

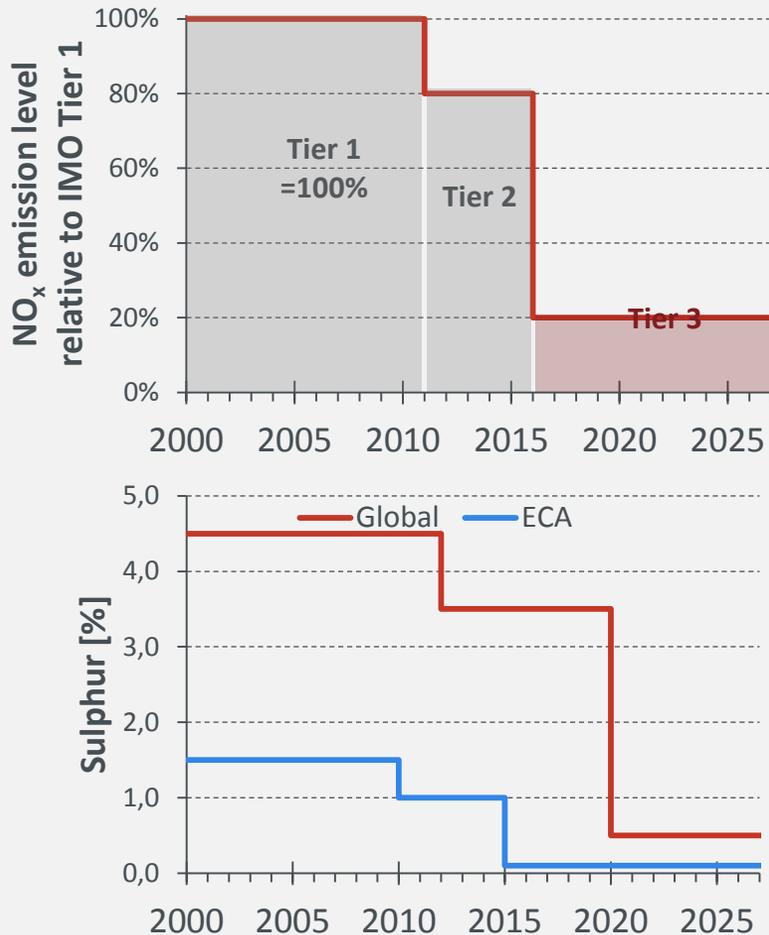


IMO Tier III Compliance ... and beyond: Global Perspective

2nd CIMAC Circle on “MARPOL 2020 Compliance - Stakeholders Readiness” at Mumbai, 5 October 2019
Marc-Tran Heller, General Manager Asia Sales

Marine Regulations

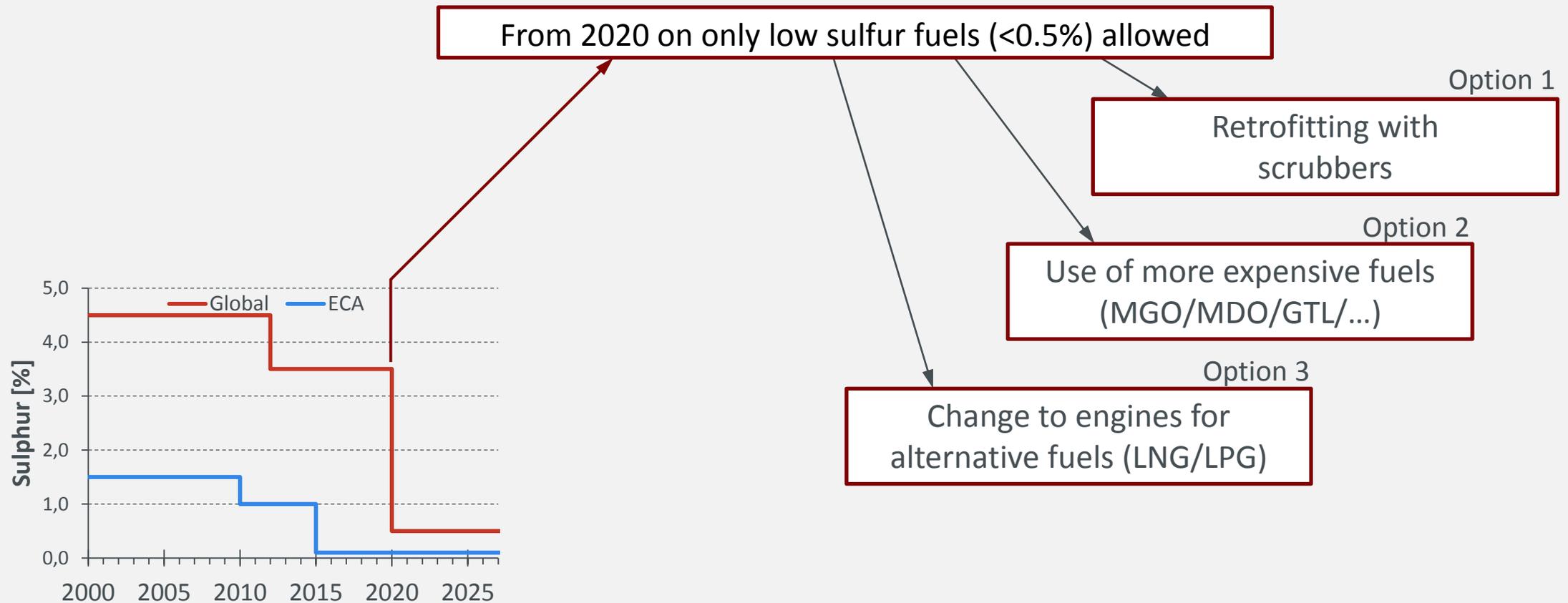
NO_x- & Sulfur Emission Regulations & Emission Control Areas



