Hybridisation in Large Engines Applications

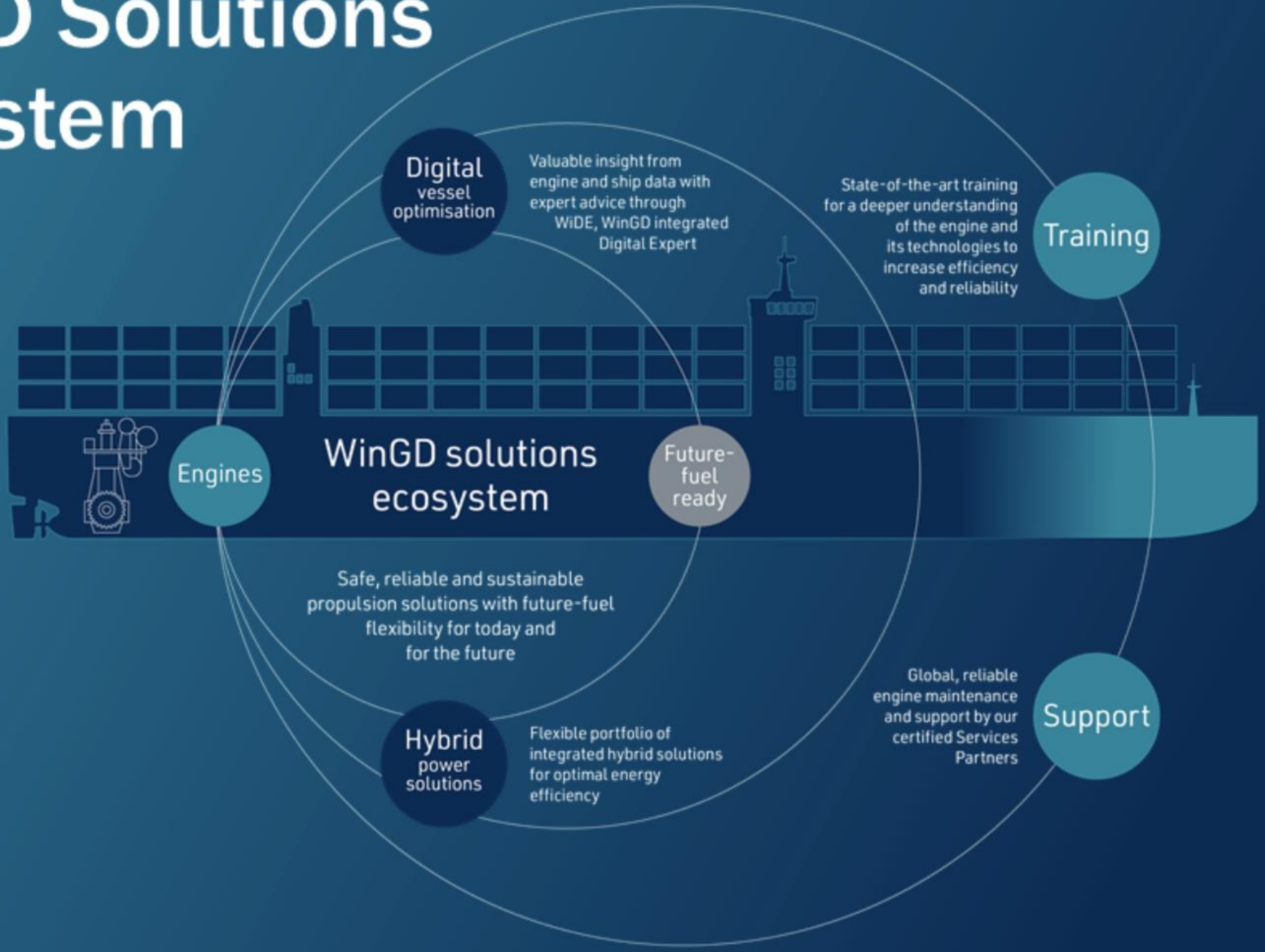
CIMAC Cascades Seminar

Graz, 22.09.2021

Stefan Goranov / Program Portfolio Manager - Digital & Hybrid

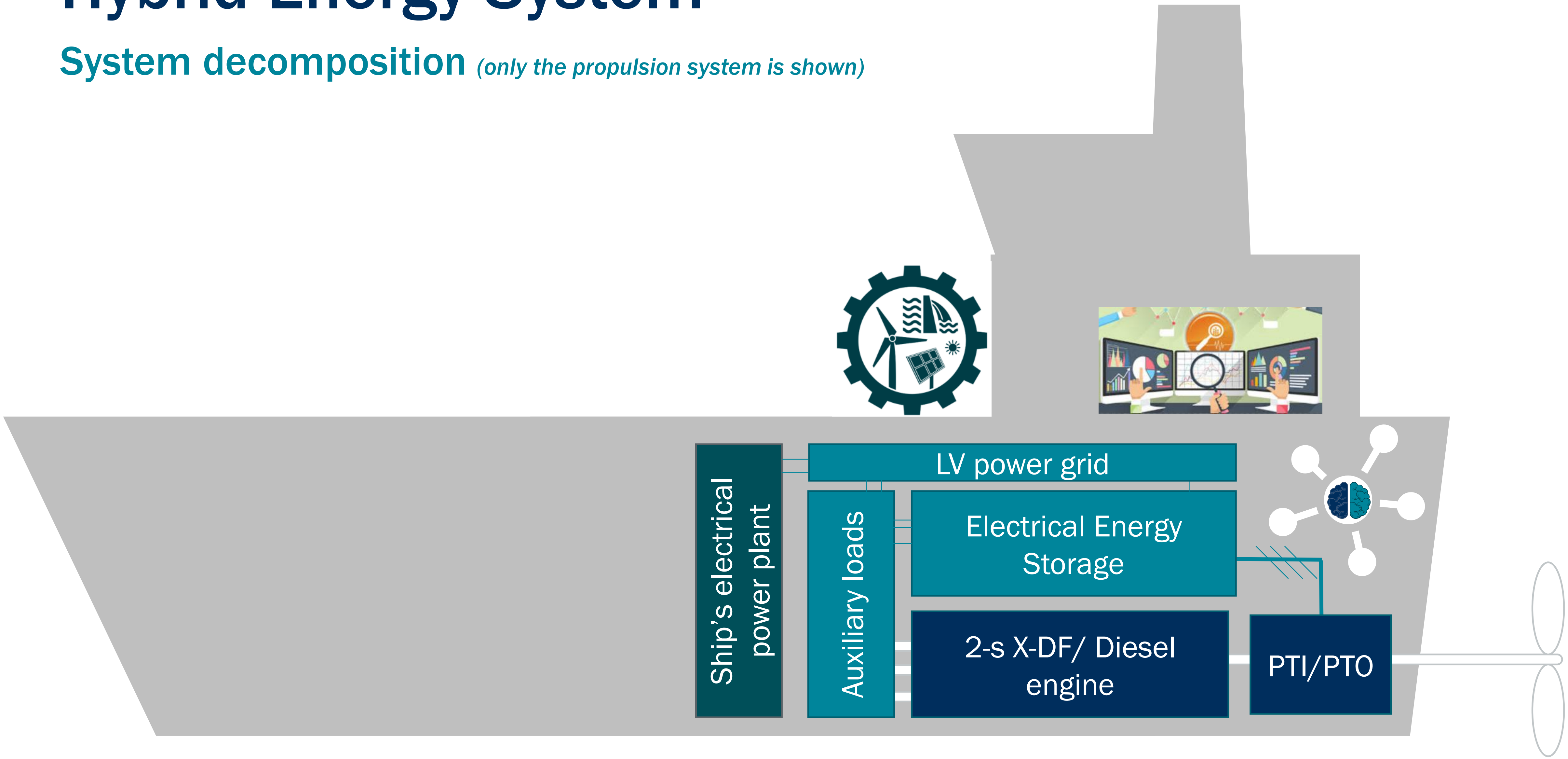
