

WARTSILA 31

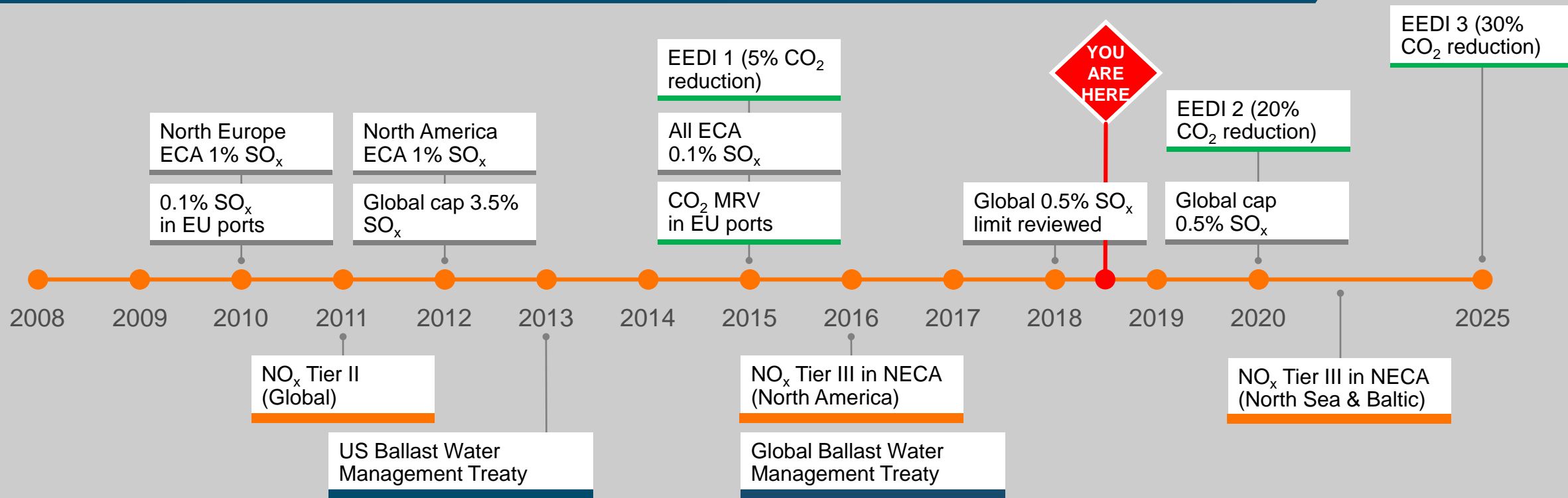
FIELD EXPERIENCE & TECHNOLOGY UPDATE

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Product Manager
November 2018



- **LEGISLATION AND SUSTAINABILITY AS A DRIVER**
- **W31 FIELD EXPERIENCE**
- **W31 CUSTOMER VALUE THROUGH INNOVATION**

ENVIRONMENTAL LEGISLATION - CONTINUED TREND TOWARD MORE STRICT LIMITS



SO_x legislation:

- Sulphur free fuels
 - LNG
 - Methanol, LPG, bio-fuels
 - Distillates
- Scrubbers in combination with HFO

NO_x legislation:

- Tier II
 - Engine internal methods
- Tier III
 - Secondary methods (SCR)
 - LNG/NG with lean burning process (dual-fuel engines)

Ballast Water Treaty:

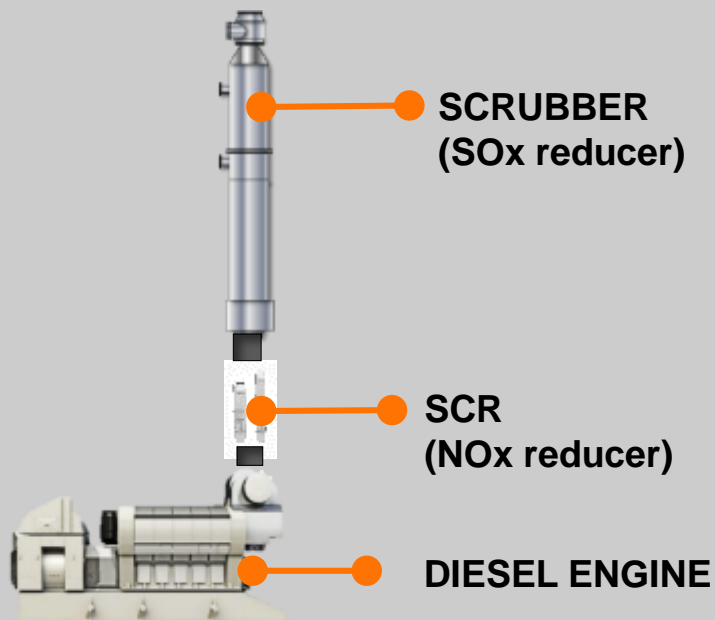
- UV ballast water treatment system
- EC ballast water treatment system
- Minimised amount of ballast water through Ship Design

Legend:

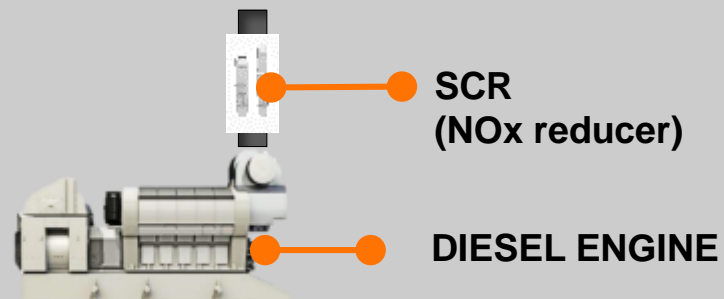
- **CO₂ MRV** - EU MRV (*Monitoring, Reporting, Verification*) regulation - to report and verify CO₂ emissions for vessels larger than 5,000 gross tonnage, that serves the purpose of transporting passengers and enter EU port.
- **Energy Efficiency Design Index**. (EEDI) - the EEDI provides a specific figure for an individual ship design, expressed in grams of carbon dioxide (CO₂) per ship's capacity-mile (the smaller the EEDI the more energy efficient ship design) and is calculated by a formula based on the technical design parameters for a given ship.

