THE ROAD AHEAD
SHIP POWER TECHNOLOGY

Teknologikonferanse 2011

Gass som energibærer i fiskeflåten

13. oktober 2011 Ålesund

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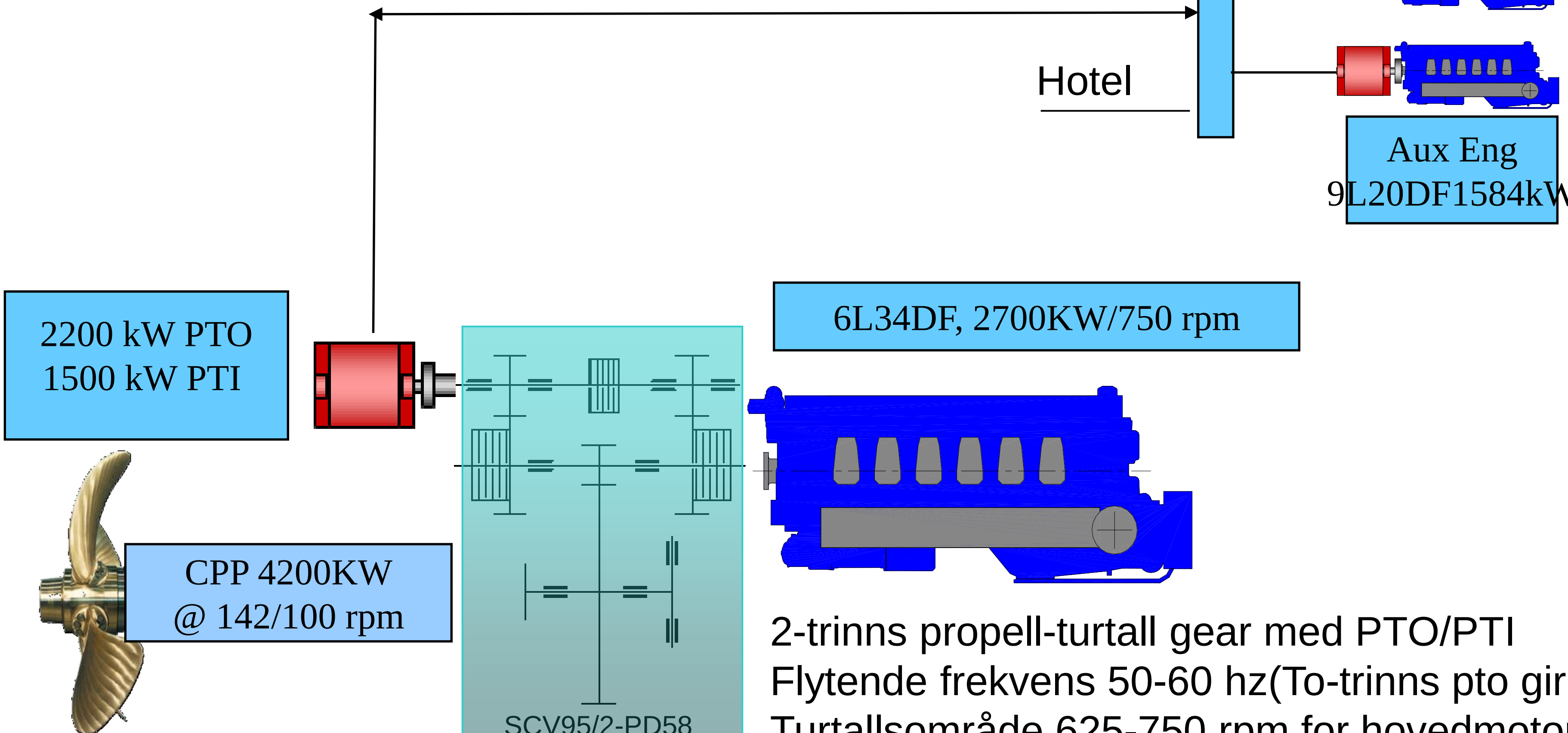
V&S , Alternativ 2, 2-trinns gear m/“booster”

DM drift: 0-3000 KW
DM + DE drift (booster): 3000-4200 KW



2-trinns propell-turtall gear med PTO/PTI
Flytende frekvens 50-60 hz(To-trinns pto gir)
Turtallsområde 625-750 rpm for hovedmotor, tilsvarende propell turtall: 83-142 rpm
Det kan velges ”lavere” turtall ved trinn II en angitt. Dette er avhengig av driftkondisjoner.

