IMO TIER 3 REGULATION - HOW TO DEAL WITH THE PRESENT SITUATION

THE OPTIMUM PLATFORM-TECHNOLOGY CHOICE FOR MAXIMISED BENEFITS IN ALL TRADES

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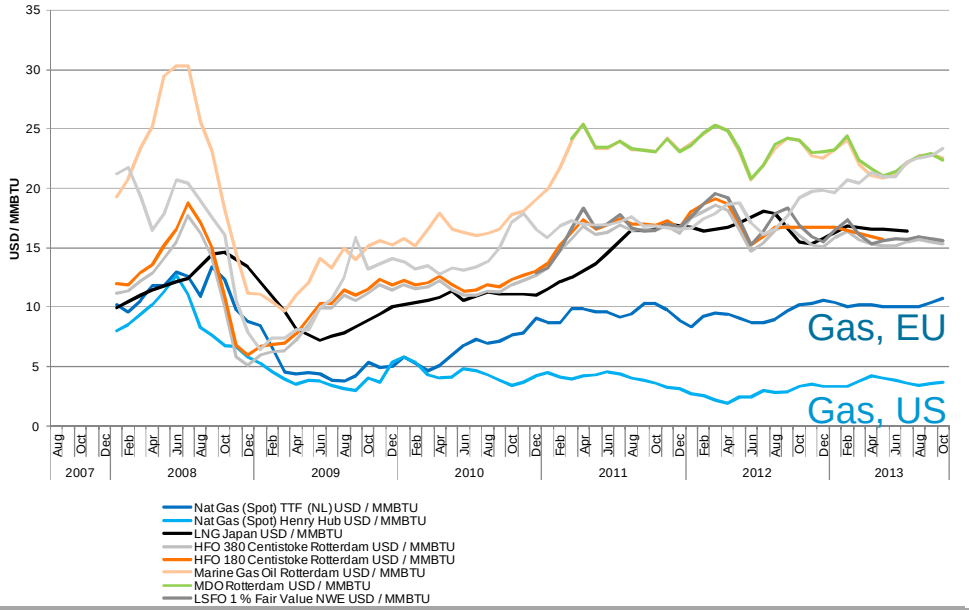
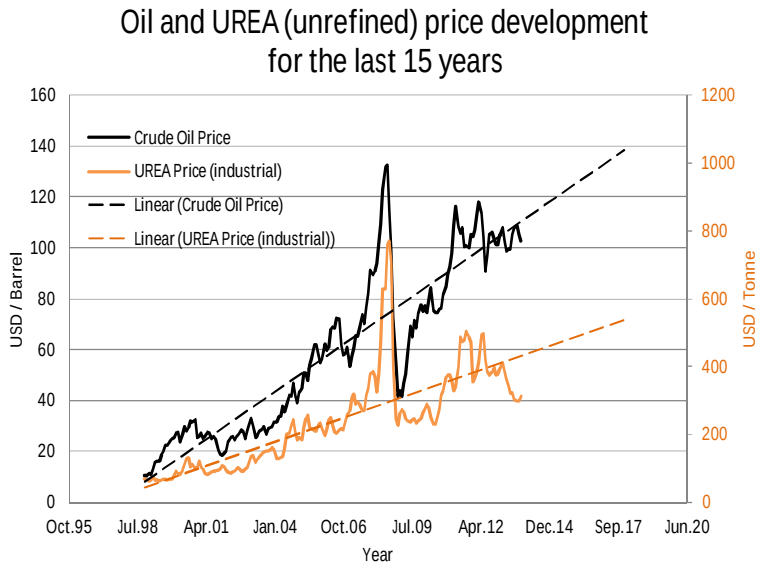
SMM Hamburg 2014

A certain market with a certain fuel



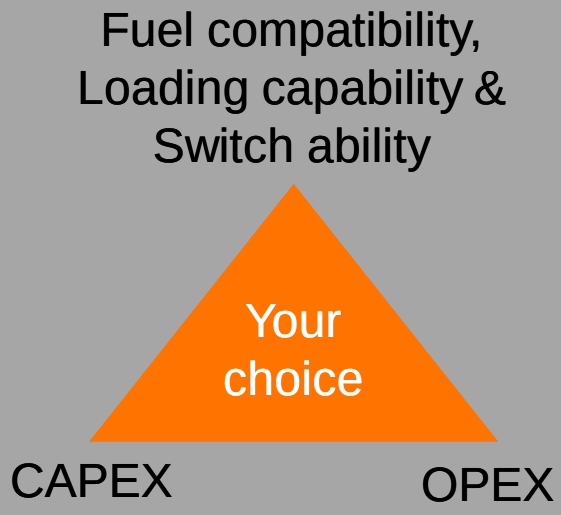


Gas is competitive

Cases evaluated, 3 years period

CAPEX and OPEX evaluation has been made for the following cases:

