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EAAW XI PORTSMOUTH

Naval use of Variable Speed Generators, VSG

Lars Appelström, Navy Solutions manager

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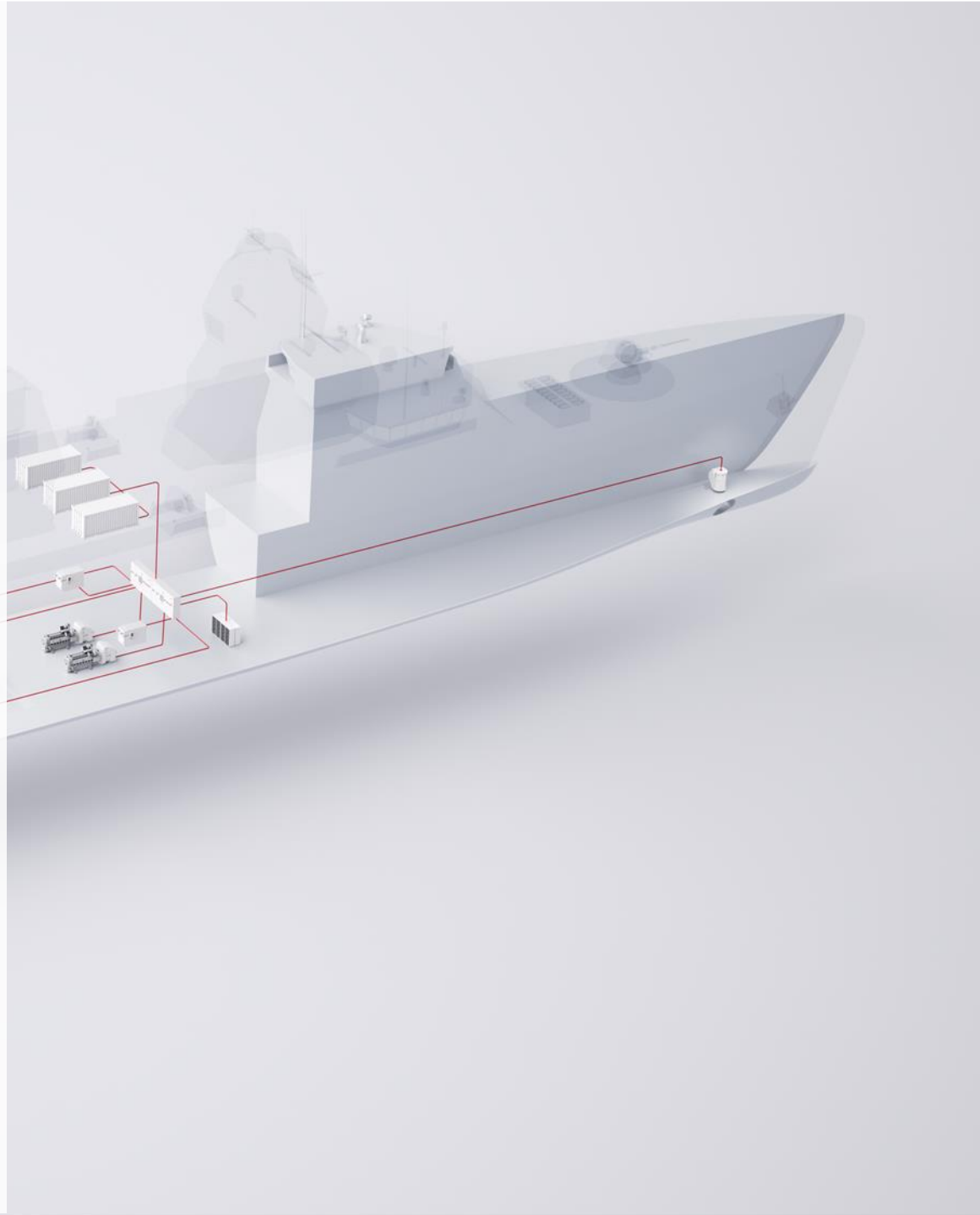
Challenges & considerations for Modern Naval Power & Propulsion design

- Process / Agenda:
  - Design considerations Naval powerplants
  - Lessons learned
  - Variable speed generators
    - Fuel economy
    - Simulation case
    - Electrical Integration
  - Summary & Q&A



Design considerations Naval Powerplants

- High speed vs medium speed Gensets.
- Load profiles
- Future growth
- Fuel efficiency
- Electrical selectivity and safety
- Vessel constraints
- And more….

