RETROFIT SOLUTIONS

by WinGD

WIN GD

WinGD Retrofit Solutions

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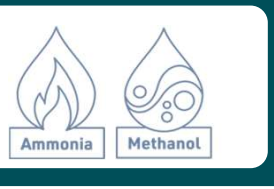
Market drivers

Regulatory Drivers

IMO and EU emissions and efficiency regulations: IMO 2050, CII, EEXI, EU ETS, FuelEU Maritime



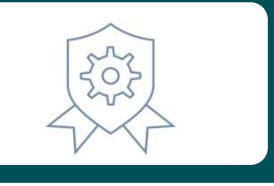
Alternative Fuels

Conversions are the only way to meet long-term decarbonisation targets on existing two-stroke powered vessels

Energy Efficiency

Improving engine efficiency extends short-term compliance, reduces fuel spend - including future spend on clean fuels

Decarbonisation translates to the need for new fuels, better energy efficiency



Reliability

Uncertain market stalls newbuild investments - keeping ageing ships running well is more important

increased reliability in the existing fleet

WinGD Retrofit Solutions

RETROFIT SOLUTIONS by WinGD

What we offer

Small Solutions

Simple and low-cost retrofit
Implementation – up to several days

- UNIC SW upgrade
- BSFC improvement
- Cylinder lubrication upgrade
- DCM and WiDE system application
- Engine Power Limitation
- Fuel Sharing Mode for X-DF
- CSM Mode

Medium Solutions

Middle sized retrofits
Implementation – up to several weeks

- TC-cut off - aSTC solution
- Engine Control System - UNIC to WiCE
- Methane Slip Reduction – Filler Gasket and Smaller GAV
- Ammonia ready
- Methanol ready
- Engine Part Load Optimization

Large Solutions

Partner projects
Implementation – during dry dock, ~ 4 weeks

- VCR Retrofit
- iCER installation
- iCER + VCR
- Diesel to X-DF
- Methanol conversion existing engine
- Ammonia conversion existing engine

WinGD Diesel to LNG DF retrofit proposal

WIN GD
Simply a better different

WinGD Diesel to LNG DF retrofit proposal

Introduction of WinGD LNG DF technology: DF1.0/DF2.0 comparation

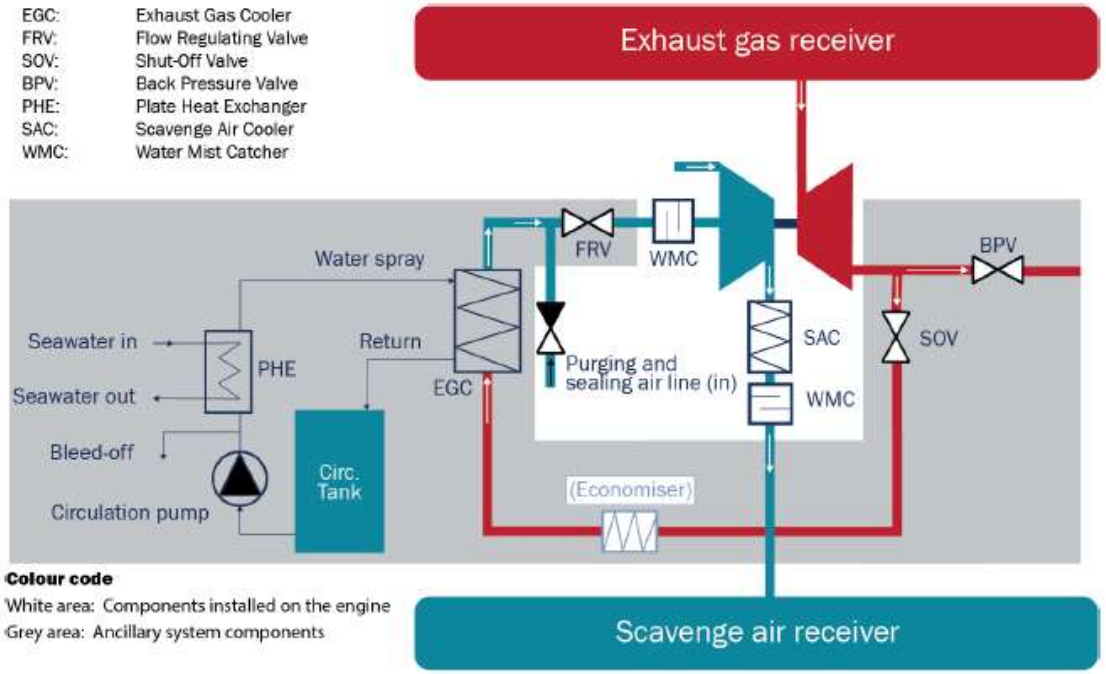
DF1.0	DF2.0
Both diesel or LNG fuel feasible	Both diesel or LNG fuel feasible
Low-pressure LNG supply system(iGPR or GVU)	Low-pressure LNG supply system(iGPR or GVU)
Low polit MGO/MDO consumption at gas mode	Low polit MGO/MDO consumption at gas mode
Tier III at LNG mode without SCR	Tier III at LNG mode without SCR(iCER activated) Tier III at diesel mode without SCR(iCER activated) Tier III at CSM mode without SCR or iCER
	Required additional iCER system **Lower diesel/LNG consumption compared to DF1.0** **Up to 50% methane slip reduced**
Lower MEP than X diesel engine	Lower MEP than X diesel engine
Option VCR system Lower fuel consumption at each load of diesel mode Lower gas consumption at low load of gas mode Lower methane slip at gas mode	Option VCR system Lower fuel consumption at each load of diesel mode Lower gas consumption at low load of gas mode Lower methane slip at gas mode

Generally: DF2.0 = DF1.0 + iCER

iCER: intelligent Control by Exhaust Recycling, it's WinGD low pressure exhaust gas recycling system.

