Dual Fuel ME-GI Engine
Performance and the economy

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Mr Diesel vs Mr Otto
Diesel to Dual Fuel Combustion

Mr Diesel's Process

- Fuel in cylinder before gas
- Diesel process maintained
- Power remain the same
- Load response unchanged
- No pre-ignition / no knocking
- Insensitive to gas mixture
- Negligible methane slip
- High-pressure gas injection
- NO_x reduction to Tier III level by EGR and / or SCR
- ME-GI retrofitable on ME-C.

Mr Otto's Process

- Gas in cylinder before fuel
- Otto process gas-air pre-mix
- Power reduction needed
- Load ramp needed
- Pre-ignition / knocking risk
- Gas mixture important
- Methane slip significant
- Low-pressure gas injection
- Lower NO_x expected.

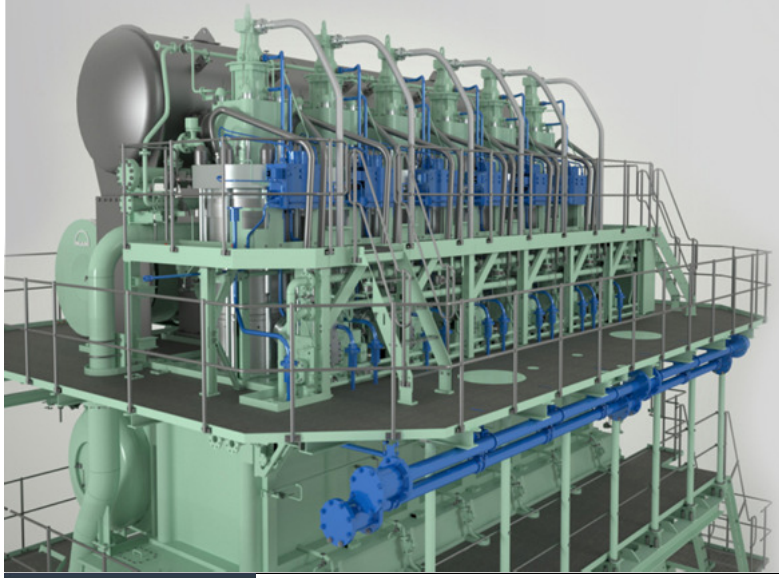
ME-GI is a Two-stroke Diesel Engine

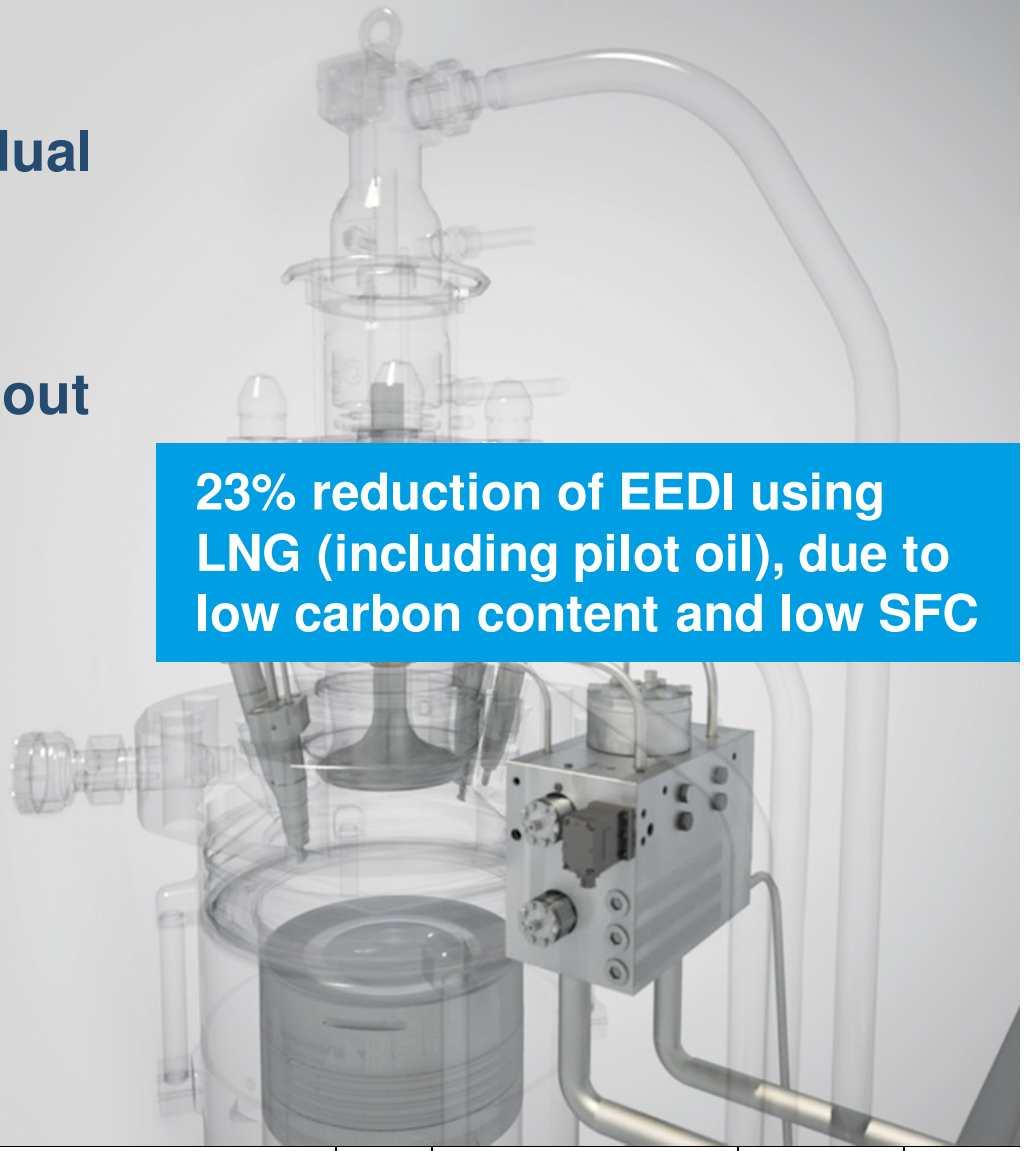
45 LNG Carriers Equipped with Two-stroke GI Retrofit is Possible

EEDI – Reduction Measures
Gas fuelled engine

EEDI reduction by ME-GI dual gas / fuel engine

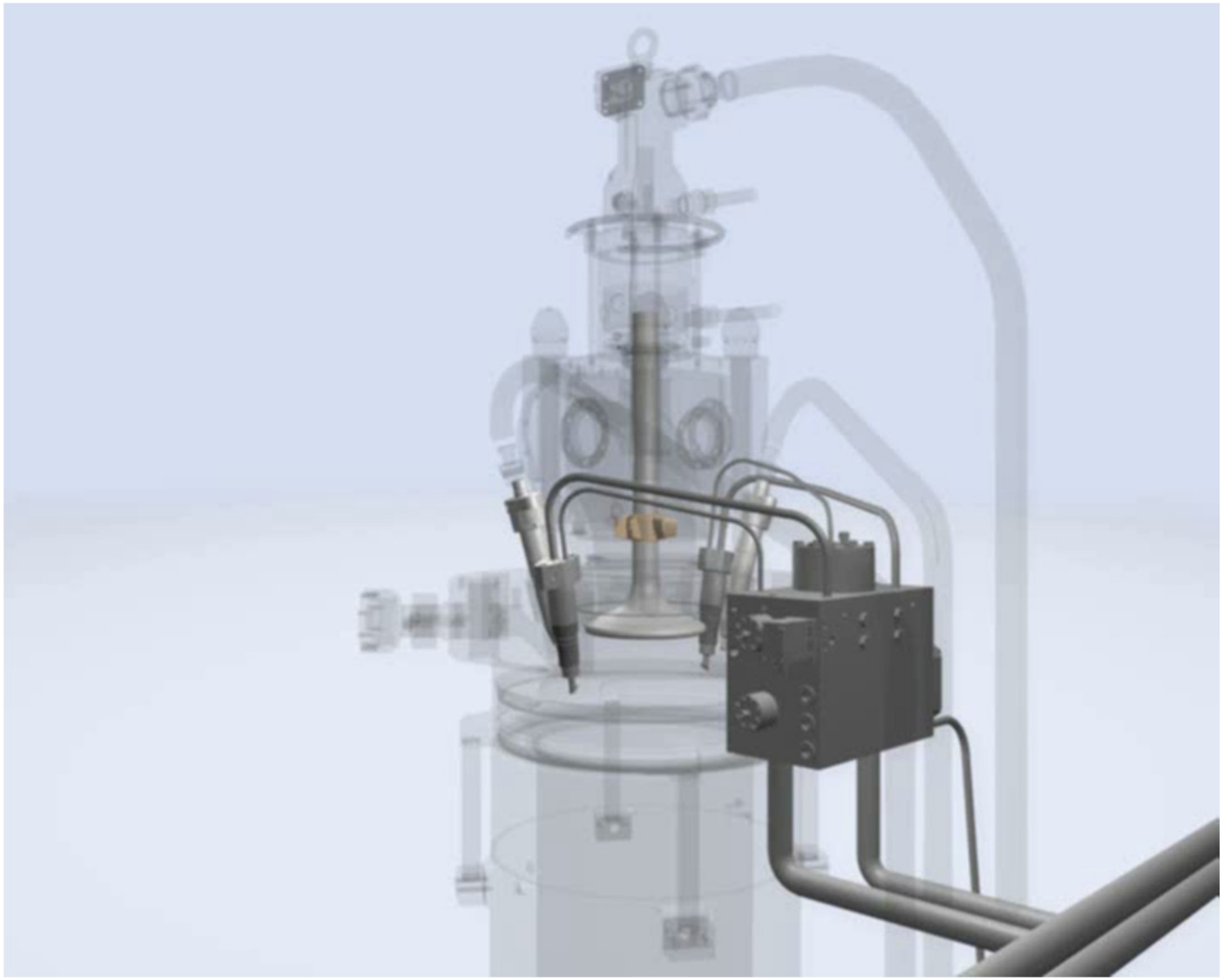
23% reduction of CO^2 without increasing methane slip





23% reduction of EEDI using LNG (including pilot oil), due to low carbon content and low SFC

