HYDROGEN FUEL CELL SYSTEMS FOR POWERING ZERO-EMISSION CRUISE VESSELS

REGULATIONS AHEAD – STATUS TODAY - SOLUTIONS AT SEA

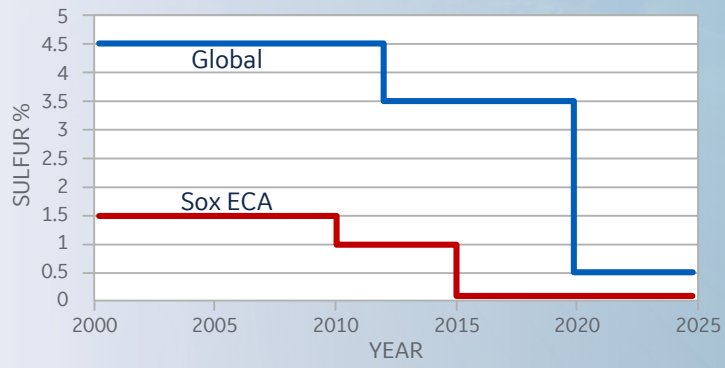
2 MWe MARITIME FUEL CELL POWER INSTALLATION

REGULATIONS AHEAD

IMO / EPA

50% reduction by 2050
0 Emission by end of the century
EPA dev strategies with port communities

MARPOL Annex VI SOx EMISSIONS LIMITS



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STATUS TODAY

3 WAYS TO DECARBONIZE

- Lower energy demand
- Capture Carbon
- Less C02

BESS: Large, Heavy, Local grid for charging

Wind: Sailing, Flettner rotor, Kite

Hydrogen

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SOLUTIONS
AT SEA

H2 Fuel Cells

Equivalent to a battery BESS w/ benefits of range
Green H2 from cheaper renewable sources

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GE and Nedstack partnership sets sights on zero emission cruise vessels

GE and Nedstack have entered into a partnership to develop hydrogen fuel cell power systems for cruise vessels

Fuel Cell power systems eliminate vessel exhaust gases and by extension prevent harmful pollutants ending up in our atmosphere, our ecosystem and in vulnerable port communities

PEM fuel cells only produce electricity and the only bi-products are water and heat -making them an ideal solution for zero-emission cruise ships

GE's variable speed drive technology manages power generated to supply electricity to propulsion and onboard systems, as well extending fuel cell life