ESTABLISHED SOLUTIONS TO FULFIL THE LIMITATIONS

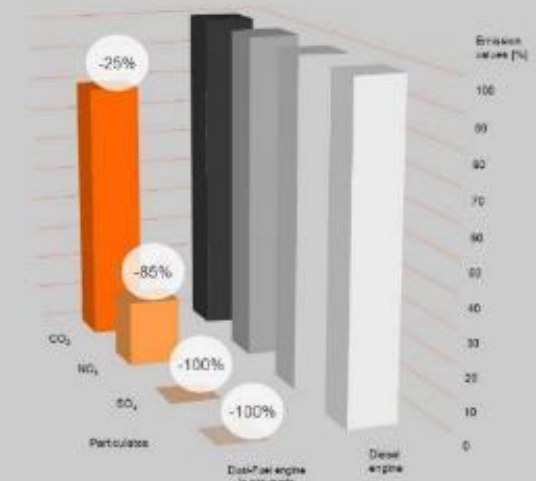
... running on **HFO/MDO**
($S > 0,1\%$)



... running on **MGO**
($S < 0,1\%$)



... running on **LNG**



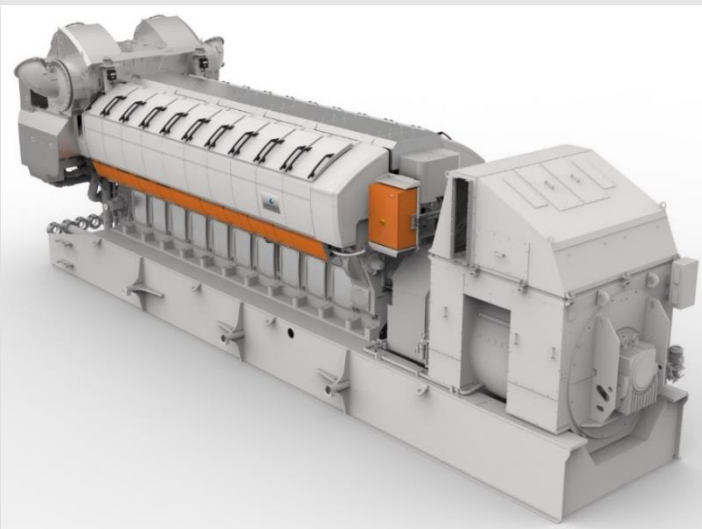
IMO TIER III

SOx compliant

EPA compliant

No need of
after treatment
devices
installed

WÄRTSILÄ 31 – PORTFOLIO OVERVIEW



Main parameters	Diesel	Dual Fuel (DF)	Spark Gas (SG)
Max. cyl. output (kW)	590 / 610	530 / 550	580 / 600
Bore (mm)	310		
Stroke (mm)	430		
Nom. Speed (rpm)	720 / 750		

Cylinder config.	8V31	10V31	12V31	14V31	16V31	20V31 (Energy Solutions)
Max. output (MW)	4.2-4.9	5.3-6.1	6.4-7.3	7.4-8.5	8.5-9.8	10.6-12.2
Weight (tonnes)	56,7	62,0	73,0	81,0	89,0	110,5
Size L x W x H (m)	L 6,2 W 3,1 H 4,7	L 6,8 W 3,1 H. 4,7	L 7,8 W 3,5 H 4,1	L 8,5 W 3,5 H 4,2	L 9,1 W 3,5 H 4,2	L 10,0 W 3,8 H 4,7

” Wide “gapless” marine portfolio 8V-16V for optimal application fit

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41 Engines Sold Globally, First Engines in Commercial Operation!



Type: Icebreaker
Owner: FSUE Atomflot
3 x W8V31



Type: RoPax
Owner: MolsLinien
2 x W8V31



Type: Fishing vessel
Owner: P. Hepsö Rederi
1 x W8V31



Type: Fishing vessel
Owner: Lunar Fishing
1 x W10V31



Type: RoPax
Owner: Viking Line MoS
6 x W10V31DF



Type: Processing vessel
Owner: Hav Line
1 x W10V31



Type: Fishing Vessel
Owner: Strand Senior AS
1 x W8V31



Type: Fishing Vessel
Owner: Research Fishing
1 x W12V31



Type: 2 x Ferry
Owner: Hankyu Ferry
2 x W14V31



Type: Cruise vessel
Owner: Comp.d Ponant
4 x W14V, 2 x W10V31DF



Type: Ferry
Owner: TBA
4 x W16V31DF



Type: Cable layer
Owner: TBA
4 x W8V31



Type: Fishing Vessel
Owner: TBA
1 x W8V31



Type: 6 x Fishing Vessels
Owner: TBA
6 x W10V31 SME

- Vessel type: RoPax
- Seatrial June 2018
- Commercial operation since September 2018



- Vessel type: Fishing vessel
- Seatrial September 2018
- Commercial operation since October 2018

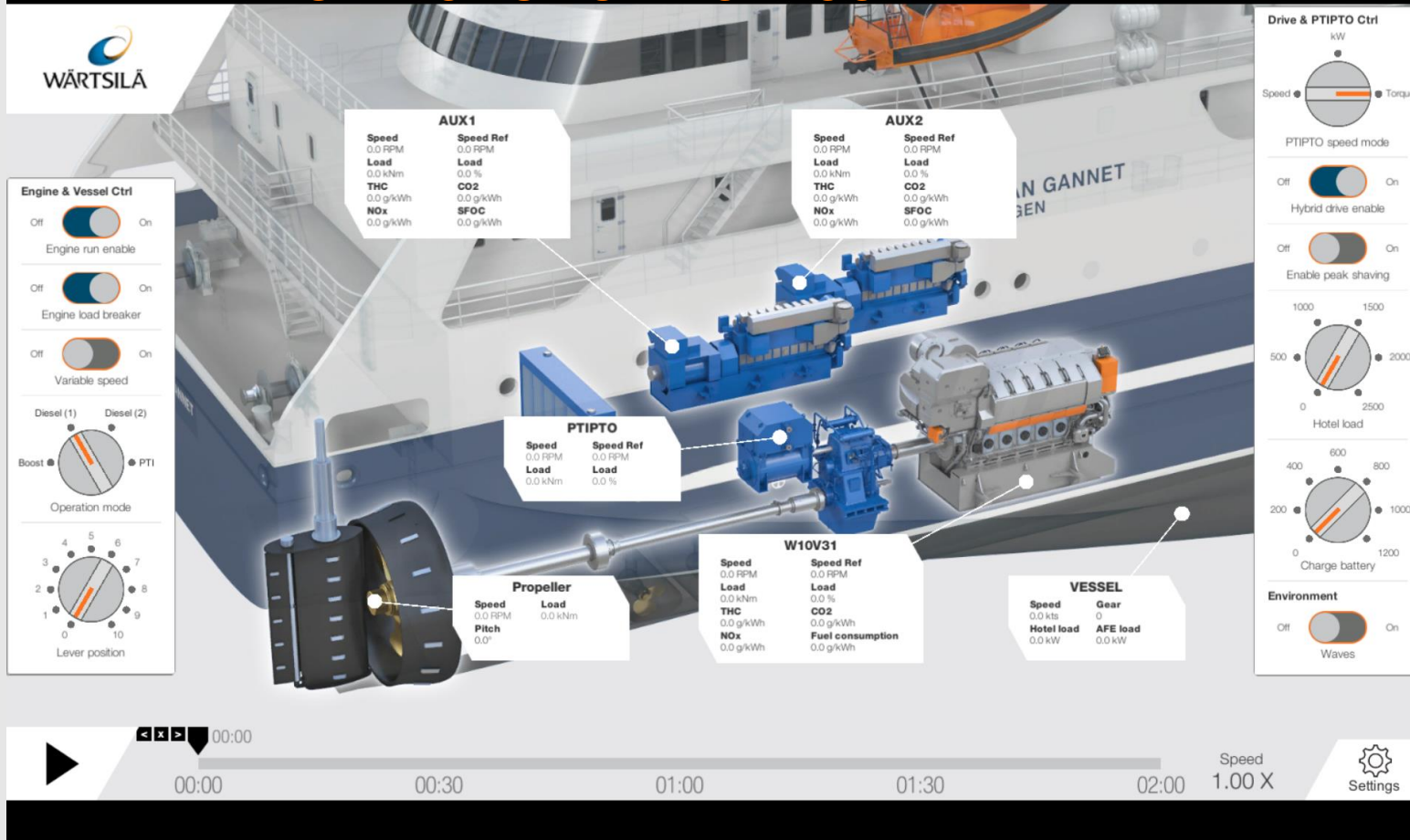


- Vessel type: Processing vessel – world first hybrid fish processing vessel
- Seatrial October 2018
- Commercial operation since November 2018