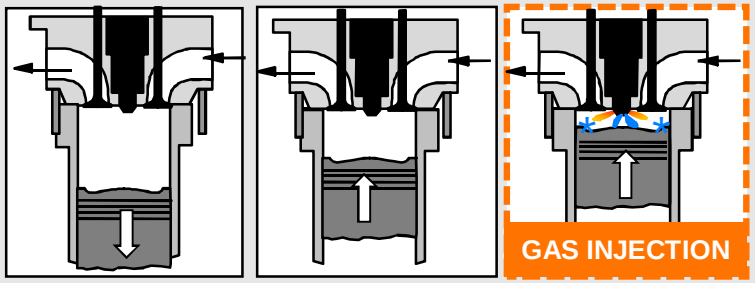
- Cost evaluations for two different operational scenarios:
  - **Worldwide trade**: 80% non-ECA (**75% average load**), 20% ECA (**50% average load**)
  - **Regional trade**: 20% non-ECA (**75% average load**), 80% ECA (**50% average load**)
  - Three years operation, **6500 running hours** per year
- Cost evaluations for two different engine installations:
  - (Small bore: 2*1600 kW)
  - **Large bore: 4*14400 kW = 57 600 kW nominal power**



Disclaimer: Costs & prices esimated based on 2014 levels.

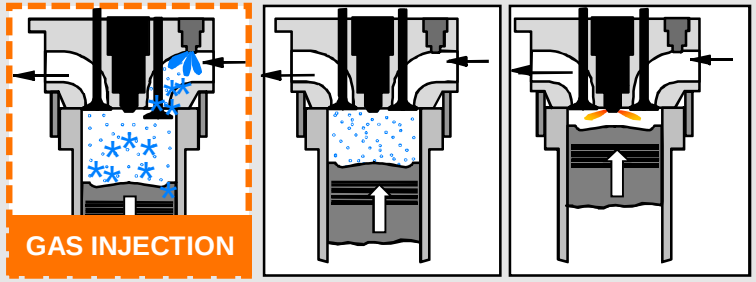
Find your optimal solution

The 4-stroke product types



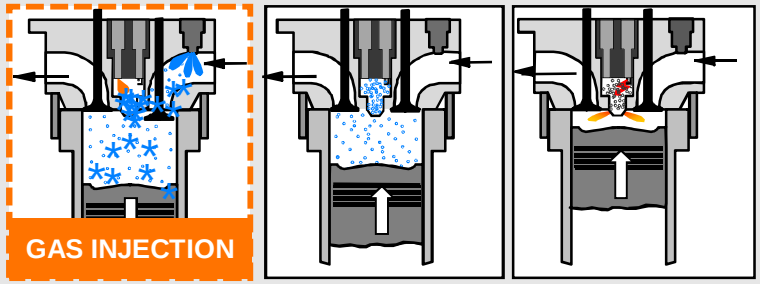
DIESEL OR GAS-DIESEL (GD)
Does NOT meet IMO Tier III

High injection or gas pressure



DUAL-FUEL (DF)
Meets IMO Tier III

Does NOT meet in back-up (HFO/LFO) mode)



SPARK-IGNITION GAS (SG)
Meets IMO Tier III

No redundancy
No HFO flexibility

> **Otto has beaten Diesel in many respects**

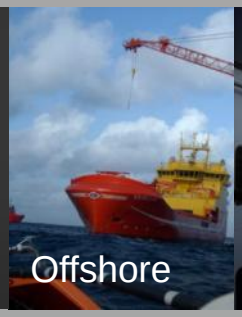
Wärtsilä gas product references

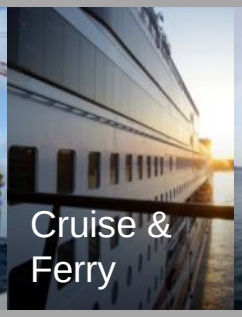
Gas Diesel (GD)

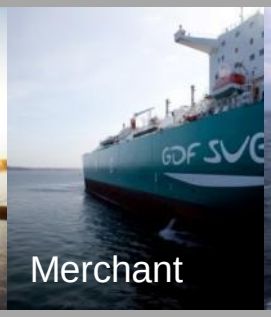
- High Pressure Gas

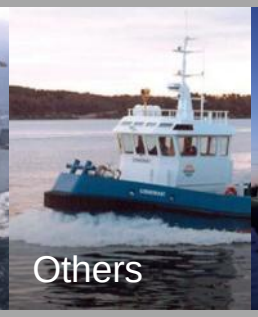
Dual Fuel (DF)

- Low Pressure Gas









Spark-ignited Gas (SG)

- Low Pressure Gas

□ 8 segments □ >800 installations
□ >2,700 engines □ >20,000,000 running hours

Technology combinations evaluated

a) **1-stage + NOR** (HFO1-2 usage in Tier II and LFO in Tier III)

b) **2-stage + NOR** (HFO1-2 usage in Tier II and LFO in Tier III)

c) **2-stage + Inter-Turbine SCR** (HFO1 usage in Tier II and LFO in Tier III)

d) **2-stage + Internal EGR** (HFO1 usage in Tier II and LFO in Tier III)

e) **2-stage + EGR** (HFO in Tier II & LFO in Tier III)

f) **1-stage + EGR** (LFO only)

g) **Scrubber + NOR** (if HFO use in ECA instead of LFO)

h) **DF including LNG plant, Low LNG price** (USA)

i) **DF including LNG plant, average LNG price** (Europe)