WIN GD

WinGD Solutions Ecosystem



Hybrid Energy System

System decomposition *(only the propulsion system is shown)*



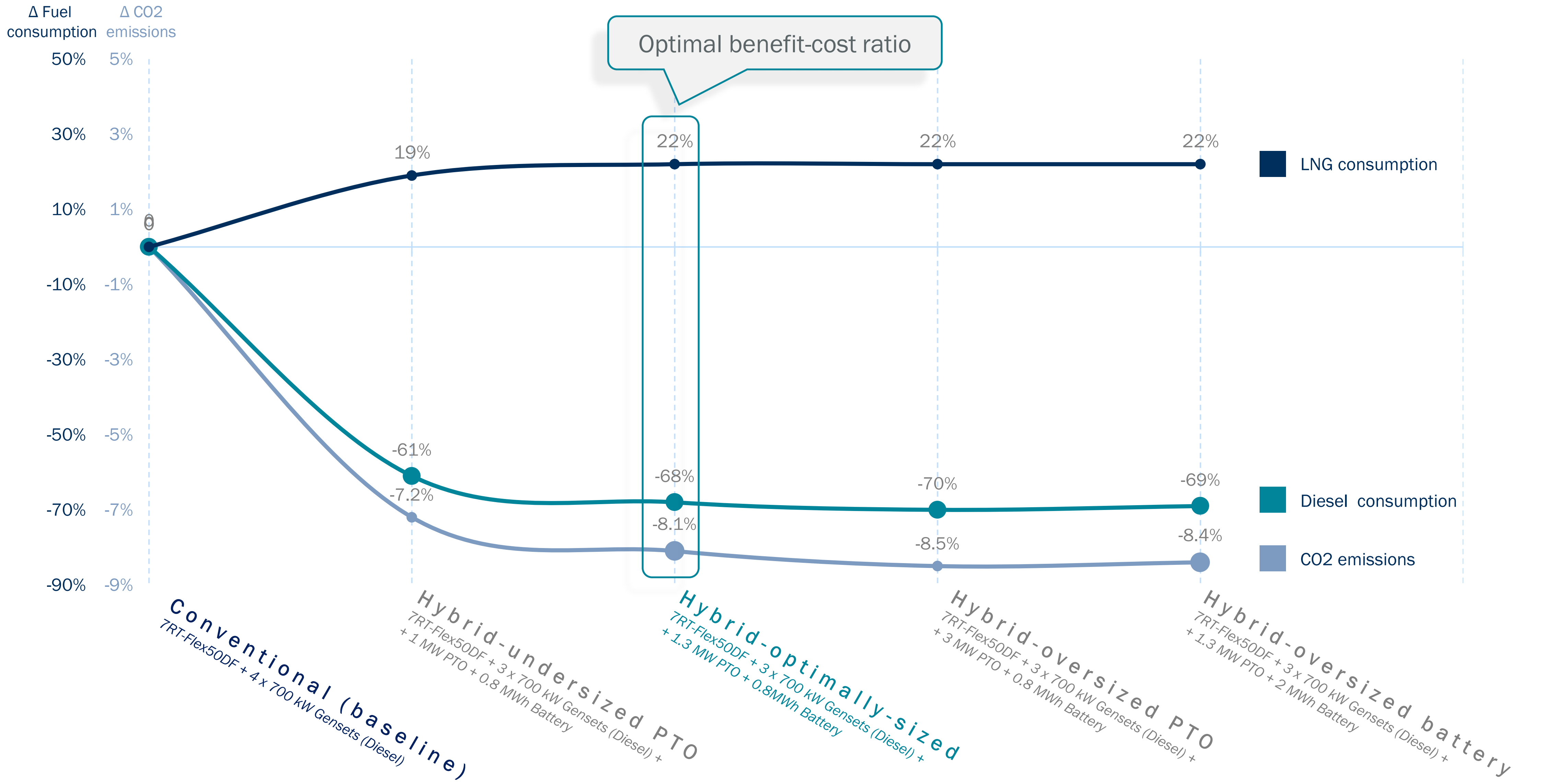
Key elements for maximising system efficiency

