POWER PLANT GAS CONVERSIONS

WÄRTSILÄ SPARK IGNITED GAS ENGINE (SG) CONCEPT
WÄRTSILÄ DUAL FUEL GAS ENGINE (DF) CONCEPT

CONVERSION CONCEPTS BASED ON EXISTING
WÄRTSILÄ VASA 32/32LN, WÄRTSILÄ 32 AND WÄRTSILÄ 46 POWER PLANTS

OVERVIEW OF A GAS CONVERSION

WÄRTSILÄ DEFINITION OF A GAS CONVERSION

THE CONCEPT

A Wärtsilä gas conversion of an existing power plant is more than just an engine conversion. We consider all aspects from safety to reliability of the operation. Our conversion concepts follow the same latest design and engineering principles as new built gas power plants made by Wärtsilä.

WÄRTSILÄ POWER PLANT GAS CONVERSIONS

Some good reasons why you should convert your Power Plant to gas operation

- Fuel flexibility
- Environmental benefits (NOx > 90 % reduction, SOx > 95%)
- Reduced fuel costs
- Modernization of assets, state-of-the-art technology
- Reduced maintenance costs

WÄRTSILÄ POWER PLANT GAS CONVERSIONS

Reasons for choosing Wärtsilä as your partner

- World class Project Management organization
  - References: 20 power plants (79 engines of total 720 MW)
- EPC provider
- Financing solutions
- We know your installation, your products and your needs
- Lifecycle support
- Long gas engine experience
- Guarantees
- Warranty

WÄRTSILÄ POWER PLANT GAS CONVERSIONS

Gas conversion concepts

- Today we have 3 concepts
  - SG (Spark ignited Gas engines), mono fuel: natural gas
  - DF (Dual Fuel), multiple fuel: HFO, LFO and natural gas
  - GD (Gas Diesel), multiple fuel: HFO, LFO, crude, natural gas, associated gas
- These concepts enable a very flexible operating window, and allow the operator to select the fuel depending on availability, price and need.
- Wärtsilä gas conversions utilise
  - same state-of-the-art technology as new delivered power plants
  - same engine technology (parts and control) as new factory made engines
  - same safety and engineering concept as new delivered power plants

POWER PLANT CONVERSION

MECHANICAL MODIFICATIONS TO AUXILIARY SYSTEMS

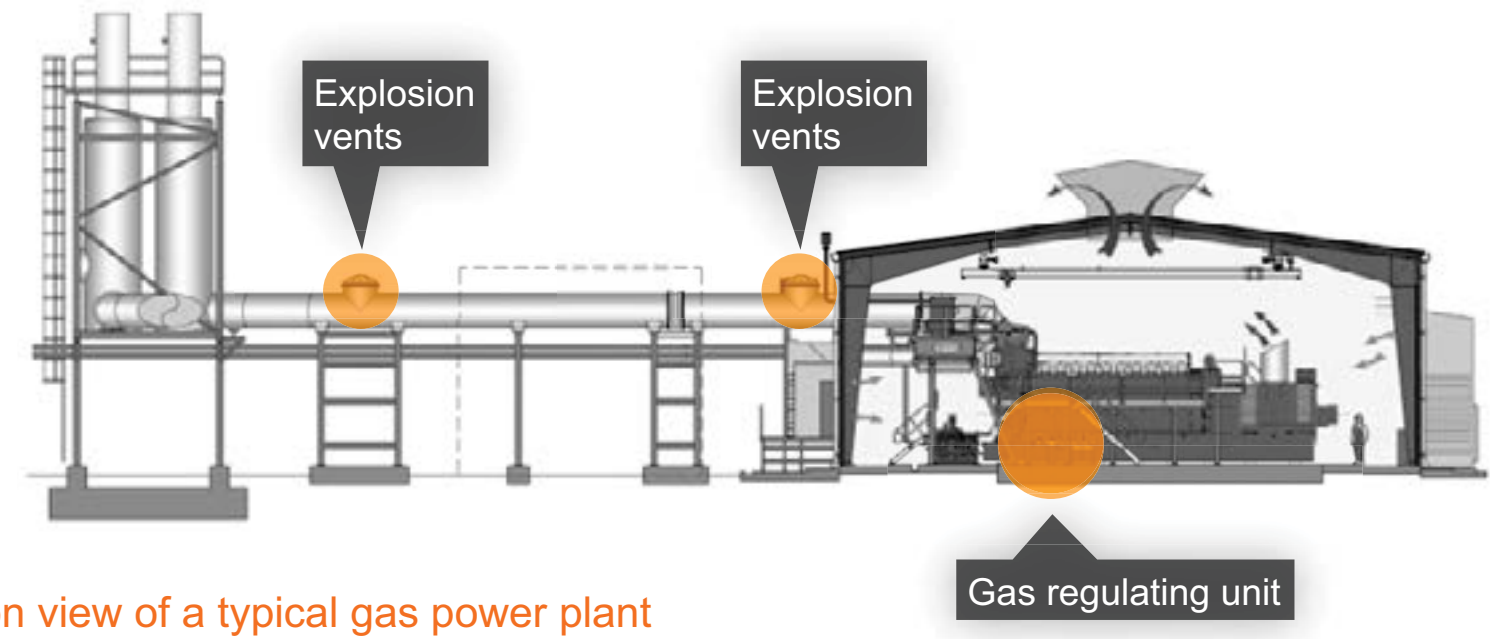
POWER PLANT GAS CONVERSION CONCEPT

So what will change on my Power Plant?

The most convenient time for doing a gas conversion is when the plant (or a specific engine) is subject to a major overhaul.

The changes and modifications depend on the age of the existing Power Plant as well as the engine type installed in the plant. In the next slides we will go through the major modifications needed.

WÄRTSILÄ 34SG CONCEPT



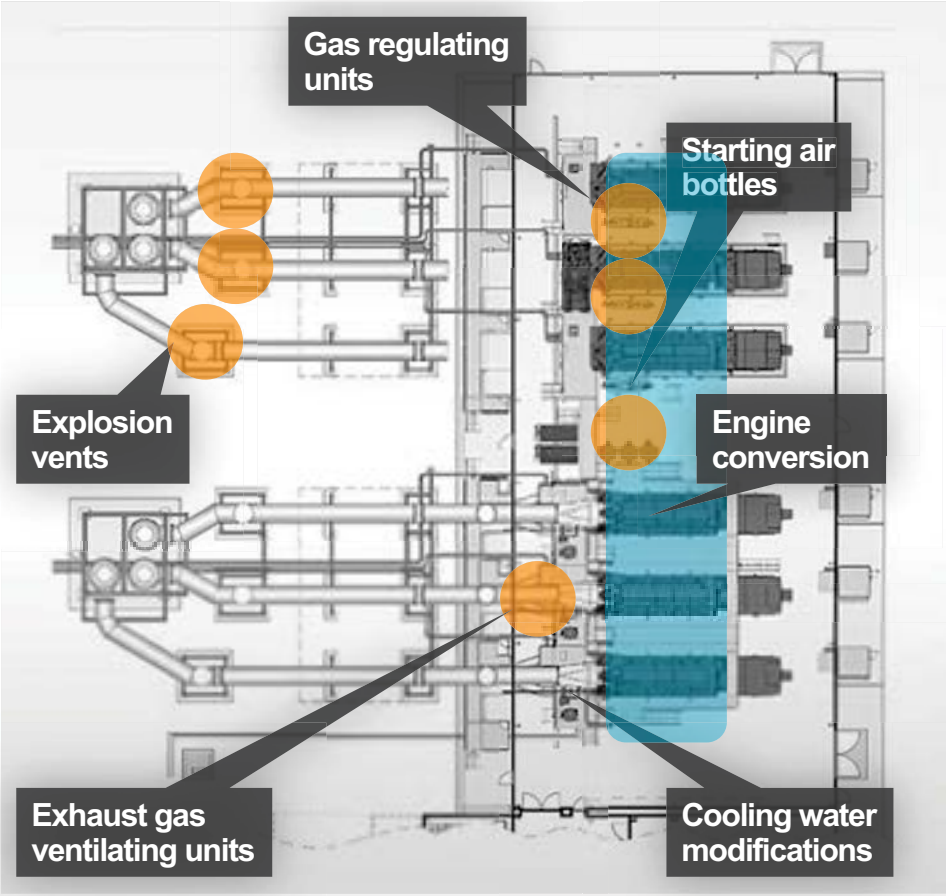
Section view of a typical gas power plant

- Explosion vents (rupture discs) are installed in the existing exhaust gas ducting system in case of an exhaust gas explosion (unburned gas).
- The number and the location of the explosion vents depends on the layout of the existing power plant, typically 2-3 per generating set.
- The gas regulating unit controls the flow and pressure of natural gas supplied to the generating set. This unit is controlled by the power plant automation system.