WinGD Diesel to LNG DF retrofit proposal

Introduction of WinGD LNG DF technology: iCER technology



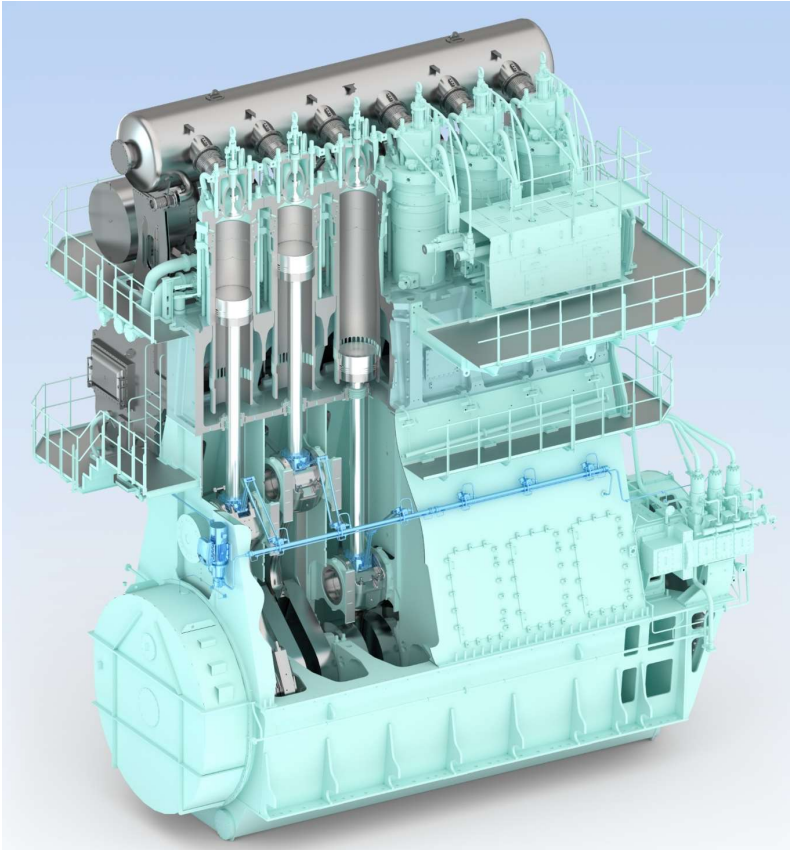
- The iCER is designed to cool and recirculate part of the exhaust gas through a low-pressure path. Compared to a high-pressure path the main benefit is the ability to use the full turbocharger capacity.
- It is possible to recirculate exhaust gas **up to a maximum rate of 50 % mass flow**. This is handled through a system adjacent to the engine that circulates part of the exhaust gas after the turbine, through an exhaust gas cooler (EGC) to the compressor inlet.
- The exhaust gas and the fresh air are mixed before entering the compressor wheel of the turbocharger.

WinGD Diesel to LNG DF retrofit proposal

Introduction of WinGD LNG DF technology: VCR technology

- VCR system developed in cooperation with our Japanese engine builder Mitsui E&S Diesel United
- VCR allows the adjustment of the compression ratio (CR) during operation of the engine
- In diesel mode, the CR can be increased to a similar level as on a conventional diesel engine
- In gas mode, the CR can be increased in part load to utilize ‘combustion margin’ and therefore achieve higher efficiency where the engines are operated most of the time

VCR: Variable Compression Ratio



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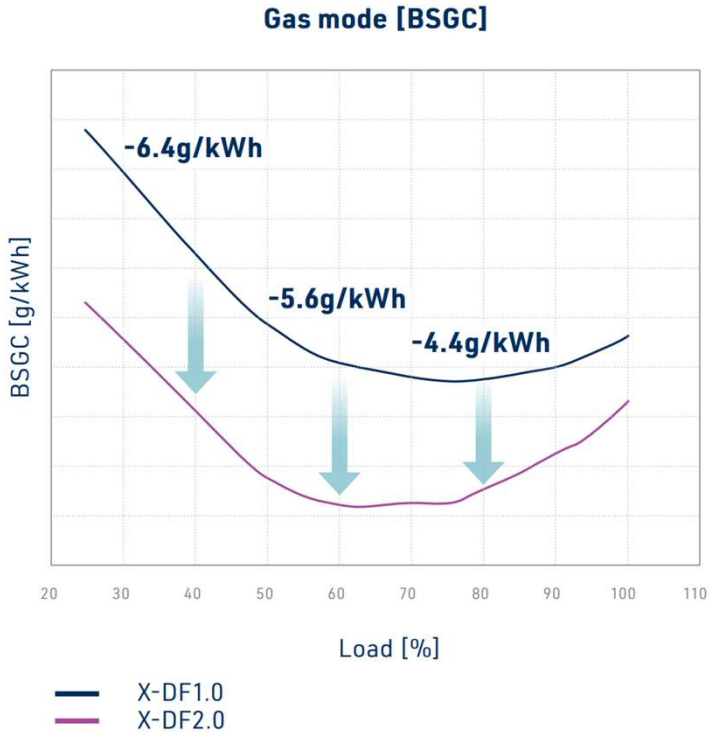
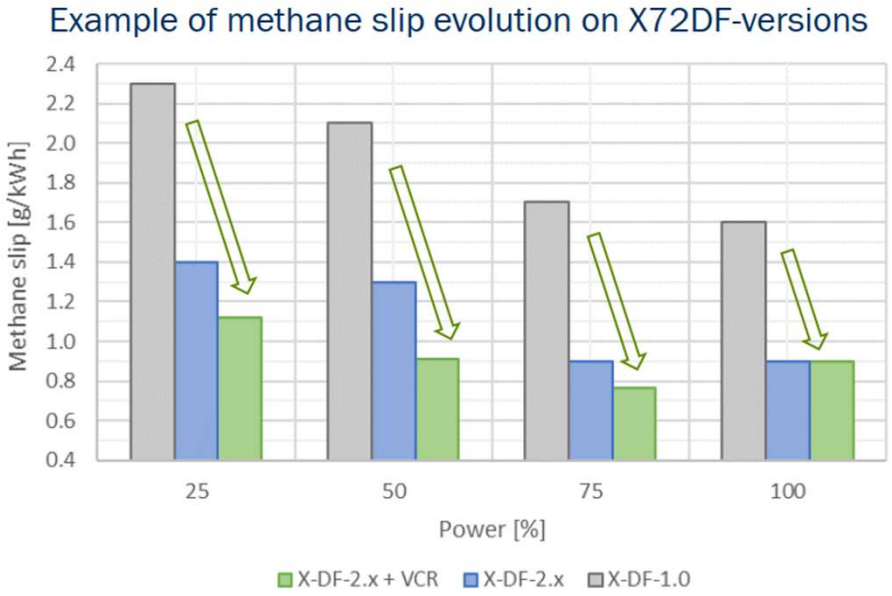
WinGD Diesel to LNG DF retrofit proposal

Introduction of WinGD LNG DF technology: DF1.0/DF2.0 comparation





Lower diesel/LNG consumption and lower methane slip of DF2.0 compared to DF1.0.