The references

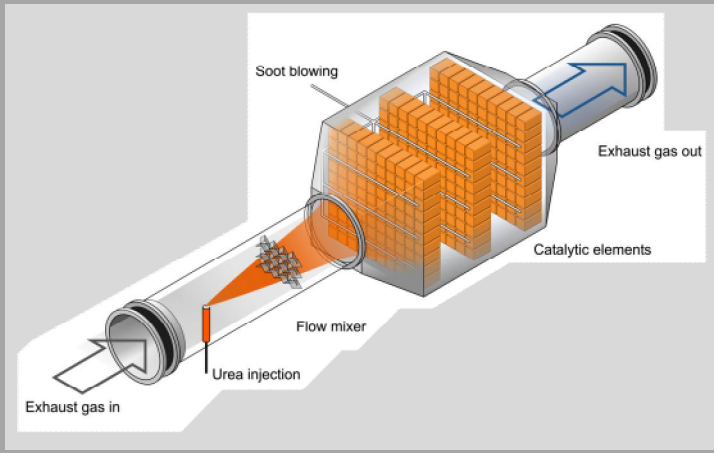
CAPEX: IMO Tier 2 HFO engine

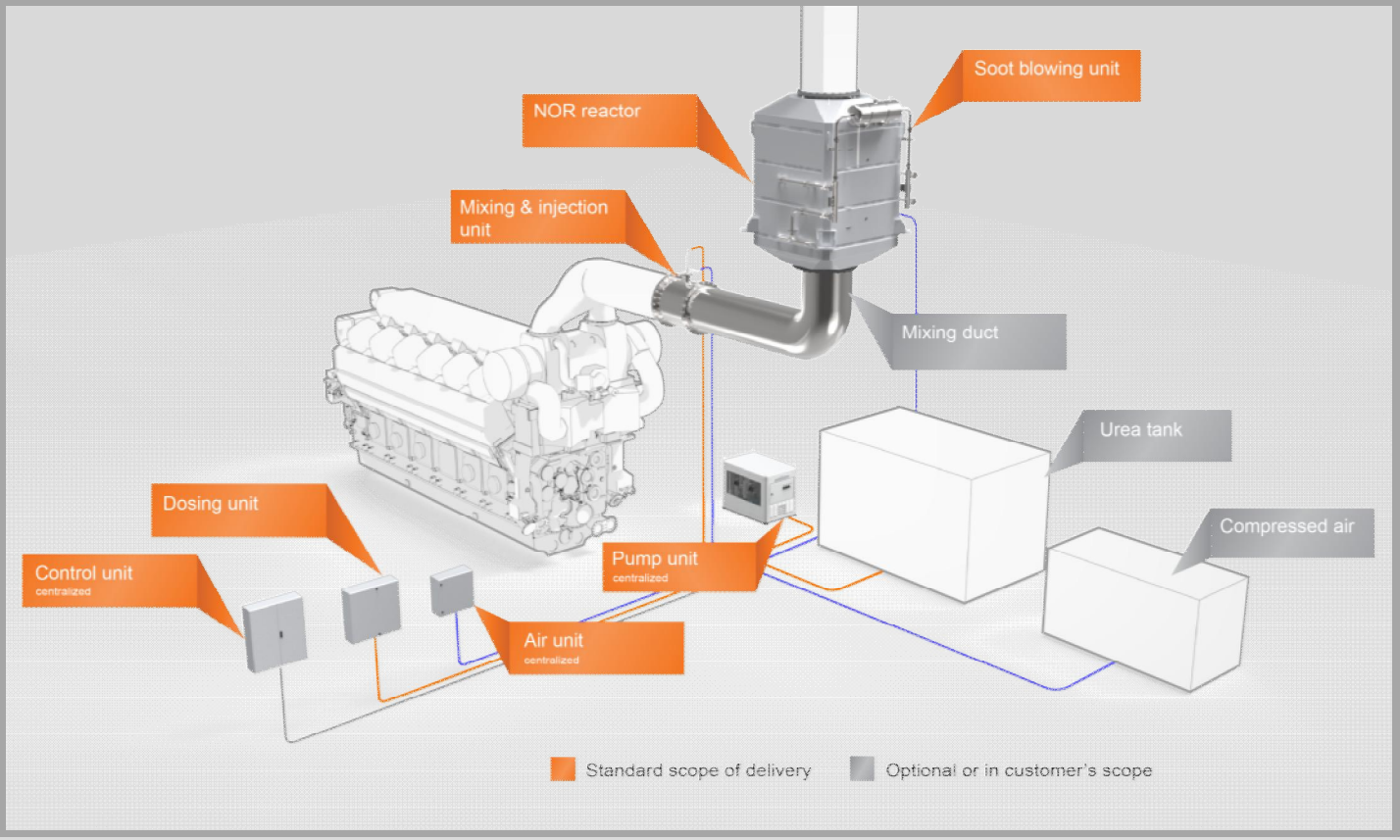
OPEX and total: 1-stage + NOR a)

