PROGRAMME

Friday, 8 March 2019

Special topics session

08:30 – 09:00 Welcome, registration & morning coffee offered by organiser

09:00 – 09:55 Propulsion systems and solutions for inland waterway transport sector

Insights into propulsion solutions and the effects on reduction of air pollutant emissions, fuel & energy consumption

- Hybrid/Diesel-electric solutions & propulsion systems for inland vessels
  Electric propulsion: Integrated solutions for inland vessels (Stephan Krahn, Baumüller Anlagen-Systemtechnik)
- Gas and gas/electric solutions & propulsion systems
  Mobile gas engine for marine applications – S4000 (Klaus Poepsel, MTU Friedrichshafen GmbH)
- Options and trends in propulsion of future river cruise vessels *(Gerhard Untiedt, MEYER WERFT GmbH & Co. KG)*

09:55 – 10:45 After-treatment solutions and greening measures in inland waterway fleets

Insights into solutions and initiatives addressing climate change by decreasing air pollutants and emissions from inland vessel

- *After-treatment solutions (SCR/DPF) for Diesel engines (Florian Franken, TEHAG Deutschland)*
- *Cleaner Future by new diesel fuels? (Sebastian Dörr, Neste / Lubtrading GmbH)*
- *How Rhenus answers the modernisation needs of its fleet (Thomas Maaßen, Rhenus SE & Co. KG)*

10:45 – 11:15 Coffee offered by organiser

11:15 – 12:15 Panel discussion: What is needed to modernise Danube inland waterway vessels?

Panellists

Gernot Pauli (CCNR)
Klaus Poepsel (MTU Friedrichshafen GmbH)
Michel Voorwinde (VIV - Vereniging voor Importeurs van Verbrandingsmotoren)
Gerhard Untiedt (MEYER WERFT)
Bernhard Bieringer (Anzböck - Consulting Engineers for Naval Architecture & Ship Technology)
Thomas Maassen (Rhenus SE & Co. KG)

Moderator

Manfred Seitz (Pro Danube International)

12:15 – 13:15 Buffet Lunch offered by organiser

Electric propulsion

Integrated solutions for inland vessels

Referent:
Stefan Krahn
Baumüller Anlagen-
Systemtechnik GmbH & Co. KG

BAUMÜLLER

AT A GLANCE

1930
FOUNDATION

The Baumüller family
OWNER

Nuremberg, Germany
HEAD QUARTER

approx. 1.950
EMPLOYEES

PRODUCTION SITES
Germany, Czech Republic, Slovenia, China

SERVICE AND SUPPORT
worldwide over 40 locations

QUALITY MANAGEMENT
DIN EN ISO 9001:2015

TOP 10 PROVIDER
Drive and automation engineering

House of Automation

Durchgängige Software für Engineering, Simulation und Industrie 4.0	**Integrated Software for Engineering, Simulation and Industrie 4.0**
Flexible und modulare Steuerungstechnik	**Flexible and Modular Control Technology**
Skalierbare Servotechnologie für komplette Automatisierungslösungen	**Scalable Servo Technology for Complete Automation**
Umfassendes Motorenportfolio für Industrie und E-Mobilität	**Comprehensive Motor Portfolio for Industry and E-mobility**
Lifecycle-Management	**Lifecycle Management**

BAUMÜLLER IN THE COURSE OF TIME

- Ongoing further development of the service spectrum
- Today: software development, application development, own system house (BAS), digitalization start-up (IEMTEC)
- Full-service provider for complex and individual automation solutions and services

SMART SYSTEM SOLUTIONS

SOFTWARE/TECHNOLOGIES

CONTROL TECHNOLOGY

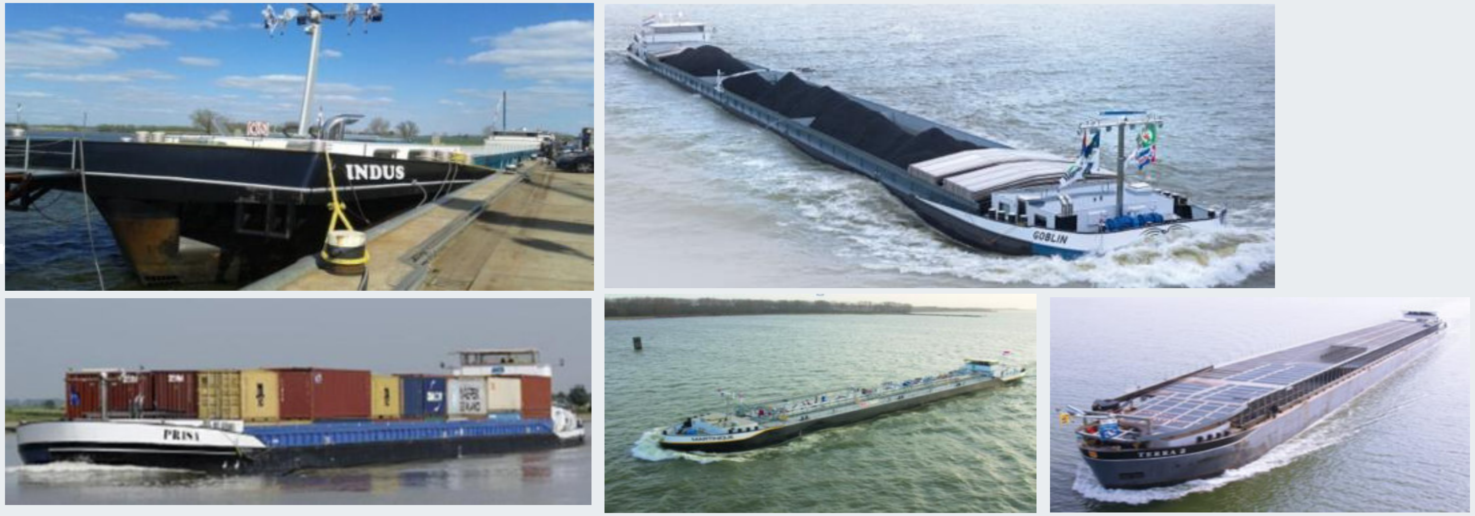
DRIVE ELECTRONICS

MOTORS

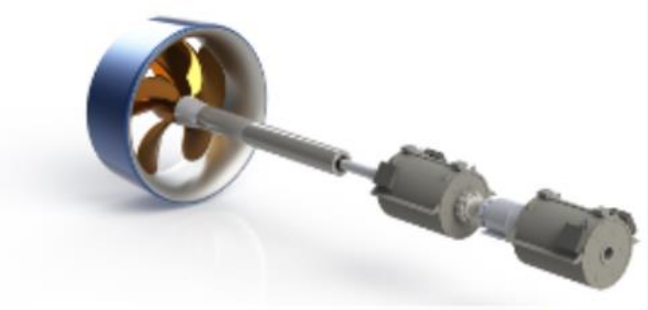
Smart Production

Smart Mobility

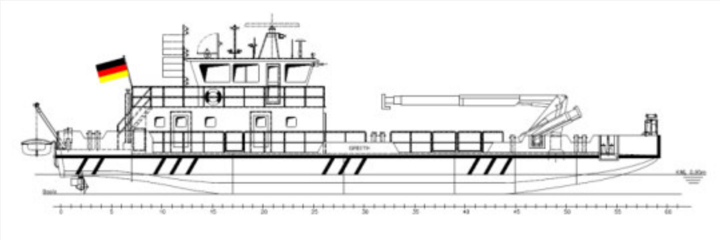
SELECTION OF PROJECTS



Inland Vessels
with serielle and parallel Hybrid



Design of an electric drive train to DNV GL



Workboats
Diesel Electrical
Serielle Hybrid

Diesel Electrical
Car Ferry
with Battery

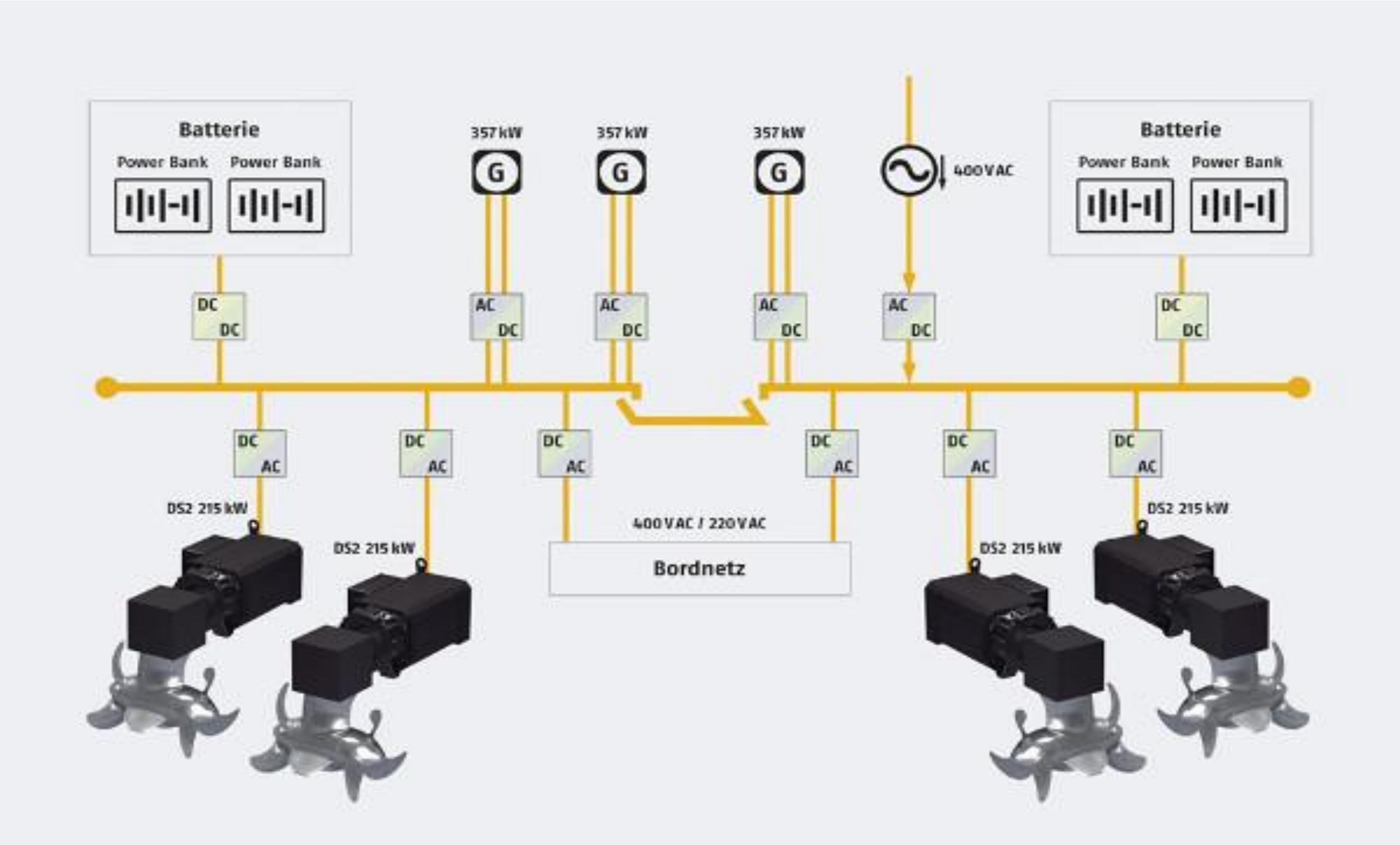
Full Electrical
Passsenger Ferry

EFFICIENT DC SYSTEMS FOR VESSELS

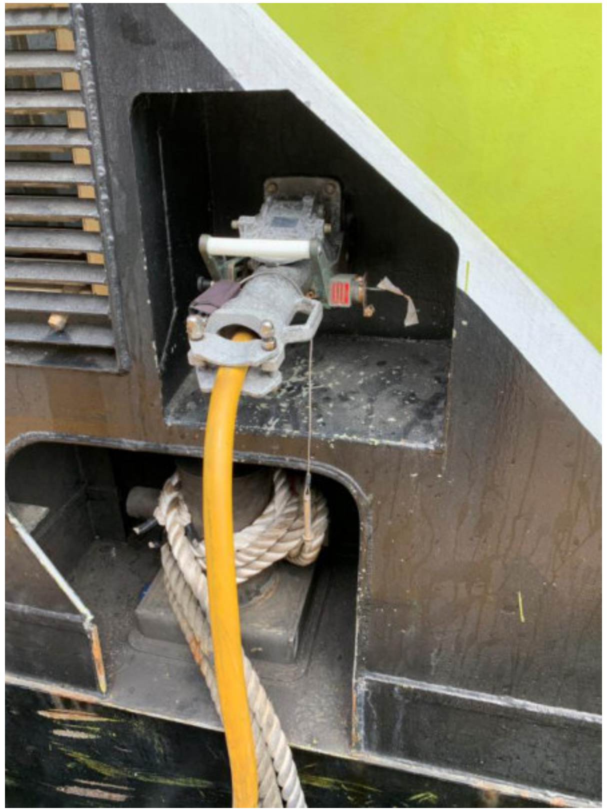
- **Gensets**
  - Diesel Speed Variable
  - LNG
  - Hydrogen Gensets
  - Fuel Cell
  - Solar Panel
  - Batteries
  - Sky Sails
  - Shore Power

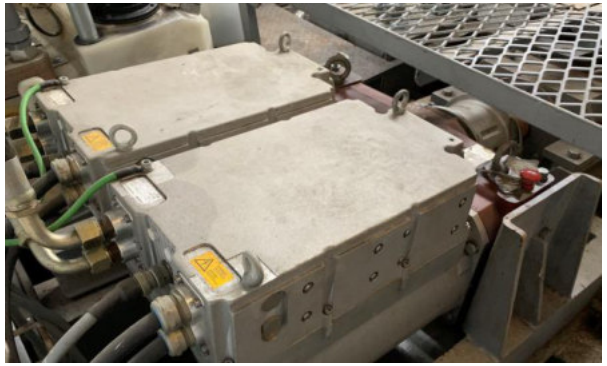
- **DC Link**
  - DNV-GL / ZSUK
  - Selective redundant

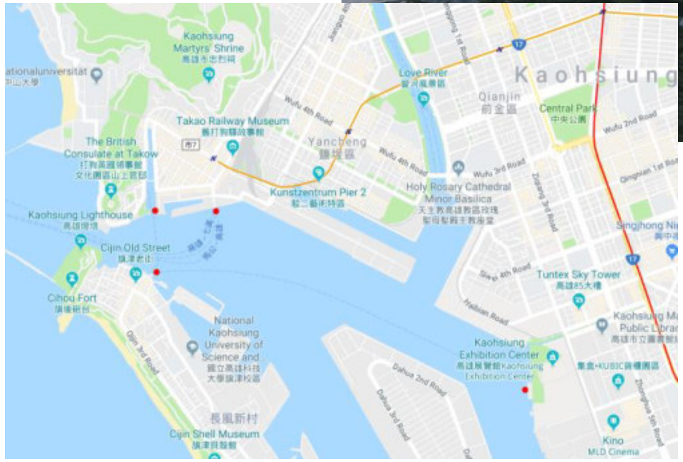
- **Propulsion**
  - Z-Drives
  - Propellers
  - Thruster
  - Board Net



FULL ELECTRICAL FERRY WITH STATIONARY SOLAR AND SHORE BATTERY

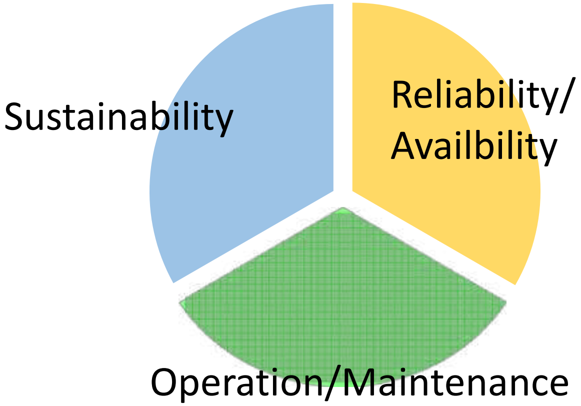






FERRY OF THE YEAR 2019 TAIWAN (SOIC REWARD)

EFFICIENT HYBRID CONTAINERS FOR INLAND VESSELS AND BARGES



Sustainablility	Low	Middle	High	High
Reliability/Availbility	High	High	Middle	Middle
Operation/Maintenance	High	Low	Low	Middle

Source © EST Floattech

BATTERIE 546KWH IN HYBRID CARGO SCHIFF

Customer

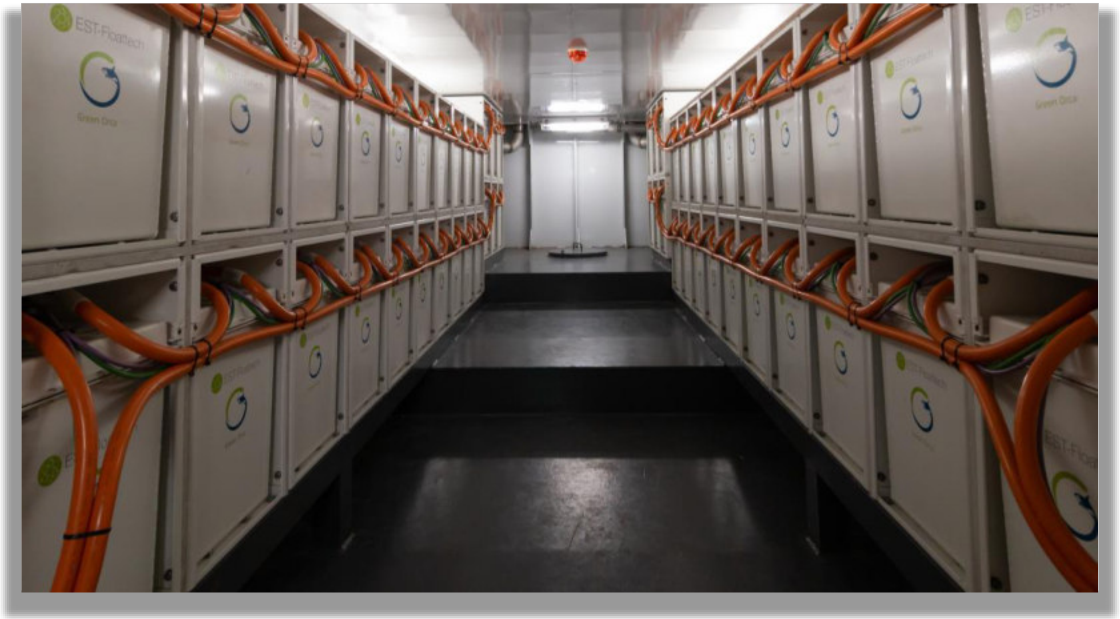
- Sendo Shipping and build by Concordia Damen
- 110 x 11,45 Inland Cargo Vessel
- First Battery Electric inland Cargo Vessel.

Product

- EST-Floattech supplies Green Orca 1050
- 546 kWh Lithium NMC
- 4 Strings of 13 Lithium Batteries

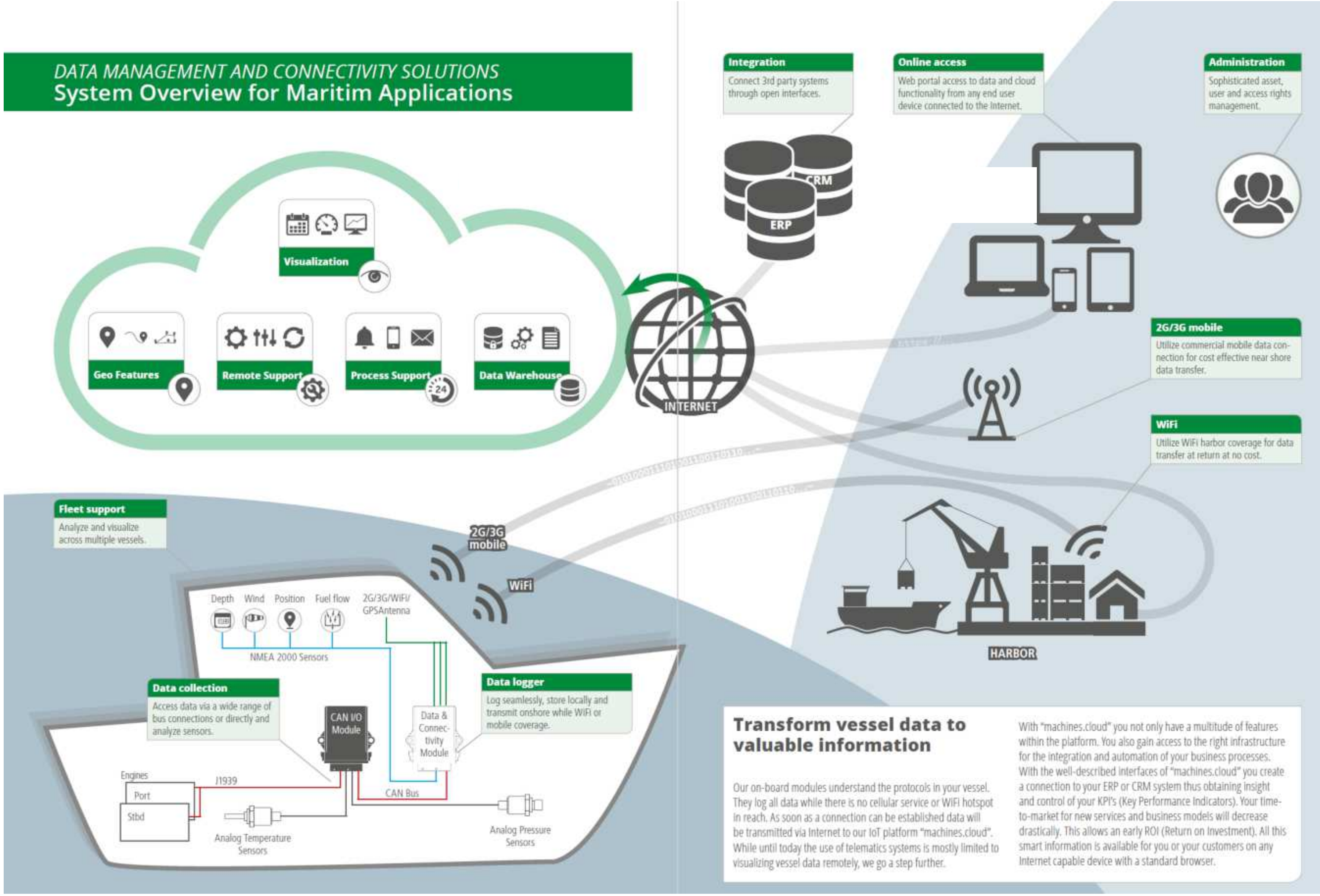
Application & Benefits

- Operate entirely on battery power for period of time
- Without No-Load power consumption
- won’t have to use generator power while it’s waiting for locks or under the crane.



Source © EST Floattech

BAUDIS PLATFORM DIGITALISATION FOR SHIPS



DATA MANAGEMENT AND CONNECTIVITY SOLUTIONS

System Overview for Maritim Applications

Integration
Connect 3rd party systems through open interfaces.

Online access
Web portal access to data and cloud functionality from any end user device connected to the Internet.

Administration
Sophisticated asset, user and access rights management.

2G/3G mobile
Utilize commercial mobile data connection for cost effective near shore data transfer.

WiFi
Utilize WiFi harbor coverage for data transfer at return at no cost.

Fleet support
Analyze and visualize across multiple vessels.

Data collection
Access data via a wide range of bus connections or directly and analyze sensors.

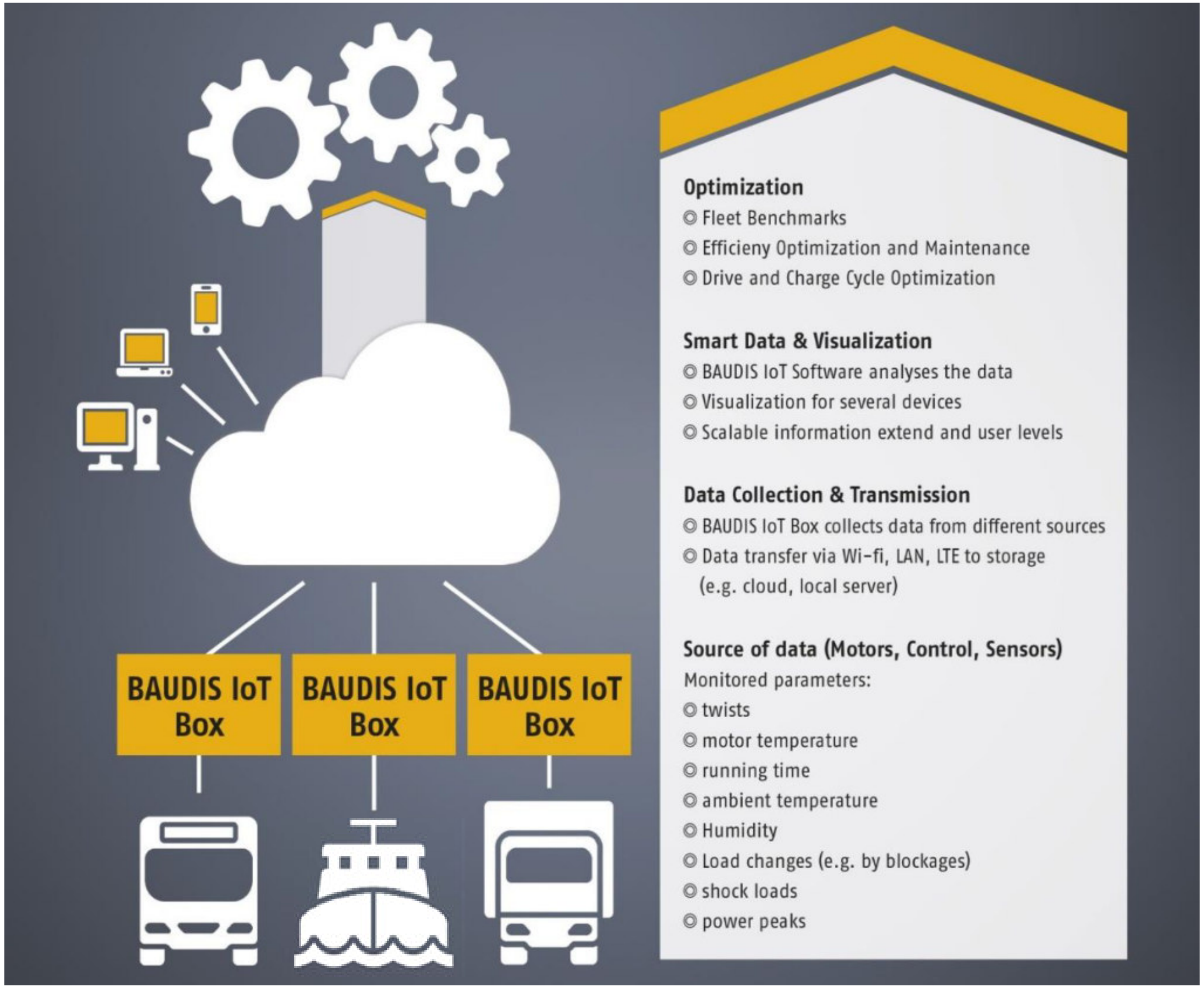
Data logger
Log seamlessly, store locally and transmit onshore while WiFi or mobile coverage.