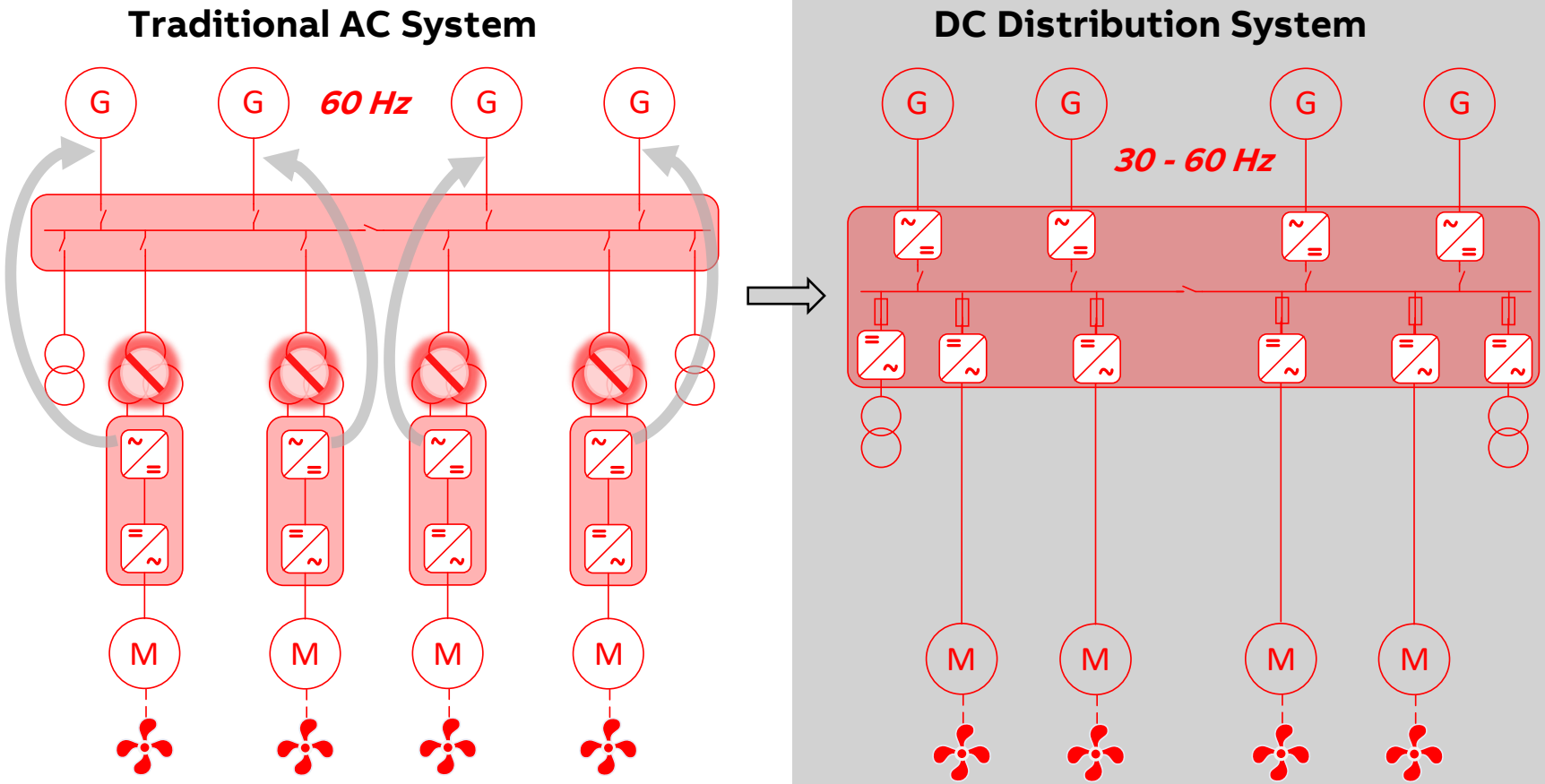
Lessons Learned for Existing Platforms

- Oversized fixed speed gensets? Disparity father/son?
- MS and HS fixed speed diesels on the same AC bus?
- Advanced gearboxes
- Idling/underloaded diesels
- Undervoltage
- Fixed speed PTO

