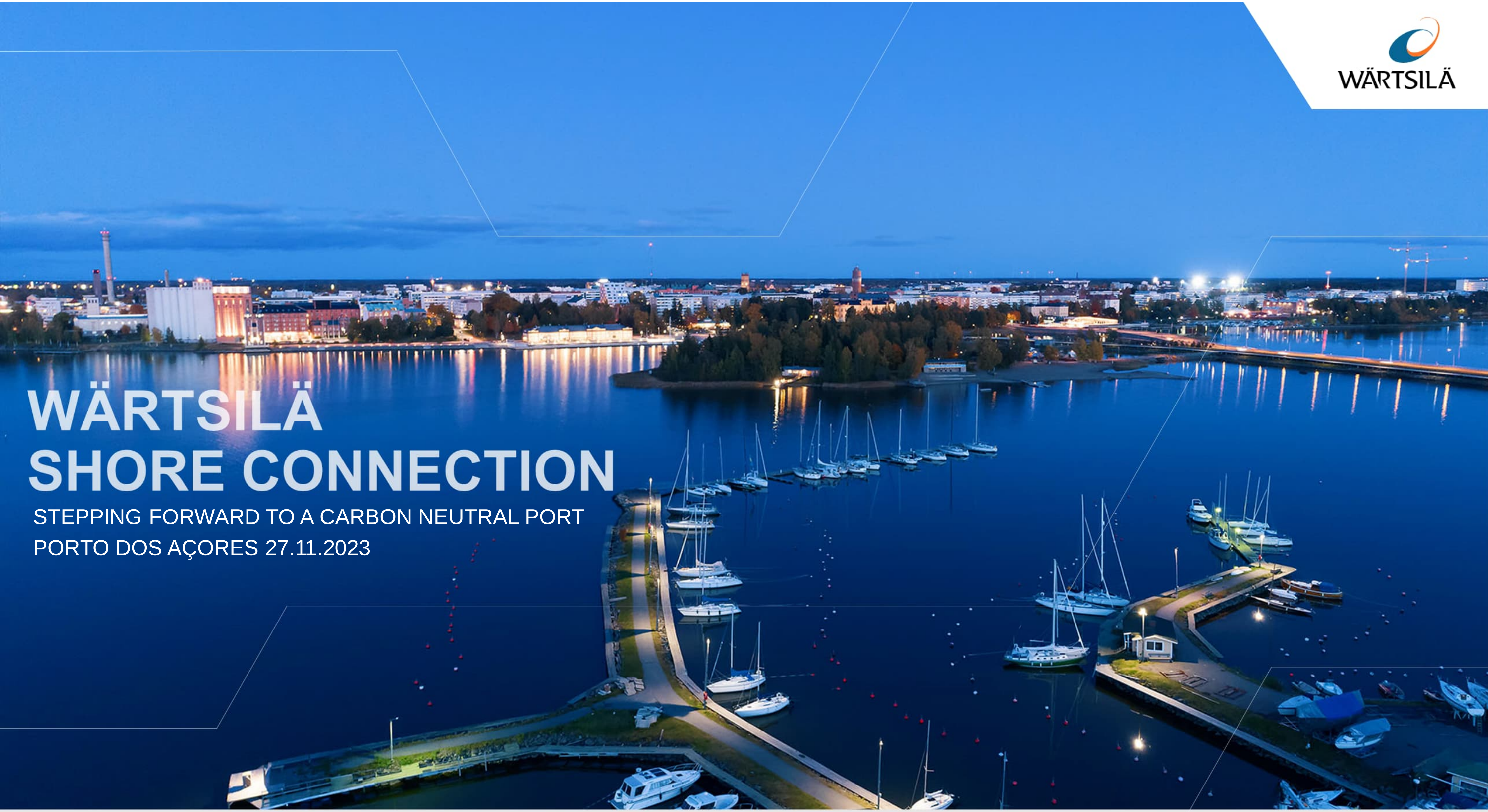


WÄRTSILÄ SHORE CONNECTION

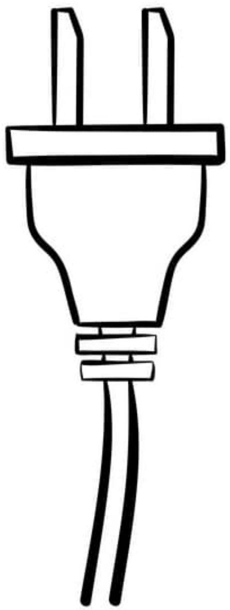
STEPPING FORWARD TO A CARBON NEUTRAL PORT

PORTO DOS AÇORES 27.11.2023

ONSHORE POWER SUPPLY

Smart Ports are not only attractive and competitive, but they are also connected.

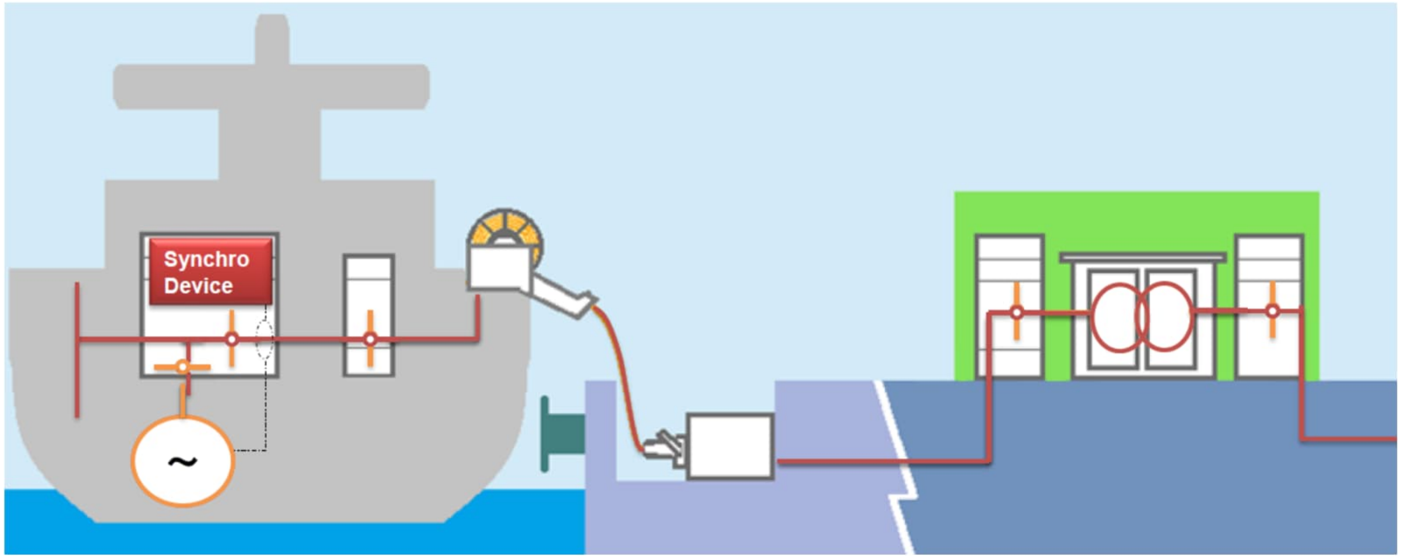
- When a ship docks, it can be plugged into an onshore power supply, allowing to shut down their engines thus cutting harmful emissions, visible smoke, noise pollution and use more efficient/greener energy for its power requirements.
- Flexibility to connect to different frequencies and voltages, with all protections in place to safeguard not only the ship, but also the shore infrastructure.
- Standardized connections depending on different rules, for different ship categories.



BASIC PRINCIPLES

How does it work?

The cable management system can be either located onboard or onshore depending on the type of vessel, as well as the number of power cables used. Typically, 6.6kV or 11kV is supplied from shore, with 50/60Hz (standard 60Hz). Its is connected via a high voltage switchboard to the ship's main power grid through which the shore power is distribute to various areas and equipment of the ship. The generator engines on the ship are shut down until ship departure when the AMP is then disconnected.



