

- Maritime contributes 2.5% of global Greenhouse Gas (GHG) emissions, delivering 80% of global trade<sup>1</sup>
- IMO targets 5% of shipping must have zero emissions by 2030<sup>1</sup>
- Carbon-neutral and zero-carbon fuels are required to meet emissions targets
- Simulation software plays a vital role in modelling propulsion system performance



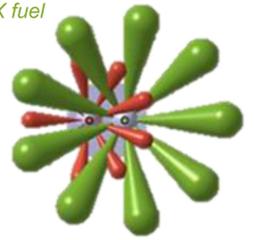
<sup>1</sup> 2023 IMO Strategy on Reduction of GHG Emissions from Ships, Resolution MEPC.377(80) Annex 1

## CFD combustion and FE thermal solutions

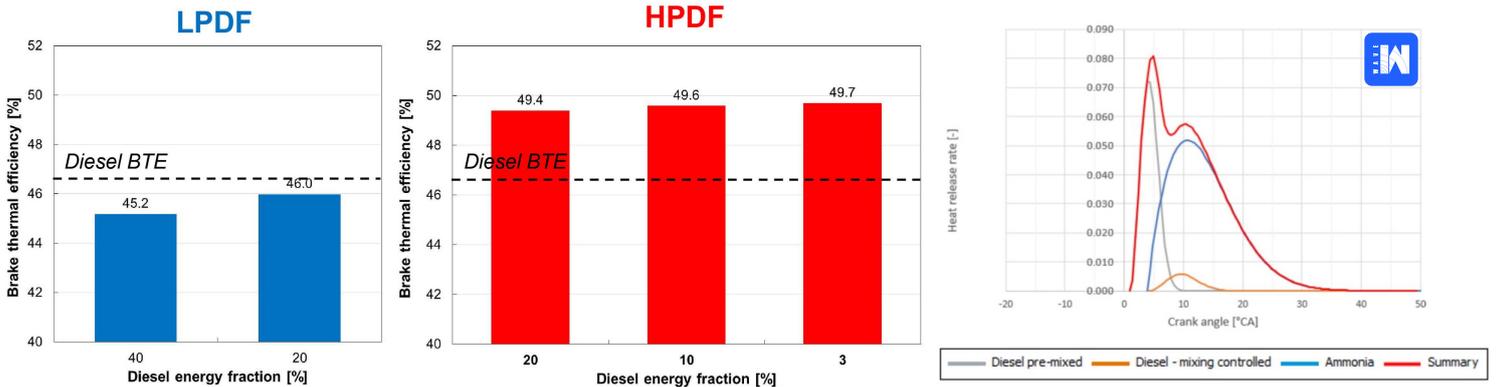


- Biofuel and Methanol carbon-neutral fuels
- Ammonia and Hydrogen zero-carbon fuels
  - SI combustion for ammonia-hydrogen blends
  - CI combustion for ammonia-diesel dual fuel
- 1D-CFD Multi-Wiebe combustion model for burn-rate of combined fuels
- Modelling of advanced fuel injectors for High Pressure Dual Fuels (HPDF)
- Unique FE thermal model of power cylinder using physical models and empirical correlations