Variable Speed Gensets in DC Distribution Systems

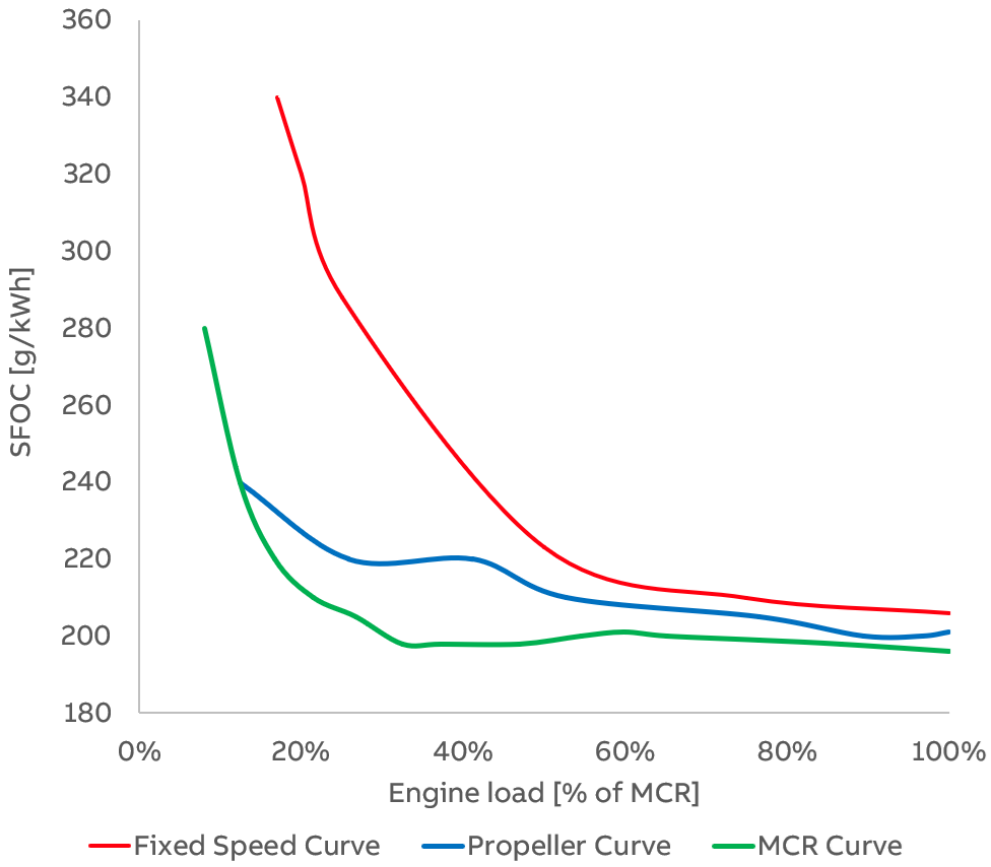
Characteristics

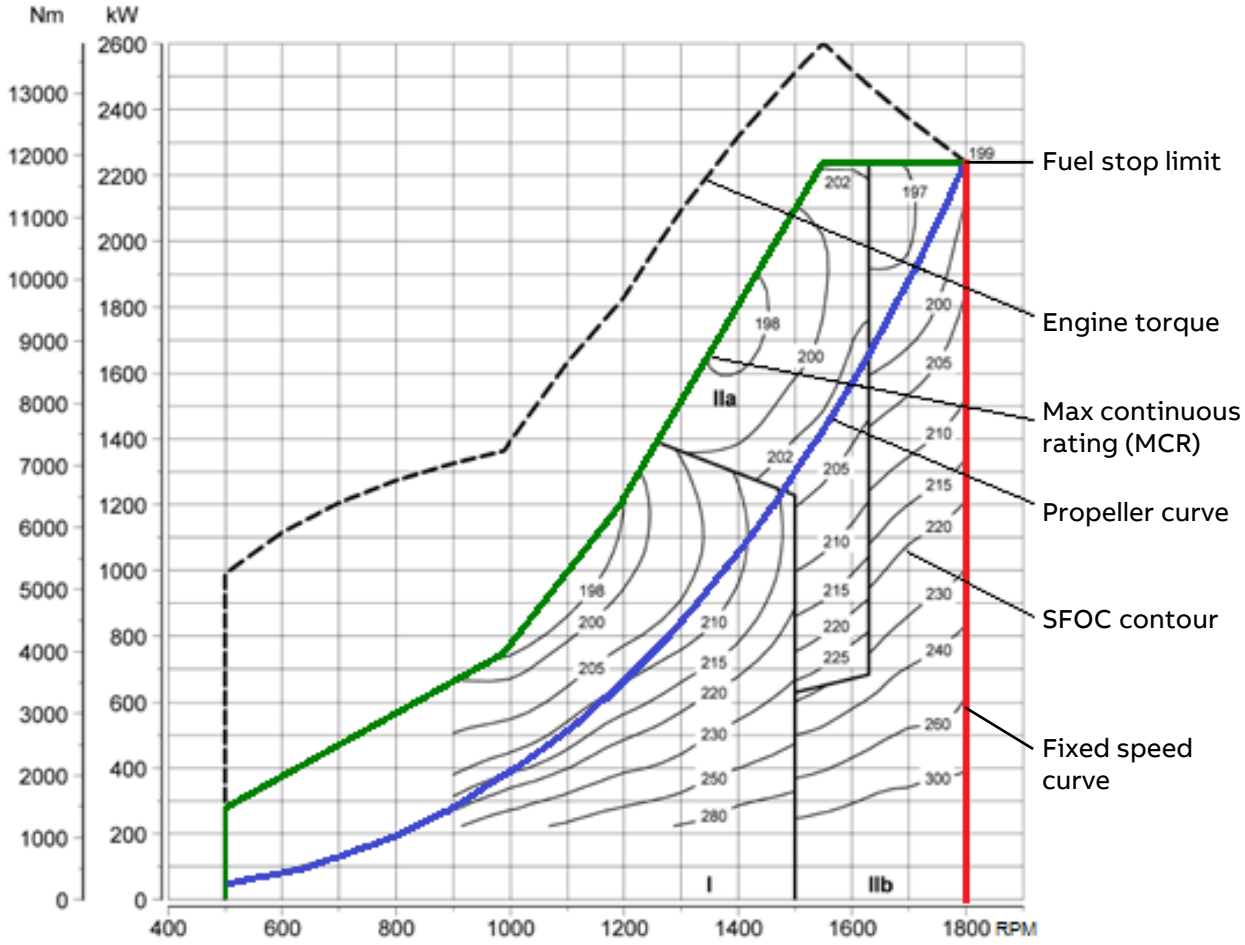
- Decouples the generator frequency from the electrical grid.
- Possible to optimize speed to load demand.