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HYBRID INTEGRATION SIMULATION TOOL

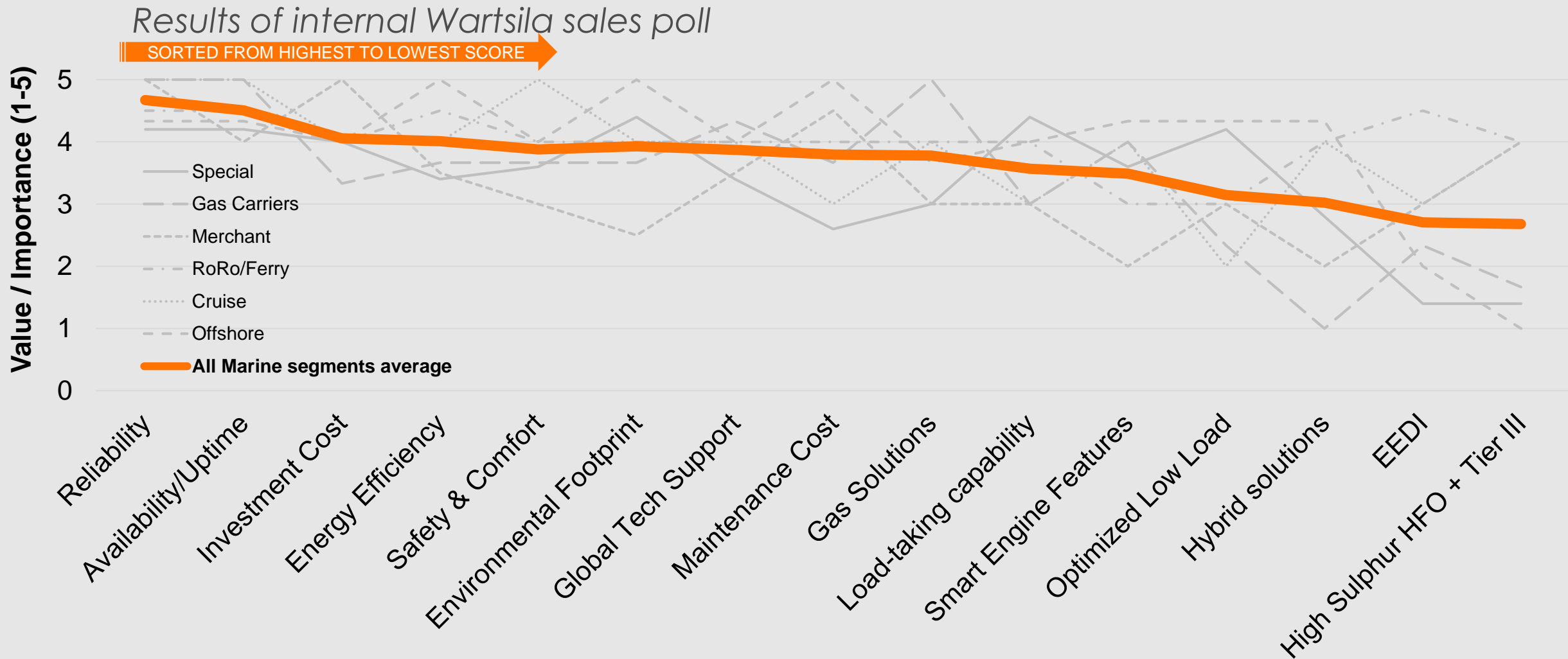


Wärtsilä Scope of Delivery:

- Ship design & classification
- W10V31 main engine
- 2 x W9L20 aux engines
- Propulsion, shaft generator
- 2-speed gearbox
- Wärtsilä ProTouch propulsion control
- Electrical & automation incl. hybrid integration of battery packs with PTO/PTI capability

- **LEGISLATION AND SUSTAINABILITY AS A DRIVER**
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- What do **you value the highest** in your business?



Lab testing & validation **10000+hrs**



Conceptual design,
FMEA & risk analysis

Product architecture and
detailed design

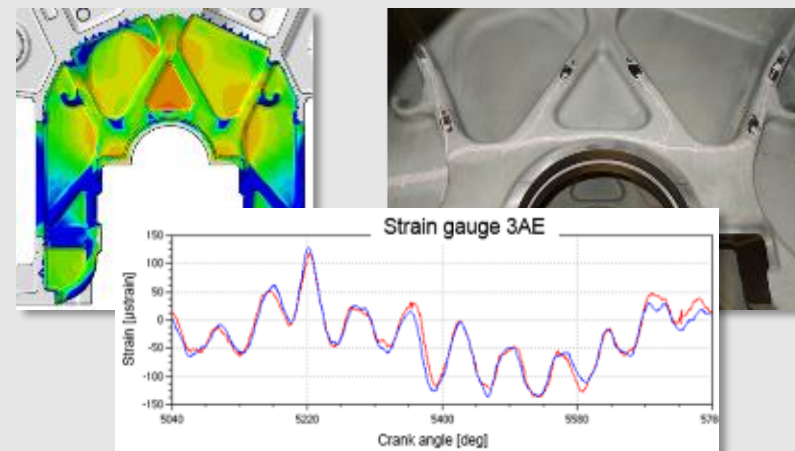


Product
requirement
& product
definition

Project quality
Product quality

**Best practices & extensive system
virtual and physical validation**

Simulation and calculation



Rig and single-cylinder testing



Maximized uptime with extended overhaul intervals

Procedures	Previous generation diesel engine (HFO)	Wärtsilä 31	Difference
Valve clearance measurement	every 1000 hr	No need	
Injection valve maintenance	every 2000 hr	every 8000 hr	+400%
Injection pump / HP fuel pumps overhaul	every 12,000 hr	every 24,000 hr	+100%
Cylinder head overhaul	every 12-20,000 hr	every 24,000 hr	+20-100%
Piston overhaul	every 12-20,000 hr	every 24,000 hr	+20-100%



Less downtime means more operations !

Extended TBO targets based on real world experience identifying critical features

- 2005-2011: HFO TBO extension project in co-development with customer
- W8L32 auxiliary engines operated on 700 cSt, +2%-S HFO,
- Target 36 000hr (major) TBO, inspections every ~4000hrs.