WinGD Diesel to LNG DF retrofit proposal

Introduction of WinGD LNG DF technology: VCR technology

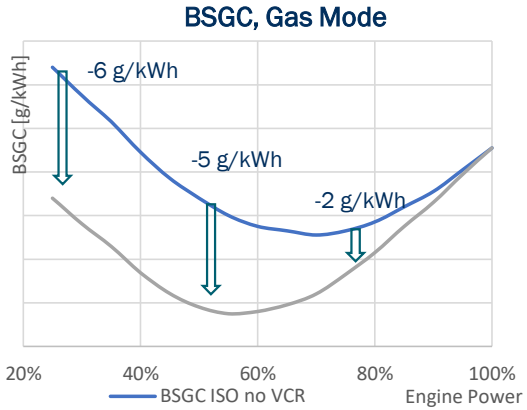
Extensive VCR performance tests have been carried out on test engines

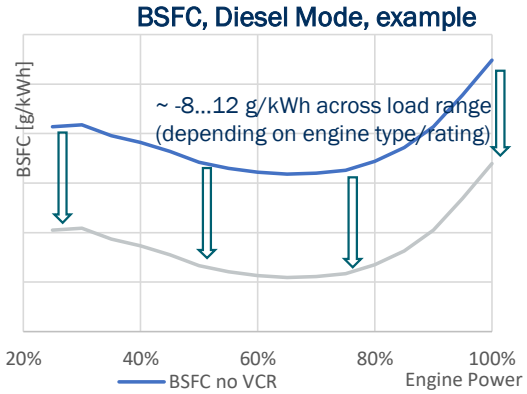
Consumption improvements are significant:

- Gas mode: reduction at part/low load operation
- Diesel mode: reduction across load range

The below shown BSGC/BSFC gains are provided for ISO conditions

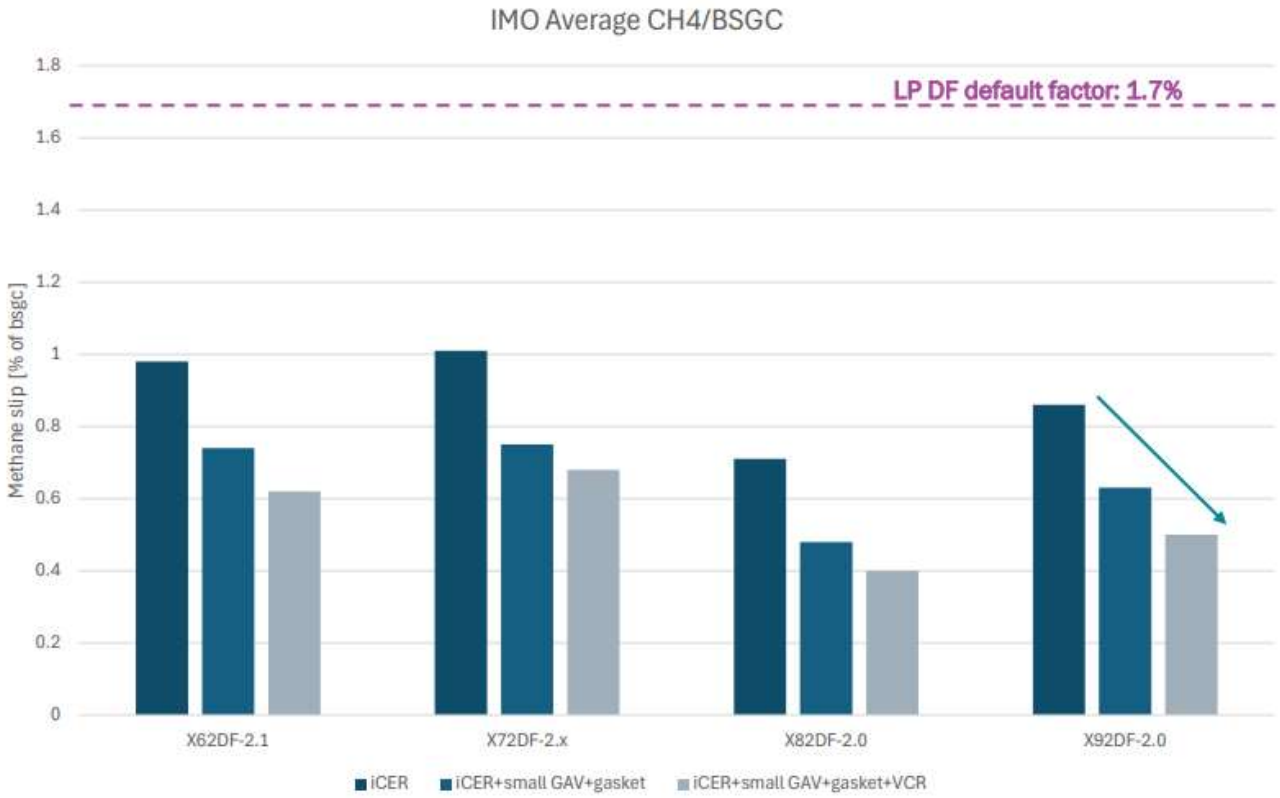
	Savings with VCR, X-DF2.0	
Engine load [%]	**BSGC reduction [g/kWh] ISO conditions**	**BSFC reduction ISO conditions**
100%	0	~ -8...-12 g/kWh depending on engine type and rating (2 g/kWh higher than equivalent diesel engine, IMO avg.)
75%	-2	
50%	-5	
25%	-6	





DF LNG – Methane Slip

Influence of technologies on methane slip figures



- Clear downward trend by application of new technologies
- iCER achieved 50% reduction
- Further reduction of approximately 40% possible when applying:
  - Small GAV design
  - Wide gasket
  - VCR technology

DF LNG

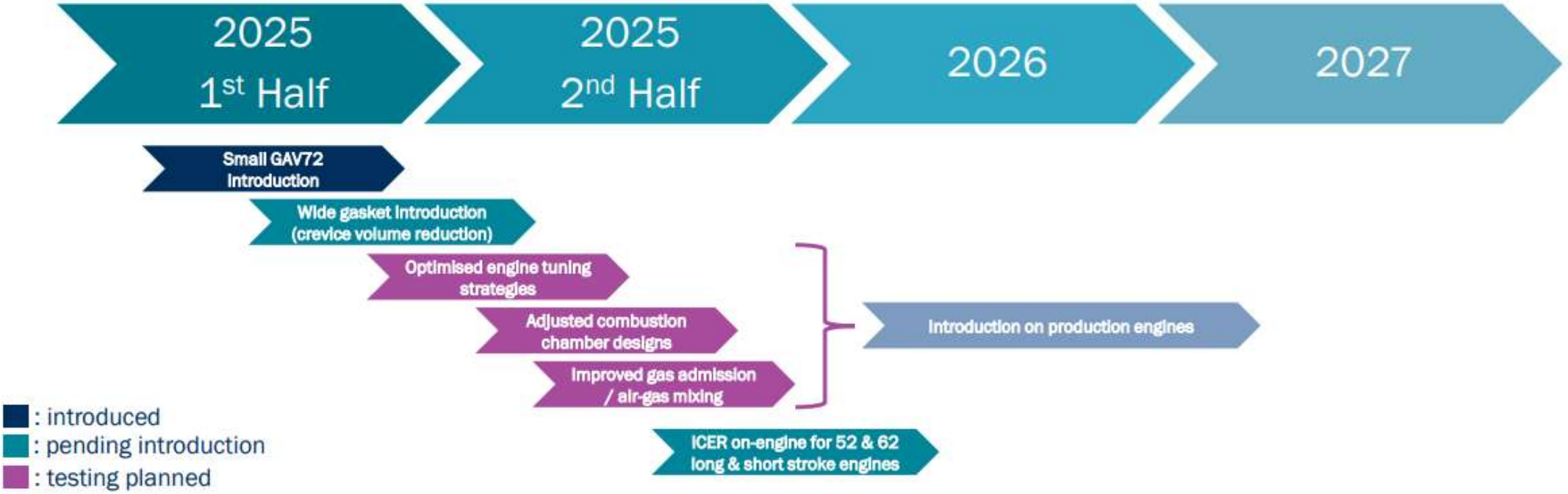
Actions to address regulatory developments