<https://www.wilhelmsen.com/marine-products/oil-solutions/>

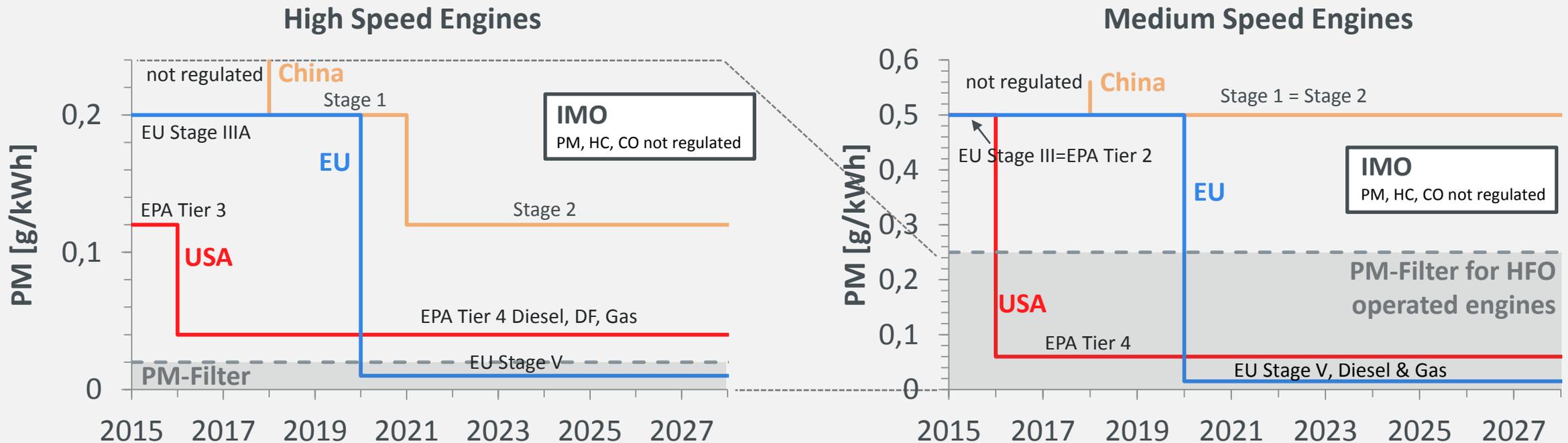
Marine Regulations

Global Sulfur Emission Regulation



Marine Regulations

Particulate Matter Emission Regulation



- different limits for 2-stroke engines
- different limits for non-marine applications

Marine Agreement

Green House Gas Reduction

Generally:

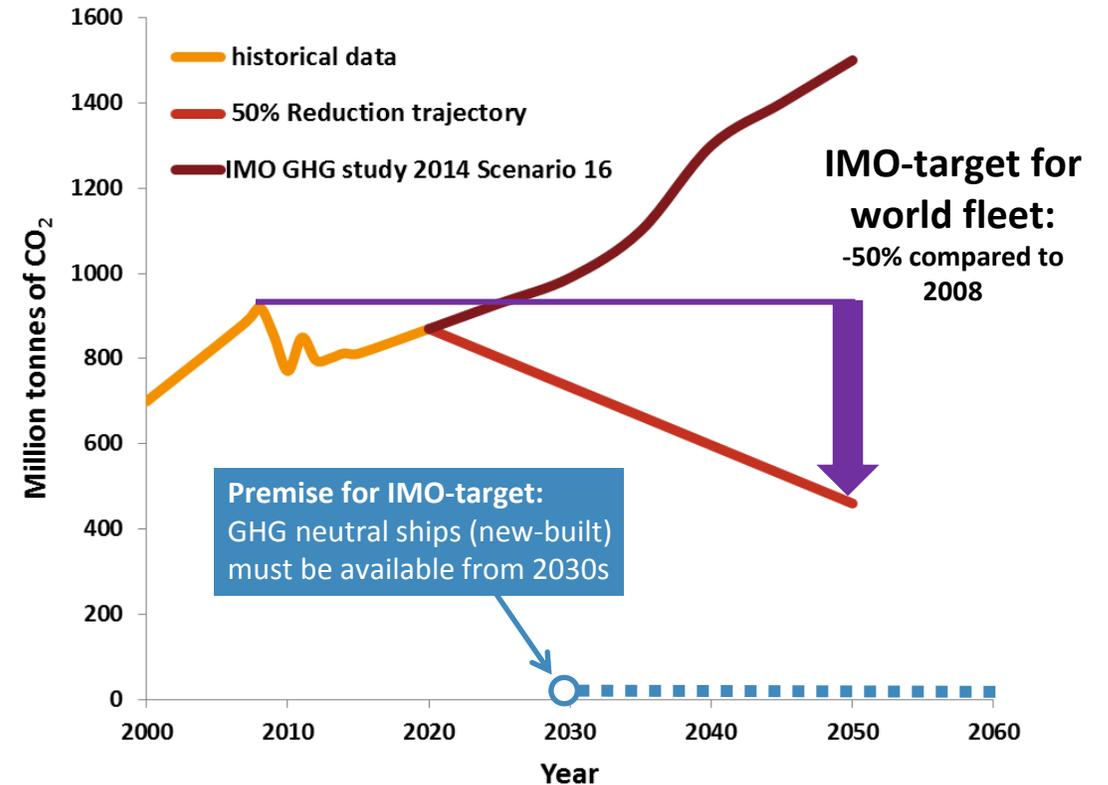
- Paris Agreement
- tightening emission legislation



Marine:

- 2020 sulfur limit
- IMO-targets for CO₂-reduction

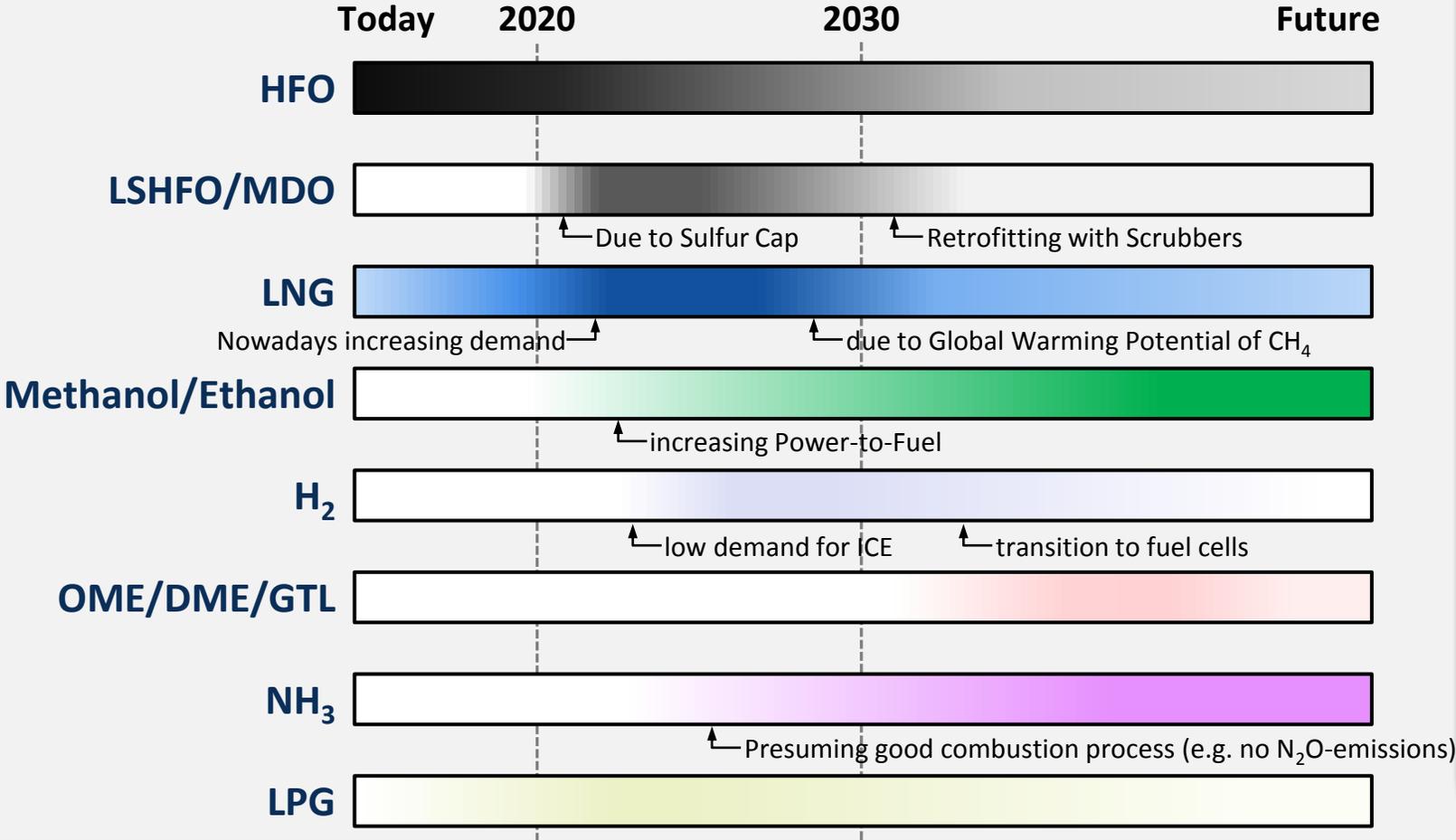
→ **LNG as marine fuel can help to massively reduce particulate and NO_x-emissions and to lower greenhouse gas emissions**



