# THE ROAD AHEAD SHIP POWER TECHNOLOGY

ONE

# **Teknologikonferanse 2011**

Gass som energibærer i fiskeflåten

13. oktober 2011 Ålesund

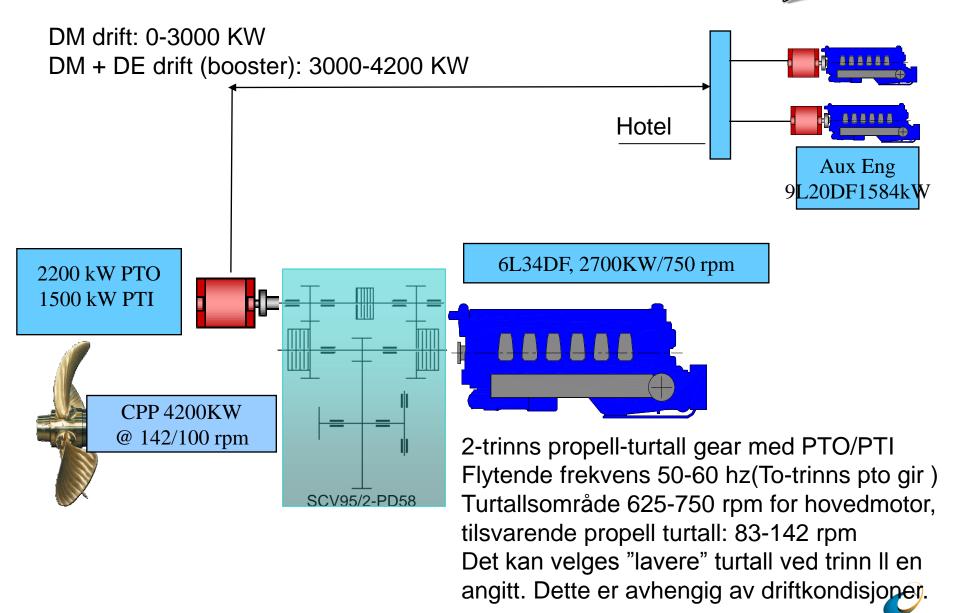








## V&S, Alternativ 2, 2-trinns gear m/"booster"



WÄRTSILÄ

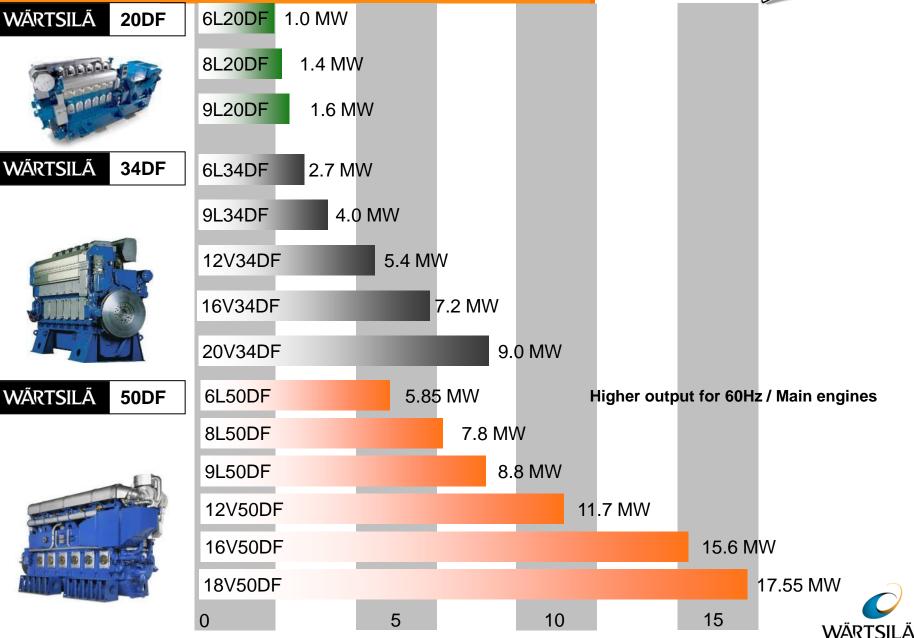


- 1. Introduction to Wärtsilä DF portfolio
- 2. What's new?
- 3. Development DF Engines