Variable Speed Engines

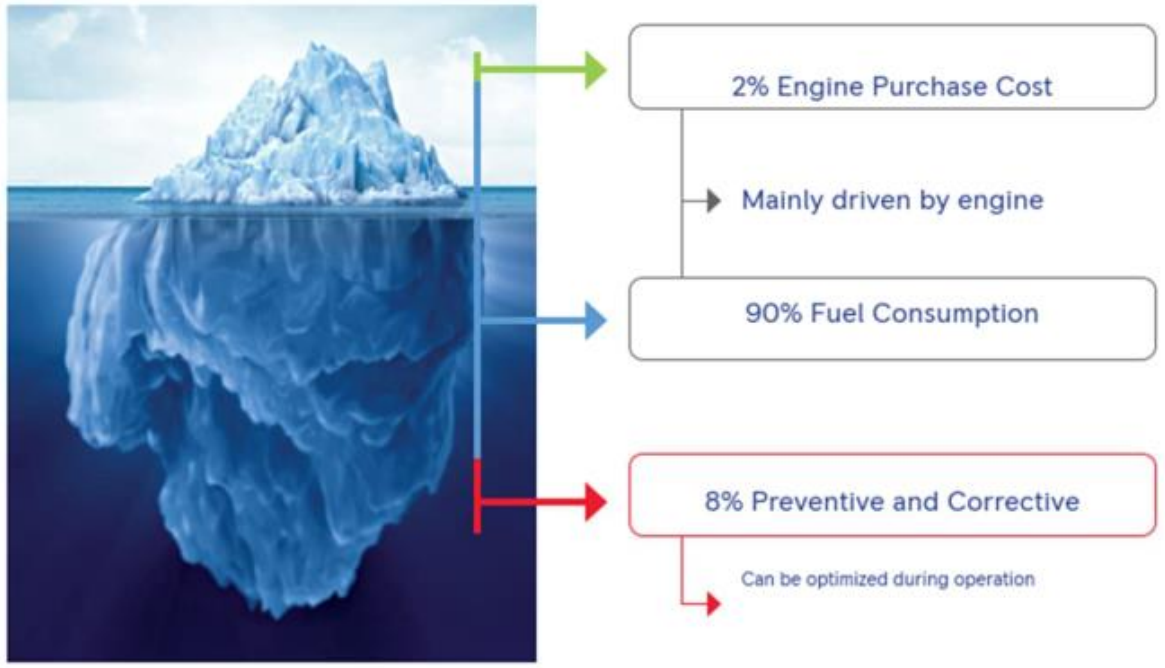
Fuel Economy





Variable Speed Engines

What is the effect of variable speed?



Reduced fuel usage

Up to 20% reduction for medium-speed engines and 40% for high-speed engines for partial load operation

Reduced emissions

Lower GHG emissions, lower particle emissions, lower NOx emissions

More quiet operation

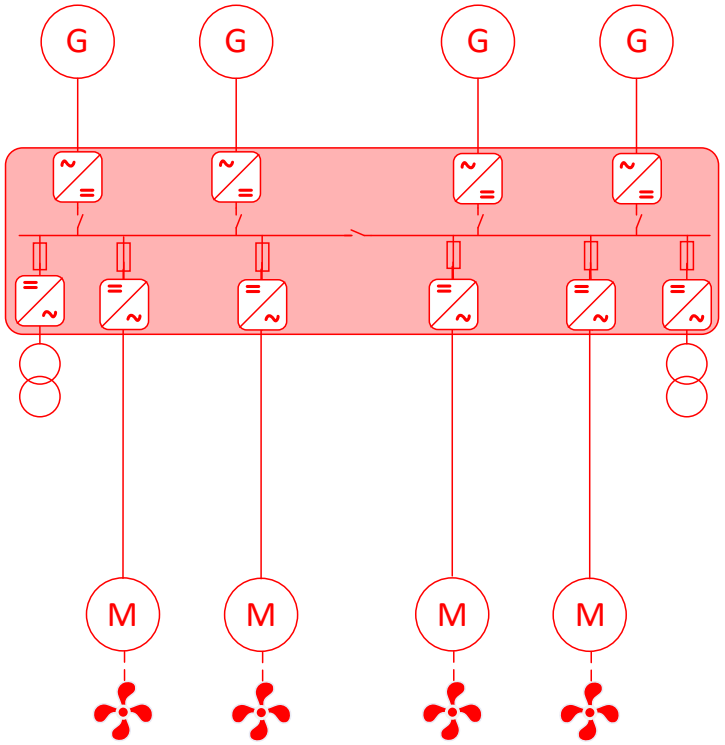
Potential reduction of the audible noise level by more than 5dB

Reduced maintenance

Up to 30% reduced wear and tear on the engine due to the low-speed operation and reduced pollution

Variable speed engines enable an exceptional fuel economy

Electrical Integration of Variable Speed Gensets



1) Generator and rectifier design considerations

- Nominal current and short-circuit withstand of rectifiers.
- Type of rectifier: diode, thyristor or IGBT.
- Stiff or floating voltage.
- Increased inductance → Slower dynamics.