Pathways for international shipping's CO₂ emissions

Alternative Fuels

Expected Fuel Developments



 ... Business as usual
 ... Our Passion

  **WOODWARD**

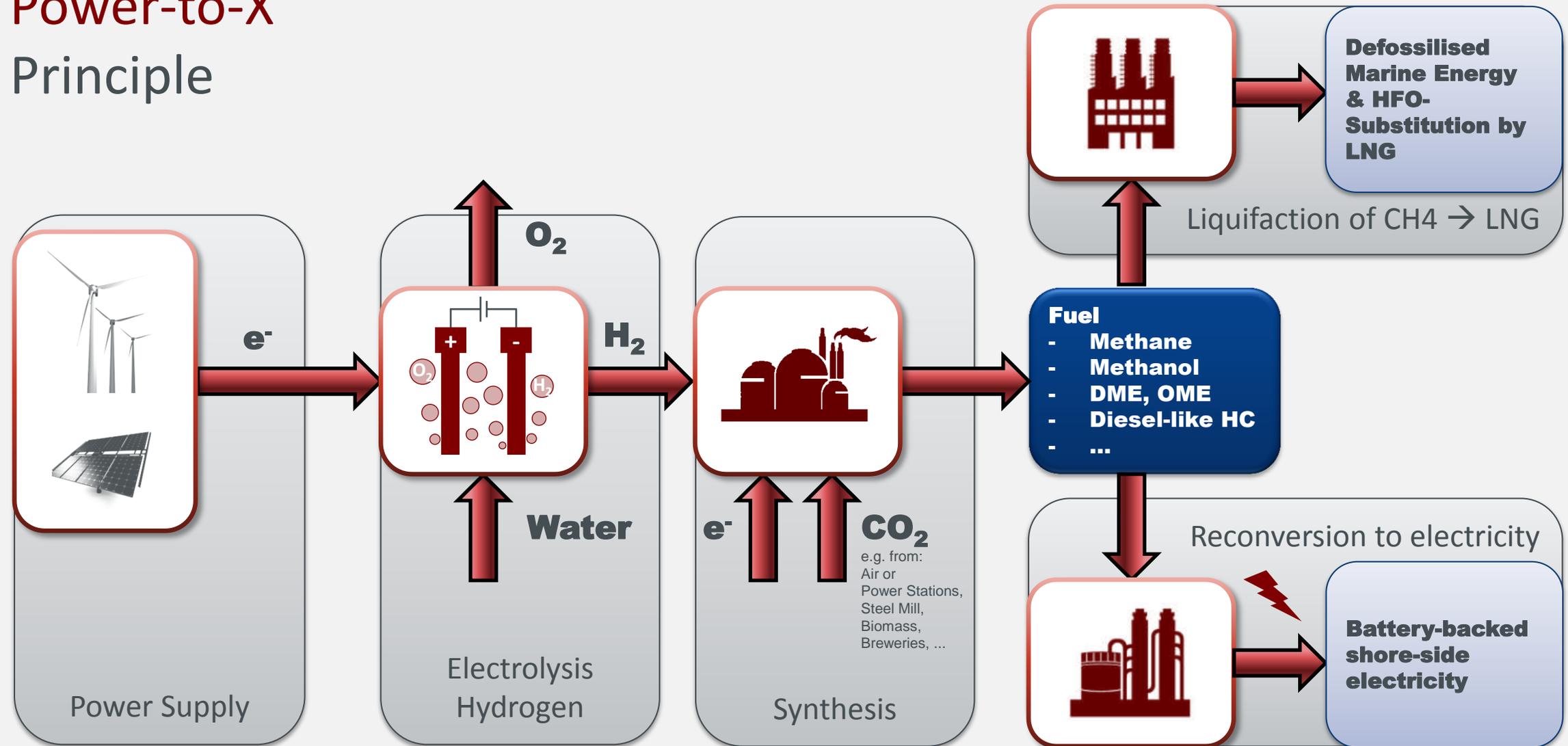

  **WOODWARD**


  **WOODWARD**


  **WOODWARD**
 

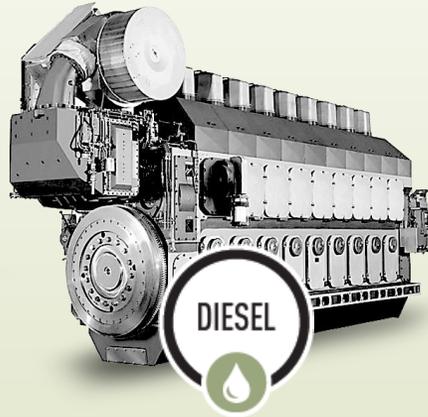
  **WOODWARD**
 

Power-to-X Principle

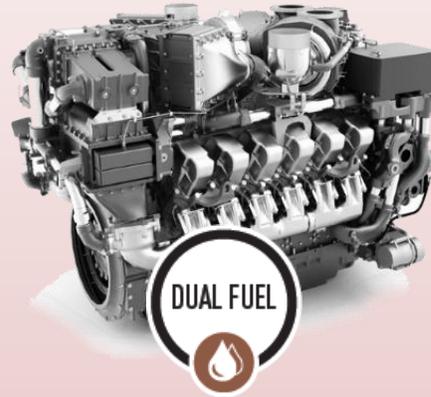


Marine Regulations

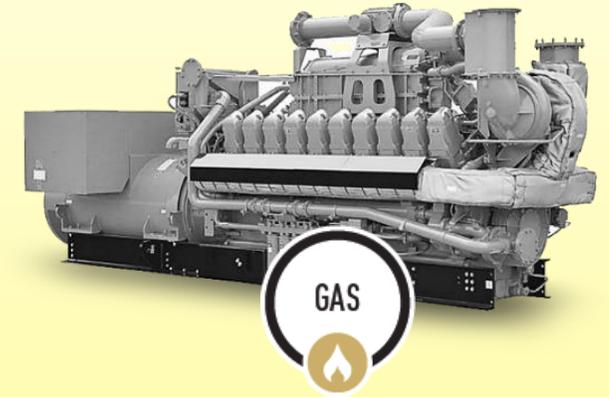
Woodward L'Orange (WLO) Solutions



- Conventional fuel rack actuated Diesel engine applications and high pressure Common Rail systems with SCR
- Woodward L'Orange Common Rail Fuel System with LECM - complete system solution



- Micro-pilot based DF strategies
- System offering comprised of Gas admission valves (SOGAV), Diesel main and μ Pilot injectors (Woodward L'Orange Single needle DF injector support), electric Waste Gate and LECM advanced control