- MEPC83 approval of emission certification procedure expected end April-2025
- WinGD already planning emission measurements & in alignment with major classification societies ahead of approval to ensure engines can be certified with lower emission factors

DF LNG Future Outlook

LP-DF developments to reduce methane slip

- LP DF technology is continuously being developed
- **0.4%-0.5%** methane slip as percentage of bsgc considered technically feasible



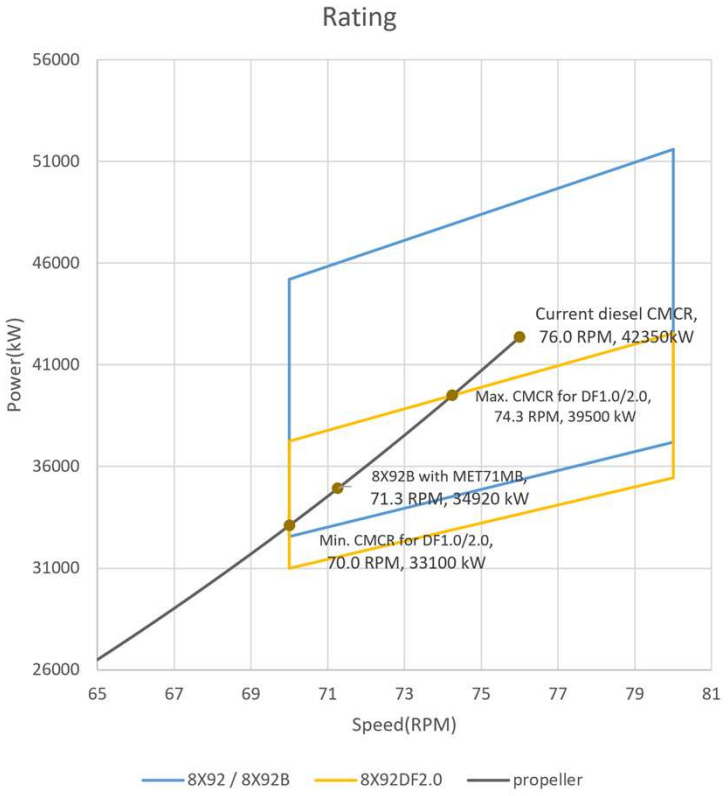
WinGD Diesel to LNG DF retrofit proposal

Rating of 8X92/ 8X92-B diesel and DF engine: engine rating

	R1	R2	R3	R4
Diesel 8X92/8X92B	51600kW@80rpm	37200kW@80rpm	45200kW@70rpm	32560kW@70rpm
LNG DF 8X92DF1.0/2.0	42560kW@80rpm	35440kW@70rpm	37240kW@70rpm	31000kW@70rpm

For the 8X92 convert to DF, due to firing pressure limitation, engine can only run up to 75% load of CMCR (29625kW / 67.4 RPM -> ~20.5 kn ship speed) at gas mode.

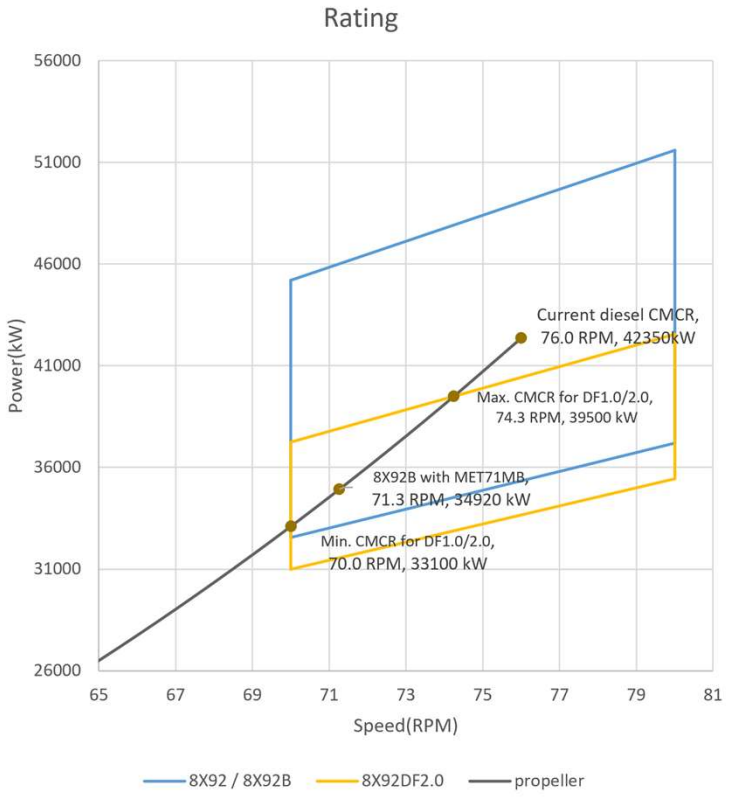
For the 8X92B engine, no firing pressure limitation existing. Limiting factor is the ancillary layout which requires a derating to 35998 kW / 72.0 RPM (Ship Speed ~21.7 kn) required (or even to 33575 kW / 70.3 RPM (Ship Speed ~21.2 kn))



WinGD Diesel to LNG DF retrofit proposal

Rating of 8X92 / 8X92-B diesel and DF engine: Turbo Chargers

	To DF1.0	To DF2.0
8X92 keep current TC MET83MB	39500kW@74.3RPM To 33100kW@70.0RPM	39500kW@74.3RPM To 34920kW@71.3RPM
8X92B keep current TC MET71MB	Out of rating, TCs need to be replaced. With changed TC (MET83MB) 39500kW@74.3RPM	34920kW@71.3RPM To 33100kW@70.0RPM With changed TC (MET83MB) 39500kW@74.3RPM



The turbo charger MET71MB of 8X92B need to be replaced.