Transform vessel data to valuable information

Our on-board modules understand the protocols in your vessel. They log all data while there is no cellular service or WiFi hotspot in reach. As soon as a connection can be established data will be transmitted via Internet to our IoT platform "machines.cloud". While until today the use of telematics systems is mostly limited to visualizing vessel data remotely, we go a step further.

With "machines.cloud" you not only have a multitude of features within the platform. You also gain access to the right infrastructure for the integration and automation of your business processes. With the well-described interfaces of "machines.cloud" you create a connection to your ERP or CRM system thus obtaining insight and control of your KPI's (Key Performance Indicators). Your time-to-market for new services and business models will decrease drastically. This allows an early ROI (Return on Investment). All this smart information is available for you or your customers on any Internet capable device with a standard browser.

BAUDIS DIGITALISATION



Optimization
- Fleet Benchmarks
- Efficieny Optimization and Maintenance
- Drive and Charge Cycle Optimization

Smart Data & Visualization
- BAUDIS IoT Software analyses the data
- Visualization for several devices
- Scalable information extend and user levels

Data Collection & Transmission
- BAUDIS IoT Box collects data from different sources
- Data transfer via Wi-fi, LAN, LTE to storage (e.g. cloud, local server)

Source of data (Motors, Control, Sensors)

Monitored parameters:
- twists
- motor temperature
- running time
- ambient temperature
- Humidity
- Load changes (e.g. by blockages)
- shock loads
- power peaks

BAUDIS IoT Box

BAUDIS IoT Box

BAUDIS IoT Box

New Functions:

- Online Software Updates
- Geo-Fencing-Functionen
- Flett Administrator
- Big-Data-Analyse
  (Propulsion Profiles, Battery Usage and State of Charge , Running Hours)
- Network and Data Transfer between Ships and Fleet
- Advanced Predictive Maintenance
- Access to Internet Data
  - WSV Waterlevels
  - Weather Informations
  - Marine Traffic
- Driver for Inverters Siemens/Visedo/Vacon
- Driver for Navigation
- Extended Gadget Database

ZERO EMISSION

THANKS FOR YOUR ATTENTION

Stefan Krahn
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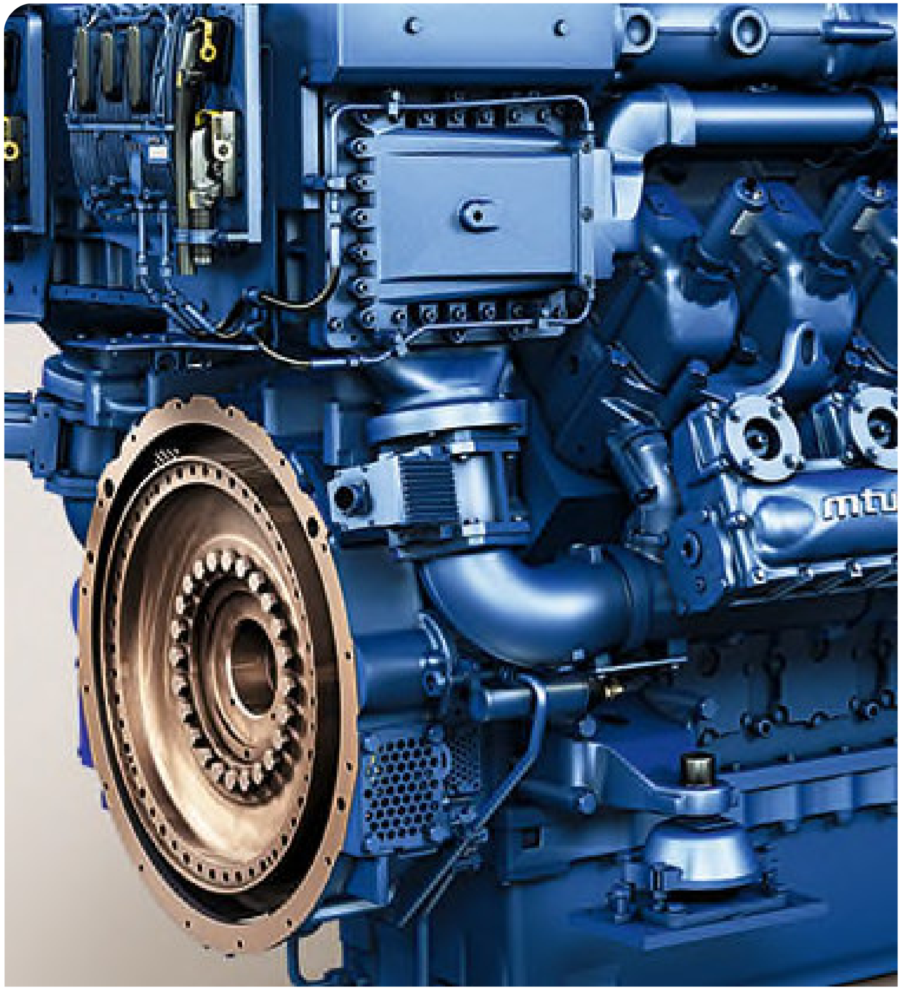


Gas Mobile Marine

S4000M05-N
Gas Mobile Marine

Interreg Danube Transnational Programme GRENDEL

Vienna, 7-8 March 2019, Arnd Lierhammer

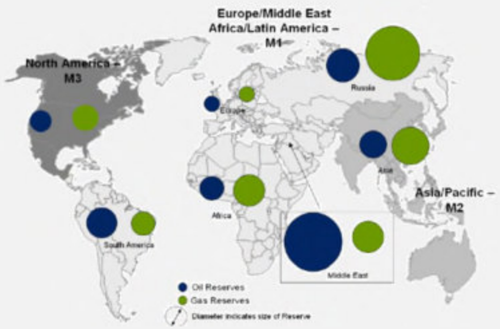
Power. Passion. Partnership.

Agenda

01 General Overview

General Overview
Main driving factors for Gas engines

Large Reserves

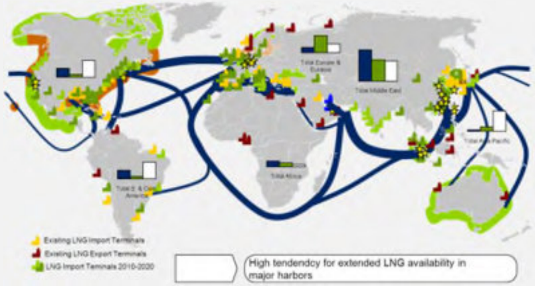


Emission Regulations

existing ECAs: Baltic Sea, North Sea

planned ECAs: Coasts of USA, Hawaii and Canada

discussed ECAs: Coasts of Mexico, Coasts of Alaska and Great Lakes, Singapore, Hong Kong, Korea, Australia, Black Sea, Mediterranean Sea (2014), Tokyo Bay (in 2015)



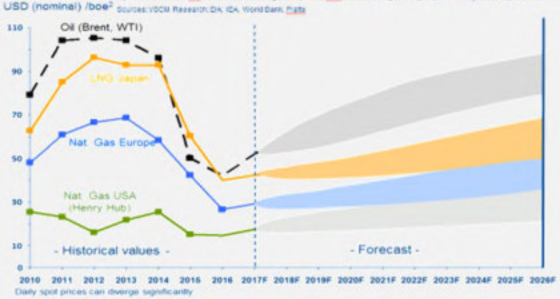
High tendendcy for extended LNG availability in major harbors

Developing LNG*-Infrastructure

1) Data as of 2017-01

2) Conversions: 1 mn cubic feet of natural gas (HH) = 172 boe (barrel of oil equivalent); 1 barrel = 42 gallons = 5.8 x 10^6 BTU

Sources: VSCM Research; DA, IEA, World Bank, Platts



Daily spot prices can diverge significantly

Low Gas Price

* LNG: Liquified Natural Gas
** ECA: Emission Controlled Area

General Overview
In-house Gas Experience

GAS MOBILE MARINE

Rolls-Royce

Rolls-Royce Power Systems AG

Rolls Royce Marine

mtu

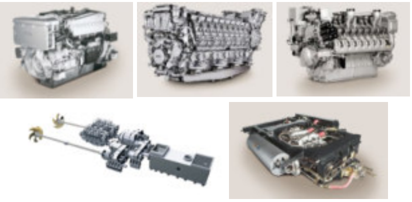
mtu onsite energy

Bergen Engines AS

Mobile Applications

High Speed Diesel Engines

Propulsion systems



Stationary Applications

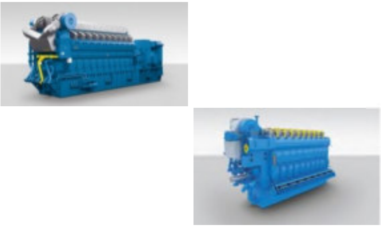
High Speed Gas Engines
High Speed Diesel Engines

Gas and Diesel Generator sets
Power supply systems

Marine and Stationary Applications

Medium Speed Gas Engines
Medium Speed Diesel Engines

Medium Speed Gas and Diesel Generator sets



Marine Design and Sytems

Ship design
Shipside gas systems

General Overview
MTU Mobile Gas Portfolio Development

Marine

Rail

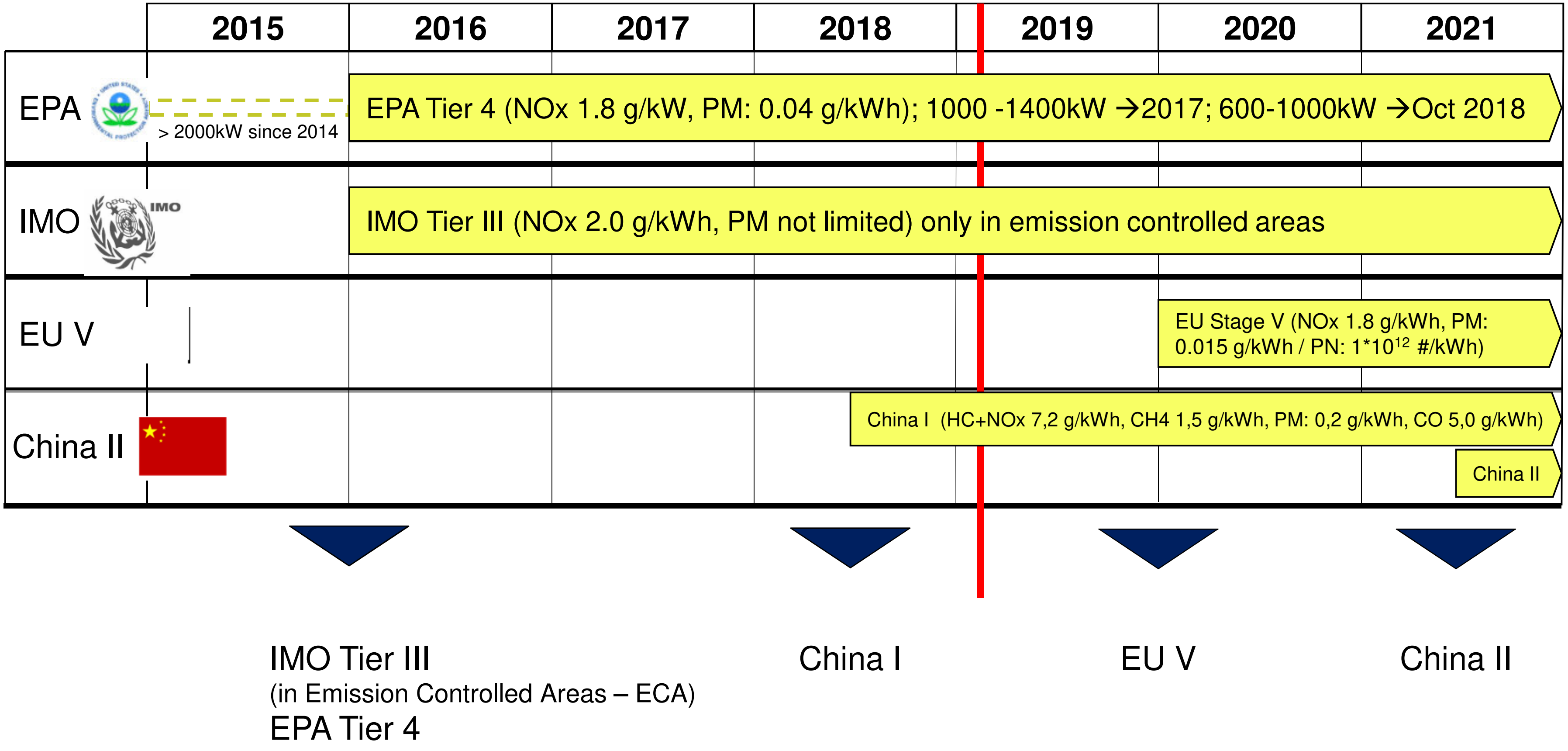
C&I / Mining

Marine application has been chosen as lead application

- Existing experience in gas fuelled ships – also in-house (Bergen)
- LNG infrastructure starts to develop from sea coast
- Technical rules and guidelines most developed (IGF-Code, DNV/GL, BV, LR)
- Highest technical requirements allows downgrade to land based applications
- Time to market

02 Emission Legislation

Emission Legislation Overview



2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021

EPA

> 2000kW since 2014

EPA Tier 4 (NOx 1.8 g/kW, PM: 0.04 g/kWh); 1000 -1400kW →2017; 600-1000kW →Oct 2018

IMO

IMO Tier III (NOx 2.0 g/kWh, PM not limited) only in emission controlled areas

EU V

EU Stage V (NOx 1.8 g/kWh, PM: 0.015 g/kWh / PN: $1*10^{12}$ #/kWh)

China II

China I (HC+NOx 7,2 g/kWh, CH4 1,5 g/kWh, PM: 0,2 g/kWh, CO 5,0 g/kWh)

China II

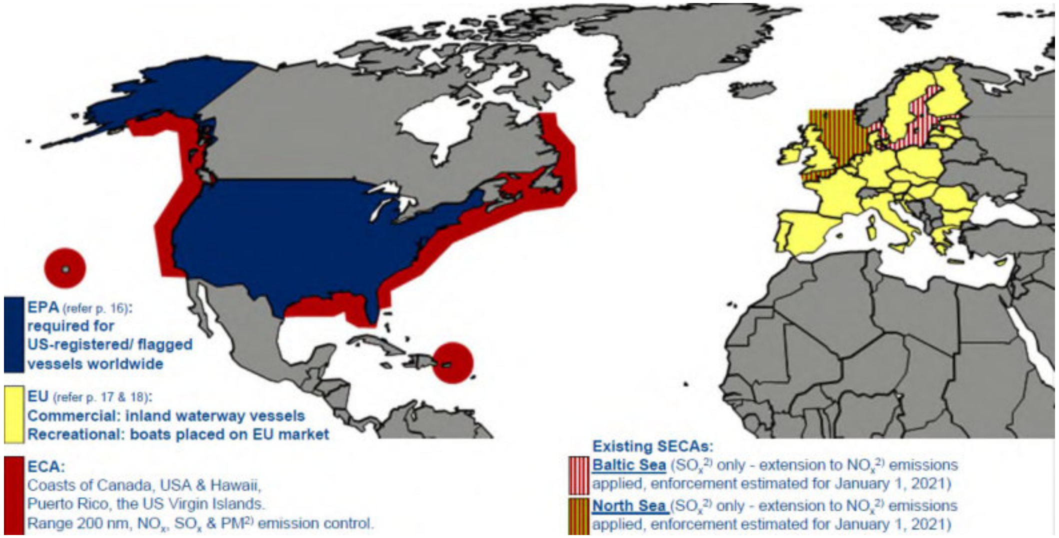
IMO Tier III
(in Emission Controlled Areas – ECA)
EPA Tier 4

China I

EU V

China II

Emission Legislation Overview



Existing ECAs
Coast of Canada, USA & Hawaii, Puerto Rico, US Virgin Islands

Applied ECAs (January 1, 2021)
North Sea and Baltic Sea

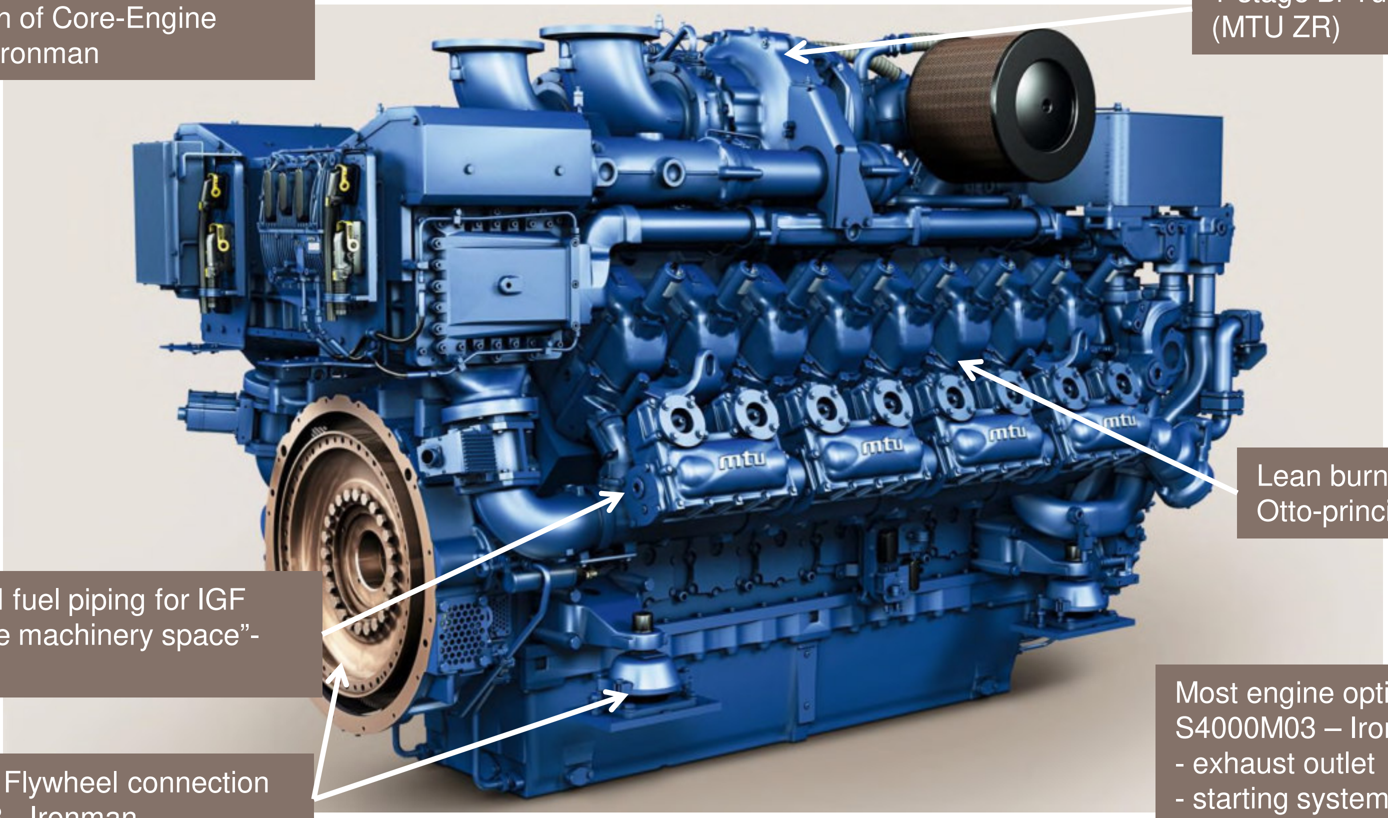
IMO Tier III
Vessels constructed on/after 1st January 2016 need to be **IMO Tier III** certified, if operation area is an Emission Controlled Area
Exemption: Recreational purpose yachts <24m length WL and/or <500GT, Naval vessels

EPA Tier 4
Vessels registered in the US need to be **EPA Tier 4 certified**, if engines manufactured on/after 1st January 2016
Exemptions: recreational provision, testing,…

EU V
Engines (>300kW) for Inland waterway vessels used in EU need **EU V** certification from **1st January 2020** on

03 Engine Concept & Technical Data

S4000 M05-N
Engine Concept & Technical Concept



Proven design of Core-Engine S4000M03 - Ironman

1-stage Bi-Turbo (MTU ZR)

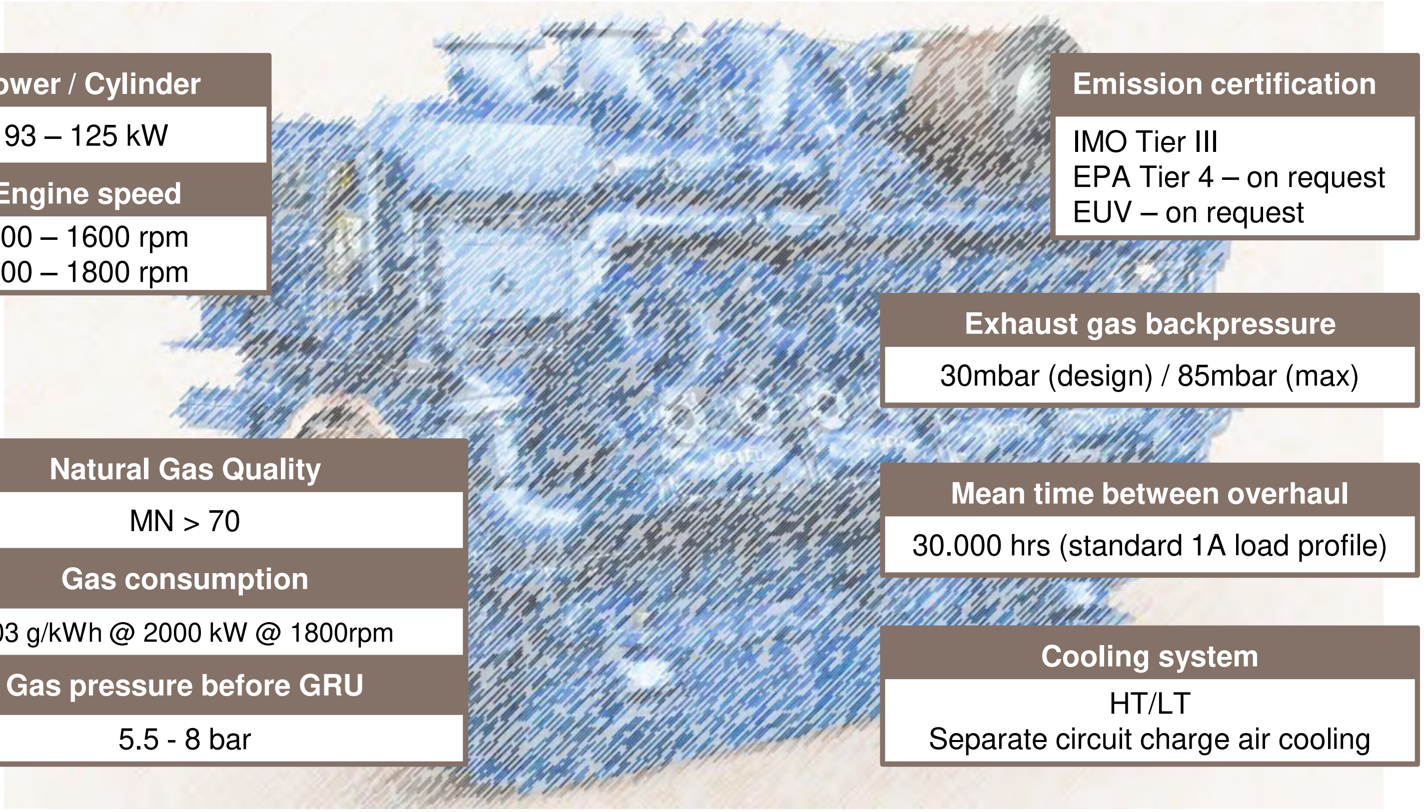
Lean burn gas engine Otto-principle

Double-walled fuel piping for IGF code “gas safe machinery space”-concept

Footprint and Flywheel connection as S4000M03 - Ironman

Most engine options as S4000M03 – Ironman e.g.:
- exhaust outlet
- starting system
- PTO´s

