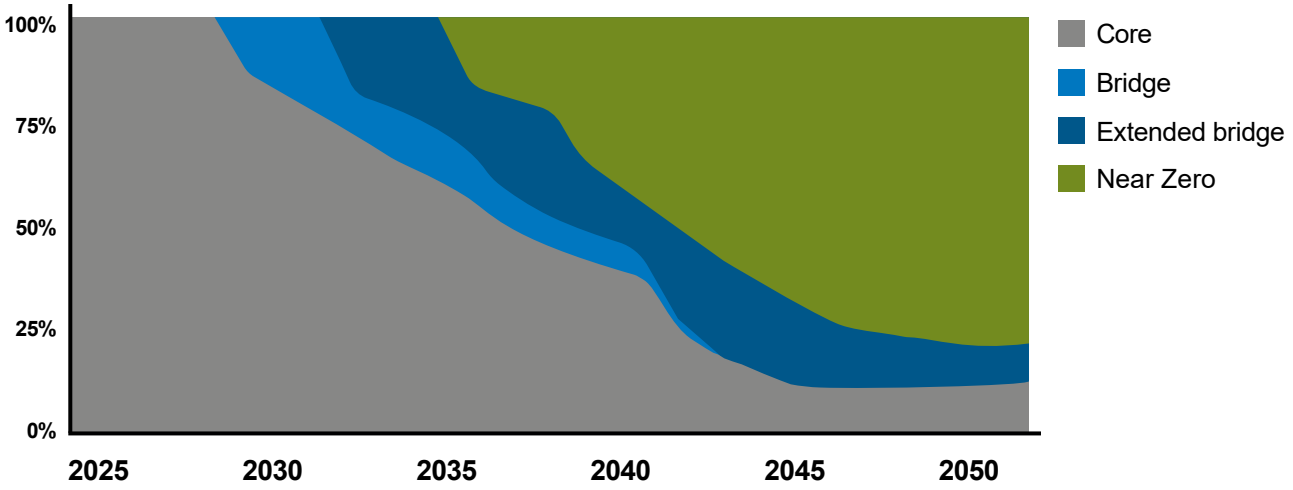
**ESG @ 2030**

**INFRASTRUCTURE**

**ASSET REPLACEMENT CYCLES**

**ECONOMICS**

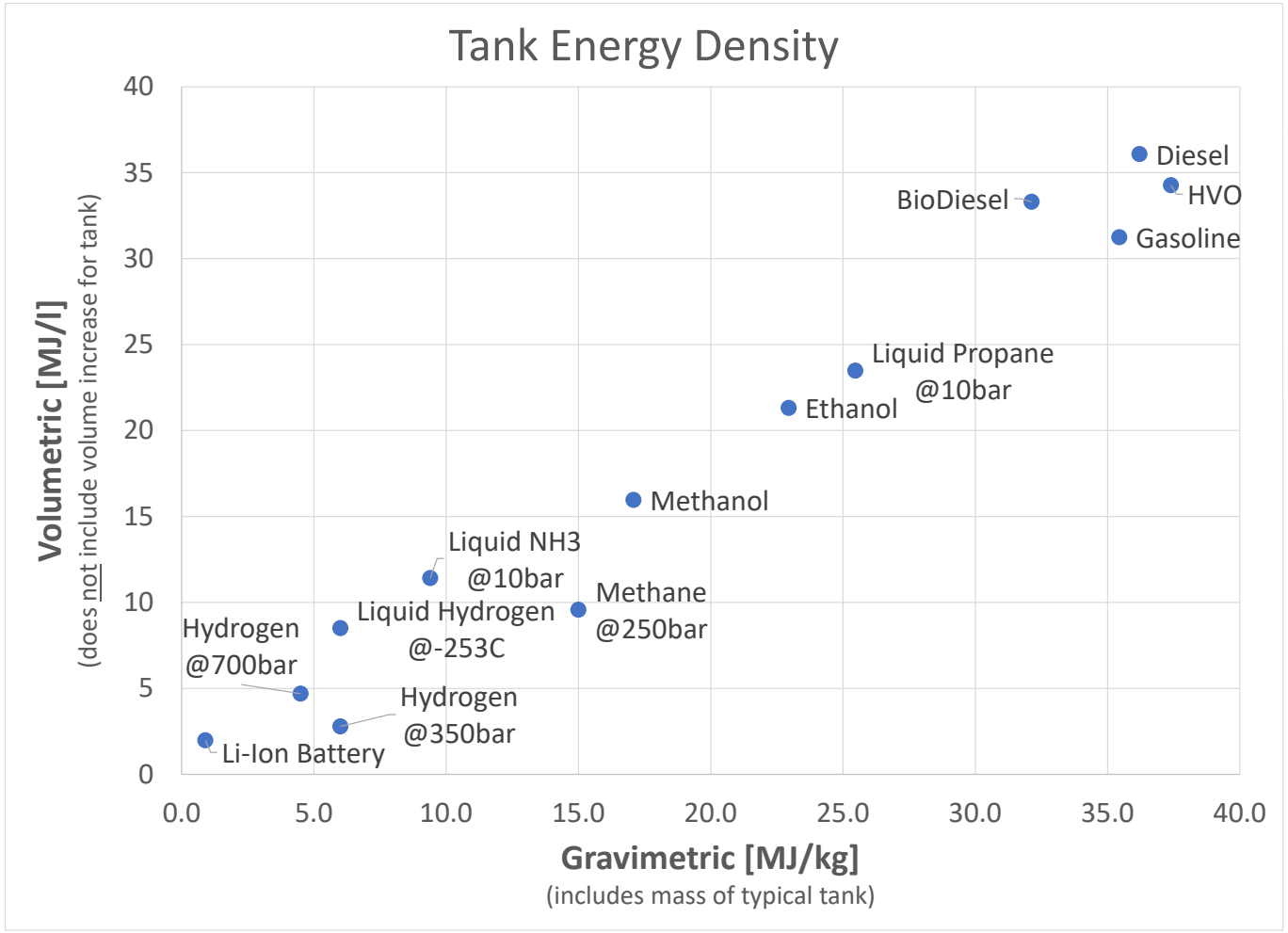
**EXAMPLE POWER TECHNOLOGY EVOLUTION**