Diesel pilot  
P2X fuel



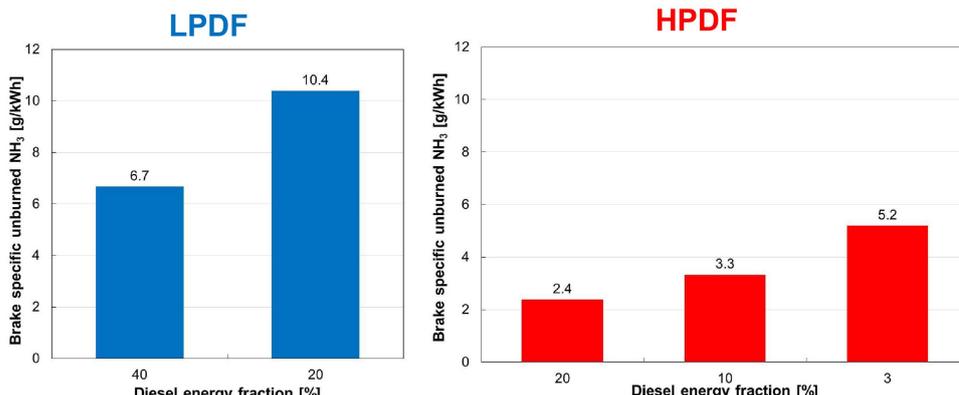
Source: Woodward L'Orange



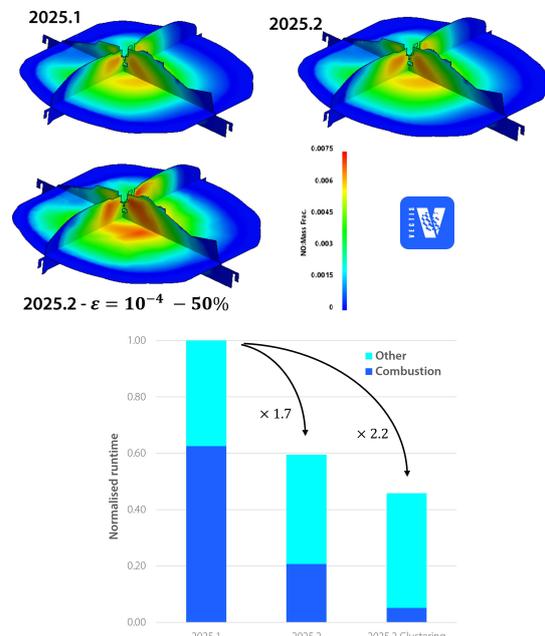
Source: Ricardo analysis - 'High-Pressure Dual-Fuel Combustion Systems for Sustainable Maritime Engines', MariNH<sub>3</sub> Conference 2025

## Cutting emissions from combustion

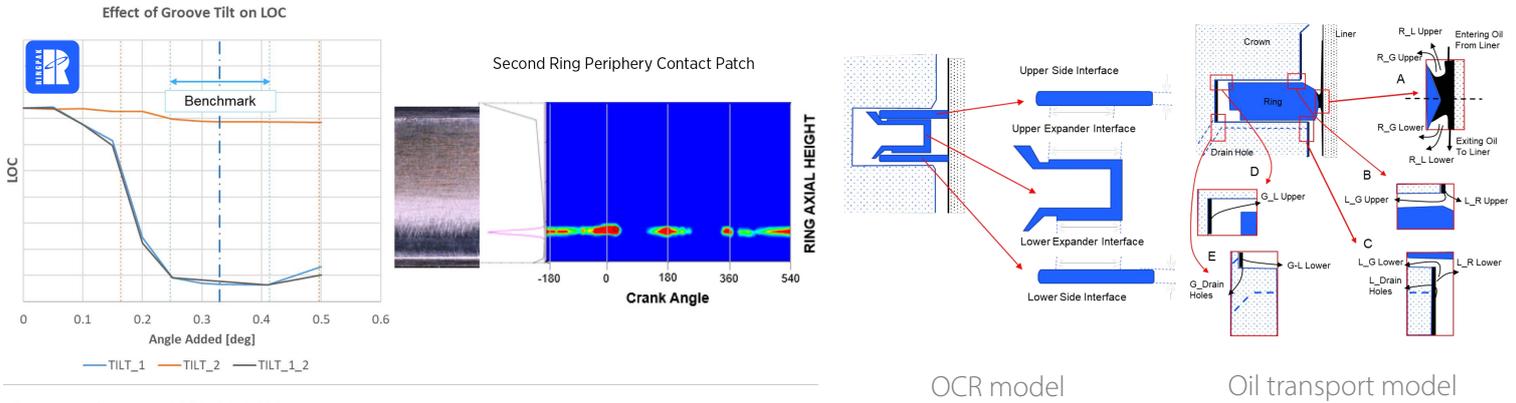
- Fast accurate detailed chemical kinetics for emissions using 3D-CFD VECTIS
- Captures fuel composition effects and pollutant formation using unique chemical clustering method