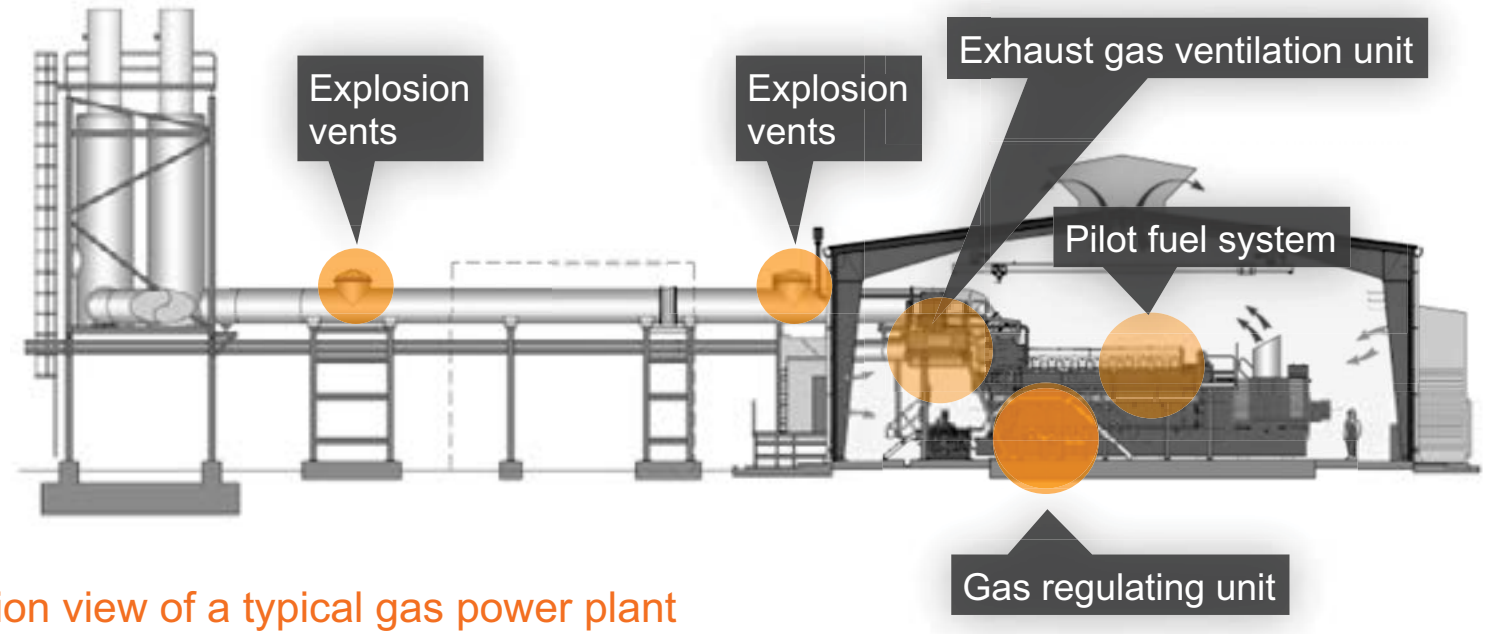
WÄRTSILÄ 34SG CONCEPT

Plan view of a typical gas power plant

- The exhaust gas ventilation unit purges the exhaust gas pipe in a 5-10 minute sequence when the generating set is stopped (part of the safety concept).
- Starting air bottle size and number of bottles will be increased for Vasa 32 based engines due to increased air consumption during start (pneumatic air starting motors).
- Cooling water system modifications are done due to more accurate temperature control and due to modifications to the existing charge air system on the engine.
- When generating sets (engines) are converted to gas operation, only parts related to gas operation (similar to factory made engines) are changed. If maintenance parts are needed, these are taken into account during the sales phase as well.



WÄRTSILÄ 34DF CONCEPT



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- A pilot fuel system is installed with the pilot fuel pump and new fuel injectors combining the main fuel oil and pilot fuel.

WÄRTSILÄ 34DF CONCEPT

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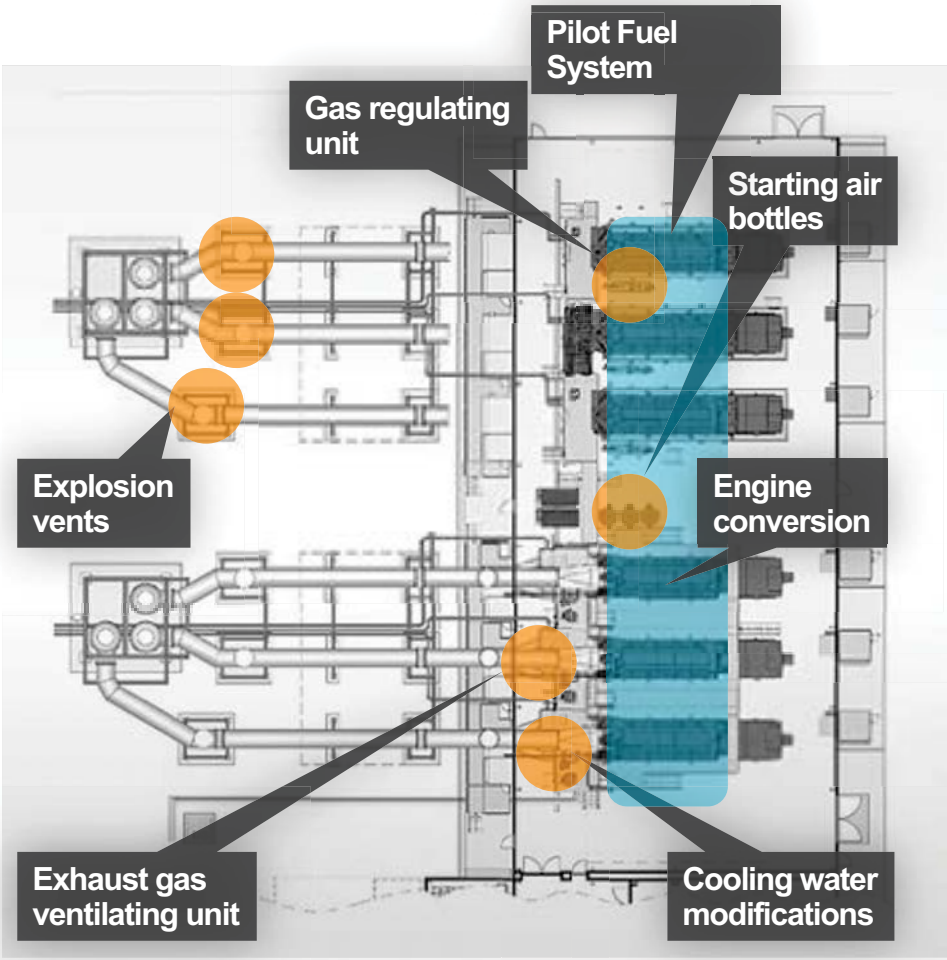
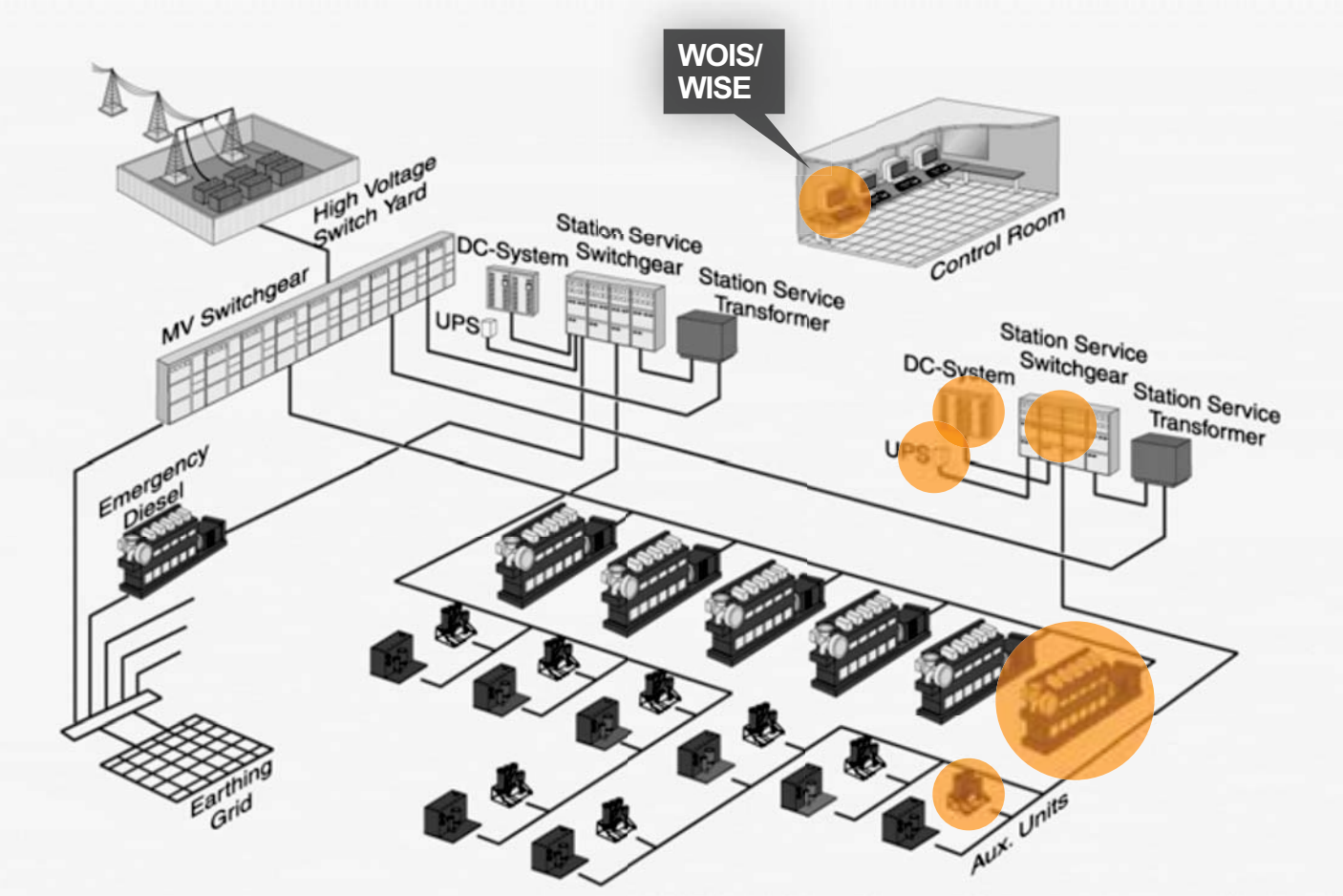


