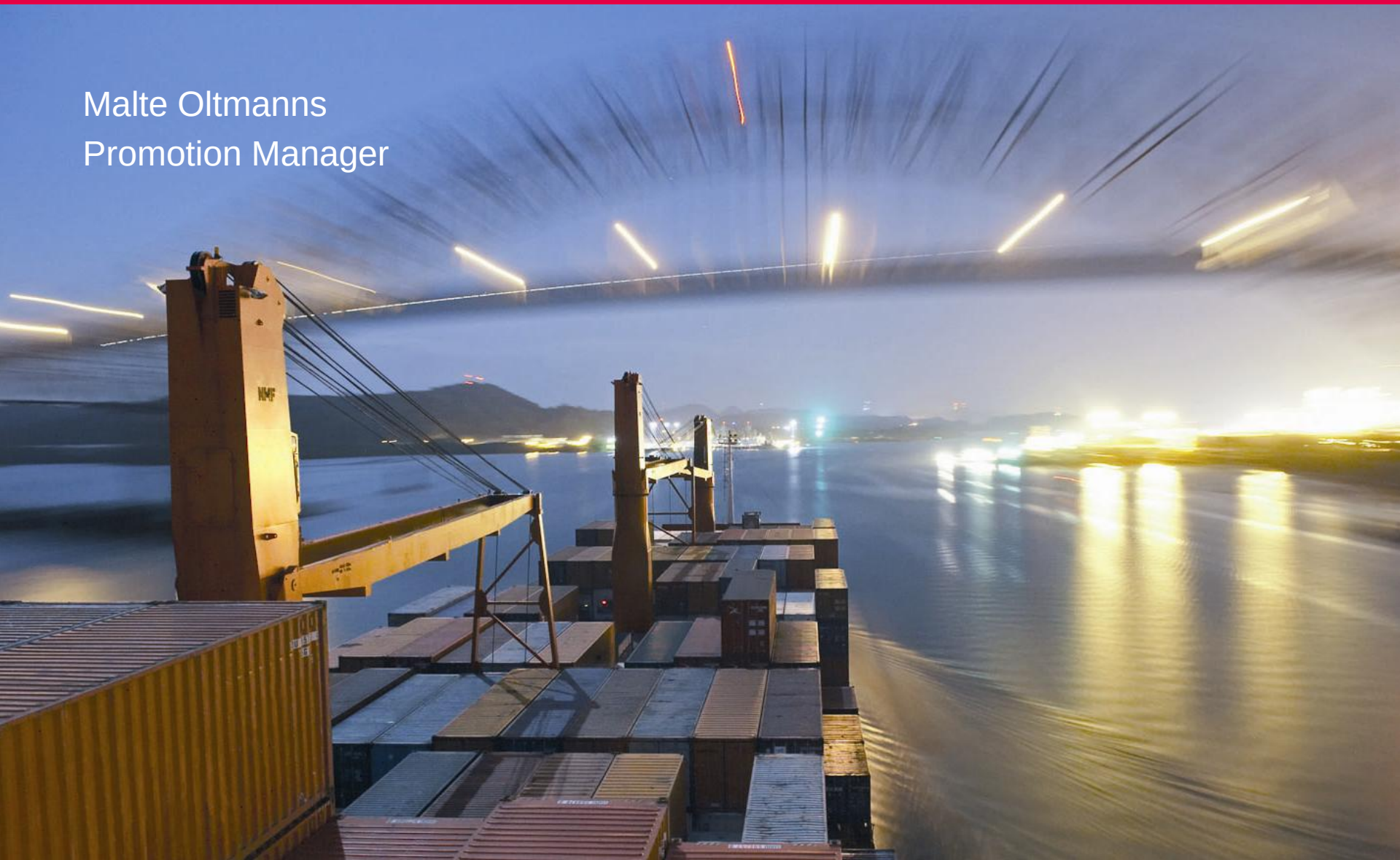
Turbocharger Seminar, Dubai 2012

MAN Turbocharger – Engineering the Future



Malte Oltmanns
Promotion Manager

Disclaimer

All data provided on the following slides is for information purposes only, explicitly non-binding and subject to changes without further notice.

Did you know…

…that our turbochargers increase engine output by more than **300%** ?

Agenda

MAN Diesel & Turbo SE

General Structure

Executive Board

Group Functions (Gx)

Engines & Marine Systems	Turbomachinery	Power Plants	After Sales
Support Functions (Ex)	*Support Functions (Rx)*	*Support Functions (Px)*	*Support Functions (Ax)*
BU High Speed (H)	BU Process Industry (I)	BU Power Plants (P)	BU PrimeServ Diesel (D)
BU Low Speed (L)	BU Oil & Gas (O)		BU PrimeServ Turbo (S)
BU Turbocharger (T)			
BU Production (W)			










World Wide Organisation

MAN Turbocharger Production Sites

MAN Diesel & Turbo
Germany

PBS Turbo
Czech Republic

MAN Diesel & Turbo
Turbocharger Plant
Changzhou, China

Kawasaki
Japan

Mitsui
Japan

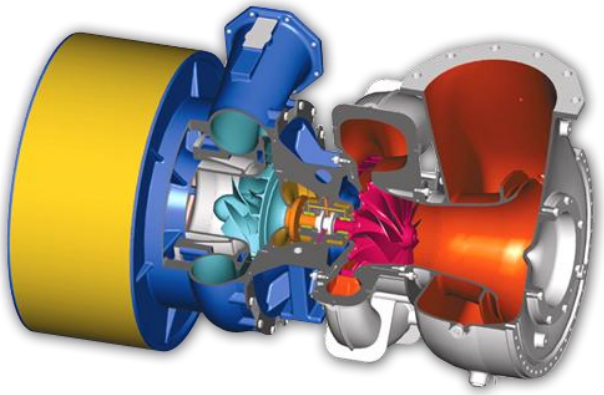
STX Metal
Korea

Agenda

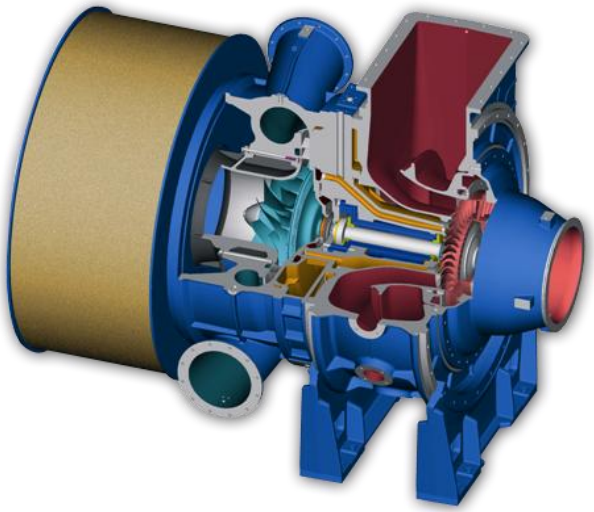
TCA- and TCR Turbocharger Series

Suitable Turbochargers for all MAN Diesel Engines

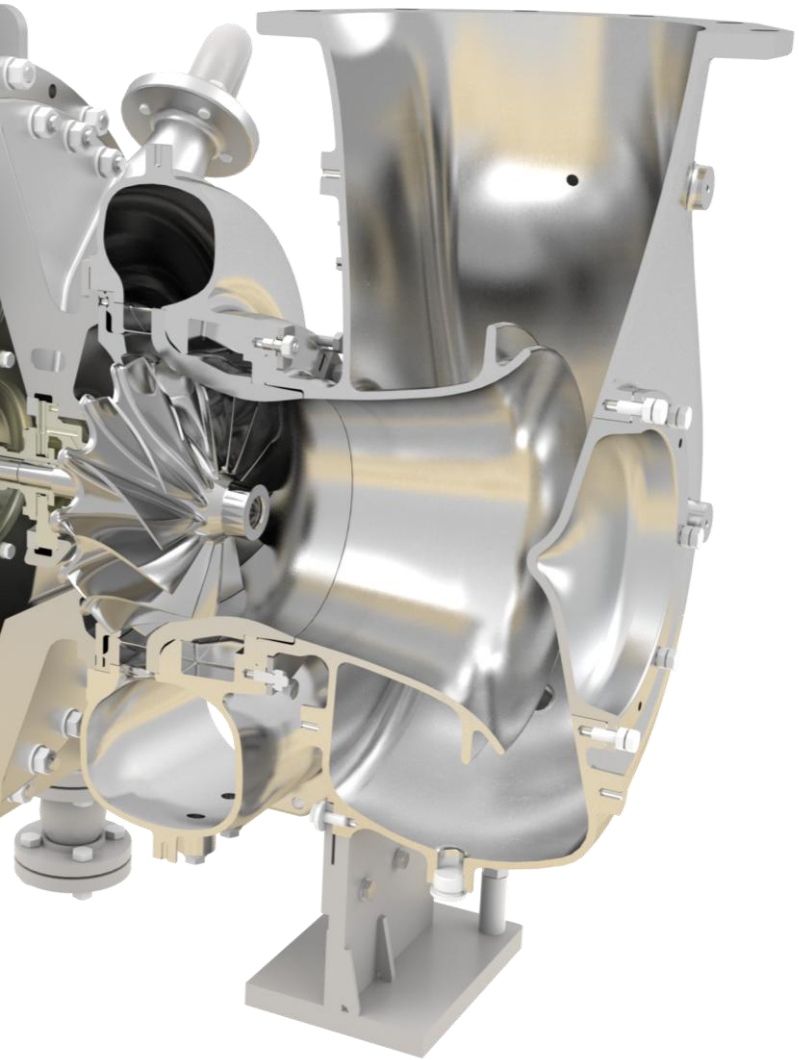
TCR – Series		Max. supercharged engine output per turbocharger
TCR10	-	600 kW
TCR12	-	800 kW
TCR14	-	1,200 kW
TCR16	-	1,800 kW
TCR18	-	2,700 kW
TCR20	-	3,900 kW
TCR22	-	6,900 kW



TCA – Series		Max. supercharged engine output per turbocharger
TCA33	-	5,400 kW
TCA44 ***NEW***	-	8,200 kW
TCA55	-	10,400 kW
TCA66	-	14,800 kW
TCA77	-	21,000 kW
TCA88	-	30,000 kW