→ Findings used as input for W31 engine component design



Services, Wärtsilä Finland Oy

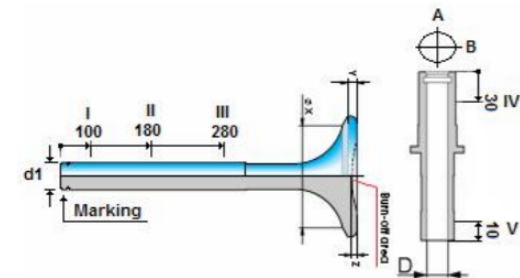
MEASUREMENT RECORD

Engine section	Engine type	Ref.	Date	Issue	Document No.	Page
12 Cylinder Head	W32	WFI-S	20.03.2007	01	W32 TBO	1(1)
Installation name:	XXX	Engine type:	W8L32	Engine No:	21279	
Cooling water additive:	Havoline XLI	Ambient temp. (°C):	30	Engine running hours:	24328	
Fuel oil used:	HFO 700cSt	Cylinder head sealing surface machining measure (max 0.5 mm)				
Cyl. Head running hours:	Same as engine	Cast No.:		Work number:		
Cylinder head number:	Cylinder 1	Note:		New model seats DAAF001529		

Cylinder Head Overhaul Report

Valves and valve guides

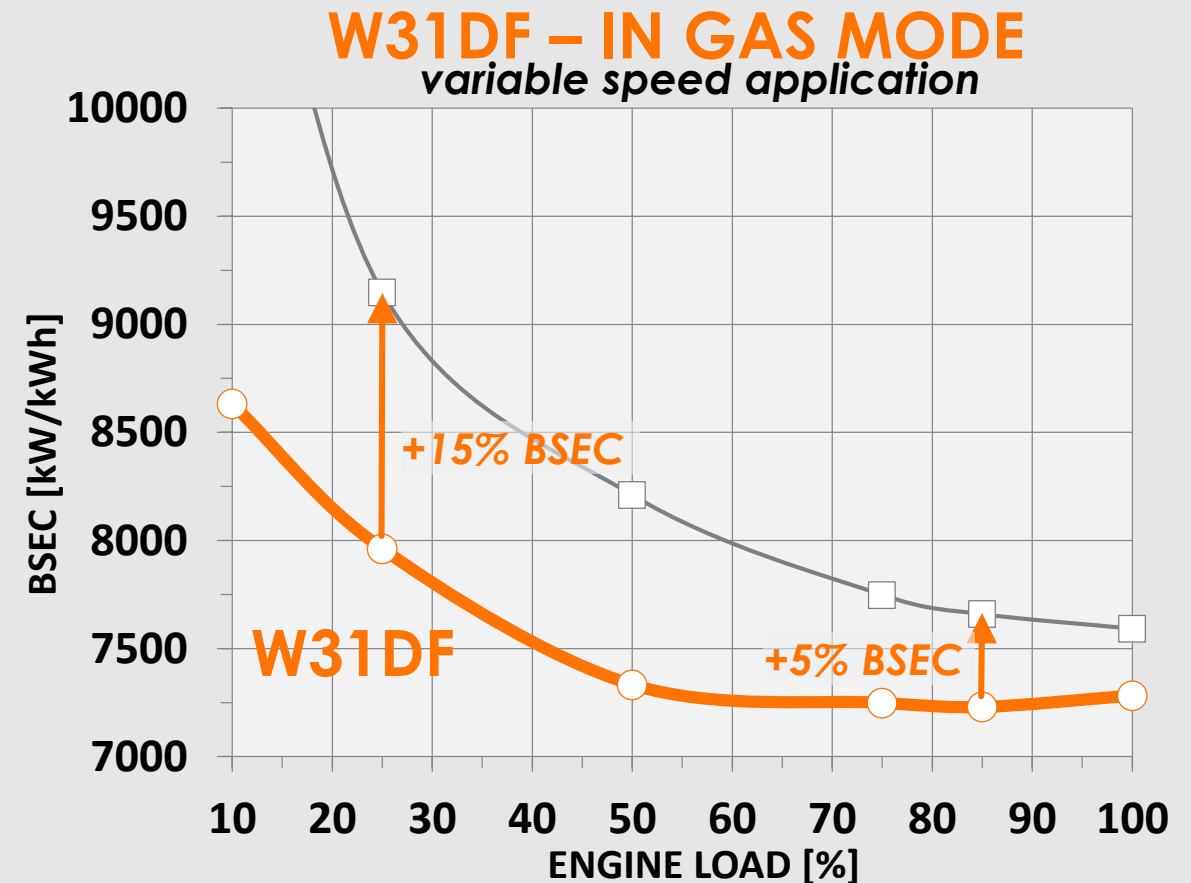
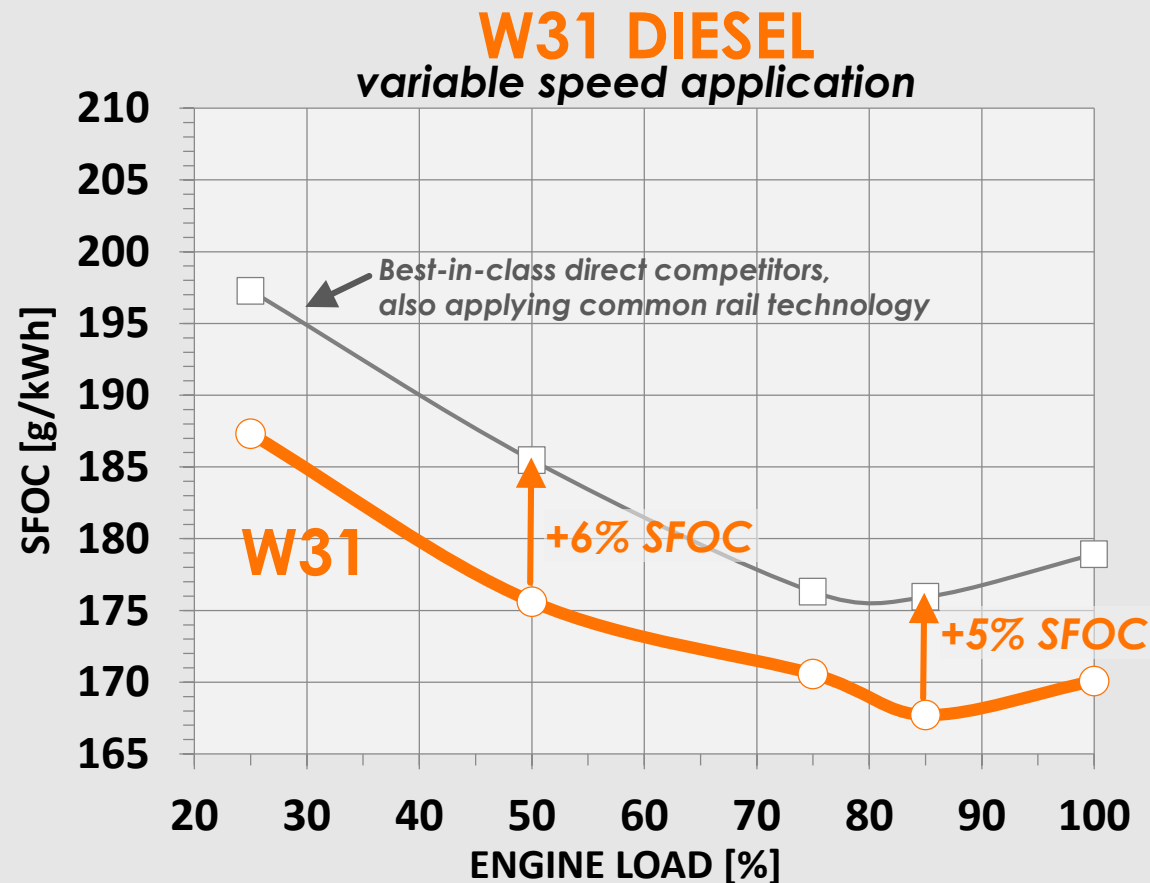
	Wear limit mm
Valve stem (d1)	23.95
Disc thickness (Y) Ex.	min. 7.8
Disc thickness (Y) In.	min 10.1
Burn-off area (Z)	max. 2
Valve guide (D)	24.25
Max clearance	0.30
Min (X) Inlet valve	87
Min (X) Ex. valve	82