HOW IT WORKS

- Roll out of cable reel;
- Cables descent from container;
- Open connection point at peer;
- Connect cables to peer;

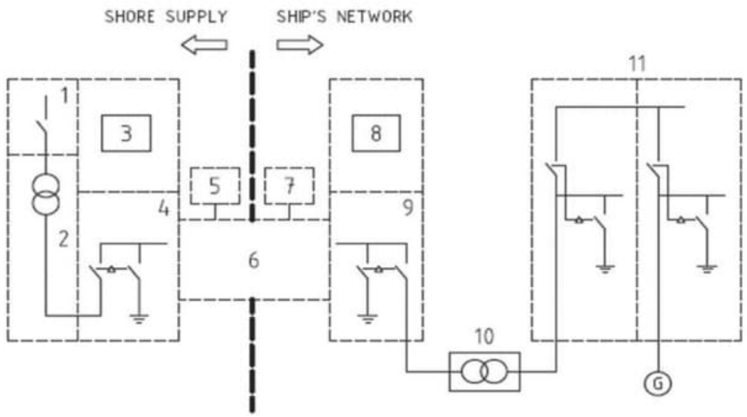
GENERAL REQUIREMENTS

Basic Overview acc. to IEC

Basic requirements for shore and ship installations

Special requirements defined for:

- Ro-Ro cargo ships
- Cruise ships
- Container ships
- LNG carriers
- Tankers

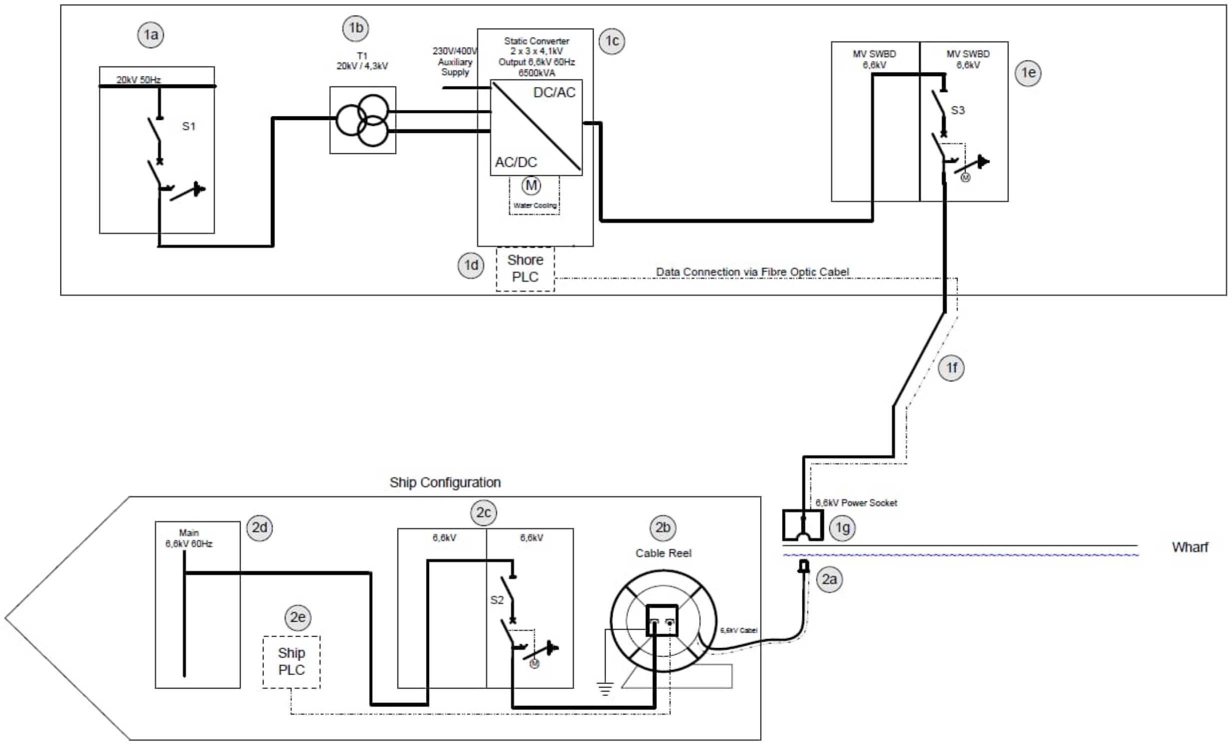


1. HV- Shore supply system
2. Shore side transformer
3. Shore side protection relaying
4. Shore side circuit breaker and earth switch
5. Control
6. Shore-to-ship connection and interface equipment
7. Control
8. Ship protection relaying
9. Shore connection switchboard
10. On-board transformer (where applicable)
11. On-board receiving switchboard

SHORE POWER

SINGLE LINE DIAGRAM

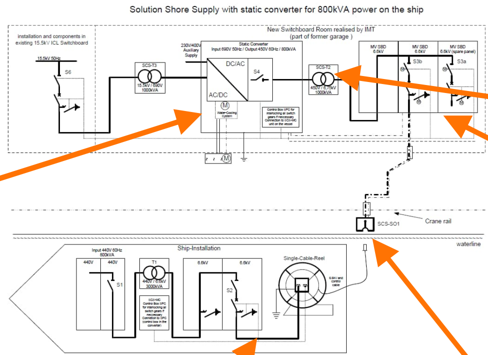
- Distribution SWBD 20kV/50Hz [1a]
- Isolation Transformer [1b]
- HV static converter 50/60Hz [1c]
- Shore PLC [1d]
- Shore supply SWBD [1e]
- Shore cable [1f]
- Shore power socket [1g]
- Ship power plug [2a]
- Ship cable reel [2b]
- Ship SC SWBD [2c]
- Ship Main SWBD [2d]
- Ship SCS PLC [2e]