- System offering comprised of Gas admission valves, LECM offering advanced control, ignition and electric waste gate
- Medium pressure Gas Admission (SOGAV) and High Pressure Direct Gas Injection (WLO)

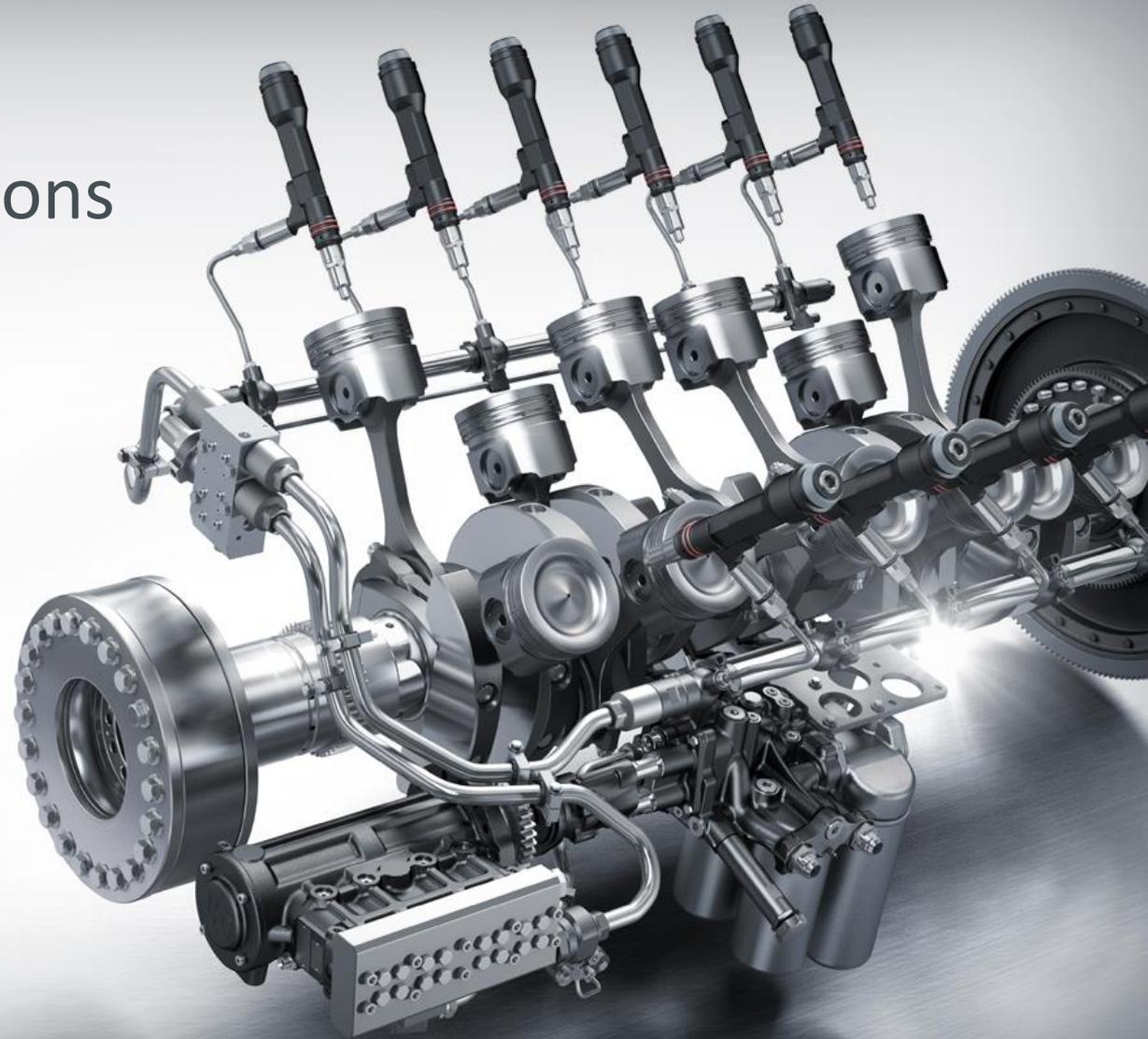
Marine Regulations

Woodward L'Orange Diesel Solutions



TECHNOLOGY MEETS INNOVATION: COMMON-RAIL SOLUTIONS

- Highest precision guarantees lowest emissions
- Robust design to reach highest lifetime expectations
- Customised to every application's unique requirements
- Made for remanufacturing to save costs and protect the environment



Marine Regulations

Woodward L'Orange Intelligent Injector Mk I



Drift-compensation

A sensor inside the injector allows to analyze the injection behavior.

This is a base for electronic drift compensation:

- improved fuel consumption/emissions
- condition monitoring
- engine protection

Load recorder

A load recorder allows to analyze life restricting parameters (number of injections, pressure,...)