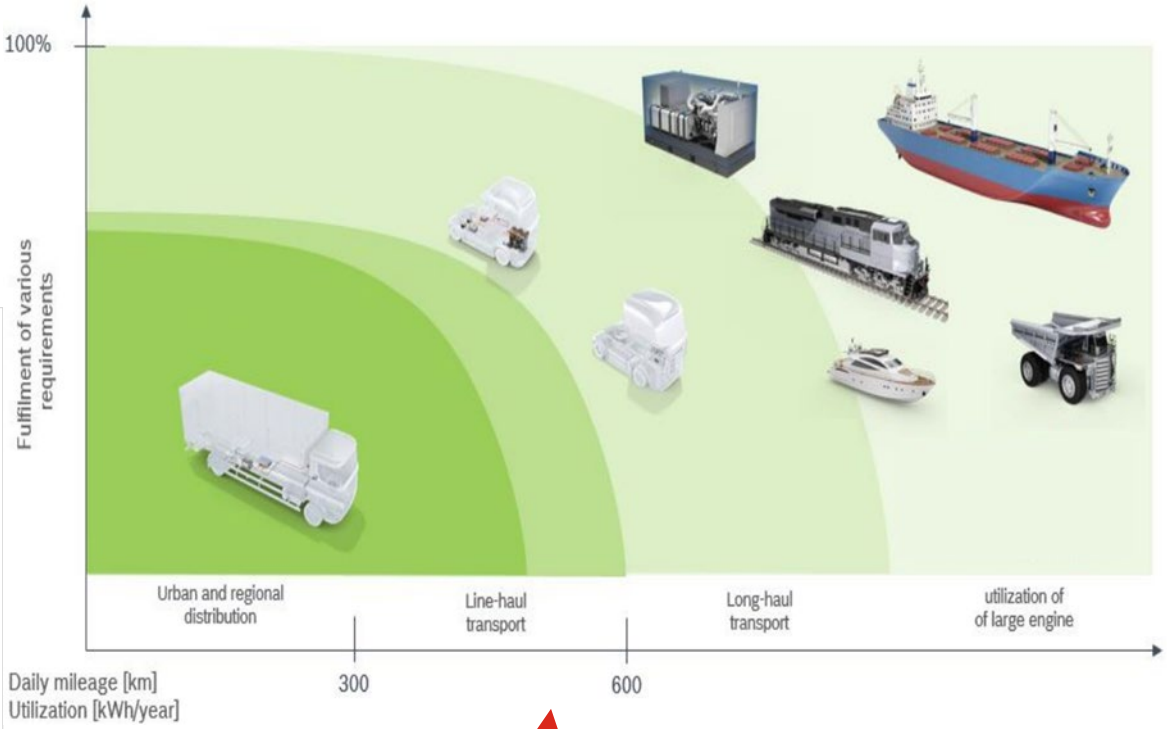



Industry projections suggest a strong **ELECTRIFICATION** pathway. However, significant hurdles are increasingly becoming apparent that will delay the eventual adoption at scale