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Wärtsilä Dual-Fuel Engine Portfolio

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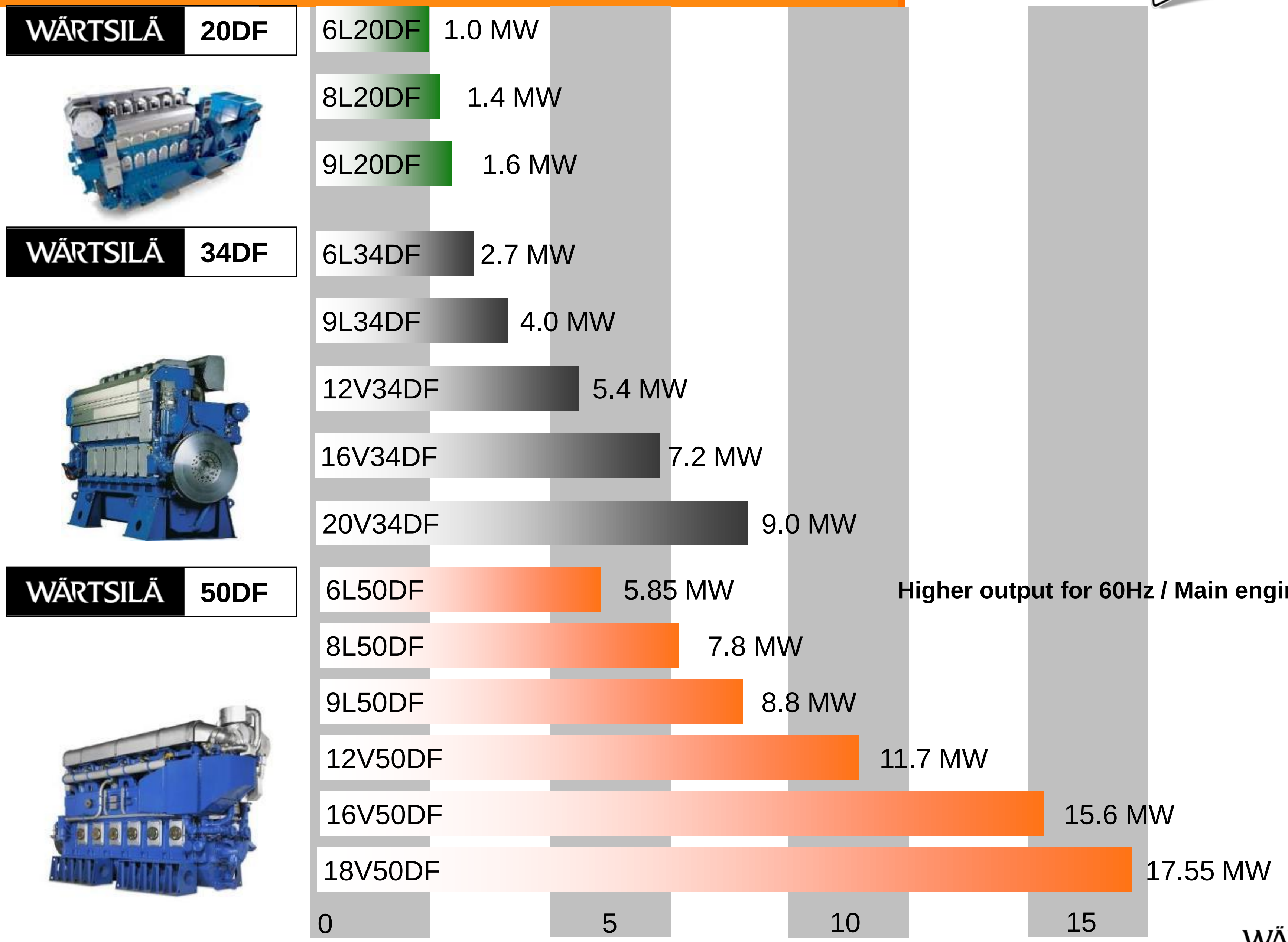