If 8X92B convert to DF2.0, and remain MET71MB, shall derate to 34920kW 71.3 RPM.

Pilot Project

VCR Pilot Retrofit on CMA CGM containership Aurora (7RT-flex50DF)

VCR Pilot Retrofit

First sea-going VCR installation

RETROFIT SOLUTIONS by WinGD

Upgrade executed:

- Installation of full VCR system
- No engine room modifications necessary

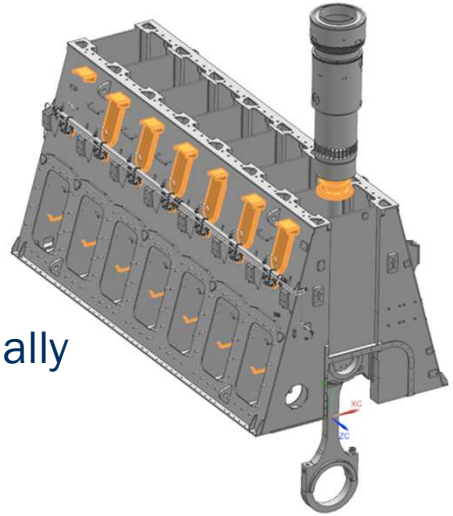
Objective:

Long term full-scale test of VCR to confirm:

- OPEX benefits
- Operation and reliability

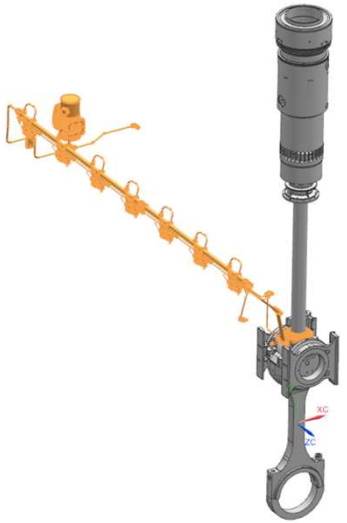
For complete system on board of a commercially operating vessel

Column Modification



Replaced parts

Additional parts



VCR Pilot Retrofit

RETROFIT SOLUTIONS by WinGD

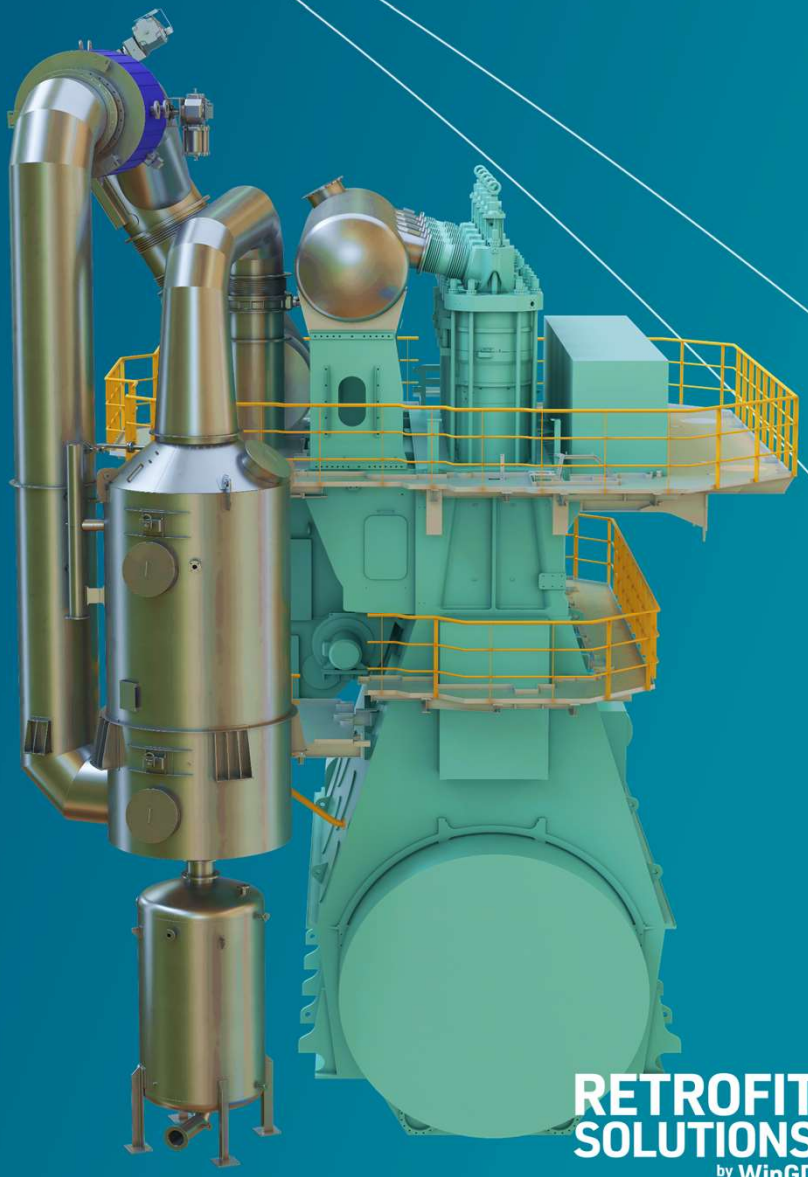
7RT-flex50DF Container ship Aurora

- Service experience since Nov 2024:
- Crew reports that the VCR system is in operation continuously
- Estimated running hours since dry dock: ~ 3500h
- WinGD field-testing experts visit vessel during field-testing
  time regularly
- Engine performance & emission targets confirmed

WinGD Delivers Customer Value

Upgrade to X-DF2.0 and Row calculations for annual saving in fuel and compliance costs

- paid back in 3.5 years



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Retrofit to 5X72DF–2.1

RETROFIT SOLUTIONS by WinGD

Overview of modifications

Turbocharger (T/C maker specification)
- Filter silencer with iCER connection
- Compressor wheel
- Nozzle ring, Diffuser

Scavenge air cooler
- Stainless steel cooler design update
- Dimensions of B-Type cooler
- Stainless steel SAC
- Wetting device
- Offline washing device (optional)

S/Y Water Treatment unit/ neutralisation plant

Hot parts
- Liner, piston changed for higher CR
- New pre-chamber; bigger volume
- Cylinder cover (new pre-chamber)
- HP pilot fuel piping

Platform and piping exhaust side
- Modified for iCER
- Accessibility of exhaust side for TC maintenance