Momentum has pivoted toward **BRIDGE** solutions with a significant focus on **RETROFIT** of existing fleets

# FUEL DRIVERS



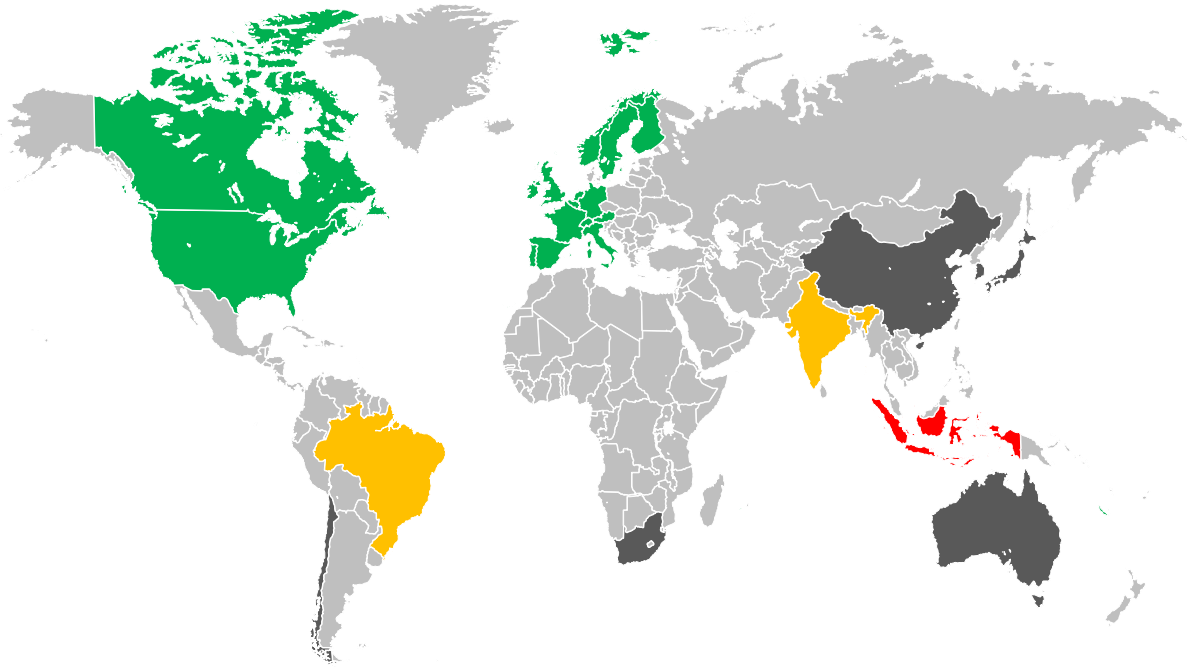



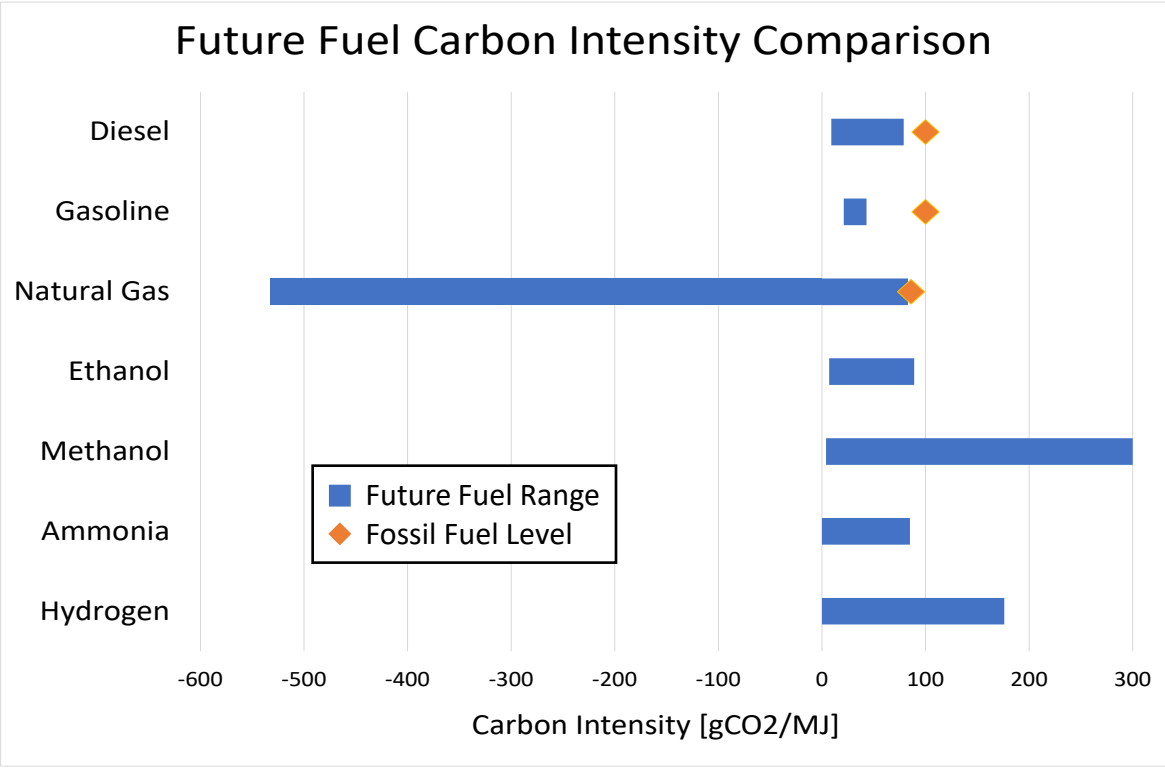

*Source: Christoph Kendlbacher, "Alternative Fuels and their applications on large engines", 2021 18th Symposium for Sustainable Mobility, Transport, and Power Generation"*