ME-GI
Gas Combustion Control



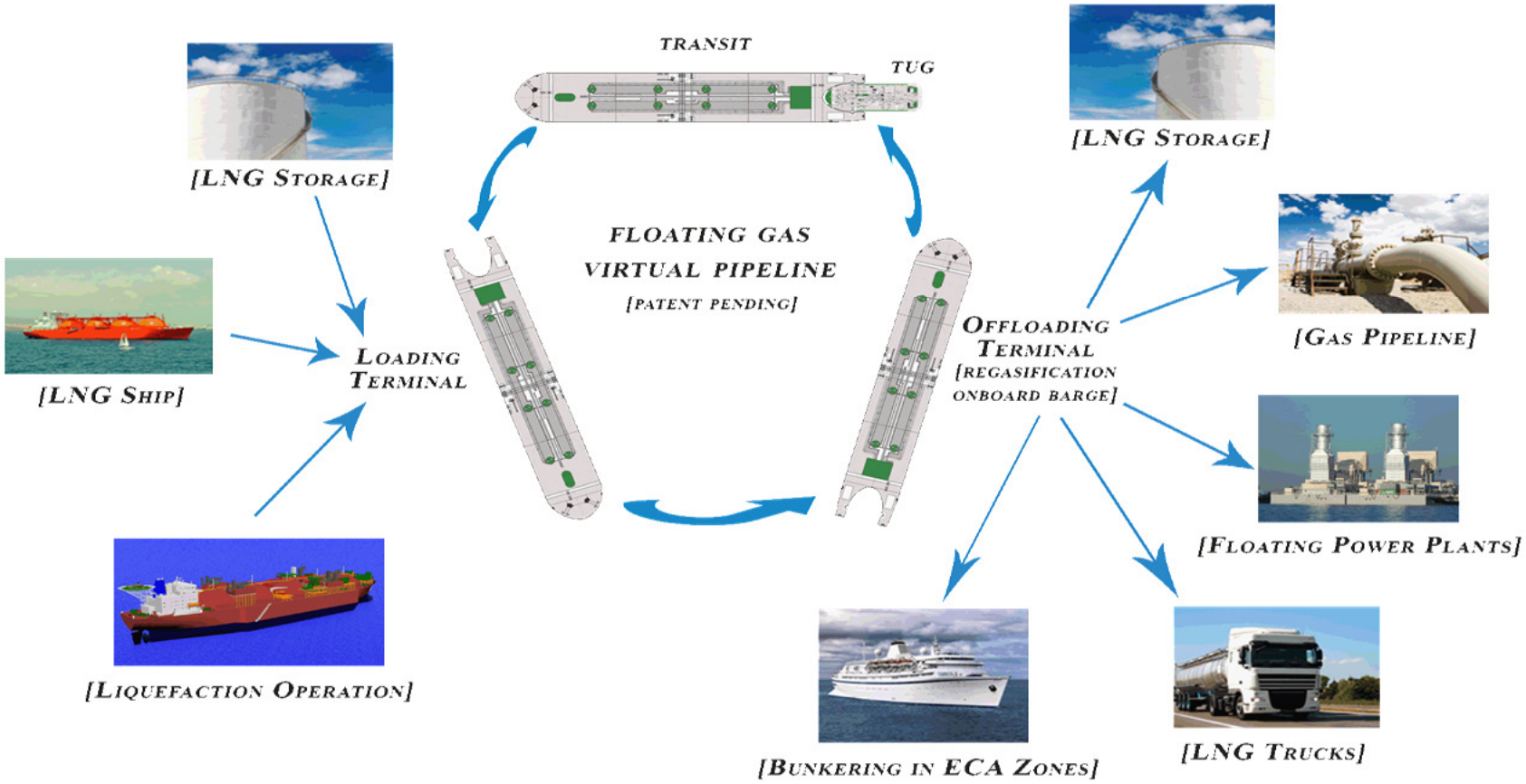
New Innovations from Waller Marine

Waller Marine
Floating Energy Solutions
Gas to Wire

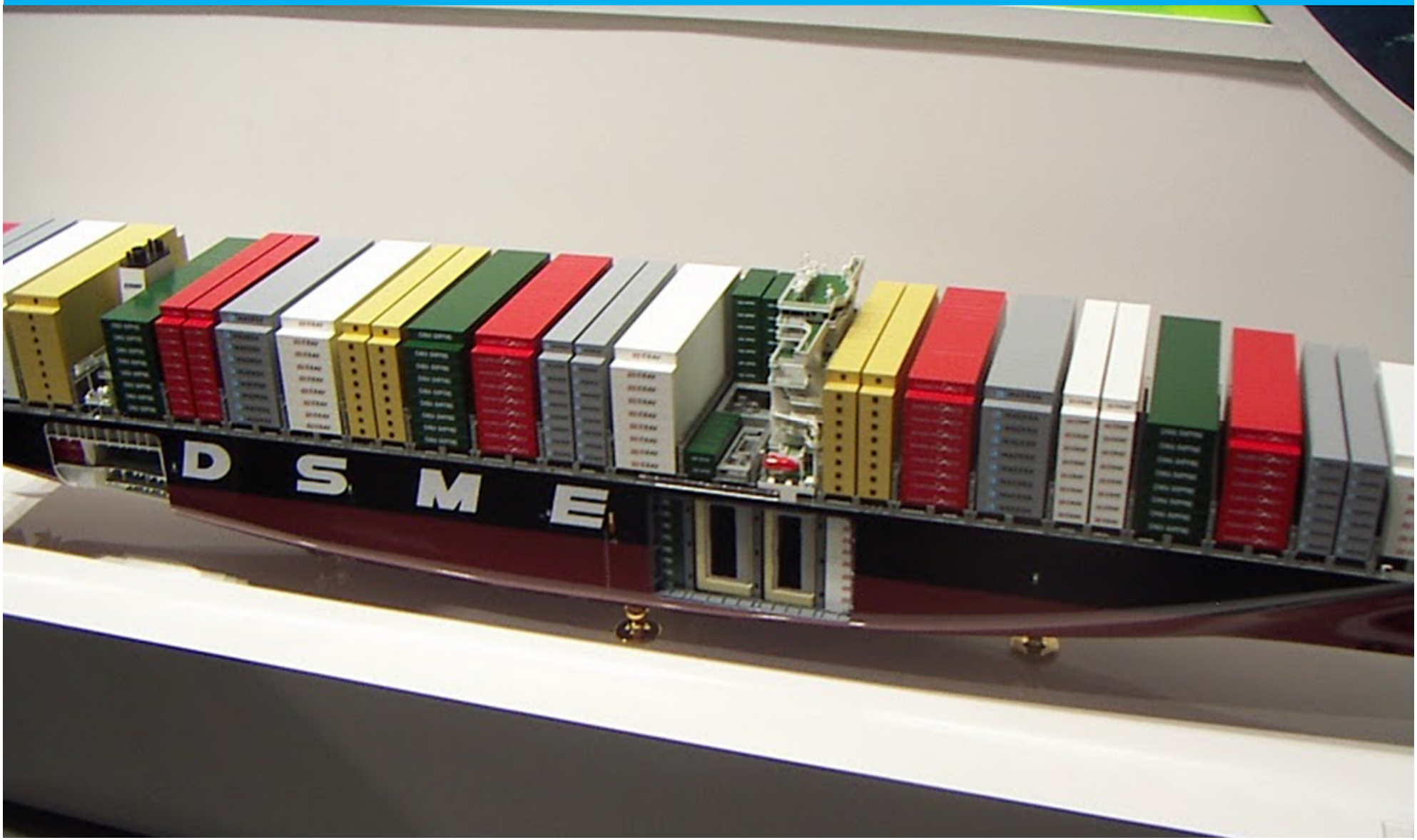
VISION, INNOVATIVE THINKING & TECHNOLOGY

PUSHING BEYOND THE LIMITS

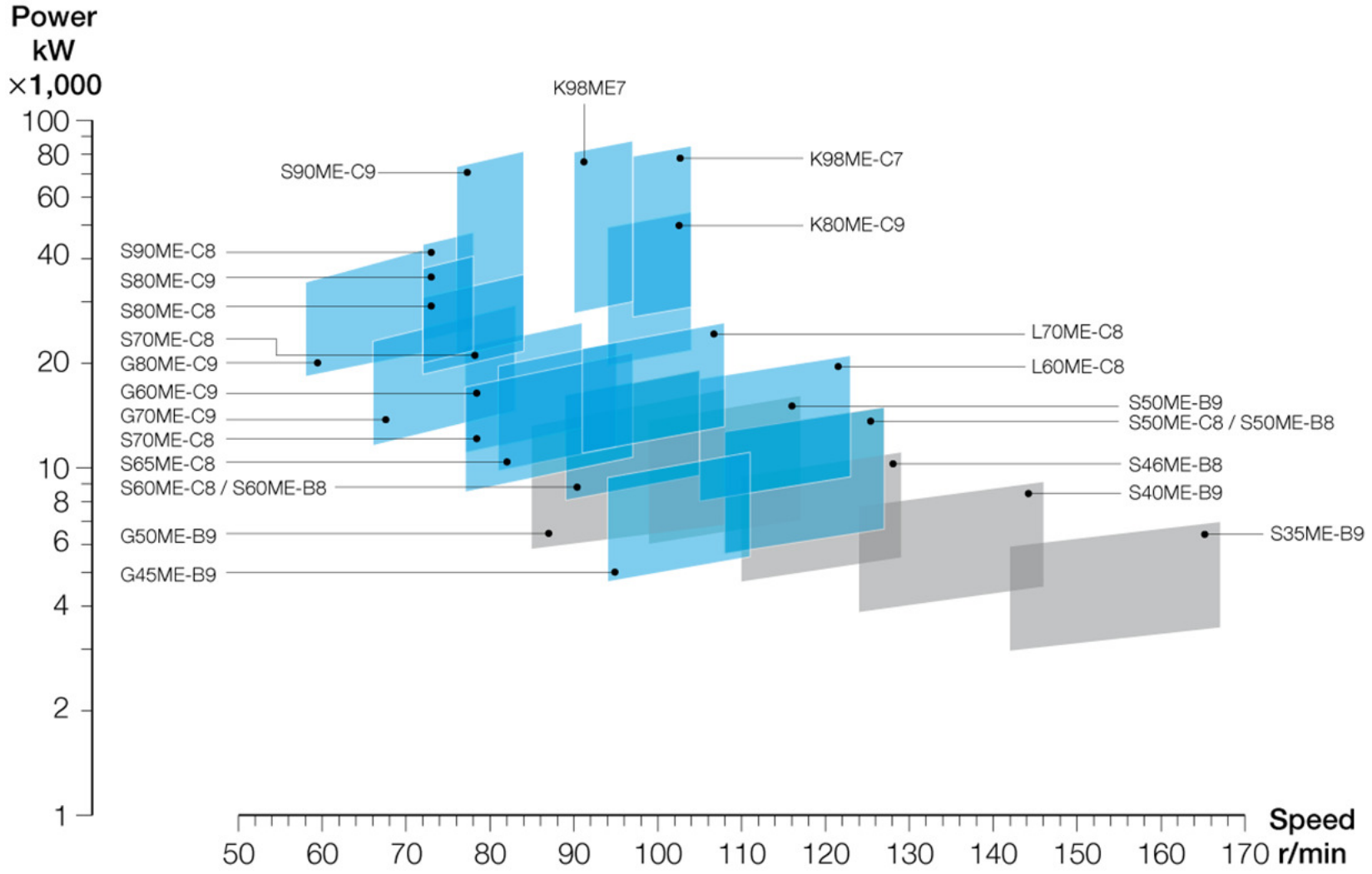
ARTICULATED TUG AND BARGE ARANGEMENT FOR LNG STORAGE, TRANSPORTATION AND REGASIFICATION