POWER PLANT CONVERSION

ELECTRICAL & AUTOMATION MODIFICATIONS TO AUXILIARY SYSTEMS

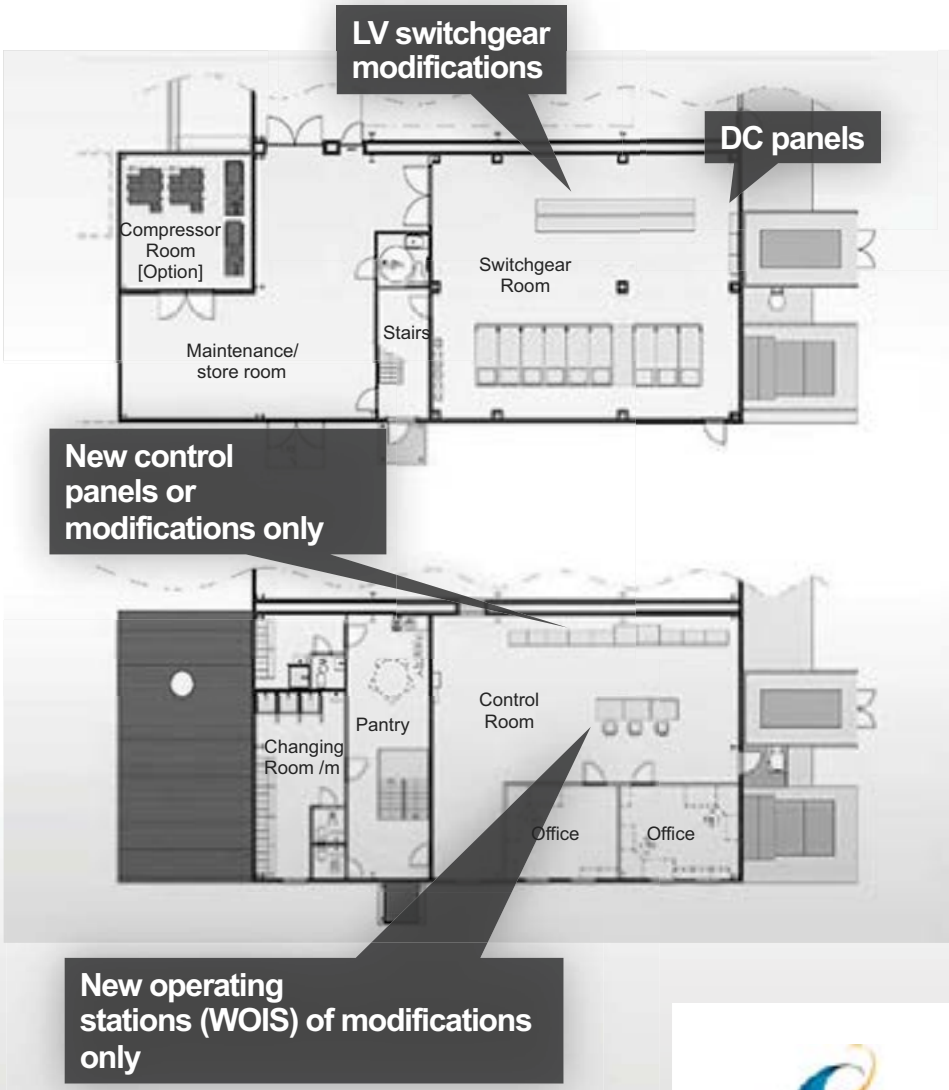
OVERVIEW OF TYPICAL ELECTRICAL AND AUTOMATION SYSTEM OF A POWER PLANT



WÄRTSILÄ 34SG CONCEPT

Plan view of a typical control, electrical & automation room

- LV switchgear modifications are done due to new consumers, e.g. exhaust gas ventilation fan.
- DC panels are added for 24V DC power for the engine control system.
- Control panels are upgraded to latest PLC standard. New common control panels and engine control panels are installed or existing ones modified depending on the age of the system.
- New operating stations for the plant are installed. WOIS (Wärtsilä Operator's Interface System) monitors and operates the functions of the plant and WISE (Wärtsilä Information System Environment) is the reporting/ management system of the plant. If the hardware is up to date, only software changes are required.



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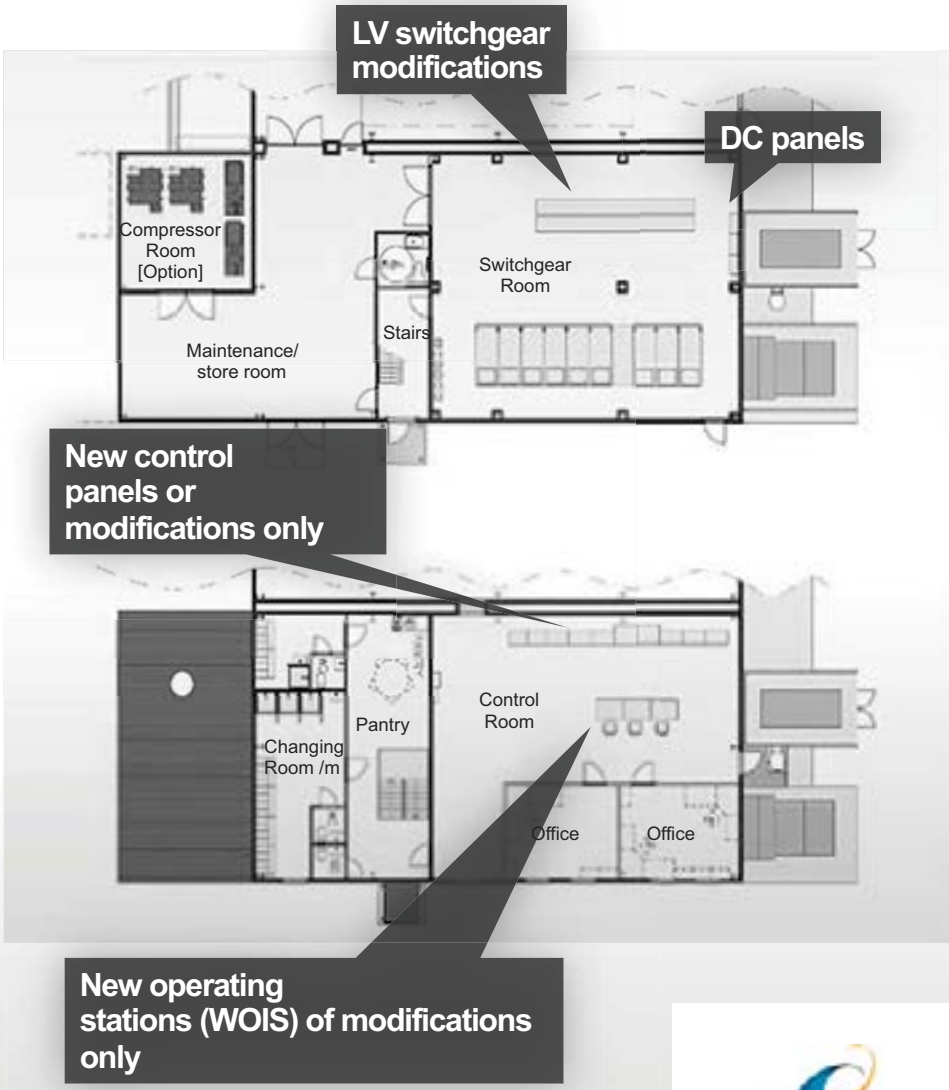
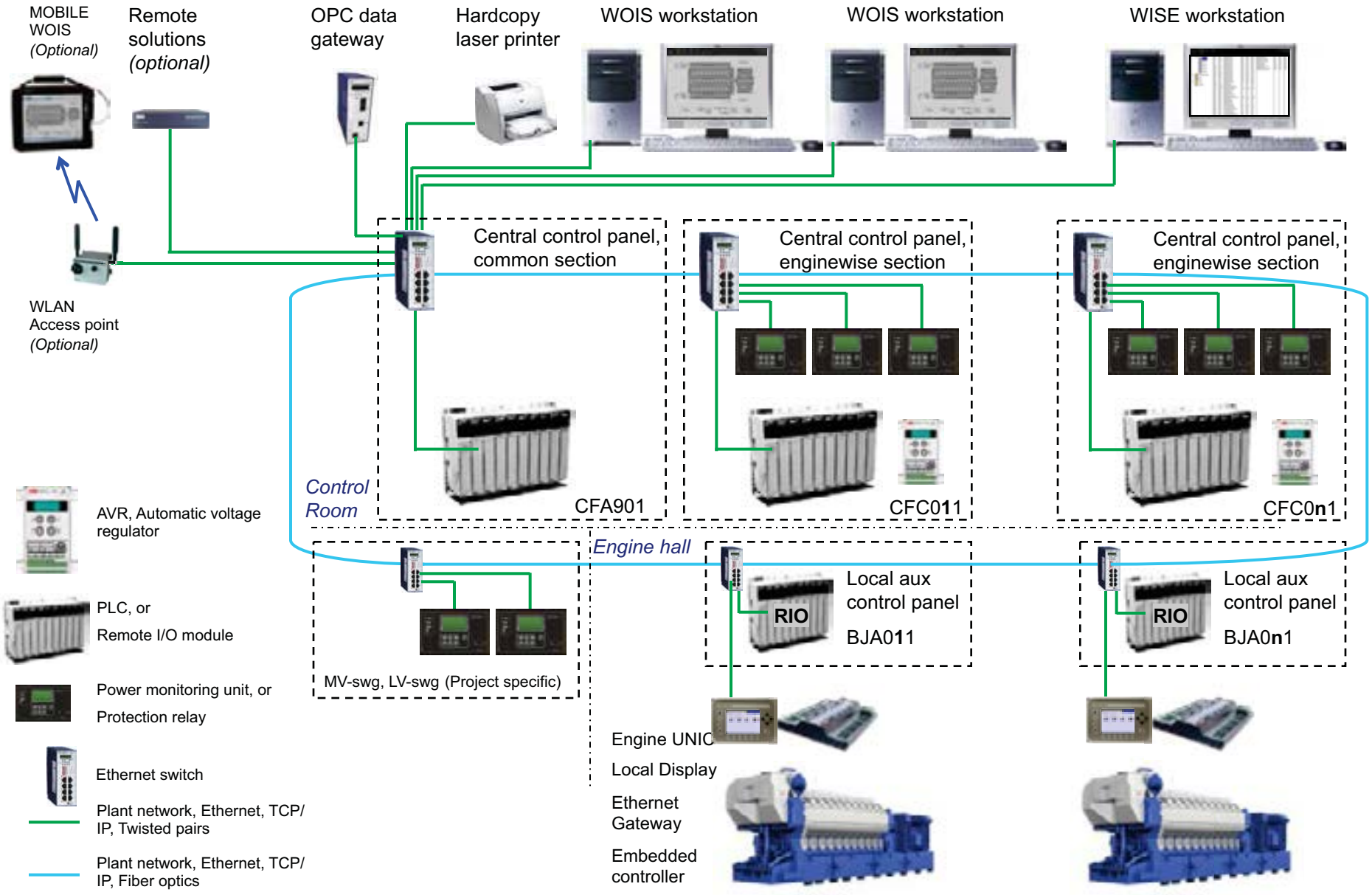