This is a base for condition monitoring:

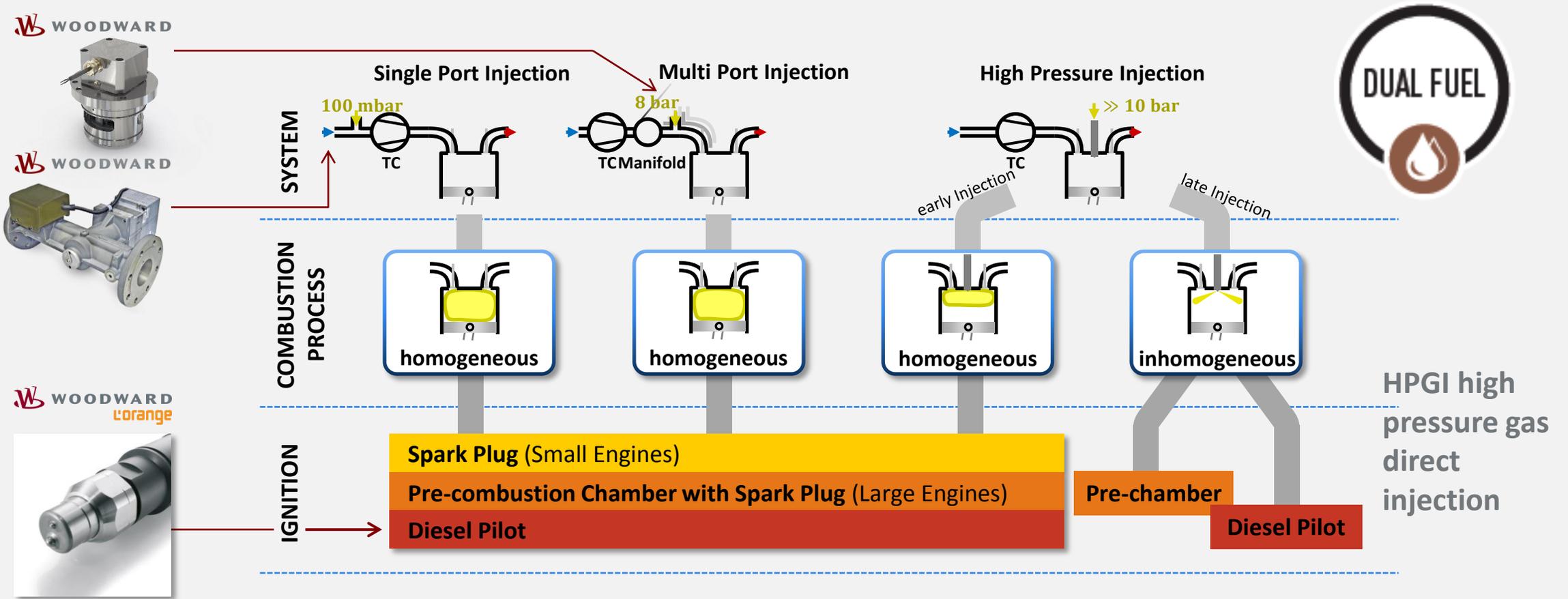
- condition based service
- target-oriented REMAN

Data collection capabilities and communication devices open the door to even more advanced features ...



Marine Regulations

Woodward L'Orange Dual Fuel Solutions





Marine Regulations

Woodward L'Orange Dual Fuel Solutions

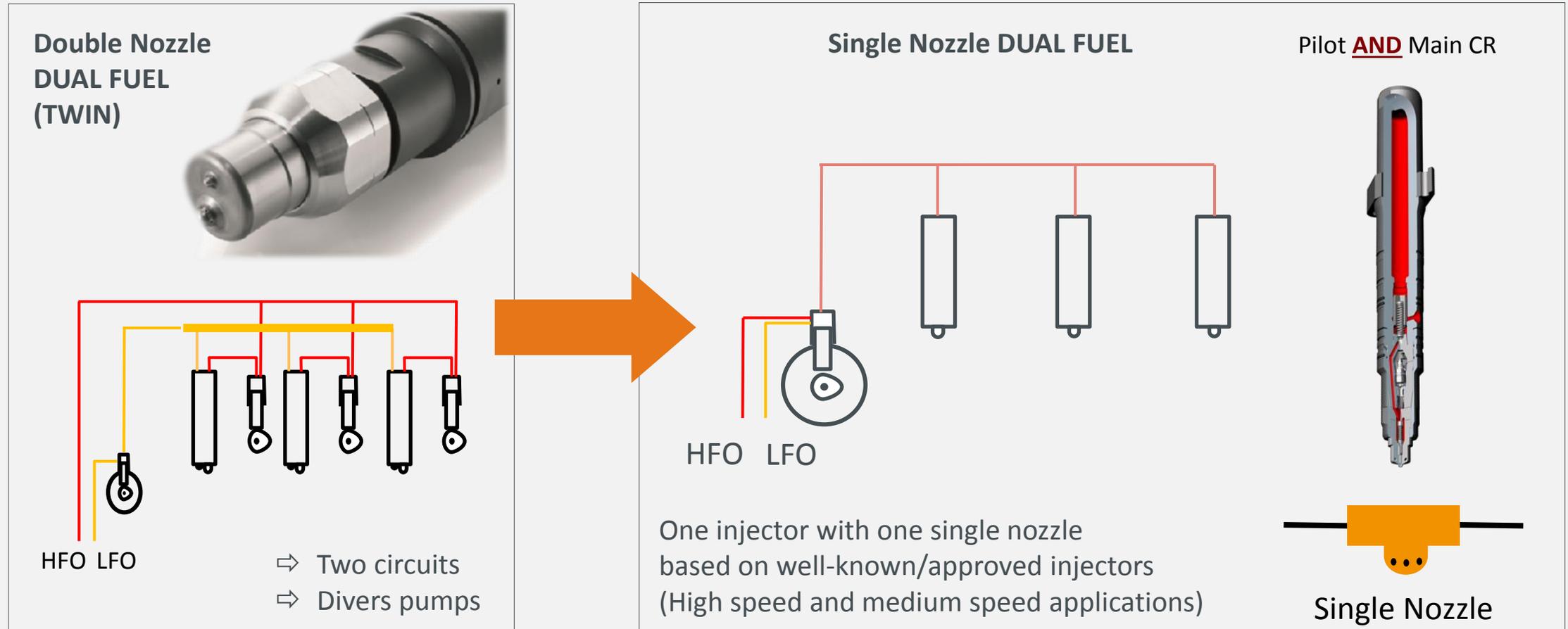


THE FUTURE IS MULTIFUNCTIONAL: DUAL-FUEL SYSTEMS

- Gas and dual-fuel operation ranks as one of the most innovative technologies for a more flexible, more efficient and lower-emission use of large engines (lower NOx / IMO tier 3).
- Dual-fuel systems are used in mobile application fields, such as LNG carriers, or in power plants with fluctuating gas supply.
- As required, the applications can be operated with gas for reduced emissions as well as with liquid fuel. This ensures a lower “carbon footprint” with less CO2 emissions and less greenhouse gas.