PTG
Programme



TCS-PTG based on TCR - Series

Type	max. P_{el}
TCS-PTG18	1,070 kW
TCS-PTG20	1,560 kW
TCS-PTG22	2,700 kW

TCS-PTG based on TCA - Series

Type	max. P_{el}
TCS-PTG55	4,020 kW

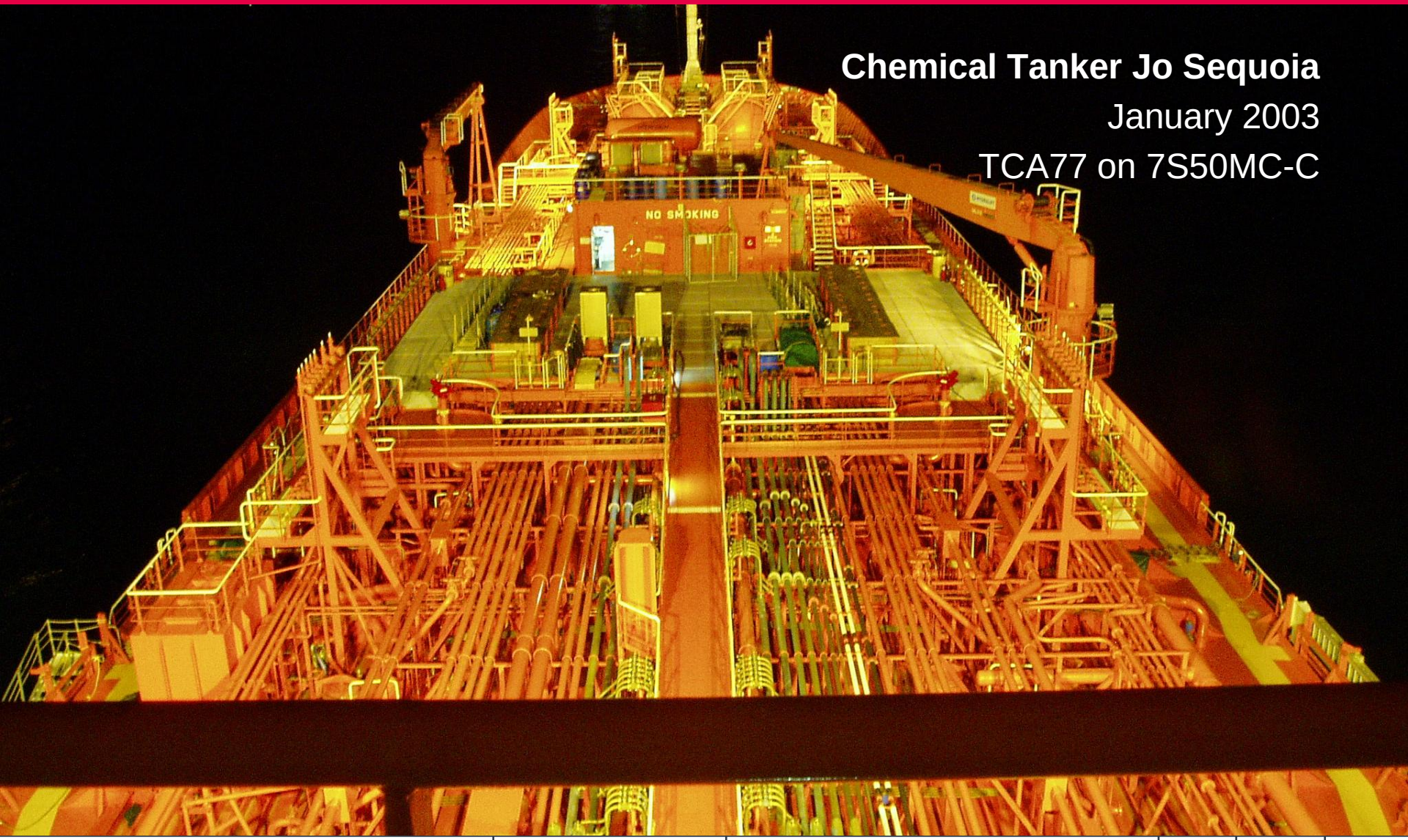
Waste Heat Recovery System

TCS-PTG

Agenda

First Application of TCA

One Decade Experience



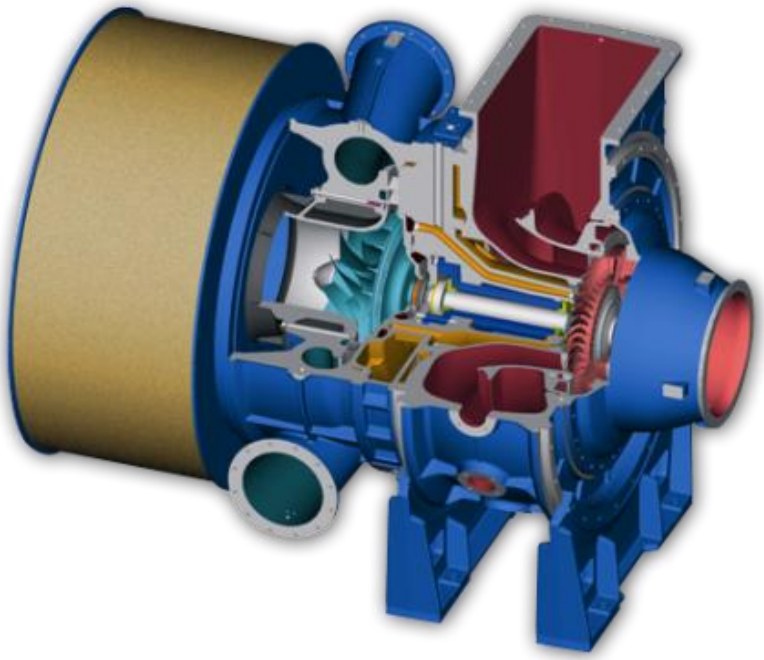
Chemical Tanker Jo Sequoia

January 2003

TCA77 on 7S50MC-C

One Decade Experience

TCA



	Deliveries		
	2-stroke	4-stroke	Total
TCA 33	-	15	15
TCA 44	16	6	22
TCA 55	633	179	812
TCA 66	2.135	281	2.416
TCA 77	950	109	1.059
TCA 88	384	158	542
Total	4.118	748	**4.866**

Status 31. June 2012

Turbochargers for DOT2/3 Engines

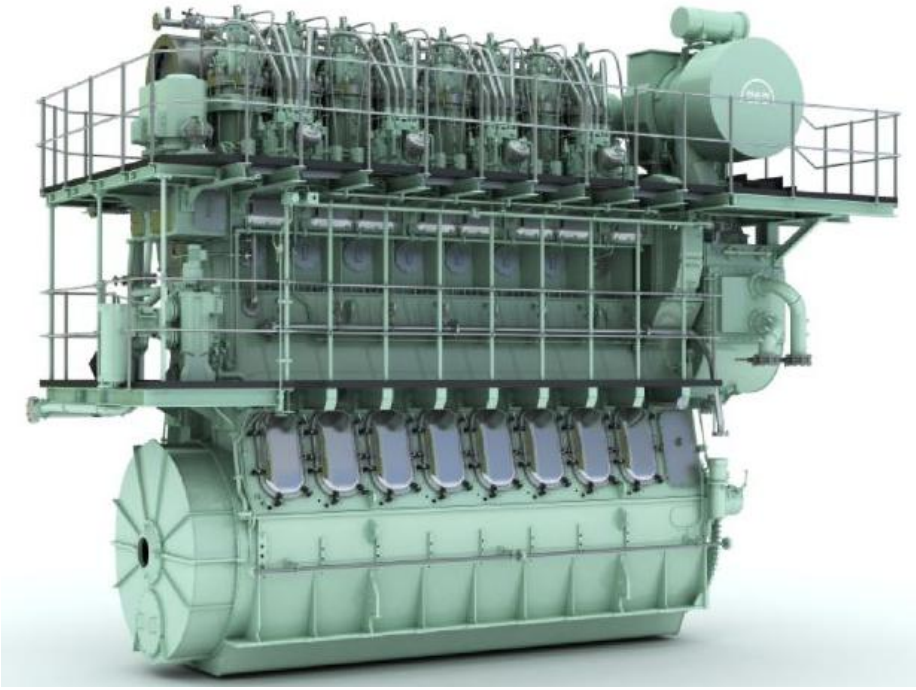
High Scavenge Air Pressure

Introduction of new DOT2/3 engines

8.2 up to 4.25 bar (πV = 4.35)
8.3 up to 4.25 bar (πV = 4.35)

9.2 up to 4.45 bar (πV = 4.55)
9.3 up to 4.45 bar (πV = 4.55)

ABB	only A100
MHI	only MET-MB
MAN	TCA



Service Life Periods of TCA

TCA
Project Guide
Exhaust Gas Turbocharger

Engineering the Future – since 1758.
MAN Diesel & Turbo

Service Life Periods

The following data is based on empirical values of MAN Diesel exhaust gas turbochargers that have been manufactured with identical materials and manufacturing procedures.

The mentioned service life periods are reference values that apply under normal operating conditions. They can be considerably reduced due to e.g., insufficient maintenance, frequent "Blackouts" or use of low-quality fuel and lube oil.

	Operating Hours
Plain bearings	up to 50 000
Nozzle ring	up to 40 000
Turbine blades	up to 100 000
Shroud ring	up to 30 000
Compressor wheel	up to 80 000 [1)]
Casing	no limitation

1) Depends on:

- The intake air temperature
- the charge pressure
- the load profile of the engine

and may fall shorter in case of unfavorable values.

Introduction of TCA44-23

New for Tier II Small 2-stroke Engines

- Especially designed for top selling small bore engines
- Compact and light
- Cost optimized design
- TCA concept – proven in millions of running hours
- Performance tailored to the demand of TIER II two stroke engines

TCAxx-26

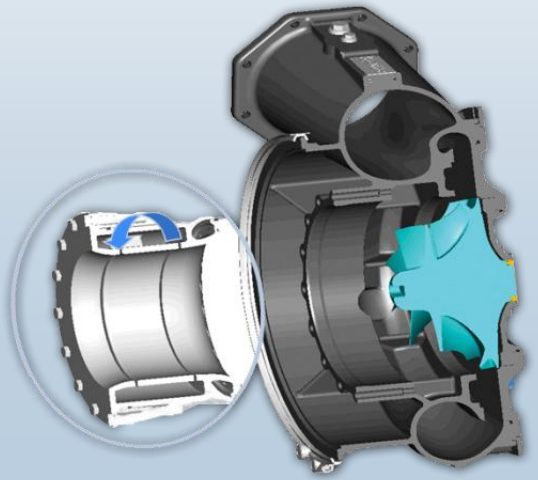
Cut Initial & Operational Costs

- Enlarged compressor stage
- New compressor geometry
- Higher air flow capacity
- Higher efficiency
- Pscav up to 4.45 bar (πV = 4.55)
- Compressor with Internal ReCirculation (IRC)

Extended Application Range

- All other well know features are unchanged
- Same connection dimensions

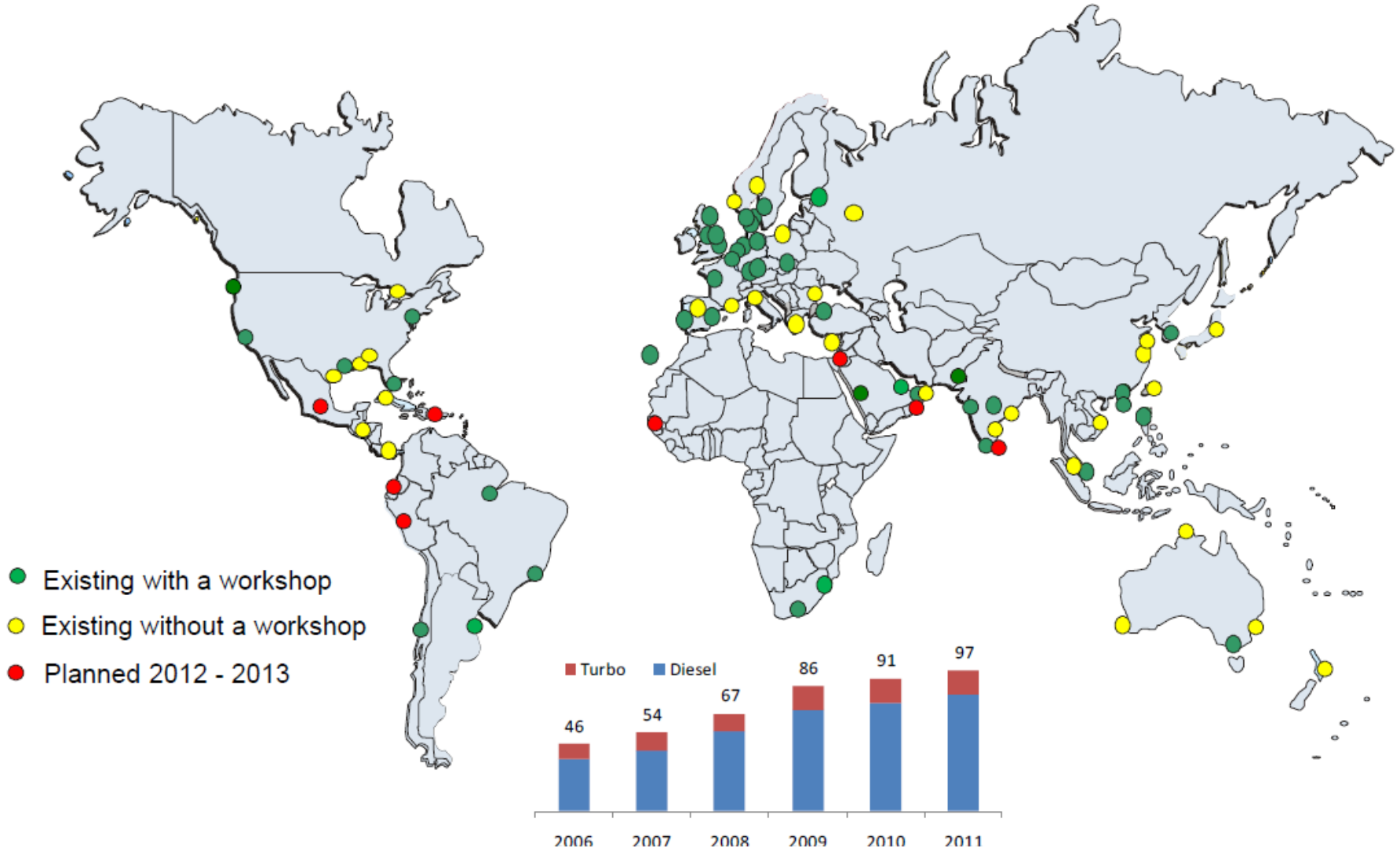
New Compressor



IRC

Single Point of Contact

Our Worldwide Service Coverage



January 2012

Open Service Concept

Turbocharger Training

- **Compressor wheel disassembly without additional tools and dismounting of the compressor casing**
- **Long maintenance intervals**