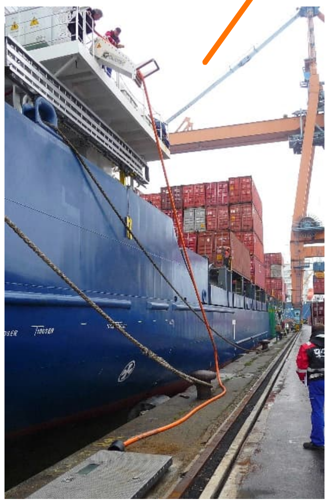


WÄRTSILÄ ON-SHORE POWER SUPPLY ICL TERMINAL ANTWERP

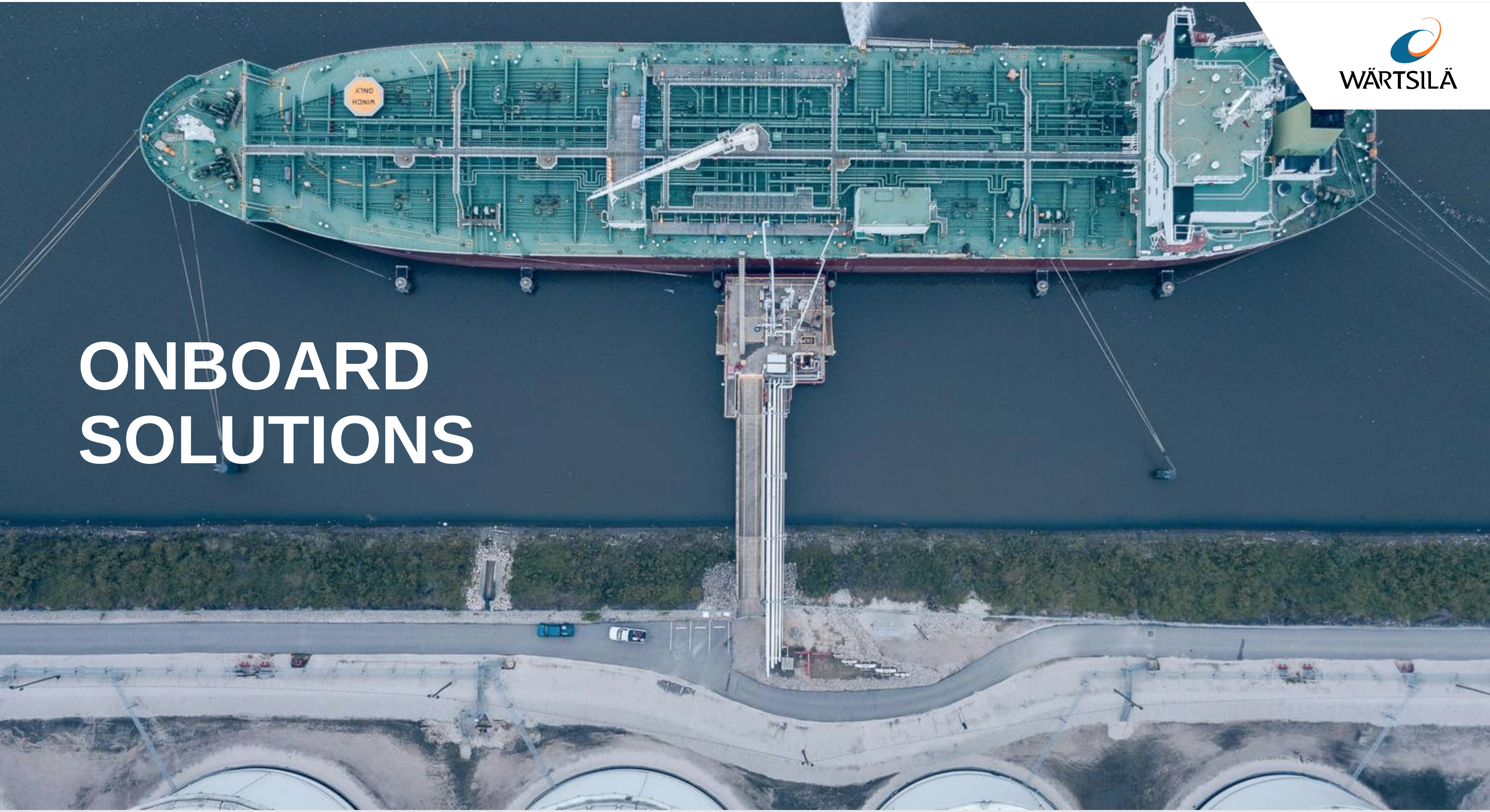
SEGMA GRUPO EDA

WÄRTSILÄ



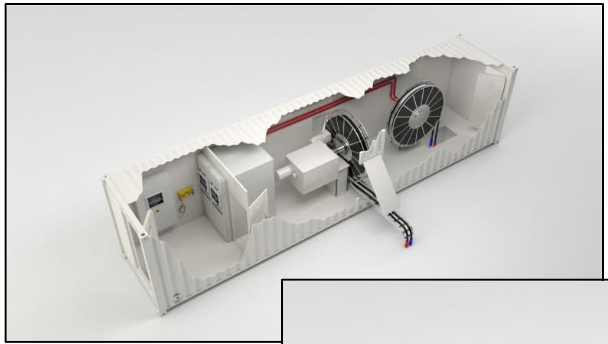


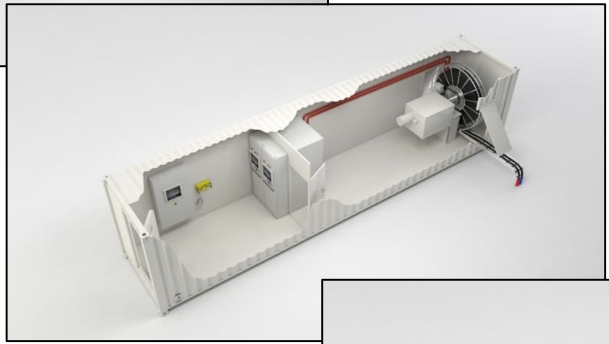
ONBOARD SOLUTIONS

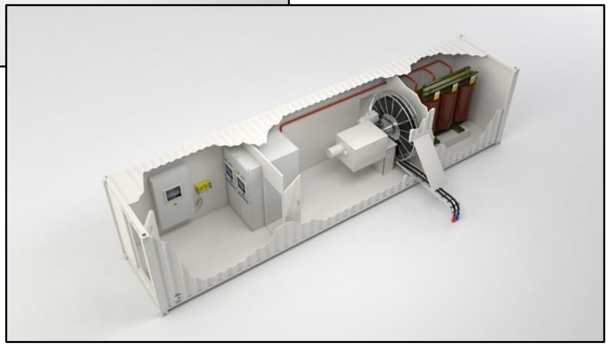


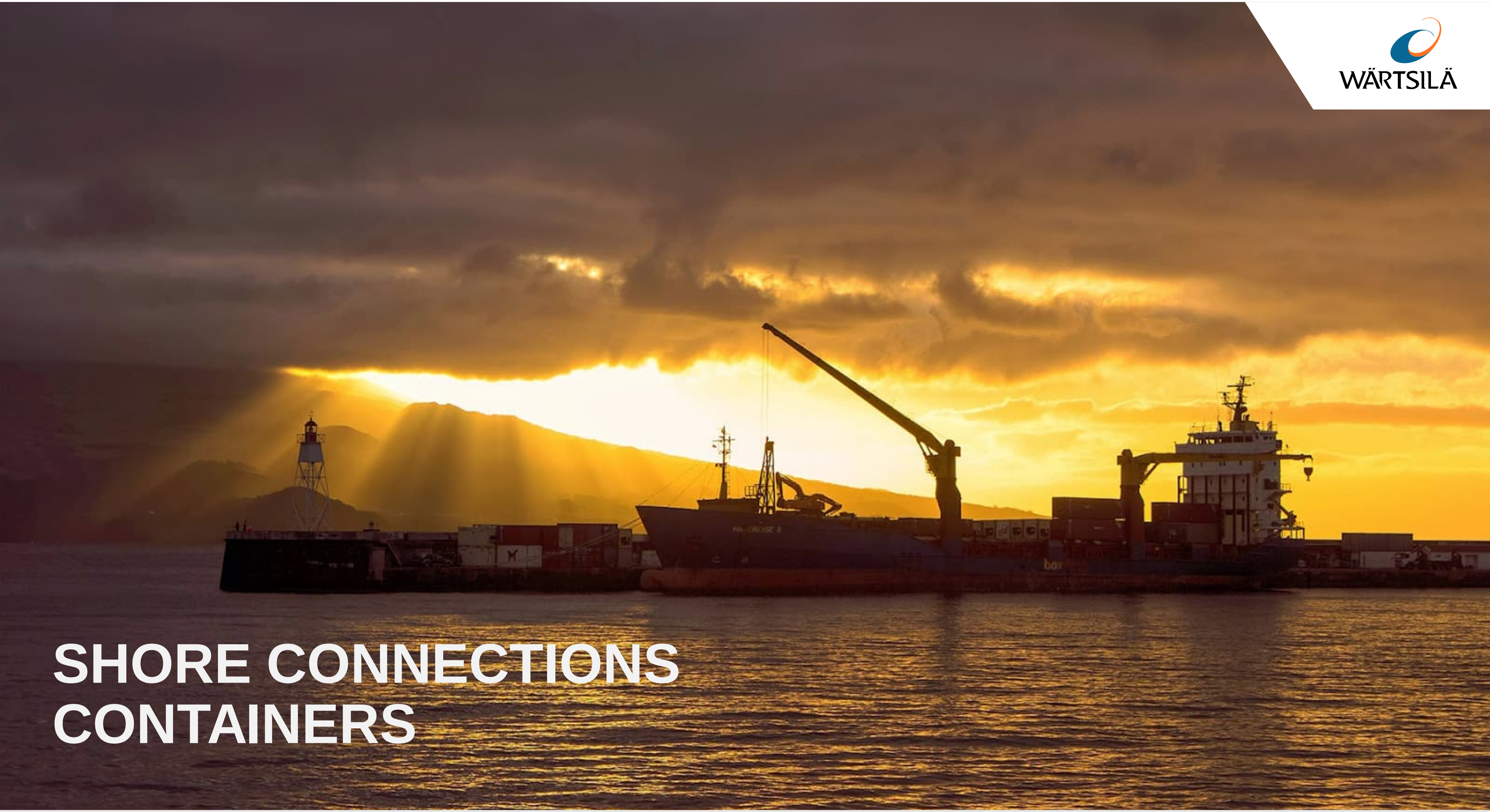
WÄRTSILÄ SAMCON CONTAINER SOLUTION

- Container solution
- Design according IEC 80005-1
- 3 different solutions plug and play
- 70 units installed and in use
- Up to 7.2MVA transferable power at 6600V / 60Hz and 45°C
- Usable on Port and Starboard side
- Container including CSC Certificate
- Safe operation area
- Electric cable reel drive including tension control
- Maintenance friendly technology
- Shore interface designed for Ports of California (Oakland, Los Angeles, Long Beach, Port Hueneme, San Diego)