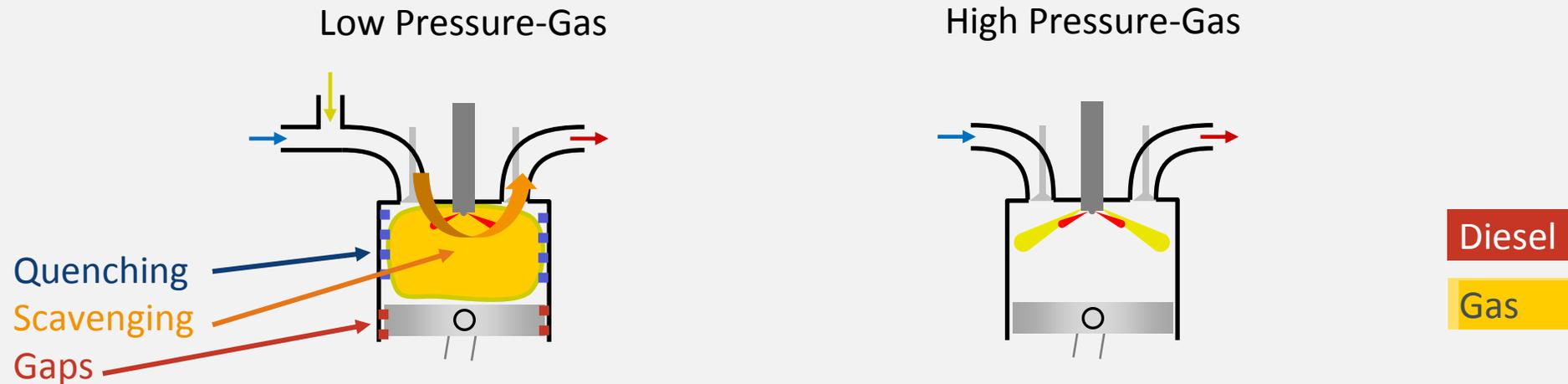
Marine Regulations

Woodward L'Orange Diesel Main & Pilot Injector (TWIN or Single Nozzle)



Woodward L'Orange High Pressure Dual Fuel Injector

Combustion concept

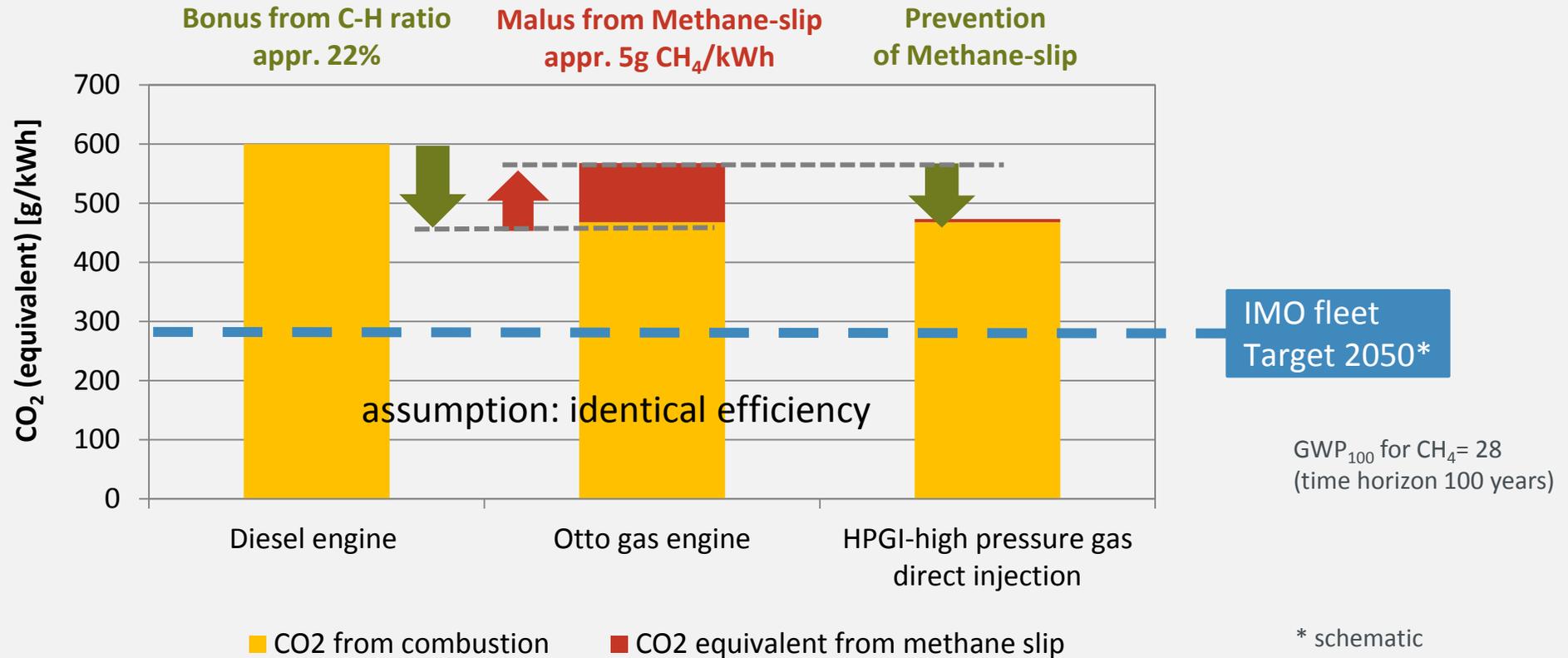


Virtually complete combustion

- No Methane slip with high pressure direct injection
- Power density and efficiency like a diesel engine