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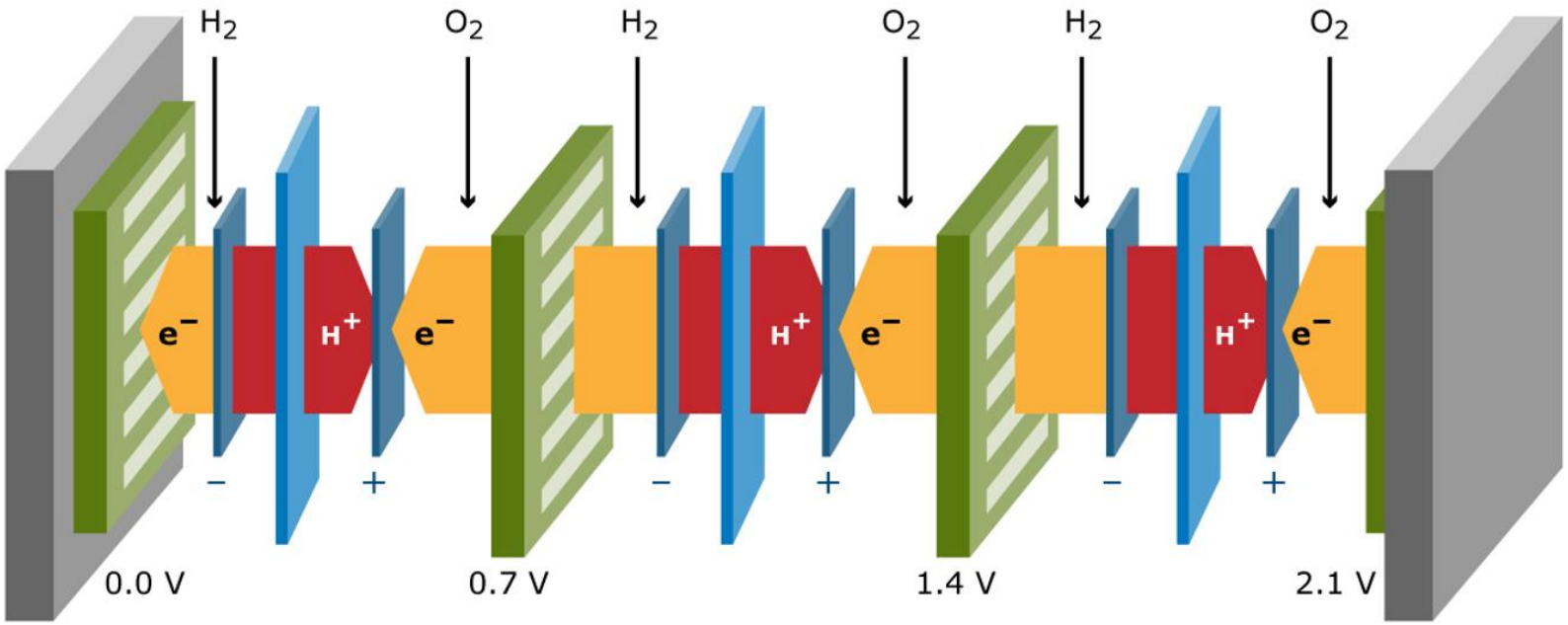
Fuel cell technology



PROTON EXCHANGE MEMBRANE (PEM) FUEL CELLS are electrochemical reactors in which a fuel and an oxidant are made to react in an electrochemical manner. Such reactors, as opposed to combustion reactions, do not produce any emissions other than pure water and can be scaled to multi-megawatt power ratings.