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Dual-fuel engine characteristics

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WÄRTSILÄ 20DF

WÄRTSILÄ 34DF

WÄRTSILÄ 50DF

- **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

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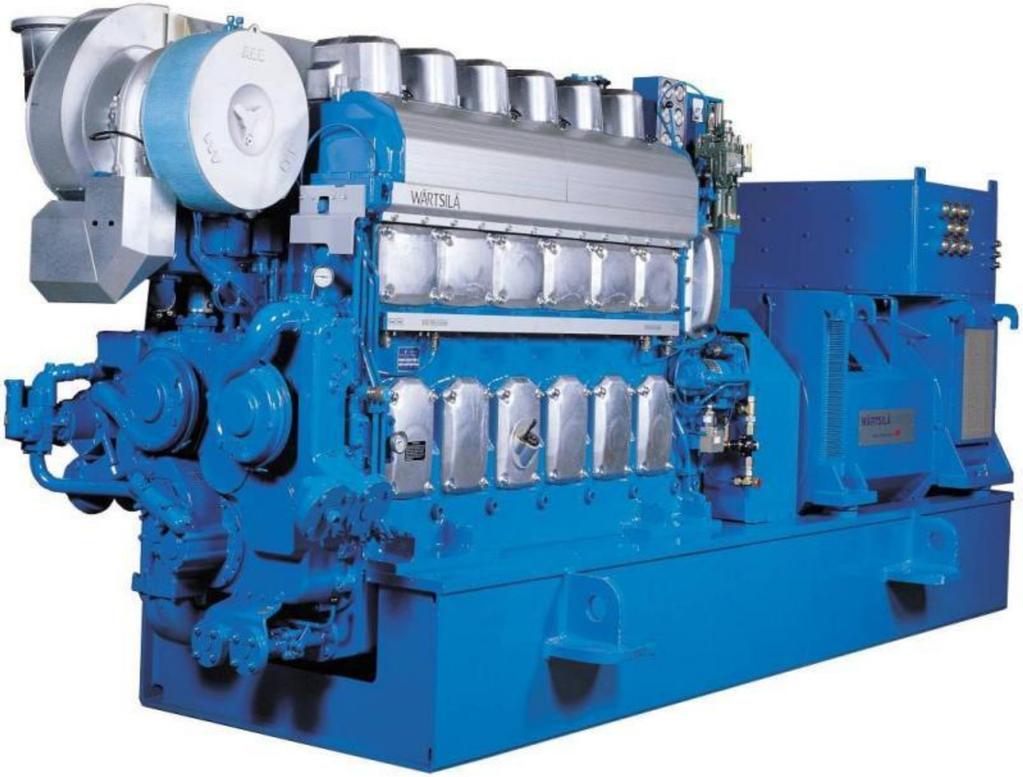
Wärtsilä 20DF features

ONE WAY THE ROAD AHEAD

- 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



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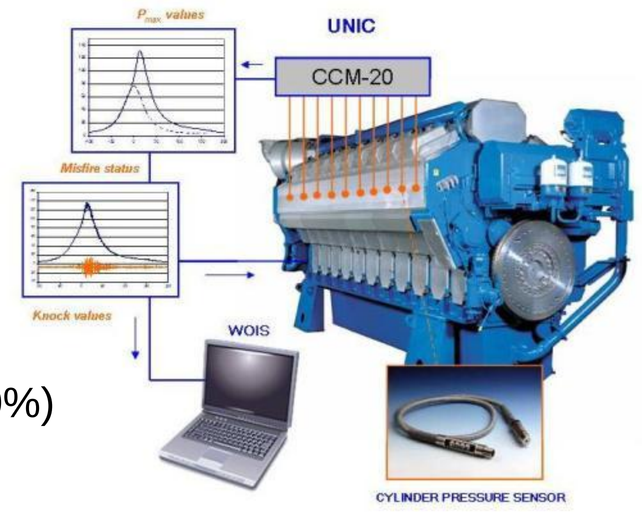
Wärtsilä 20DF main technical data