- Thrust bearing inspection without rotor removal
- Easy replacement of turbine blades
- No external pipes

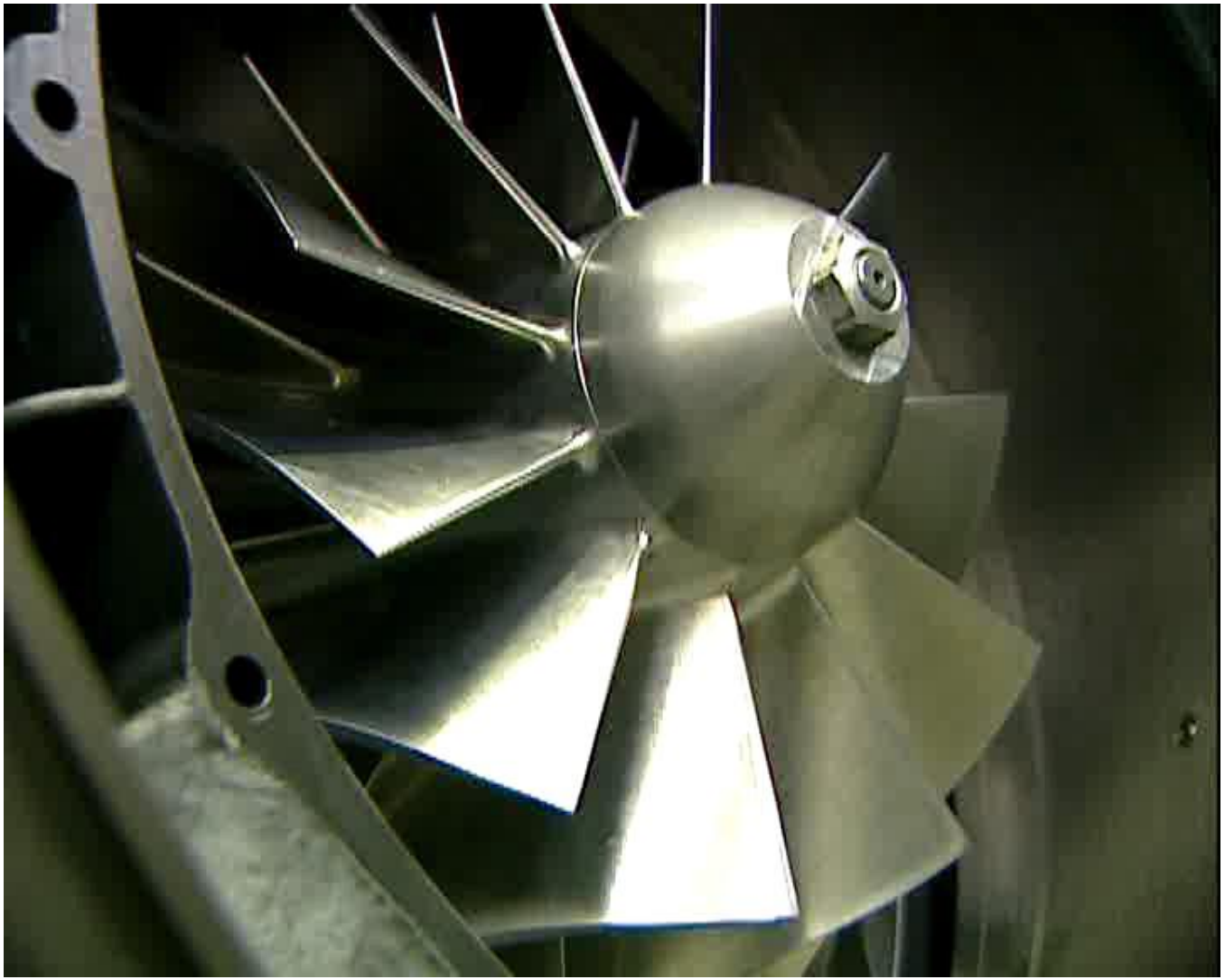
Detailed manuals and working cards are delivered with the turbocharger

Maintenance can be done by the crew

Training can be provided
(Augsburg, Shanghai, Fort Lauderdale)

Service Friendliness

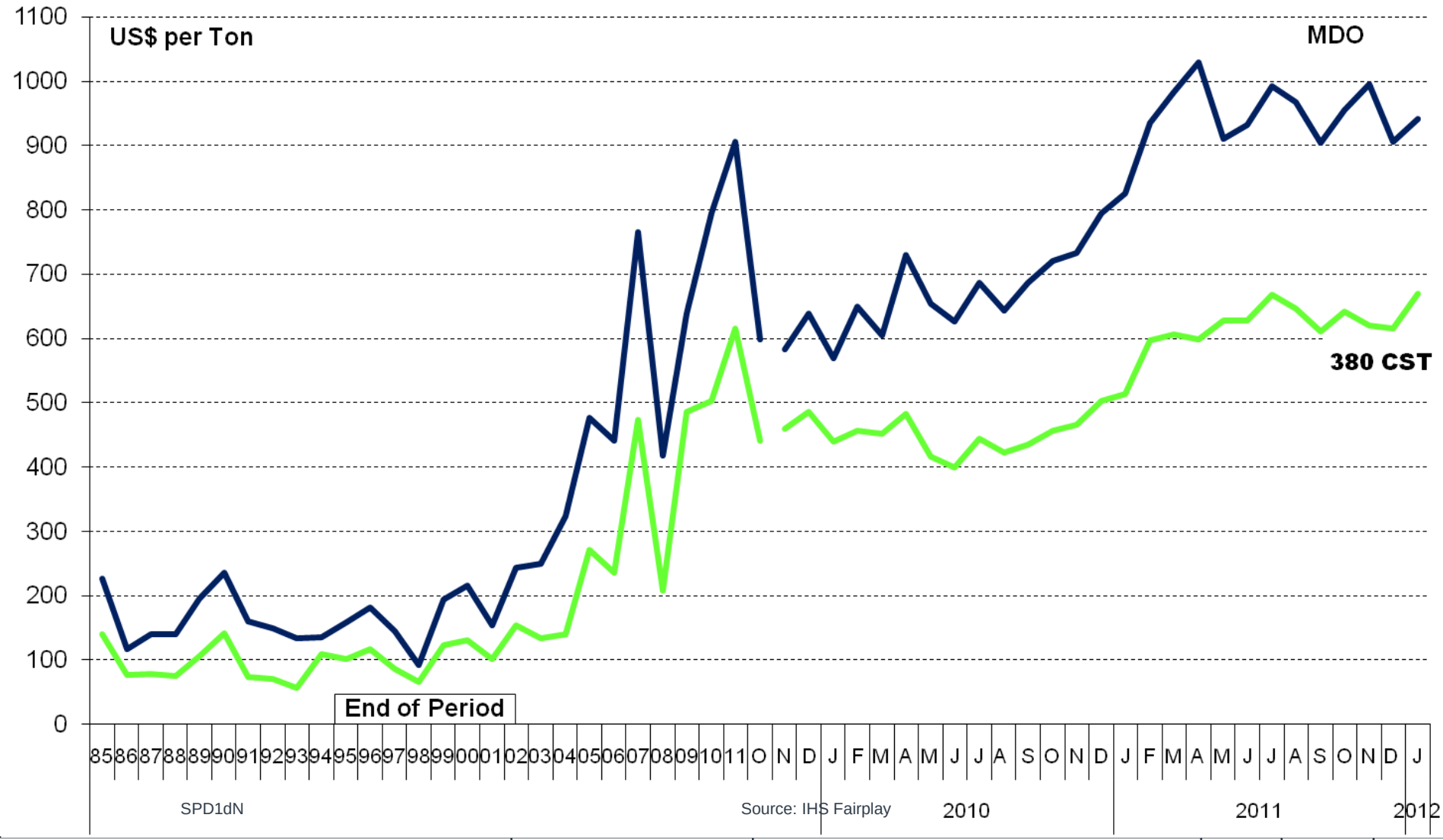
Compressor Wheel Disassembly



Agenda

Fuel Oil Prices

Rotterdam



Fuel Oil Prices

September 2011 to September 2012

Latest 04 Sep 2012 ▲ $683.50

History		
03 Sep 2012	▲	$679.50
31 Aug 2012	▲	$674.00
30 Aug 2012	▲	$672.50
29 Aug 2012	▼	$670.50
28 Aug 2012	▲	$686.50
27 Aug 2012	▲	$674.00

Please subscribe to download historical data ('Plus' package required).

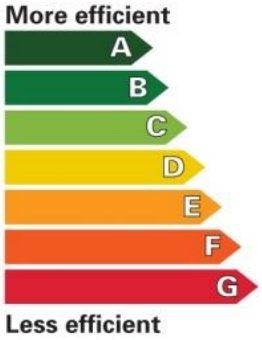
About Bunkerworld Index

Source: Ibunkerworld.com

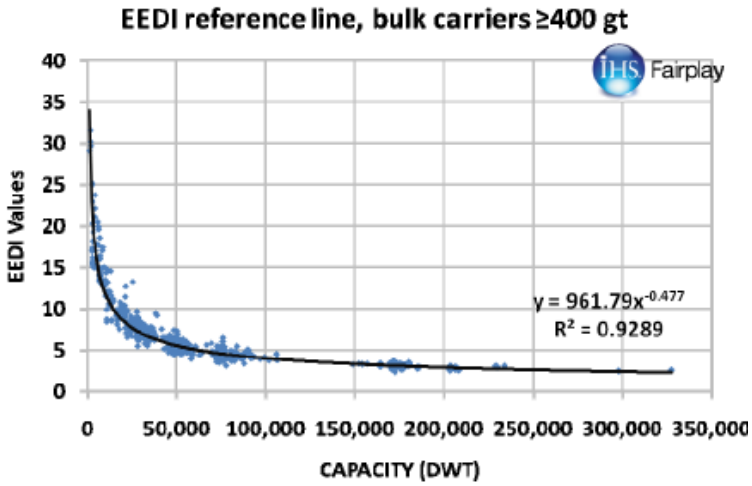
Energy Efficient Design Index

$$EEDI = \frac{CO2\ emission}{Benefit\ of\ ship} = \frac{\Sigma P \times CF \times SFC}{Capacity \times Speed}$$

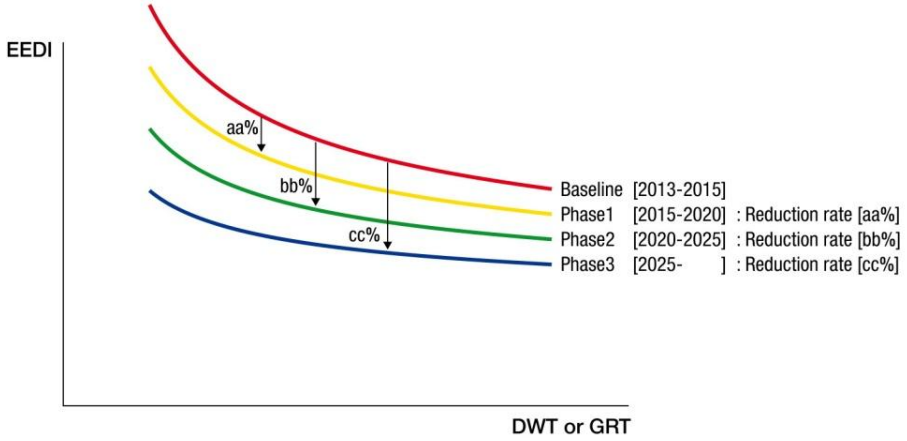
Unit: g CO_2 per (Ton x Nautical Mile)



Reference:



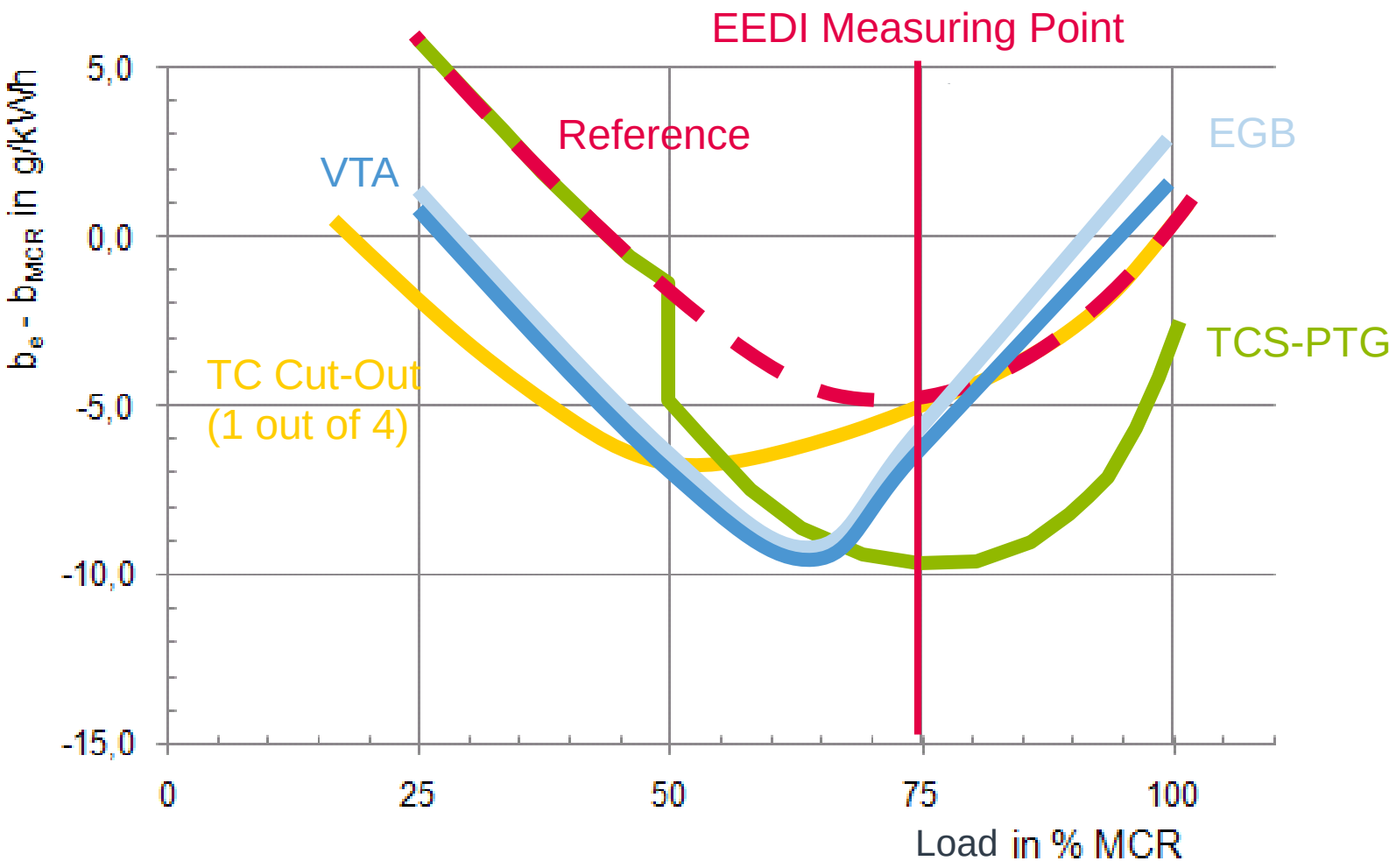
Requirement :



Agenda

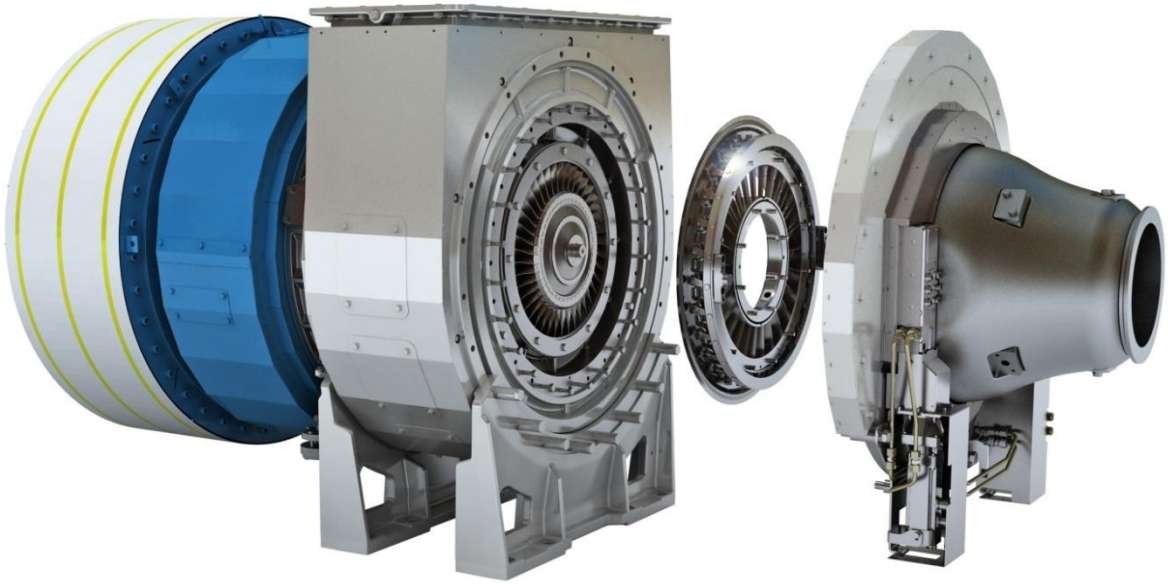
Turbocharger Solutions to Reduce SFOC

Additional Savings by T/C Optimization



Low and Part Load Optimization

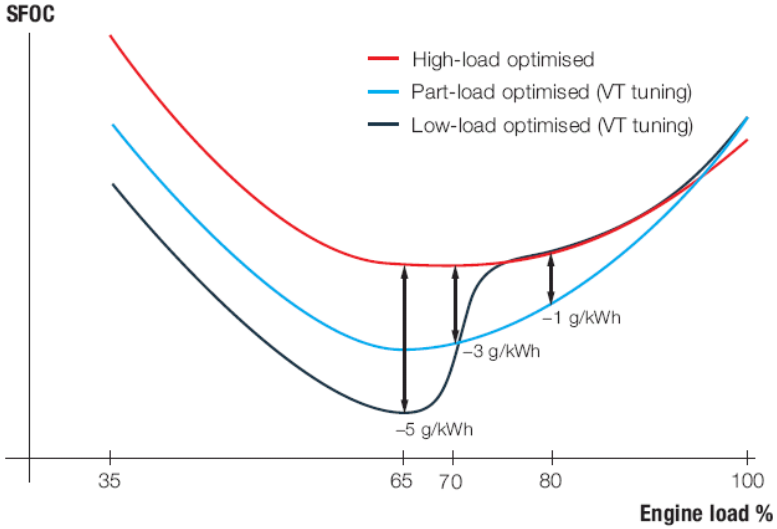
VTA – Variable Turbine Area

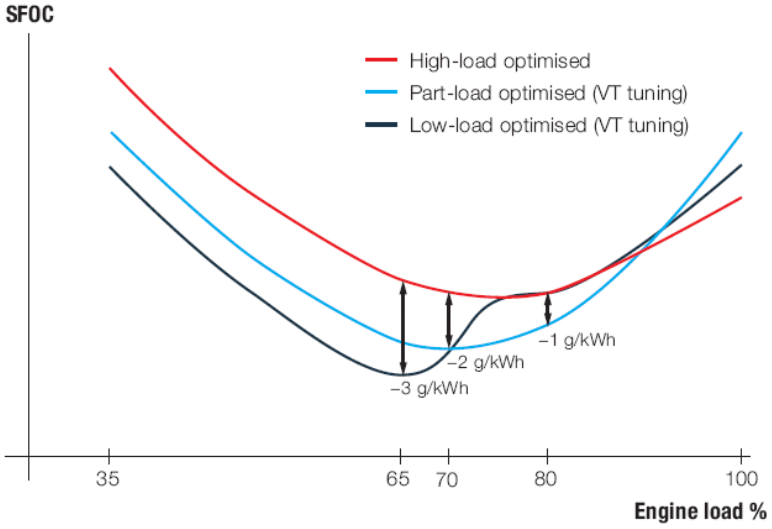


» MAN Diesel & Turbo brings variable turbines to marine diesel engines! «

VTA – Variable Turbine Area

Save Fuel Oil at Part and Low Load





ME/ME-C		35%	50%	65%	85%	100%
Part Load [50-85%]	g/kWh	-3	-3	-3	-1	+0,5
Low Load [25-70%]	g/kWh	-5	-5	-5	0	+0.5

MC/MC-C/ME-B		35%	50%	65%	85%	100%
Part Load [50-85%]	g/kWh	-2	-2	-2	-1	+2
Low Load [25-70%]	g/kWh	-3	-3	-3	0	+1

Variable Turbine Area

VTA References/Orders

2-Stroke Engines

1x TCA55-2V for 4T50ME-X (test engine)

9 x TCA55-2V for 6S46MC-C for Stena (Tanker)

11 x TCA66-2V for 6S50ME-B for Torm (Tanker)

8 x TCA88-2V for 8K80ME-C for RHL (Container)

4x TCA66-2V for 6S50MC-C for Hermann Buss (MPV)

6x TCA77-2V for 6S60MC-C for Kyklades (Tanker)

1x TCA66-2V for 6S50MC for MOL (Bulker)

3x TCA55-2V for 6S50ME-C for CSG (Bulker)

1x TCA66-2V for 6S50MC-C for CSG (Tanker)

1x TCA66-2V for 6S50MC-C for CSG (Bulker)

3x TCA66-2V undefined

4x TCA55-2V for 6S50ME-C for Alterna (Bulker)

2x TCA55-2V for 6S50ME-C for Pleiades (Product Tanker)

1x TCA66-2V for 5S60MC-C for K-Line (Bulker)

1x TCA77-2V for 8S50MC-C for Ryukyu (RoRo)

1x TCA66-2V for 6S50MC-C for Norden (Bulker)

4x TCA55-2V for 6S50ME-C for Norden (Bulker)

1x TCA88-2V for 6S70MC-C for SHOEI (Bulker)

1x TCA66-2V for 6S50MC-C (test engine)

1x TCR20-2V for 2S50ME-C (test engine)

1x TCA55-2V for 4S50ME-C (test engine)

1x TCA66—V for 6S50ME-C for COSCO (Bulker)

4x TCA66-2V for 6S50ME-B for COSCO (Cargo)

2x TCA77-2V for 6S70ME-C for Ciner (Bulker)

1x TCA77-2V undefined

1x TCA55-2V for Gestioni (Bulker)

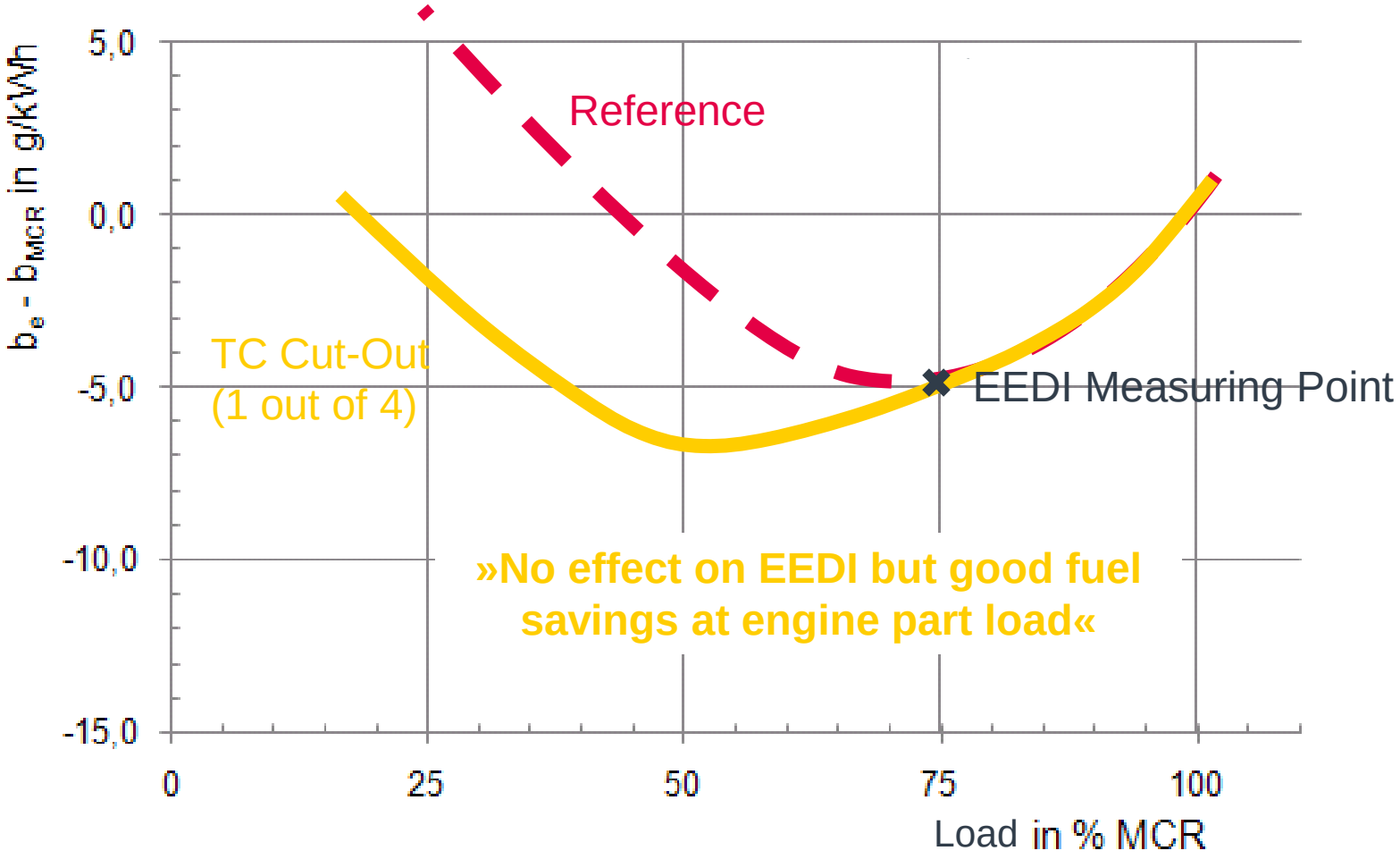
74 x VTA in service, on order or specified