Design Proposal from DSME
Type B Tanks



All ME Engines Available as Dual Fuel
Marine Engine List 2012 - Tier II

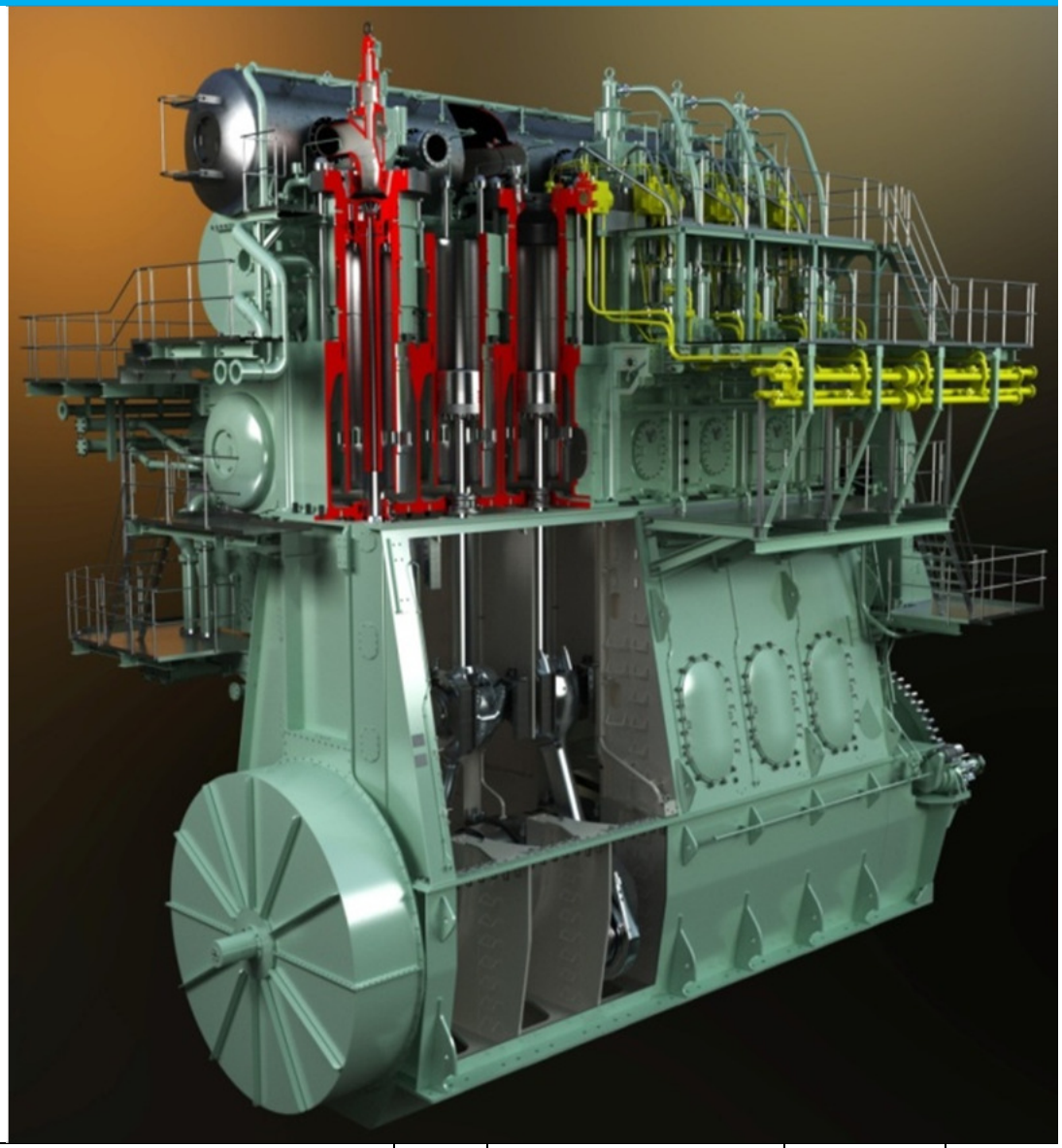


MAN B&W ME-GI/ME-LGI Engines
Powered by NG, HFO, MDO, LPG, MeOH or DME

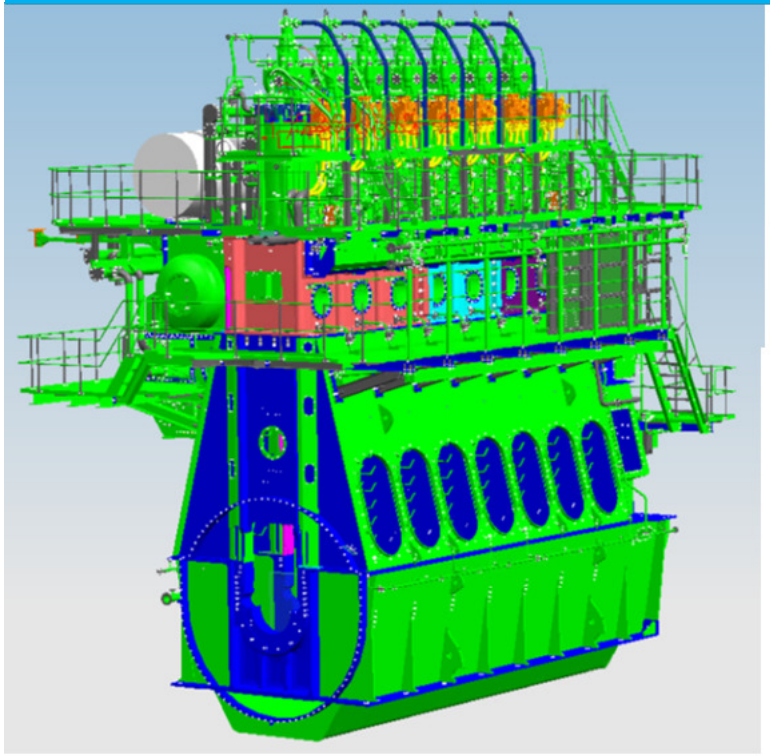
Simple modifications enable two-stroke gas injection

Proven engine design

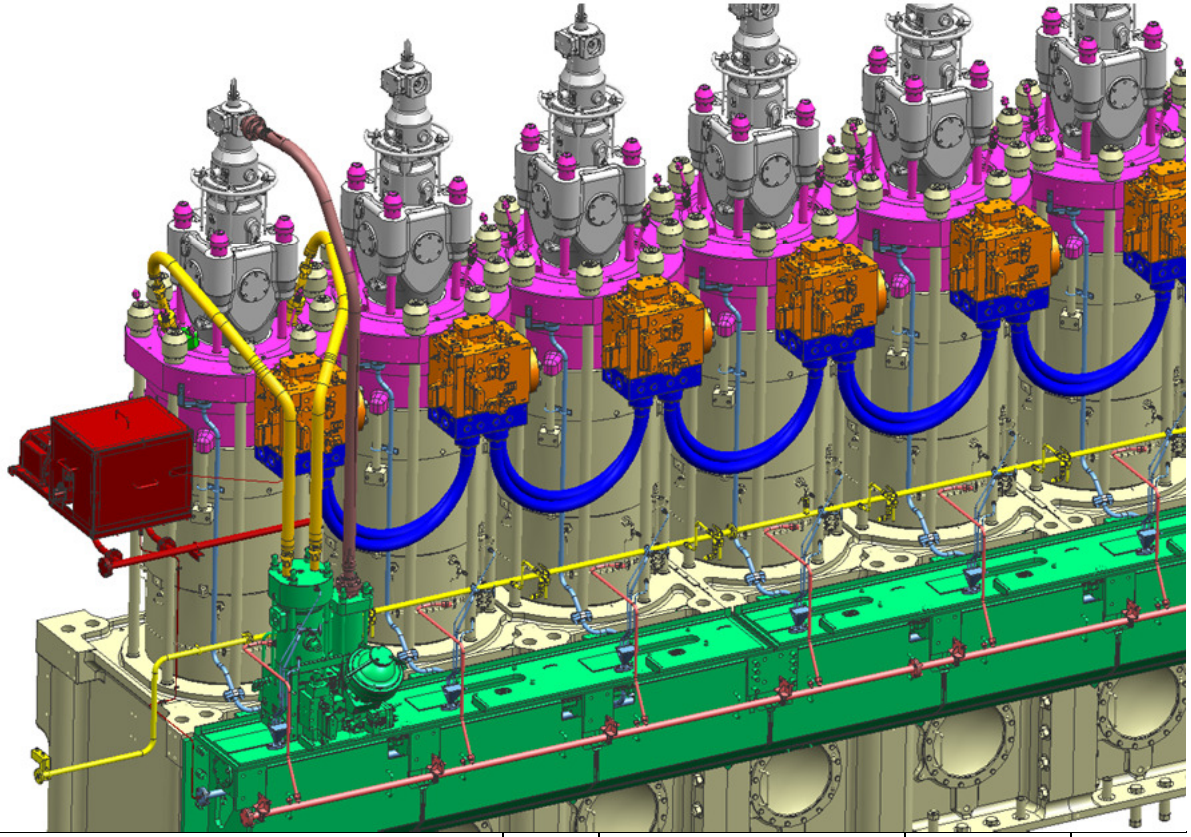
- High fuel efficiency 50%
- High fuel flexibility
- High reliability



ME-GI Design updates
Overview



More compact design introduced

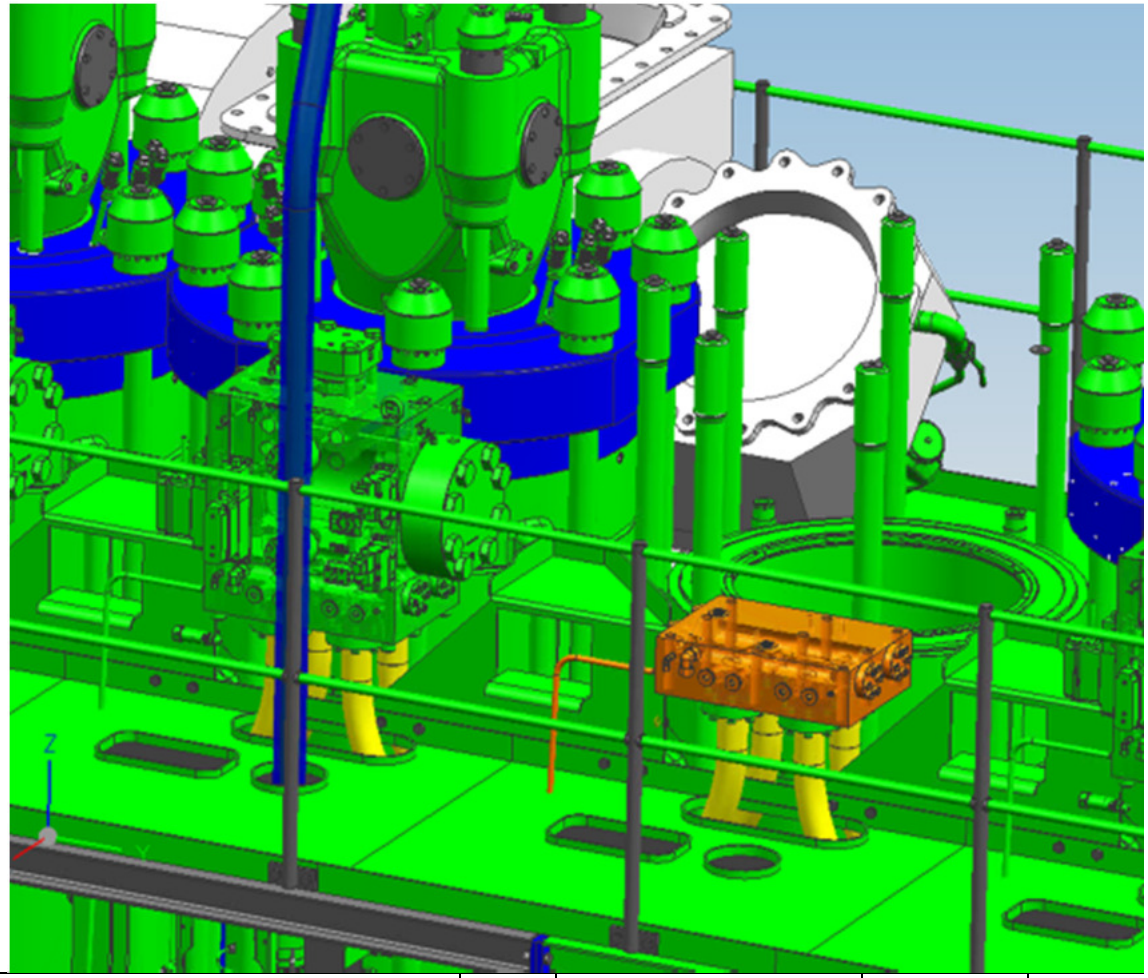


ME-GI Design updates
Easy maintenance

All connections through adapter block

- Gas inlet
- Gas outlet
- Hydraulic oil
- Sealing oil
- Hydraulic oil drain
- Oil drain window/gas-valve
- Low pressure oil

- **Connector block with pipes, remains on the engine during cylinder cover dismantling**