	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)

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GAS ENGINE EMISSIONS

Wärtsilä DF

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Content

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

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Environmental challenge

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Natural gas as marine fuel

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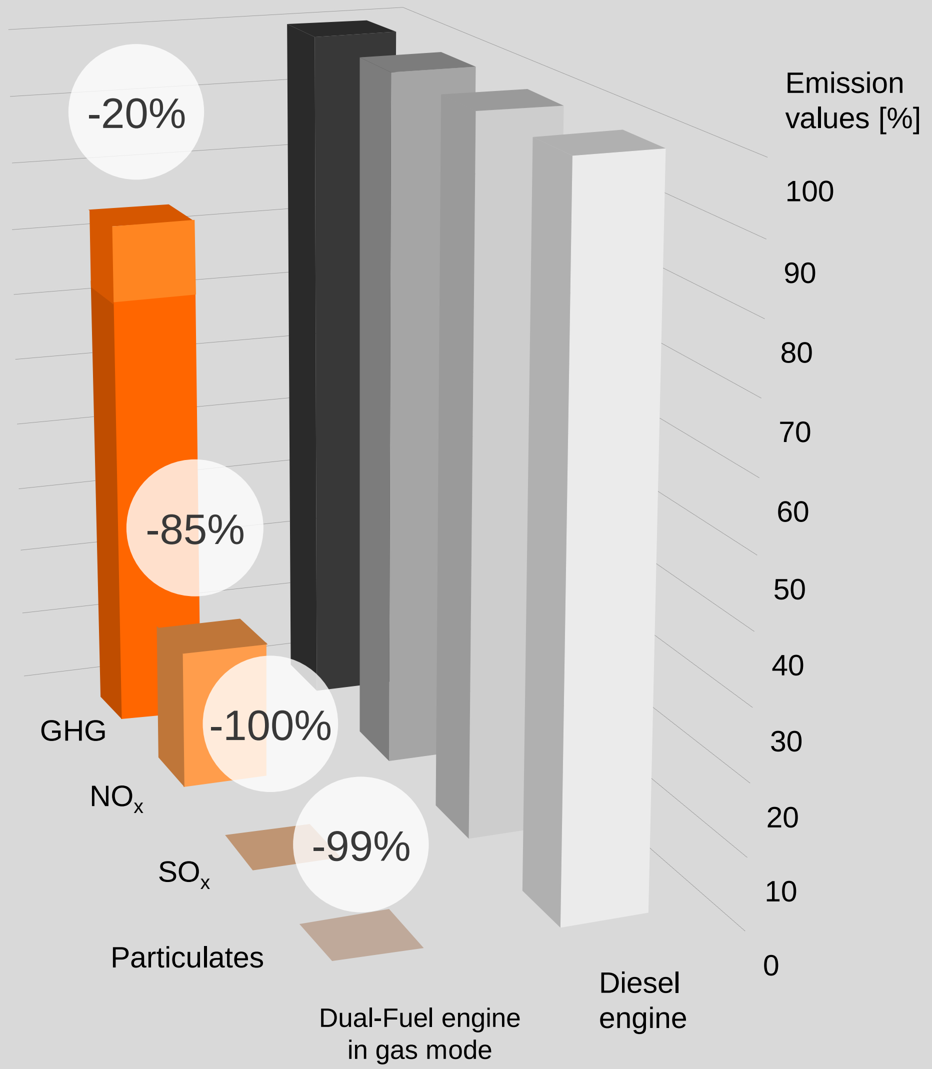