on 2-stroke engines

Status April 2012

Turbocharger Cut-Out

Save Fuel Oil at Part and Low Load



Turbocharger Cut-Out

Field Test on „HS Humboldt“ / 9K90MC-C / 3x TCA77

- Performance
  - Rotor remained installed
  - Bearings were continously lubricated with normal oil pressure
  - No additional external sealing air
- Little Fouling
- No wear or deformations on bearings and rotor

Approved for 6 months

Waste Heat Recovery Systems

Why Waste Heat Recovery Systems?

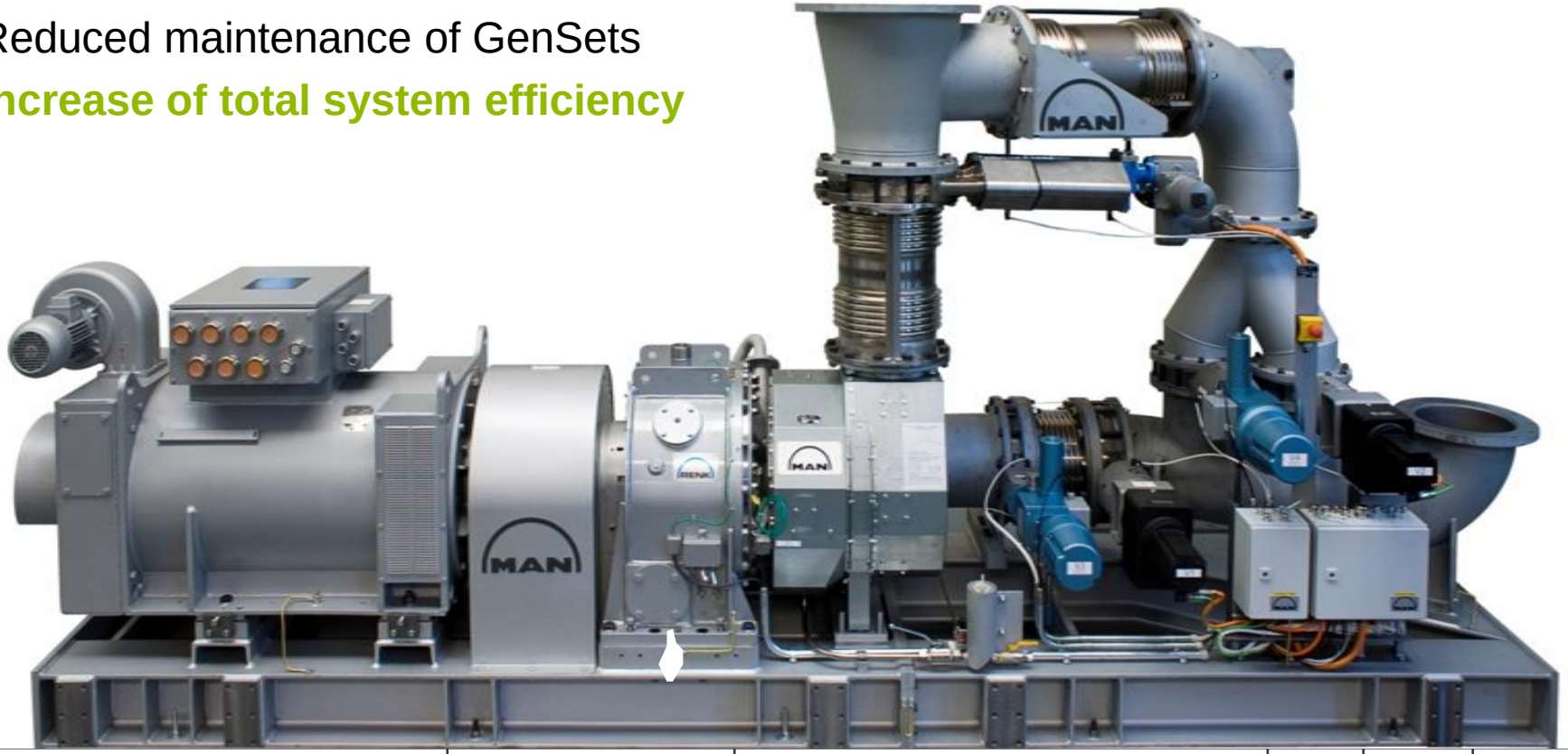
- **Fuel oil price increase**
- **Increase of system overall efficiency (EEDI)**

- Reduction of total fuel oil consumption
- Reduction of emissions
- Increasing power demand on container vessels, VLCC's and stationary power plants
- Reduction of GenSet operating hours and maintenance

Economical & Ecological

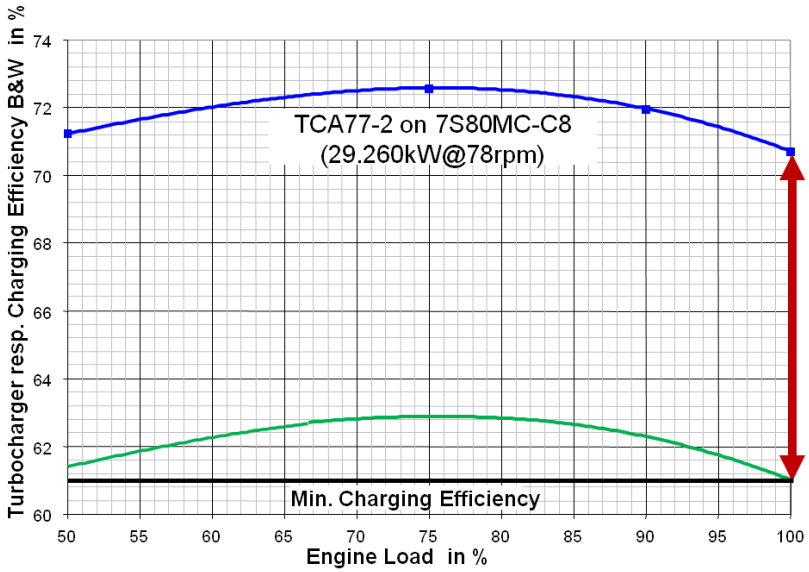
Turbo Compound System - Power Turbine Generator

- Win up to 5% additional electrical power vs. main engine power
- Up to 3% total fuel oil savings (either GenSet, or shaft motor)
- Total production of ME/ME-C hydraulic power through E-HPS
- Reduced emission by shutting-off GenSets
- Reduced maintenance of GenSets
- **Increase of total system efficiency**



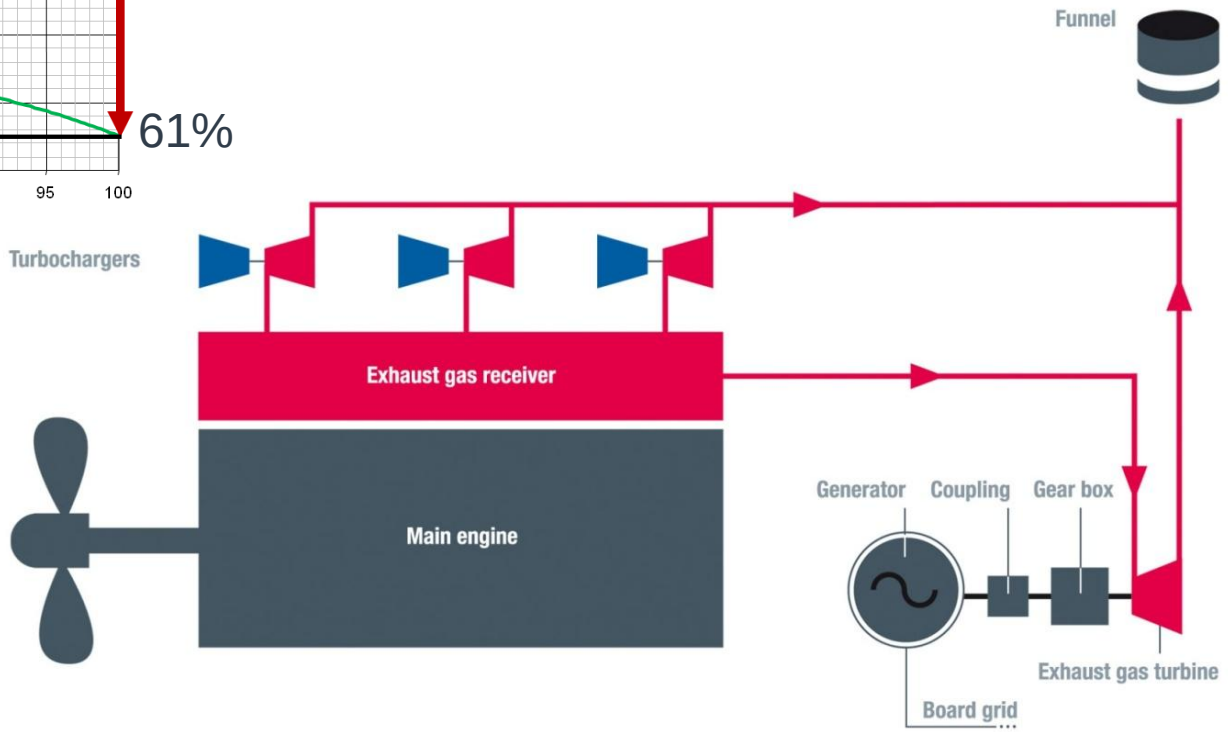
TCS-PTG

Functional Schematic



61%

"TCS-PTG is utilizing the **surplus of exhaust gas** of a two-stroke engine in in an exhaust gas turbine (Power Turbine) to produce electrical power"