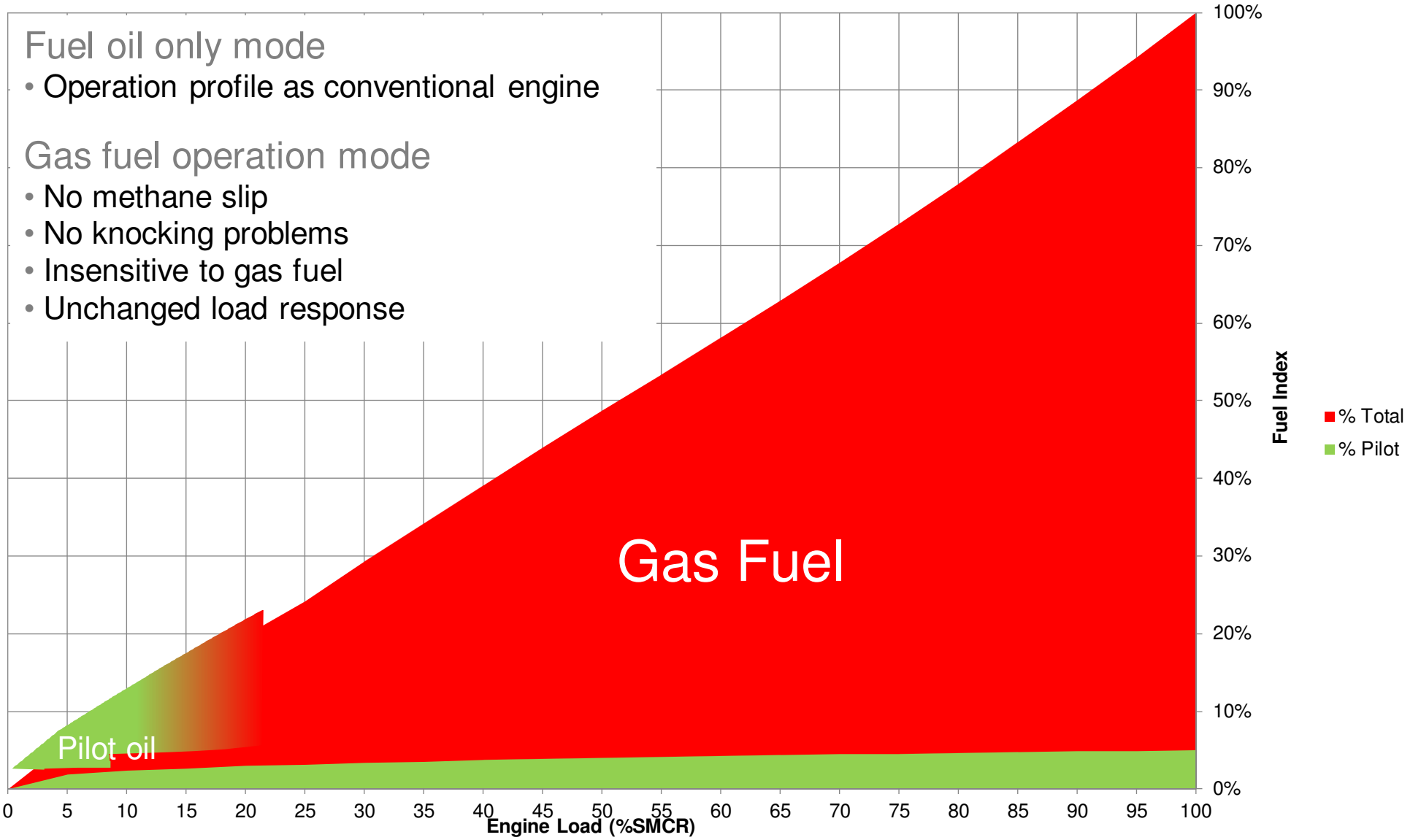
ME-GI Gas Fuel Mode
Port to port in gas mode

Fuel oil only mode

- Operation profile as conventional engine

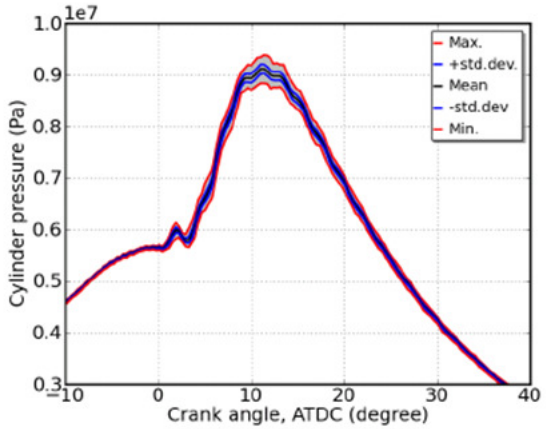
Gas fuel operation mode

- No methane slip
- No knocking problems
- Insensitive to gas fuel
- Unchanged load response

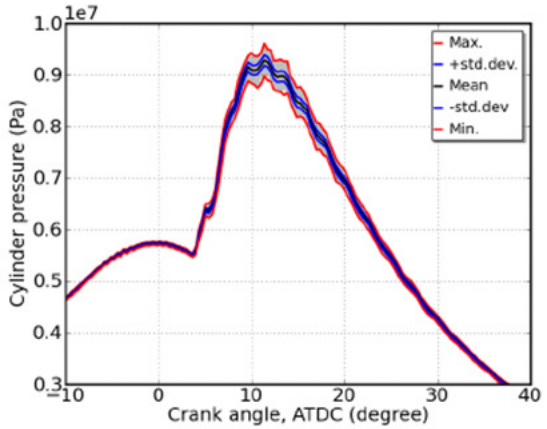


ME-GI Results
Performance

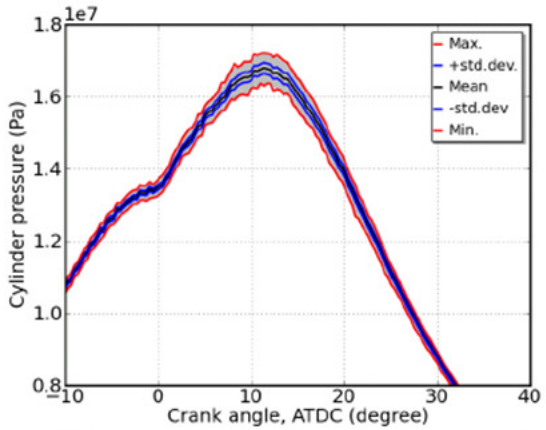
Engine stability: Cycle-to-cycle



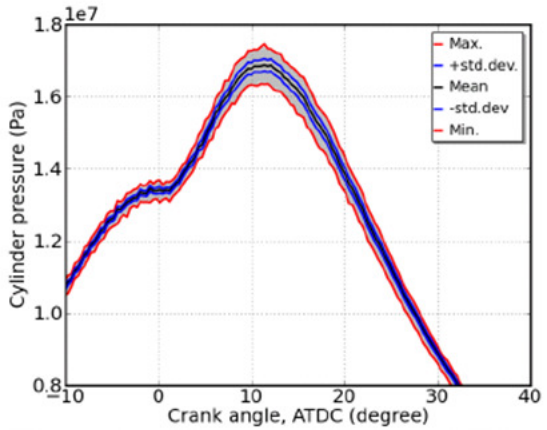
25% Load Gas



Diesel



75% Load Gas



Diesel

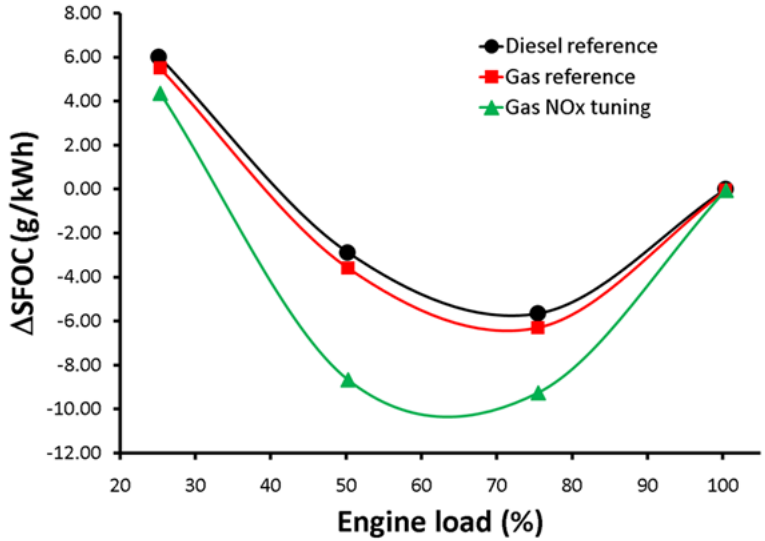
ME-GI Development
Results: SFOC/NO_x Tuning

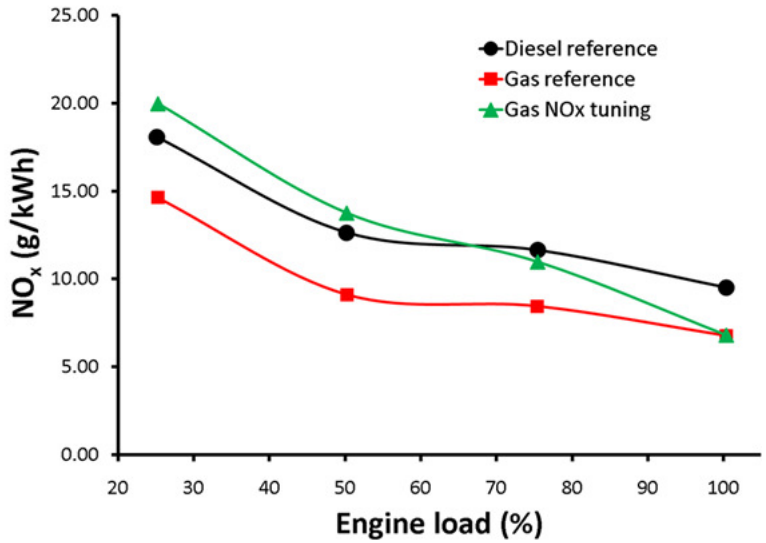
Improving efficiency in gas mode:

SFOC/NO_x tuning
- NO_x margin in gas mode
- SFOC reduction potential
- Design limits maintained

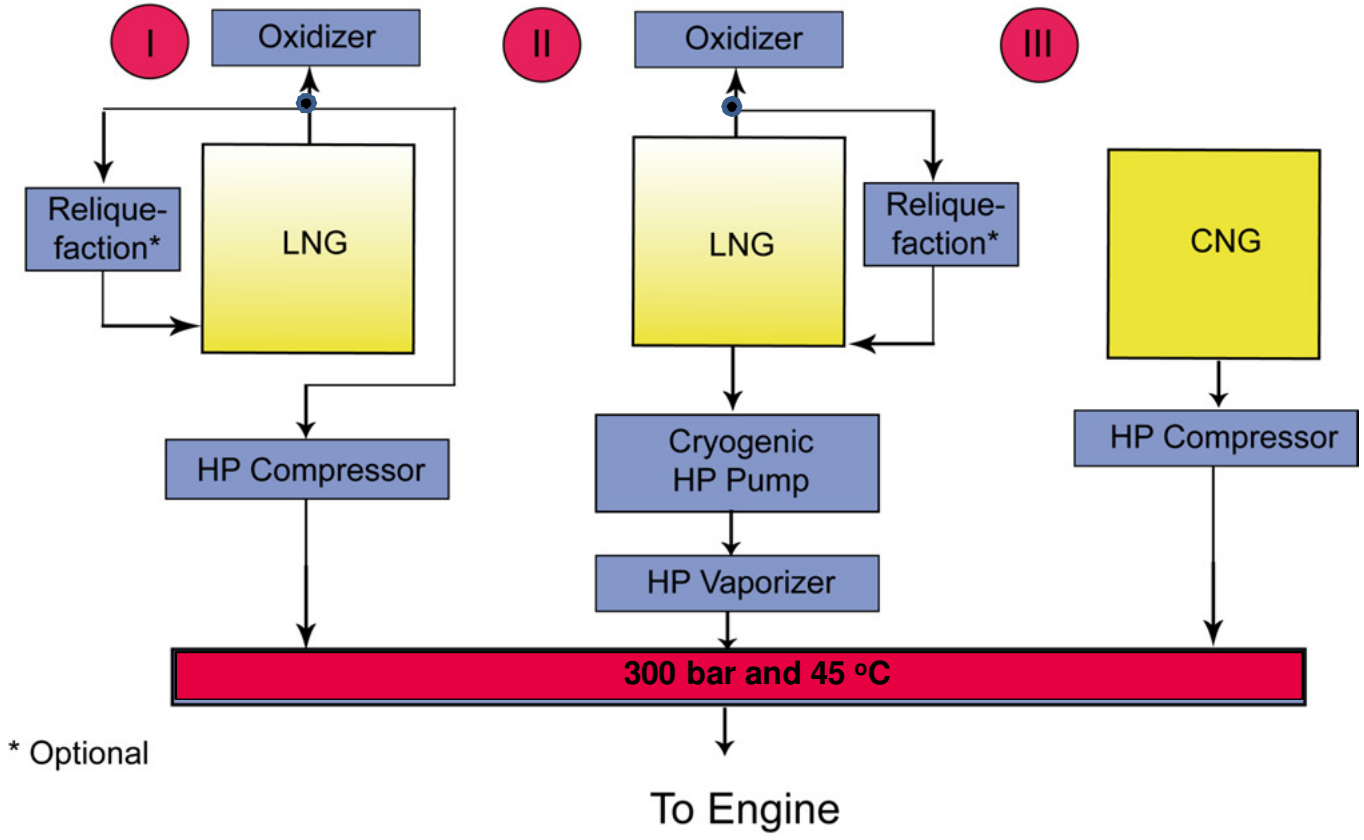
Results
- SFOC reduced 1-3%
- NO_x margin is still available