Woodward L'Orange High Pressure Dual Fuel Injector

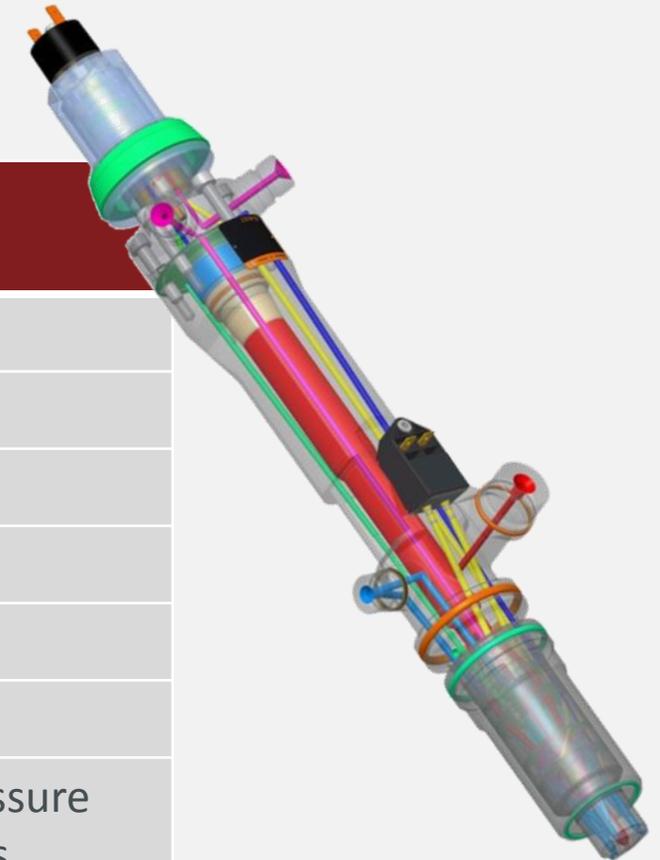
Motivation: HPDF as a solution to lower GHG emissions



Woodward L'Orange High Pressure Dual Fuel Injector

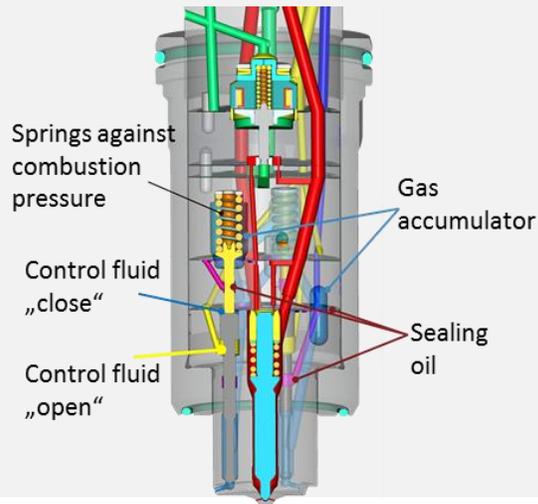
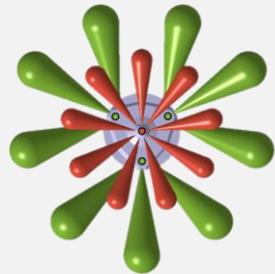
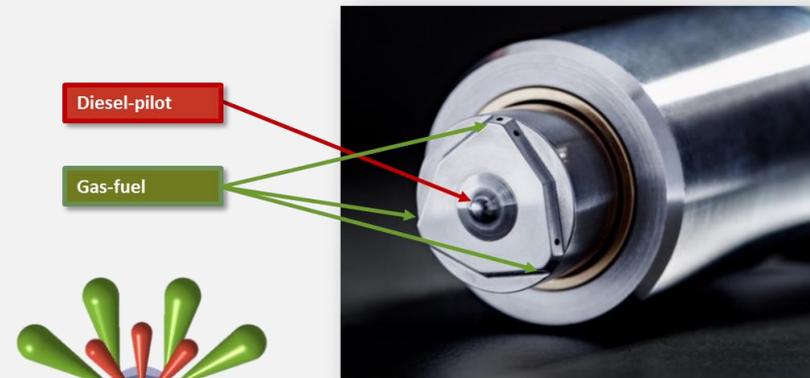
Injector design – development targets

	Baseline: GD-injectors for Wärtsilä	Targets for new injector
Engine size (bore)	> 320 mm	170 mm
Nozzle tip diameter	38 mm	25 mm
Gas pressure	350 bar	500 bar
Diesel technology	1400 bar PLN	2200 bar CR
Control oil / Sealing oil	Engine oil	Diesel
100 % Diesel Backup operation	Yes	Yes
Additional specifications for research prototypes	-	Independent pressure levels for all fluids



Woodward L'Orange High Pressure Dual Fuel Injector

Injector design – Multi-needle Concept



Control valve for gas-needle activation

Control fluid and gas sealing fluid (MDO)

CR-Accu (MDO)

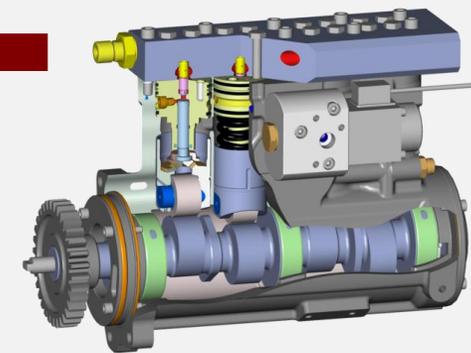
HP-gas
500 bar
Base: LNG



3 needles for gas
1 CR needle for MDO

**- GD-ENGINE -
Zero methane slip
@
Diesel-like performance**

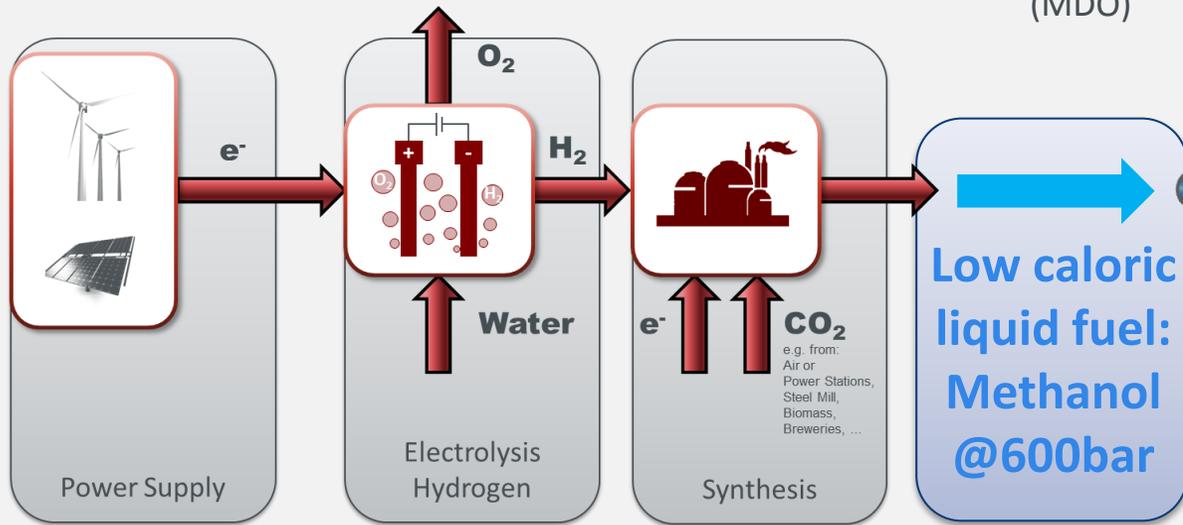
CR-System (MDO)
Pilot- + Main Injection
2200 bar
Injection quantity:
0,5 -100%



Woodward L'Orange High Pressure Dual Fuel Injector

Injector design – Multi-needle Concept

Power-to-X !