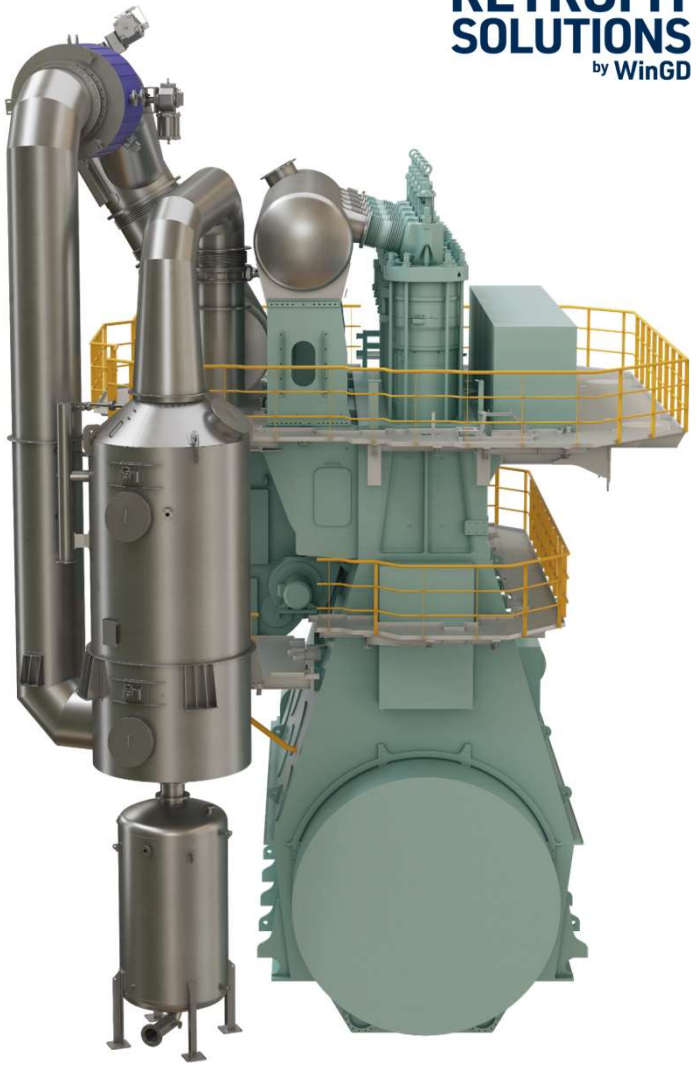
Retrofit to 5X72DF–2.1

RETROFIT SOLUTIONS by WinGD

OPEX assumptions

Vessel type	LNG Carrier
Main engines	2 x 5X72DF (CMCR 24,0440 kW)
Mission profile	**100% Gas Mode,**
Sailing route	30% to Fuel EU regulated directive port
Engine operation profile	To calculate exact savings

Running hrs	8.000 hrs / yr
Rated power (2 x 5X72DF)	24.040 kWm
ETS	100 USD / ton of CO_2 equivalent
Gas (LNG) price	600 USD/t
Diesel price (MDO 0,5% S)	610 USD/t



Retrofit to 5X72DF–2.1

Example only

RETROFIT SOLUTIONS by WinGD

OPEX savings

Saving calculated against ***baseline case -*** X-DF1.0 to current engine configuration

CASE 1 gas mode only - Tier III

Year	2025	2026	2027	2028	2029
Cashflow (Year)	1	2	3	4	5
Fuel EU Penalty / Credit (EUR/t) LNG (25 Otto)	149.00	149.00	149.00	149.00	149.00
Fuel burnt under Fuel UR regulation (50% of rated power)	8,895	8,895	8,895	8,895	8,895
Gas Saving	509,802	509,802	509,802	509,802	509,802
ETS Saving	498,879	498,879	498,879	498,879	498,879
Fuel EU Saving	1,325,017	1,325,017	1,325,017	1,325,017	1,325,017
Total Cash flow	2,333,698	2,333,698	2,333,698	2,333,698	2,333,698
Present Value (PV) of cash inflow	2,121,543	1,928,676	1,753,342	1,593,947	1,449,043
Cumulative cash flow discounted	2,121,543	4,050,219	5,803,561	7,397,508	8,846,551

Cost of capital xx%

LNG price 600 USD / t

30% of the sailing to Fuel EU regulated directive port

Approx saving per year :

2.3M EUR

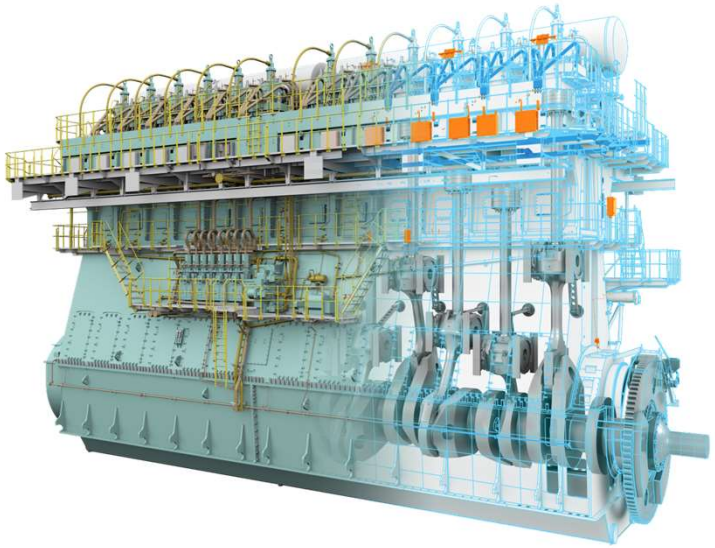
Calculation by WinGD

WinGD Diesel to Methanol DF retrofit proposal

WinGD Diesel to Methanol retrofit proposal

Introduction of WinGD methanol technology

X-DF-M = diesel engine + methanol injection system

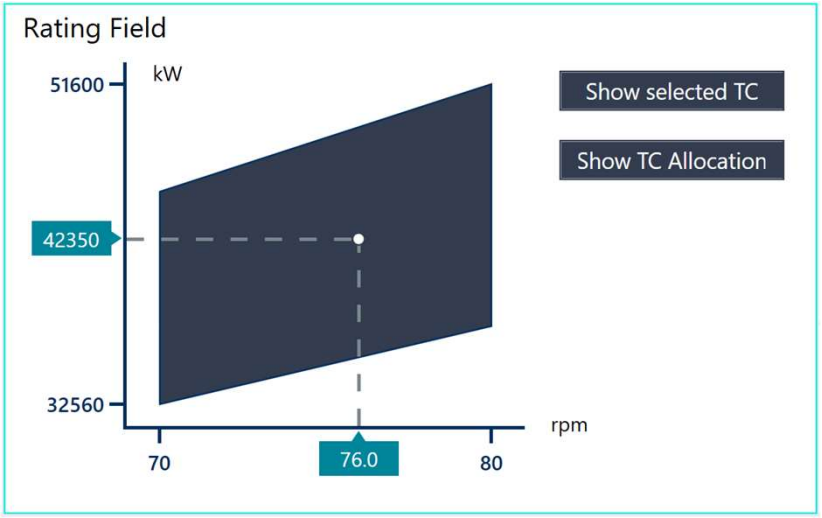


- Same parts and components as on diesel engine (+ methanol injection system)
- Diesel mode efficiency same as of a diesel engine
- Same conventional fuels can be used as on diesel engine
- Full redundancy of diesel engine remains available
- In methanol mode, same power output, similar performance as a diesel engine
- Same proven emission abatement concept (SCR) as on diesel engines