The more work applications need to do between refills/recharges the more important energy density becomes.

# FUEL DRIVERS

Means to produce alternate green fuels is highly variable across the globe

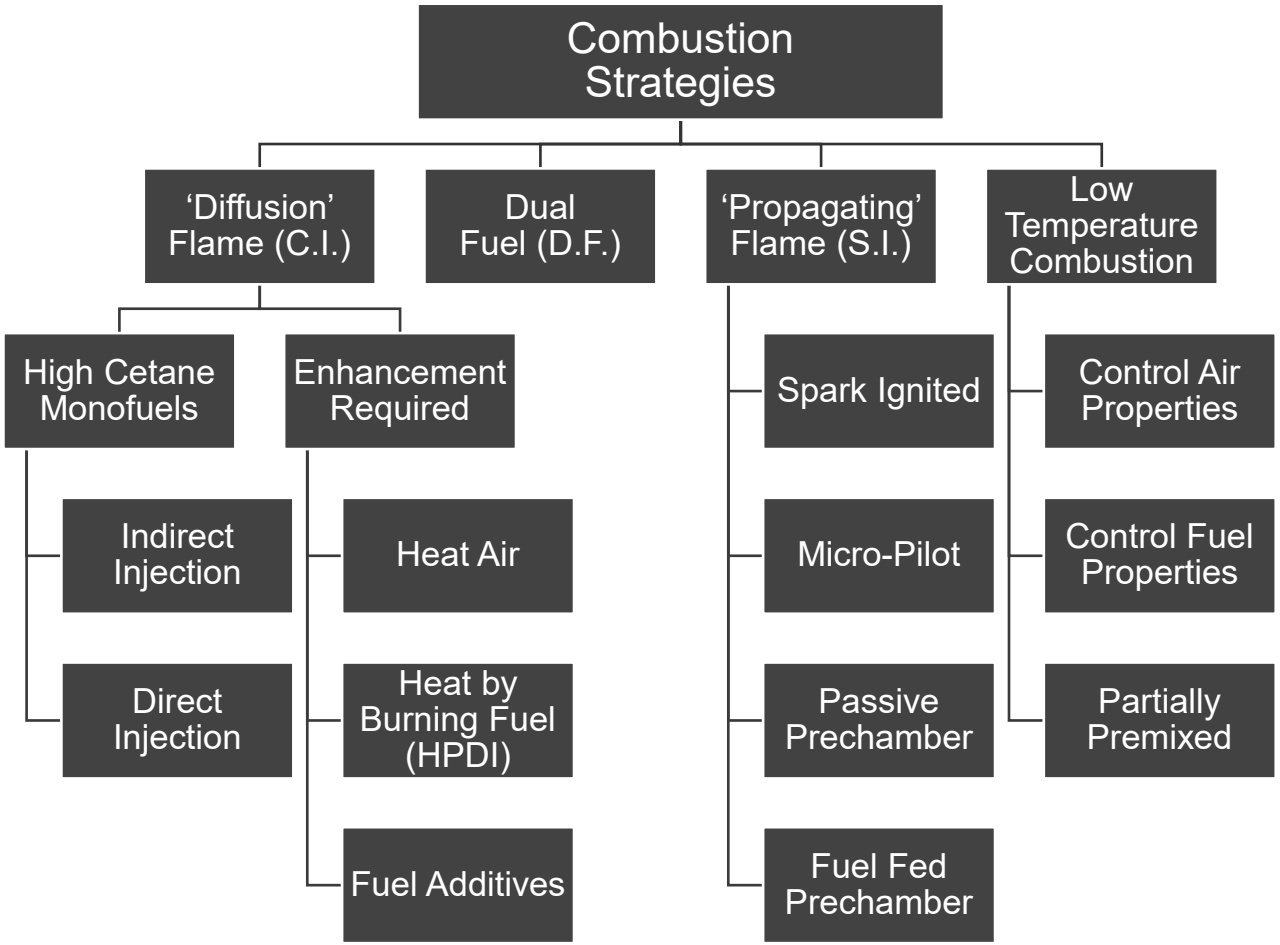





- How you make the fuel has a huge impact on the carbon intensity.
- Lifecycle analysis is required to understand true decarbonization.