ELECTRICAL & AUTOMATION, TYPICAL GAS PLANT



MAIN CONTROL PANELS

Standardized control panels, yet ready for plant specific interface design (mainly Common panel)

Genset Control panel CFC0n1:

- Genset related meters (P, Q, V Ax3)
- Manual Control Interface
- Power Monitoring Unit
- Protection Relays

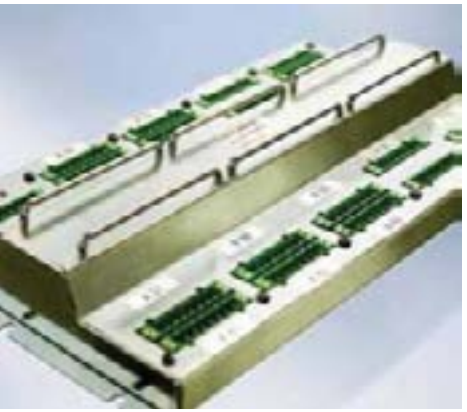
PLC for Genset control

Common panel CFA901:

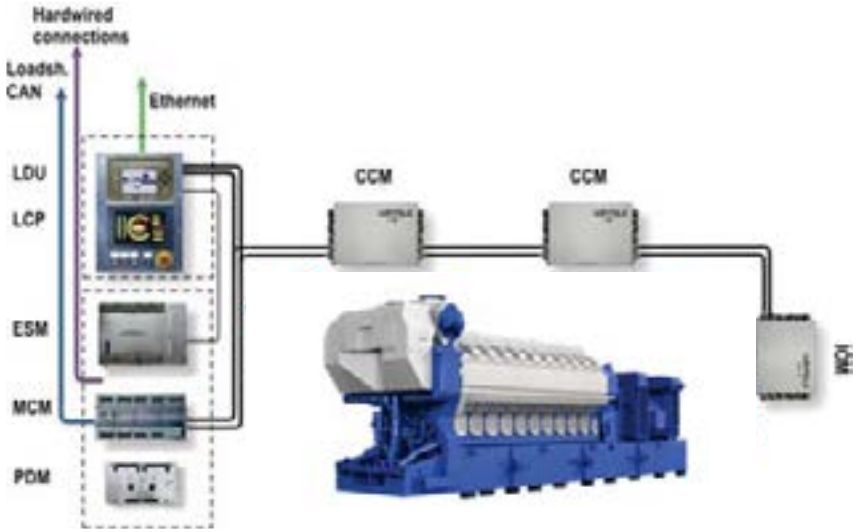
- Synchronizing interface
- Double frequency meter
- Double voltage meter
- Synchroscope
- Mimic for single line diagram

PLC for Plant control

ELECTRICAL & AUTOMATION, ENGINES



- Wärtsilä's own hardware and software designed for the harsh embedded environment
- Same engine automation platform for Power Plants and Ship Power: UNIC™
- Gas plant engines
  - LDU Local Display Unit
  - ESM Engine Safety Module
  - MCM Main Controller Module
  - CCM Cylinder Control Module
  - IOM Input/Output Modules
  - PDM Power Distribution Module



PLANT OPERATION

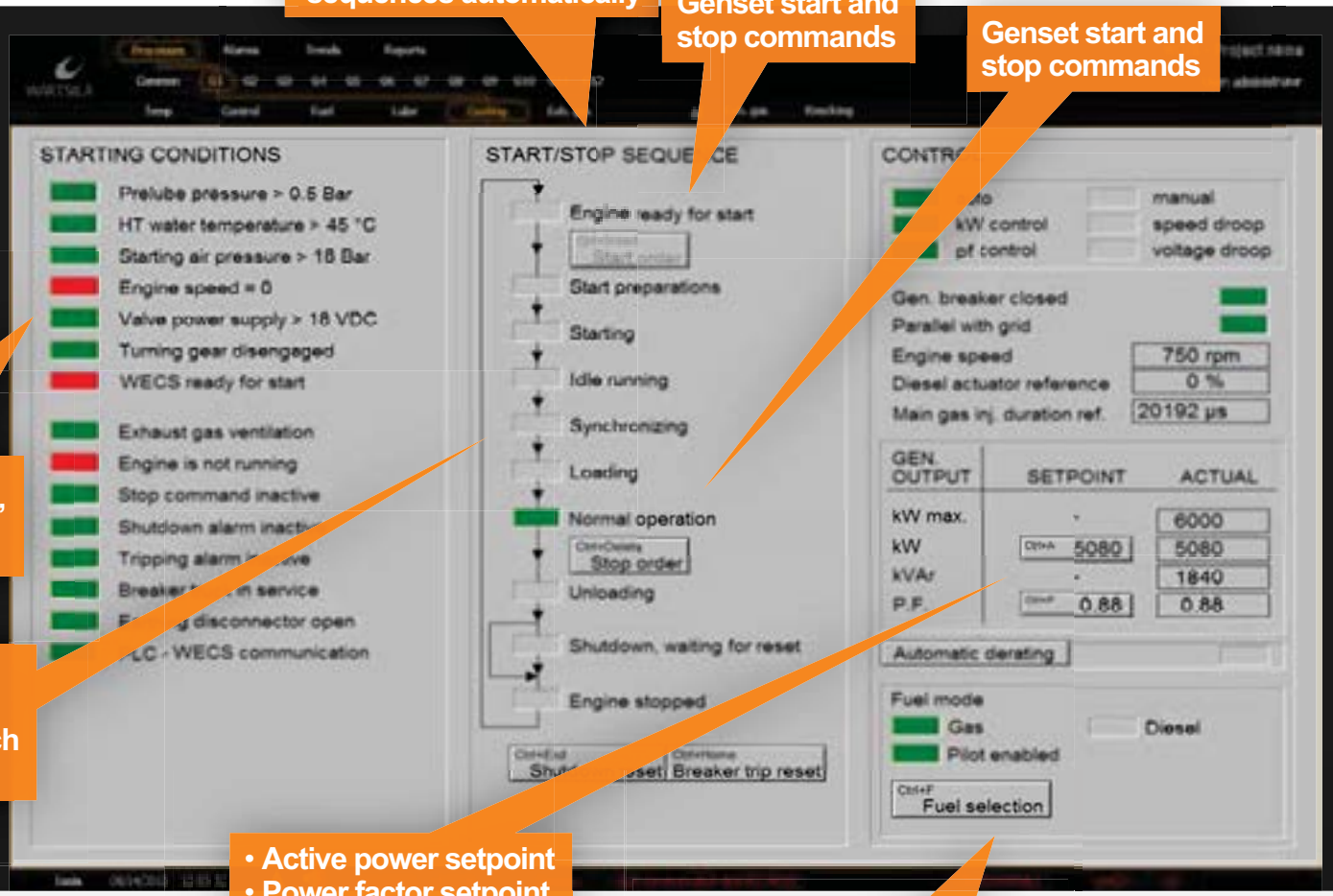
WOIS display;
Control Display

Typical examples from operator, WOIS point of view

The start/stop sequence can be followed while the PLC controls the sequences automatically