There are technologies to meet Tier III

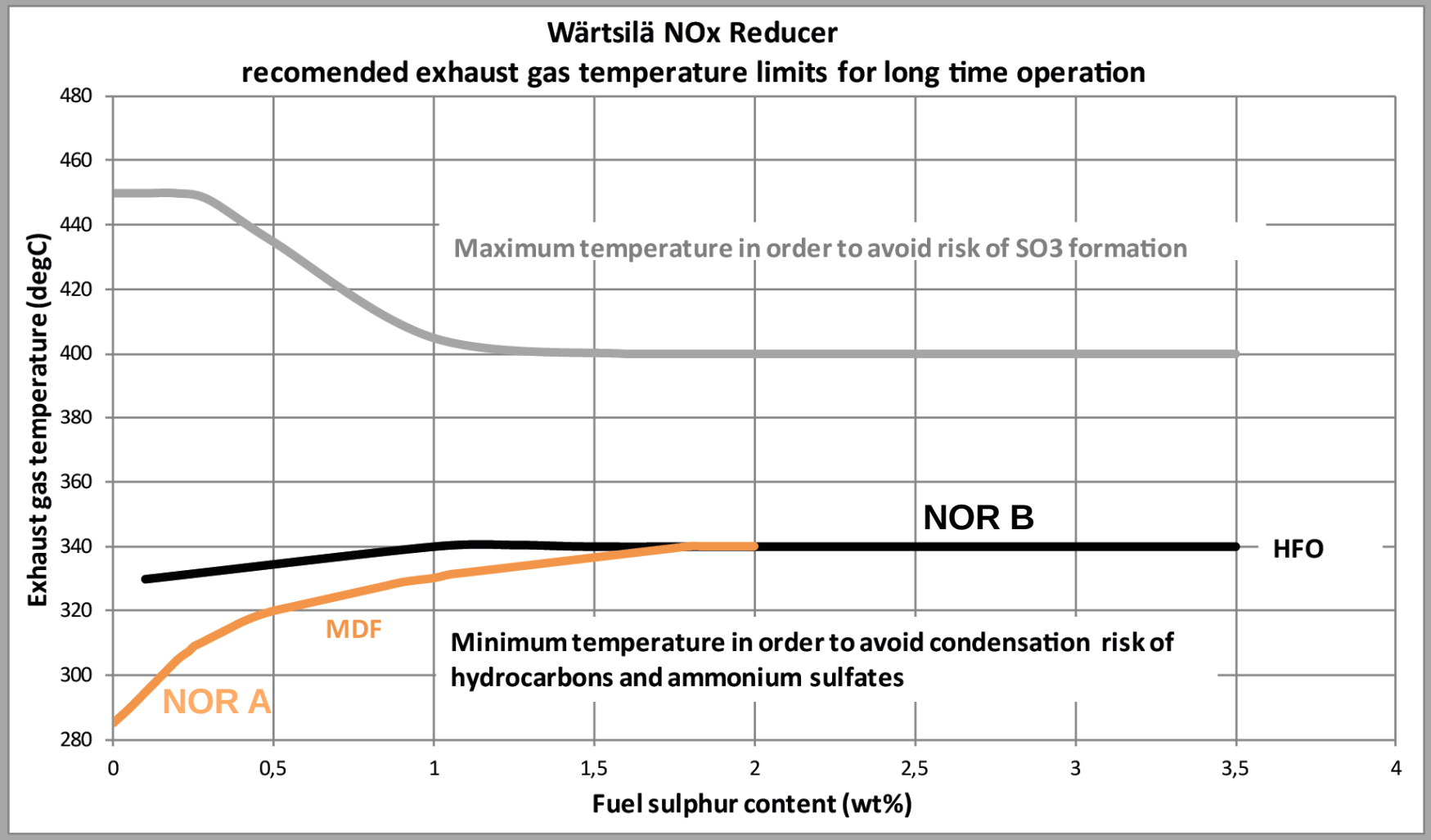
NOx Reducer (NOR)

- Nitrogen oxides (NO_X) are reduced into nitrogen (N_2) and water vapour (H_2O) using ammonia or urea at a suitable temperature on the surface of the catalyst.





Exhaust gas temperature window



Scrubber technology

Open loop scrubber – sea water operations

- Uses seawater i.e. no freshwater needs
- Slightly higher power demand than FWS
- Does not need caustic soda

Applications: main alternative for ocean-going ships

Closed loop scrubber – fresh water/closed loop operations

- Independent of seawater alkalinity
- Zero effluent discharge an option
- Low power demand
- Needs caustic soda as a reagent

Applications: seas with extremely low alkalinity and for operators looking for continues closed loop operation