***Note:*** *Carbon intensity values below zero are for Renewable Natural Gas based fuels with accounting for methane emissions that are avoided*

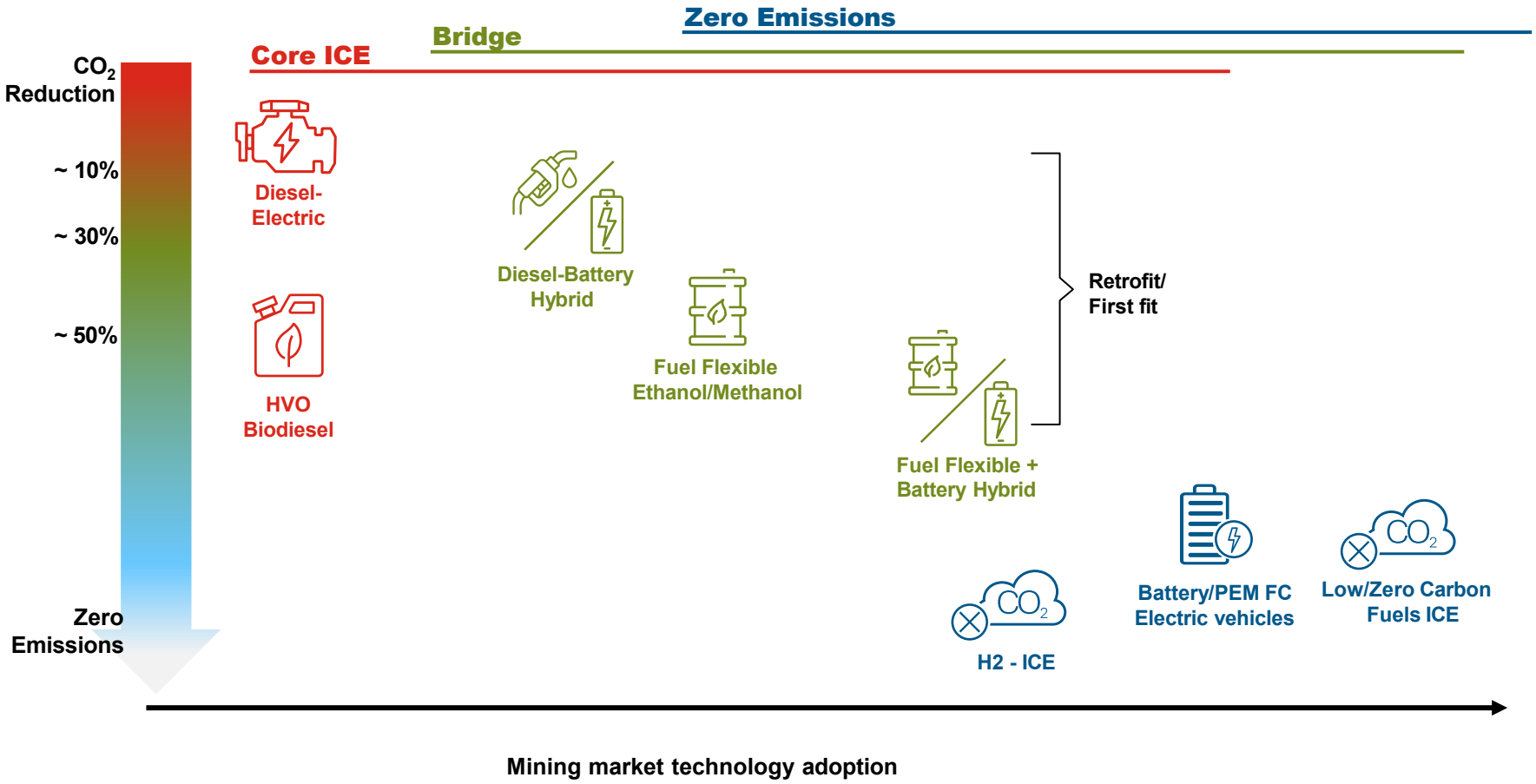
# COMBUSTION ARCHITECTURE OPTIONS




| | | Charge Motion | |
|---|---|---|---|
| | | Swirl | Tumble |
| Injection Location | Direct In-Cylinder | **Liquid C.I.**<br>**Liquid/Gas HPDI** | **Liquid S.I.**<br>Gaseous S.I. |
| | Port Fuel | **Liquid S.I.**<br>Gaseous S.I.<br>**Liquid/Liquid D.F.**<br>**Liquid/Gas D.F.** | **Liquid S.I.**<br>Gaseous S.I. |
| | Upstream of Ports | Gaseous S.I.<br>**Liquid/Gas D.F.** | Gaseous S.I. |