S4000 M05-N
Engine Concept & Technical Concept



Power / Cylinder

93 – 125 kW

Engine speed

600 – 1600 rpm
600 – 1800 rpm

Natural Gas Quality

MN > 70

Gas consumption

203 g/kWh @ 2000 kW @ 1800rpm

Gas pressure before GRU

5.5 - 8 bar

Emission certification

IMO Tier III
EPA Tier 4 – on request
EUV – on request

Exhaust gas backpressure

30mbar (design) / 85mbar (max)

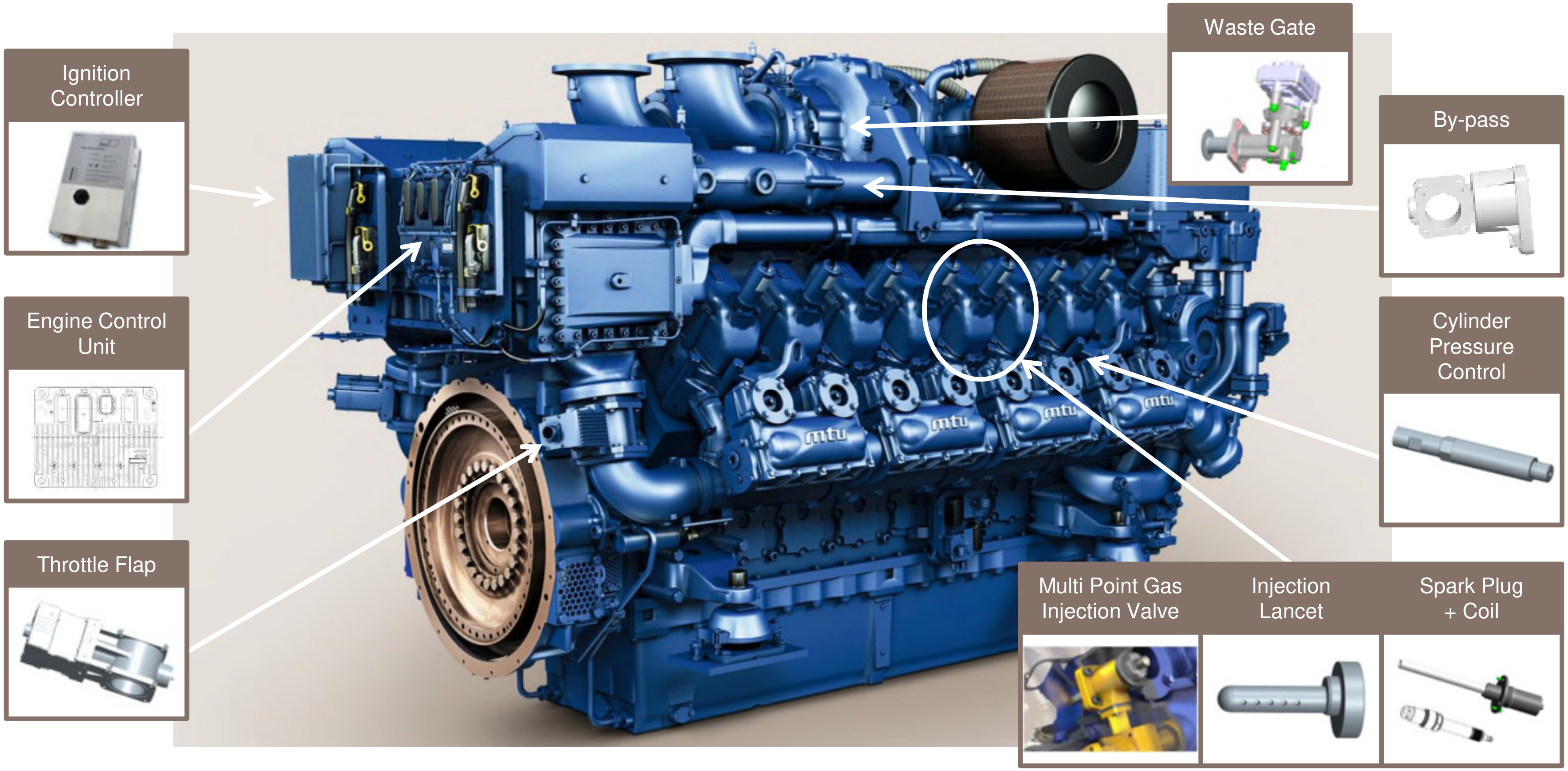
Mean time between overhaul

30.000 hrs (standard 1A load profile)

Cooling system

HT/LT
Separate circuit charge air cooling

S4000 M05-N
Engine Concept & Technical Concept



Ignition Controller

Engine Control Unit

Throttle Flap

Waste Gate

By-pass

Cylinder Pressure Control

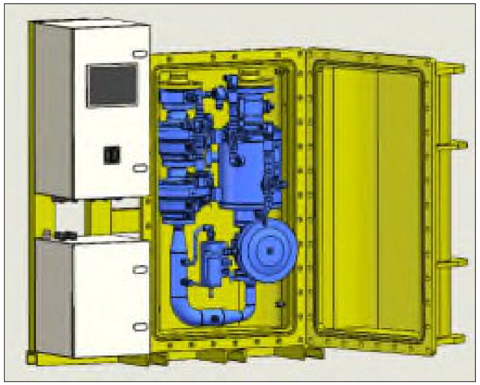
Multi Point Gas Injection Valve

Injection Lancet

Spark Plug + Coil

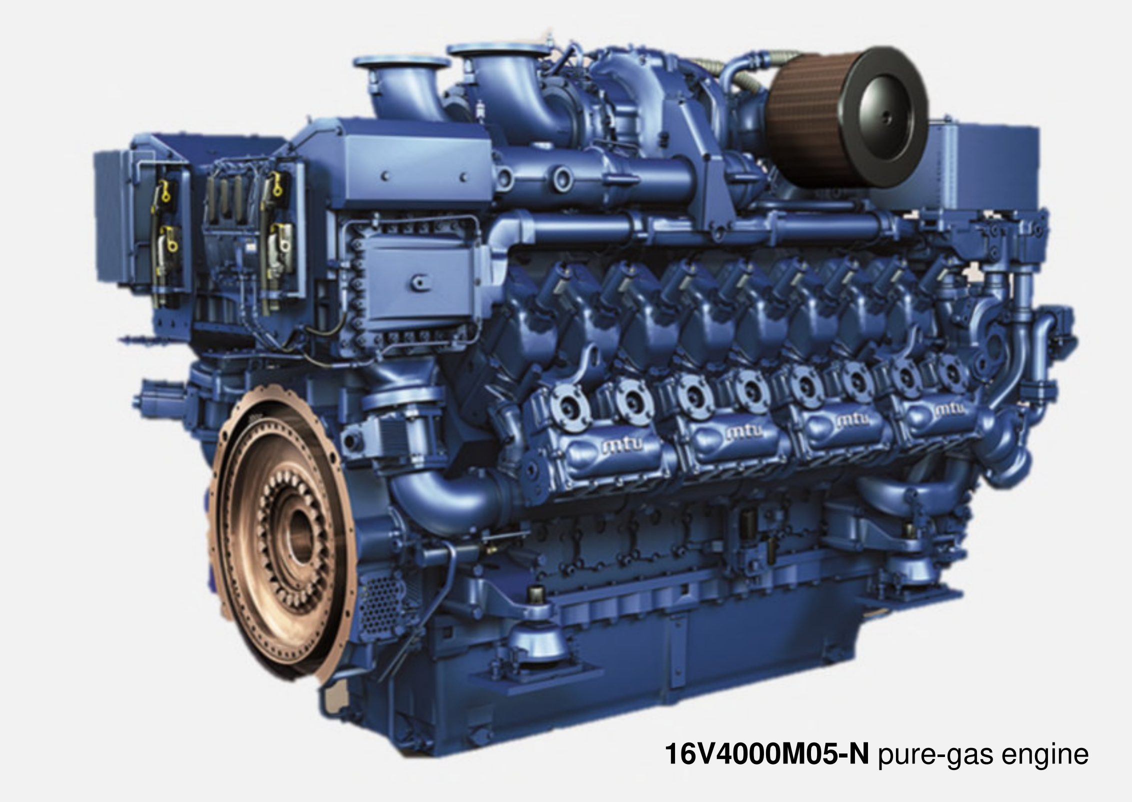
04 Standard scope of supply

16V 4000 M05-N
Standard Scope of Supply



Gas Regulation Unit (GRU)

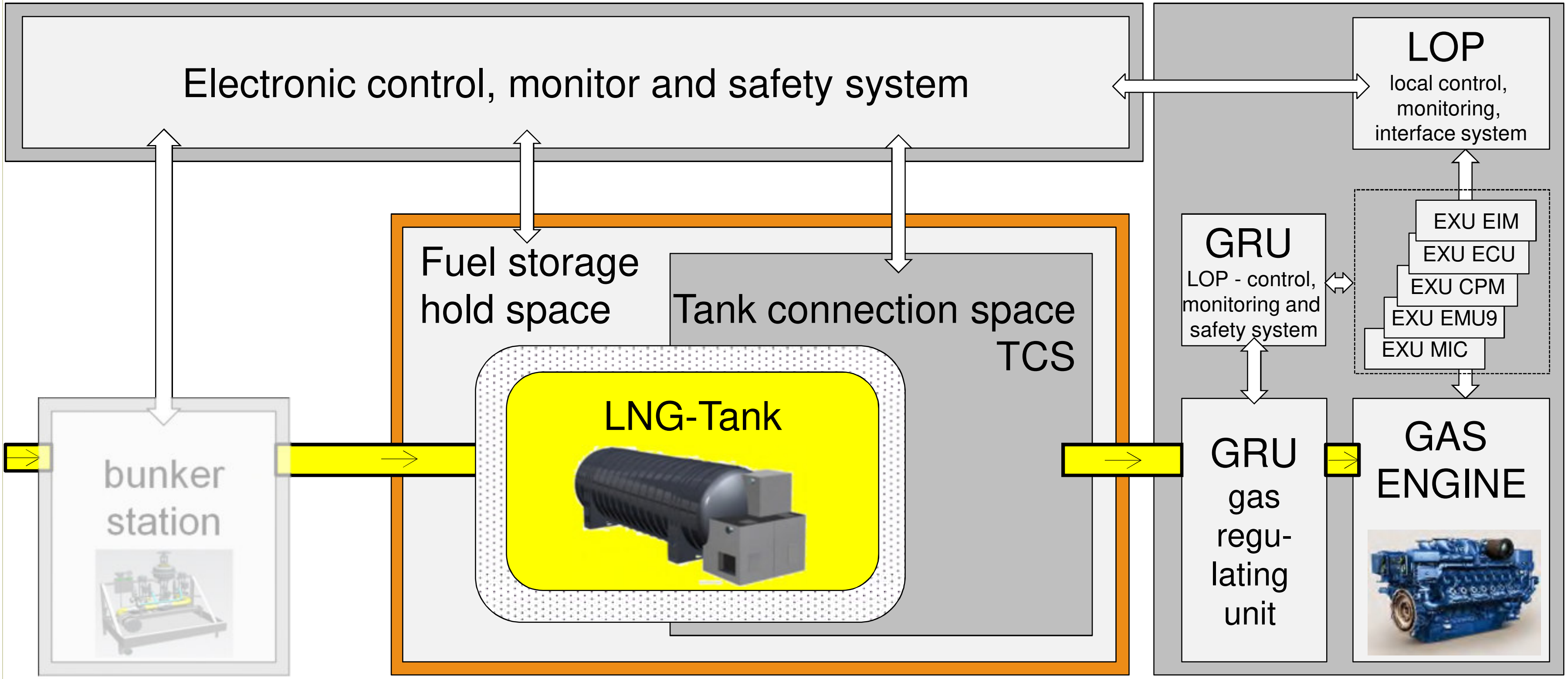
Local Operator Panel (LOP)



16V4000M05-N pure-gas engine

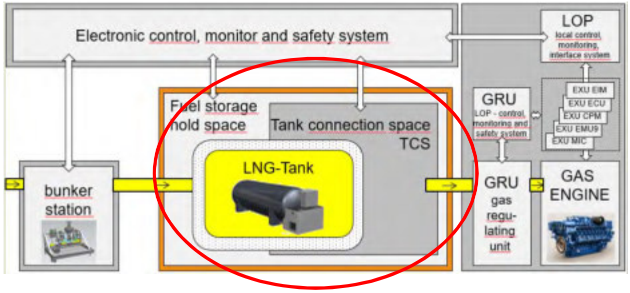
05 Shipside Gas System (optional)

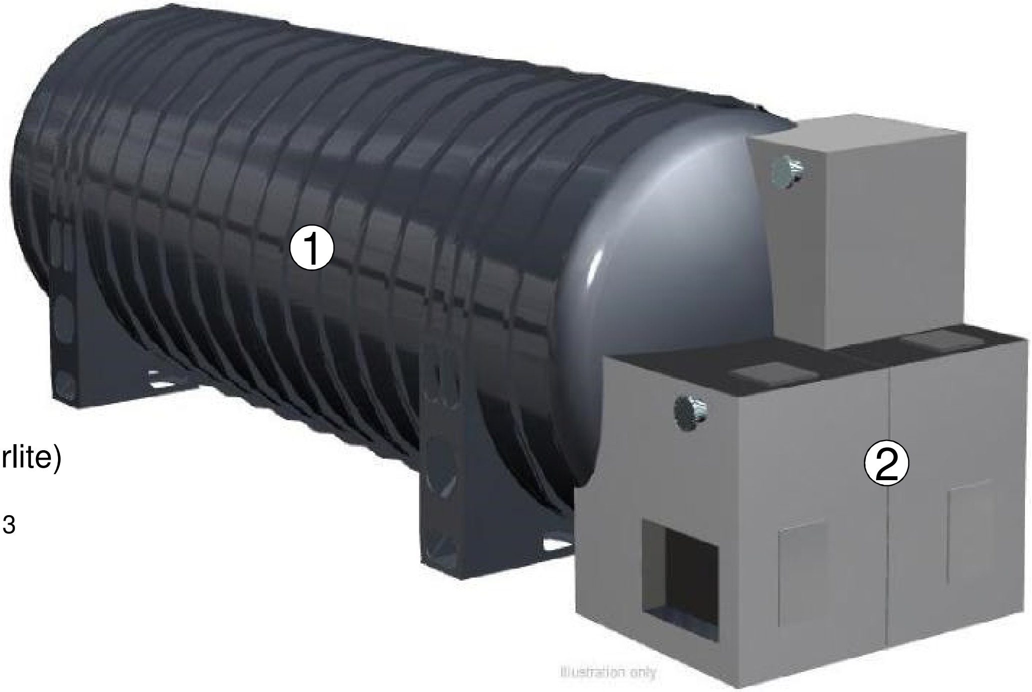
Shipside Gas System
Fuel gas system (LNG) – overview



Shipside Gas System
Fuel gas system (LNG) – tank and TCS

STORAGE TANK FOR LNG:





① **Storage tank for LNG:**

-Double walled tank (vacuum isolated / filled with perlite)

-The volume depends on the ship and load profile.

-Typical tank size for MTU gas engines: 10 … 100m^3

-Tank mounting position: horizontal or vertical

② **TCS (tank connection space):**

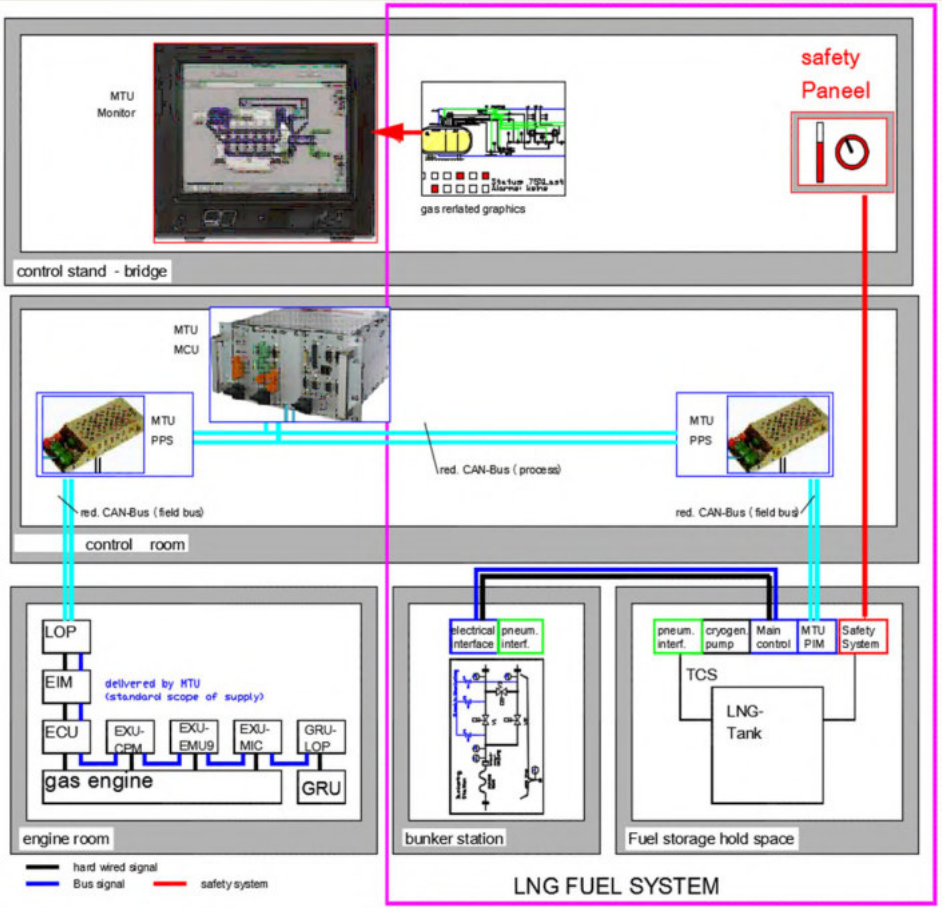
-Regasification of LNG to NG with temperature and pressure, needed for MTU engines (within limits).

-Monitoring and control of the tank pressure

-Monitoring of the tank level (filling / consumption)

-Boil-off gas (BOG) handling

Shipside Gas System
Fuel gas system (LNG) – Automation and control system



LNG Fuel System:

2 independent systems for:

- Control and monitoring system
- Safety system

Visualization:

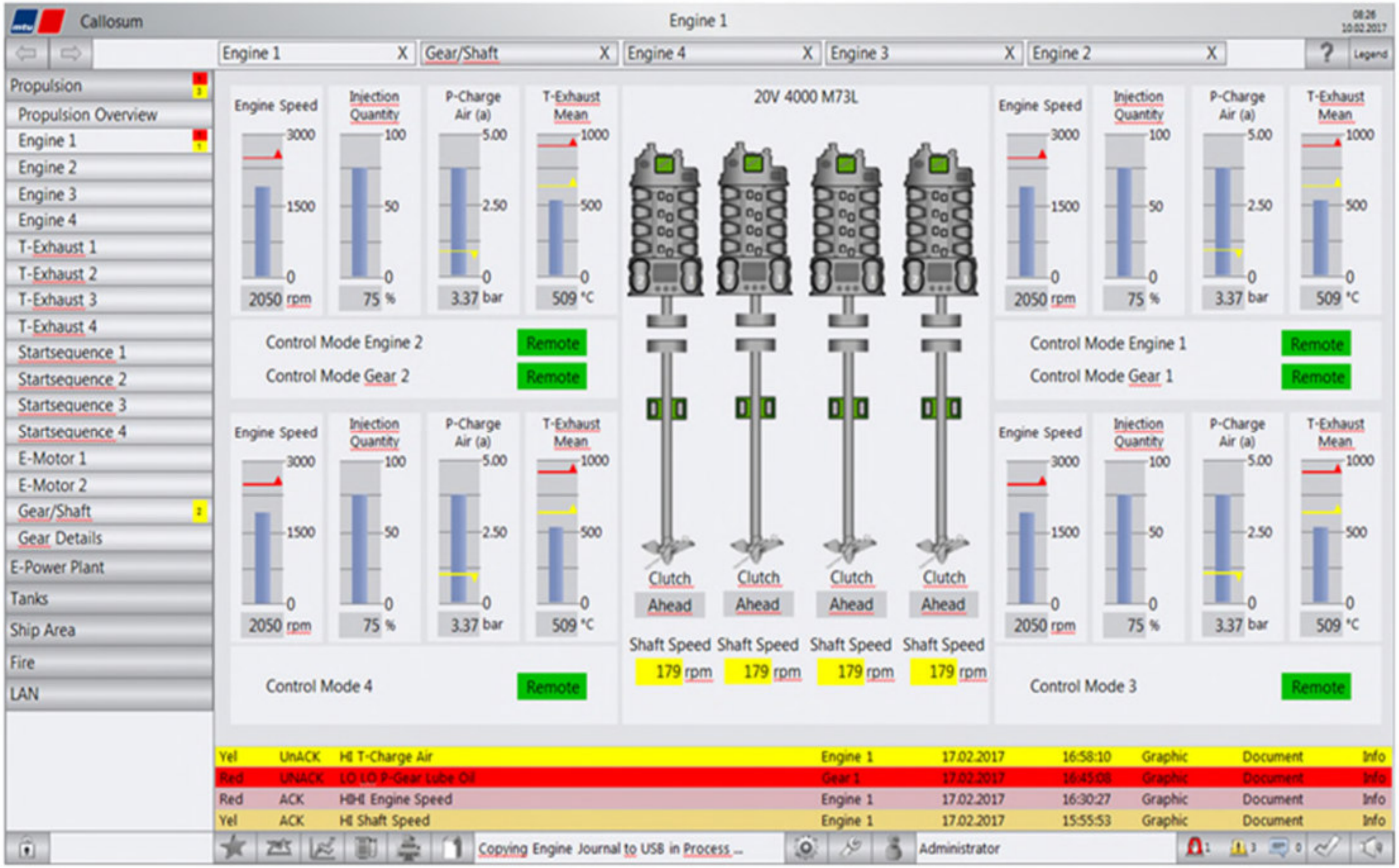
- engine control room
- control stand (bridge)

Shipside Gas System
Fuel gas system (LNG) – Automation and control system

Main Process Functions:

- bunkering
- gas supply during normal operation (gas engines supply)
- Safety System (LNG-fuel-system) and monitoring to avoid critical situations
- Monitoring of all necessary information with regards to control of the regasification process in accordance to the acceleration behavior
- Alarm processing & Alarm monitoring
- Interface to the ship automation system
- Control and monitoring of the pneumatic panels

Shipside Gas System
Engine monitoring – typical monitoring layout



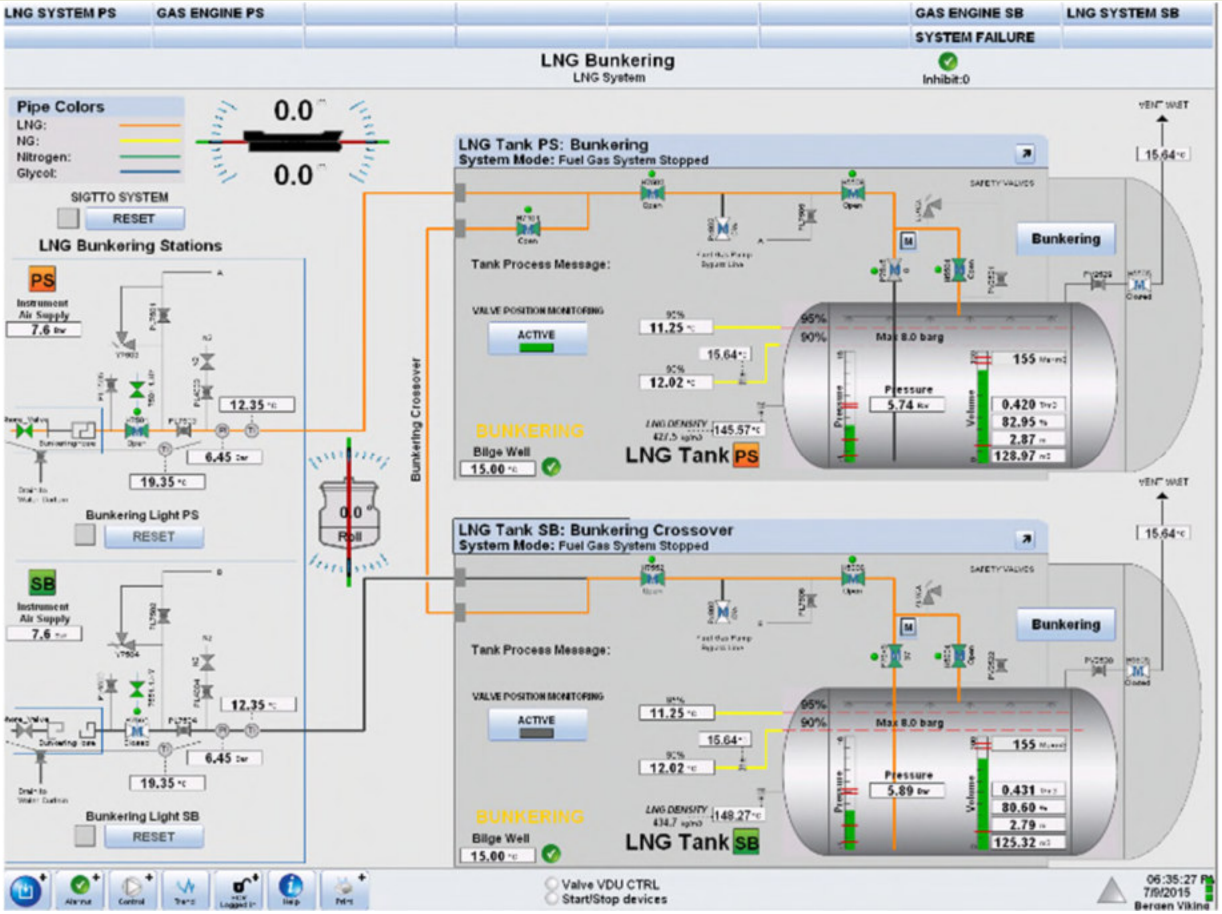
Control Mode Engine 2: Remote
Control Mode Gear 2: Remote
Control Mode 4: Remote
Control Mode Engine 1: Remote
Control Mode Gear 1: Remote
Control Mode 3: Remote

Yel	UnACK	HI T-Charge Air	Engine 1	17.02.2017	16:58:10	Graphic	Document	Info
Red	UNACK	LO LO P-Gear Lube Oil	Gear 1	17.02.2017	16:45:08	Graphic	Document	Info
Red	ACK	HIHI Engine Speed	Engine 1	17.02.2017	16:30:27	Graphic	Document	Info
Yel	ACK	HI Shaft Speed	Engine 1	17.02.2017	15:55:53	Graphic	Document	Info

Copying Engine Journal to USB in Process ...