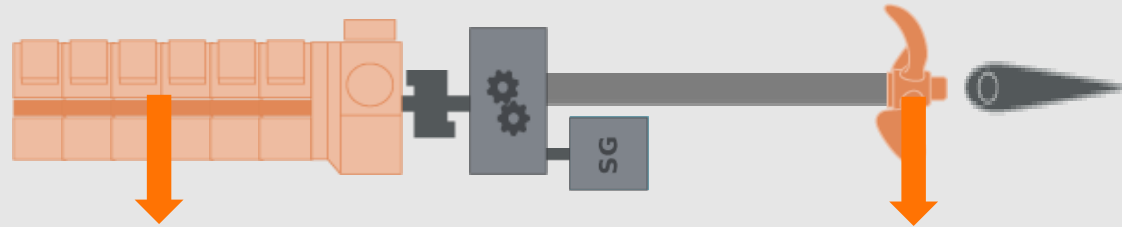
	Stem diameter (d1)			Valve disc			Marking	Valve Guide D				Clearance
	I	II	III	Z	X	Y		IV	B	A	V	
A	23.99	23.99	23.99	0.00				24.12	24.12	24.11	24.11	

Superior efficiency thanks to

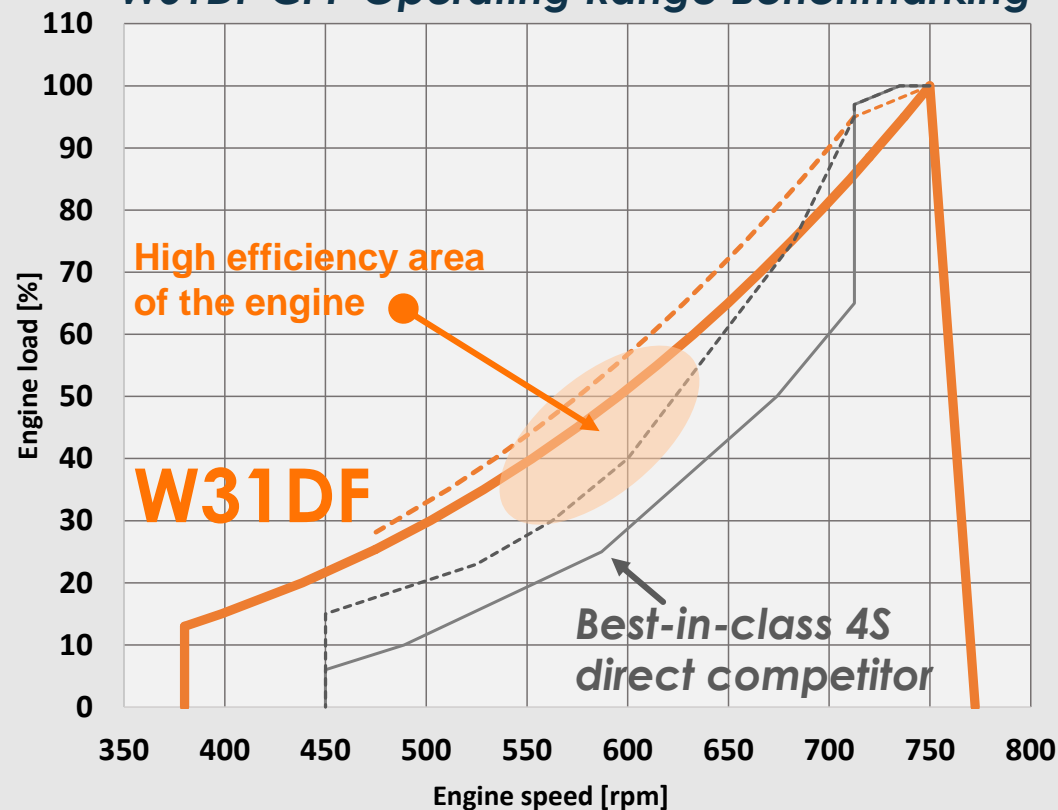
- Wärtsilä 2nd generation common rail – **ultimate injection control**
- 2-stage turbocharging – **highest gas exchange thermodynamic efficiency**
- Variable inlet and exhaust valve timing – **complete air fuel ratio and recirculation control**



Wide engine operating range allows propulsion system optimization for lower speeds and **highest vessel total efficiency**