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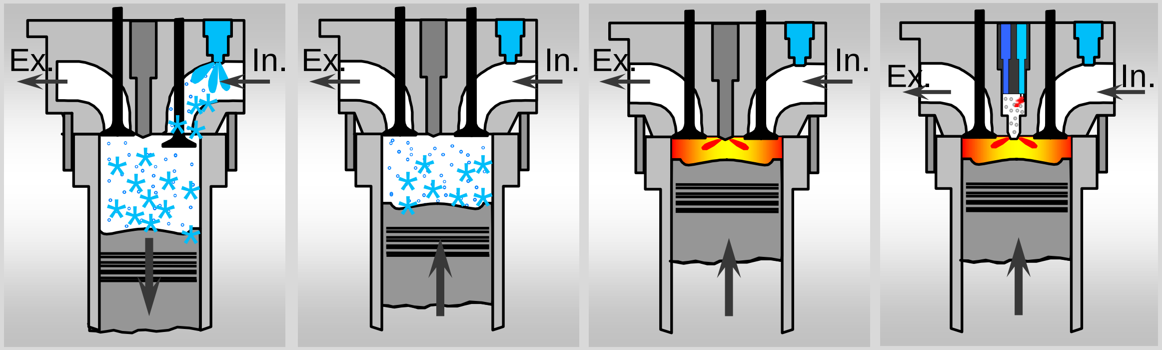
DF characteristics – Operating modes

Gas combustion:

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



Intake of air and gas

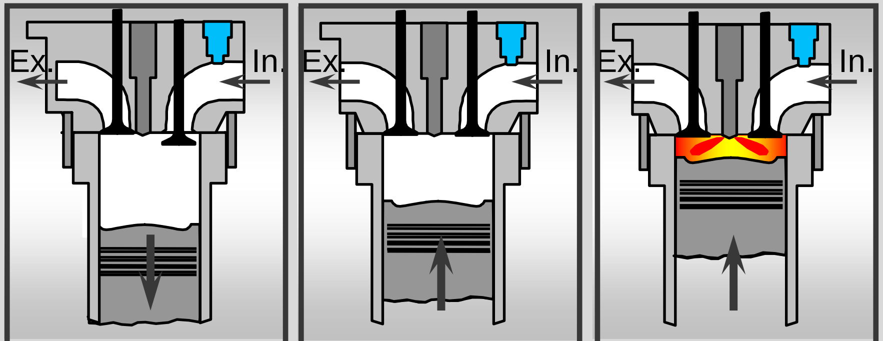
Compression of air and gas

Ignition by pilot diesel fuel

Ignition by spark plug

Diesel combustion:

- Diesel principle
- Diesel injection



Intake of air

Compression of air

Injection of diesel fuel

Why methane slip?

- Oxidation of CH_4 requires t>540°C
- Heavier C_nH_m do oxidize at lower temperatures
- CH_4 is one of the greenhouse gases listed in the Kyoto protocol
- Methane is 25 times more harmful greenhouse gas than CO_2
  - NG produces about 200 g/kWh less CO_2 than HFO
  - 6 g/kWh CH_4 (methane slip) gives 8-10% lower GHG