# Wärtsilä Dual-Fuel Engine Portfolio





## **Dual-fuel engine characteristics**





- High efficiency
- Low gas pressure
- Low emissions, due to:
  - High efficiency
  - Clean fuel
  - Lean burn combustion
- Fuel flexibility
  - Gas
  - LFO (DF)
  - Bio Fuel
  - HFO (TF)

## Double wall gas piping

- Three engine models
  - Wärtsilä 20DF
  - Wärtsilä 32DF
  - Wärtsilä 50DF





- Dual-fuel engine gas and liquid fuel
- Otto principle at gas operation
- Pilot fuel for ignition of gas
- High efficiency
- Low emissions, thanks to:
  - Clean fuel
  - Lean burn combustion
- Low gas pressure
- Double wall gas piping
- Embedded automation system







	Marine generating sets	Marine main engines
Cylinder bore [mm]	200	200
Piston stroke [mm]	280	280
Engine speed [rpm]	1000 / 1200	1200
Piston speed [m/s]	9.3 / 11.2	11.2
Mean effective pressure [bar]	20	20
Output per cylinder [kW]	146/176	176
Cylinder configurations	6L, 8L, 9L	6L, 8L, 9L



# **Optimised Cylinder Load Balancing**



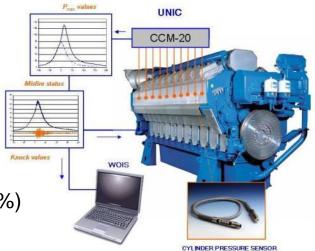
# Engine control and cylinder load balancing based on cylinder pressure sensors

### First achievements:

- More reliable knock detection
- Real-time misfire detection
- Maximum cylinder pressure control
- Gas operation on all EIAPP load points (including 10%)
  Wärtsilä recommend liquid fuel on lower loads as it is a better fuel for low load operation

### Development:

- Automatic engine de-rating control
- Improved fault detection/ diagnostics for preventive maintenance
- Increase of load and efficiency due to better engine control and possibility to run closer to maximum cylinder pressure and knock limits







# **DF Engine Technology is Inherent Redundant**

#### The Dual Fuel technology give the following advantages:

- A disturbance in gas mode leads to an automatic and instant switch-over to diesel mode and continued operation at desired load/speed
- In case of malfunction of external gas supply or lack of gas, the vessel has the flexibility to operate on diesel fuel
- Can be operated on liquid fuel outside ECA-area, even on HFO

#### Operation in ECA area – in case of failure:

Operation on pure liquid fuel resulting from restricted gas supply in cases of failures shall be exempted for the voyage to the next appropriate port for the repair of the failure. (MEPC 58/23/Add.1 ANNEX 14)

# THE ROAD AHEAD Ship power technology

# GAS ENGINE EMISSIONS

Wärtsilä DF



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- Legislation
- Combustion
- Methane slip
- Methane slip reduction measures



## **Environmental challenge**

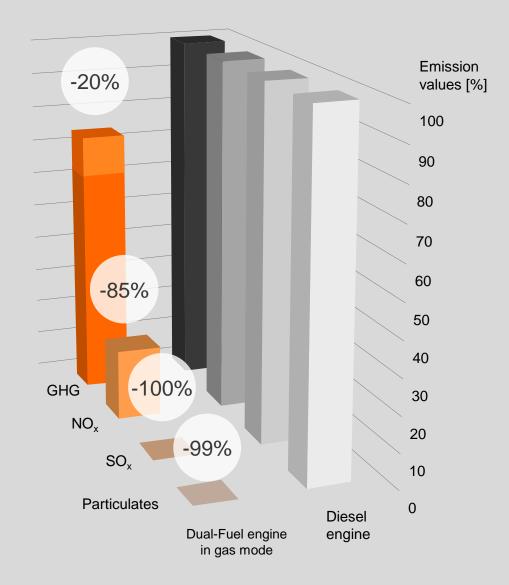






## Natural gas as marine fuel







# **DF characteristics – Operating modes**



Gas combustion:

- Otto principle
- Low-pressure gas admission
- Pilot diesel injection

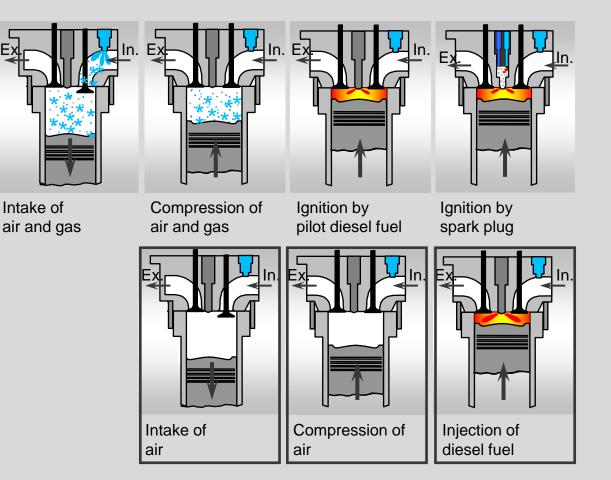
**Diesel combustion:** 

**Diesel principle** 

**Diesel** injection

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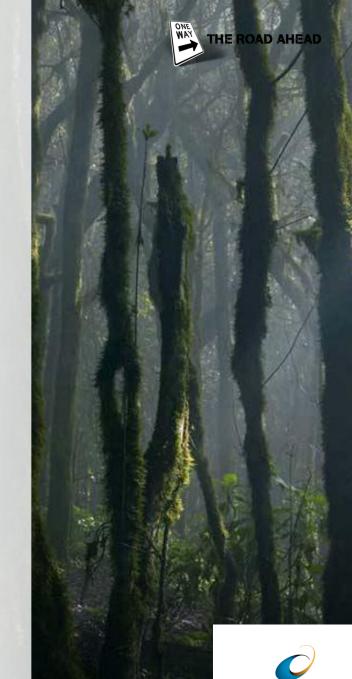
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# Why methane slip?

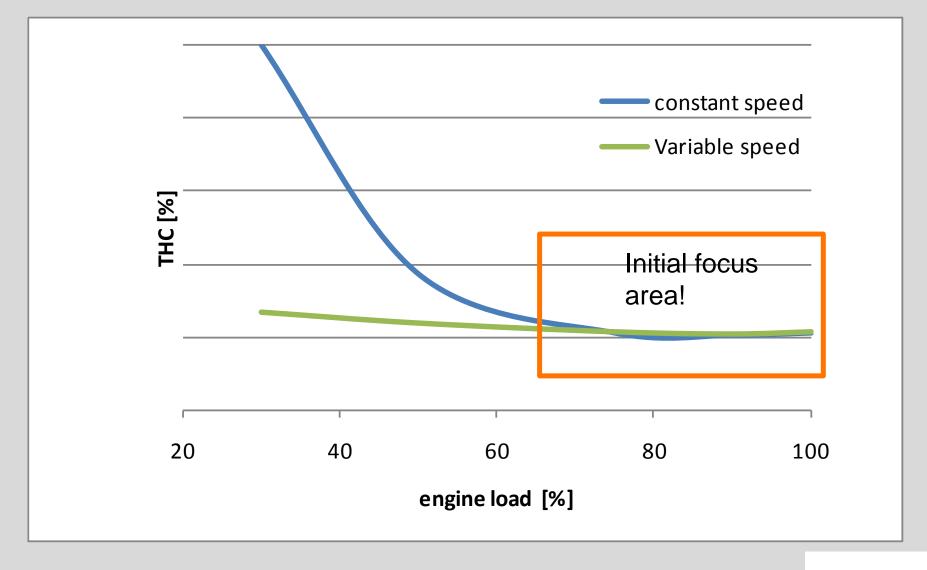
- Oxidation of CH<sub>4</sub> requires t>540°C
- Heavier C<sub>n</sub>H<sub>m</sub> do oxidize at lower temperatures
- CH<sub>4</sub> is one of the greenhouse gases listed in the Kyoto protocol
- Methane is 25 times more harmful greenhouse gas than CO<sub>2</sub>
  - NG produces about 200 g/kWh less CO<sub>2</sub> than HFO
  - 6 g/kWh CH<sub>4</sub> (methane slip) gives 8-10% lower GHG