Hybrid scrubbers – open loop / closed loop operations

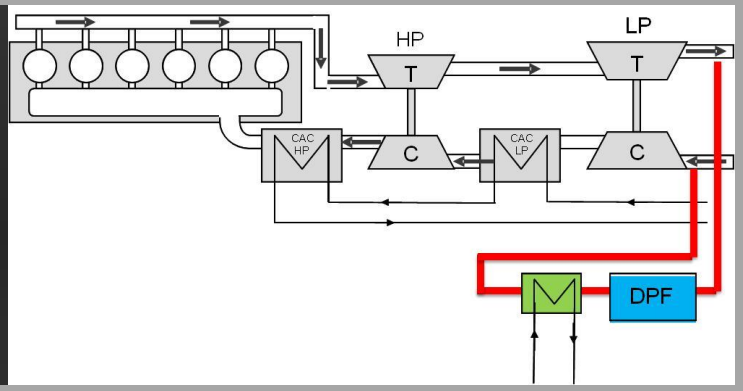
- Flexible system
- More complex system

Applications: ships requiring full flexibility of operations

Main division of different EGR systems

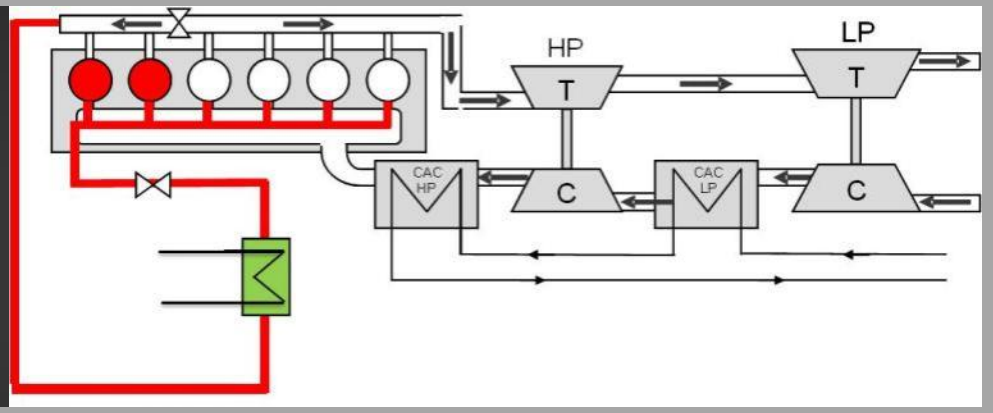
Long route EGR

- **Long route**



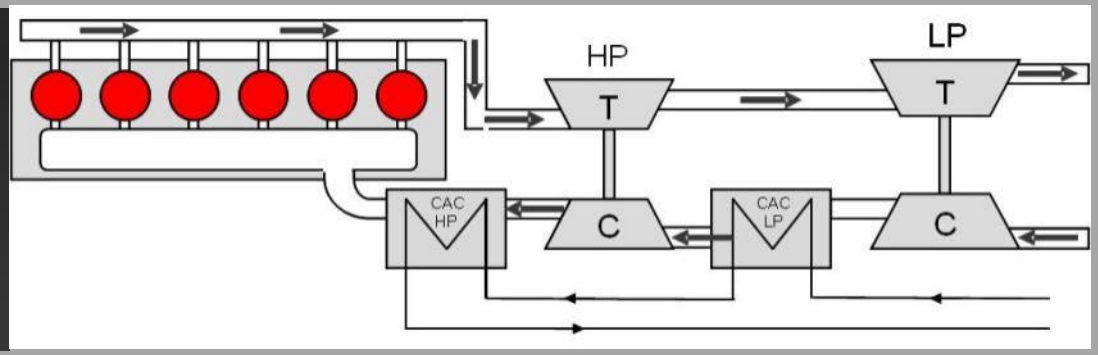
Short route EGR

- **Donor cylinder**
- EGR-Turbo + compressor
- Turbo compound (backpressure driven EGR)