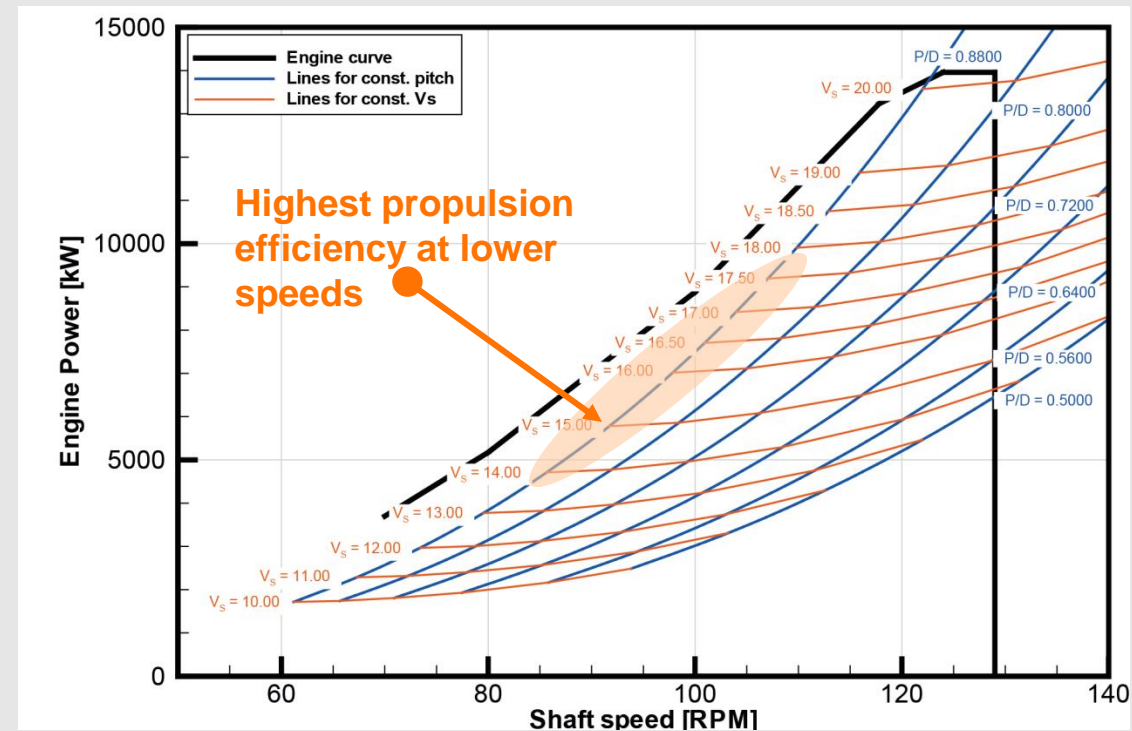


W31DF CPP Operating Range Benchmarking



&

Typical Propulsion Efficiency Curves



- Design focus on **noise reduction**

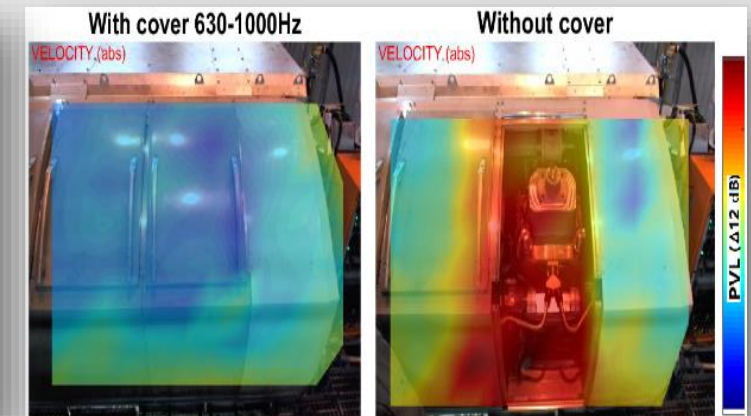
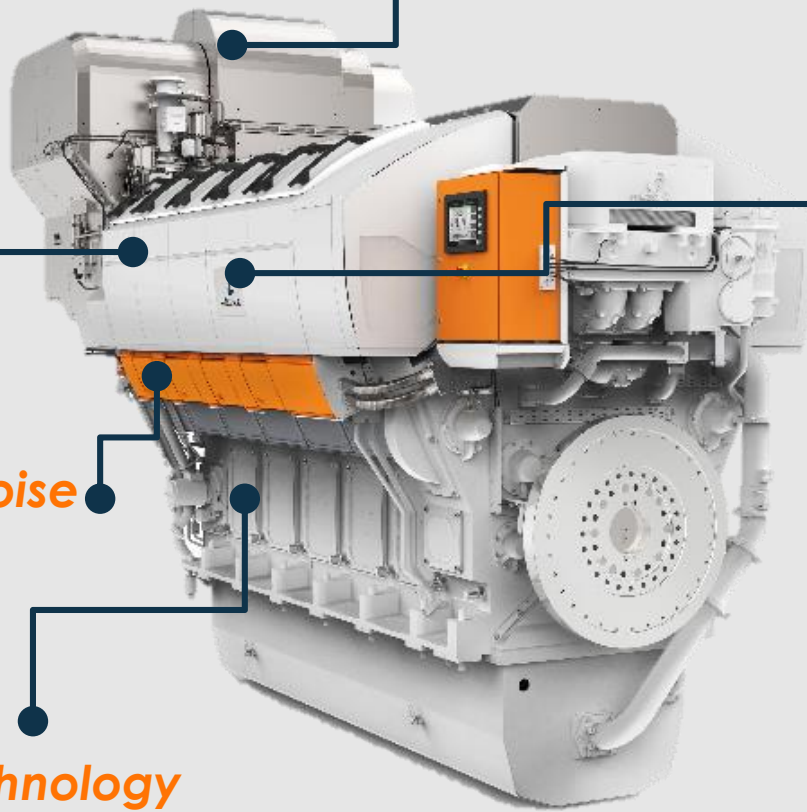
Reduced valvetrain noise
with hydraulic actuation

Exhaust noise suppression
with 2-stage turbocharging

Composite low noise
cover technology

Reduced geartrain noise
with CR fuel system

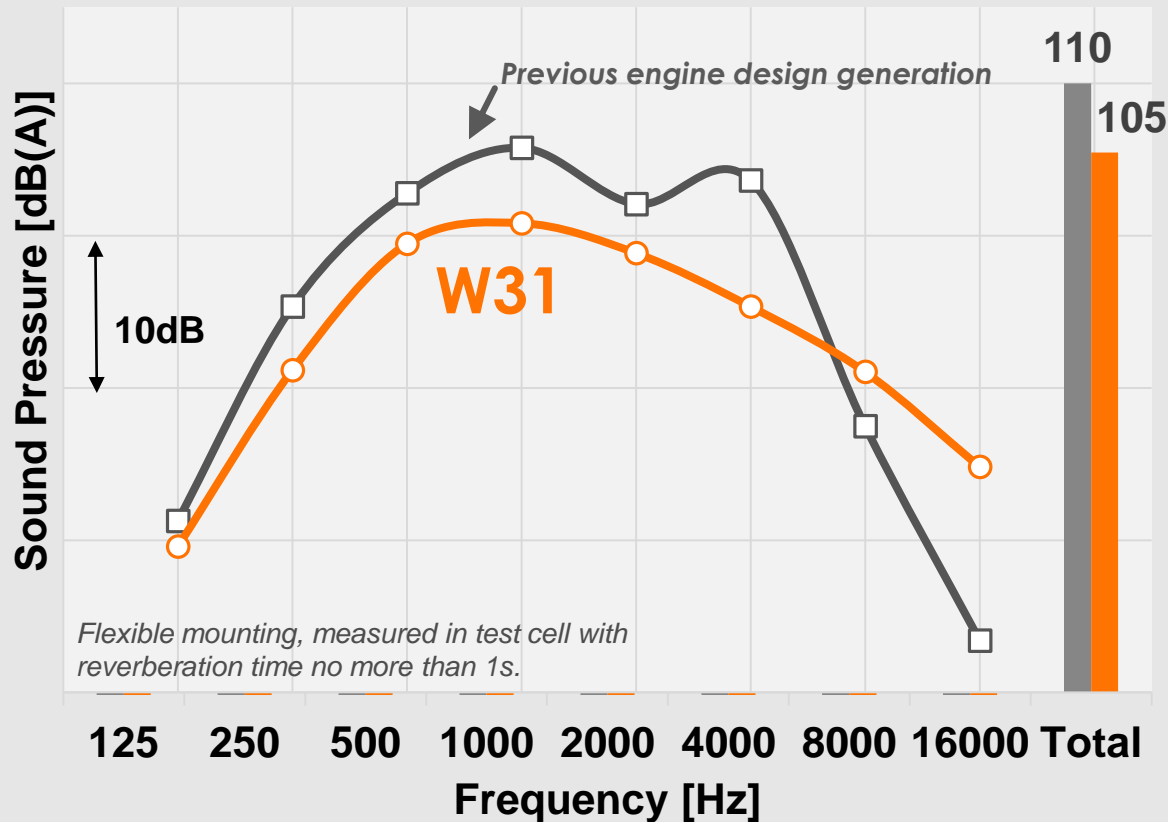
Composite low noise
crankcase cover technology