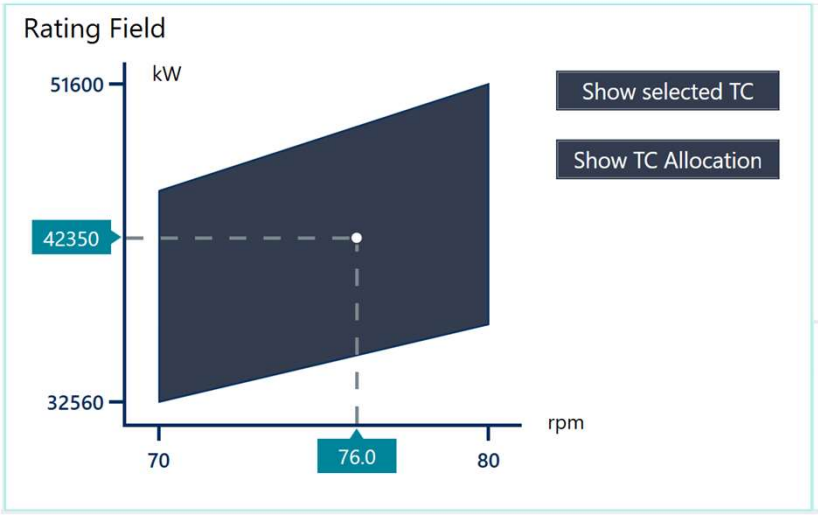
WinGD Diesel to Methanol retrofit proposal

Rating of diesel and DF-M engine

8X92 or 8X92-B



8X92DF-M



- After retrofitting 8X92/8X92B to 8X92DF-M, the CMCR can be kept at 42350kW@76rpm.
- The original turbo chargers and scavenge air coolers can be kept.

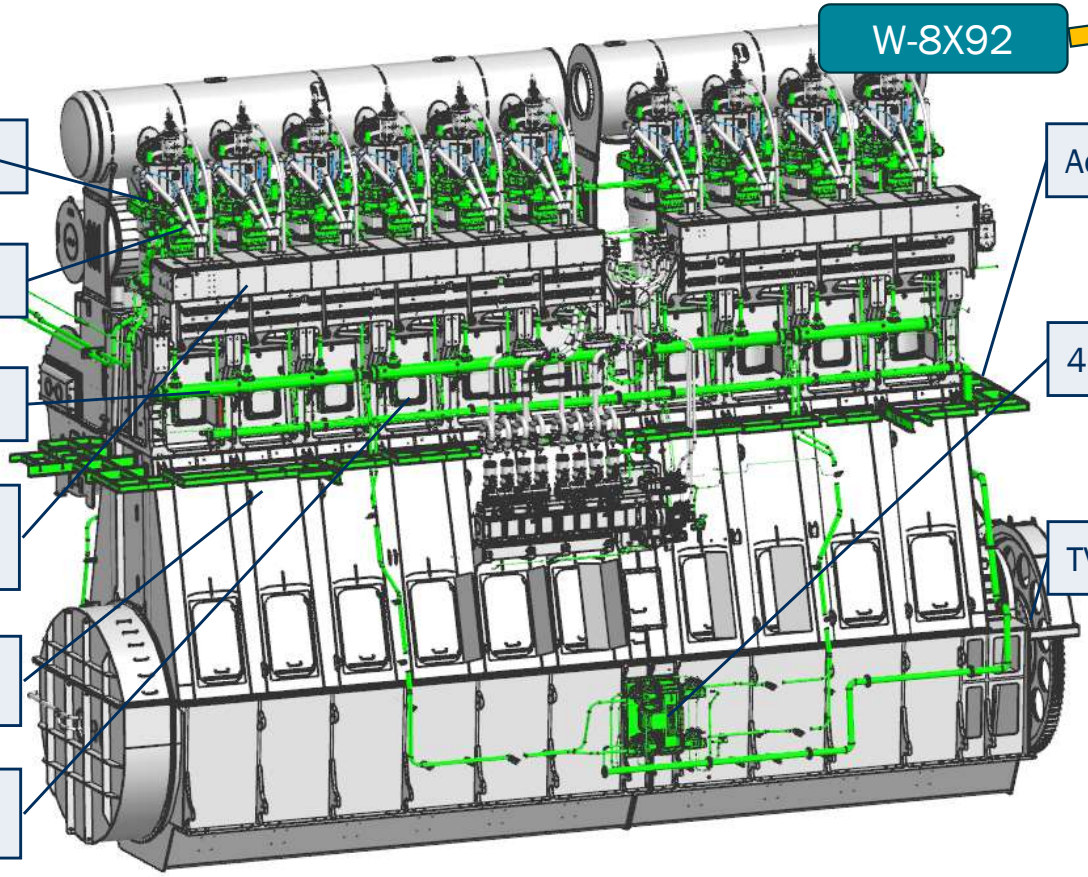
WinGD Diesel to Methanol retrofit proposal

4. Engine retrofit scope

8X92-B

W-8X92

8X92DF-M



4.1 New cylinder cover

4.2 Methanol fuel injection system

4.3 Additional servo oil rail

4.5 WiCE engine control system

4.6 Cross head LO piping

4.7 Cylinder jacket

Adapted platforms and piping

4.4 Additional servo oil supply unit

TVC to be confirmed

WinGD Diesel to LNG / Methanol DF retrofit proposal

General retrofit project schedule

	Before ship docking												In shipyard			
Items	**1 m**	**2 m**	**3 m**	**4 m**	**5 m**	**6 m**	**7 m**	**8 m**	**9 m**	**10 m**	**11 m**	**12 m**	**13 m**	**14 m**	**15 m**	**16 m**
Engine engineering	■	■	■													
On board survey	■															
Engine detail desgin			■	■	■	■										
Ship retrofit desgin(by shipyard)				■	■	■	■									
Long lead parts			■	■	■	■	■	■	■	■	■	■				
CLASS approval								■	■							
Retrofit detail planning/training					■	■	■	■	■	■	■					
Vessel retrofit in shipyard													■	■	■	
Engine retrofit in shipyard													■	■		
Commisioning															■	
Diesel sea trail/Gas bunkering/Gas sea trail																■

The actual project lead time is determined by the contracted retrofit scope. The following estimated schedule is for reference purposes only.