Administrator

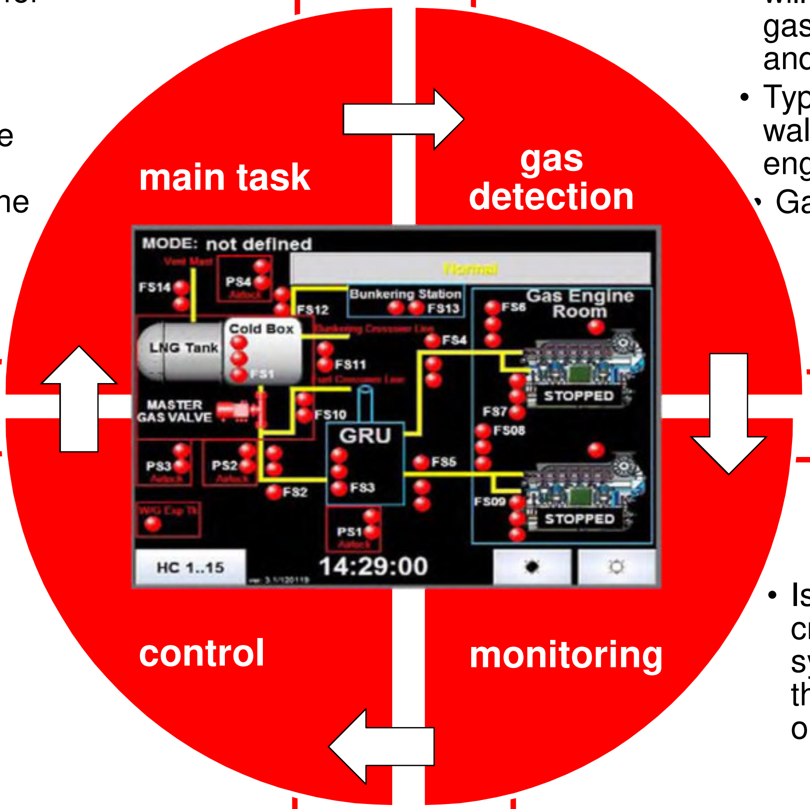
Shipside Gas System
Fuel gas system (LNG) – typical monitoring layout



Shipside Gas System
Fuel gas system (LNG) – safety system

- monitor safety critical elements for the LNG fuel system.
- will perform a series of predetermined actions to reduce the safety hazard and if the situation calls for it make sure the LNG Fuel system will be shut down and returned to a safe state.

- will monitor the level of dangerous gases at strategic places in the ship and along the LNG fuel system.
- Typical mounting places are double walled piping of gas supply to the engine and in the TCS.
- Gas detection are built on a system of dual sensing, where two gas sensors operate in pair.



- In the case of a safety critical event the Safety System (LNG-fuel-system) will execute appropriate action to reduce or eliminate safety risks.
- Is built up with several levels of control depending of the safety critical event.

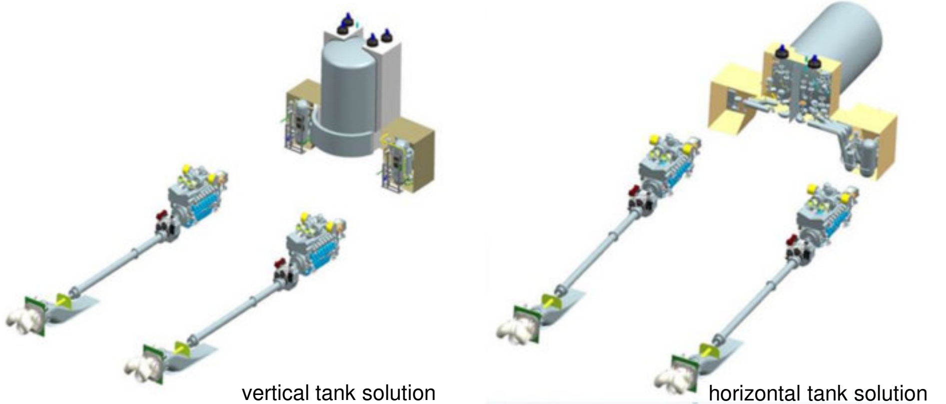
- Is designed to monitor safety critical signals from the LNG fuel system as well as other signals that are important to the safety of operating the LNG fuel system.

Shipside Gas System
Fuel gas system (LNG) – actual design studies

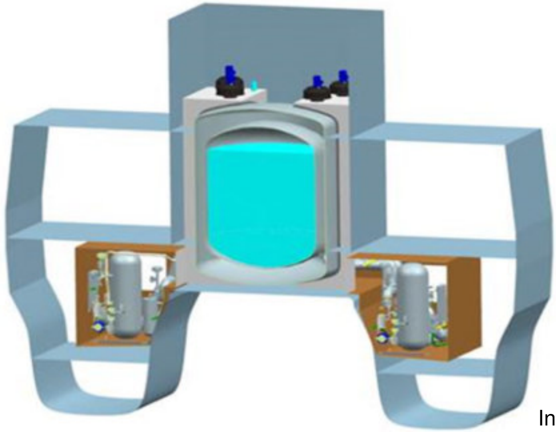
Brødrene Aa

a specialist for high speed catamarans (HSLC) made in carbon composite.


exemplary representation


vertical tank solution

horizontal tank solution


Intersection of hulls

06 Ratings, Portfolio & Market introduction

Portfolio, Ratings & Market introduction
Planned Marine Portfolio

Marine prop. IMO III / EPA 4* / EU V*	**8V 746 kW / 1000 kW 1600 rpm / 1800 rpm**	12V max 1500 kW	**16V 1492 kW / 1840 kW / 2000 kW 1600 rpm / 1800 rpm /1800 rpm**	20V max 2500 kW
Marine gens. IMO III / EPA 4* / EU V*	8V max 1000 kW	12V max 1500 kW	16V max 2000 kW	20V max 2500 kW

16V4000M05-N for main propulsion	SOD Q12/2018 with Lloyds Register - ABS, BV, DNV / GL subsequently
8V4000M05-N for main propulsion	SOD Q02/2020
12V4000 and **20V**4000	development subject to market demand
Constant speed engine	development subject to market demand
* **EPA 4** (with oxi-cat) and **EU V**	8V and 16V certification subject to market demand

07 References

References

High Speed Ferries:
2x 16V4000 gas engines @1.492kW
for *Reederij Doeksen*
2 vessels

Ro-Ro Ferry:
2x 8V4000 gas engines @ 746W
for *Stadtwerke Konstanz*
1 vessel

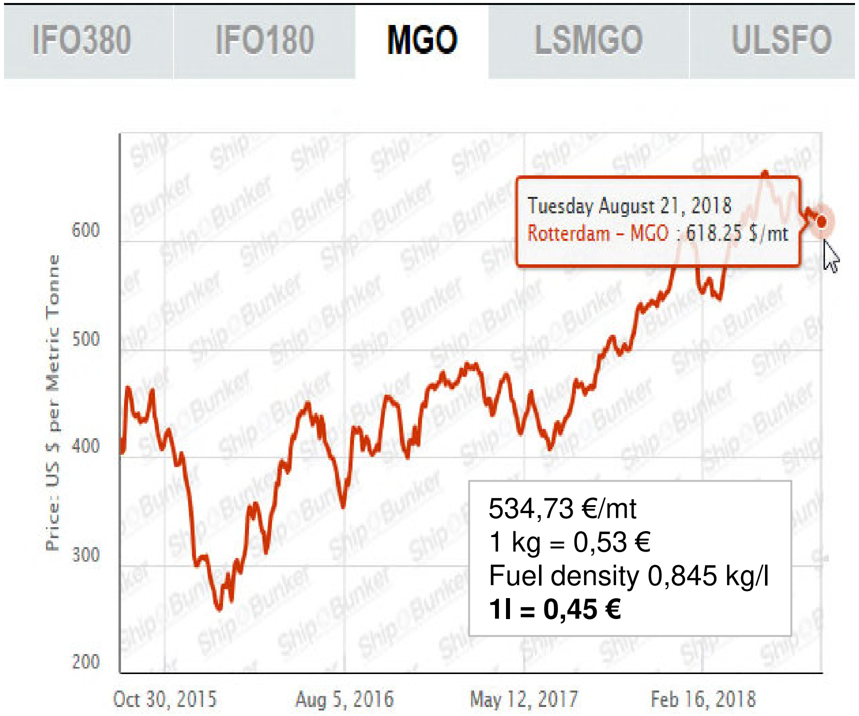
08 Customer Benefits

LCC Comparison IMO III - Gas vs. Diesel

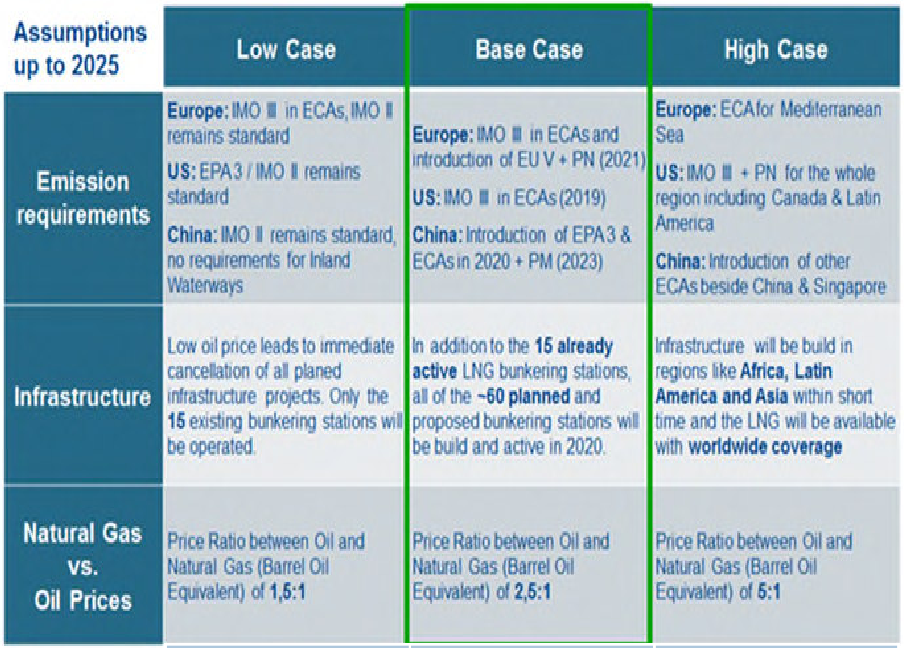
Fuel price scenario - Oil / Natural gas

Current price of MGO (Marine Gasoil) → Scenarios

618,25 USD/mt → **0,45€/l**



534,73 €/mt
1 kg = 0,53 €
Fuel density 0,845 kg/l
1l = 0,45 €



Assumptions up to 2025	Low Case	Base Case	High Case
Emission requirements	**Europe:** IMO III in ECAs, IMO II remains standard **US:** EPA3 / IMO II remains standard **China:** IMO II remains standard, no requirements for Inland Waterways	**Europe:** IMO III in ECAs and introduction of EU V + PN (2021) **US:** IMO III in ECAs (2019) **China:** Introduction of EPA3 & ECAs in 2020 + PM (2023)	**Europe:** ECA for Mediterranean Sea **US:** IMO III + PN for the whole region including Canada & Latin America **China:** Introduction of other ECAs beside China & Singapore
Infrastructure	Low oil price leads to immediate cancellation of all planed infrastructure projects. Only the **15** existing bunkering stations will be operated.	In addition to the **15 already active** LNG bunkering stations, all of the **~60 planned** and proposed bunkering stations will be build and active in 2020.	Infrastructure will be build in regions like **Africa, Latin America and Asia** within short time and the LNG will be available with **worldwide coverage**
Natural Gas vs. Oil Prices	Price Ratio between Oil and Natural Gas (Barrel Oil Equivalent) of **1,5:1**	Price Ratio between Oil and Natural Gas (Barrel Oil Equivalent) of **2,5:1**	Price Ratio between Oil and Natural Gas (Barrel Oil Equivalent) of **5:1**
	Diesel 0,45 €/l	Diesel 0,45 €/l	Diesel 0,45 €/l
	LNG 0,30 €/l	LNG 0,18 €/l	LNG 0,09 €/l

Source: https://shipandbunker.com/prices/emea/nwe/nl-rtm-rotterdam#MGO / 22/08/2018

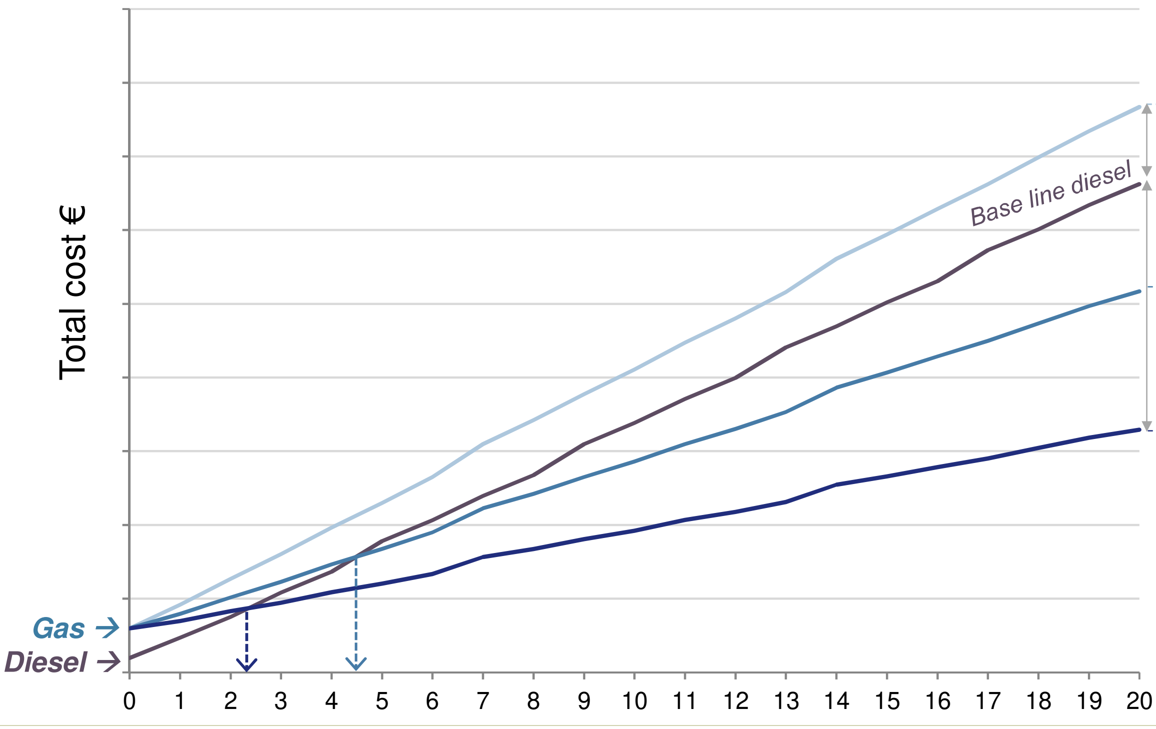
1 liter LNG equal to 0,6 m³ LNG gaseous

LCC Comparison IMO III - Gas vs. Diesel

Ferry ship scenario – 2x engines 16V4000M05 – 5,250h p.a.

Maintenance, *Invest & Consumption cost over 20 years

Costs are based on a generic Diesel / Gas engine 16V4000M05 (2.000 kW), operated in medium engine load. Calculation Aug. 2018



Low Case → Add'l cost gas engine + 16%

Base Case → Savings gas engine - 22 %

High Case → Savings gas engine - 50 %

Low Case: Price ratio Oil /Gas → **1.5 : 1**
Base Case: Price ratio Oil /Gas → **2.5 : 1**
High Case: Price ratio Oil /Gas → **5.0 : 1**

Assumed price for Marine Gasoil 0,45 €/l

Operating years

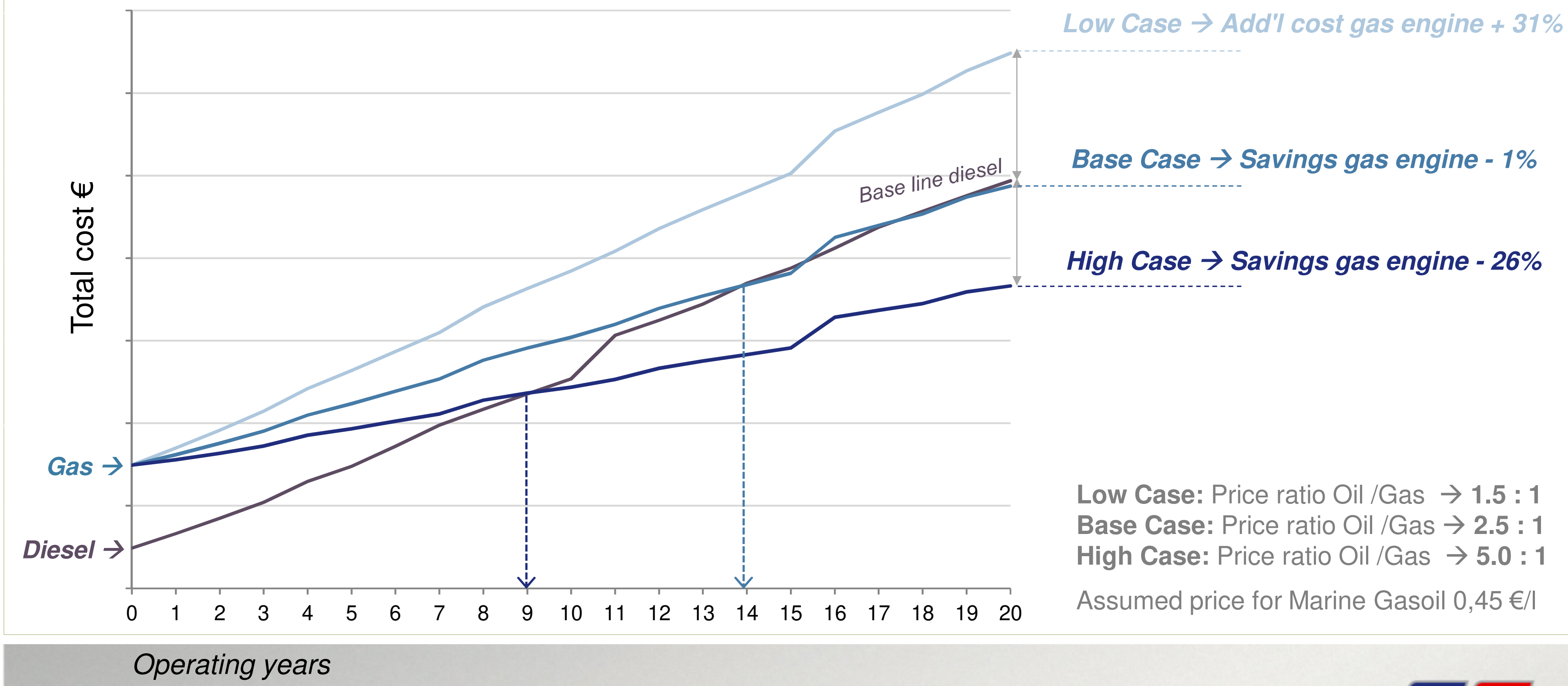
**Invest cost: 2 x engines + Tank system*

LCC Comparison IMO III - Gas vs. Diesel

Tug boat scenario – 2x engines 16V4000M05 – 2,400h p.a.

Maintenance, *Invest & Consumption cost over 20 years

Costs are based on a generic Diesel / Gas engine 16V4000M05 (2.000 kW), operated in medium engine load. Calculation Aug. 2018



Low Case: Price ratio Oil /Gas → **1.5 : 1**
Base Case: Price ratio Oil /Gas → **2.5 : 1**
High Case: Price ratio Oil /Gas → **5.0 : 1**

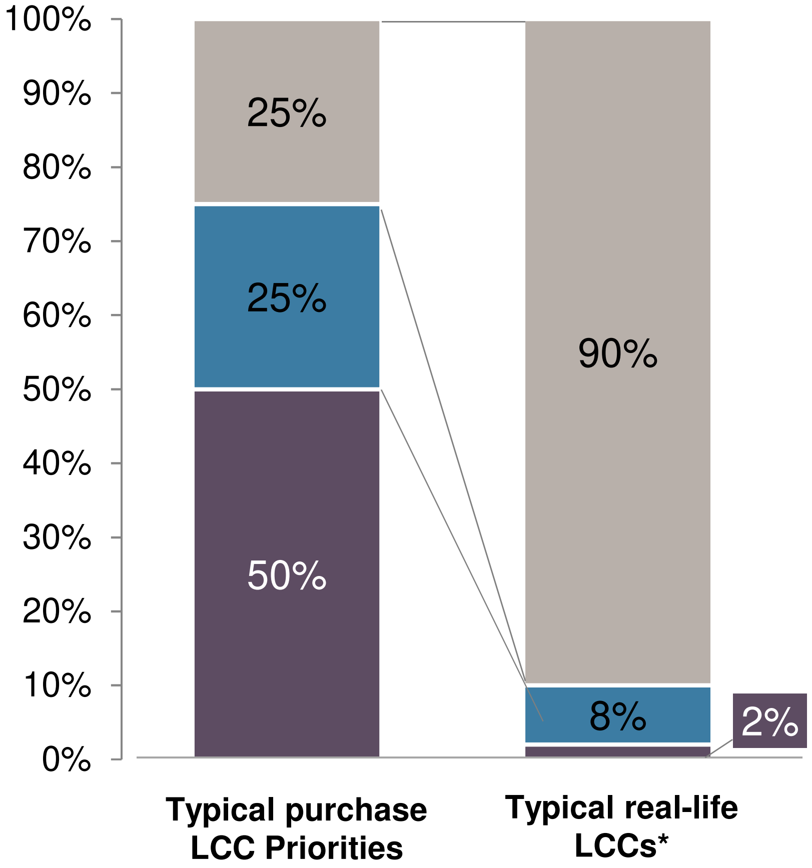
Assumed price for Marine Gasoil 0,45 €/l

Operating years

**Invest cost: 2 x engines + Tank system*

LCC Comparison IMO III - Gas vs. Diesel

Customer LCC priorities in the acquisition phase



■ **Operational costs**
Often seen as individual cost and not part of LCC. Operating cost are frequently asked separately. They are hard to predict due to uncertain fuel cost

■ **Maintenance costs**
Often seen as an individual cost and not part of typical LCC. They contain Preventive, corrective and condition based tasks.

■ **Acquisition costs**
Capital expenditure still the most important. Limited funds are frequently prioritised over break-even point and ROI.

* Costs are based on a generic Series 4000 diesel engine with 2xTBO operating life and one overhaul and continuous operation

Why lifecycle costs matter
https://www.youtube.com/watch?v=tcP8NDQ_Nws

09 Key Facts & Highlights

S 4000 Gas engine for Marine application
Key Facts & Highlights

S4000 Gas engine for Marine application Key Facts / Highlights

Dynamic Acceleration Behavior

➢ Comparable performance characteristics to that of our series 4000 diesel engine for workboat application, no visible smoke, even at acceleration

Better environmental footprint compared with that of the diesel engine

- 25% less Carbon Dioxide (CO_2)
- Health-threatening substances in the exhaust gas - such as nitrogen oxides, sulfur oxides, fine particulate matter - of gas-powered engines are reduced by 80 up to 100% compared to IMO II diesel engine

➢ No Exhaust Gas After Treatment (SCR, Particulate Filter) required for IMO Tier III and EUV

Gas Safe Machinery

- Engine built for "gas safe machinery space"

➢ No need for separate engine housing and ventilation within the engine room

First high speed pure gas engine in high power range

- Currently available gas engines are primarily medium speed engines

➢ Pure gas high speed engines offer significantly less weight than medium-speed gas engines for the same performance → improved power-to-weight-ratio

S 4000 Gas engine for Marine application
Key Facts & Highlights

S4000 Gas engine for Marine application Key Facts / Highlights

Multi Point Injection

– Cylinder individual injection of gas
➢ Identical combustion period in each cylinder
➢ Stable engine operation, increased availability

Engine Map

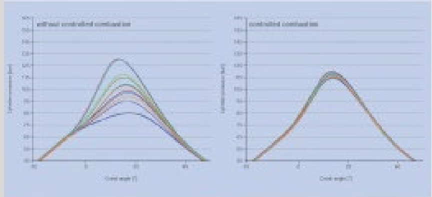
➢ All propulsion modes possible (fixed and variable pitch propeller)

Wide rpm range

➢ The rpm range is suitable for fixed pitch propellers to provide low-cost drive systems

Cylinder Pressure Based Combustion Control

– Minimization of the scatter band of the cylinder individual peak pressures
– Control of mean effective pressure, gain stability
➢ Reduction of fuel consumption and emissions



Thank you very much for your attention.