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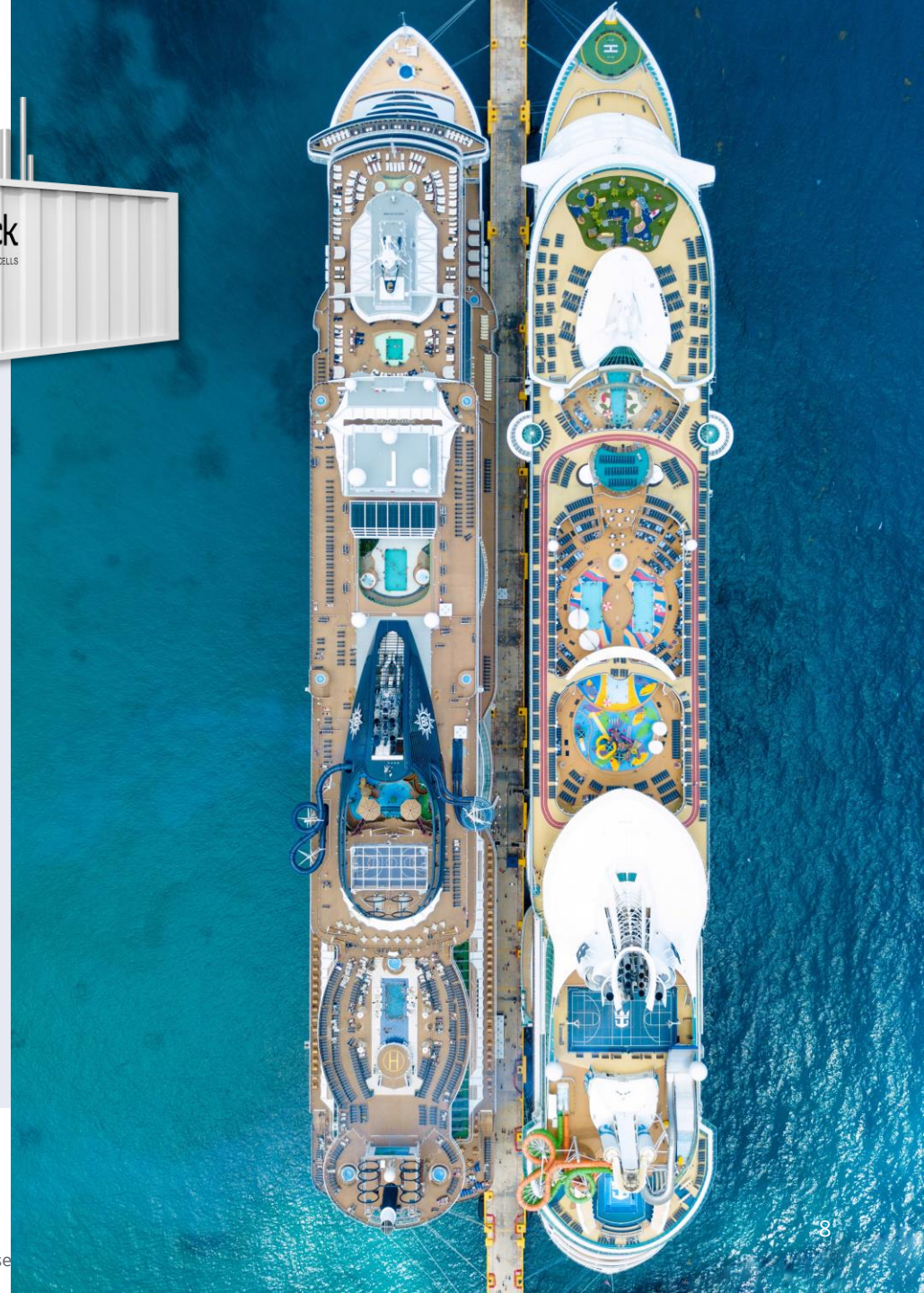
MARCH 2019 | GE'S POWER CONVERSION BUSINESS AND NEDSTACK, A LEADING FUEL CELL MANUFACTURER, ARE COLLABORATING ON DEVELOPING HYDROGEN FUEL CELL SYSTEMS FOR POWERING ZERO-EMISSION CRUISE VESSELS.

This partnership brings together GE's recognized expertise in cruise electrical power and propulsion solutions plus system integration capability, with Nedstack's extensive experience in megawatt-scale hydrogen fuel cell technology. **The target will be highly efficient fuel cell solutions that enable a zero-emission cruise industry.**



An industry leading consortium

A leader in marine electric power propulsion syst.

>500 marine power & propulsion plants in ops;

System engineering for optimized hybridization

Over >100 years experience in marine systems

Nedstack PEM FUEL CELLS

Built worlds longest running PEM FCPP (>70k h)

Bullt worlds first MW size PEM FCPP (2011)

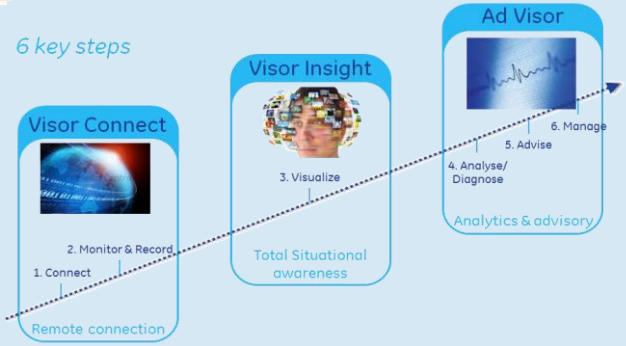
Built worlds largest PEM FCPP (2016)

Build worlds 2nd class approved FCPP (2011)