Genset start and stop commands

Genset start and stop commands



The Starting conditions are checked to be “all green” before start order is given

Genset breaker Synchronization is automatic in synch “auto” mode

- Active power setpoint
- Power factor setpoint

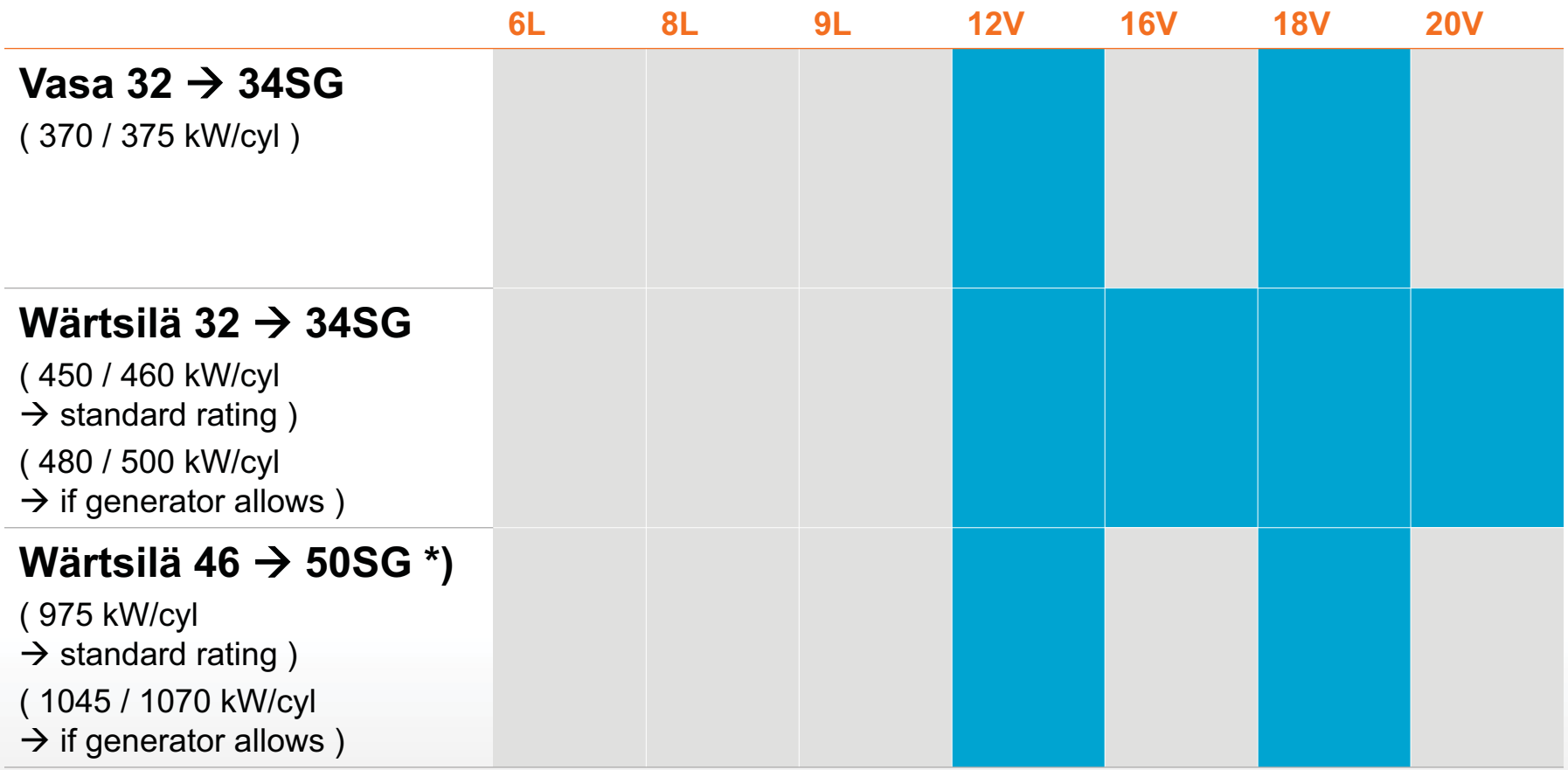
(Fuel mode selection for multi-fuel engines)

POWER PLANT CONVERSION

ENGINE MODIFICATIONS – SG CONCEPT

WÄRTSILÄ SG CONCEPT

Gas engine conversion portfolio – which engine types and models can be converted?



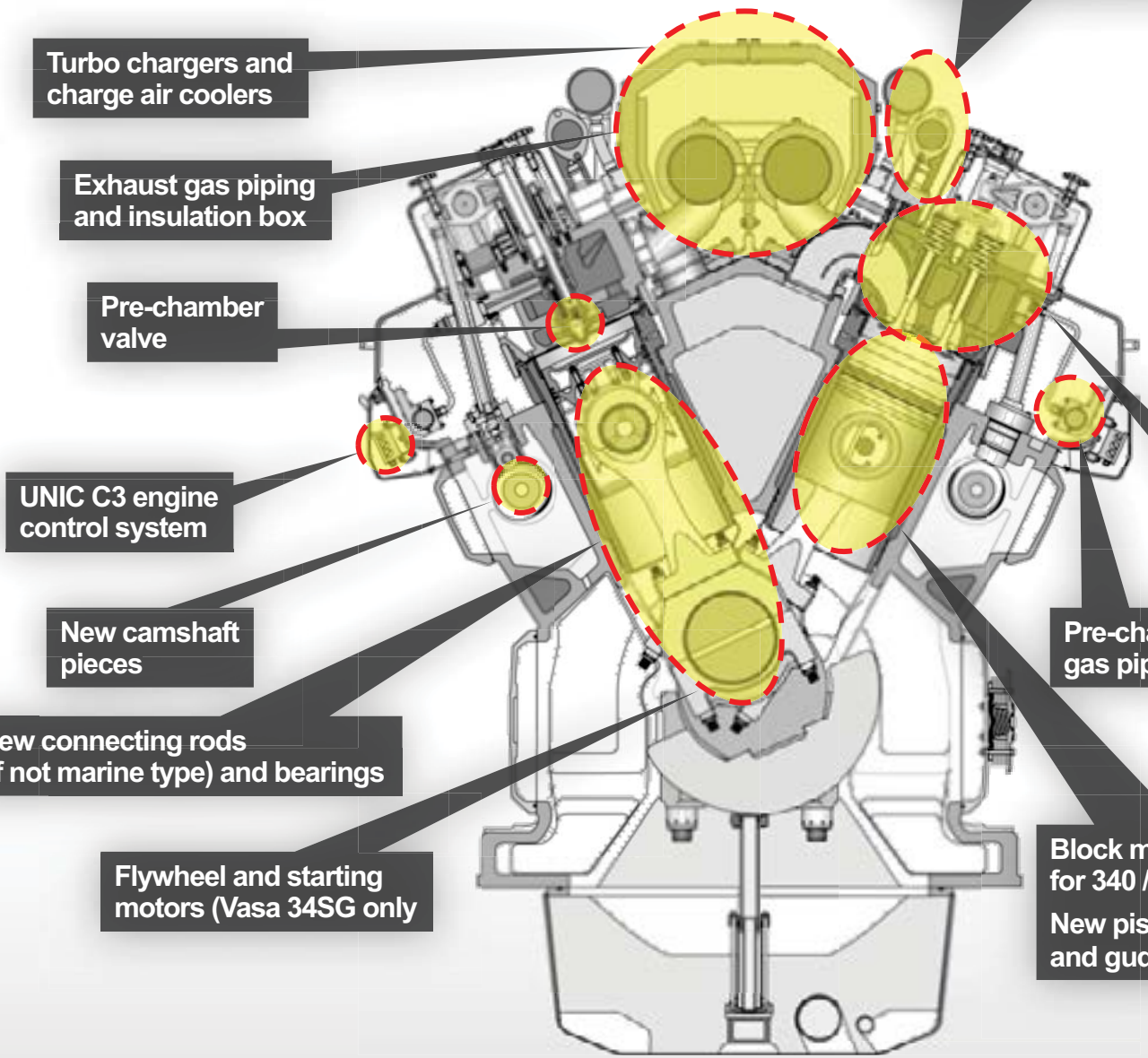
*) Older design platform (A, 905 kW/cyl) can not be converted to SG

PERFORMANCE OF CONVERTED POWER PLANTS

	Heat rate (kJ / kWh)		Engine power (kW / cyl)	
Existing engine → Type of conversion	Before	After	Before	After
Vasa 32 → 34SG (50 Hz)	8,540	8,290	375	345
Vasa 32 → 34SG (60 Hz)	8,480	8,290	370	330
Wärtsilä 32 → 34SG (50 Hz)	8,216	8,130	460	450
Wärtsilä 32 → 34SG (60 Hz)	8,216	8,130	450	435
Wärtsilä 46 → 50SG	8,100	7,900	975	975

Estimated performance figures above, installation specific performance figures can be given once needed inputs for calculations are known (ambient conditions, gas quality and pressure, etc).