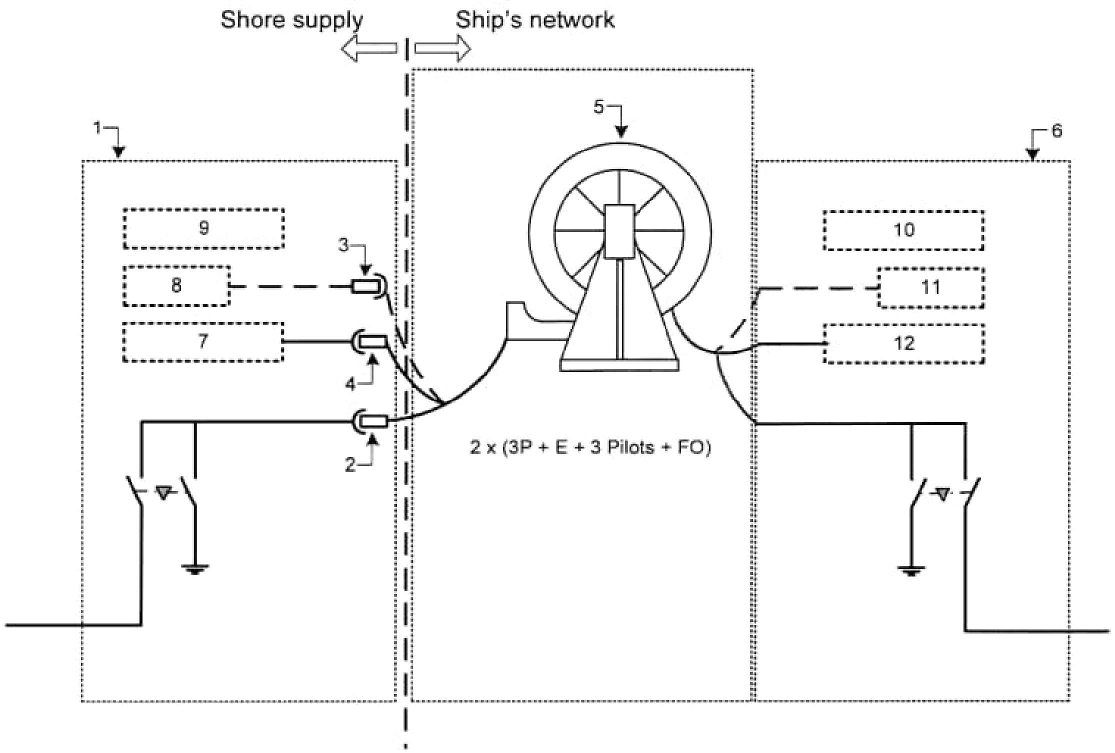


SHORE CONNECTIONS CONTAINERS

SEGMA GRUPO EDA WÄRTSILÄ

Main data

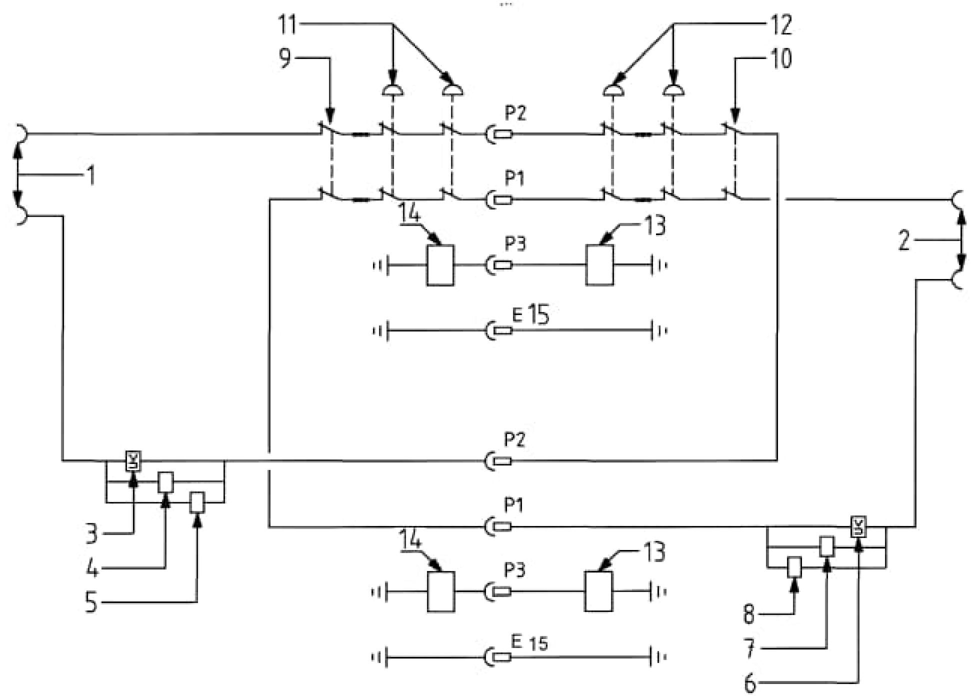
- 2 parallel cables
- Rate power up to 7.5MVA
- Cable management onboard
- Nominal voltage: 6.6kV
- Nominal frequency: 50/60*Hz



Key

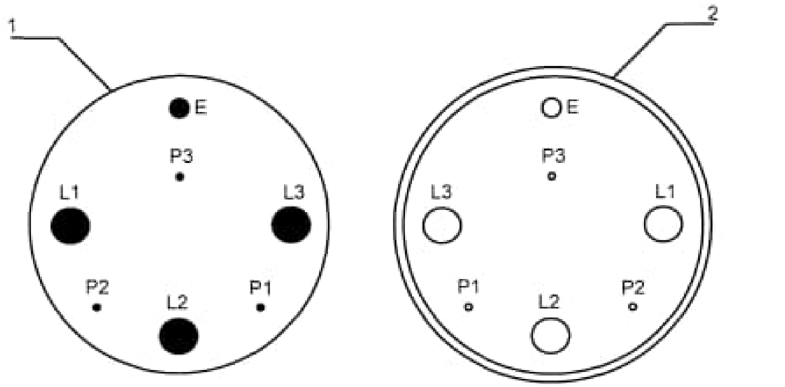
1 Shore supply system
2 Socket-outlet (shore-side) and plug (onboard)
3 Fibre optic communication for control and monitoring (integrated in power cable); plug (shore-side) and socket-outlet (onboard)
4 Pilot wires (integrated in plug and socket-outlet)
5 Cable management system
6 Onboard shore connection switchboard
7. Interlocks with pilot wires shore-side
8 Control shore-side
9 Protection relaying shore-side
10 Protection relaying onboard
11 Control onboard
12 Interlocks with pilot wires onboard

IEC CONTAINER LAYOUT



Key

1 Control power pilot loop shore-side
2 Control power pilot loop on-board
3 Circuit-breaker undervoltage coil (shore-side)
4 Safety circuit coil shore-side
5 Earthing switch permission shore-side
6 Circuit-breaker undervoltage coil (onboard)
7 Safety circuit coil on-board
8 Earthing switch permission onboard
9 Control ES shore-side (emergency shutdown)
10 Control ES on-board (emergency shutdown)
11 Manual ES shore-side (two shown)
12 Manual ES on-board (two shown)
13 Equipotential bond monitoring device (where utilized)
14 Equipotential bond monitoring termination device (where utilized)
15 E denotes earth conductor (PE)