System Topology
Optimally sized components, fulfilling technical and commercial requirements

Control Strategy
Holistic energy management system, aiming for maximum efficiency of the ship as a whole

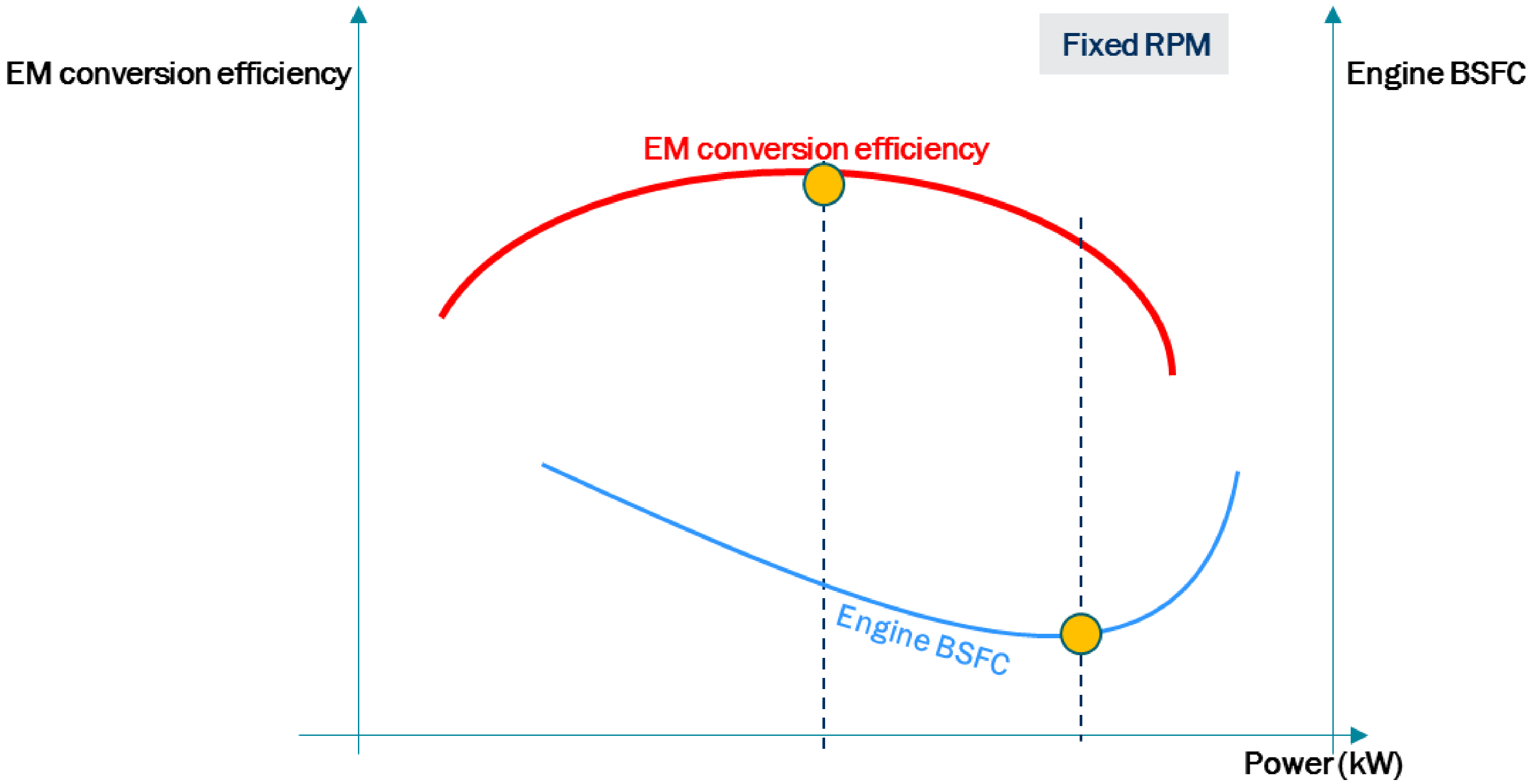
Lifecycle management
An integrated advisory system for operation, diagnostics and maintenance

Why a proper components' sizing is crucial? / Example CV feeder



Finding the operational «sweet spot» of the system

The importance of overall system tuning



The questions we need to answer

How to ensure efficient performance of a complex integrated system?

- What is the optimal design point of an integrated system, if everything is varying?
- How to select and size components that they work in “harmony” together?
- What is the optimal control strategy of the complete system, including the main engine?
- What investments are need and what operational gains are achieved?
- How to reduce variants? Is “unified”, parameterizable solution possible?
- How to plausibly identify trade-offs? e.g. Battery performance vs lifetime
- …

> Some answers are given by using simulation methods to:
> - iterate alternatives until the optimum setup is found
> - early verify the efficiency of the **system** integration
> - estimate quantitative operational benefits vs. the investment required

Our approach for system integration

01 Collect & Analyze Requirements

Gathering and analysis of requirements

- Ship and route data
- Commercial *(CAPEX, OPEX)* and design *(weight, size)* constraints
- Specific customer needs

02 Model and Run Virtual System

Model-based system engineering

- System Components *(Engines, e-machines, power electronics, clutches, shafting, etc.)*
- Energy Management Strategies
- Application Particulars *(hull, propeller)*