2) System considerations

- Sizing and configuration.
- Usable speed range affected by voltage requirement.
- Protection system (short-circuit and over/undervoltage).

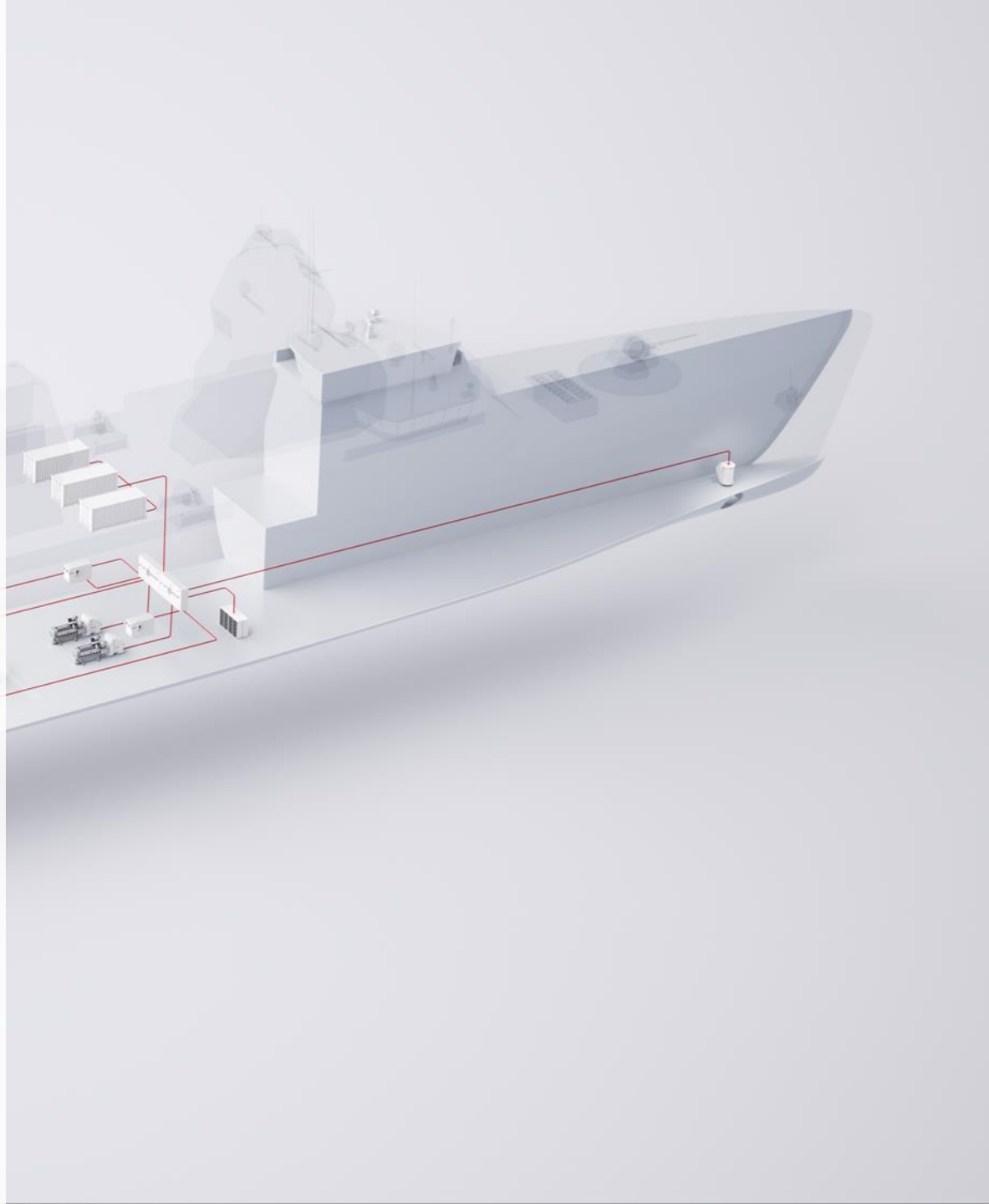
Naval Context

Advantages:

- Faster startup and connection time due to simpler synchronization.
- In cooperation with ESS, reduced runnings hours and number of starts/stops.
- Sizing flexibility.
- Possible use case for signature management.

Possible power and control modes:

- Ecomode: slow load ramps, control for low SFOC.
- Silent/Signature Mode: low rpm, varying rpm or different rpm of each genset.
- Power Mode: fast load ramps, gensets above nominal rpm.
- IR Management Mode: control loops focusing on low exhaust temp.



Simulation Case: Naval Vessel with AC vs DC

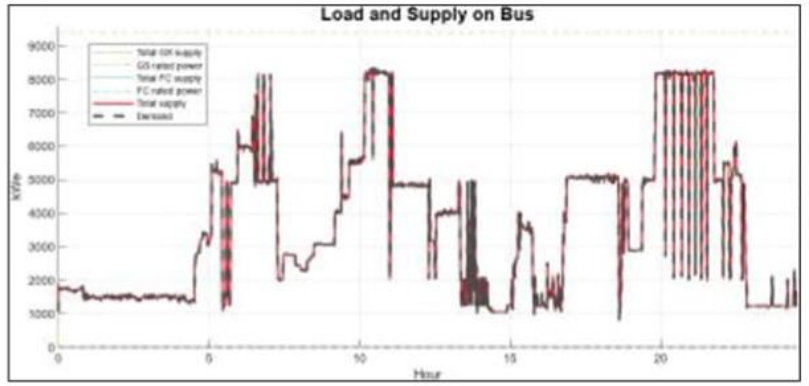
Note: Not all efficiency gains are attributable solely to VSG. The DC architecture also incorporates batteries for spinning reserve and peak shaving, enabling fewer generators to run simultaneously

AC Distribution

Power Plant 252 MWh - Load 84 MWh = 168 MWh

25.3 t fuel Fuel Efficiency = 33.3%

Genset running hours = 73.6 hours



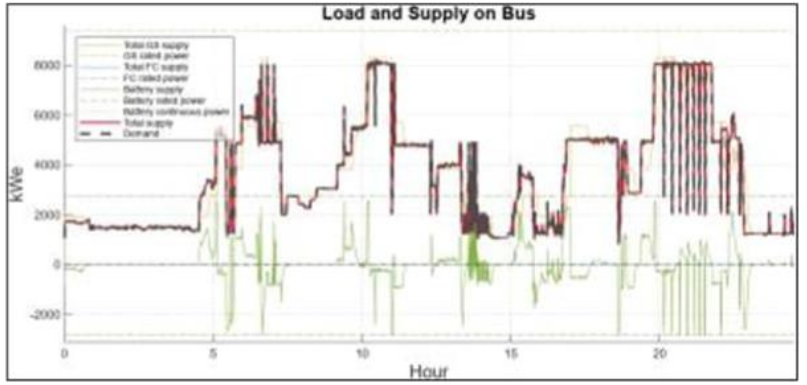
DC Distribution

Power Plant 209 MWh - Load 84 MWh = 125 MWh

21.0 t fuel Efficiency = 40.2%

Fuel: -4.3 t /day Fuel Efficiency: +20.7 %

Genset running hours = 44 hours



VSG for Naval usage
Summary

- **Tested Reliability, TRL9:** Over a decade of proven performance in commercial and naval environments
- **Challenges** are nowadays mainly commercial
- Enhanced fuel efficiency across a broader load range
- Potential for more power as VSG are not tied to 60 Hz
- Reduced maintenance
- Greater flexibility in system sizing and configuration
- Faster startup and simplified synchronization


ABB