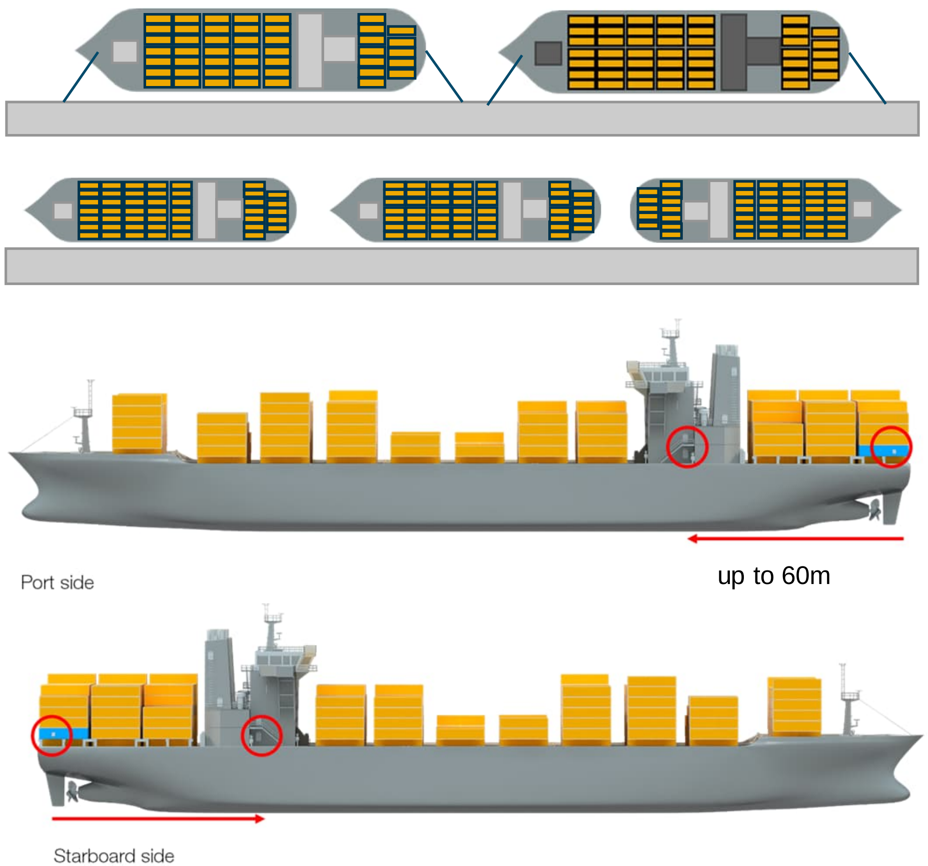
Key

1 Ship plug face
E Earth
L1 Phase A – Phase R
L2 Phase B – Phase S
L3 Phase C – Phase T
2 Shore socket-outlet face
P1 Pilot line 1
P2 Pilot line 2
P3 Pilot line 3

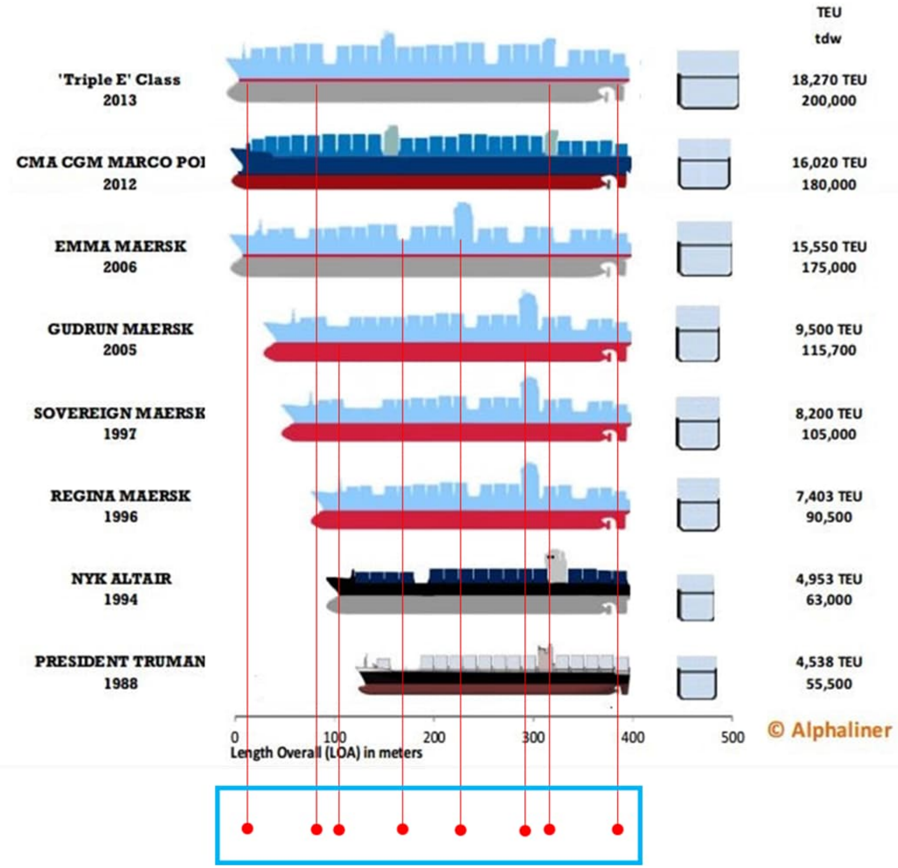
SEGMA GRUPO EDA

WÄRTSILÄ

Port and starboard berthing requirements…



Changing sizes of ships calling and positions of onboard cable management systems…



AMP power outlet

- integrated along the berth to connect container and bulk vessels.

Advantage:

- No interaction with port operations
- No interference with ropes, bollard and moving cranes.

Disadvantage:

- More power outlets needed to serve different size of vessels
- Retrofit of existing ports may cause higher costs (depending on the existing port infrastructure)

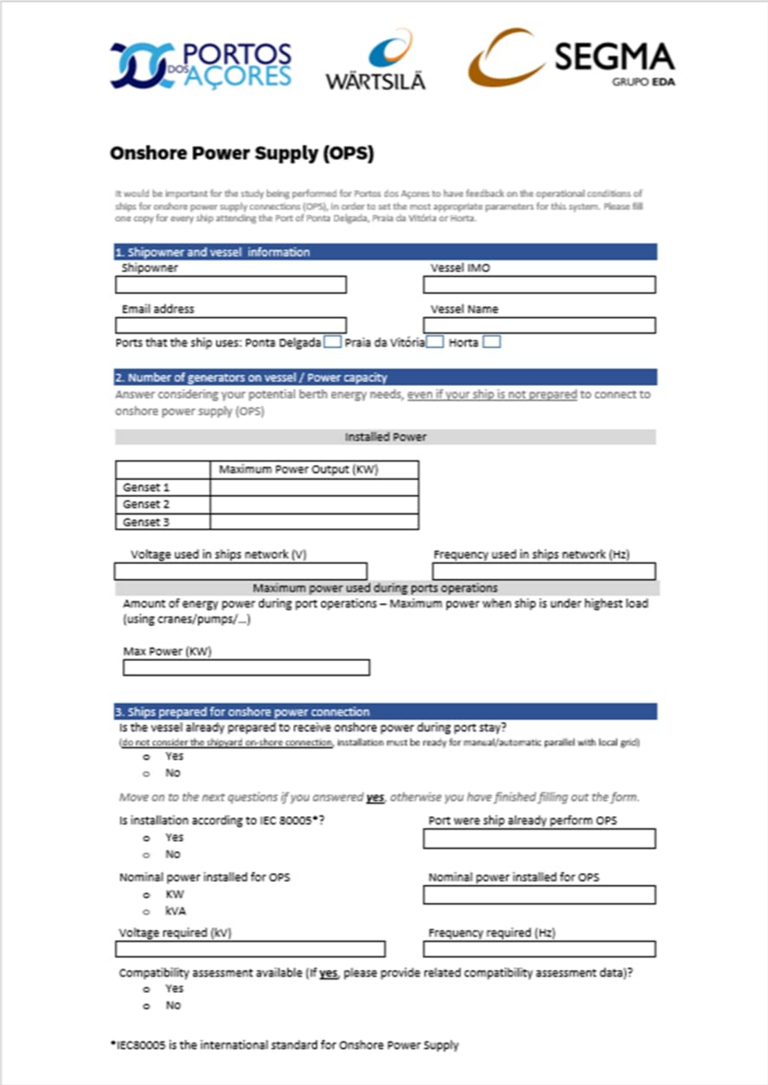
MOBILE POWER OUTLET

AMP movable power outlet

Advantage:

- Flexibility
- Connect ships regardless of size and mooring position
- Integrated safety interlocking procedure
- Reduce the work involved to make connections and increase occupational safety

QUESTIONNAIRE SHIP OPERATORS



Onshore Power Supply (OPS)

It would be important for the study being performed for Portos dos Açores to have feedback on the operational conditions of ships for onshore power supply connections (OPS), in order to set the most appropriate parameters for this system. Please fill one copy for every ship attending the Port of Ponta Delgada, Praia da Vitória or Horta.