Source: Ricardo analysis, Li et al. (2022) 'A comparison between low- and high-pressure injection dual-fuel modes of diesel-pilot-ignition ammonia combustion engines'



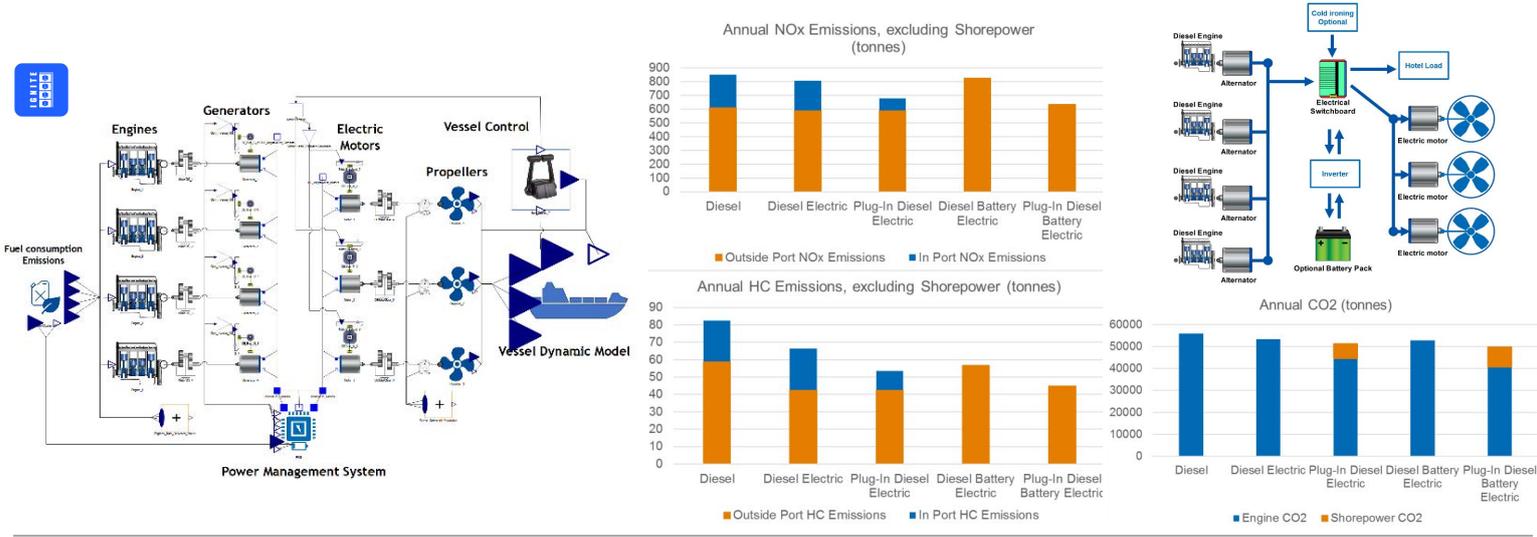
- Piston ring pack optimisation to minimise oil consumption for 4-stroke engines
- 3-piece Oil Control Ring (OCR) modelled as 3 separate bodies to accurately capture the dynamic interactions between them
- Oil transport model that evaluates the inertia driven oil flows that sweep the piston crown surfaces



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# Ship vessel hybridisation

- Hybrid electric systems can prevent in-port harmful NOx and HC emissions and significantly reduce global CO<sub>2</sub> emissions
- System modelling compares benefits of battery and/or plug-in on-shore hybrid 'cold ironing' propulsion options with conventional vessels across Diesel Electric, Plug-in Diesel Electric, Diesel Battery Electric and Plug-in Diesel Battery Electric
- Models are used to quantify capital expenditure and operating expenditure options, trading-off cost versus benefits



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# Predictive engine maintenance and diagnostics

- Model Based Development (MBD) using faster than real-time predictive engine plant models for engine optimisation, calibration, maintenance and diagnostics
- MiL, SiL and HiL applications, linked to MATLAB/Simulink
- Predictive combustion, kinetics and emissions