03 Design and Implement

Integrated energy system

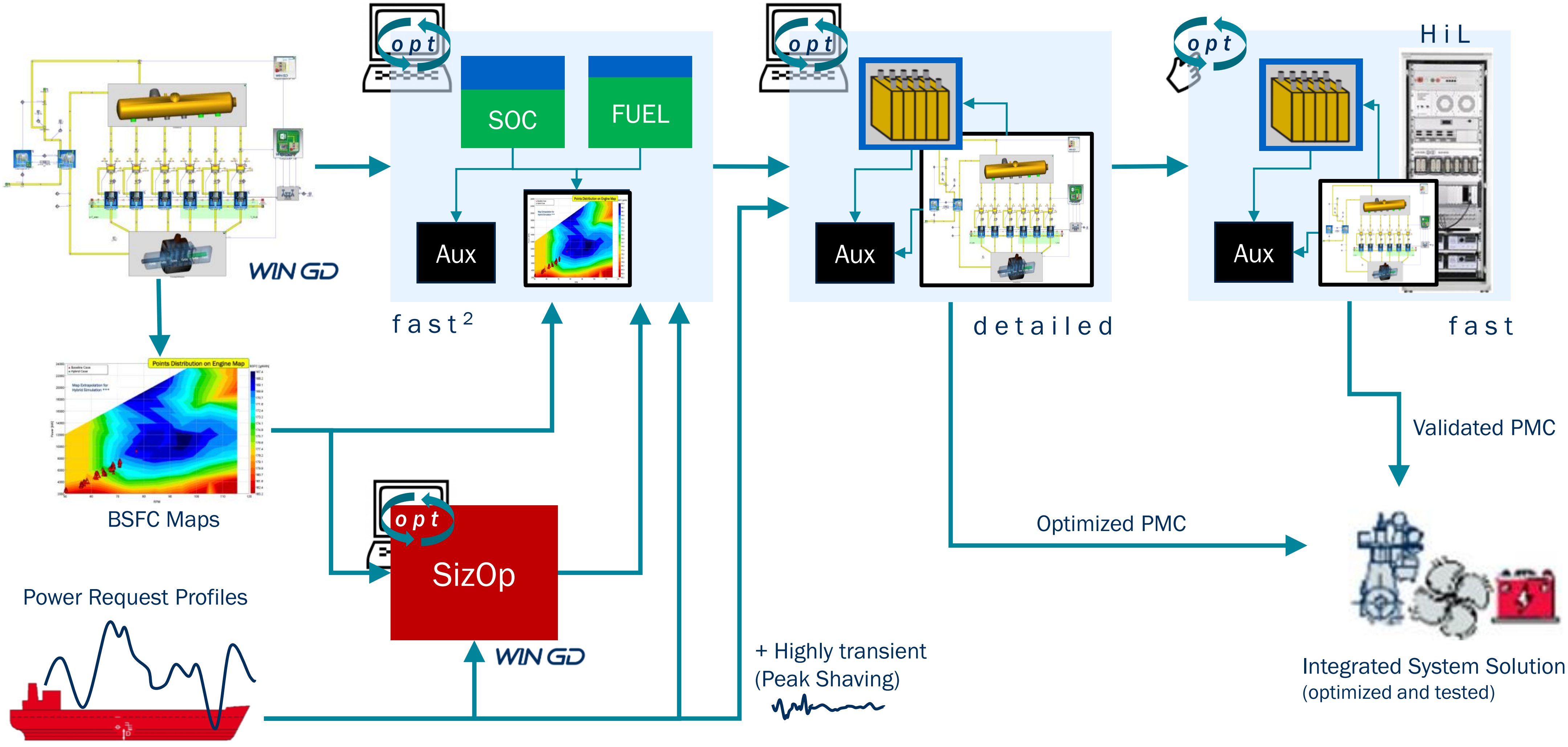
- System Architecture
- Components integration
- Energy Management System