Nedstack PEM FUEL CELLS

Objective – 2 MWe PEM Fuel Cell Power Installation

PWM Drive / Trafo and PMS



PEMGEN™ FC Power Systems

2 MW BoP Module Appearance

2 MW Stack Module Appearance

ACHIEVING FUEL CELL SOLUTIONS THAT ENABLE A ZERO-EMISSION CRUISE INDUSTRY

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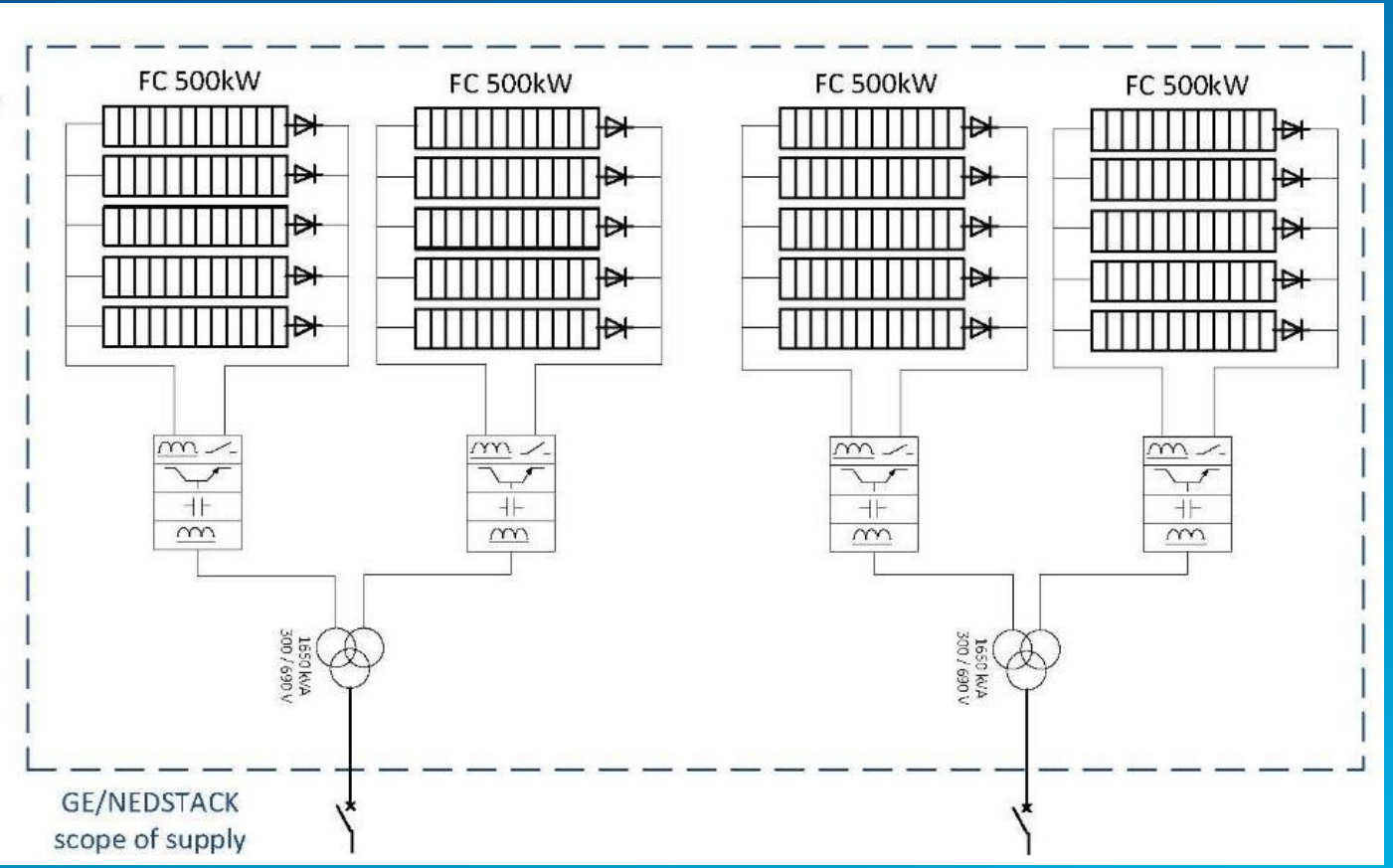
2MWe Fuel Cell Power Installation (FCPI)