1. Shipowner and vessel information

Shipowner

Vessel IMO

Email address

Vessel Name

Ports that the ship uses: Ponta Delgada ☐ Praia da Vitória ☐ Horta ☐

2. Number of generators on vessel / Power capacity

Answer considering your potential berth energy needs, even if your ship is not prepared to connect to onshore power supply (OPS)

Installed Power

	Maximum Power Output (KW)
Genset 1	
Genset 2	
Genset 3	

Voltage used in ships network (V)

Frequency used in ships network (Hz)

Maximum power used during ports operations

Amount of energy power during port operations – Maximum power when ship is under highest load (using cranes/pumps/…)

Max Power (KW)

3. Ships prepared for onshore power connection

Is the vessel already prepared to receive onshore power during port stay?
(do not consider the shipyard on-shore connection, installation must be ready for manual/automatic parallel with local grid)

- Yes
- No

*Move on to the next questions if you answered **yes**, otherwise you have finished filling out the form.*

Is installation according to IEC 80005*?

- Yes
- No

Port were ship already perform OPS

Nominal power installed for OPS

- KW
- kVA

Nominal power installed for OPS

Voltage required (kV)

Frequency required (Hz)

Compatibility assessment available (If yes, please provide related compatibility assessment data)?

- Yes
- No

*IEC80005 is the international standard for Onshore Power Supply

Vessel	Power Demand (peak)	OPS Ready
Corvo	500KW	No
Funchalense 5	850KW	No
Furnas	600KW	No
Laura S	450KW	No
Rebecca S	450KW	No

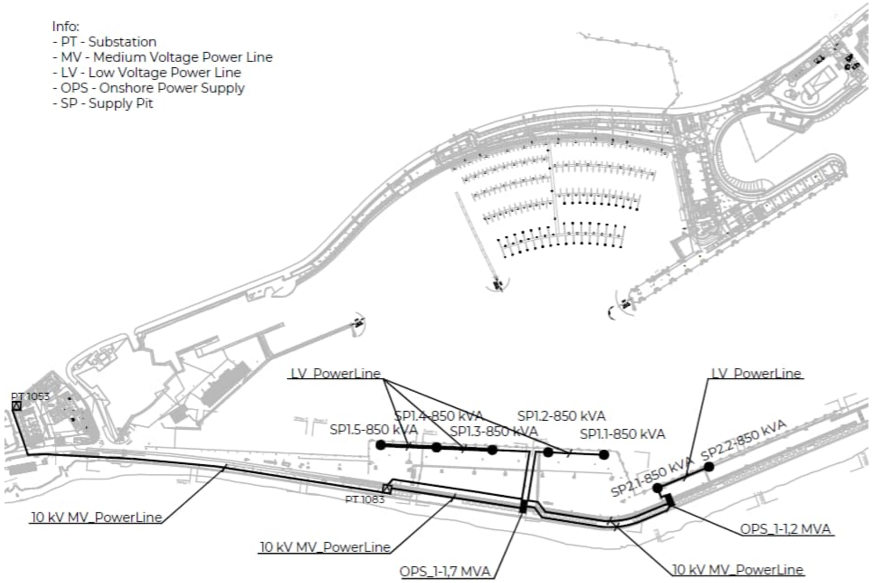
EXISTING POWER ON PORTS

TRANSFORMER SUBSTATION

**The Average Power was calculated based on 2022 measurements.*

Island	Transformer Substation	Voltage	Site Power	Power Peak 2022	Average Power* 2022
		[kV]	[kW]	[kW]	[kW]
São Miguel	PT 1083 (New)	10 / 0,42	630	241,3	75,08
Terceira	PT 1197	15 / 0,42	400	110,28	35,12
Faial	PT 1055	15 / 0,42	400	104,93	29,53

SOLUTION CHOOSEN



OPS 1 – Supply berth 6 and 10, with a power output of up to 1.7MVAs

OPS 2 – Supply berth 12, with an output of 1.2MVAs

SEGMA GRUPO EDA

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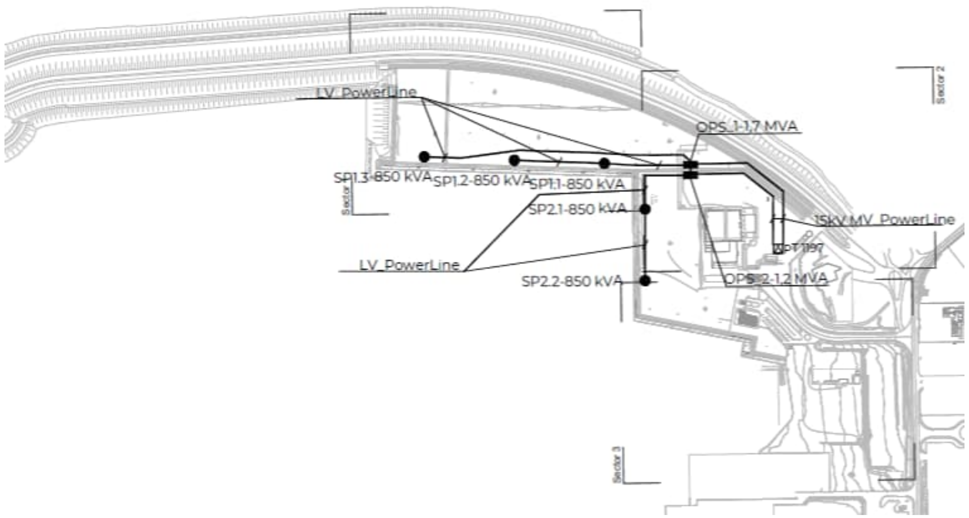
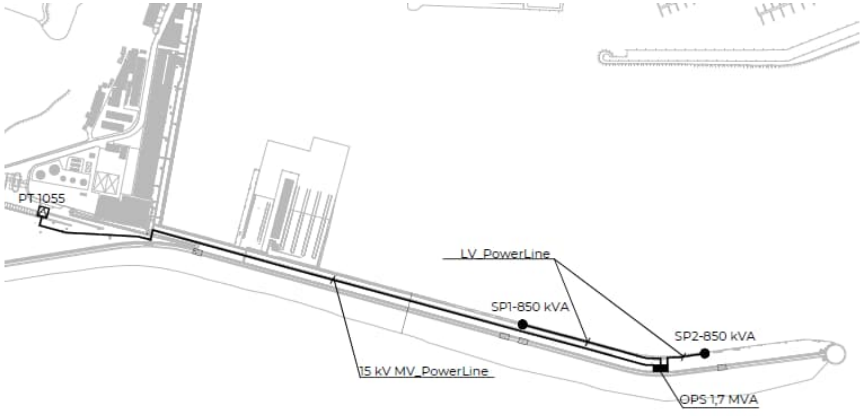
Info:
- PT - Substation
- MV - Medium Voltage Power Line
- LV - Low Voltage Power Line
- OPS - Onshore Power Supply
- SP - Supply Pit



OPS 1 – Supply berth 10, with a power output of up to 1.2MVAs

OPS 2 – Supply berth 12, with an output of 1.7MVAs

HORTA



Info:
- PT - Substation
- MV - Medium Voltage Power Line
- LV - Low Voltage Power Line
- OPS - Onshore Power Supply
- SP - Supply Pit

OPS to supply berth Alpha and Bravo, with a power output of up to 1.7MVAs

SOLUTION BASED IN CONTAINERS AND SOCKETS

1.7 MVA dual system:

- 2 vessels: 2 x 700A, 400V to 690V, 50 to 60Hz, with individual voltage and frequency

EXECUTIVE SUMMARY

After analysing the different client requests in terms of power, voltage and frequency, and given the layout and port calls in the different islands, we conclude that all ships have a switchboard with 400V and 50Hz frequency. Power is bellow 1MVA, so according to international standards, this can be handled in low voltage, minimizing the impact of retrofits to be done onboard the ships.