04 Operate and Maintain

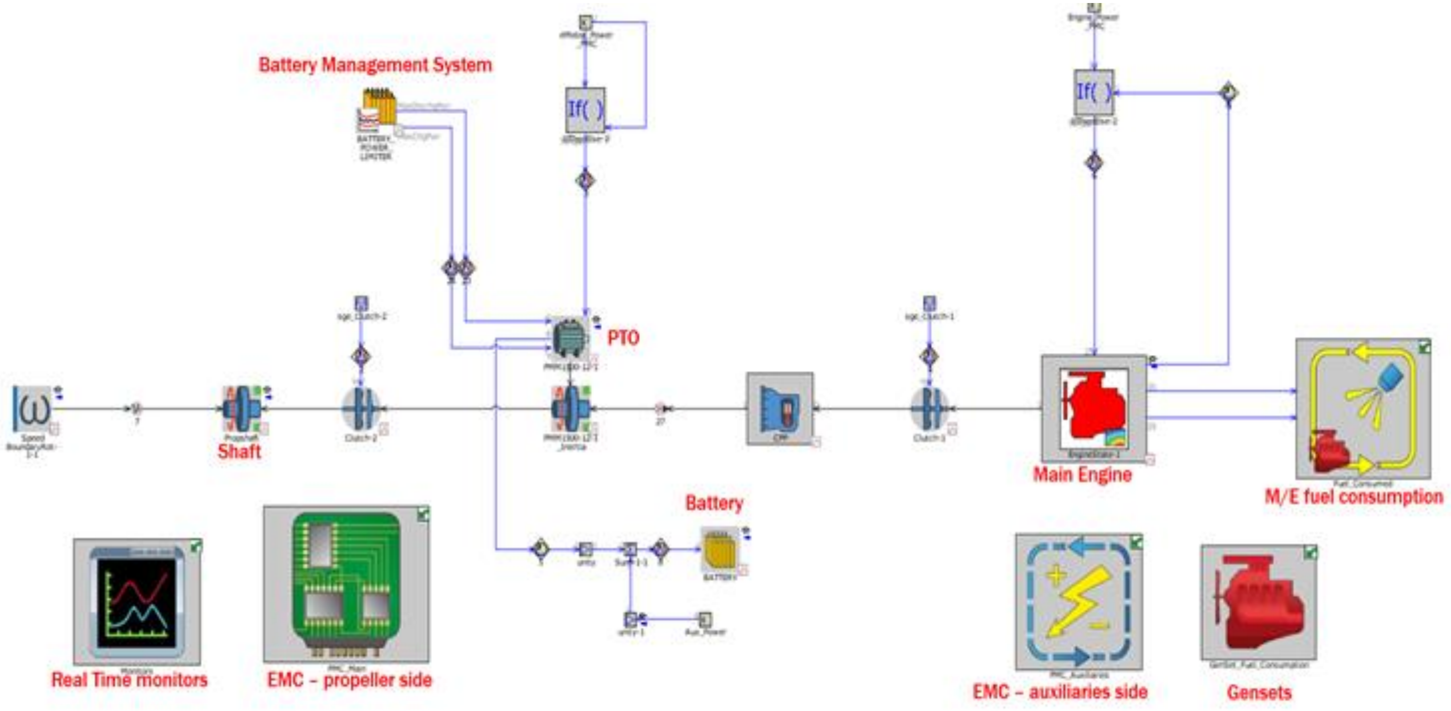
Data-driven lifecycle management

- Data-driven advisory services
- Asset life-cycle management
- Tank/battery-to-propeller performance optimization,

WinGD System Optimisation Landscape



Energy system simulation



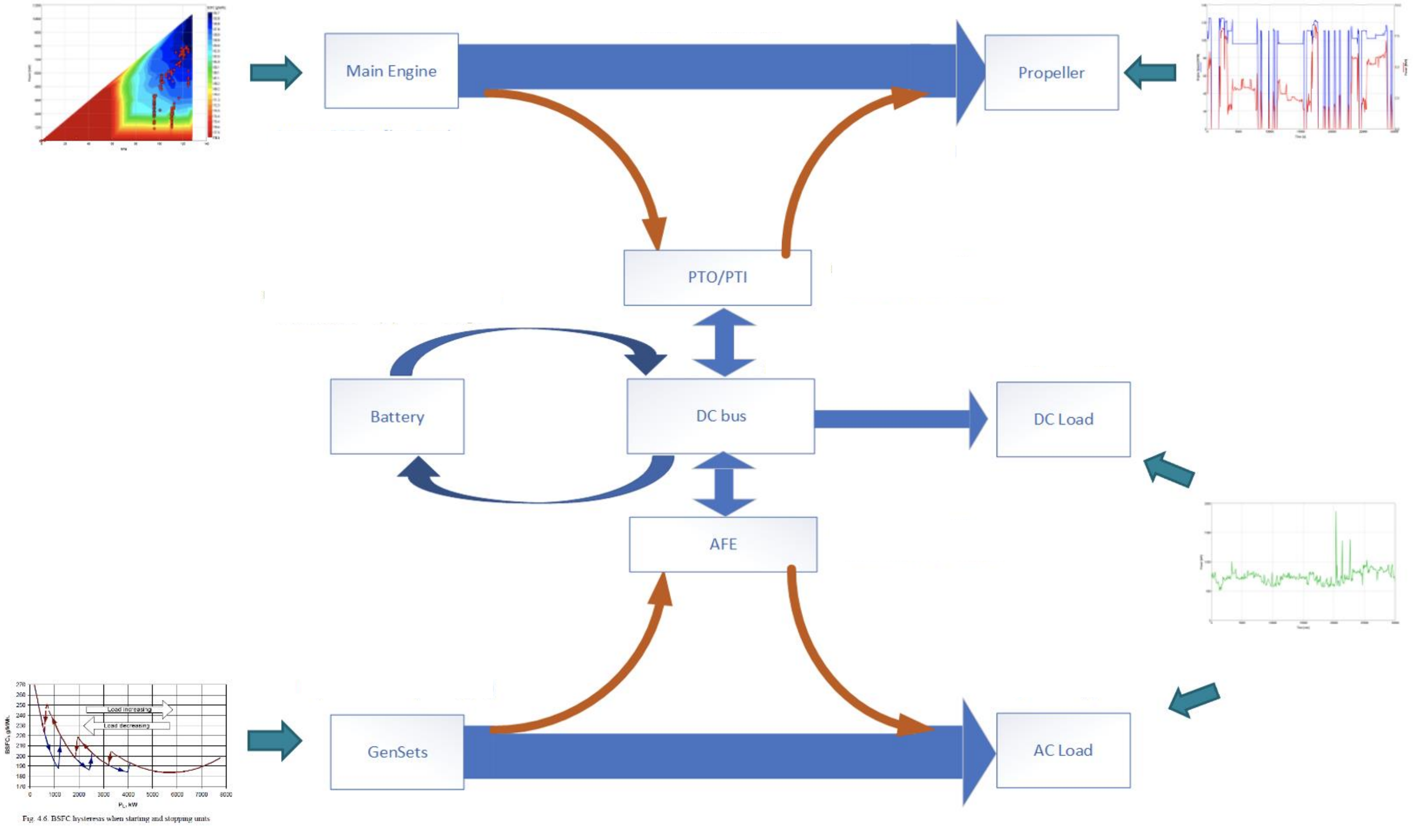
- The simulation process at WinGD follows two approaches:

  1. **Quasi-steady,** where all the components are modelled as performance maps while the system is operated in a transient way.
  2. **Detailed components' models,** where the main engine is represented using the validated in-house-developed physical transient-capable models. They are capable to operate dynamically in a simulation environment and reproduce the transient behaviour of a real engine

- The system control strategy, aiming for optimal energy production from various sources and power flow among the components, is an integral part of the simulation process.