# ENERGY TRANSITION BRIDGE

ENABLING MINERS TO ACHIEVE MID-TERM DECARBONIZATION GOALS
WHILE CREATING A PATHWAY TO ZERO CARBON SOLUTIONS.



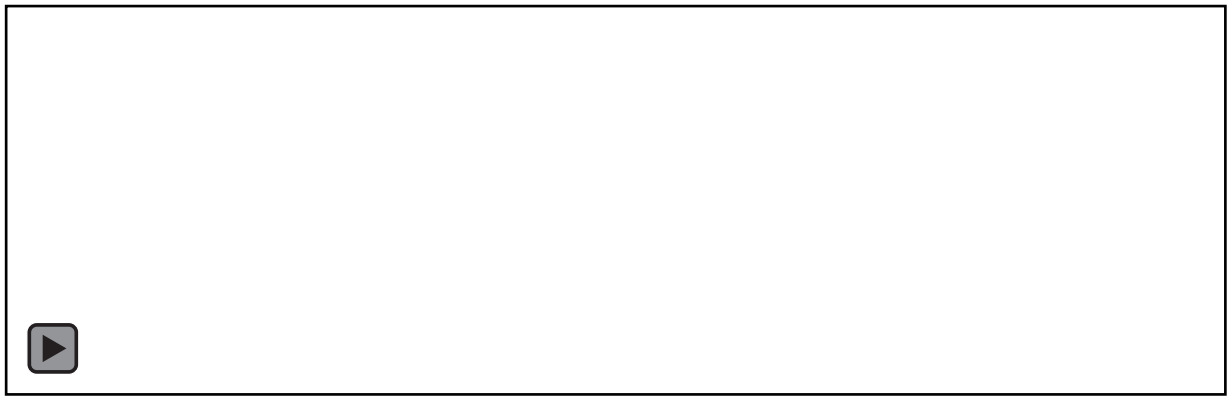

## Two bridge pathways towards a zero emissions future:

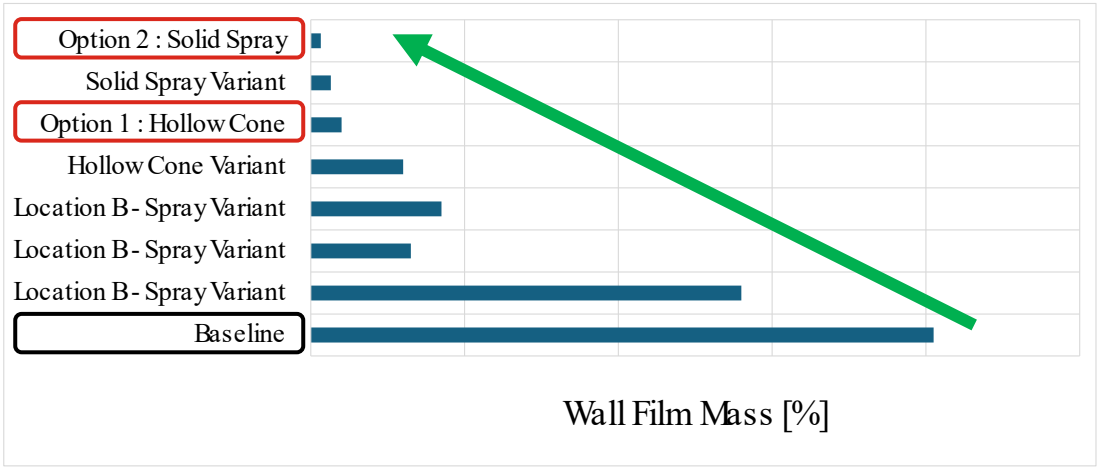
1. Low Carbon Fuels (LCF – Dual Fuel) → Clean fuels pathway
2. Battery Hybrid → Electrification