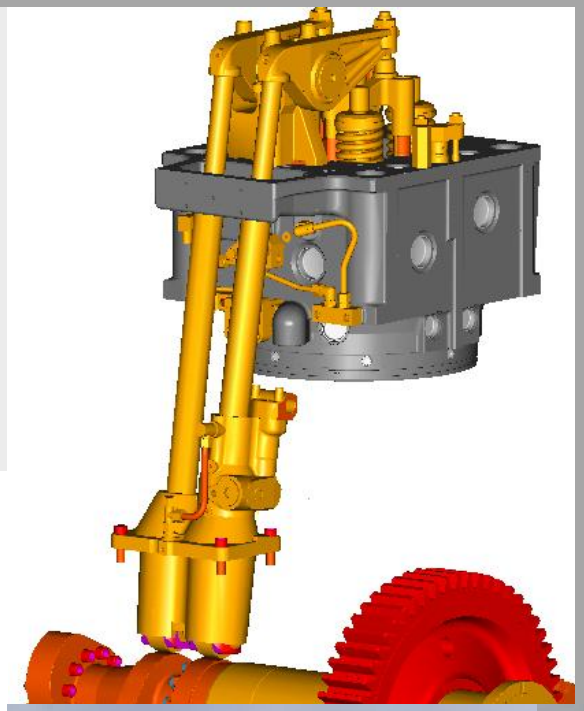
Internal EGR

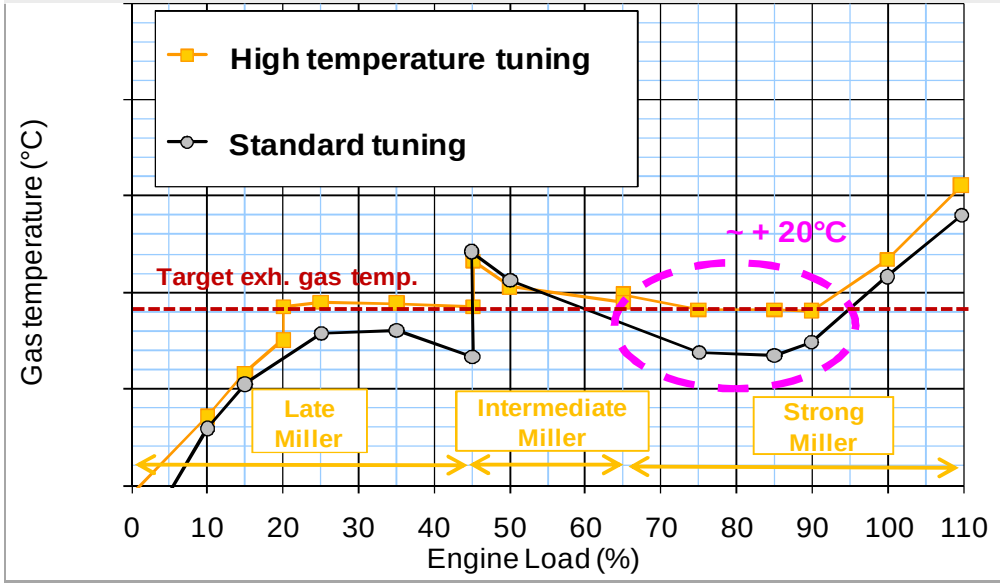
- **Zero scavenging**
- Water cooled



Variable Valve Train

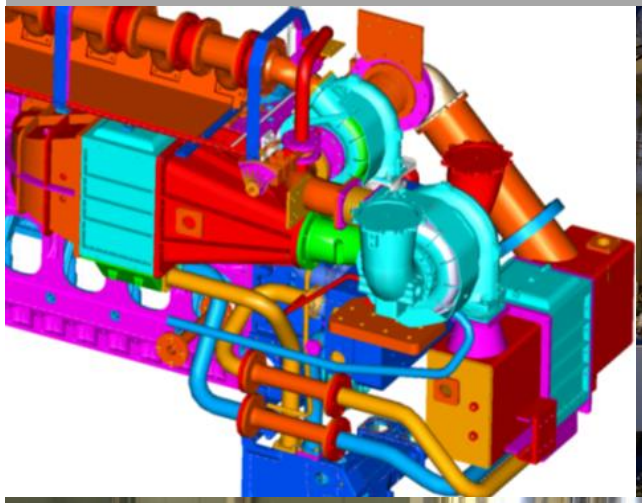
- **Enabled by**
  - VIC (Variable Inlet Closure)
- **In order to**
  - Reduce smoke during load ramps
  - Control exhaust gas temperatures
  - Optimise efficiency also at part load