Methane slip – not optimised

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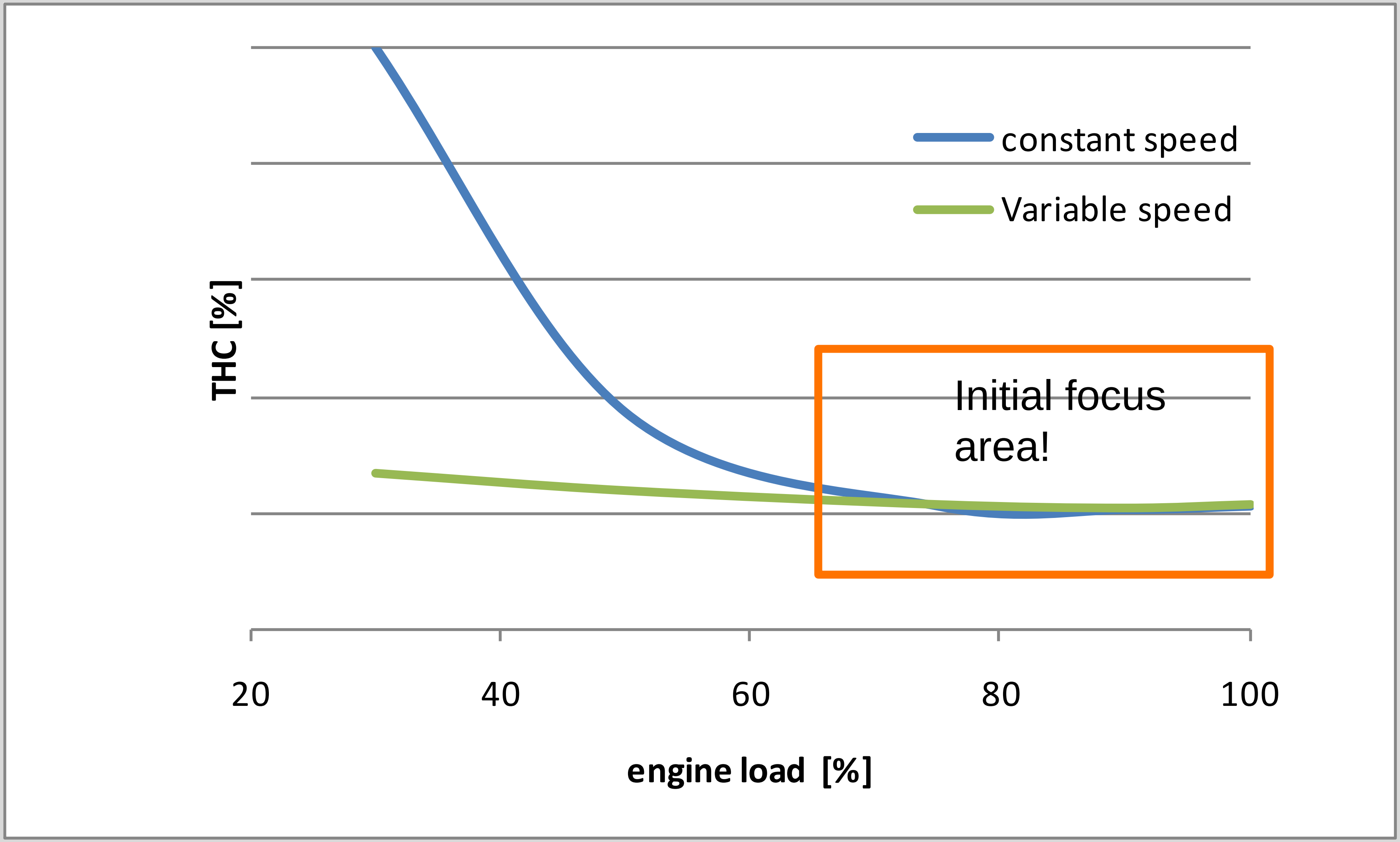

R&D technology exploration - status 19.4.2011

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Method	Applicable load (%)	Reduction in THC (%)
Lower boost level (Higher NOx with IMO Tier 3)	60…80	0…40
Higher charge air temperature		
Skip firing	0…30	50…85
MFI timing	~30…100	20…30
Minimizing dead volumes (clearances)	0…100	~20
Optimized combustion chamber (piston bowl shape)	~50…100	~18
Usage of Air by-pass (On constant speed)	20…60	25...60
EGR		
Catalyst (Oxicat)	0…100	50…70
Catalyst (Xcat)	0…100	>90

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

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CO_2 equivalent emissions W50DF