It must be taken into account the viability from EDA that has to be respected and fulfilled to make the necessary power increments for the ports to have the required power available.

Civil works, new cables and rearrangement of the protections of substations also have to be adapted as described in the study.

To conclude, for the following ports, our recommendation is:

Ponta Delgada Port - It was identified the best berth places to make the shore connection, in particular berth 6, 10 and 12, that can handle the bigger ships. The system should be divided between two OPS stations, one for berth 60 and 10 with output power of up to 1.7MVAs and another for berth 12 with an output power of up to 1.2MVAs.

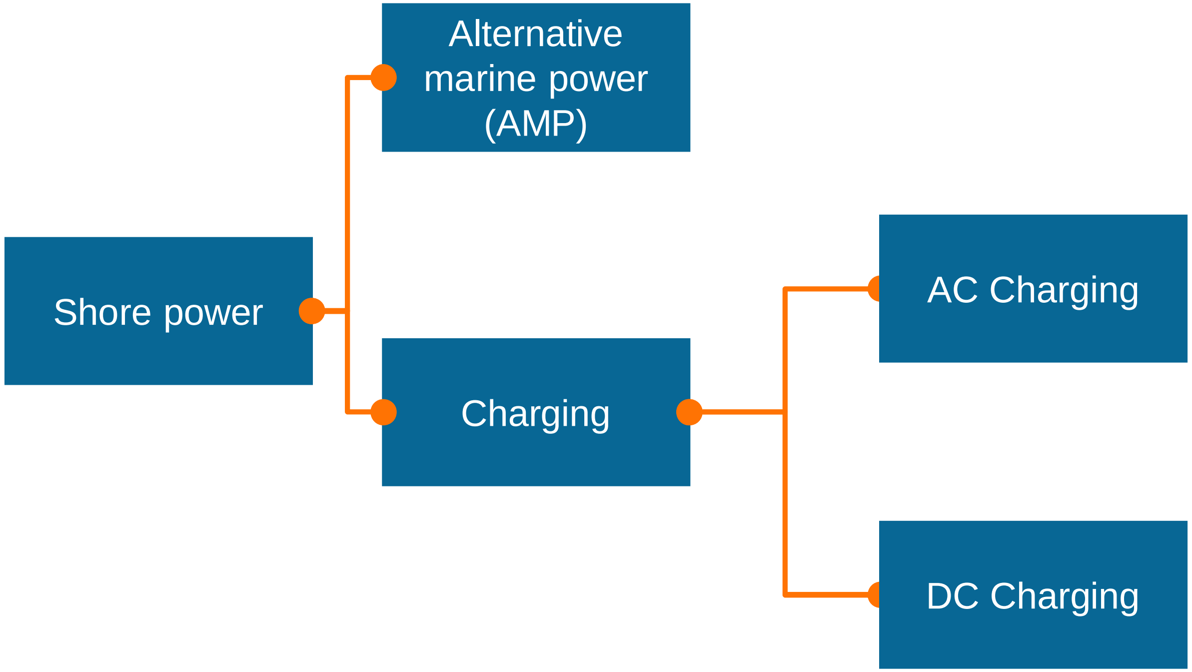
Praia da Vitória Port - It was identified the best berth places to make the shore connection, in particular berth 10 and 12, that can handle the bigger ships. The system should be divided between two OPS stations, one for berth 12 with output power of up to 1.7MVAs and another for berth 10 with an output power of up to 1.2MVAs.

Horta Port - Due to the small size of this port, it was identified berth Alpha and Bravo for shore connection points. The system consists of only one OPS station, with an output power of up to 1.7MVAs.


MOVING TOWARDS A
SUSTAINABLE WORLD

ELECTRIC SHIPS

TYPES OF SHORE POWER



- Medium Voltage possible and solutions up to 15MW charging power available
- Power conversion to DC grid has to happen onboard with more weight and volume needed onboard

- DC is 1000V and solutions up to 8MW charging power available, for more parallel solutions needed
- Power conversion from AC to DC happens onshore, direct connection to vessel DC grid

Charging of an on board energy storage system, usually batteries either as a fully electric or hybrid vessel. This option can be applied either with a wireless inductive charging system or automated/manual plug in system. Both options allow a vessel to operate on batteries only - enabling zero emission sailing.
This solution is often used for shorter journey lengths such as tugs or ferries or on defined routes with fixed ports where the charging terminal can be installed.

SEGMA GRUPO EDA WÄRTSILÄ

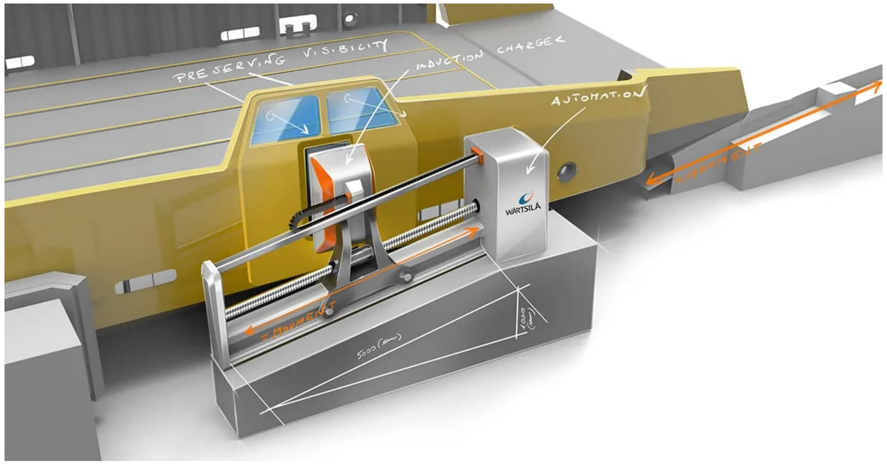
There are two types of charging systems:

Manual marine charging systems

With a manual vessel charger the operator manually connects their vessel to the shore power charging station. This type of vessel charging is typically used for vessels that do not have short turnaround times. Wärtsilä is delivering a manual marine vessel charging solution for a fast, zero-emission passenger ferry as part of the TrAM Project. This will be the first marine charging system to use the CCS plug standard that is common in the automotive industry.

Automated marine charging systems

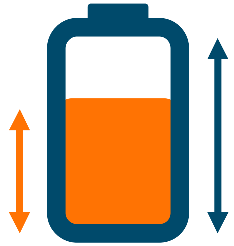
Automated vessel charging maximises the time available for charging an electric or hybrid vessel by starting the vessel charging process as soon as the ship is in range of the wireless charger. Wärtsilä has delivered wireless marine charging systems including charging towers for two zero-emission ferries operate by the Norwegian company Boreal Sjö.