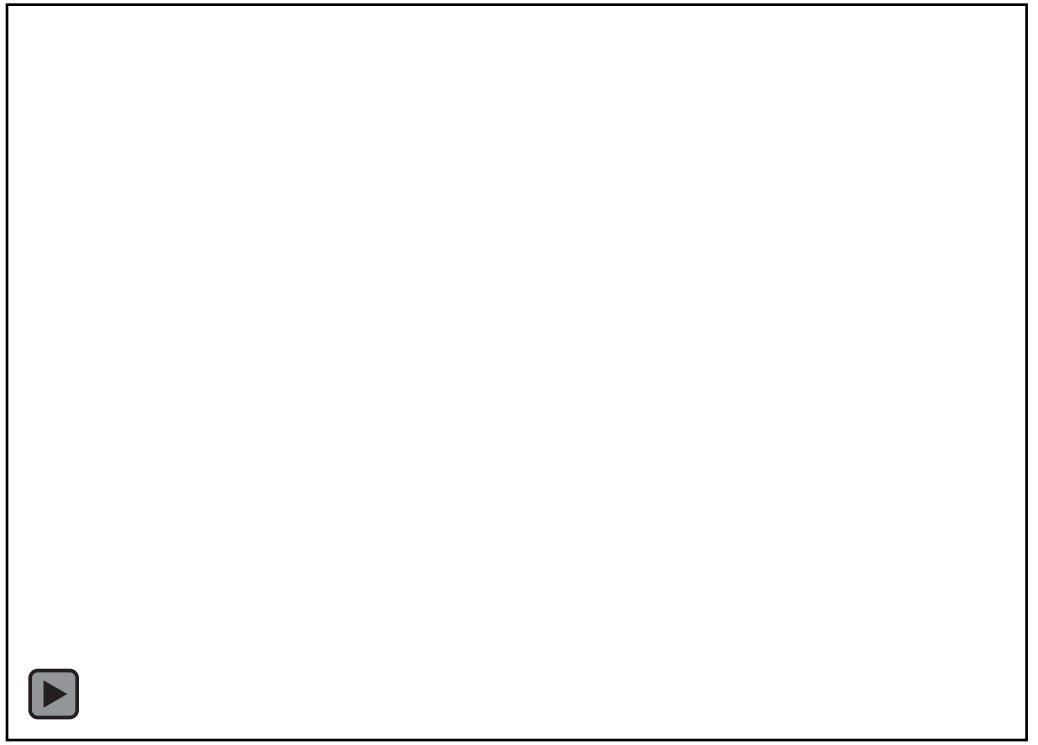
# METHANOL LOCATION & SPRAY OPTIMIZATION

**Objectives** (1) Uniform mixing (2) Minimize Wall Wetting (3) Minimize Variation (cylinders and cycles)

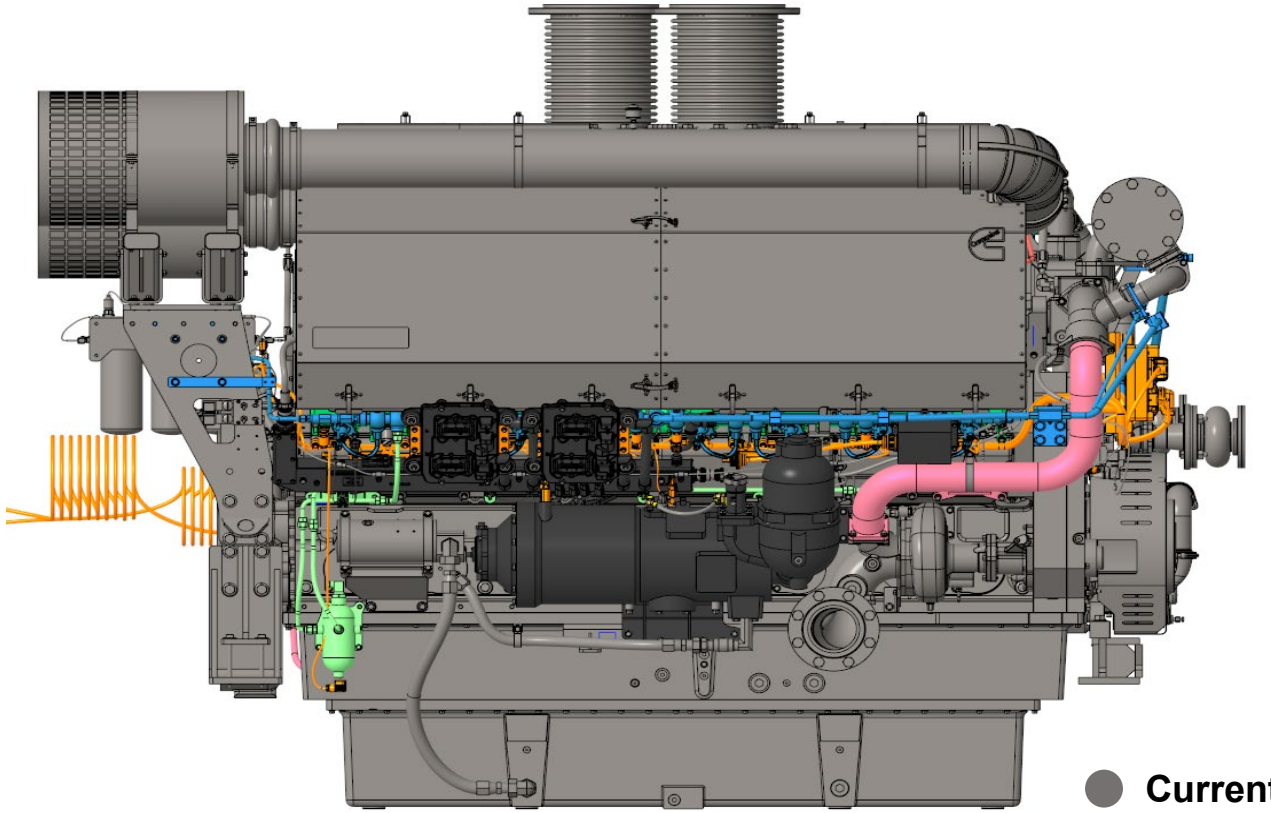
**Approach** (1) Spray Optimization, (2) Multi-cylinder/Multi-cycle simulations, and (3) Multiple operating conditions.