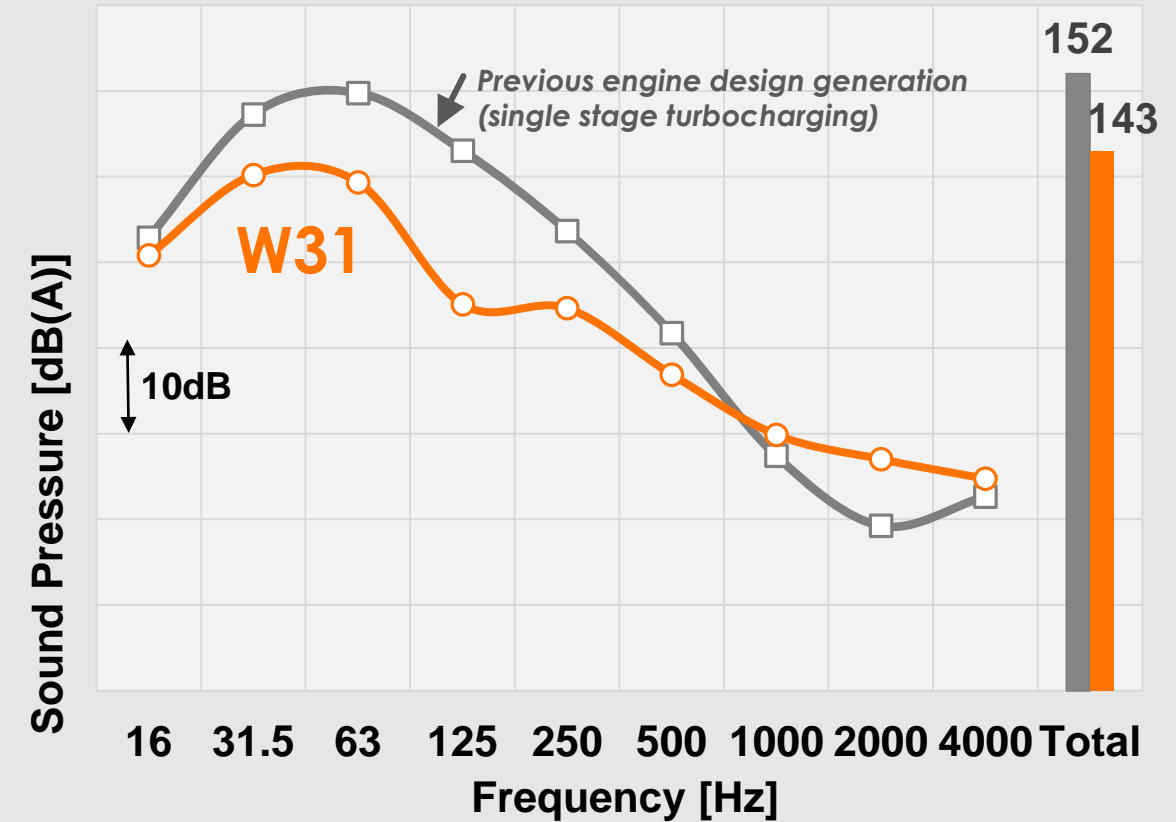
- Design focus on **noise reduction**

- For flexibly mounted applications sound pressure level of down to ~105dB(A) demonstrated (SOLAS limit 110dB(A)), potential savings in machinery space sound attenuation

Engine Airborne Noise



Engine Exhaust Noise



CASE STUDY: LNG-fuelled 7000 CEU PCTC – 2-stroke vs 4 stroke

Machinery concept #1

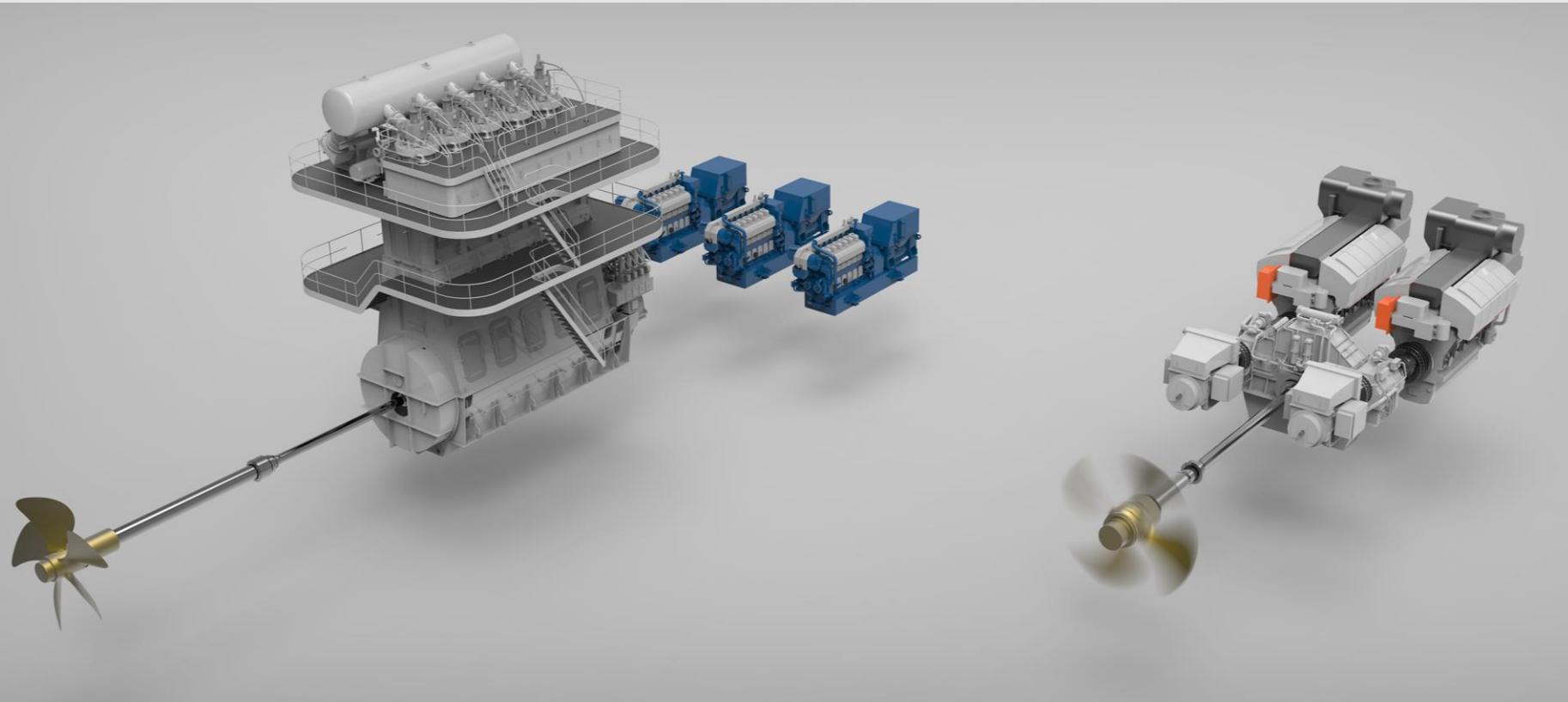
- 2-stroke MAN 8G50ME-C9.6-GI-EGRBP
- High pressure Gas compressors
- Fixed Pitch Propeller
- Auxiliary Gensets (3x8L20DF)
- Power 13'140 kW + 4440 kW = 17580 kW