TCS-PTG

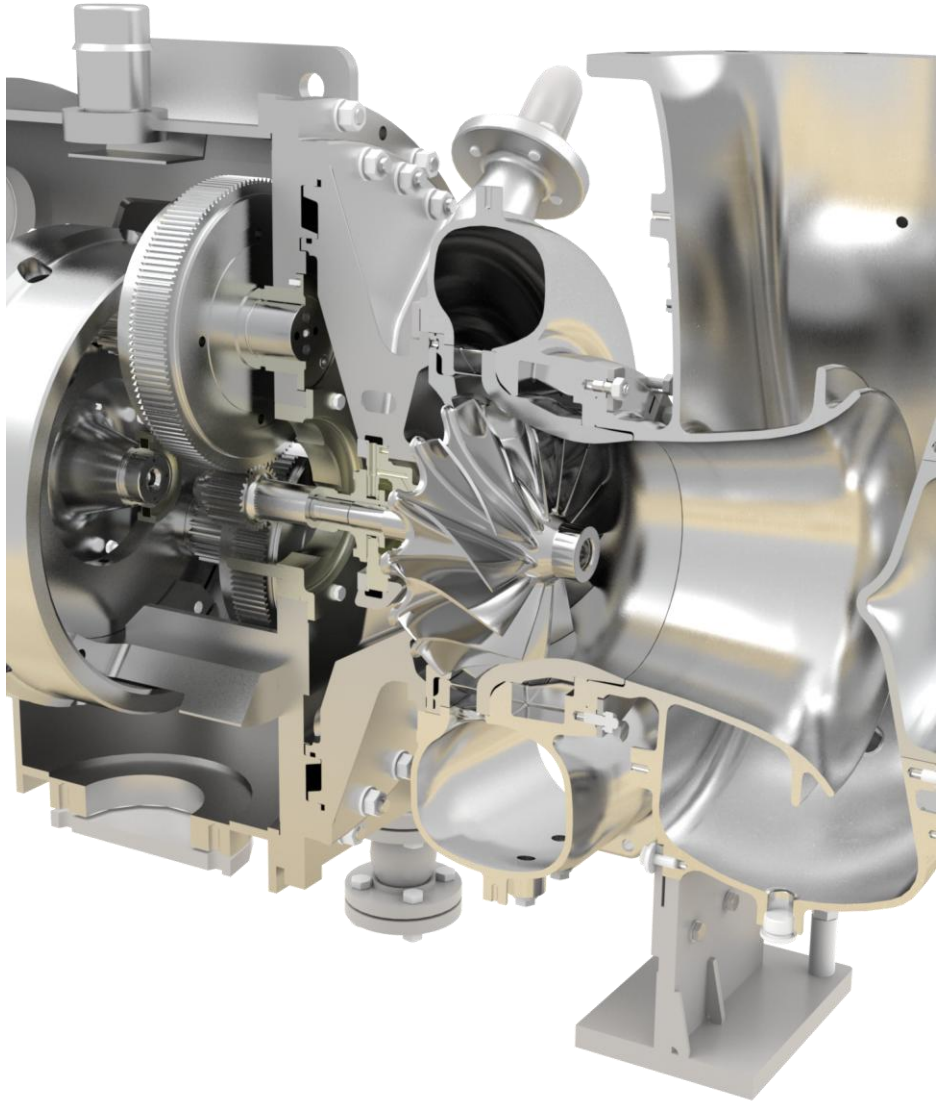
Programme

TCS-PTG based on TCR - Series

Type	max. P_{el}
TCS-PTG18	1,070 kW
TCS-PTG20	1,560 kW
TCS-PTG22	2,700 kW

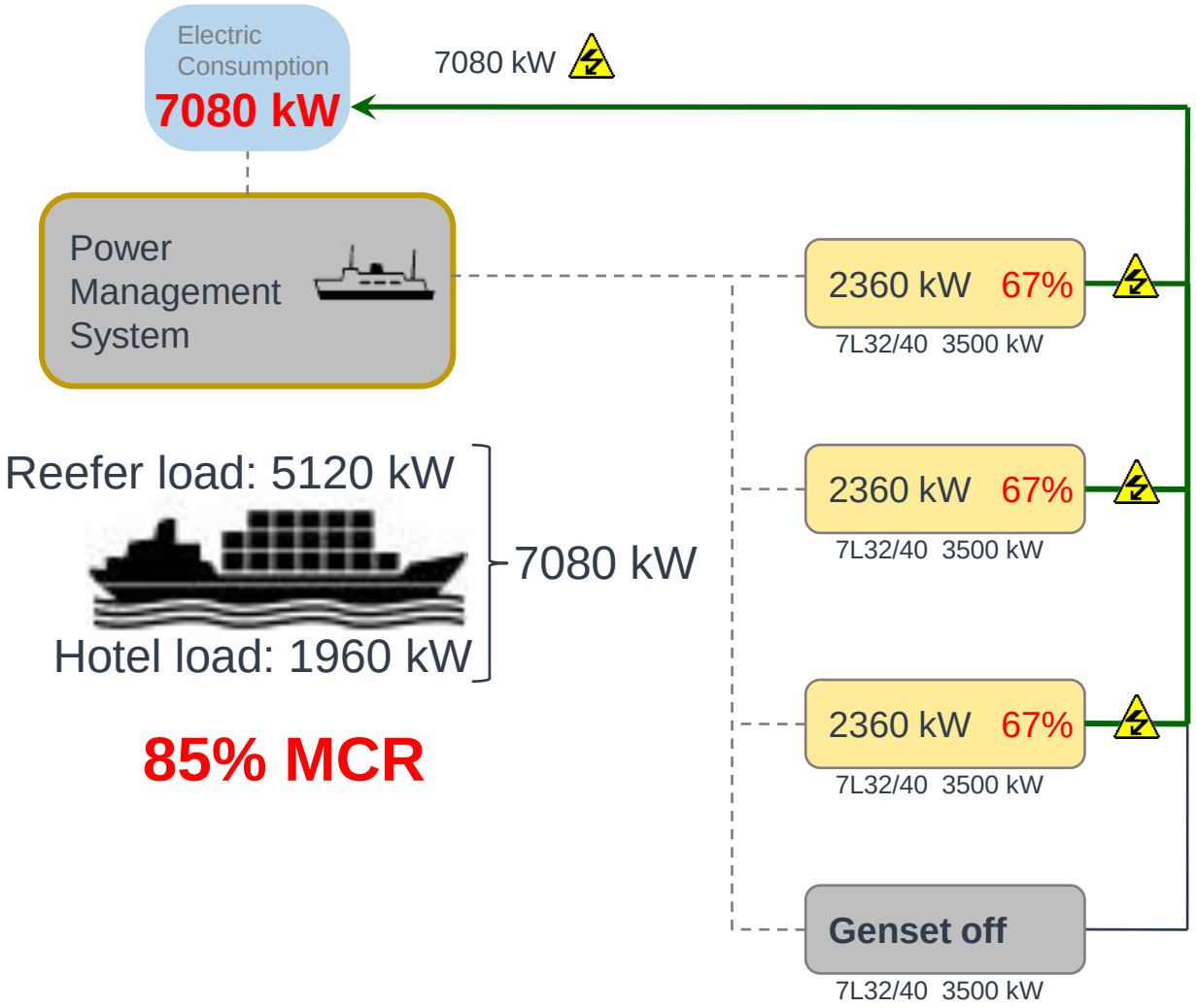
TCS-PTG based on TCA - Series

Type	max. P_{el}
TCS-PTG55	4,020 kW



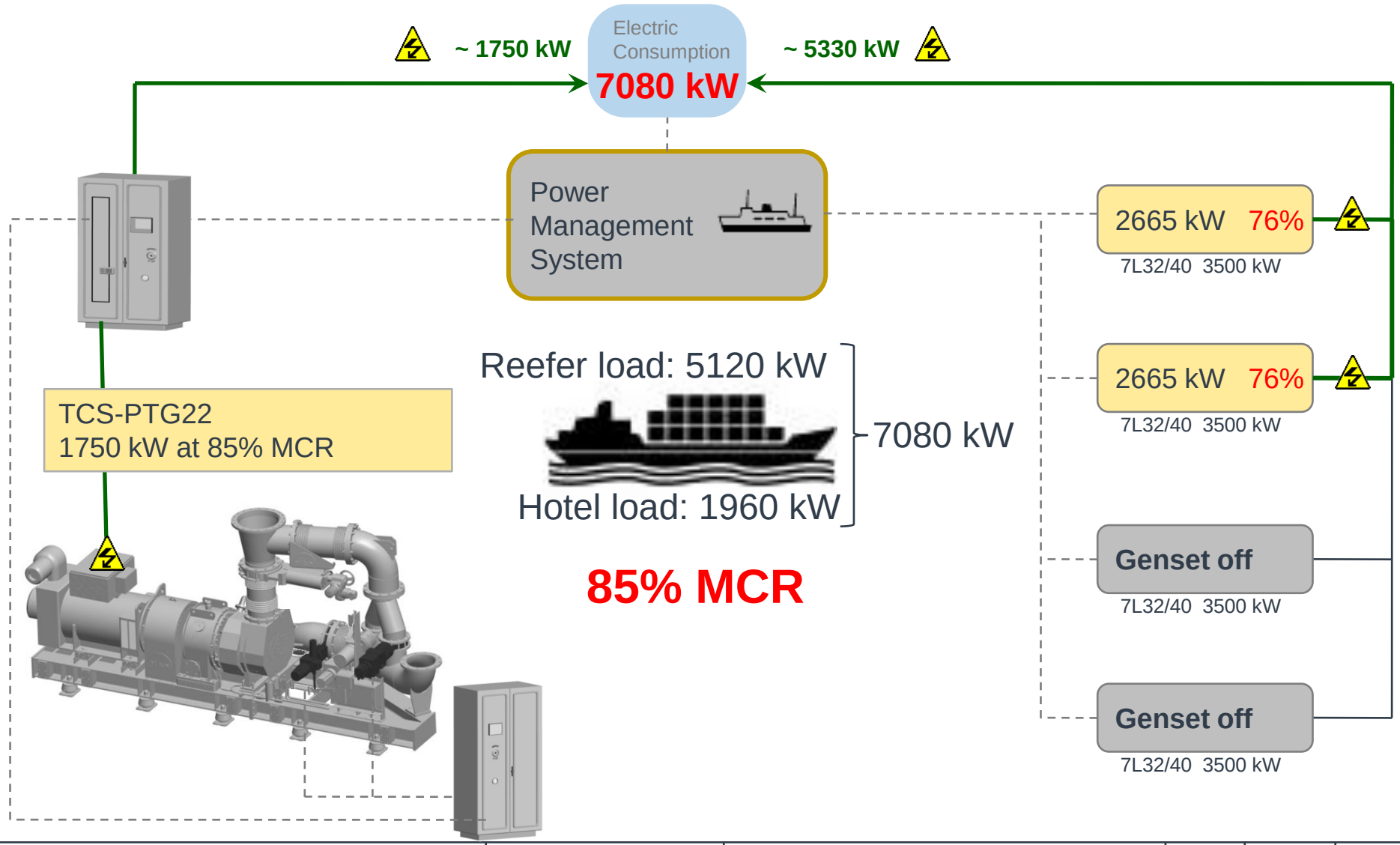
Case Study 16,400 TEU CV

Power Management System



Case Study 16,400 TEU CV with TCS-PTG

Power Management System



TCS-PTG Projects

Power Plant

Power Plant London

TCS-PTG18 **570 kWe**

7K60MC-S

13.860 kW @ 150 rpm

+ 4,00 % Additional power

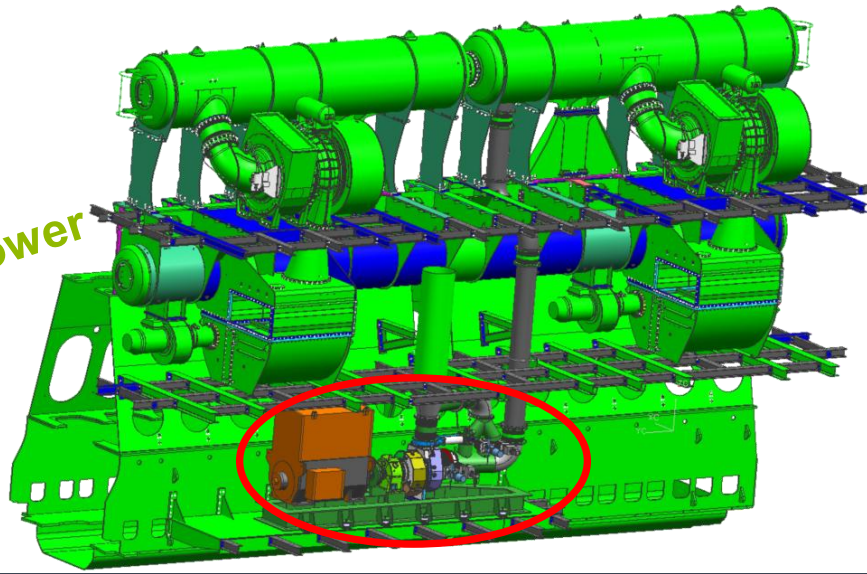
Power Plant Miraflores

TCS-PTG22 **1440** kWe

12K80 MC-S

40.320 kW @ 109,1 rpm

+ 3,57 % Additional power



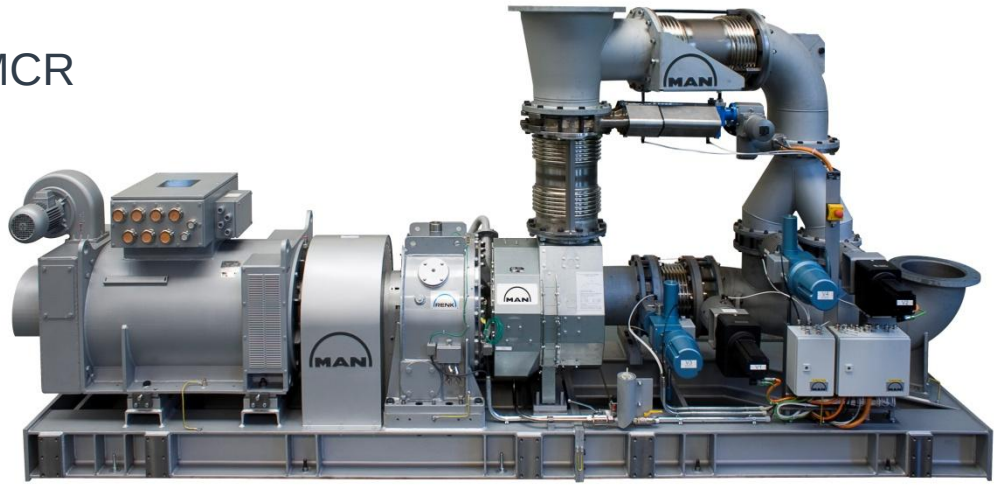
TCS-PTG Projects

4,700 TEU Container Vessel

TCS-PTG20 for 4,700 TEU Container Vessel

+ 3,70 %
Additional power
at 90% MCR

Engine Type:	6S80ME-C9.2
Rating:	27,060 kW @ 78 rpm (100% MCR)
Turbocharger:	1x TCA88-21
TCS:	TCS-PTG20
Max. TCS Power:	**920 kWe** @ 90% MCR