Power. Passion. Partnership.

Options and Trends in Propusion of future River Cruise Vessels

Research & Development
Gerhard Untiedt
Modernisation of Danube Vessels Fleet
Vienna, March 8th 2019

MEYER WERFT
PAPENBURG 1795

MEYER Group

MEYER WERFT
PAPENBURG 1795

NEPTUN WERFT
ROSTOCK 1850

MEYER TURKU
SHIPYARD 1737

Portfolio

Cruise Ships

River Cruise Ships

(Cruise) Ferries

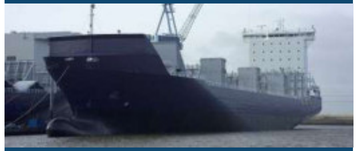
Passenger Ships

Island Ferries

Gas Tankers

Research Vessels

Container Ships



Emissions

Pollutants

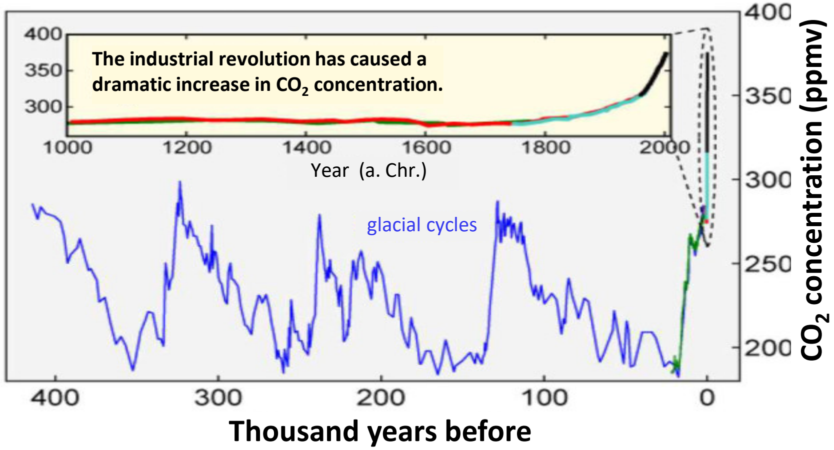
Harmful for health, “poisonous”, “dirty air”

- Soot, particulate matter (PM)
- Nitrogen oxides NO_x
- Sulphur oxides SO_x

Greenhouse gases

Harmful to the climate, Global warming

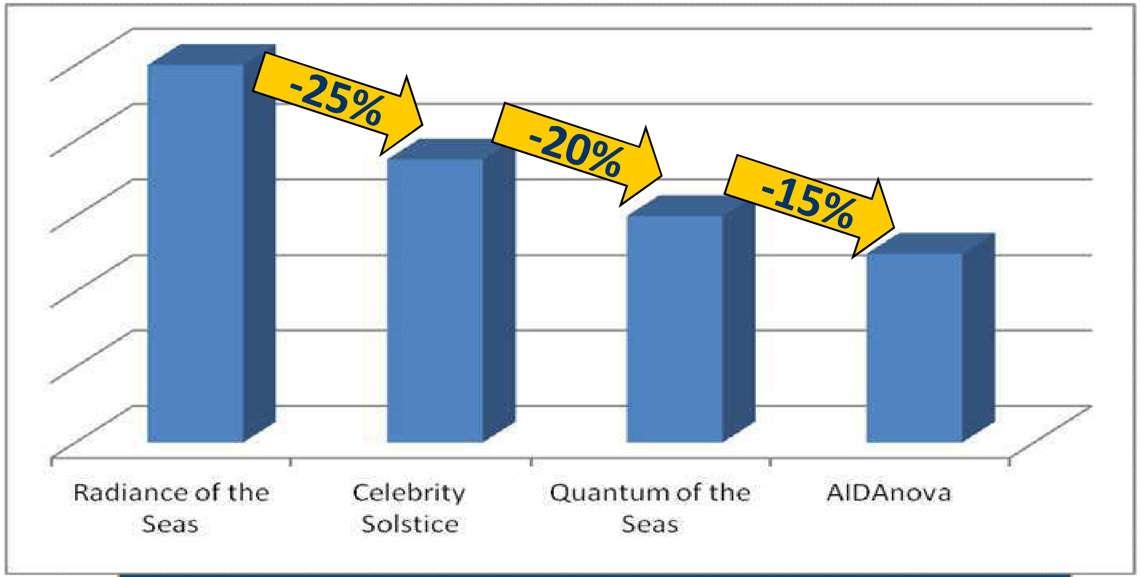
- Carbon dioxide CO_2
- Unburned methane CH_4



Change of carbon dioxide content

Energy Efficiency

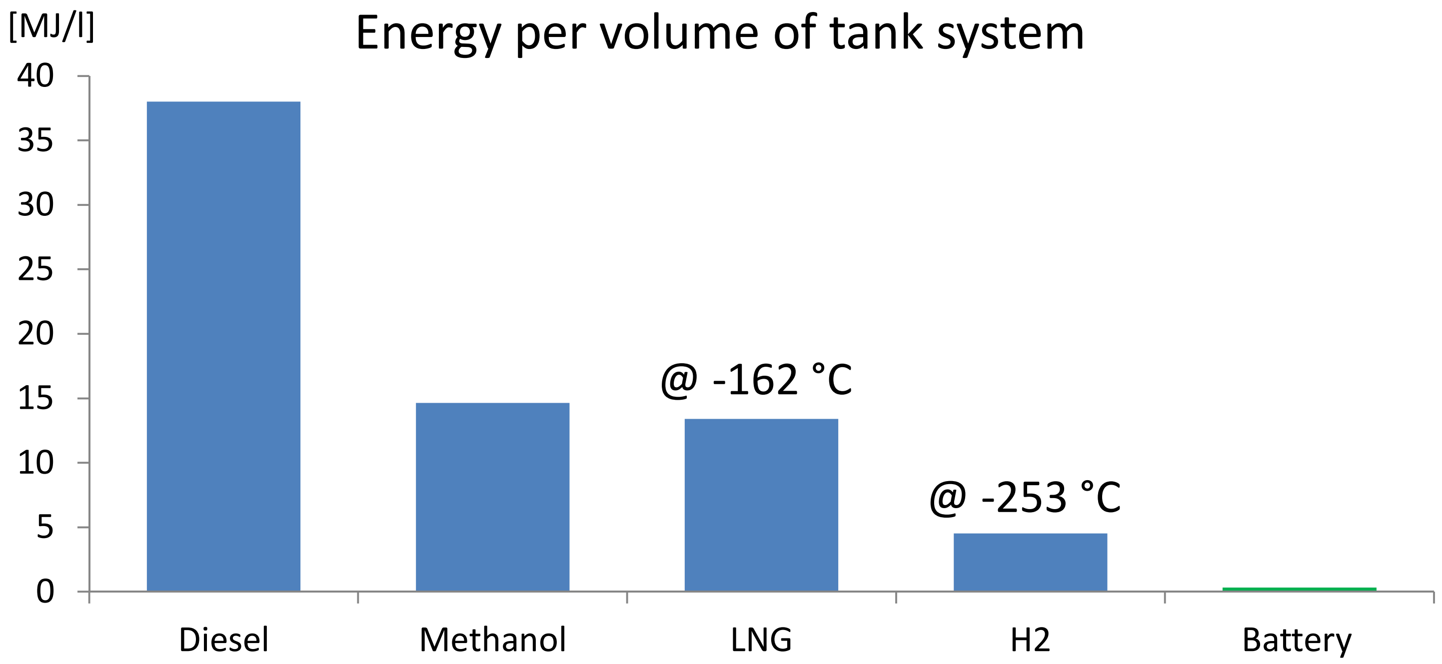
Less energy demand -> less effort:



2001	2008	2014	2018
90.090 GT 1.056 cabins 40.0 MW	122.000 GT 1.426 cabins 41.0 MW	167.400 GT 2.074 cabins 41.0 MW	183.900 GT 2.626 cabins 37.0 MW

… but efficiency alone is not enough

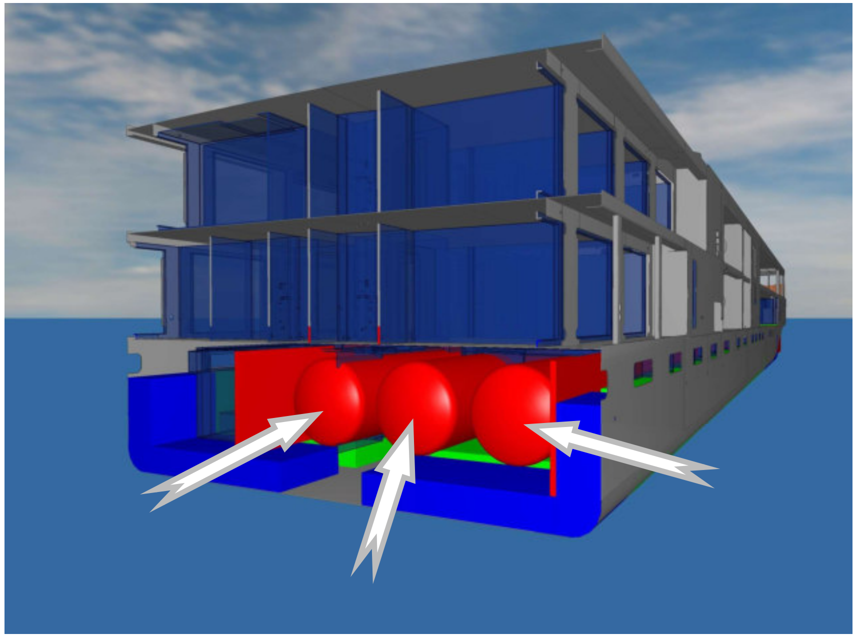
Energy storage for seagoing vessels



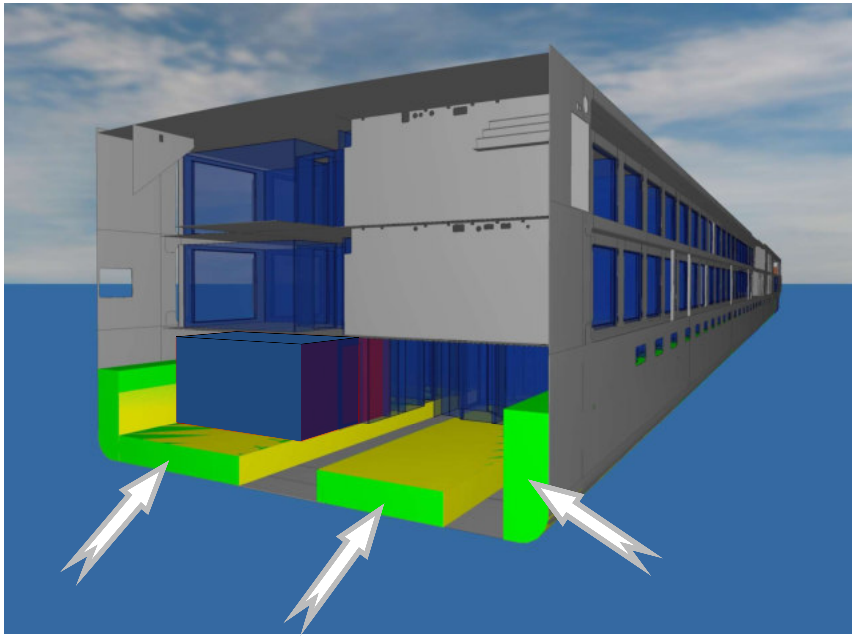
Battery and H_2 not suitable for long distances

Energy Storage on Board

Methane (LNG)



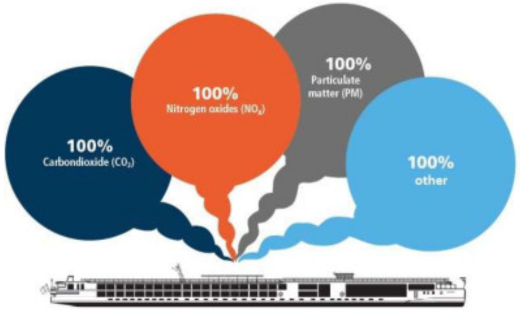
Methanol



Convenient integration required

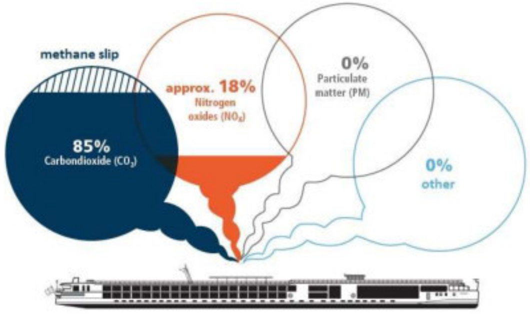
Fossil Fuels

Conventional



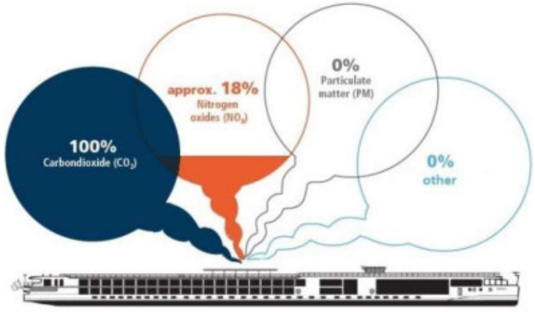
- exhaust gas treatment necessary

LNG



- gas plant, complex integration
- high space demand

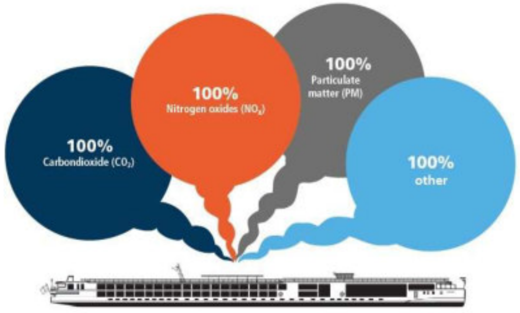
Methanol



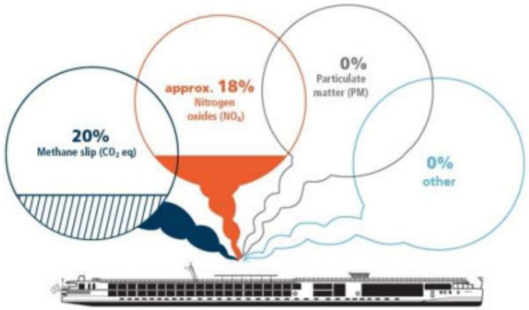
Reduce pollutans with clean fuels

Renewable Fuels

Fossil Reference



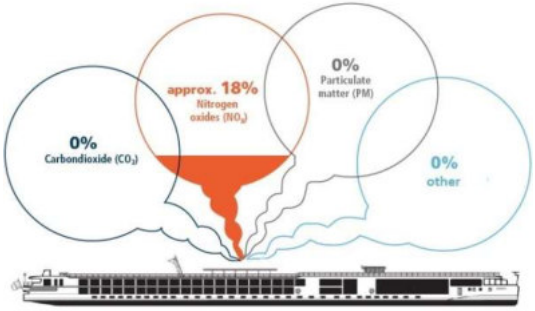
LNG



- Methane slip

-> not climate neutral

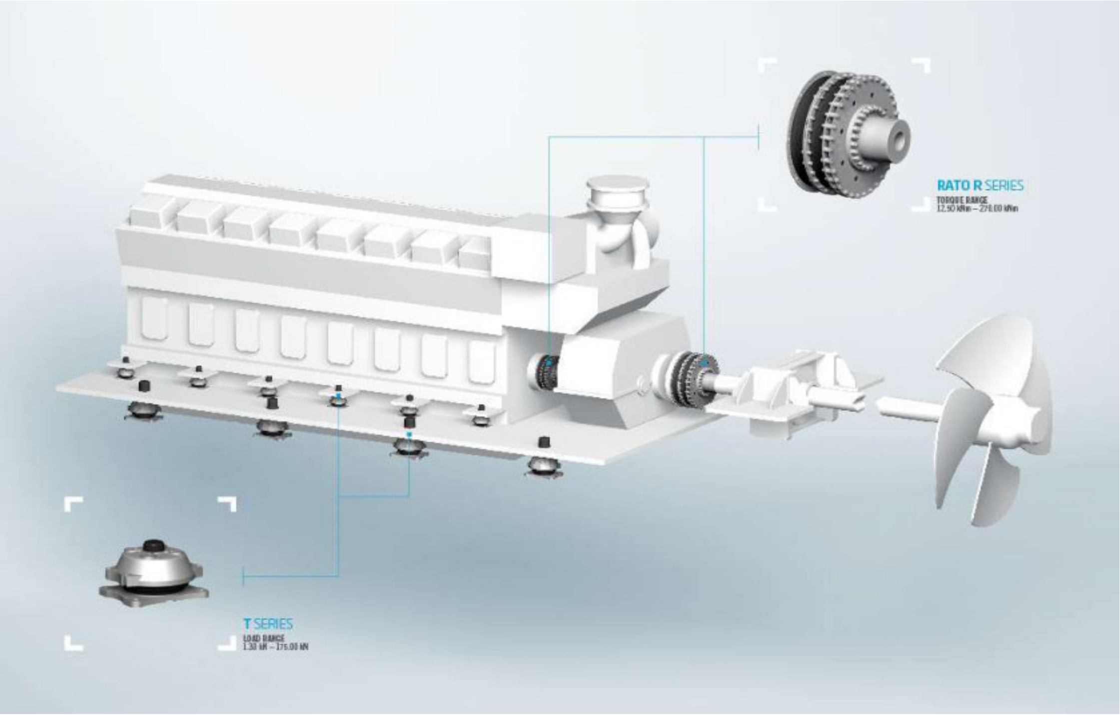
Methanol



- climate neutral

Reduce Greenhouse gases with renewable fuel production

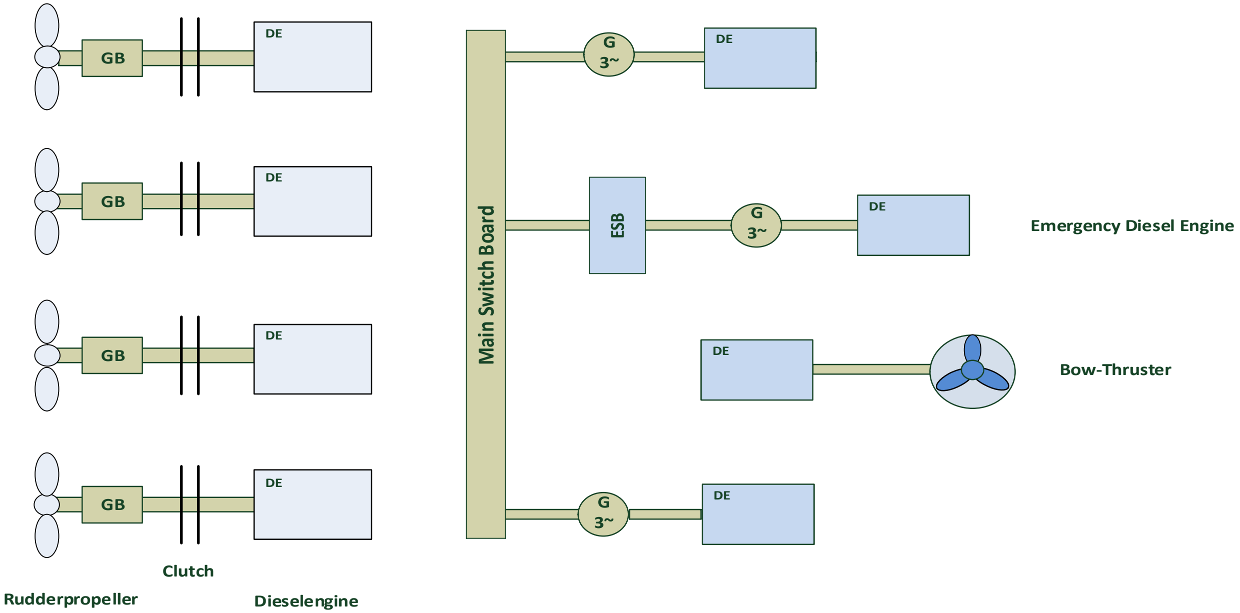
Diesel-Mechanic Drive



Quelle: www.vulkan.com

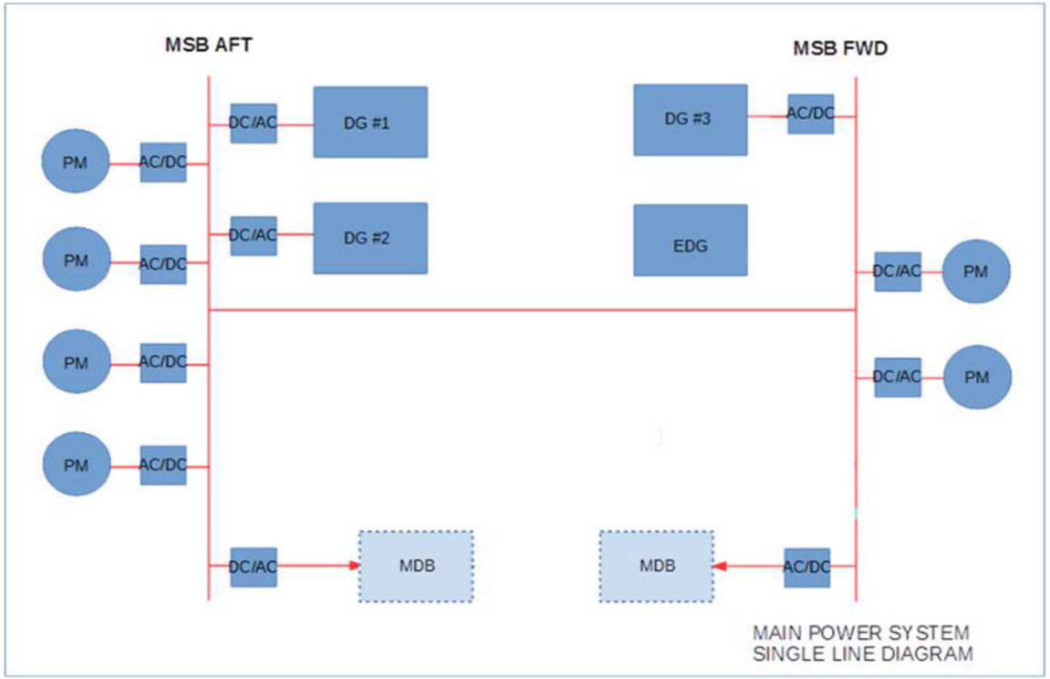
Diesel-Mechanic Plant

Engine/ Propulsion Concept



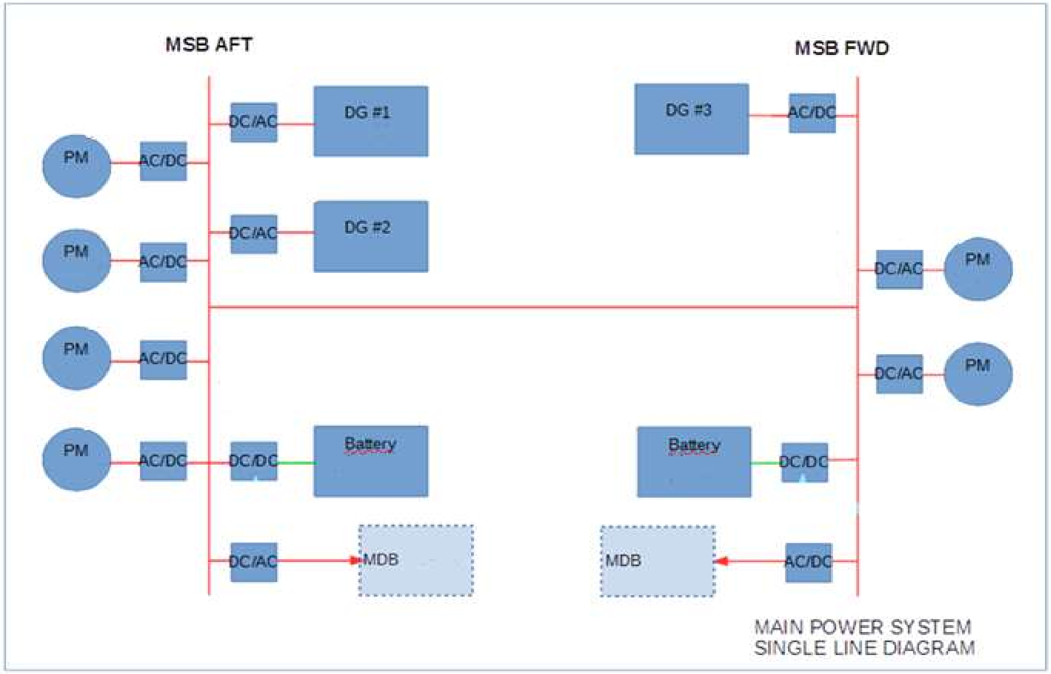
Usual Propulsion

Diesel-Electric Drive



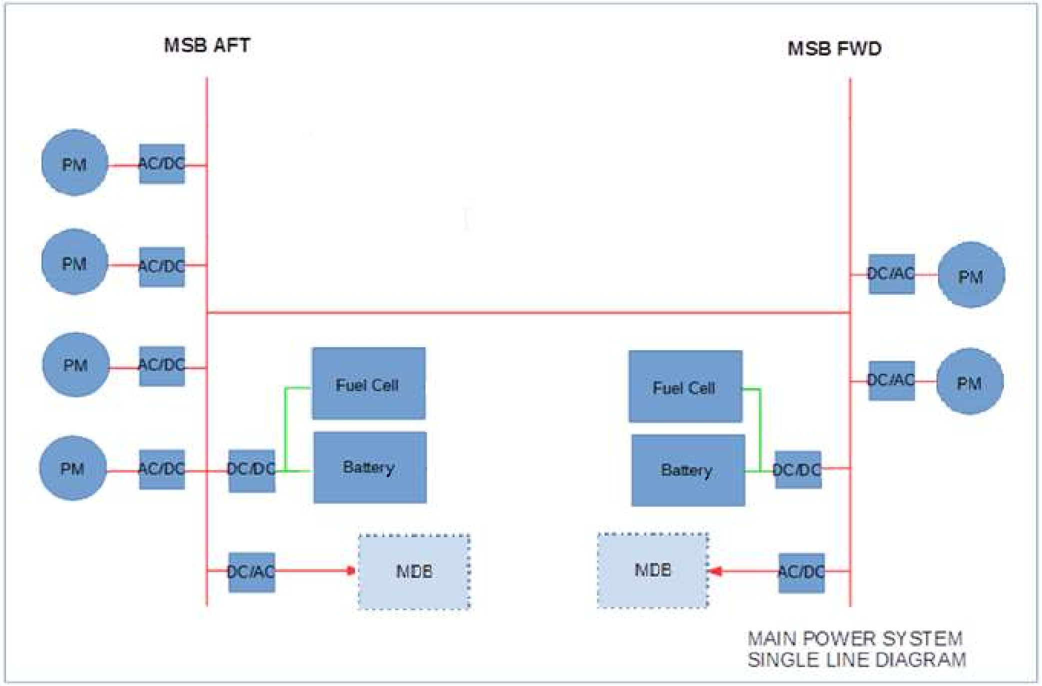
- electric drive increases flexibilty
- engine switch off in part load
- DC enables variable engine speed