Released in engine program and CEAS

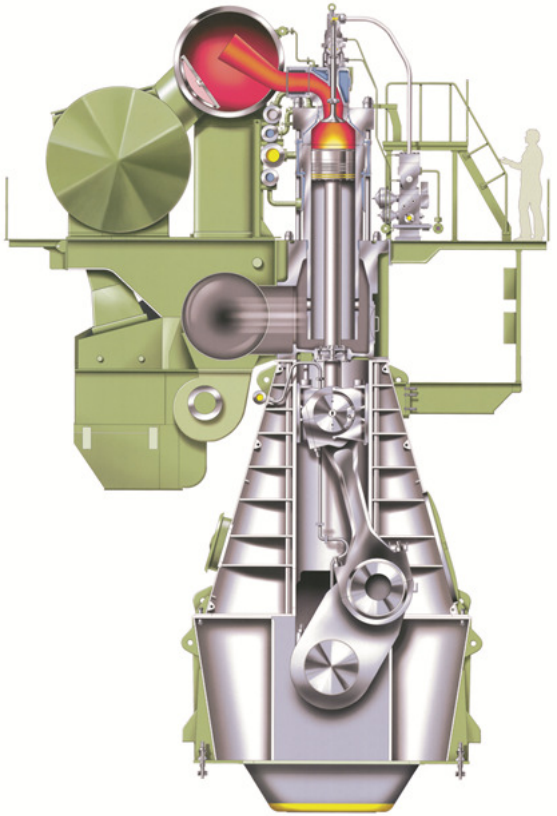




ME-GI
From Gas Tank to Engine

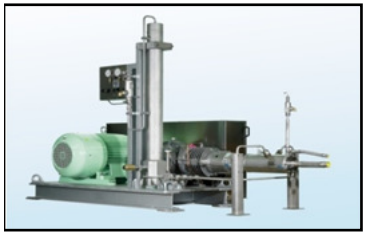


ME – GI Engine

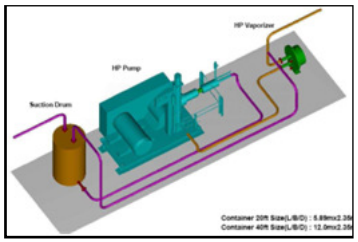


ME-GI
7 FGS System Suppliers

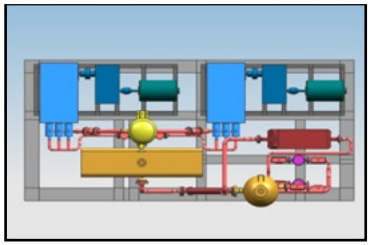
Cryostar
LNG Pump System



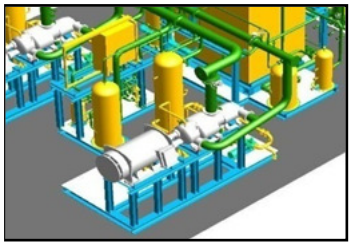
DSME
LNG Tank & Pump System



Hamworthy
LNG Tank & Pump System

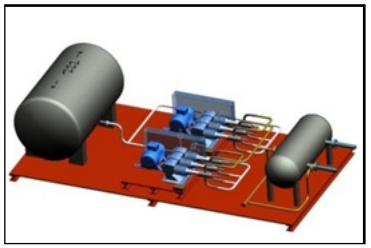


TGE
LNG Tank & Pump System

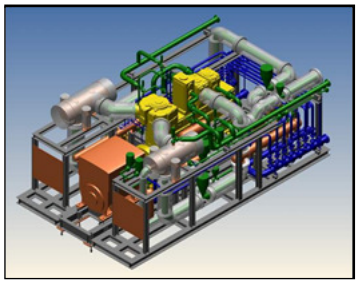


MHI
LNG Tank & Pump System

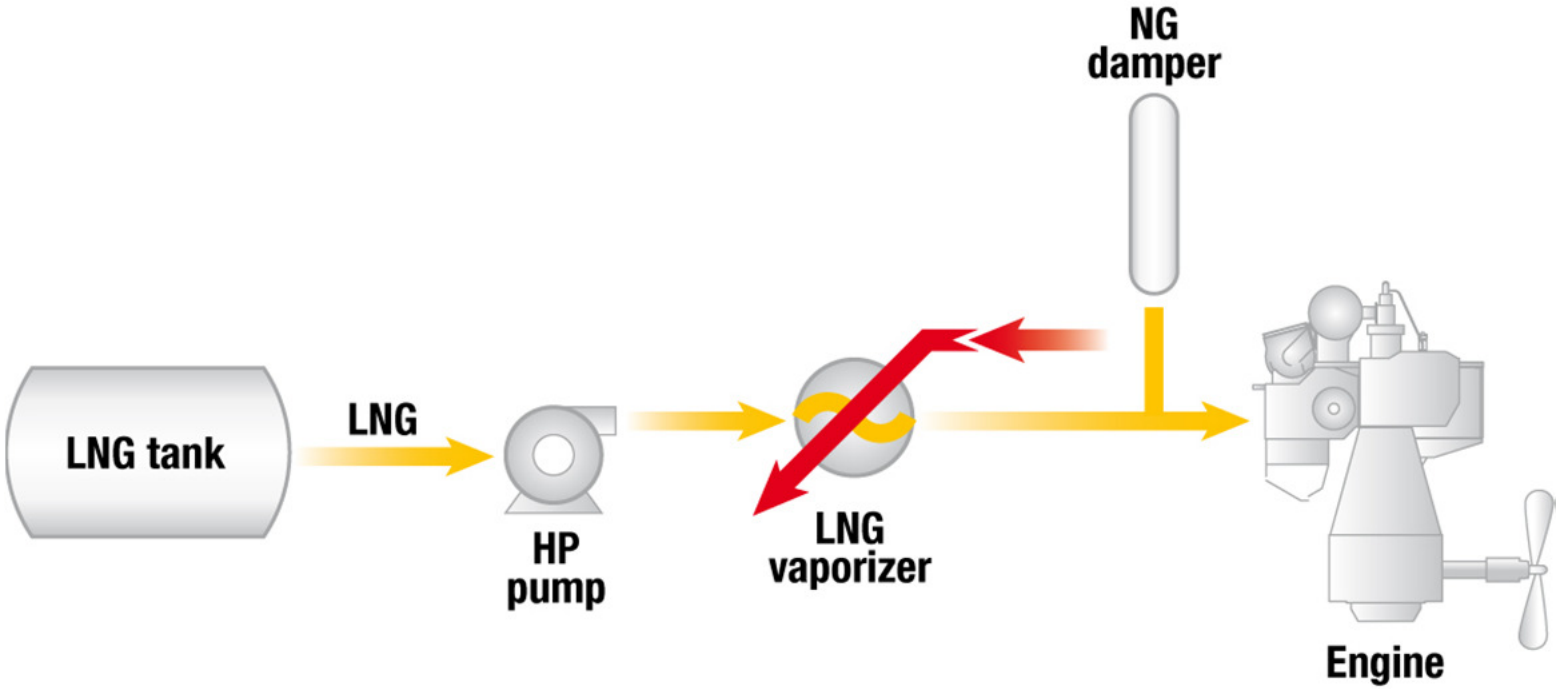
HHI
LNG Tank & Pump System



Burckhardt Compression
Laby-GI Compressor



FGS System



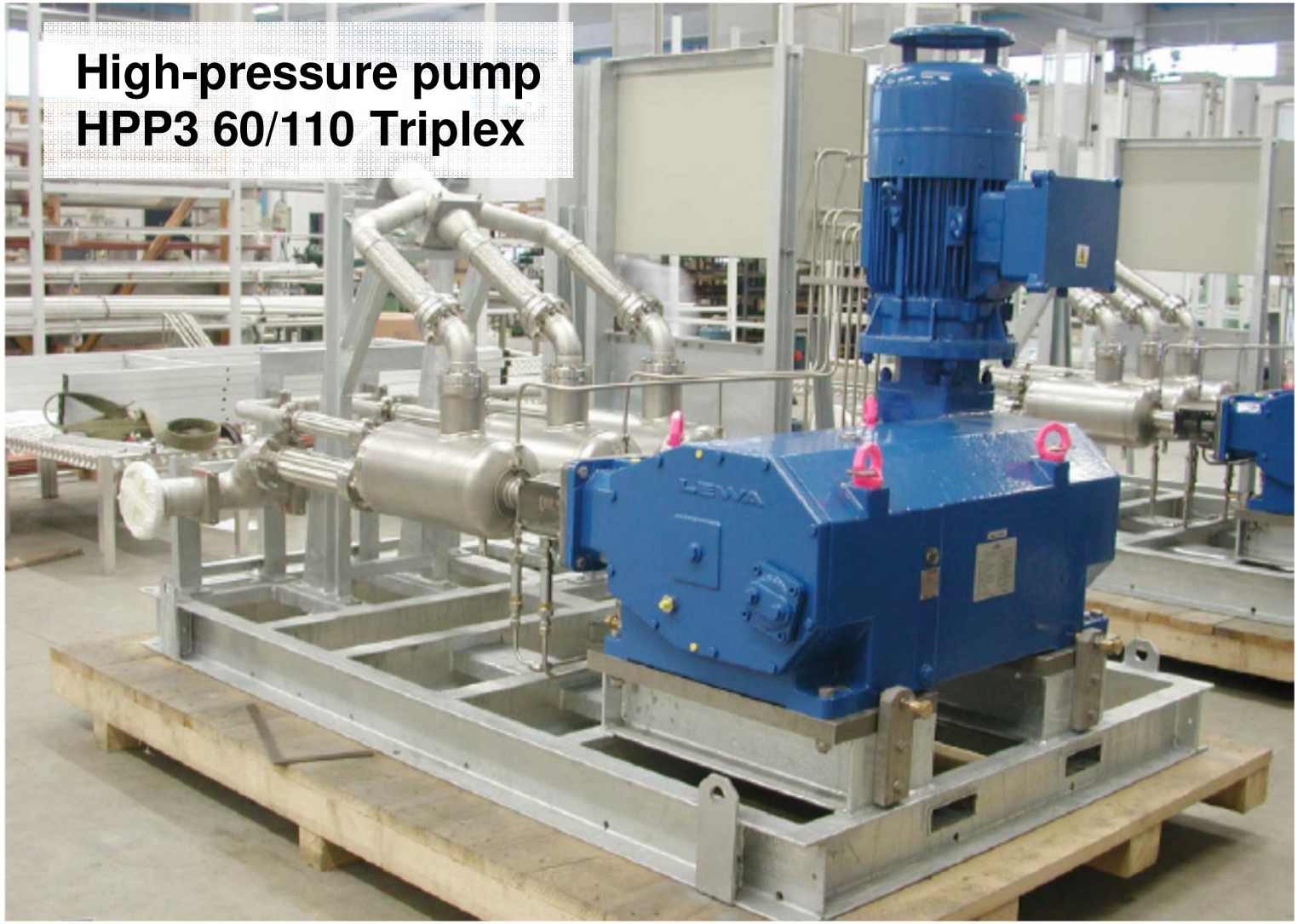
Example:

8S90ME-C8.2-GI - Output: 45,760 kW

HP Cryogenic pump: 5,600 kg/hr. & 200 kW

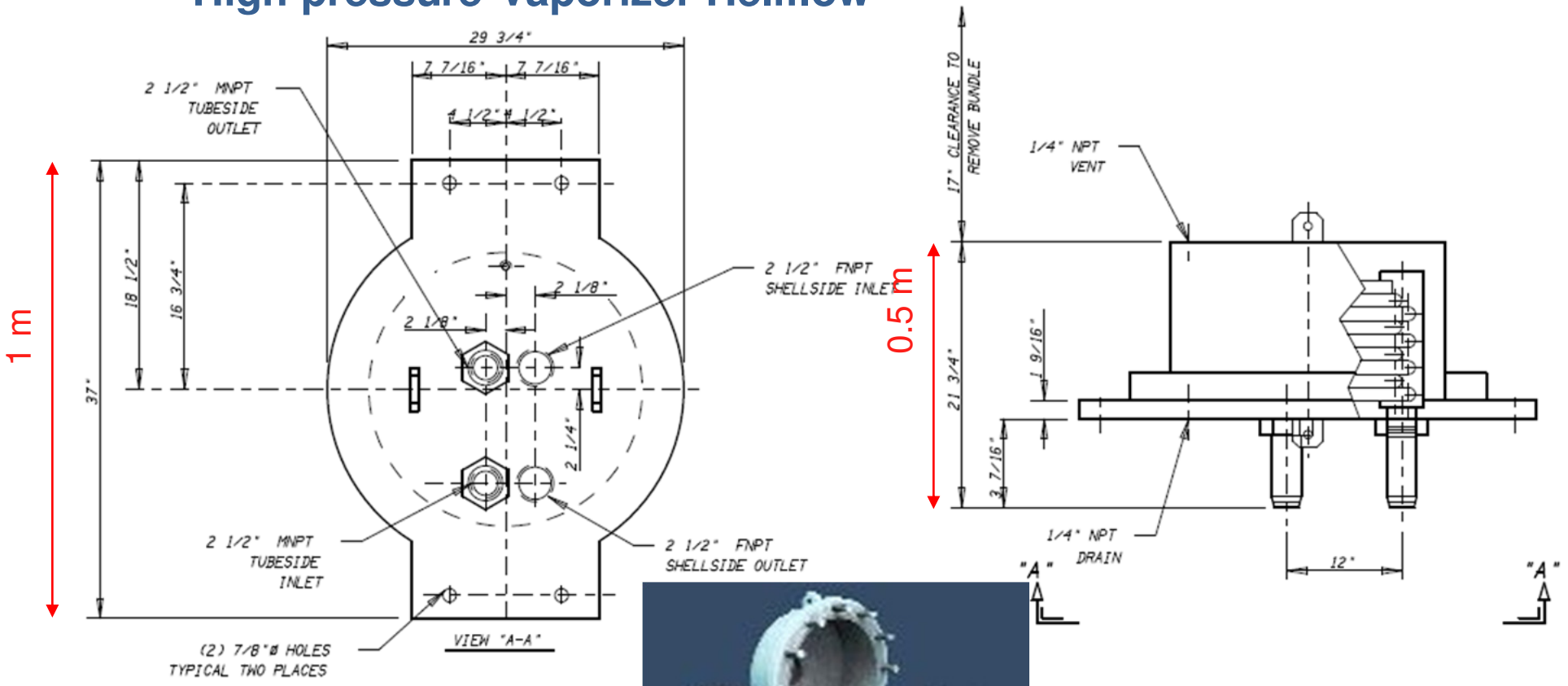
Less than 0.5% efficiency reduction

HP Pump and Vaporizer from Cryostar



HP Pump and Vaporizer from Cryostar

High-pressure Vaporizer Heliflow

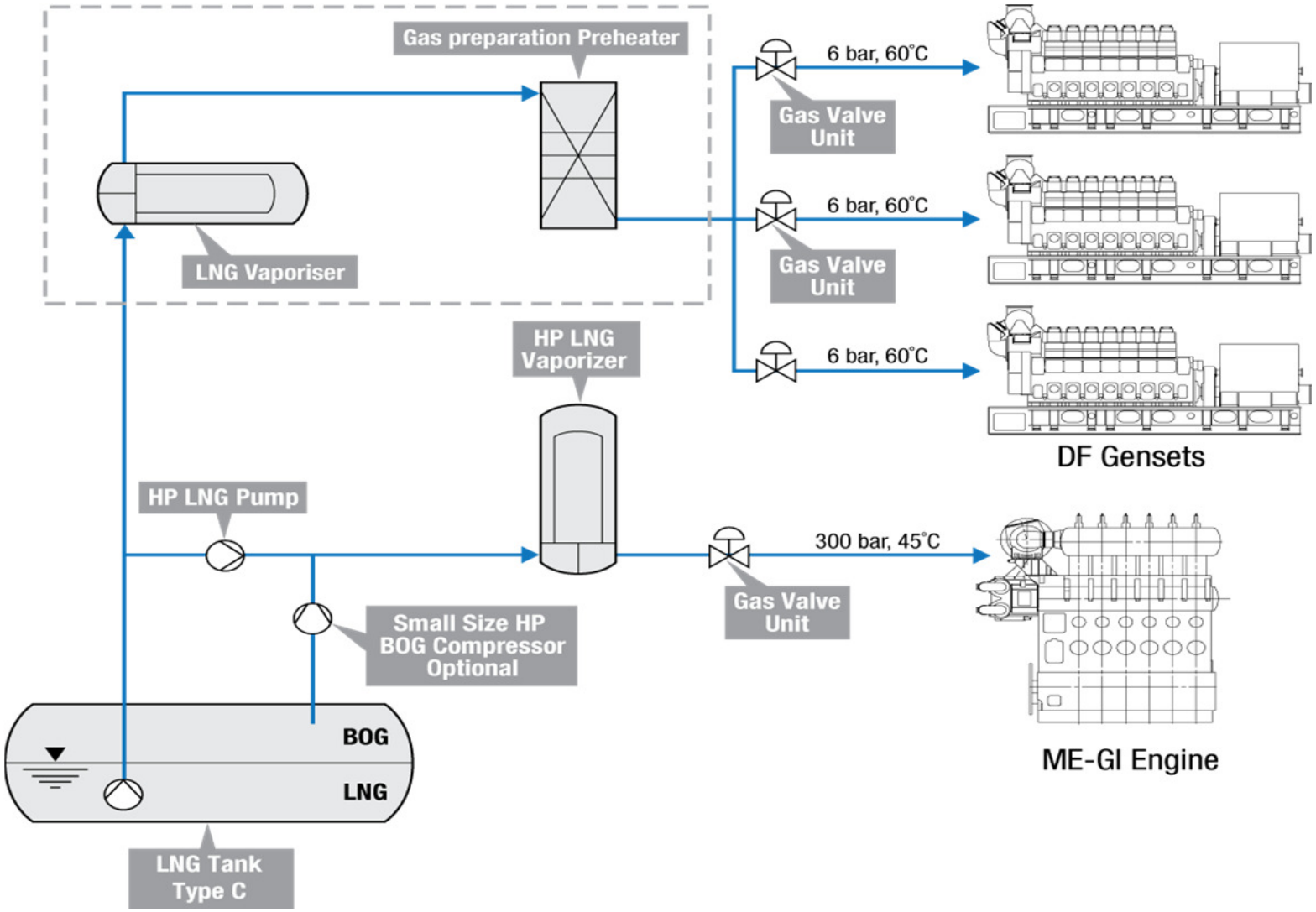


Previously supplied for LN2 converter

Technical Data GenSets
Marine L+V35/44DF Available 2014

Bore: 350 mm, Stroke: 440 mm		
Speed (r/min)	750	720
MEP (bar)	20.0	20.1
	kW	kW
6L35/44DF	3,180	3,060
7L35/44DF	3,710	3,570
8L35/44DF	4,240	4,080
9L35/44DF	4,770	4,590
10L35/44DF	5,300	5,100
12V35/44DF	6,360	6,120
14V35/44DF	7,420	7,140
16V35/44DF	8,480	8,160
18V35/44DF	9,540	9,180
20V35/44DF	10,600	10,200
Consumption		
MCR	100%	85%
Specific fuel oil consumption (HFO)*	187 g/kWh	186 g/kWh
Heat rate **	7,700 kJ/kWh	
Specific lube oil consumption 0.5 g/kWh		
* Diesel or HFO fuel operation, with attached pumps (LO, LT and HT) with +5% tolerance	** Gas operation (including pilot fuel)	
LHV_{min}= 32,800 kJ/m³ (STP)		

Fuel Gas Supply System from TGE for Two-stroke Main Engine and DF GenSets

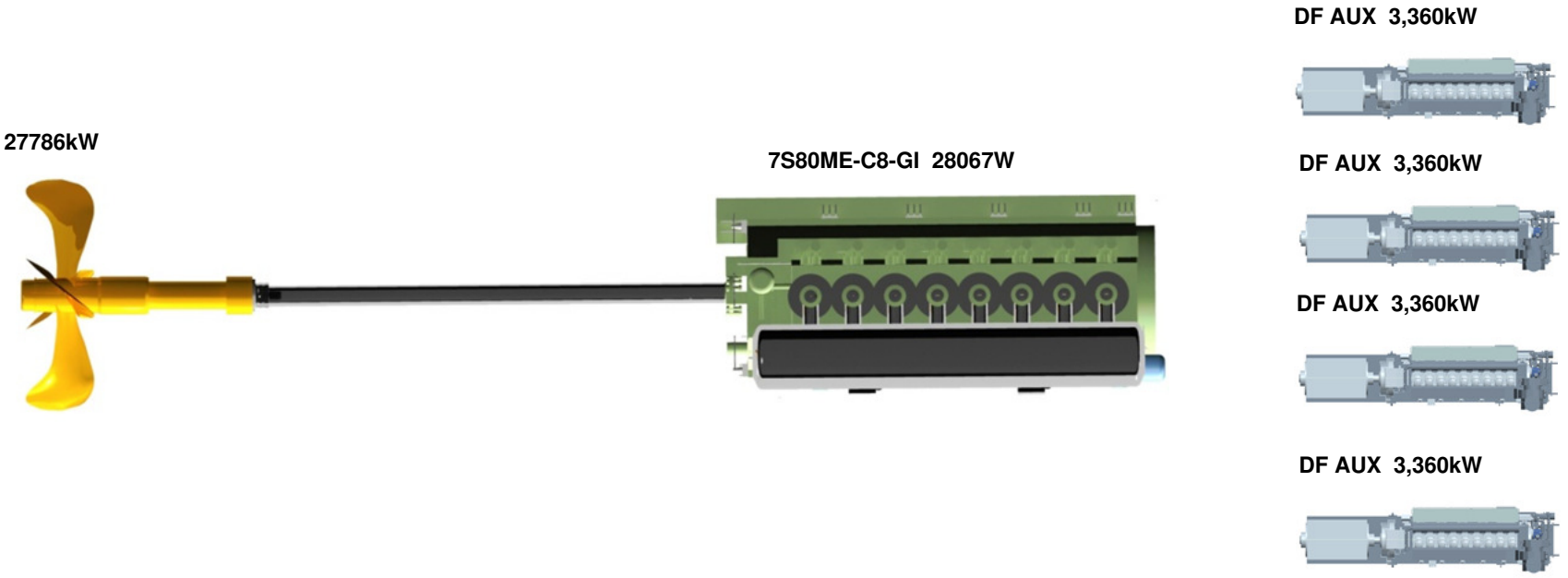


162,000 m³ LNG Tanker

1. Propulsion power demand
2. ME-GI powered LNG Carrier with fulll fuel flexibility
3. LNG Carrier with DFDE
4. Shipowner considerations

Propulsion Power Demand

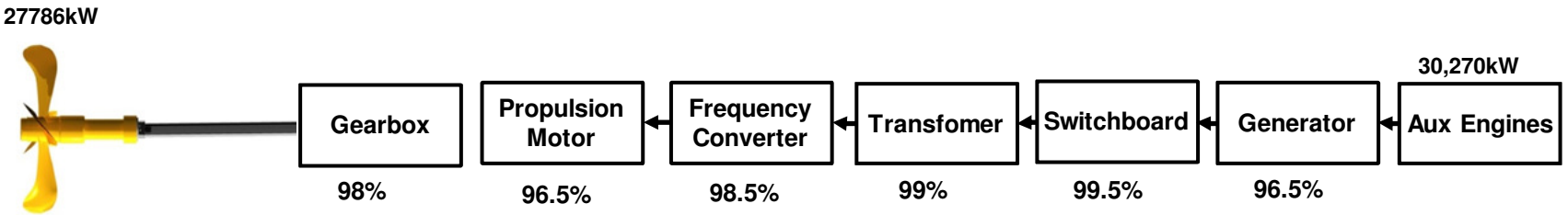
Comparison between ME-GI Solution



- 7S80ME-C8-GI with 28067kW
- 4x DF aux engines with 3360kW each
- Total 41,507kW installed