4,700 TEU Container Vessel

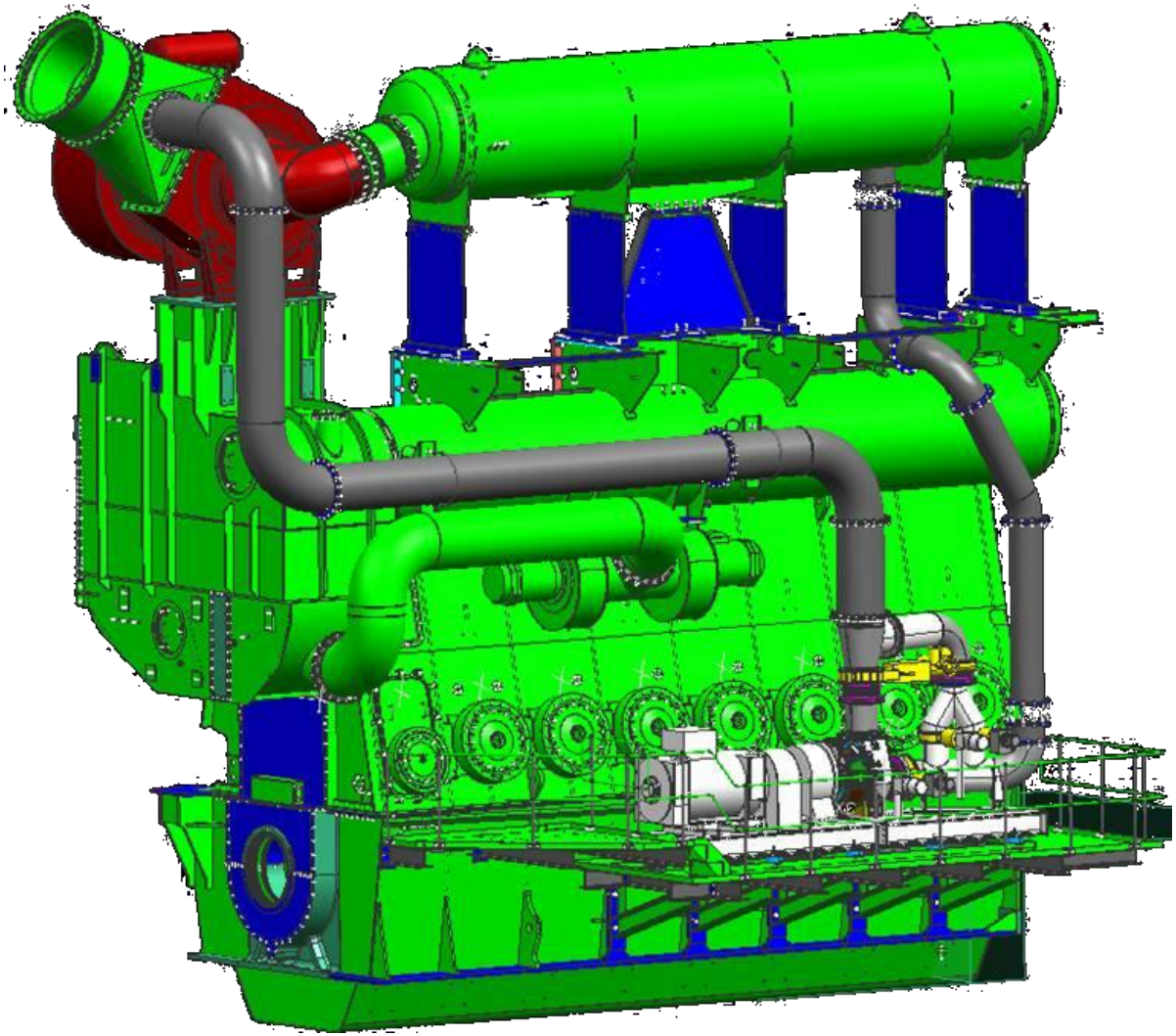
Payback Periods of 3 years

- 4,700 TEU Reefer

Engine type	6S80ME-C8.2
Turbocharger	1 x TCA88-21
Engine power output at MCR	27,060 KW
Assumed engine load	90 %
Pmax. TCS-PTG at MCR	~ 850 kW +/-15%
Pmean TCS-PTG (90% of MCR)	~ 920 kW +/-15%
TCS-PTG Type	TCS-PTG20
Payback period	**3 years**

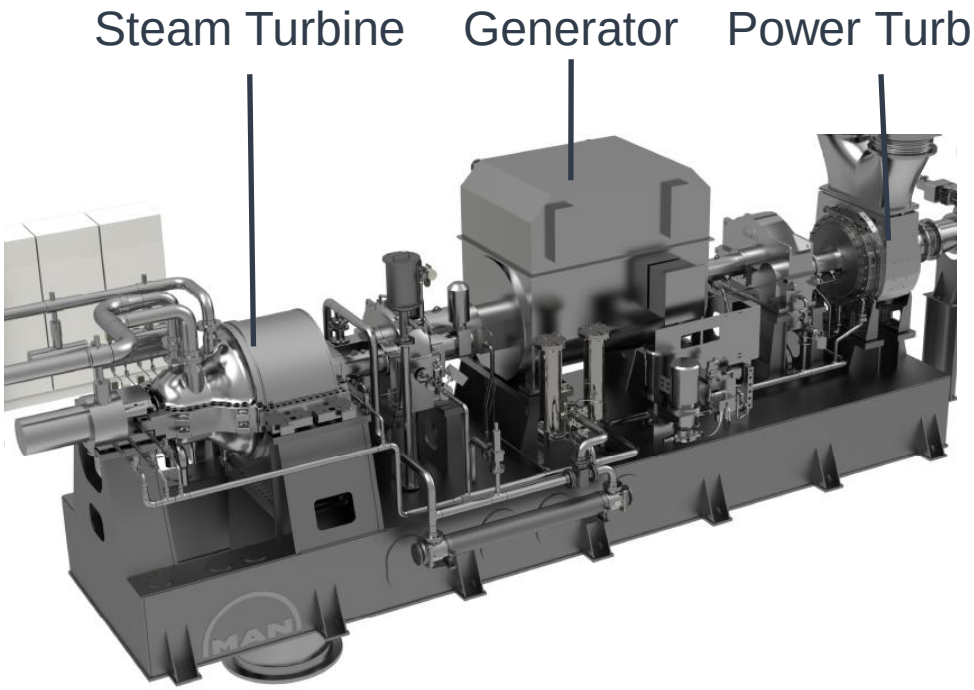
Installation Comparison

TCS-PTG and complete WHR



Exploiting Waste Heat Recovery

MARC_HRS



- Combined steam and exhaust gas turbine (or steam only)
- Only one generator
- Power output up to **10%** of engine power
- Especially designed for marine applications
- MAN Diesel & Turbo design
- Complete package incl. control system
- Competence and responsibility out of one hand

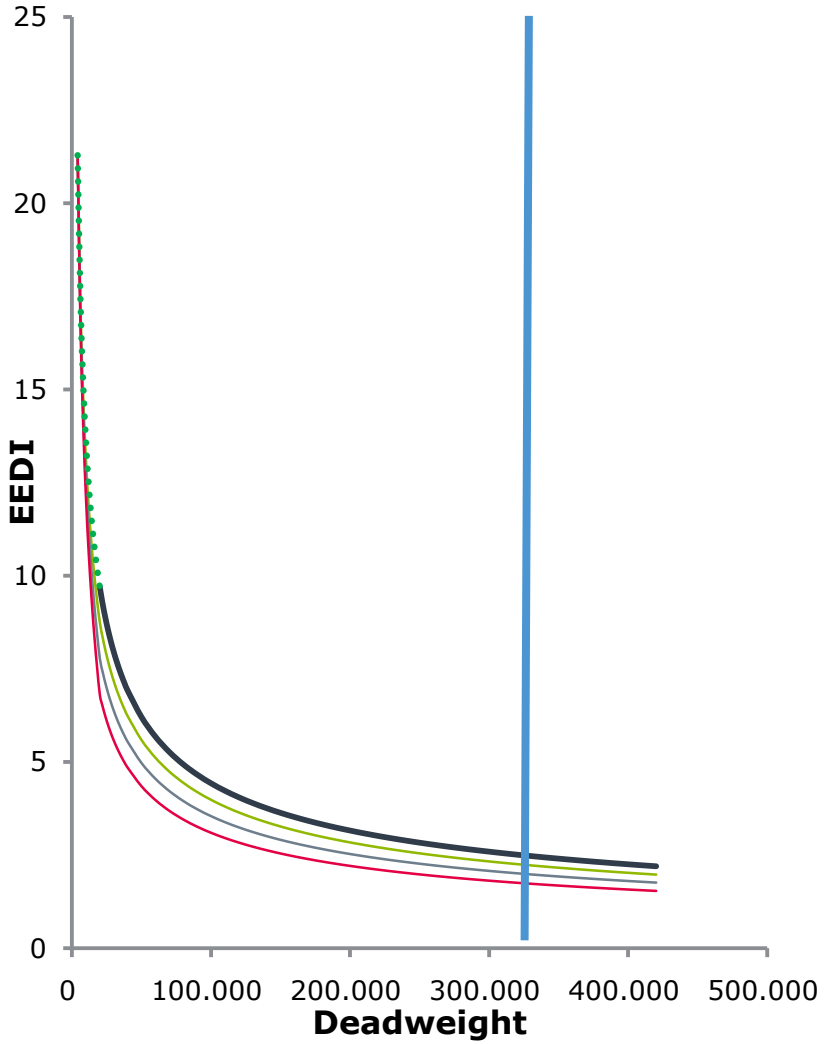
Case Study

Influencing EEDI

320.000 dwt Tanker

6S80ME-C9.2
27.060 kW @ 78 rpm
9,7m Propeller
15,3 kn @ 75% SMCR

TCS-PTG:
621kW @ 75% SMCR (3,3%)



320.000 dwt VLCC

6S80ME-C9.2

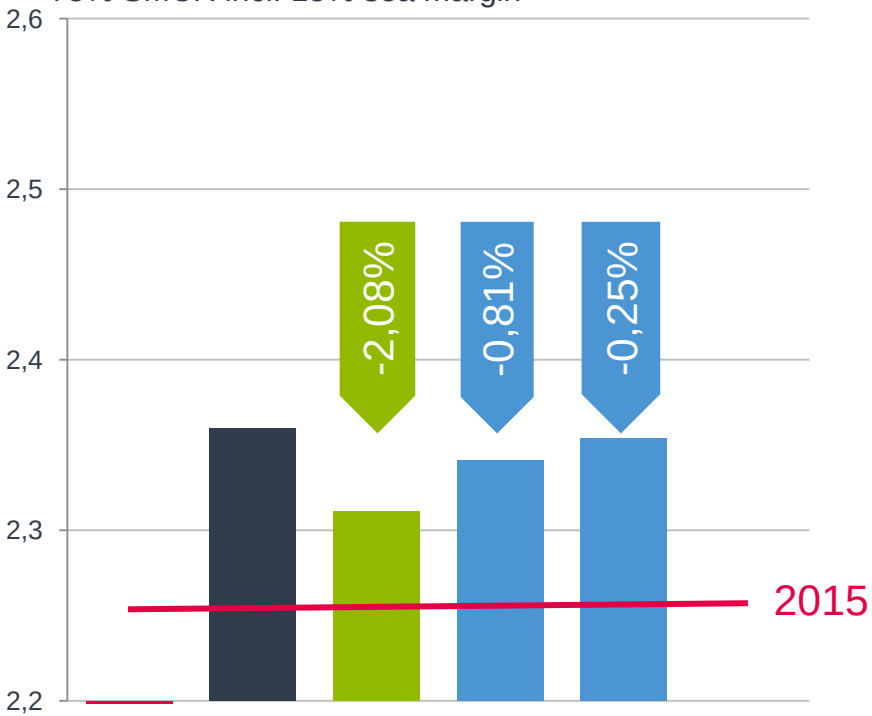
27.060 kW @ 78rpm 9,7 m Propeller 15,3 kn @ 75 % SMCR	Normal	TCS-PTG	VTA Part Load	VTA Low Load
SFC @ 75% [g/kWh]	164,1	166,1	162,6	163,6
SFC incl. 6% Tolerance	173,9	176,1	172,4	173,4
Required EEDI				
2013-2015		2,509		
2015-2020		2,258		
2020-2025		2,007		
2025		1,756		
Attained EEDI	2,360	2,311	2,341	2,345
Δ relative in %	0	-2,08	-0,81	-0,25