GE/Nedstack 2MWe FCPI integrates:

- PWM technology
- Power Plant PEM fuel cell
- In an holistic system approach



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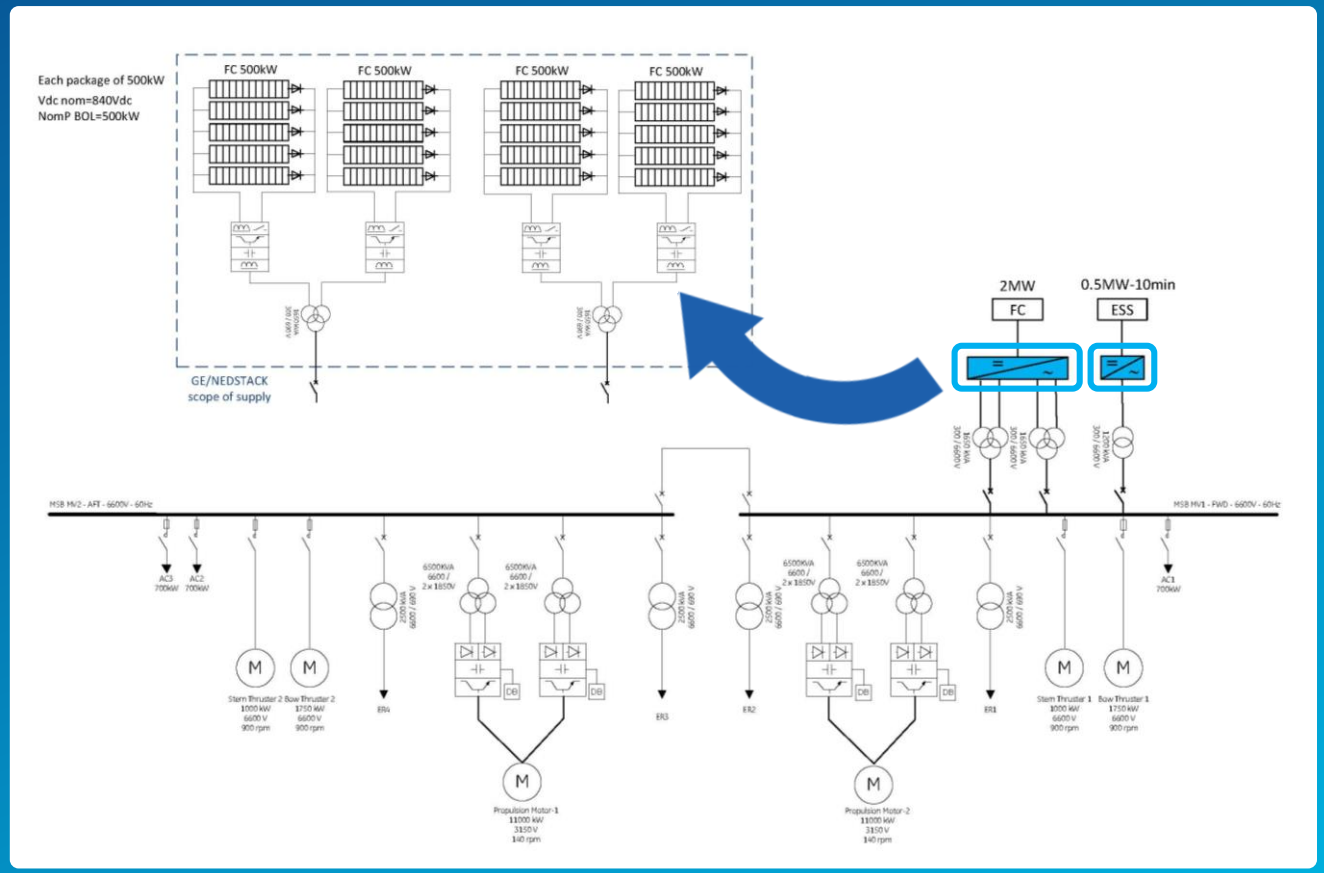
PEM FUEL CELLS