Optimal system control

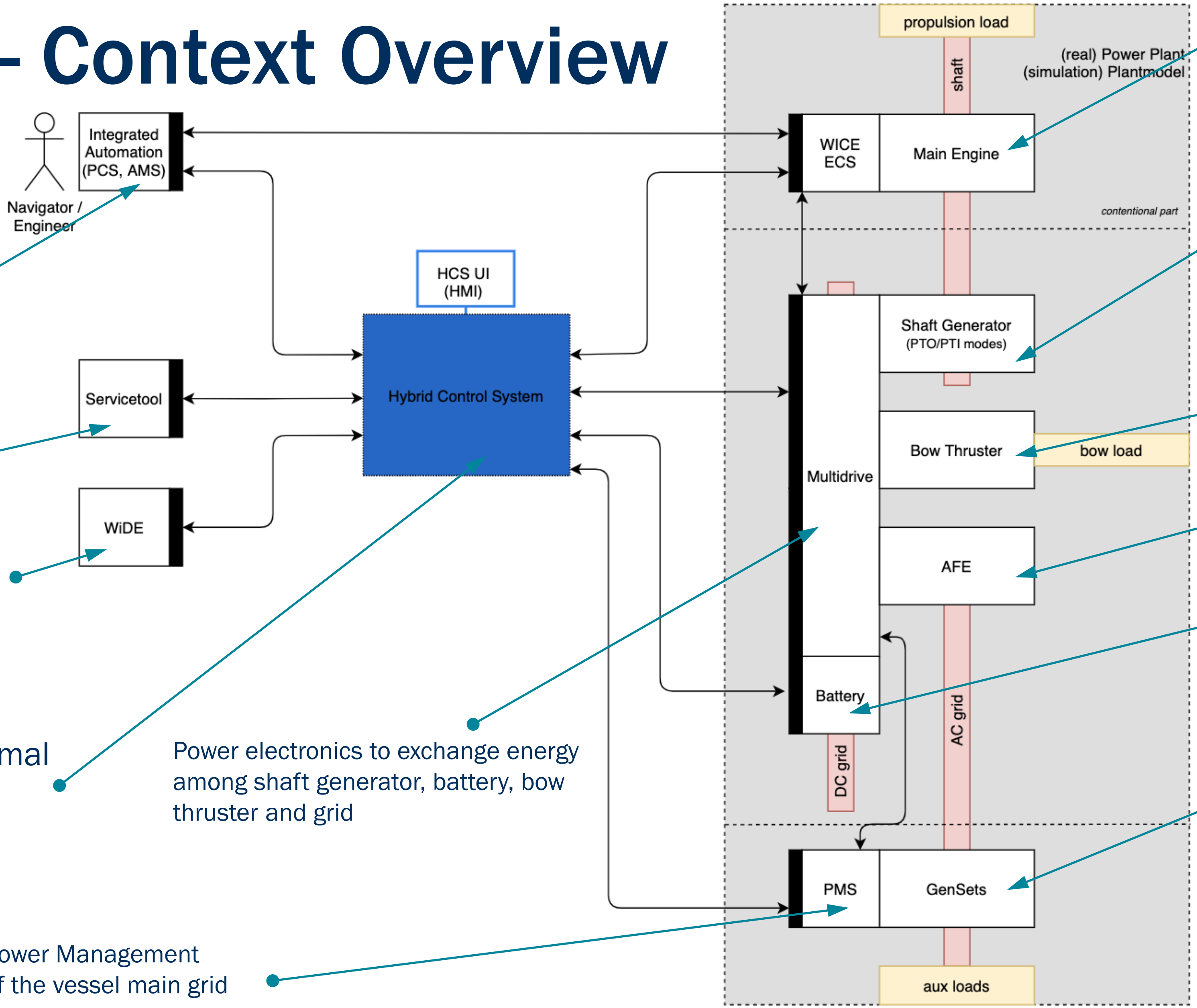
Where, when and how much energy to produce, store and use?



Considerations:

- **Constrains** in terms of power limits, transient capabilities
- **Efficiencies** of the M/E+SG, Gensets, converters, batteries
- **Emissions** reduction of CO2, CH4, NOx, etc…
- **Maintenance** cost of the M/E, Gensets, other components
- **Energy storage capabilities**, determined by Power, cycles, temperature
- **Reliability and availability** of the system
- **Lifetime** of the components

The HCS - Context Overview



Main combustion engine for the propulsion

Add-on generator for the main propulsion shaft as key element for hybridization. Supports power take-out and power take-in operation.

Thruster motor to support manoeuvring

Converter to integrate hybrid system with main vessel grid

Energy storage

Auxiliary engine sets with alternators to provide electricity to ship electrical grid

Propulsion control and alarm monitoring

Support tool for commissioning, updating, monitoring and tuning.

Digital ecosystem for performance optimisation, diagnostics, and lifecycle management support