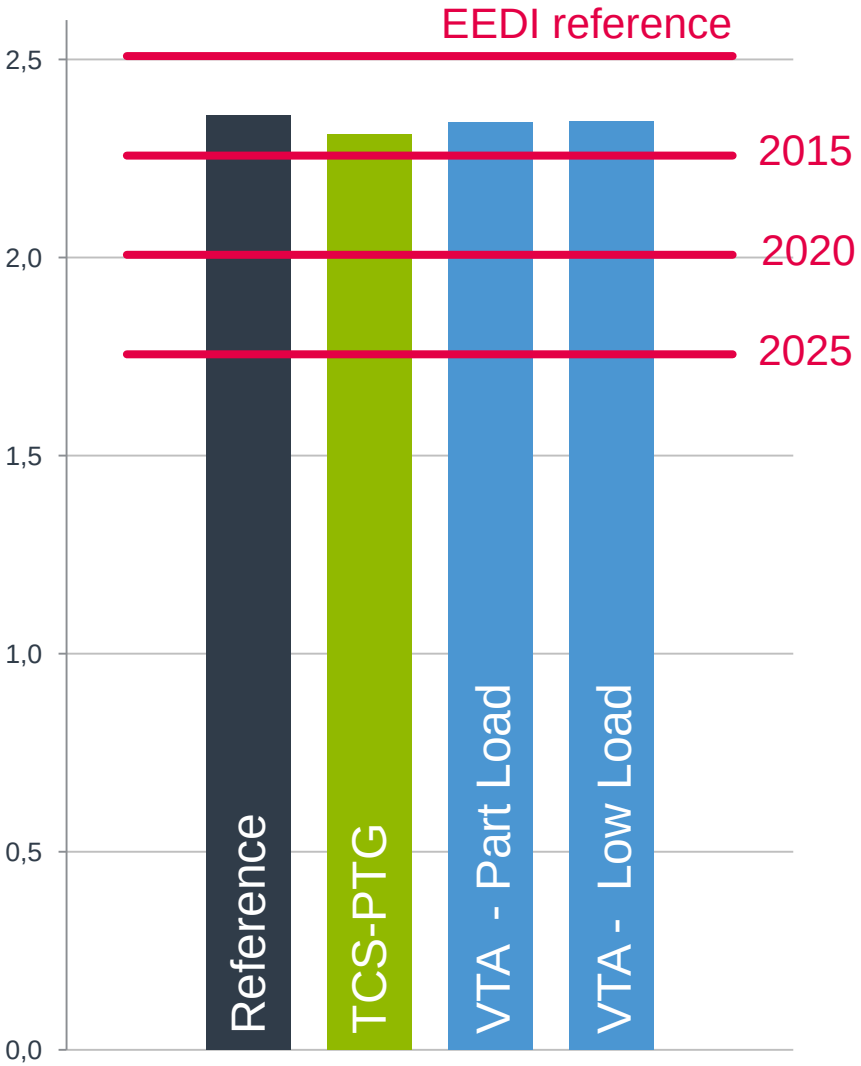
320.000 dwt VLCC

6S80ME-C9.2

SMCR	27.060 kW
Speed	78 rpm
Propeller diameter	9,7 m
Ship speed	15,3* kn

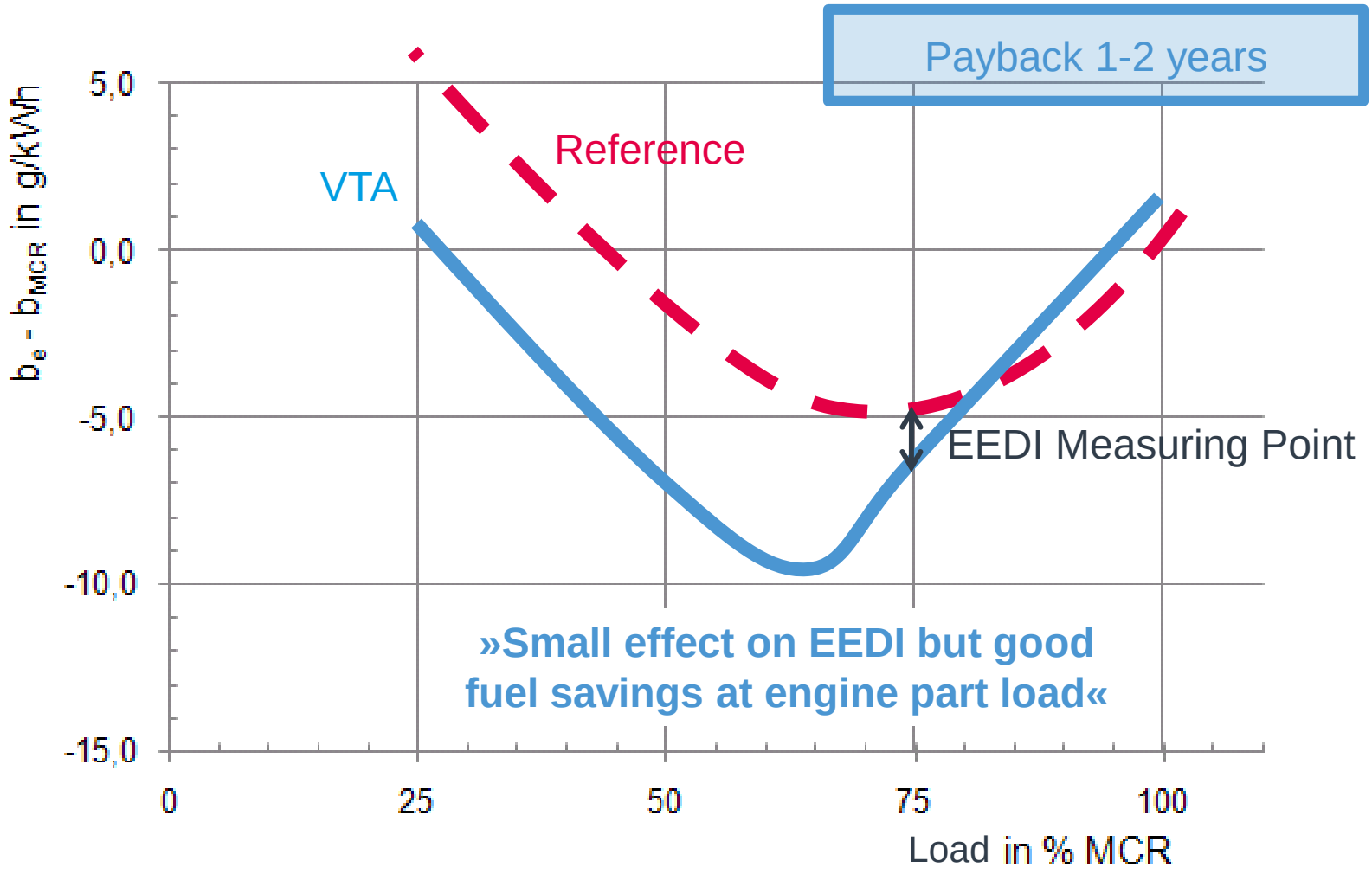
*75% SMCR incl. 15% sea margin





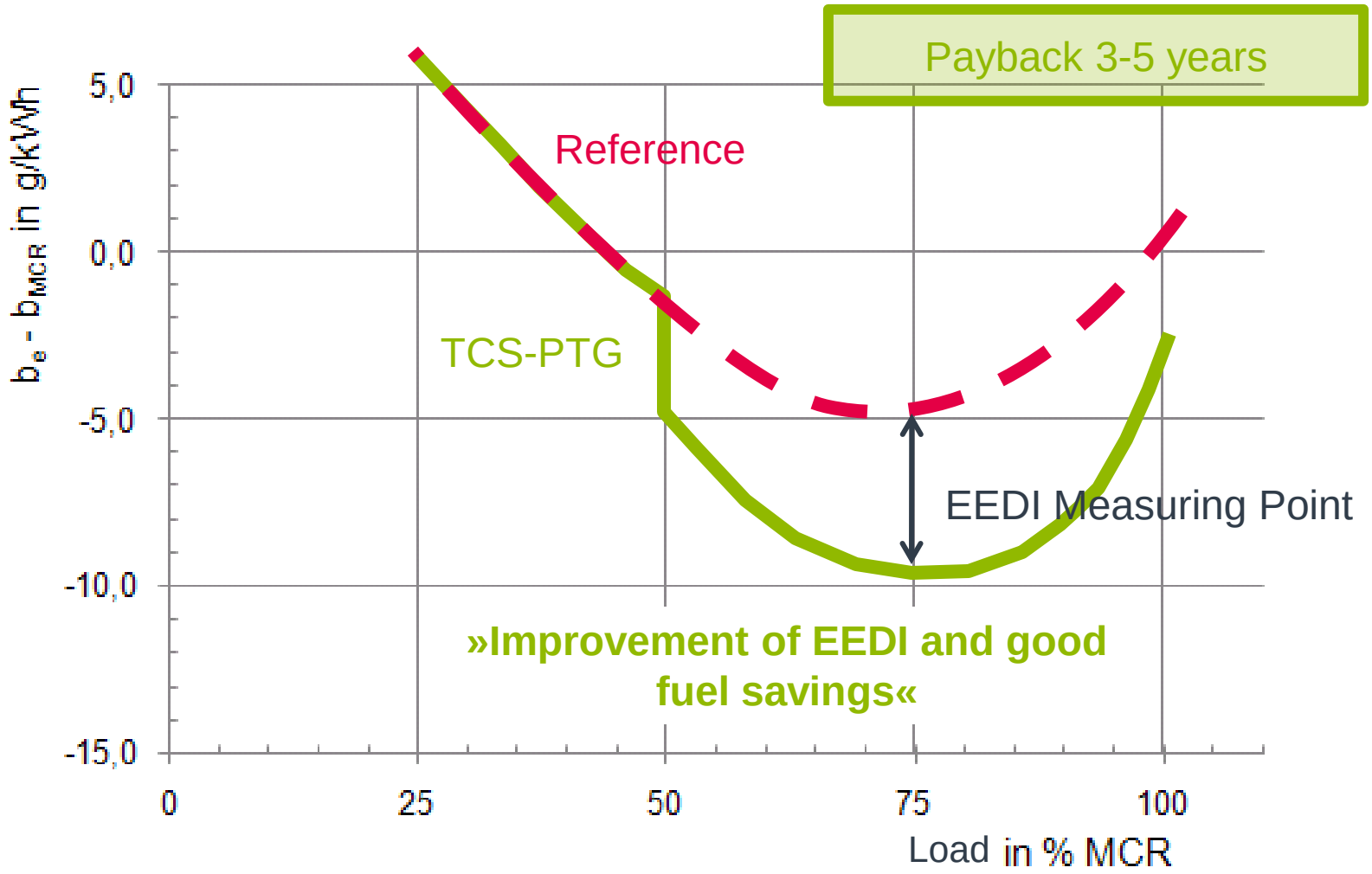
Savings with VTA

Payback Times of 1-2 years



Savings with TCS-PTG

Payback Times of 3-5 Years



* TCS-PTG output replaces auxiliary engine output

Do you have any more questions?

Malte Oltmanns
Promotion Manager
+49 821 322-1086
+49 160 7077685
malte.oltmanns@man.eu

Disclaimer

All data provided in this document is non-binding.

This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

Thank You for Your Attention!

All data provided in this document is non-binding.

This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.