2MWe Fuel Cell Power Installation (FCPI)

GE/Nedstack 2MWe FCPI is optimized

- Integration in hybridized electric propulsion system
- Advanced control features
  - Lifetime
  - Efficiency
  - Predictive maintenance



*Sample architecture only capability to scale up to suit application

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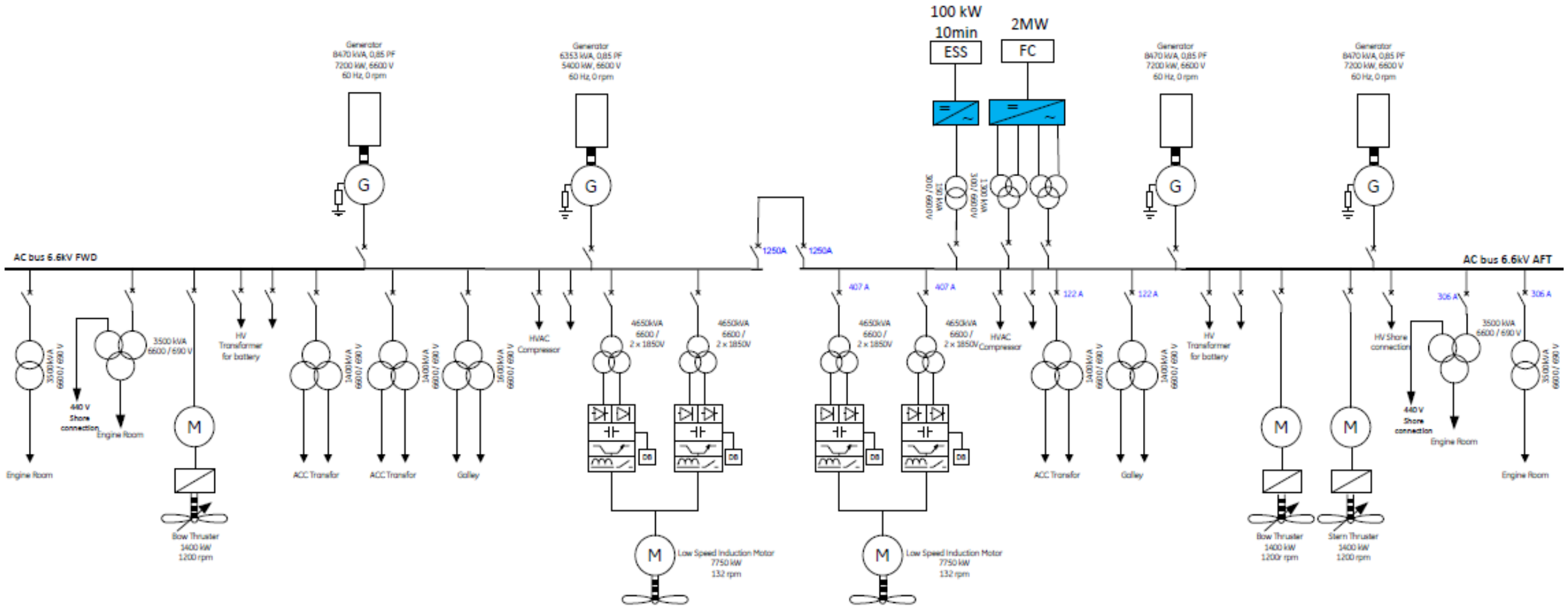
Single line diagram



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