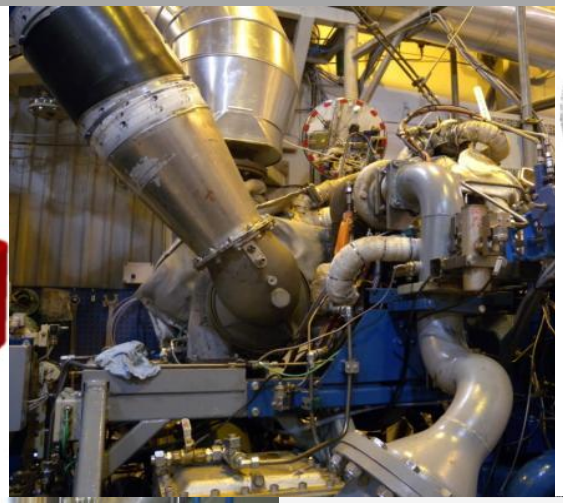


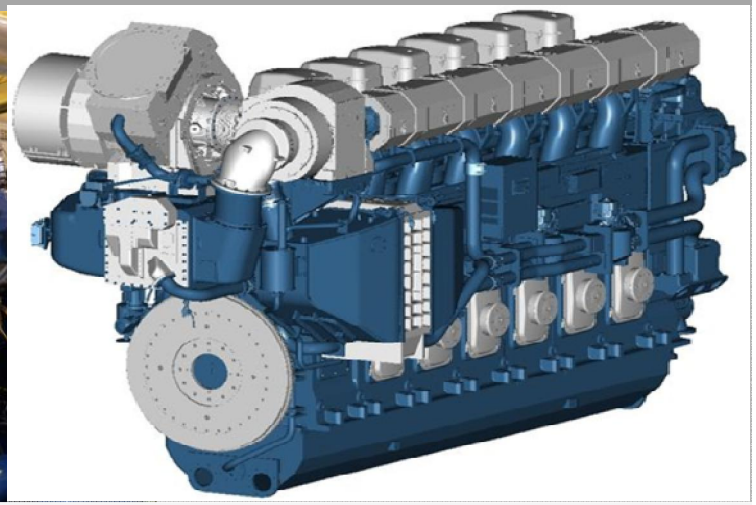


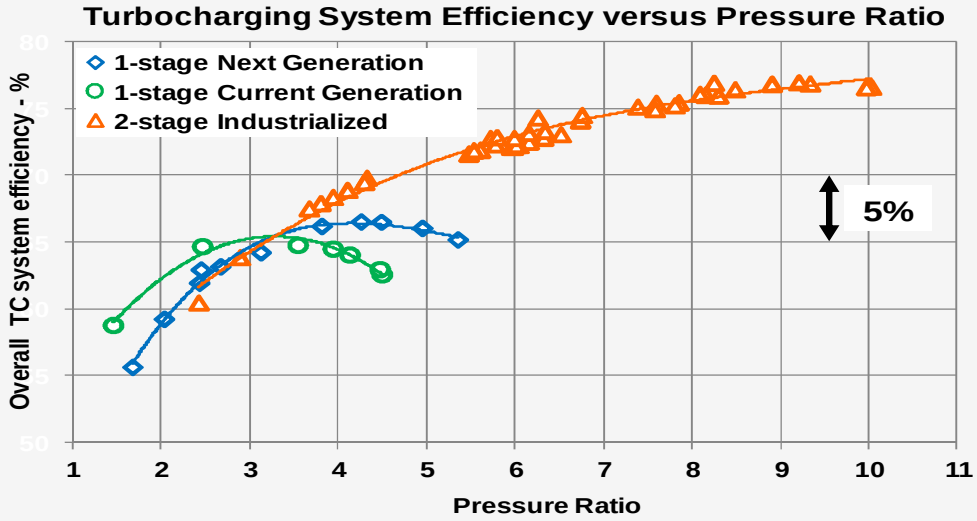
The customer can run at lowest total operation cost both inside and outside of ECA areas with less smoke

2-stage Turbocharging





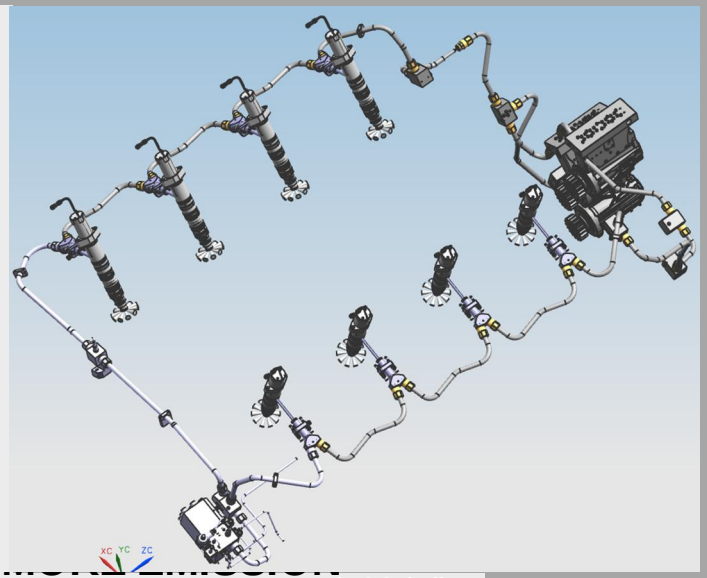


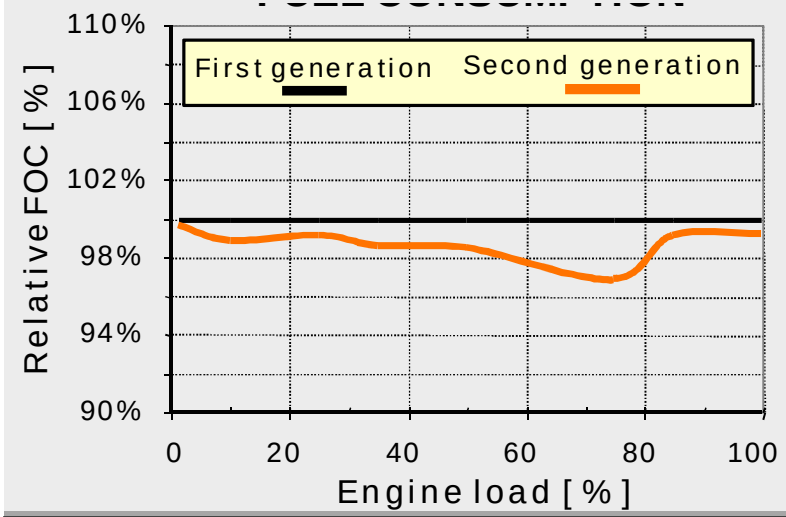


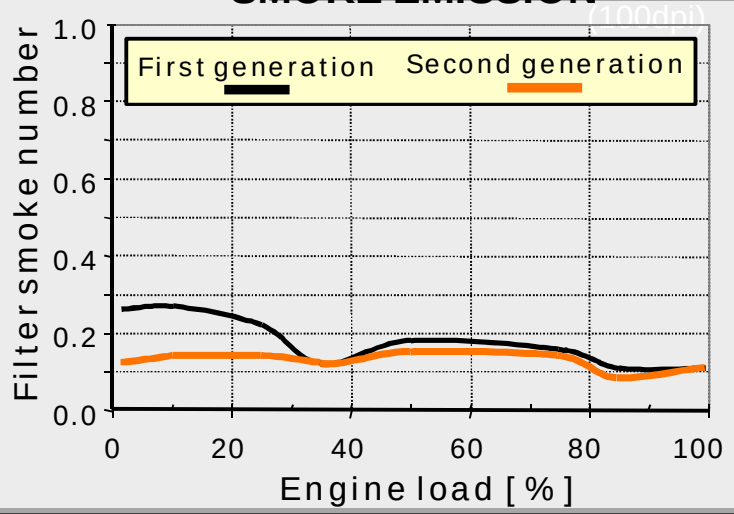
2-stage TC – a safe bet for the future

Electronic fuel injection system

- **Second generation common rail**
  - electronic fuel injection features
  - simplified architecture
  - accu-injector-design
  - higher flexibility
  - highest pressure only at nozzle
  - reduced losses
  - jumper rails