Propulsion Power Demand

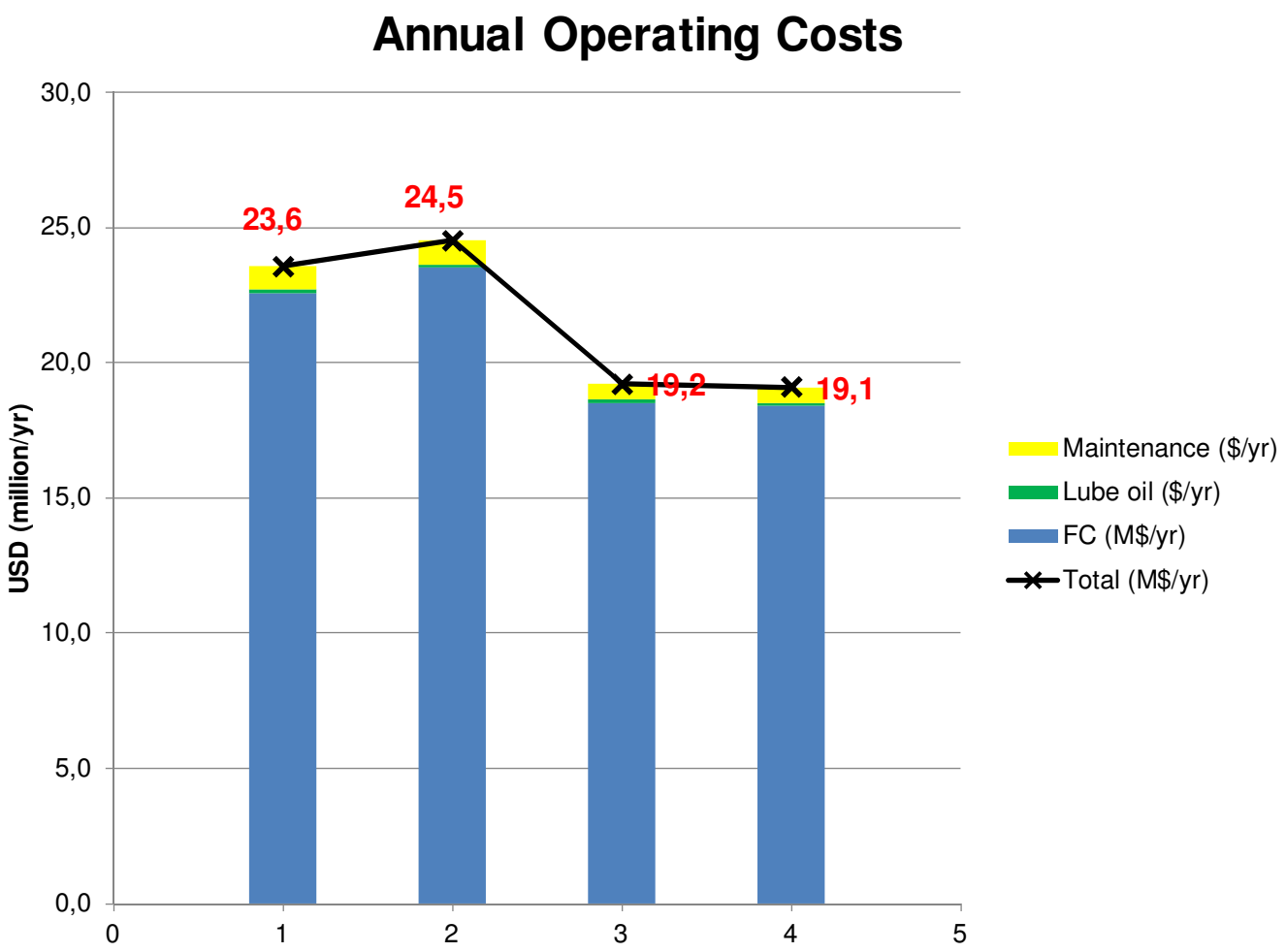
…and DFDE Solution



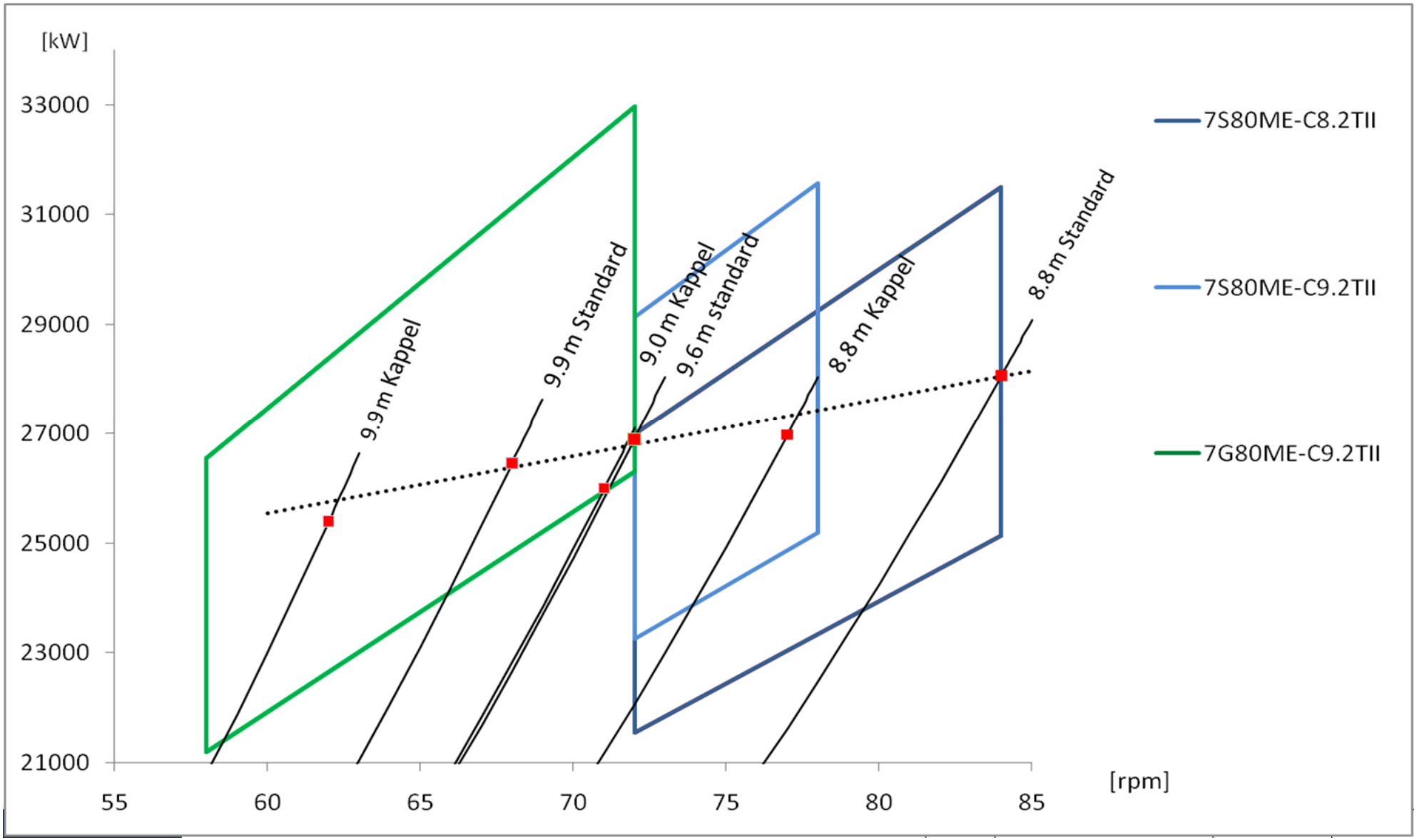
- 2 x Wartsila12V50DF + 2 x 6L50DF for provision of electrical power requirement shown in slide 14
- Total 35,100kW installed

Shipowner Considerations

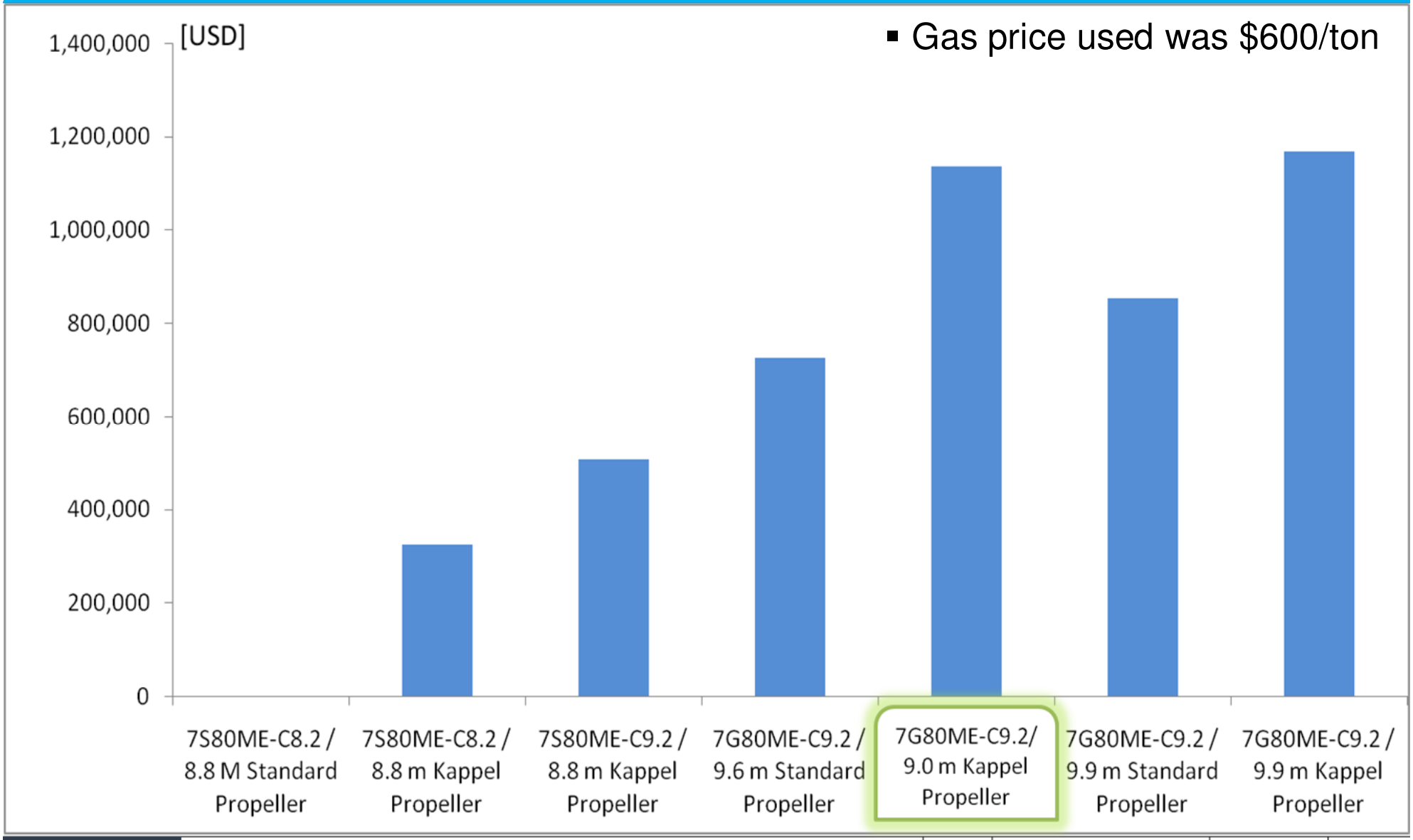
1. DFDE gas mode
2. DFDE fuel mode
3. ME-GI gas mode
4. ME-GI fuel mode