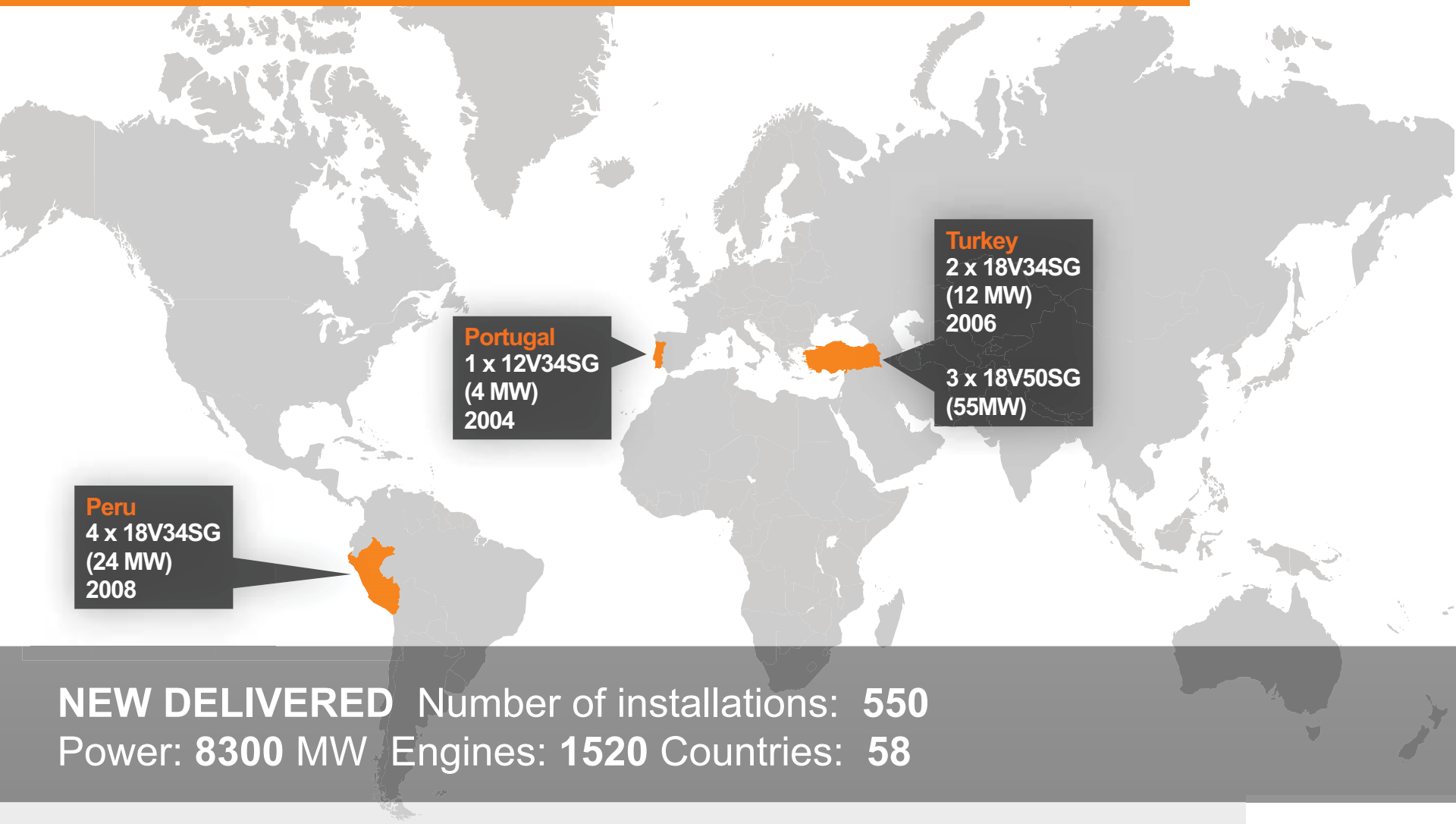
WÄRTSILÄ SG CONCEPT



Engine components to be added or replaced

- Normal maintenance parts are not part of conversion scope
- HFO/LFO equipment will be dismantled
- Only main components listed. All engine types have specific components to be added or replaced, even varying from engine to engine.

CONVERTED NUMBER OF INSTALLATIONS: 4
POWER: ~95 MW



NEW DELIVERED Number of installations: **550**
Power: **8300** MW Engines: **1520** Countries: **58**

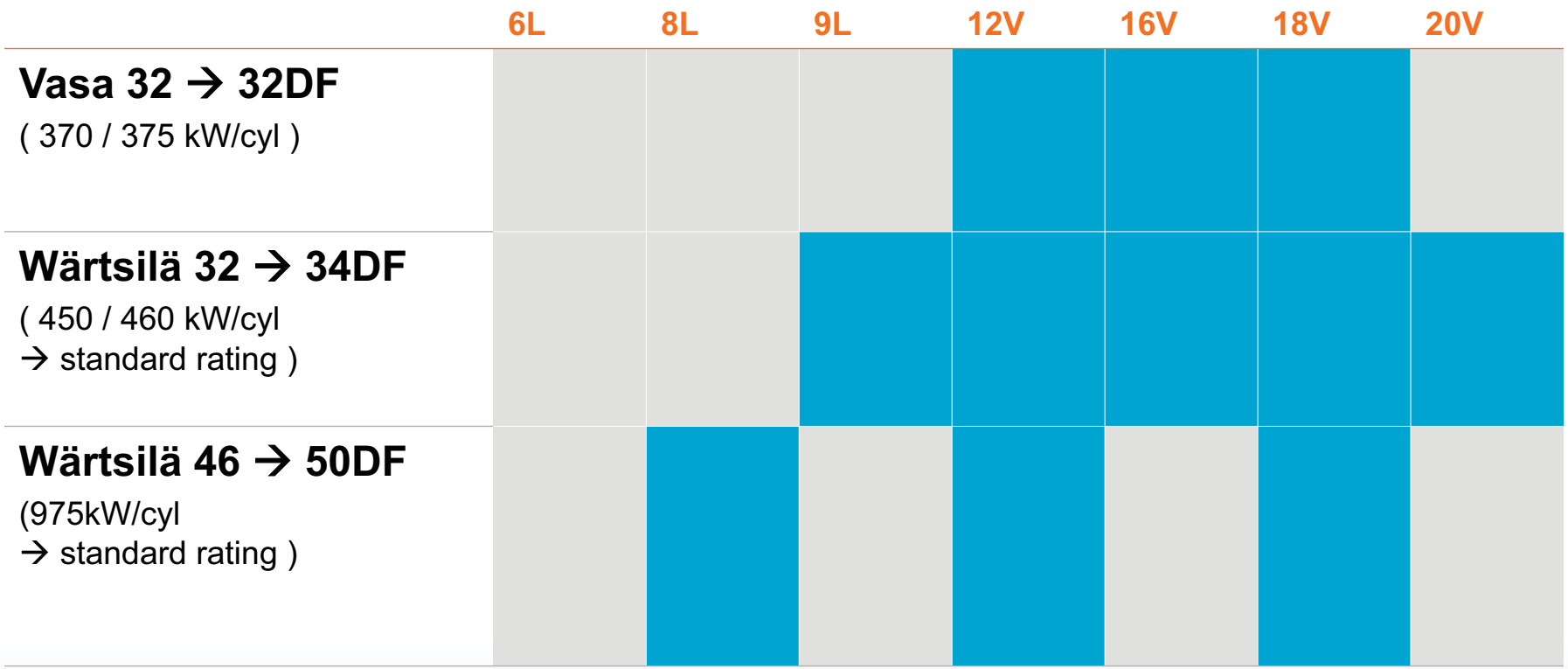
REFERENCE

POWER PLANT CONVERSION

ENGINE MODIFICATIONS – DF CONCEPT

WÄRTSILÄ DF CONCEPT

Gas engine conversion portfolio – which engine types and models can be converted?



*) Older design platforms, Wärtsilä46 A and B (905 kW/cyl) can not be converted to a full output DF

PERFORMANCE OF CONVERTED POWER PLANTS

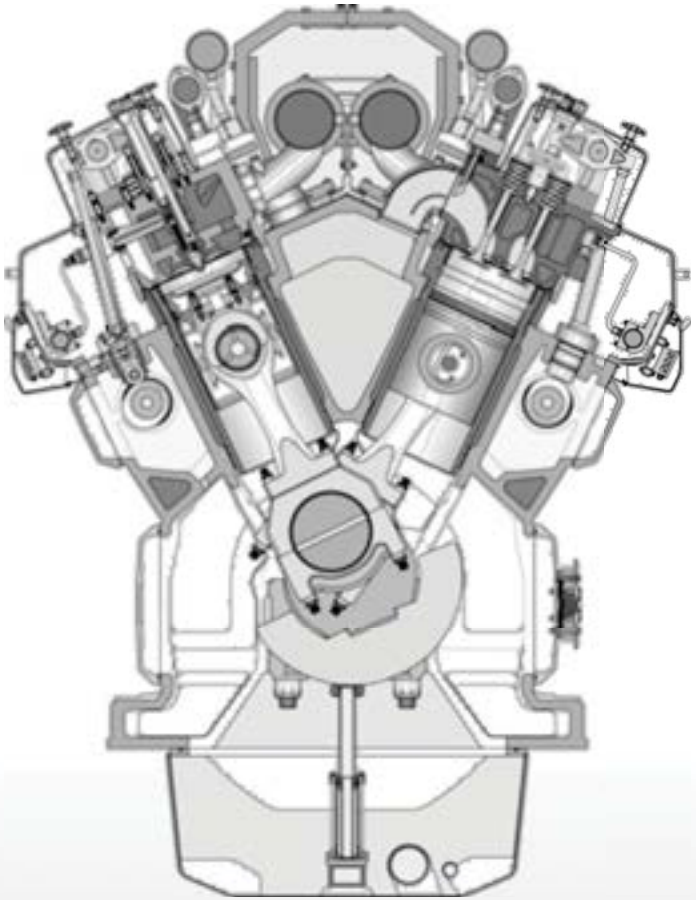
	Heat rate (kJ / kWh)		Engine power (kW / cyl)	
Existing engine → Type of conversion	Before	After	Before	After
Vasa 32 → 32DF (50 Hz)	8,540	8,480	375	350
Vasa 32 → 32DF (60 Hz)	8,480	8,480	370	335
Wärtsilä 32 → 34DF (50 Hz)	8,216	8,433	460	450
Wärtsilä 32 → 34DF (60 Hz)	8,216	8,433	450	435
Wärtsilä 46 → 50DF (50 Hz)	8,100	7,930	975	950
Wärtsilä 46 → 50DF (60 Hz)	8,100	7,880	975	975

Estimated performance figures above, installation specific performance figures can be given once needed inputs for calculations are known (ambient conditions, gas quality and pressure, etc).