Control valve for gas-needle activation

Control fluid and gas sealing fluid (MDO)

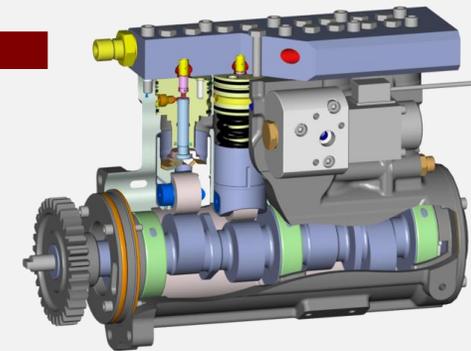
CR-Accu (MDO)



3 needles for gas
1 CR needle for MDO

**- OTTO-FUELS -
Use of E-Fuels
@
Diesel-like performance**

CR-System (MDO)
Pilot- + Main Injection
2200 bar
Injection quantity:
0,5 -100%



Marine Regulations

Woodward Gas Admission Solutions



GAS ADMISSION SOLUTIONS

- The performance and characteristics of a gas and dual-fuel internal combustion engine are significantly influenced by Gas Admission Valves (SOGAV).
- The SOGAV valves are a family of electrically-actuated, high-response gas admission valves for in-manifold (port) fuel admission. They are used on f4cycle, turbocharged, natural gas or dual-fuel engines. One SOGAV valve is required for each cylinder.
- The SOGAV valve is designed as the valve portion of an overall gaseous fuel admission system delivering precise gas mass flow metering per cylinder. This enables gas engines and dual-fuel engines to operate lean burn, increased efficiency & reduced emissions.
- SOGAVs are available with IGF code to meet marine compliance



Marine Regulations

Woodward LECM Solutions



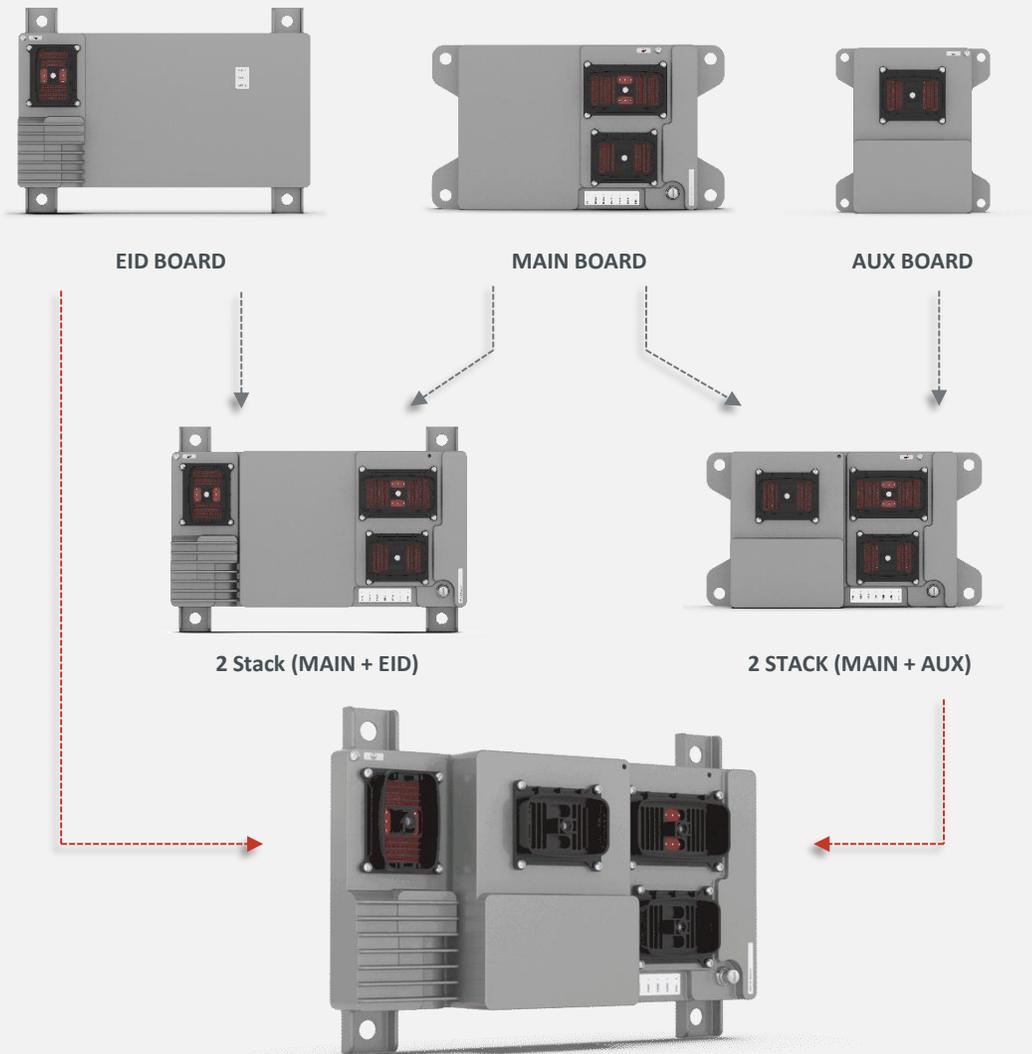
COMPLETE, SINGLE-UNIT ENGINE CONTROL: LECM

- The LECM provides an open and modular platform that can be built up with interlocking modules into a single engine-mountable assembly. This control scheme uses a modular approach for both the electronic control modules hardware and software. These modules can be mixed and matched to address different applications all using the same software interface. This single-module approach lowers hardware, wiring and troubleshooting costs, while reducing development and installation time.
- The features and benefits: Speed & load control, Air / fuel ratio control, Air, gas, exhaust flow control, Ignition & injector control, Misfire & knock detection, ROHS and marine-listed, Multiple CPUs

Marine Regulations Woodward LECM Solutions



- Combines all the engine controls functions in one
- Modular hardware– stacked or stand alone
- **Standard products & application software** available for turn key solutions of Gas, Diesel or Dual Fuel.
- Supports **connectivity** through Ethernet, real time data logging, analytics, diagnostics and prognostics
- **LECM software tools** allows OEMs to build their IP on top of standard applications or port proprietary software on a open platform



ALWAYS INNOVATING FOR A BETTER FUTURE



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