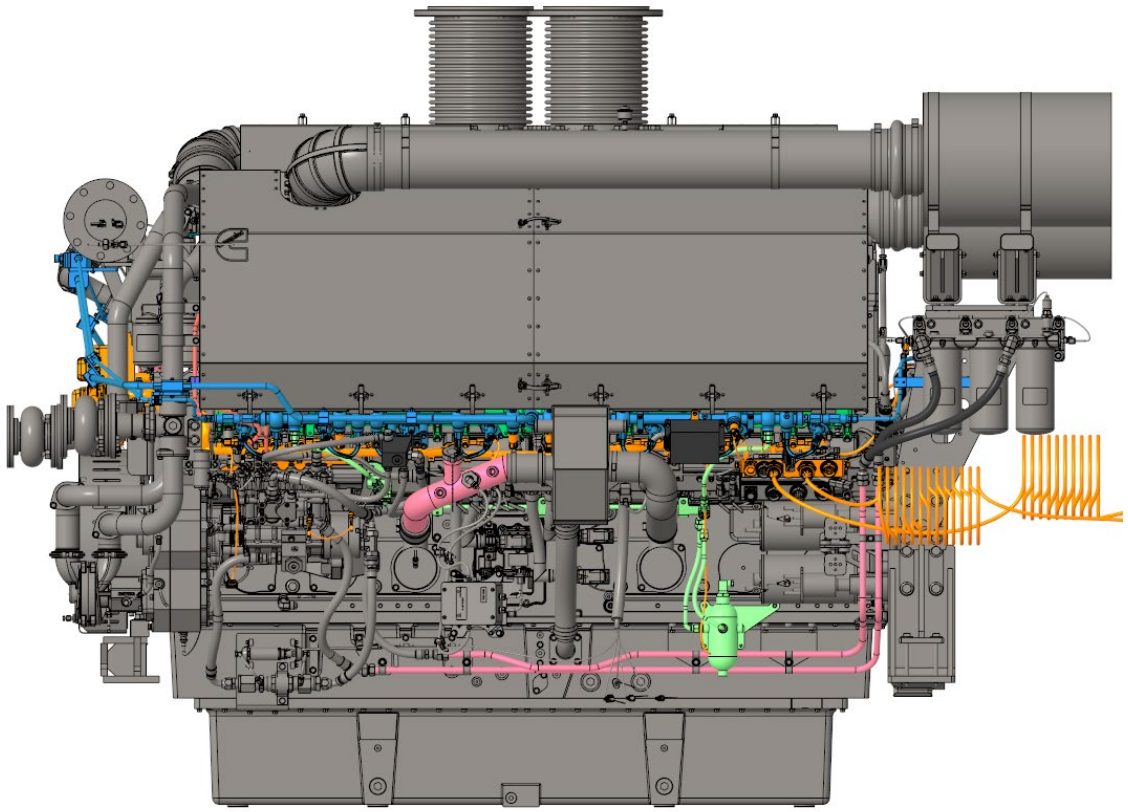




# MARINE UPFIT KIT





- Current
- New
- New
- Repositioned
- Fuel Leak Detection Tank
- Relocated


Thank you!