It’s recommended to launch the project at least one year before starting retrofit in shipyard.

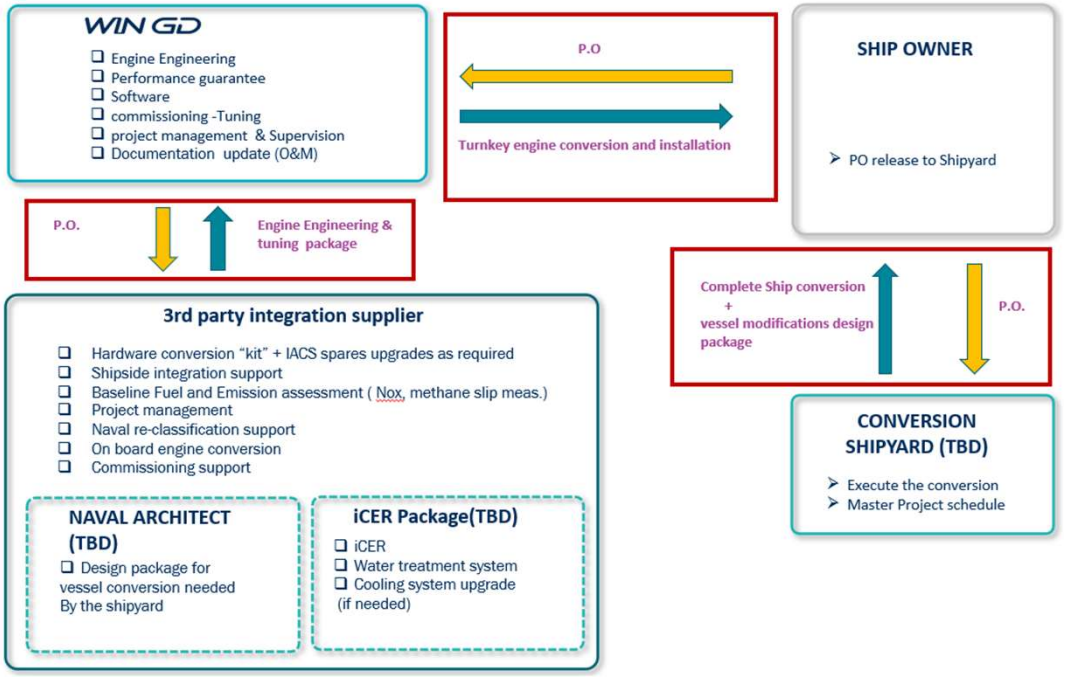
Financing & Contracting

WinGD can support financing retrofit projects with dedicated finance and infrastructure partners

KFW IPEX-Bank
Bank aus Verantwortung

serv

Transactional framework
to be defined project specific



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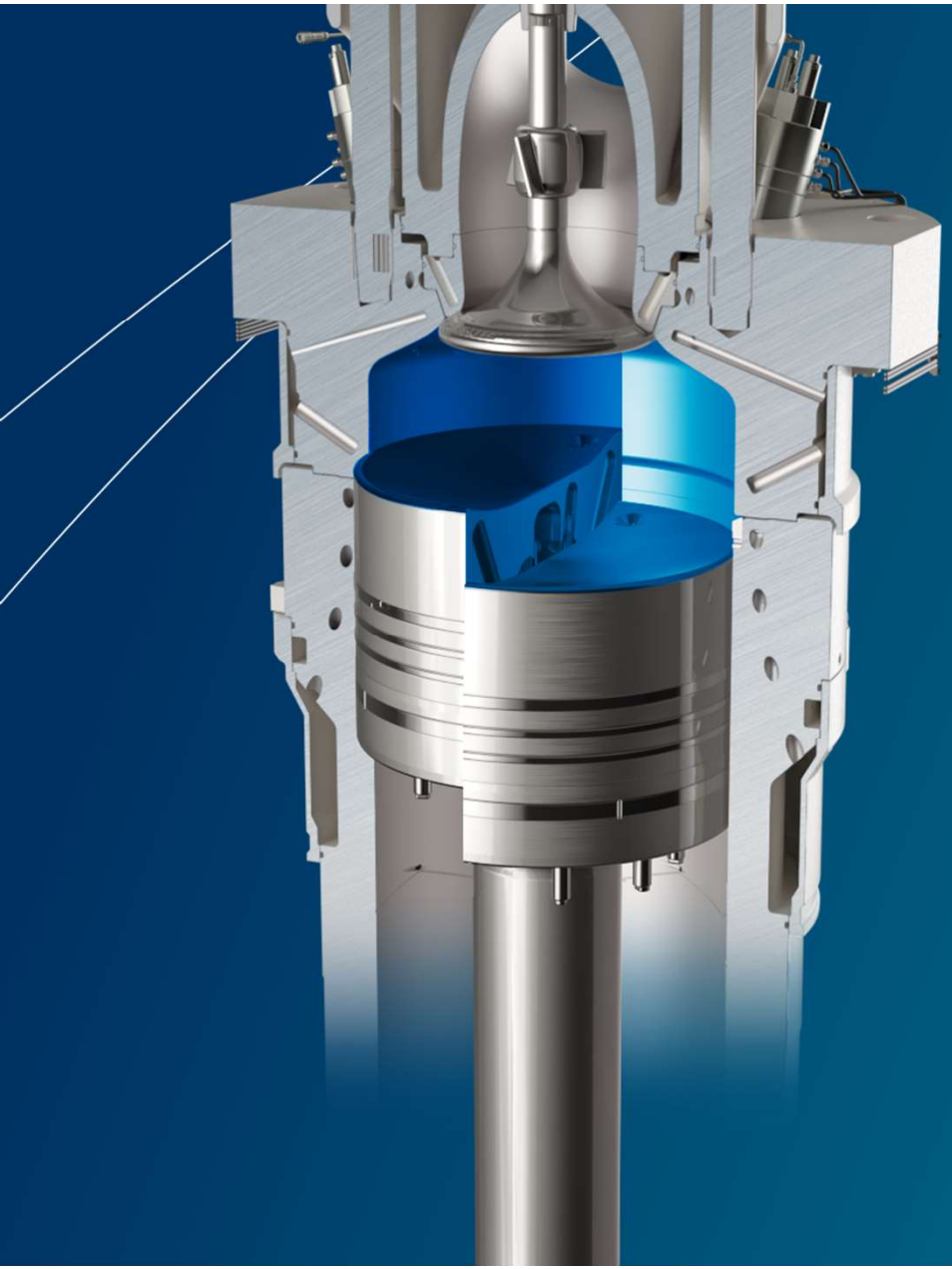

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WinGD for your successful retrofit solutions

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