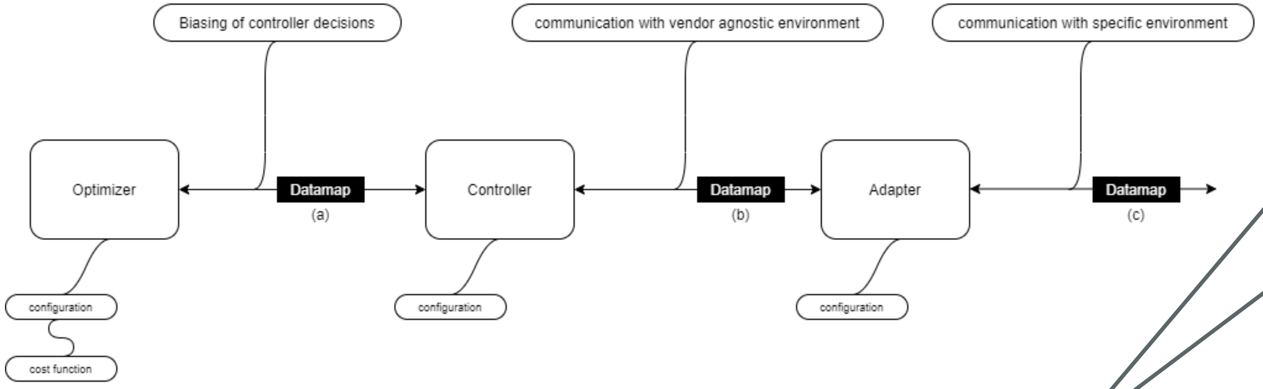
The control system for the optimal operation of the (HE) Hybrid Energy Management System

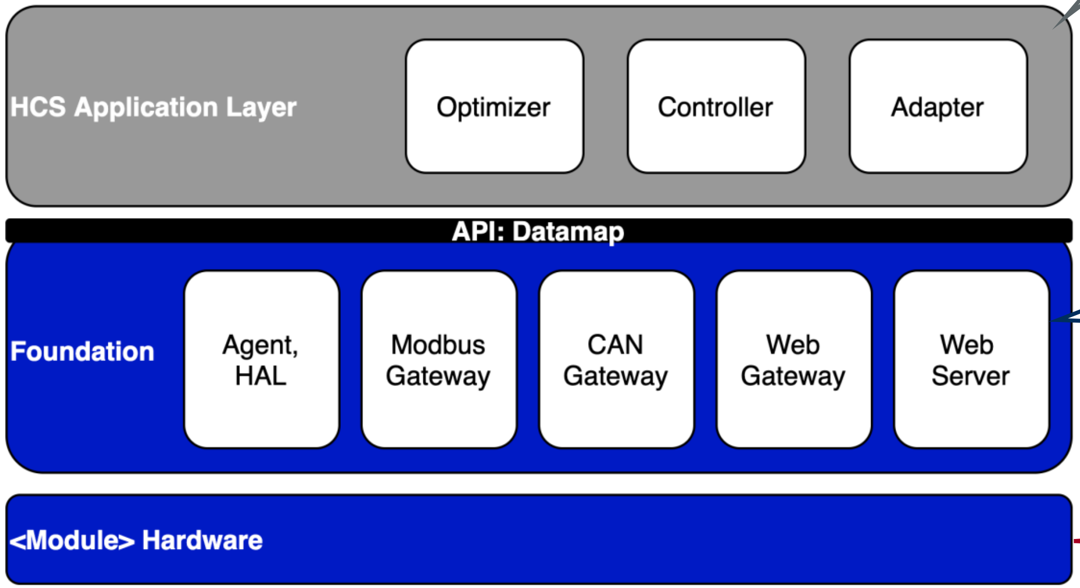
Power electronics to exchange energy among shaft generator, battery, bow thruster and grid

Power Management of the vessel main grid

WIN GD

HCS realisation





Applications define the functional behaviour of HCS. They make use of base functionality provided by the **Foundation.**

Functional elements for hybrid energy management handling:

- **Optimiser** - biases the Controller decisions based on additional historical or prognostic information.
- **Controller** - achieves best operation point for the hybrid system, based on current conditions
- **Adapter** - translates the input/output for specific vendor products on the hybrid vessel

Foundation provides the functions that the **Applications** needs to run. It abstracts and interfaces the underlying hardware and supports different types of hardware modules and application types

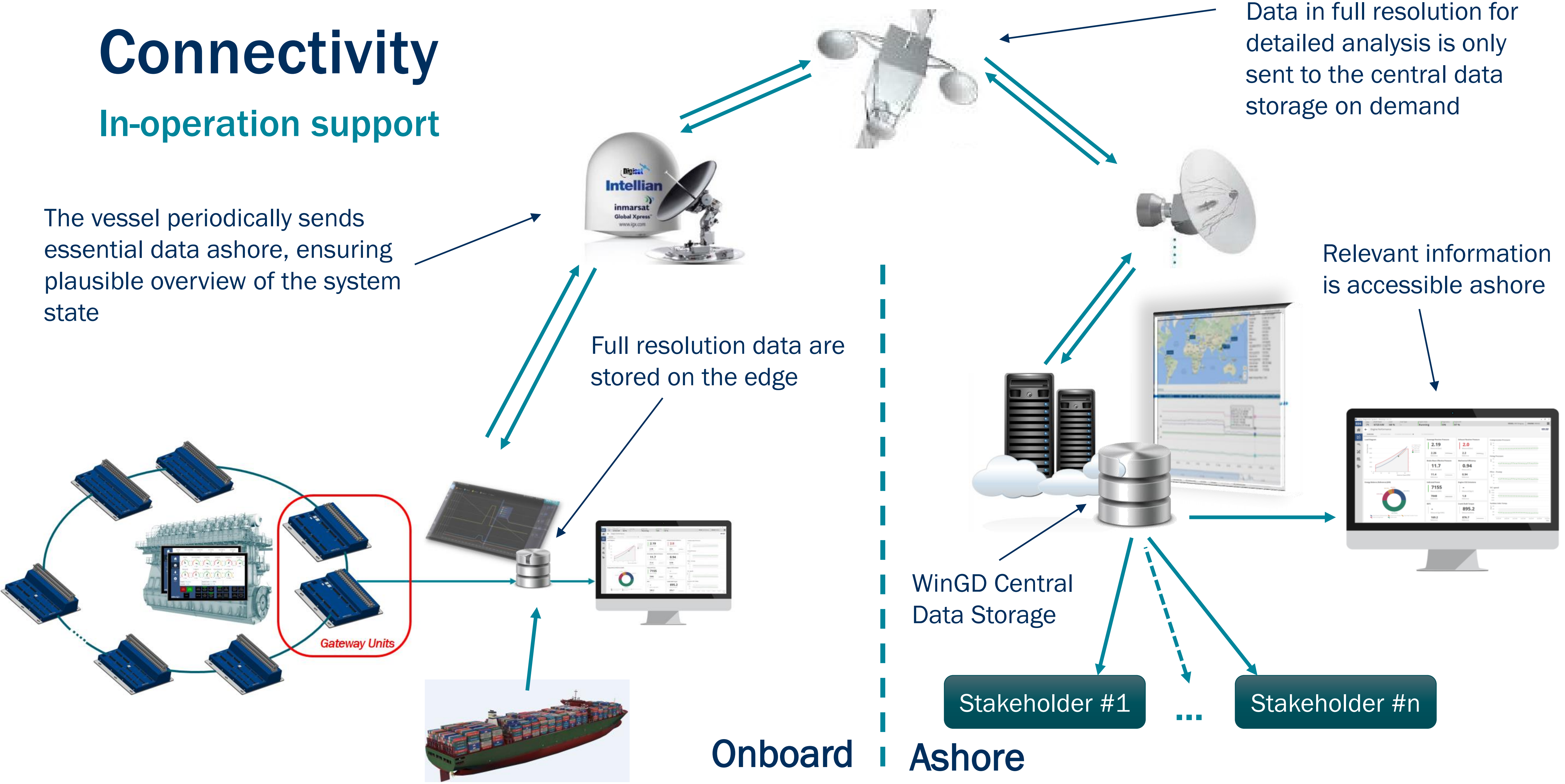
Gateway aspects, without own intelligence:

- **CAN, Modbus Gateway** - translate between data map and the related protocol data units
- **Web Gateway** - translate between data map and web client requests
- **Web server** - provide web content for web client

Hardware provides specific IOs and communication ports, as well as processing power by means of CPU and FPGA.

Connectivity

In-operation support



Summary: The 2-stroke engine in a hybrid setup

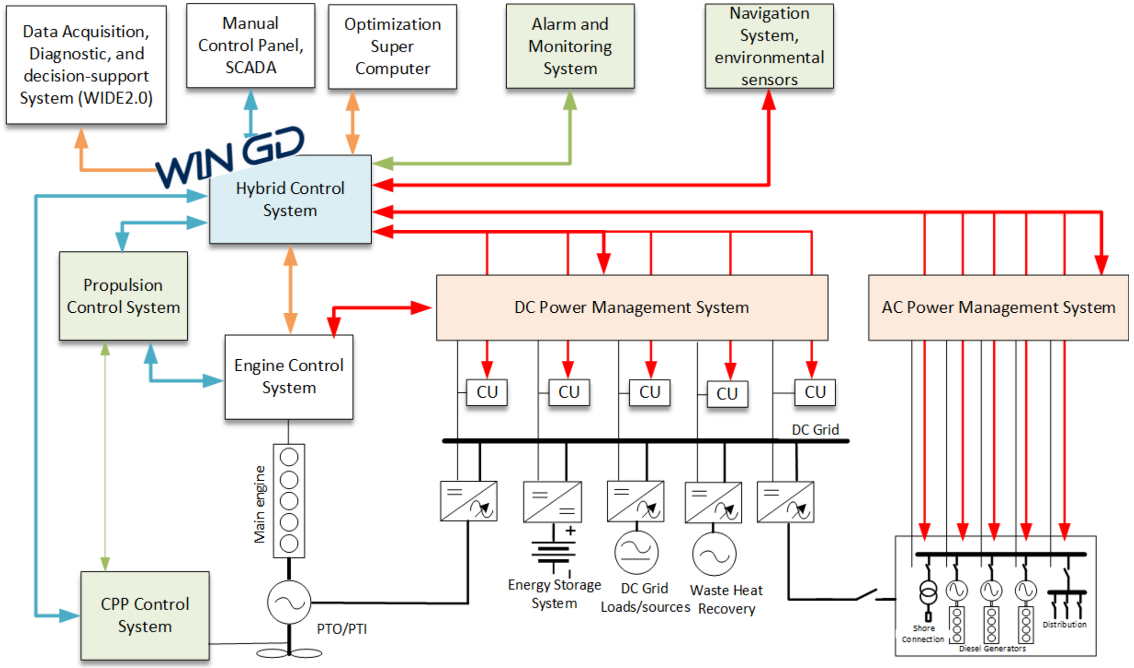
The main engine and optimally sized components around it should be brought into a system, so they function together as a coordinated whole. Maximum ships' efficiency at any given moment is the Goal.

High operational flexibility

Intelligently optimised power production on board at any given moment, considering various factors, such as actual cargo capacity utilisation, ship speed demand, environmental conditions and route

Optimal energy resources utilisation

- ✓ **Maximised usage of the main engine** and alternative energy resources in a hybrid setup for electrical power production
- ✓ **Increased propeller efficiency** by utilizing the LRM for electrical energy production (PTO); Power boost (PTI) feature implemented when needed
- ✓ **Reduced CO2-eq emissions from the ship** as a whole by minimising the running hours of the Auxiliary Engines; or operating them with maximised efficiency when required
- ✓ **Safe no-auxiliary-engines operation** en route and optimal energy production for safe manoeuvring
- ✓ **Improved overall system performance** and stability in transient conditions



The WinGD Hybrid Control System is:

- fit-for-purpose real-time optimiser, applicable on any system topology.
- built with embedded modularity for efficient configuration, testing, and deployment

Thank you

Propelling shipping towards a greener future

WIN GD

Winterthur Gas & Diesel Ltd.
Schützenstrasse 3,
8401 Winterthur, Switzerland
www.wingd.com