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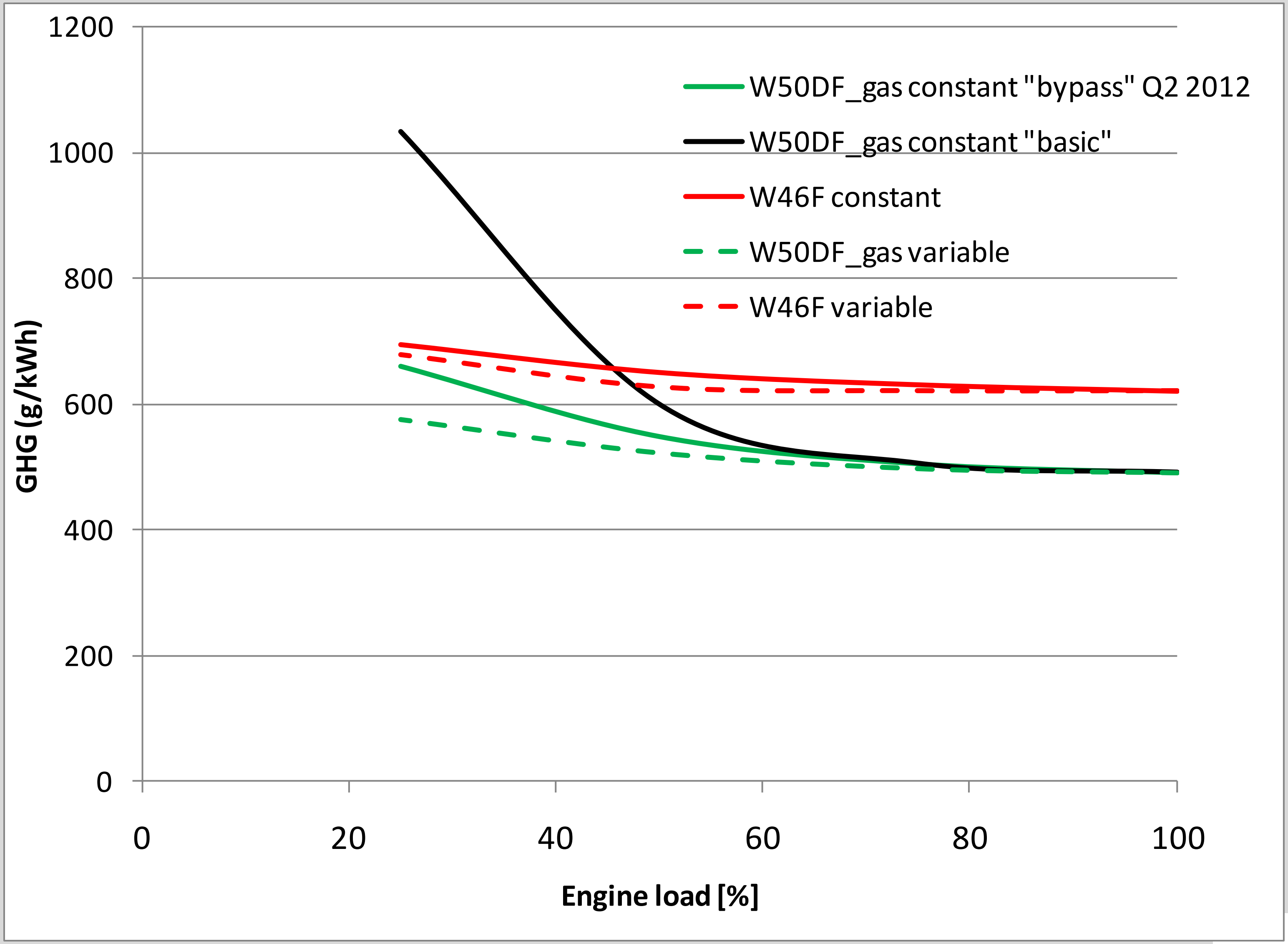

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Status May 2011

- Implementation plan of CH_4 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_x limits below IMO Tier III
- SO_x nearly zero
- PM nearly zero
- Less CO_2

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

In spite of CH_4 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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