DF CONVERSION

CONVERSION CONCEPT

- Same engine components as in new factory built DF engines.
- Well proven and reliable ported gas injection with pilot fuel oil concept.
- Same operating safety concept as for new power plants.
- Latest engine control and automation system (same as new power plants).



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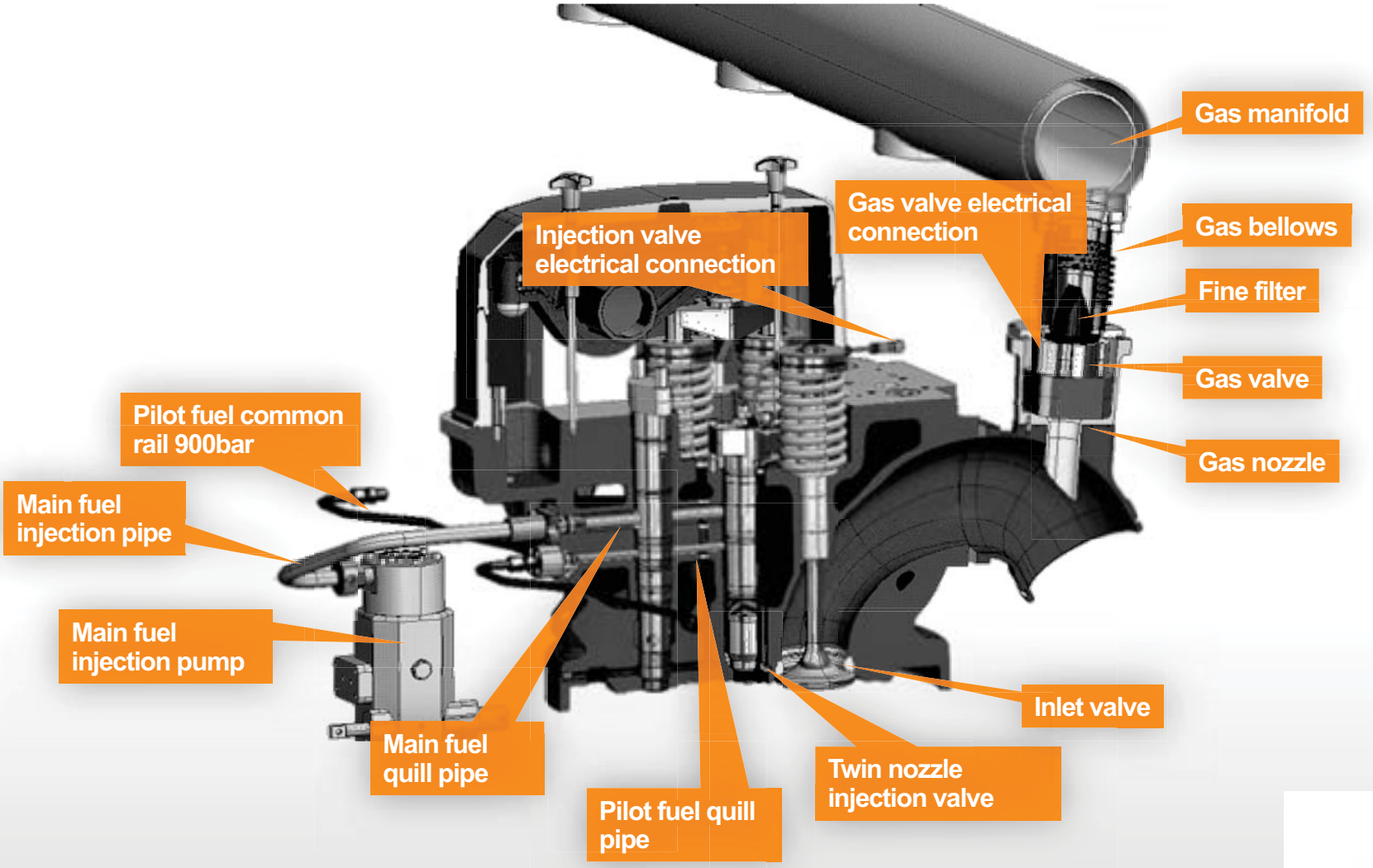
FUEL SYSTEM IN CYLINDER HEAD COMPONENTS



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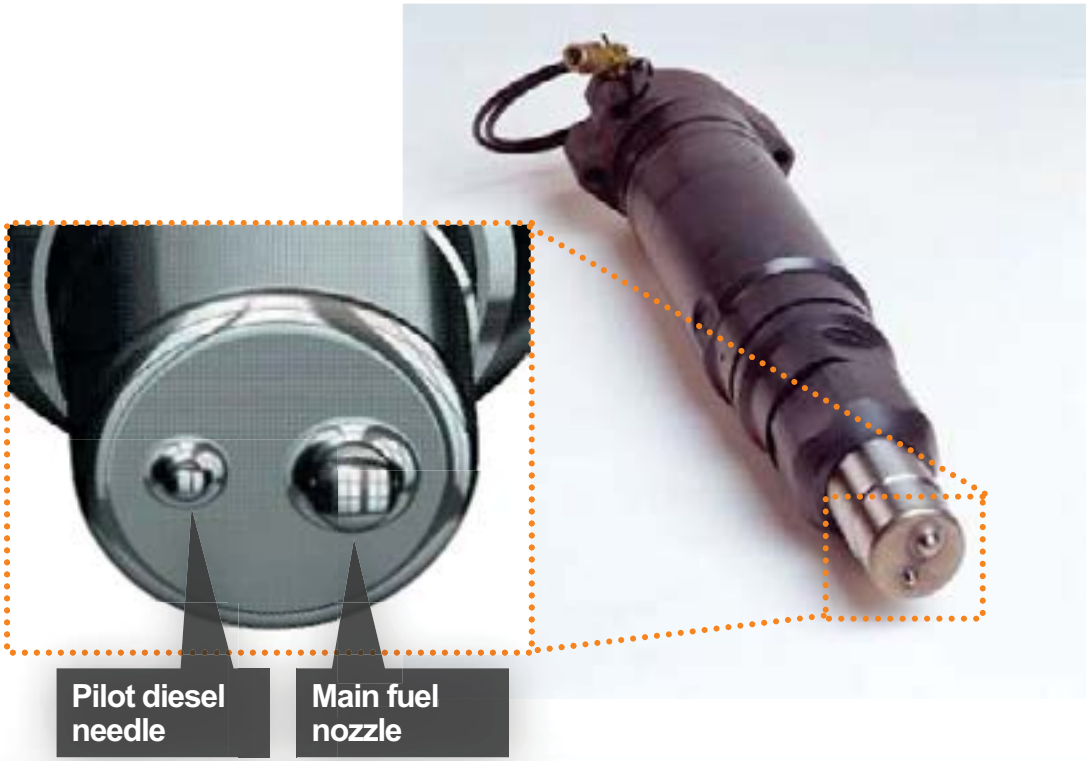
ENGINE SYSTEMS - PILOT FUEL SYSTEM (2/3)