Layout Diagrams

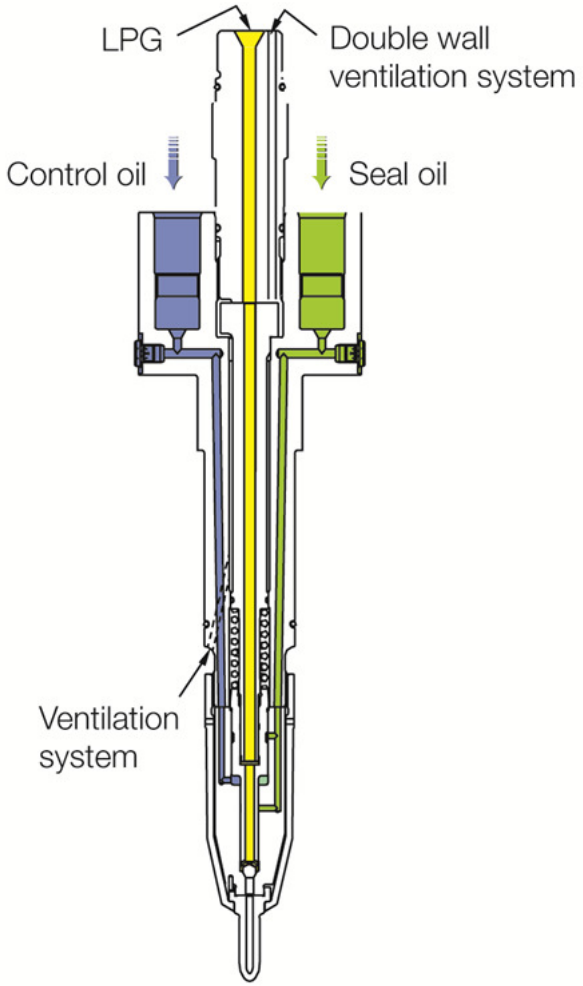


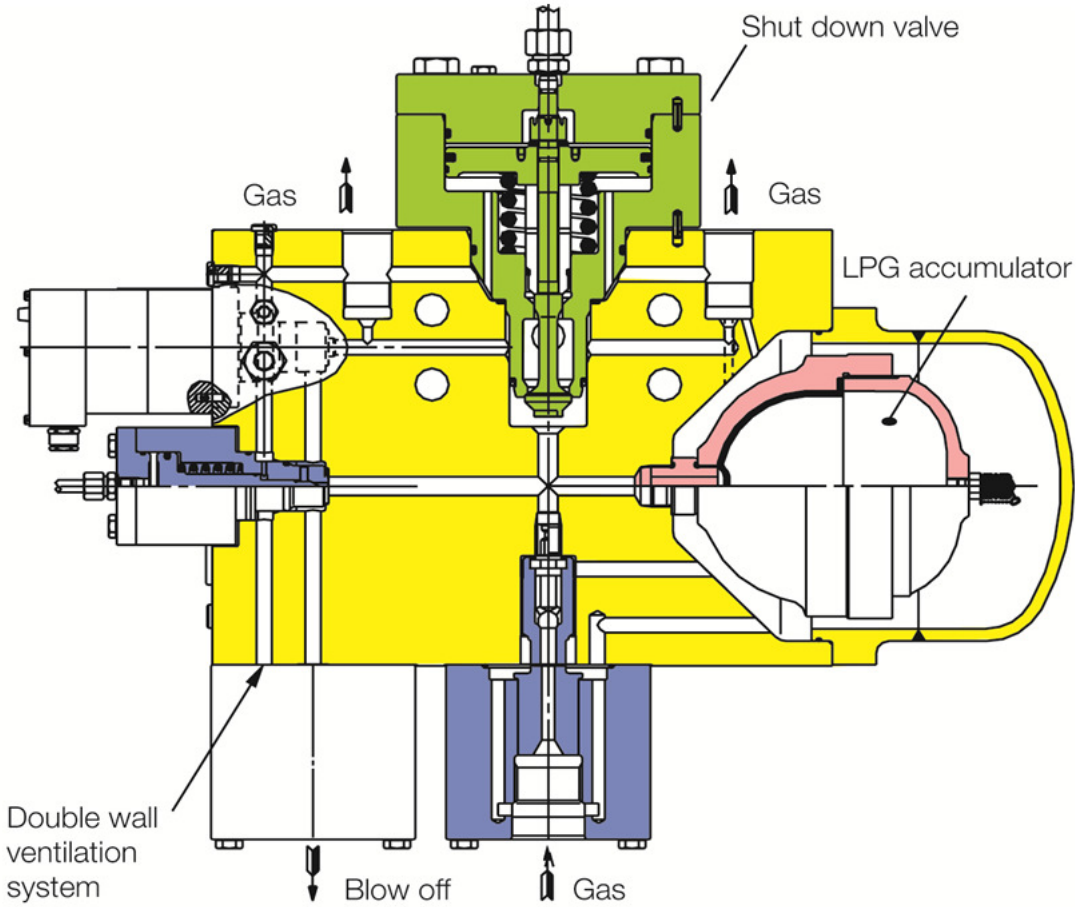
Potential Annual Cost Savings Relative to the Load Profile



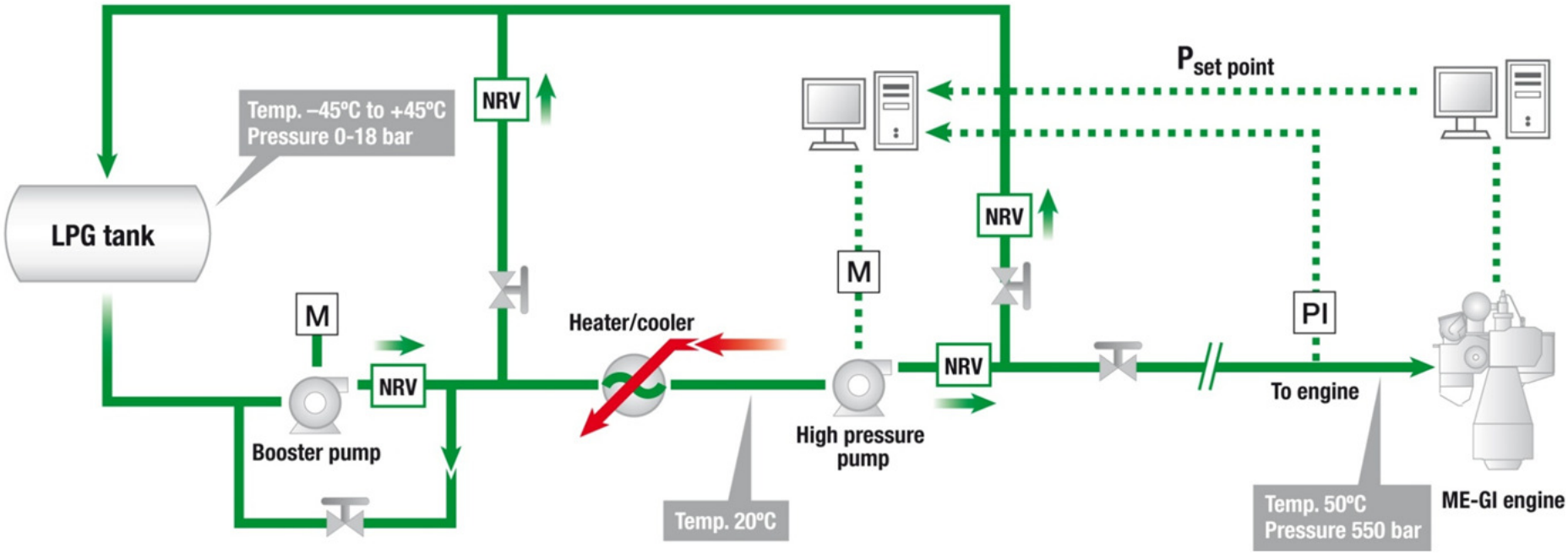
- Gas price used was $600/ton

LPG as Fuel: Gas Injection Valve & Valve Block with Accumulator



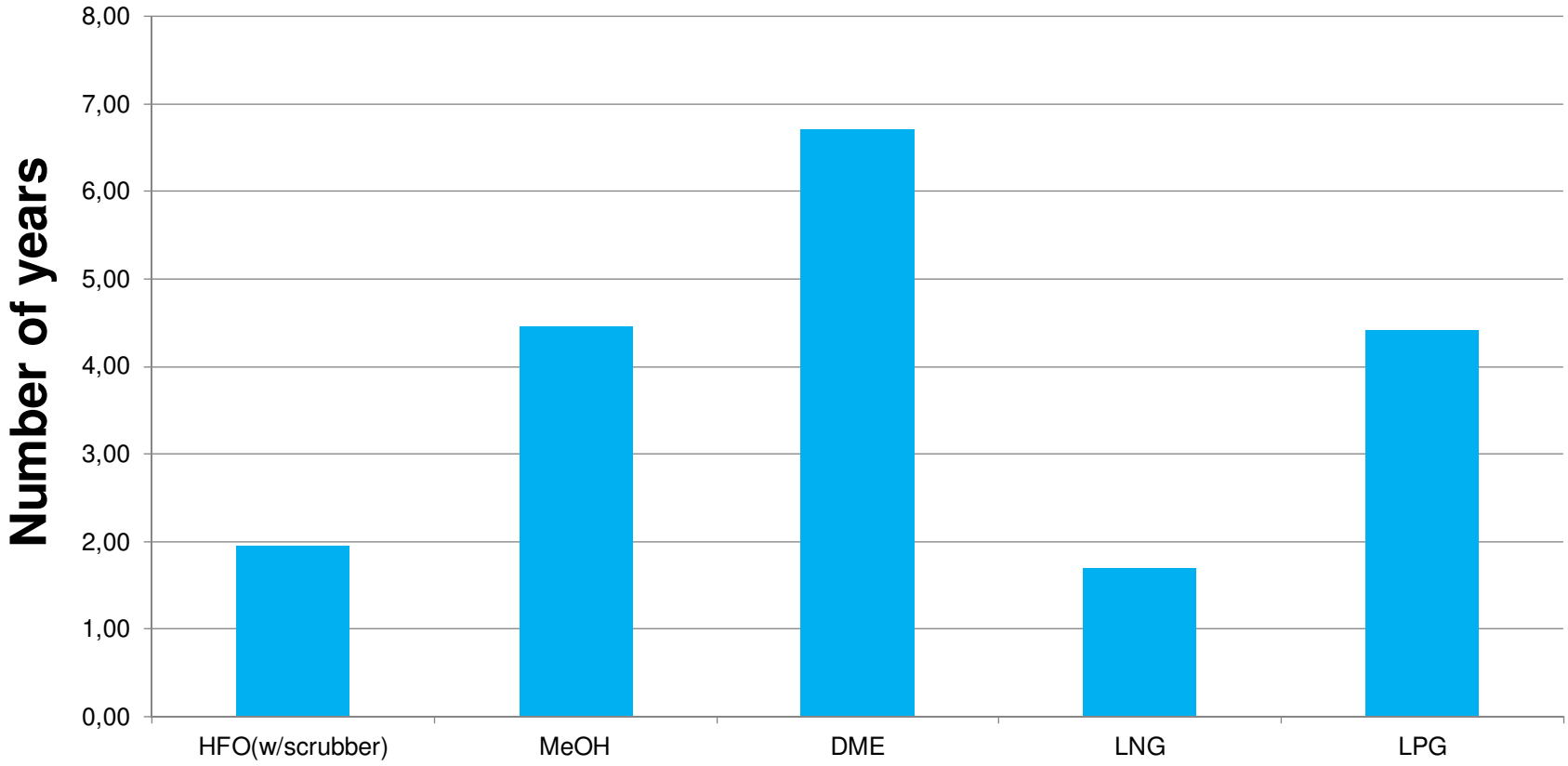


Gas Supply System from HGS Using LPG as Fuel



Comparison of Altenative Fuels For ECA operation - 6 MW

Payback time relative to MGO operation



ME-GI & ME-LGI

2012

Thank you for your kind attention

The presentation material will be available on the following link: www.mandieselturbo.com/me-gi from 8 March 2012

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