## **Methane slip – not optimised**







# **R&D technology exploration - status 19.4.2011**

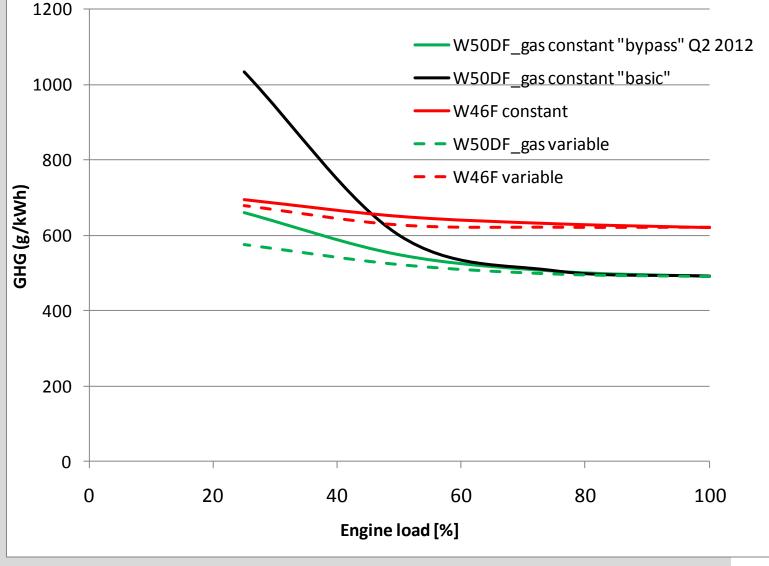
THE ROAD AHEAD

Method	Applicable load (%)	Reduction in THC (%)
Lower boost level (Higher NOx with IMO Tier 3)	6080	040
Higher charge air temperature		
Skip firing	030	5085
MFI timing	~30100	2030
Minimizing dead volumes (clearances)	0100	~20
Optimized combustion chamber (piston bowl shape)	~50100	~18
Usage of Air by-pass (On constant speed)	2060	2560
EGR		
Catalyst (Oxicat)	0100	5070
Catalyst (Xcat)	0100	>90

By combining these measures reduction of 50-80% can be reached at all loads! Some measure can be implemented also on existing engines!

### CO<sub>2</sub> equivalent emissions W50DF





# Status May 2011

- Implementation plan of CH<sub>4</sub> reduction measures to production June 2011
- W34 DF: Weighted average acc ISO 8178 E2 and E3 cycle THC< 6 g/kWh for deliveries >Q2 2012
- W50 DF: Weighted average acc ISO 8178 8178 E2 and E3 cycle THC< 3.5 g/kWh for deliveries >Q2 2012

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# Conclusion

Lean burn otto-cycle gas engines have great environmental benefits:

- NO<sub>x</sub> limits below IMO Tier III
- SO<sub>x</sub> nearly zero
- PM nearly zero
- Less CO<sub>2</sub>

Methane emissions at low load and nominal speed for "base-engine"

- In spite of CH<sub>4</sub> 25\* CO2 effect, total GHG for DF well below same size diesel engine
- R&D project finished which explored number of technologies to reduce methane slip. Potential: 50-80% reduction with primary measures Oxidation catalyst under development



# Thank you



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# More information from johannes.martinsen@wartsila.com