For optimum pilot and diesel fuel distribution



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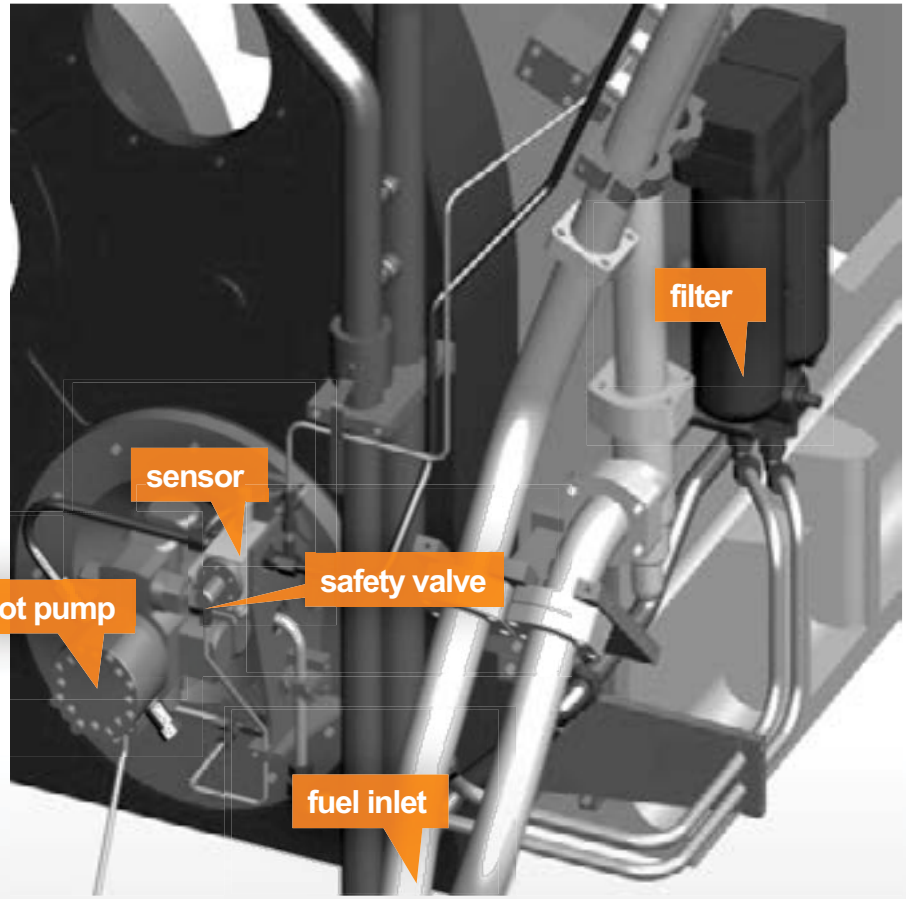
ENGINE SYSTEMS - PILOT FUEL SYSTEM (3/3)

- Radial piston pump with internal fuel lubrication (engine driven on 50DF and electrical motor driven on 34DF)
- Suction throttling controlled pressure regulation
- Duplex fine filter
- Valve block with safety valve and pressure sensor
- Double walled high pressure fuel pipes



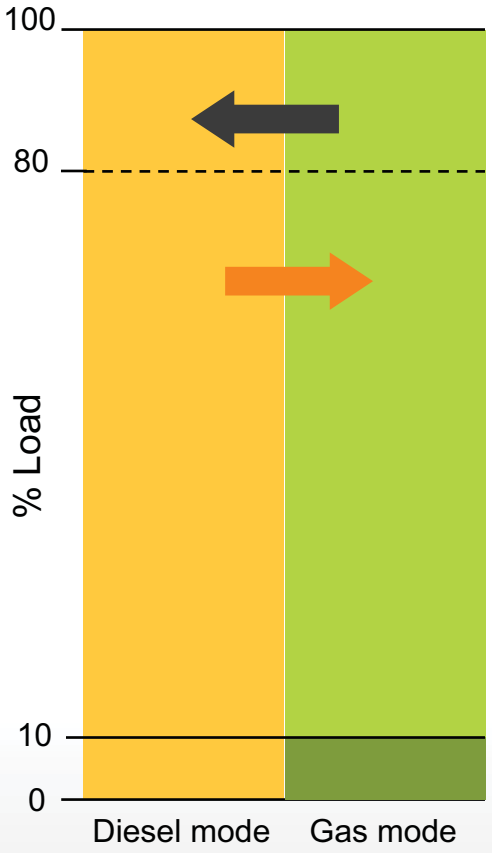
OPERATING MODE CHANGES (1/2)

Gas mode

- Running on GAS with MDO pilot fuel injection.
- Automatic and instant trip to diesel mode in alarm situations without loss of engine power and speed.
- Automatic transfer to diesel mode on request at any load without loss of engine power and speed.
  - Automatic trip to diesel mode after 5 minutes at engine loads below 10%.

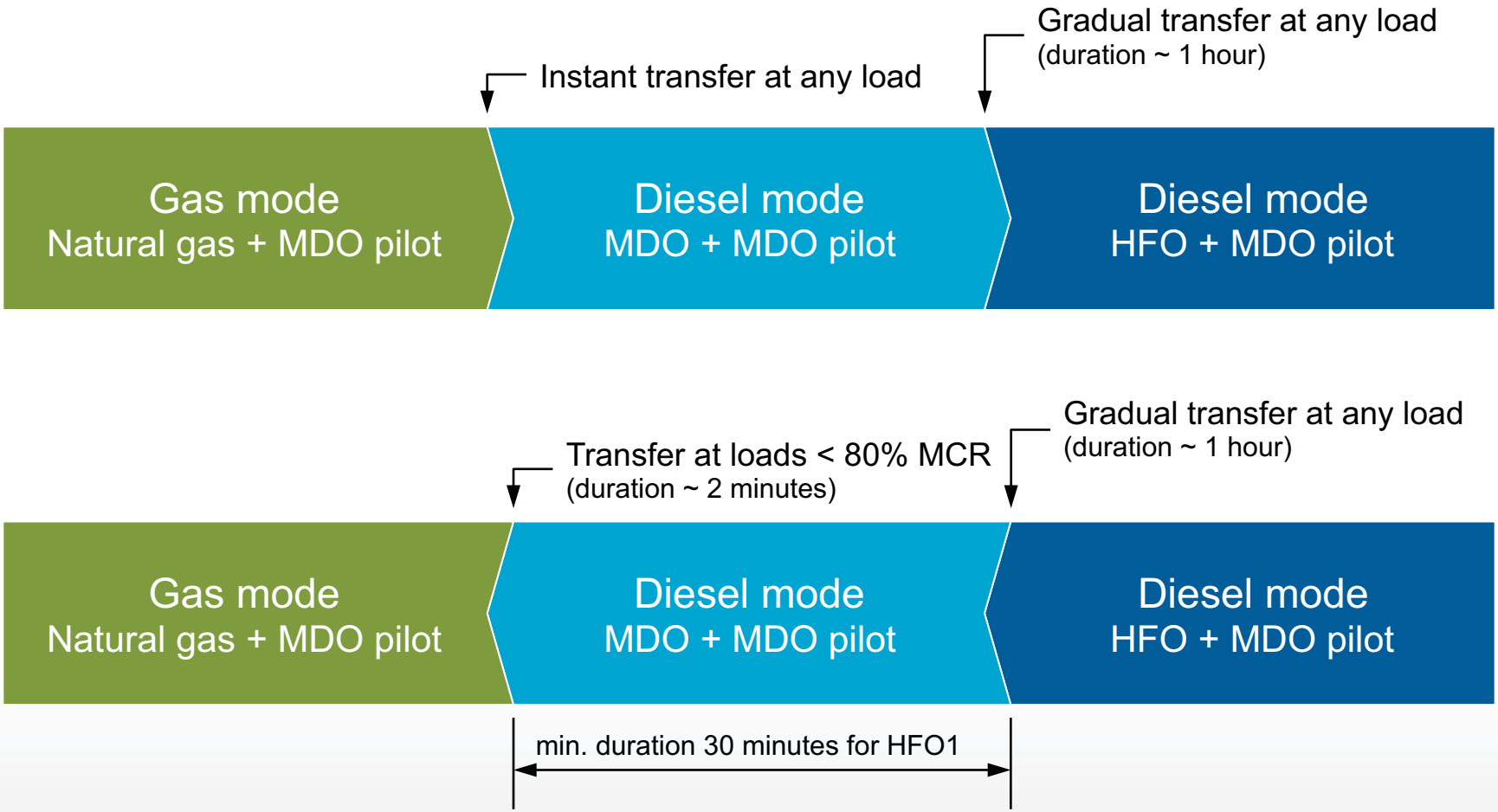
Diesel mode

- Running on HFO* or MDO with MDO pilot fuel injection.
- Automatic transfer to gas mode on request at loads below 80% without loss of engine power and speed.



* Wärtsilä 34DF & 50DF

OPERATING MODE CHANGES (2/2)



REFERENCE LIST – DUAL FUEL GAS CONVERSIONS
STATUS, 2012

Project Name	Country	Year		Conversion type	Status
Almeida	Portugal	2004	1 x	12V32 HFO → 12V32DFc	**Ready**
Tearfil	Portugal	2005	1 x	12V32 HFO → 12V32DFc	**Ready**
Century Power	Pakistan	2005	3 x	12V32 HFO → 12V32DFc	**Ready**
Denizli	Turkey	2006	1 x	16V46 HFO → 16V50DF	**Ready**
Cerestar	German	2006	1 x	16V46 HFO → 16V50DF	**Ready**
Batamindo I	Indonesia	2005	5 x	18V32 HFO → 18V32DFc	**Ready**
Batamindo II	Indonesia	2006	7 x	18V32 HFO → 18V32DFc	**Ready**
Batamindo III	Indonesia	2007	4 x	18V32 HFO → 18V32DFc	**Ready**
Cresent Textile Mills	Pakistan	2007	1 x	16V32 HFO → 16V32DFc	**Ready**
Bilag	India	2007	1 x	18V32 HFO → 18V32DFc	**Ready**
Lucky Cement	Pakistan	2008	7 x	18V32 HFO → 18V32DFc	**Ready**
Lucky Cement	Pakistan	2009	3 x	12V46 HFO → 12V50DF	**Ready**
Cengiz	Turkey	2010	7 x	18V46 HFO → 18V50DF	**Ready**

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REFERENCE LIST – NEW GAS ENGINES

	Wärtsilä 32DF	Wärtsilä 50DF	Wärtsilä 34DF
Power Plant engines	66 engines	84 engines	37 engines
Ship Power engines	28 engines	178 engines	22 engines

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