Direct Current Drive with Batteries



- integration of alternative sources (batteries, photovoltaics, fuel cells)

Fuel Cell-Electric Drive with Batteries



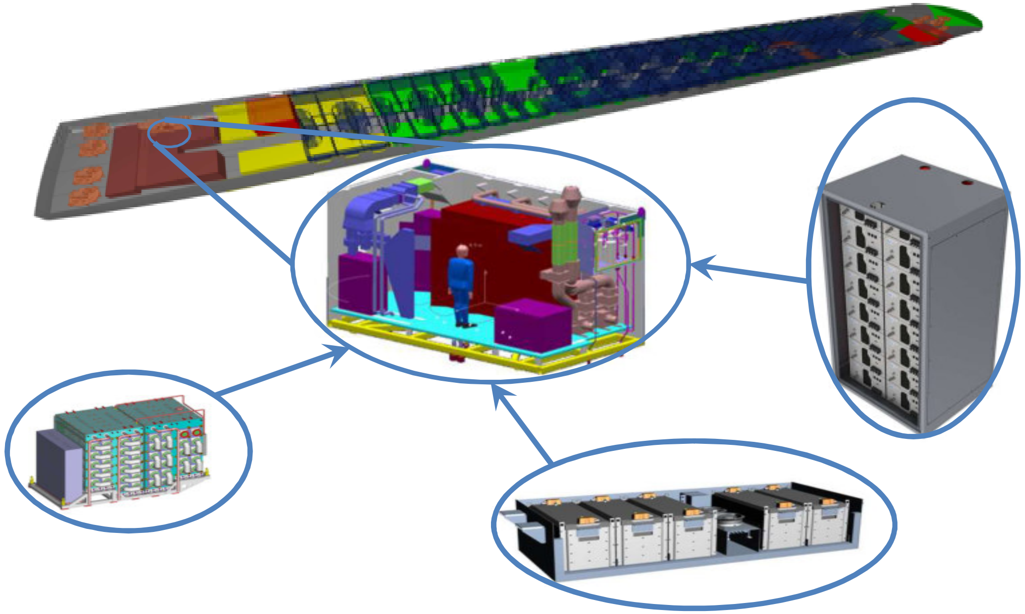
- Fuel Cells replace engines

The Concept

Modular power generation

The Fuel Cell Power Room:

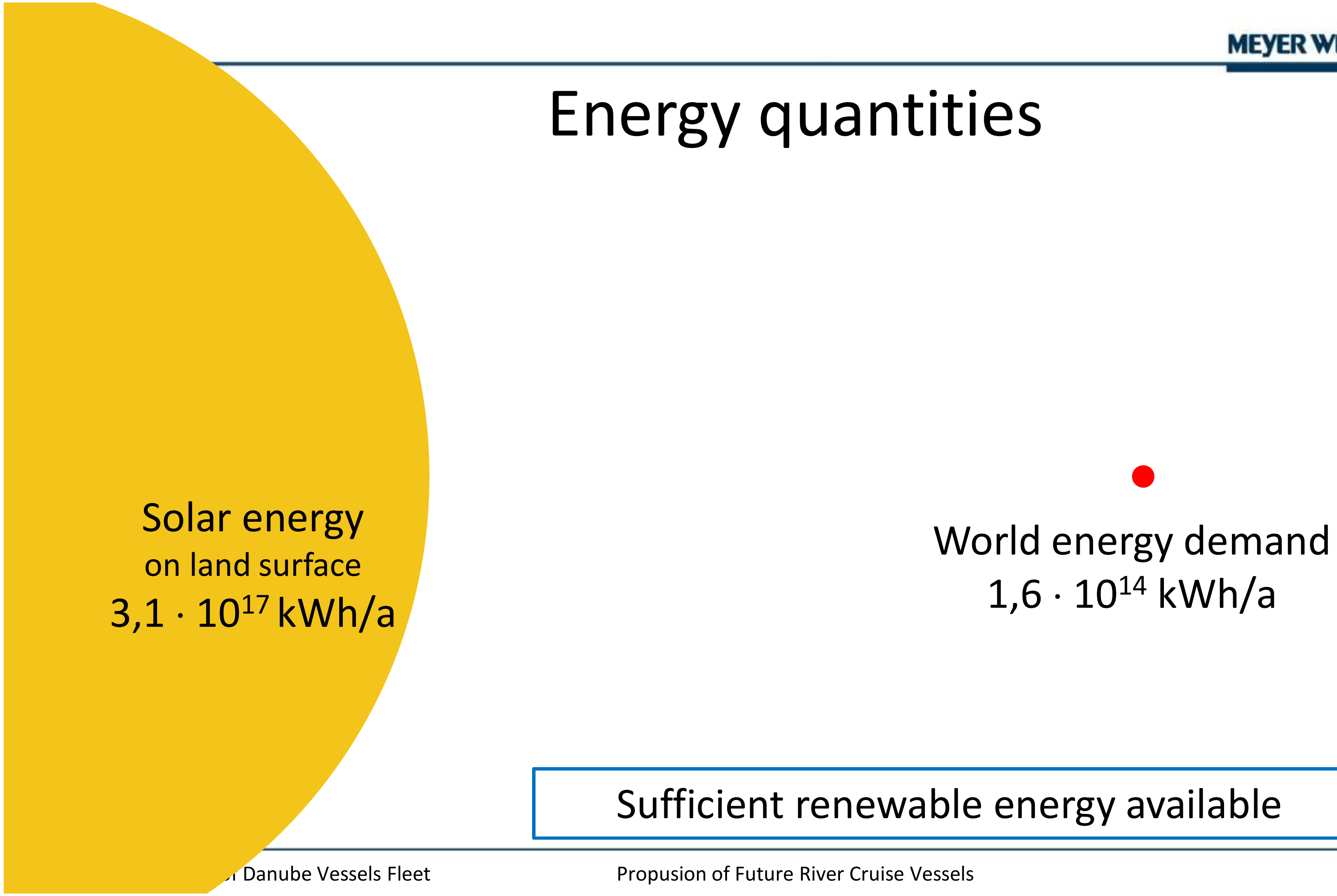
- Scalable and autonomous power supply unit with minimal interfaces to ship
    - Fuel Cell plant
    - Battery plant
    - Independent aux. systems
    - Waste heat recovery
    - Safety systems
- Flexible arrangement in ship (no noise and exhaust issues)



Summing-up

- **Sustainable and simple – from well to propeller**
- **higher efficiency – lower efford**
- **converters and systems required**
- **Clean fossil fuels as transition**

Energy quantities



Solar energy
on land surface
$3{,}1 \cdot 10^{17}$ kWh/a

World energy demand
$1{,}6 \cdot 10^{14}$ kWh/a

Sufficient renewable energy available

MEYER WERFT GmbH & Co. KG

Industriegebiet Süd
26871 Papenburg
Tel. + 49 4961 81-0
info@meyerwerft.de

MEYER WERFT
PAPENBURG 1795

NESTE
The only way is forward

Cleaner Future by new diesel?

Marku Honkanen
Sebastian Dörr

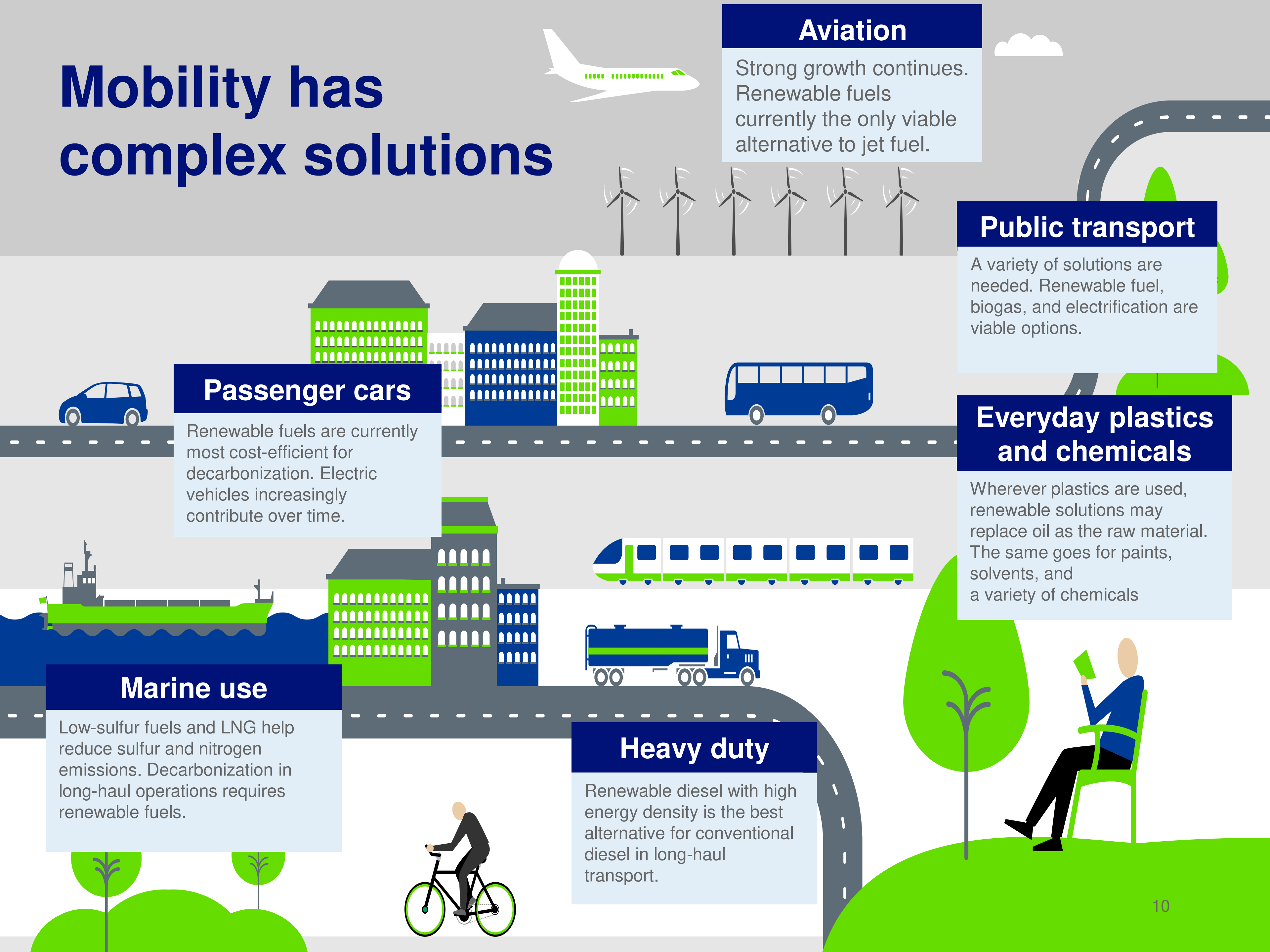
Workshop Modernisation
Danube Vessels

Chris Castanen
US Version

Table of Contents

- HVO Process
- Field Experience
- xTL vs EN 590 Diesel a new base line
- xTL volumes and sustainable feedstocks
- Innovation – super clean fuel

Mobility has complex solutions



Aviation

Strong growth continues. Renewable fuels currently the only viable alternative to jet fuel.

Public transport

A variety of solutions are needed. Renewable fuel, biogas, and electrification are viable options.

Passenger cars

Renewable fuels are currently most cost-efficient for decarbonization. Electric vehicles increasingly contribute over time.

Everyday plastics and chemicals

Wherever plastics are used, renewable solutions may replace oil as the raw material. The same goes for paints, solvents, and a variety of chemicals

Marine use

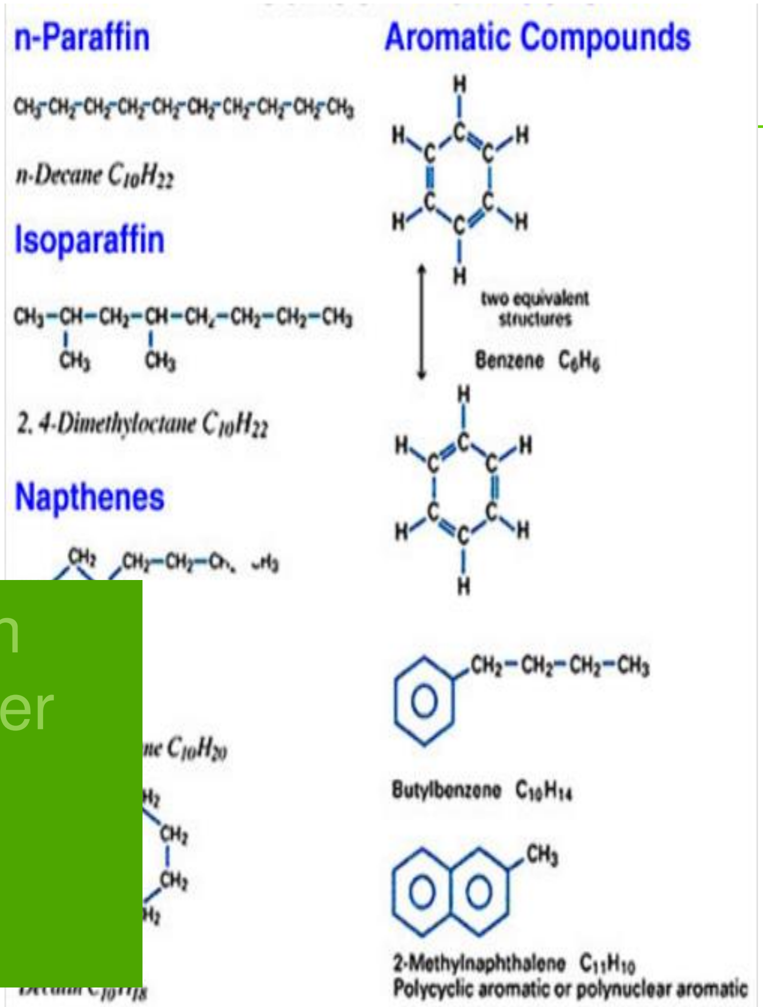
Low-sulfur fuels and LNG help reduce sulfur and nitrogen emissions. Decarbonization in long-haul operations requires renewable fuels.

Heavy duty

Renewable diesel with high energy density is the best alternative for conventional diesel in long-haul transport.

Petroleum Diesel
A collection of thousands of molecules

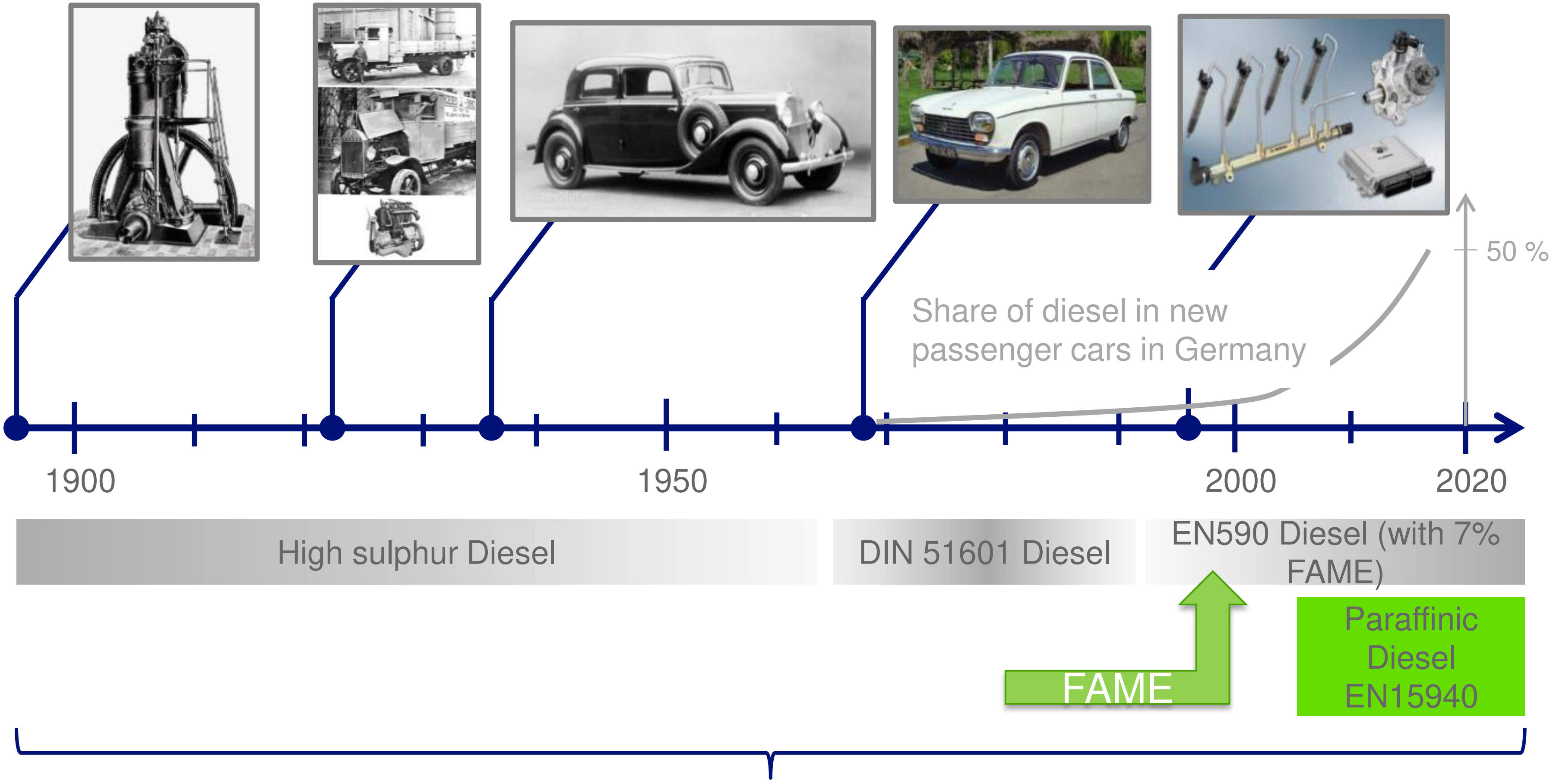
- Paraffins that burn easily and cleanly
- Cyclic Napthenes that are harder to burn but are energy dense
- Cyclic Aromatics that bring a host of complications and



- Each of these structures is found in combination and with N, S and other contaminants.
- Tens of thousands of different molecules

http://criticalfueltech.com/faq.html

Development of Diesel engine and Diesel fuel over the past century



High sulphur Diesel

DIN 51601 Diesel

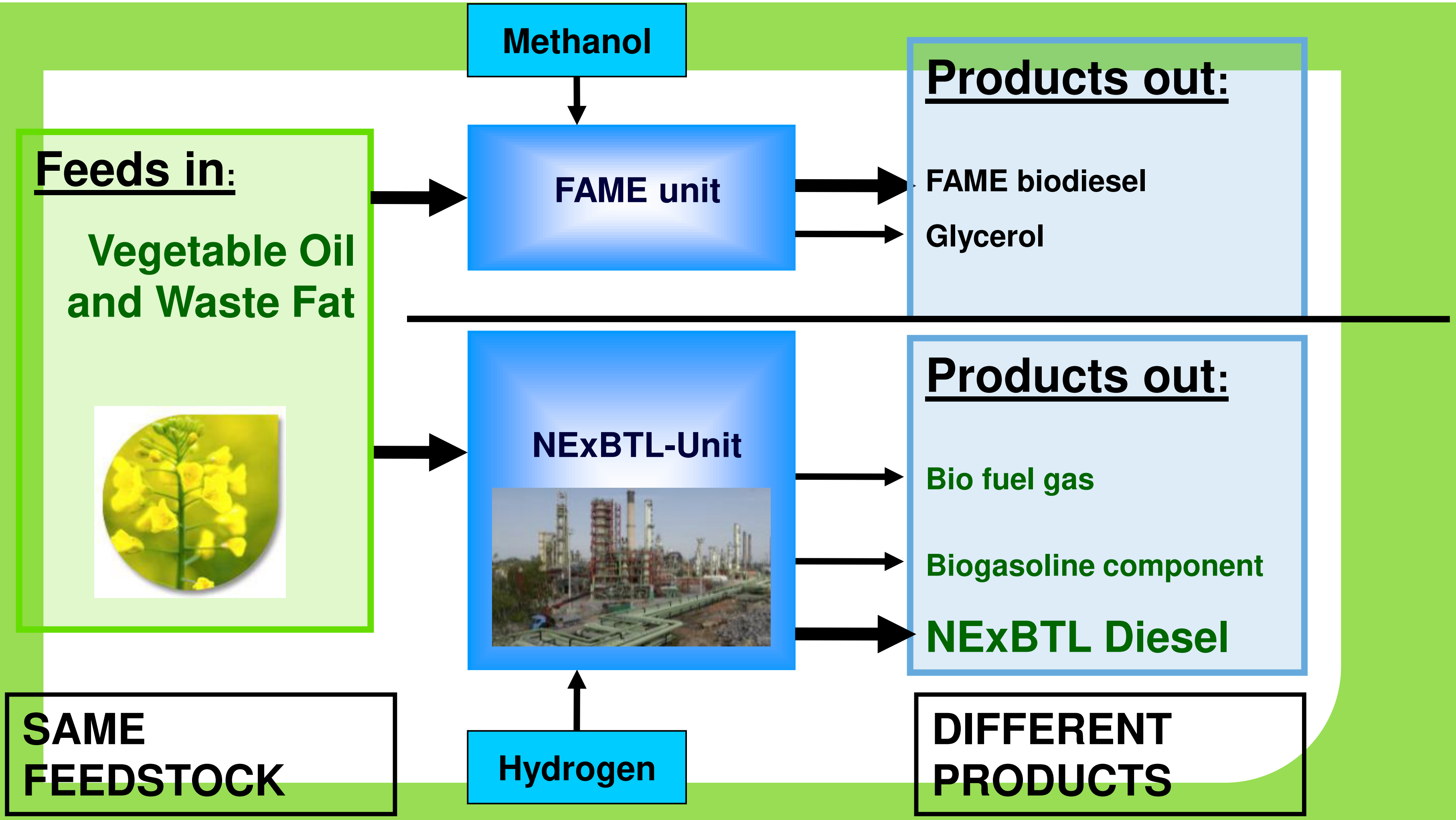
EN590 Diesel (with 7% FAME)

FAME

Paraffinic Diesel EN15940

For over 100 years Diesel fuel has not developed much and combustion engine was developed around the fuel

NExBTL & FAME Process



Methanol

Feeds in:

Vegetable Oil and Waste Fat

FAME unit

Products out:

FAME biodiesel

Glycerol

NExBTL-Unit

Products out:

Bio fuel gas

Biogasoline component

NExBTL Diesel

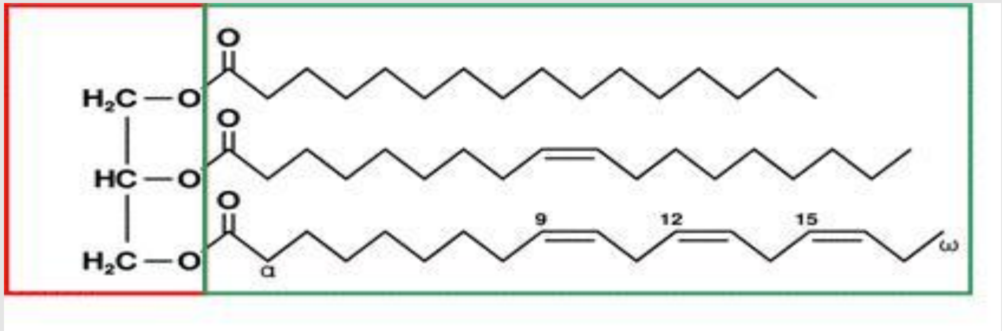
Hydrogen

SAME FEEDSTOCK

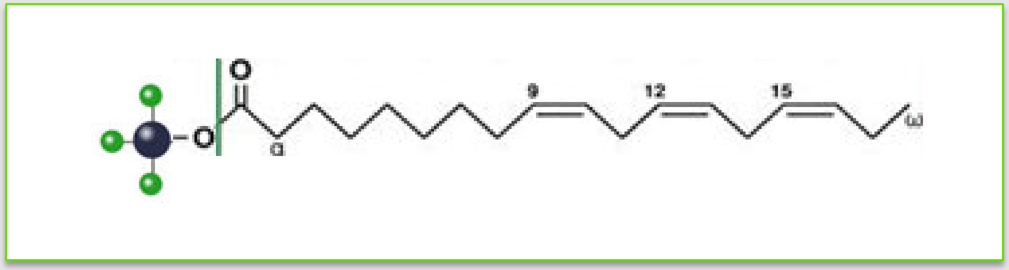
DIFFERENT PRODUCTS

Converting Triglycerides to Diesel Fuel

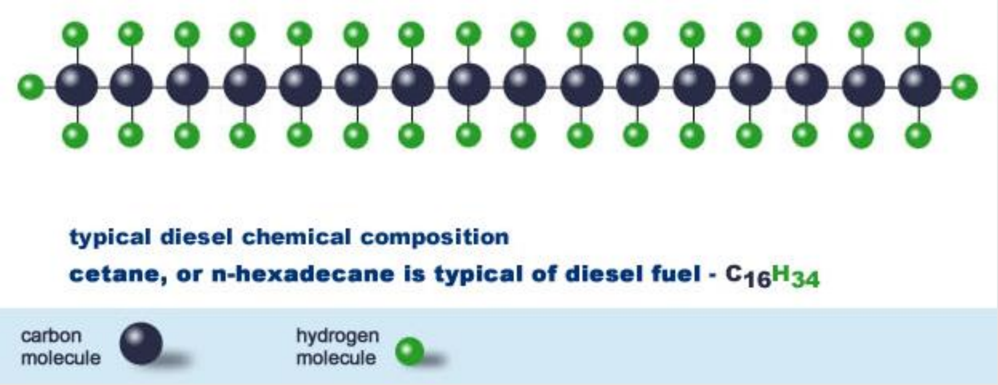
Plants and animals store energy as triglycerides. The majority are C_{16}-C_{18}



Biodiesel (FAME) liberates the Fatty Acids leaving the Oxygen and unsaturated bonds



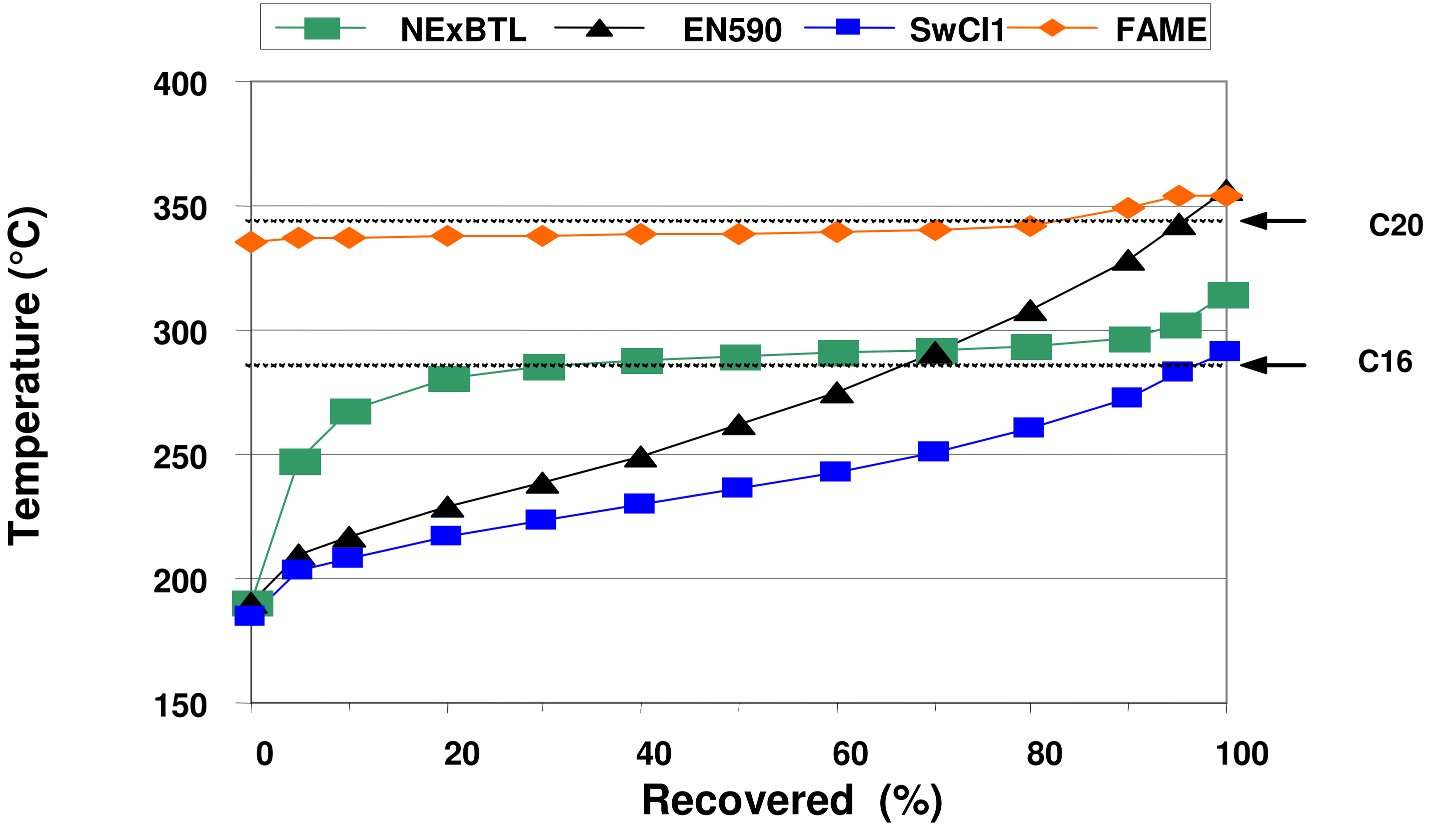
NEXBTL (HVO) creates fully saturated paraffin diesel and propane



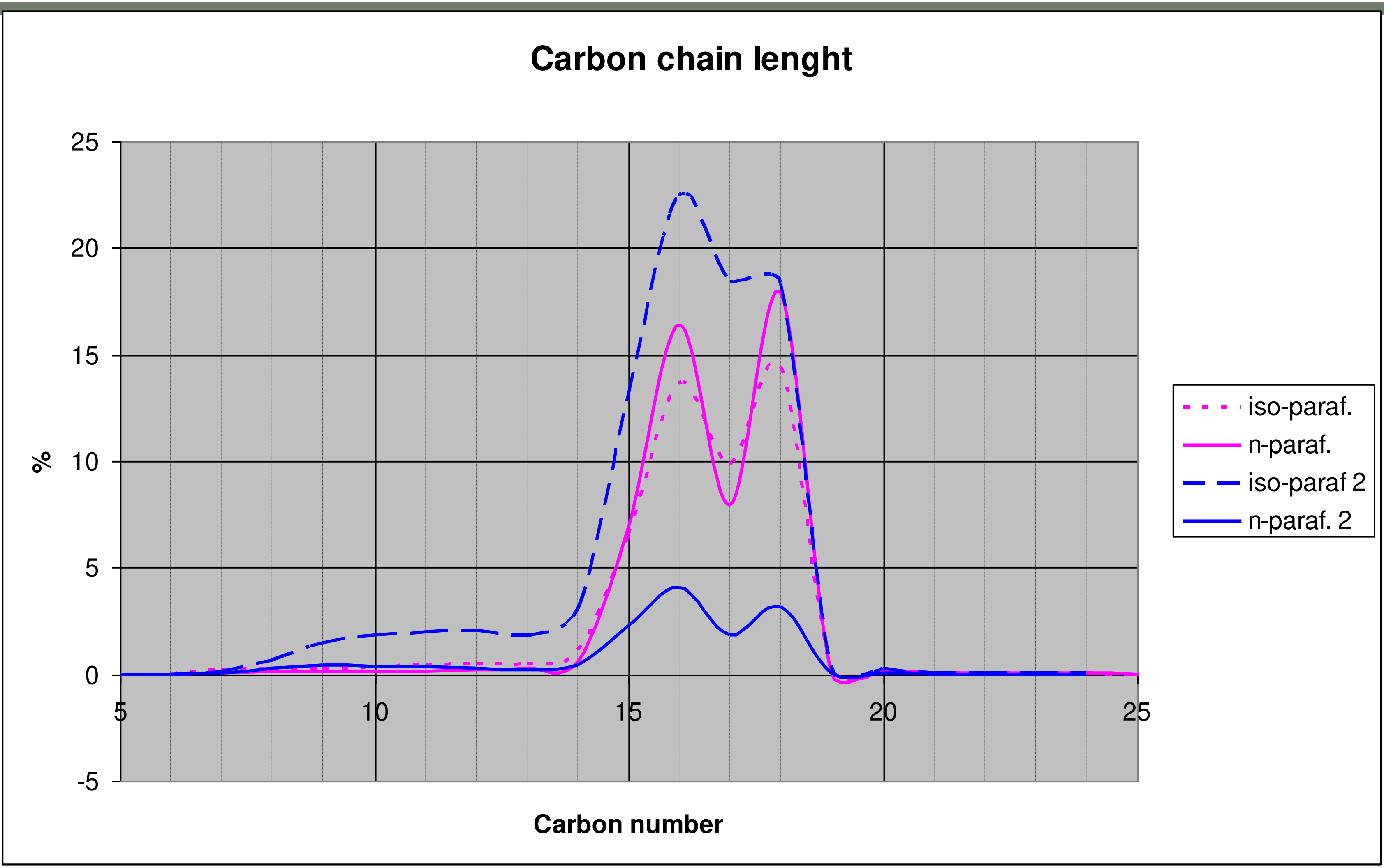
HVO - diesel

- Next step from traditional Biodiesel
- Improved Technology and Product
- Pure Hydrocarbon, fully compatible with Mineral Diesel
- No compromises on Fuel Quality or Vehicle Performance
- In Commercial Production

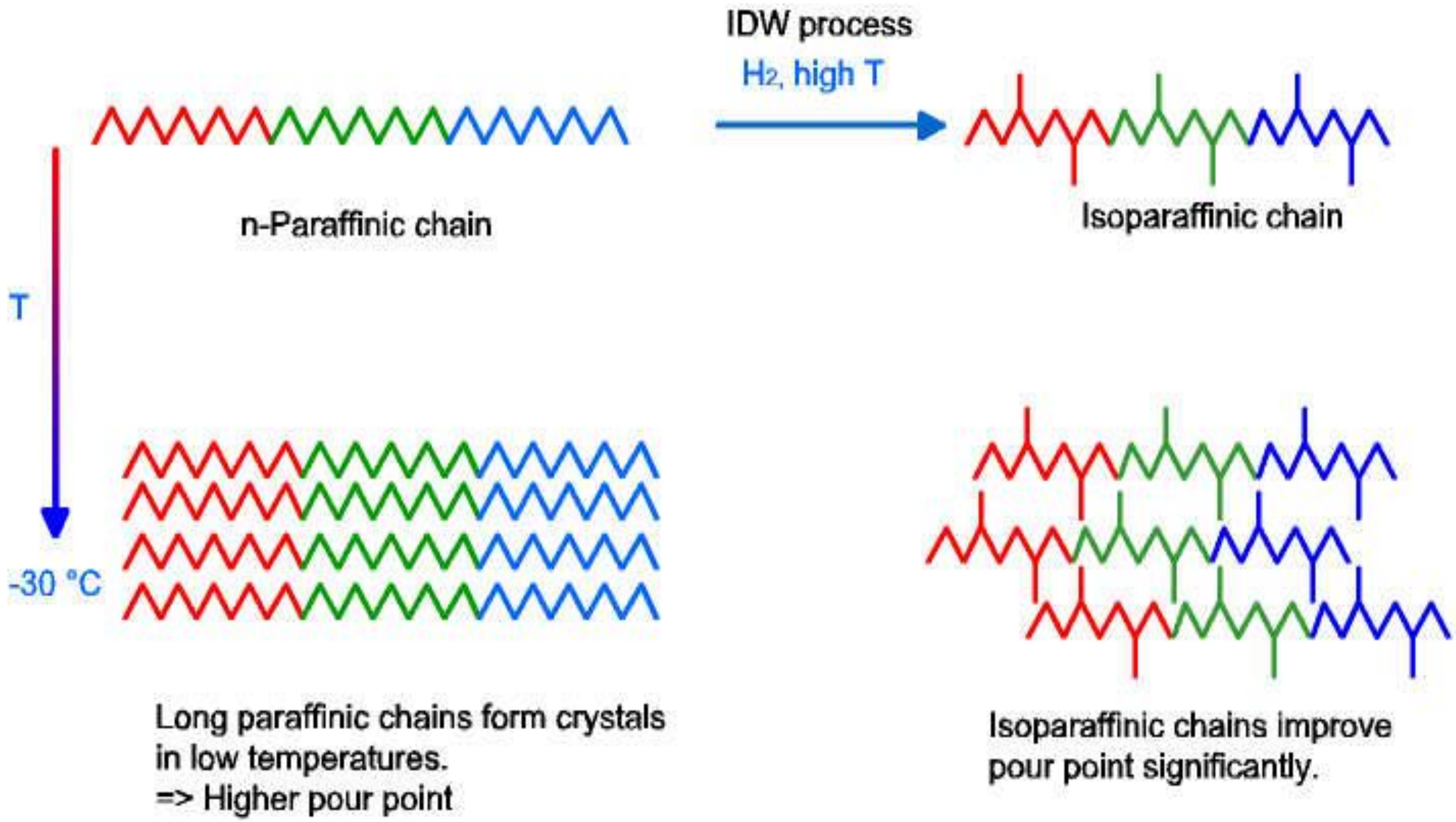
Distillation curves



Carbon distribution



IDW process
Low temperature properties



IDW process

H_2, high T

n-Paraffinic chain

Isoparaffinic chain

T

-30 °C

T

-30 °C

Long paraffinic chains form crystals in low temperatures.
=> Higher pour point

Isoparaffinic chains improve pour point significantly.

HVO (xTL) significantly reduces greenhouse gas and tailpipe emissions

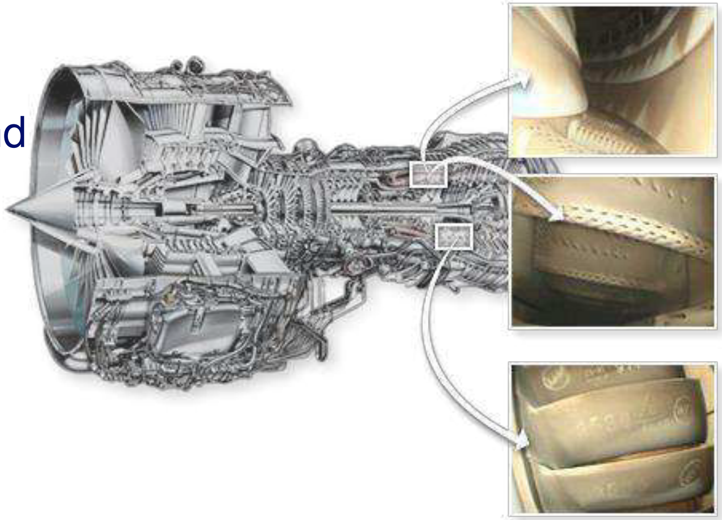
50 million kilometers covered in the world's largest biofuel trial (Helsinki 2007-2010)

HVO contributes to a significant reduction in exhaust emissions:

- Nitrogen oxide (NOx)
  10% reduction
- Particulates (PM)
  30% reduction
- Greenhouse gases
  (LCA-GHG)
  >50% reduction

Perfect fuel for aviation

1. During the operation
Aircraft and engine performed excellently
1% lower fuel consumption due
to the higher energy content
2. Inspection after the program
Fuel system, combustion chamber and
turbines in a perfect condition
Normal function and tightness of
fuel bearing parts
3. Storage stability
Density steady at 783 kg/cbm
No microbial issues



Source of the picture: Lufthansa

Renewable raw materials

Flexible raw material mix

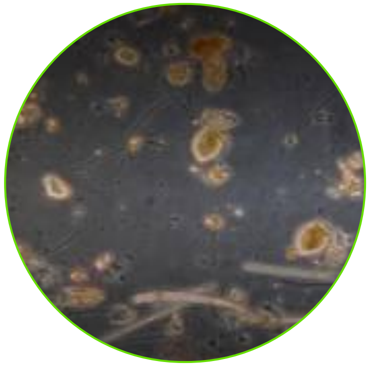
- Neste renewable products can be produced flexibly from a mix of various vegetable oils and waste and residues
- The products have constant high quality independent from raw material used

Expanding our raw material portfolio

Short term

Long term

Waste animal fats, waste oils, residue and side streams



Biological pathways

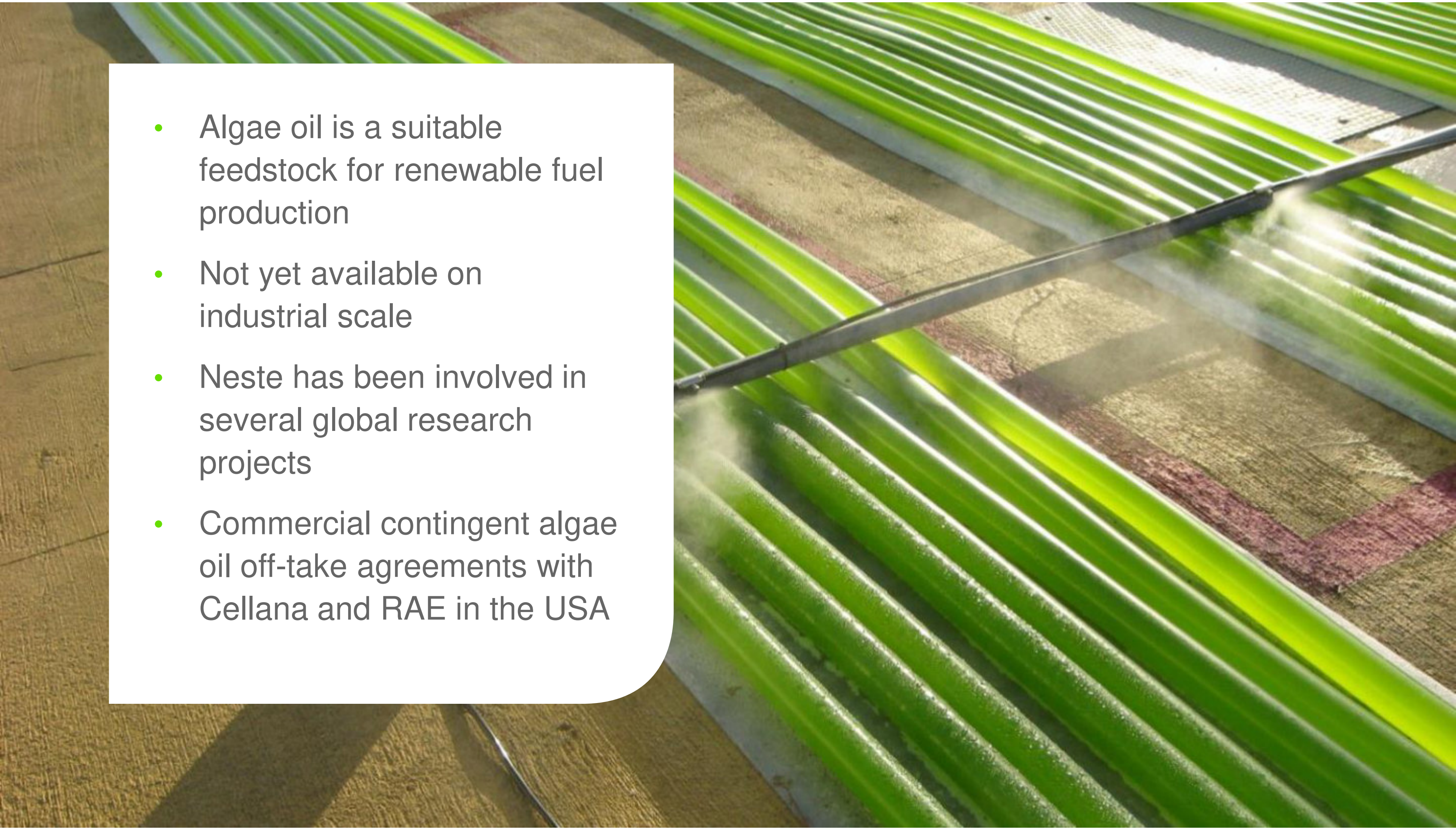
Thermo-catalytic pathways

Photo-synthesis

Cutting-edge research

- Continuous research to expand renewable raw material base and further develop NEXBTL technology
- 70% approx. euro 41 million of R&D costs in 2015
- Cooperation with over 20 research institutions around the world
- Approx. 1,000 people working with research and engineering

Microalgae oil – one of the future raw material alternatives



- Algae oil is a suitable feedstock for renewable fuel production
- Not yet available on industrial scale
- Neste has been involved in several global research projects
- Commercial contingent algae oil off-take agreements with Cellana and RAE in the USA

How sustainability can be measured

– example by Corporate Knights

Starting Universe

All publicly-listed companies with latest gross revenue of a minimum of US$1 billion* (~7,300 companies) are assessed based on public domain data.

Screening

4 screening criteria: sustainability disclosure practices (~90% dropped out), financial health, product category, and financial sanctions → shortlist of 100 companies

Selection

21 performance indicators (KPI) - not a reputation or opinion survey:

Financial management
(e.g. R&D spend, taxes paid)

Resource management
(e.g. environmental emissions, energy, climate)

Employee management
(e.g. pension fund status, employee turnover)

New KPIs:
Clean Revenue, Sanctions

The Global100

100 best according to 21 KPI’s

Source: Criteria for Global 100 most sustainable companies by Corporate Knights

OUR VISION:

We create responsible choices every day.

Global 100: Neste is the world's **3rd** most sustainable company.

NESTE

NEXBTL production capacity of 2.4 Mt/a

Unit	Capacity	Year
Finland #1	200 000 t/a	2007
Finland #2	200 000 t/a	2009
Singapore	1 000 000 t/a	2010
Rotterdam	1 000 000 t/a	2011

All Neste’s NEXBTL plants are ISCC-EU and EPA-approved.
Neste’s aim is to increase production capacity to 2.6 million t/a by 2017.