Machinery concept #2

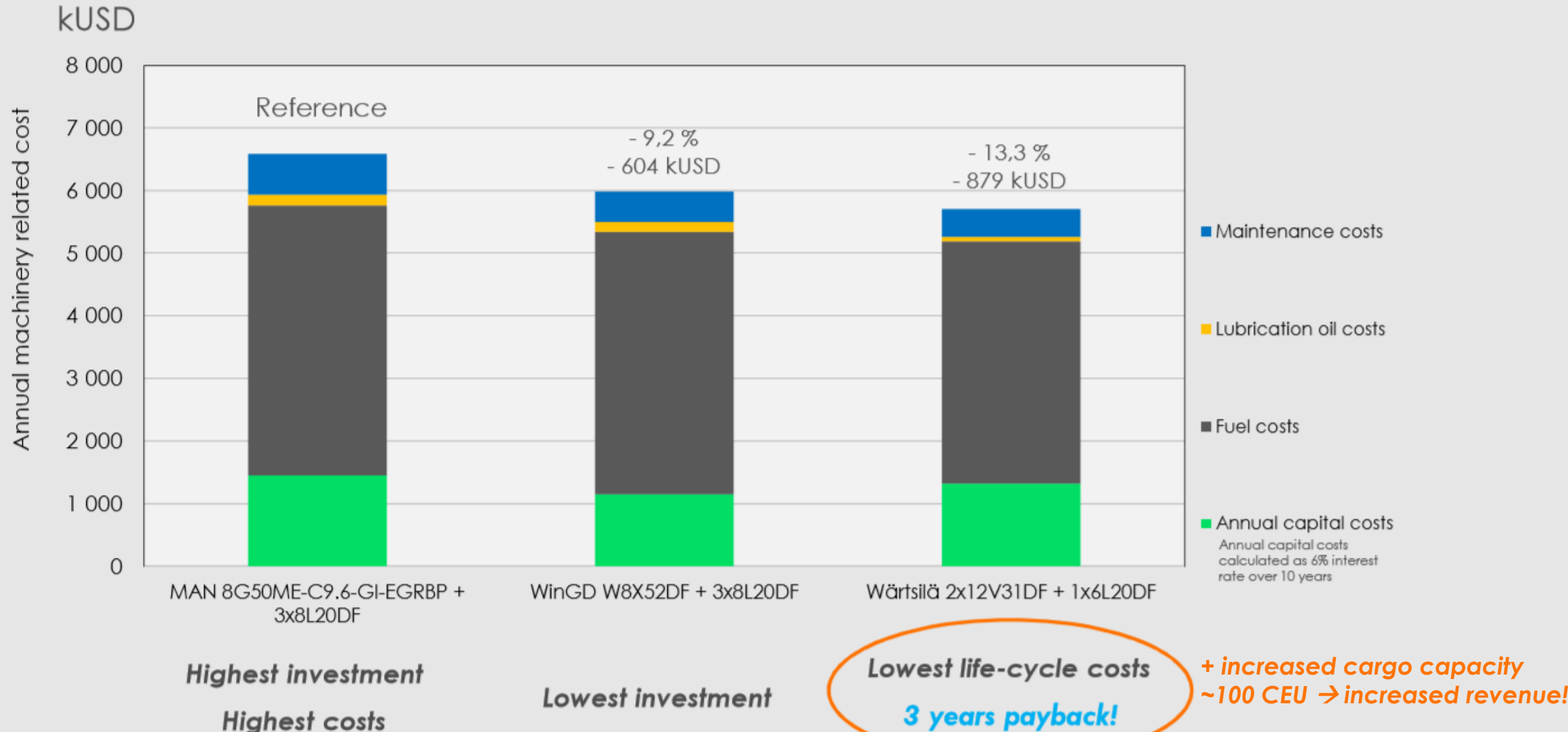
- 2-stroke WinGD W8X52DF
- Medium pressure Gas compressors
- Fixed Pitch Propeller
- Auxiliary Gensets (3x8L20DF)
- Power 11'351 + 4440 = 15791 kW

Machinery concept #3

- 4-stroke Wärtsilä 2x 12V31DF
- Reduction Gear Box
- Controllable Pitch Propeller
- Shaft generators
- Frequency drives for SG
- Auxiliary Genset (1x6L20DF)
- Power 13'200 kW + 1110 kW = 14310 kW

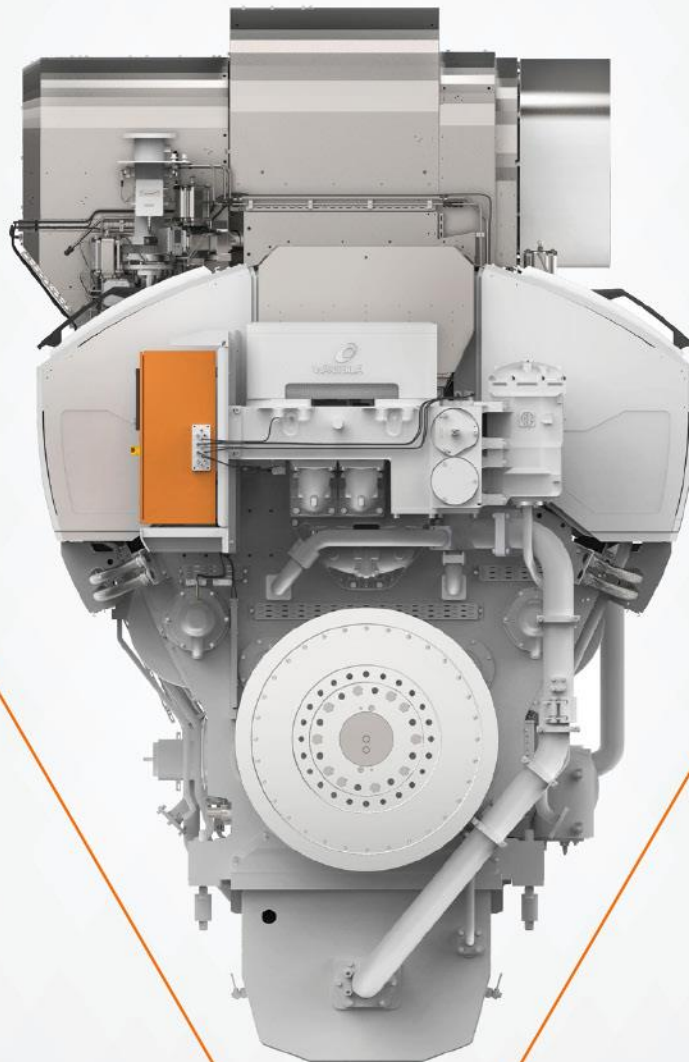


CASE STUDY: LNG-fuelled 7000 CEU PCTC – 2-stroke vs 4 stroke



WÄRTSILÄ CONNECTS THE DOTS

**You make
record-breaking
profits**



**WÄRTSILÄ 31 BREAKS
GUINNESS WORLD
RECORD FOR FUEL
EFFICIENCY**

FENNIAPRIZE 14
WINNER



**FUEL COSTS AND
EMISSIONS ARE
REDUCED – A LOT**

**marine
propulsion**
& auxiliary machinery

Marine engine award