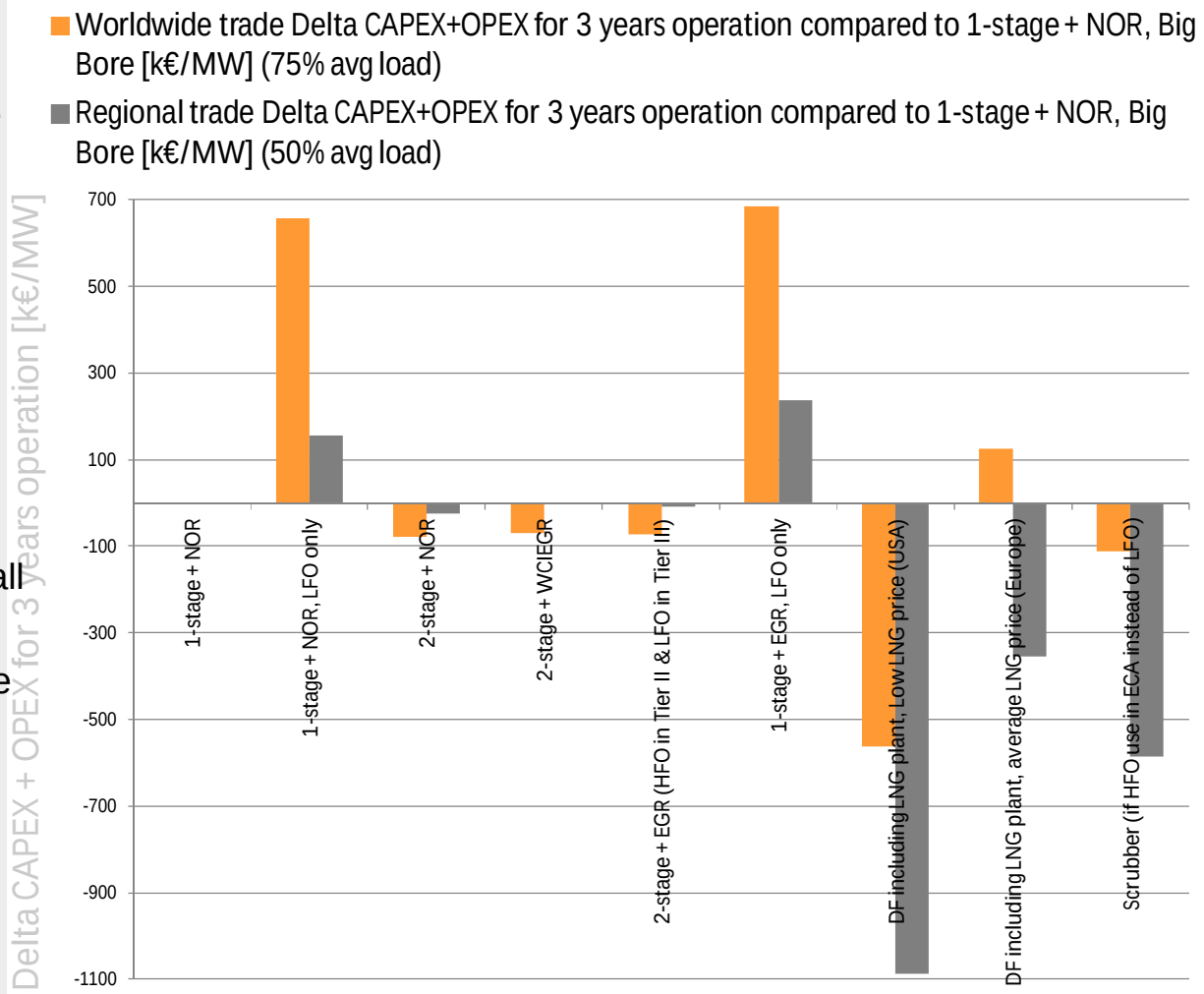




CR2 – ready for the flexibility Tier III requires

CAPEX & OPEX Evaluations, all trades

- Worldwide trade
  - All 2-stage solutions are attractive
  - Scrubber solution is attractive
  - 1-stage + EGR is not a good solution
  - DF solution is only attractive if the LNG price is very low
- Regional trade
  - DF solution is attractive even with European LNG price (also for small bore)
  - Scrubber solution is very attractive (even for small bore)
  - All 2-stage solutions are slightly better than the reference
  - 1-stage + EGR has potential, especially if the yearly running hours are low.



Overall drive: Gas, 2-stage, Scrubber (HFO)

Summary

- There are technologies to meet Tier III
- CR2 – ready for the flexibility Tier III requires
- 2-stage TC – a safe bet for the future
- Engine automation is a strategic enabler
- CAPEX drives: 1 or 2-stage, EGR & LFO
- OPEX drives: 2-stage TC, Gas, Scrubber, NOR
- Loading & switch ability drives: (variable valve train), 2-stage, (flexible fuel injection), EGR
- Overall drive: Gas, 2-stage, Scrubber (HFO)

Passion for optimising lifecycle value with modern and sustainable power solutions.