Emerging local competition offers more support for biofuels

Emerging HVO competitors

ENI

- Conversion of Venice refinery to HVO production plant completed in 2014
- Planned conversion of Gela refinery to HVO production plant

TOTAL

- Conversion of La Mede refinery to HVO production by 2017
- Conversion of Dunkirk refinery by 2017 (not HVO)

PREEM

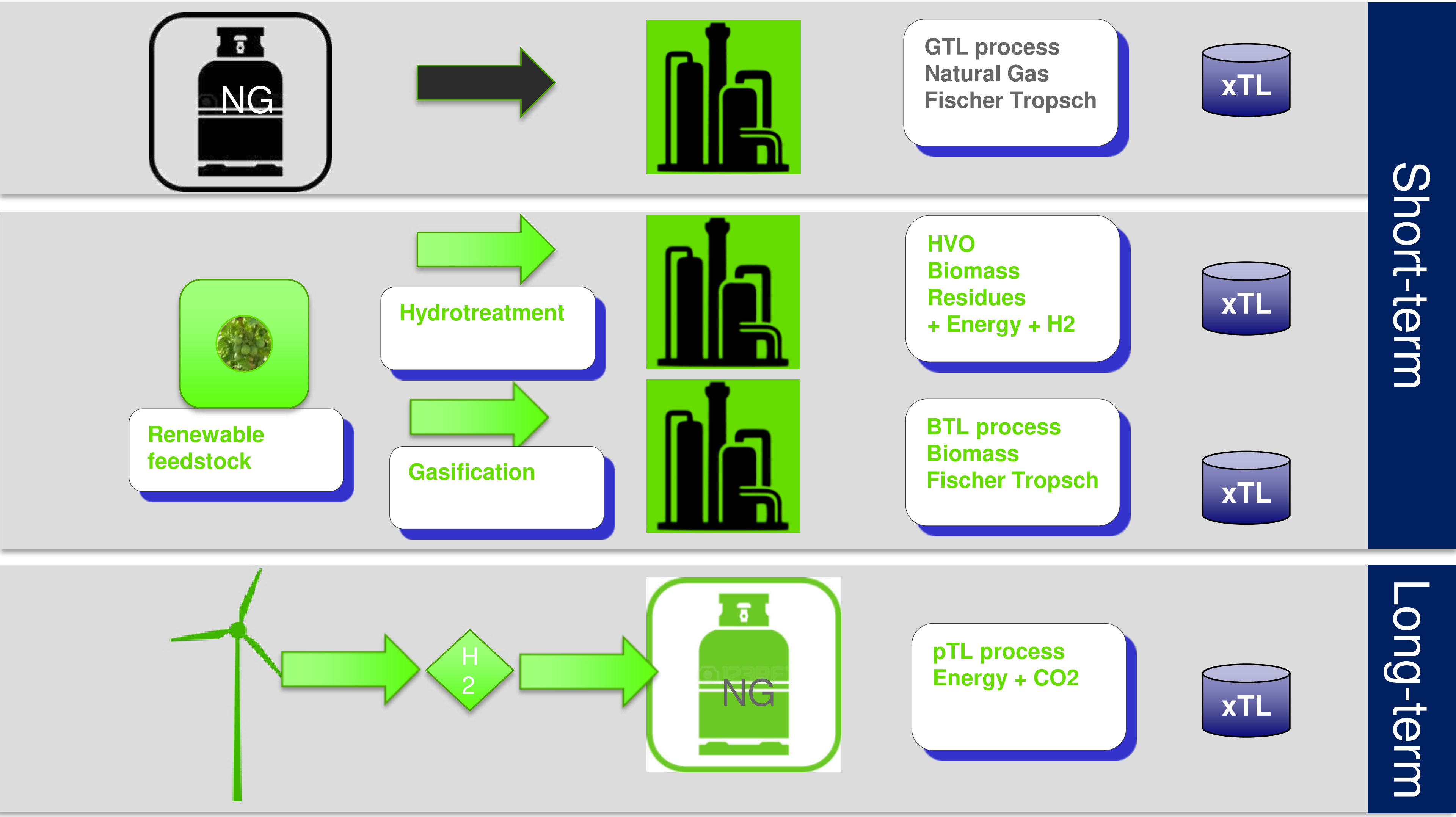
- Plan to double biofuel production in 2015

UPM

- Commercial production of HVO from tall oil in Finland since Q1/2015

Total potential capacity approx. 2 Mton/a

xTL Feedstock and Process



GTL process
Natural Gas
Fischer Tropsch

Renewable feedstock

Hydrotreatment

HVO
Biomass
Residues
+ Energy + H2

Gasification

BTL process
Biomass
Fischer Tropsch

pTL process
Energy + CO2

xTL Feedstocks and Processes

	CTL **GTL**	**HVO Renewable diesel**	**BTL**	**PTL**
Raw material	Black Coal Brown Coal Natural Gas	Vegetable Oil fatty waste residues	Biomass	From Electric Power to H2 Methan
Tec				om ces
End product	Fossil based paraffinic hydrocarbon	hydrocarbon (renewable diesel, jet fuel, bionaphta, biopropane)	(renewable gasoline, jet fuel, diesel)	Renewable paraffinic hydrocarbon
Chemical composition	C_nH_{2n+2}	C_nH_{2n+2}	C_nH_{2n+2}	C_nH_{2n+2}

xTL hydrocarbon diesel is fully compatible with petroleum diesel and can be produced from many different sources and processes

CTL = Coal to liquid
GTL = Gas to liquid

HVO = Hydrotreated Vegetable Oil, advanced biofuel i.e. renewable fuel
BTL = Biomass to Liquid
PTL = Power to Liquid

xTL (EN 15940)- Superior Quality

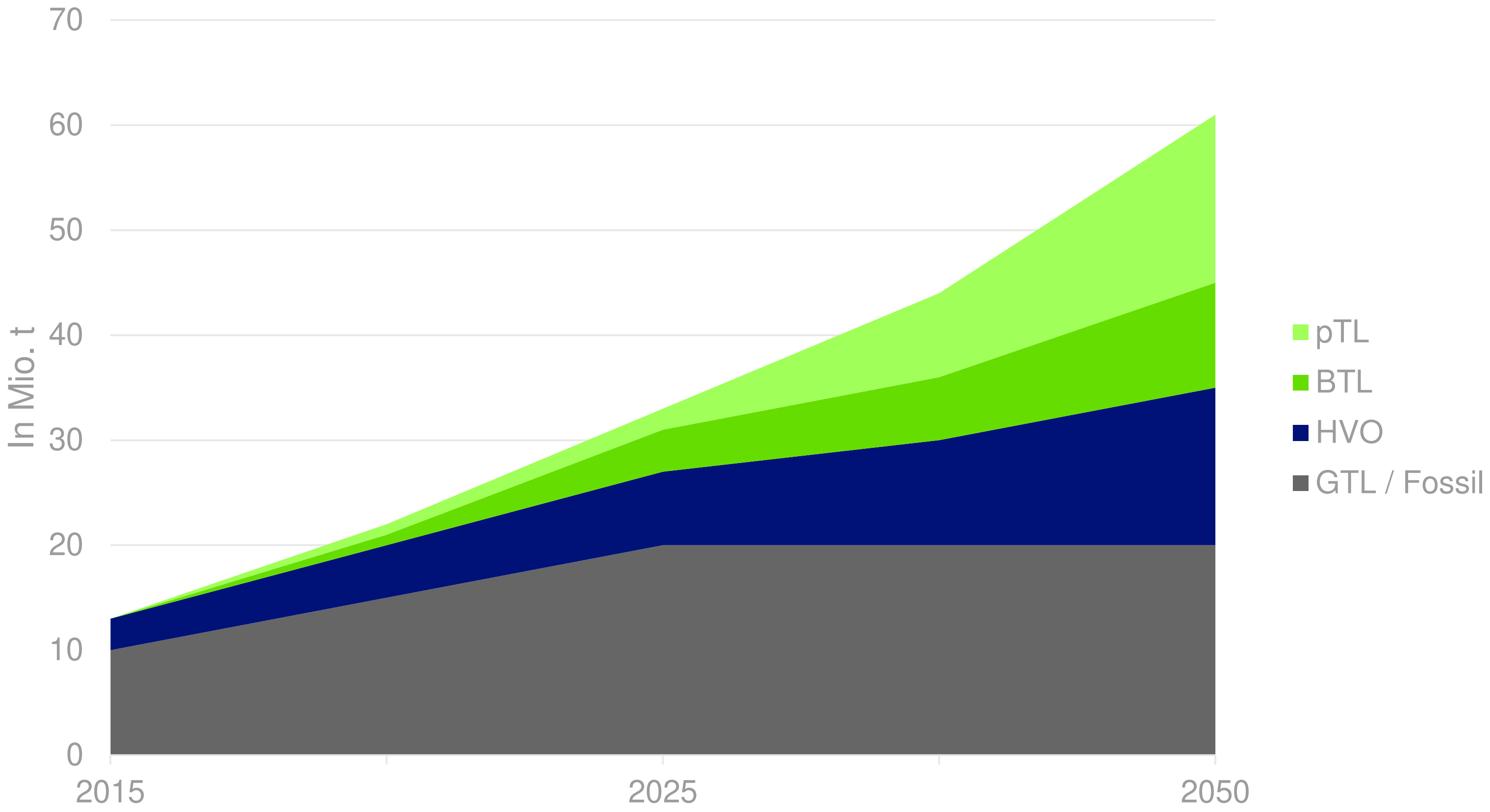
Fuel Properties Typical values	**EN590 diesel fuel**	**xTL fuels**
Cetane number	**53**	**75-99**
Cloud point (°C)	**0 - -12**	**-5...-30**
Heating value (lower) (MJ/kg)	**43**	**44**
Heating value (lower) (MJ/l)	**36**	**34**
Density at +15 °C (kg/m3)	**835**	**780**
Sulfur content (mg/kg)	**< 10**	**0**
Distillation range °C	**180-360**	**180 - 320**

xTL – reduced emissions

xTL diesel

Diesel fuel with aromatic content

xTL Potential Volumes



Field tests and experience

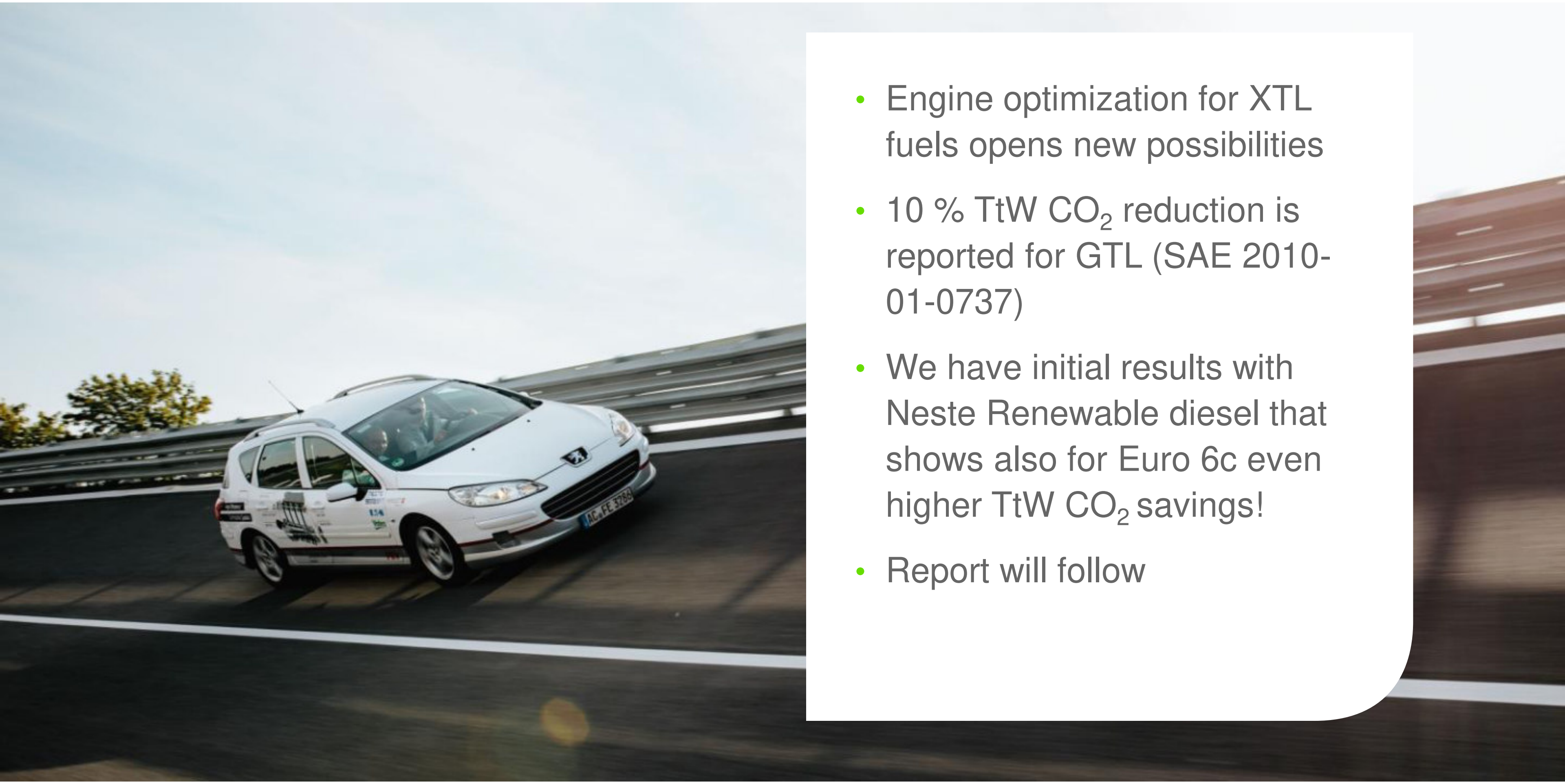
HVO100 - from fleet tests to commercial operations

- **Helsinki bus fleet test**, 2007-2010, 300 vehicles of different makes and emission classes
- **DHL-Daimler-Stuttgart Public Transport**, 2008-2011, semitrailers, vans, buses, 3 million km
- **Scania 60 ton fuel tankers**, 300,000 km
- **Volvo- DHL-Renowa**, Euro V and Euro VI trucks in Sweden
- **Swebol Logistic**, Volvo and Scania trucks in Sweden

- **Commercial use of 100% NEXBTL started about 2 years ago**
- **Austria:** around 5000 vehicles run daily on NEXBTL (semitrailers, trucks, agricultural machinery, snow cats)
- **USA:** more than 5,000 vehicles (trucks, busses, construction machinery, i.e. for mines)
- **Sweden:** over 30 fleets with more than 1000 vehicles
- **Netherlands:** several fleet operations and free sales to end consumers as well as off-road
- **Finland:** Helsinki buses

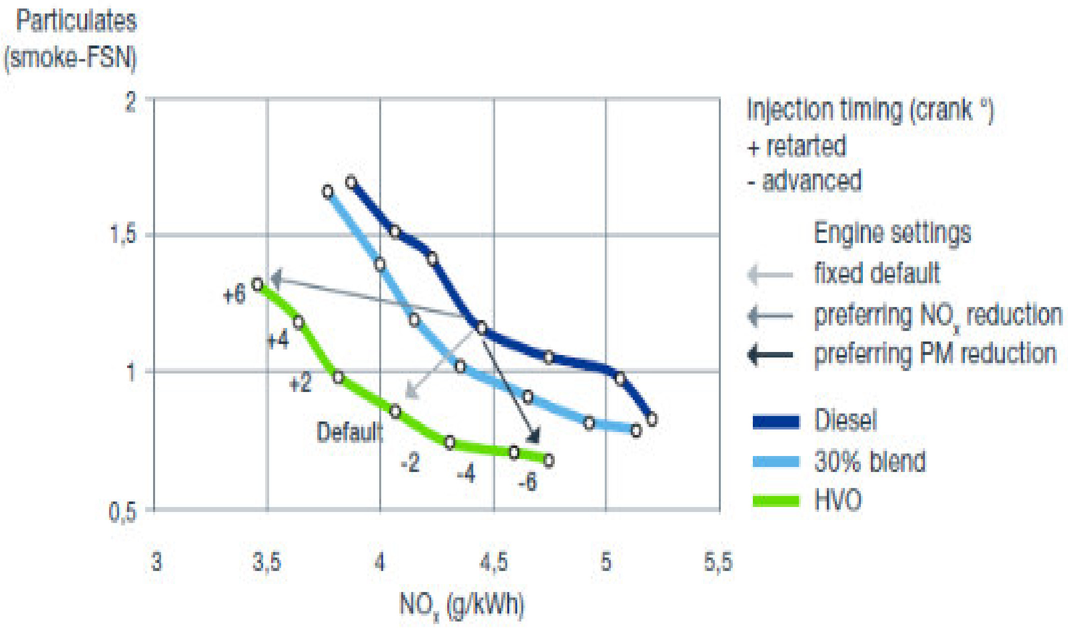
- **Reliable operations**
- **Similar service intervals**
- **Significantly reduced GHG and tailpipe emissions**

CO_2 reduction with XTL



- Engine optimization for XTL fuels opens new possibilities
- 10 % TtW CO_2 reduction is reported for GTL (SAE 2010-01-0737)
- We have initial results with Neste Renewable diesel that shows also for Euro 6c even higher TtW CO_2 savings!
- Report will follow

Fuel Plays a Role in Engine Out Emissions



- In 2008 a non road engine test at one speed and load shows
- That injection timing can be advanced about 4 deg with same NOx level
- Significant PM reduction
- When changing from EN590 to HVO

XTL in future mobility

EN 15940 Parafinic Diesel Plattform

WWFC Category V Field test experience and Euro VI approvals

Engine Optimisation brings significant efficiency gains!

Together with Bio Oxygen Componets Ultra clean Diesel Fuel Concept

ADVANCED FUEL FORMULATION APPROACH USING BLENDS OF PARAFFINIC AND OXYGENATED BIOFUELS: ANALYSIS OF EMISSION REDUCTION POTENTIAL IN A HIGH EFFICIENCY DIESEL COMBUSTION SYSTEM

Presenter:

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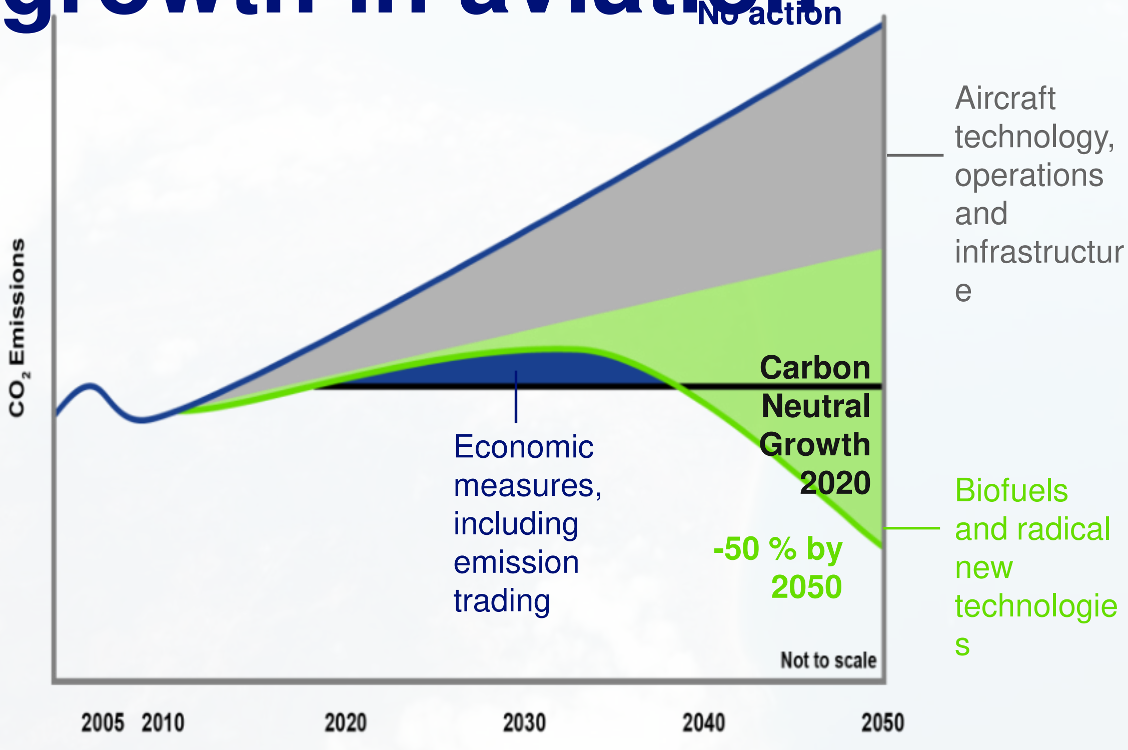
S. Doerr and J.Nuottimäki	NESTE Inc.

Renewable jet fuel is currently the only viable fuel solution for decarbonizing growth in aviation



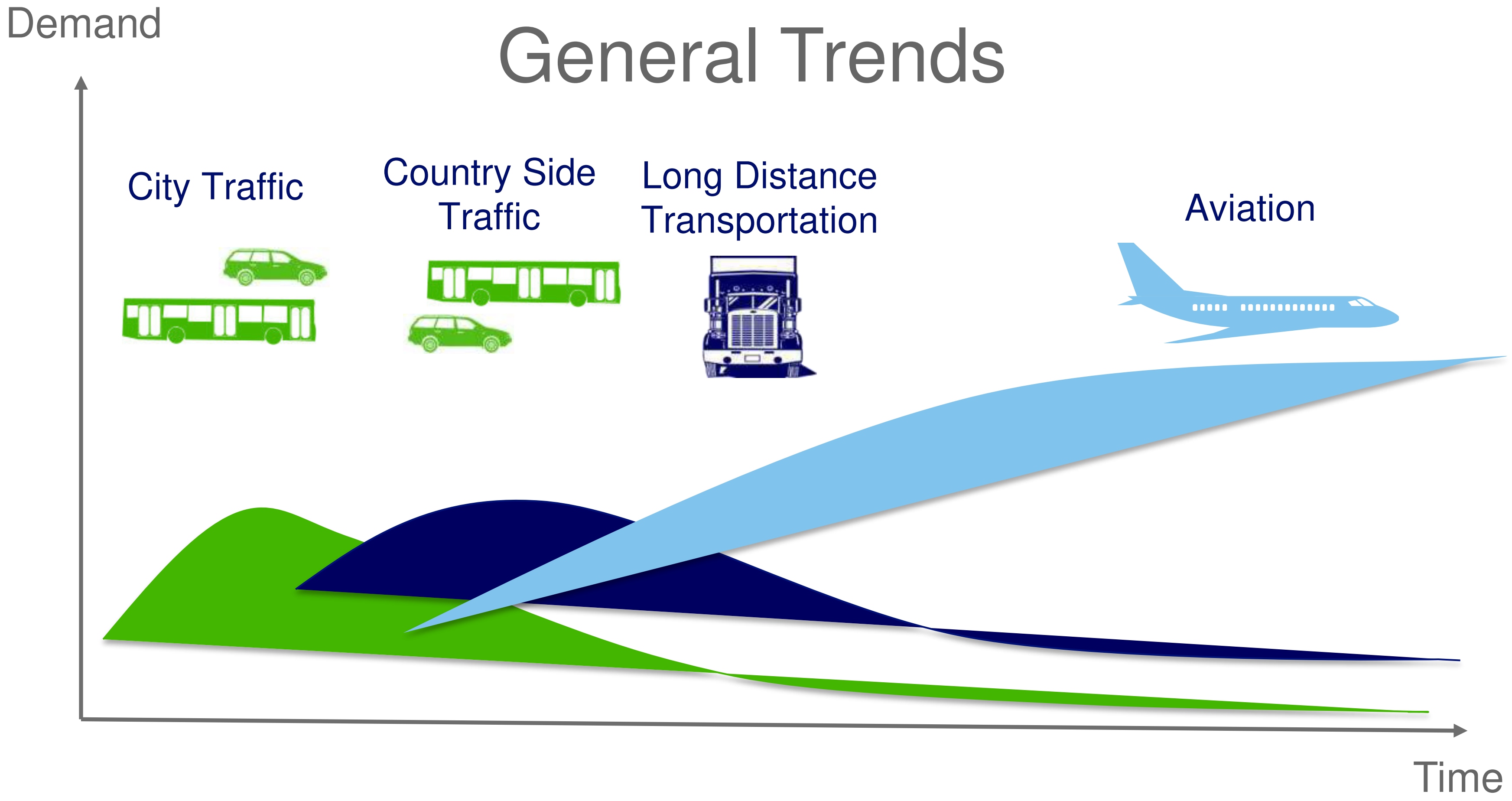
Source: International Aviation Transport Association, *Technology Roadmap 4th Edition,* 2013

Did you know

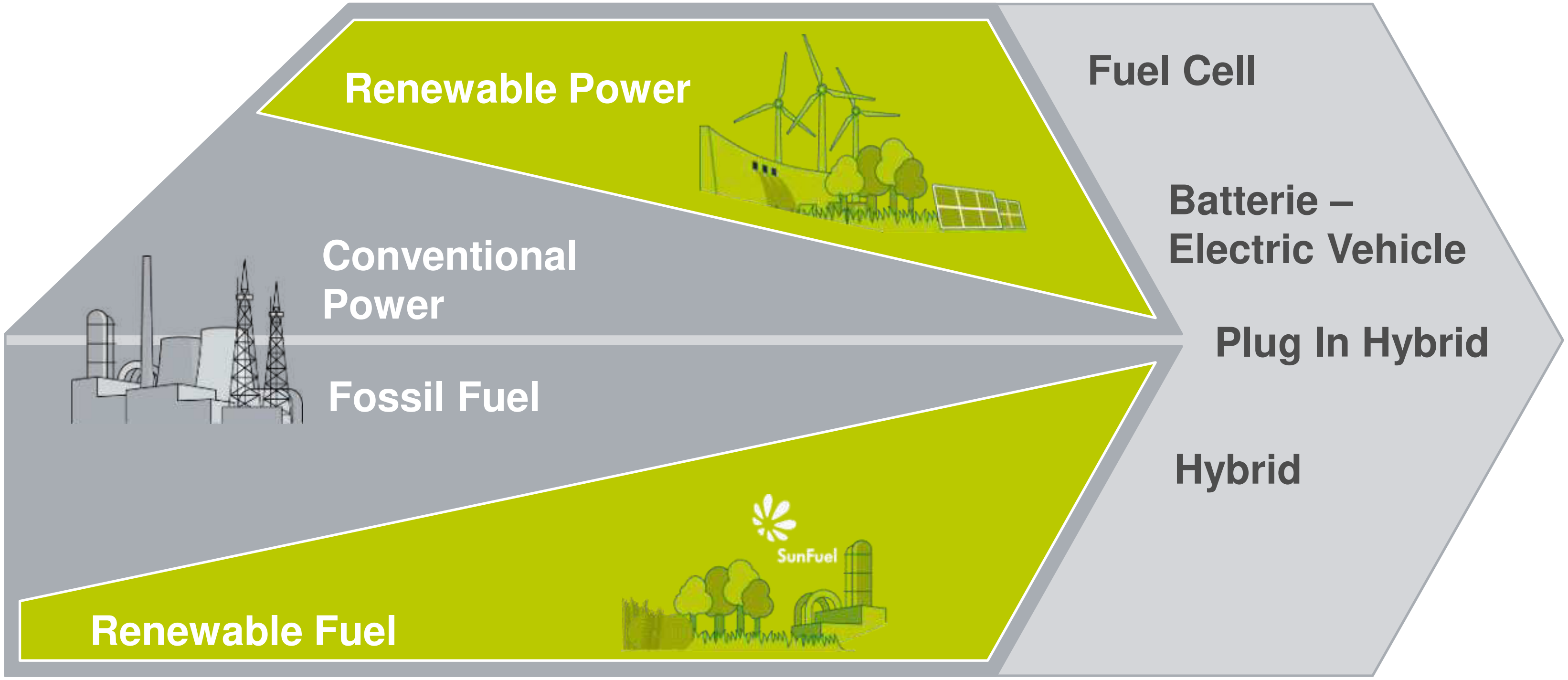
> 30 Airlines around the world have operated flights using renewable jet fuel

"We realized about seven years ago that the aviation industry needed to participate in energy source decisions and options, to ensure our industry's long-term growth and a more sustainable future. So Boeing decided to get involved in shaping the development of sustainable aviation biofuel."
- Boeing

xTL Demand over Time and Application



Decarbonisation Strategy



Decarbonisation needs all options:
E mobility as well as decarbonised clean fuels

In what condition
do we leave this planet
for the next generation?

NESTE

https://www.youtube.com/watch?v=ppNBtcOdH-I