TERMS DEFINITIONS

SoC: State of Charge

→ Is the percentage of the energy remaining in the battery

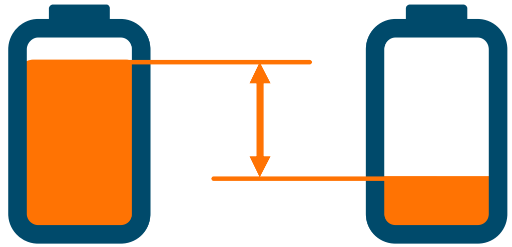


C-Rate: **Current** Rate

→ The rate of charge or discharge expressed as a function of the rated capacity

DoD: Depth of Discharge

→ Is the percentage of the energy removed from the battery

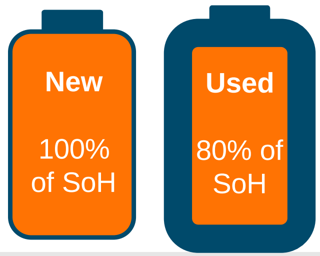


SoH: State of Health

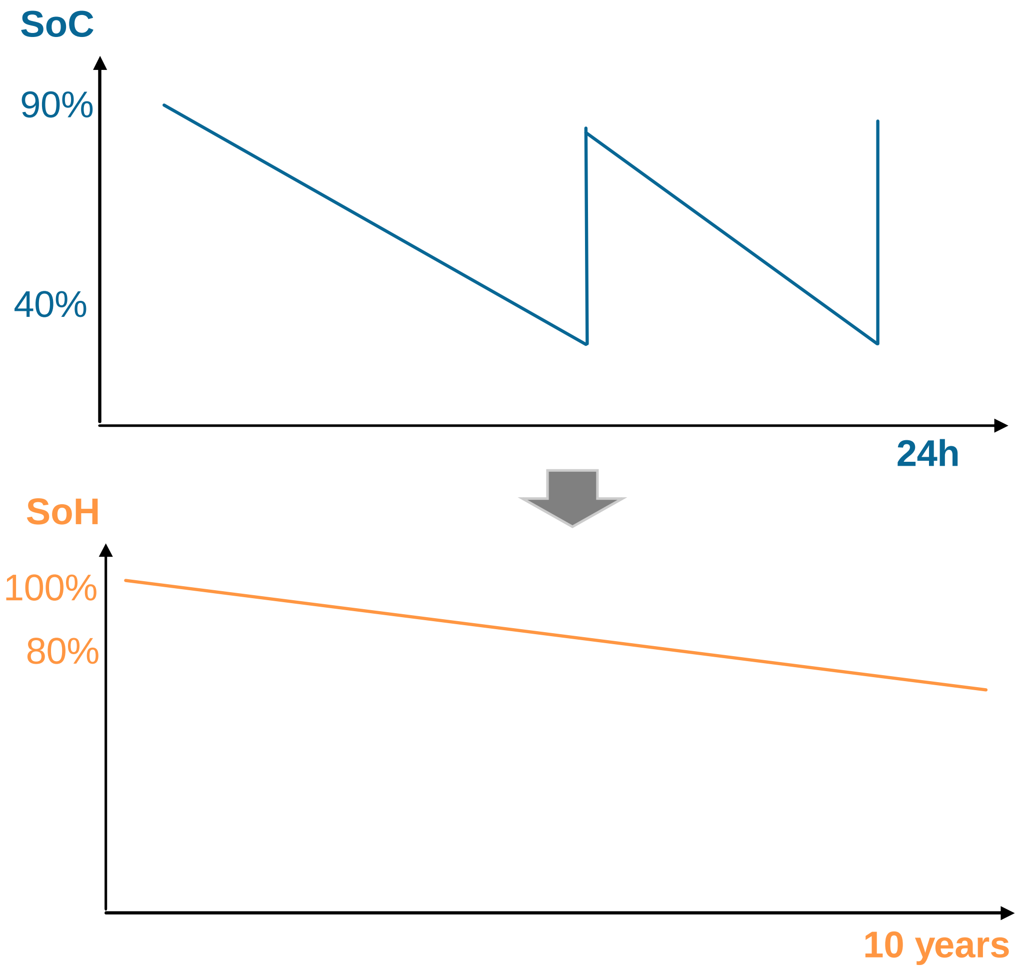
→ The remaining capacity as a function of the capacity when the battery was new

BoL / EoL: Begin and End of (design) life

→ The battery is designed that it can do the same BoL as EoL, after EoL we either miss power or energy (in marine design life is typically 10 years)

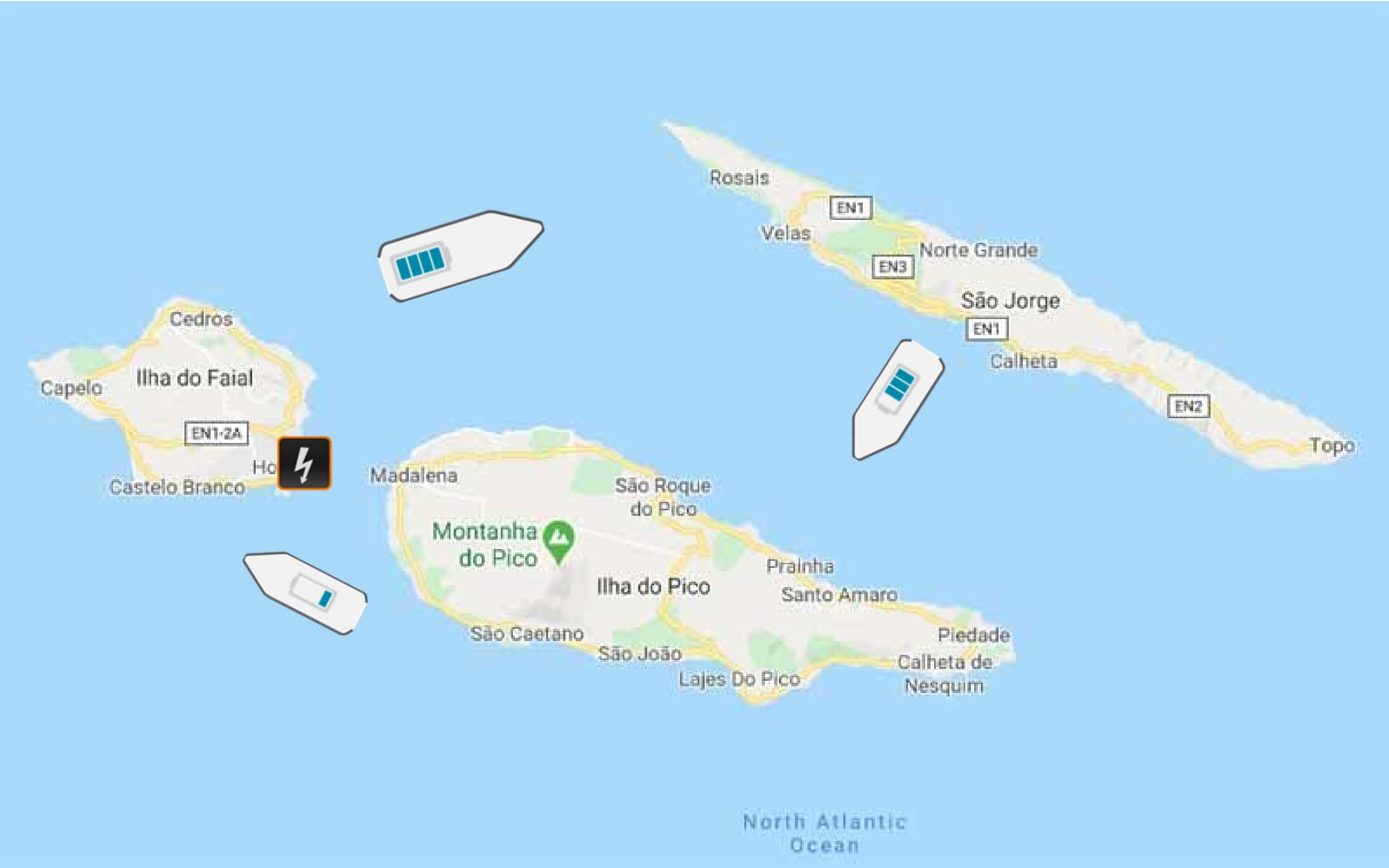


DEEP DISCHARGES MAINLY IMPACT BATTERY LIFE AND CONSEQUENTLY DESIGN SIZE



- Deep discharges consume battery life, small discharges do not
- If you have too many deep discharges than allowed by battery chemistry you make them smaller discharges by increasing battery size
- Operational profile and battery use cases are important to determine right size
- High charge current influence battery ageing, accurate current control via EMS is important

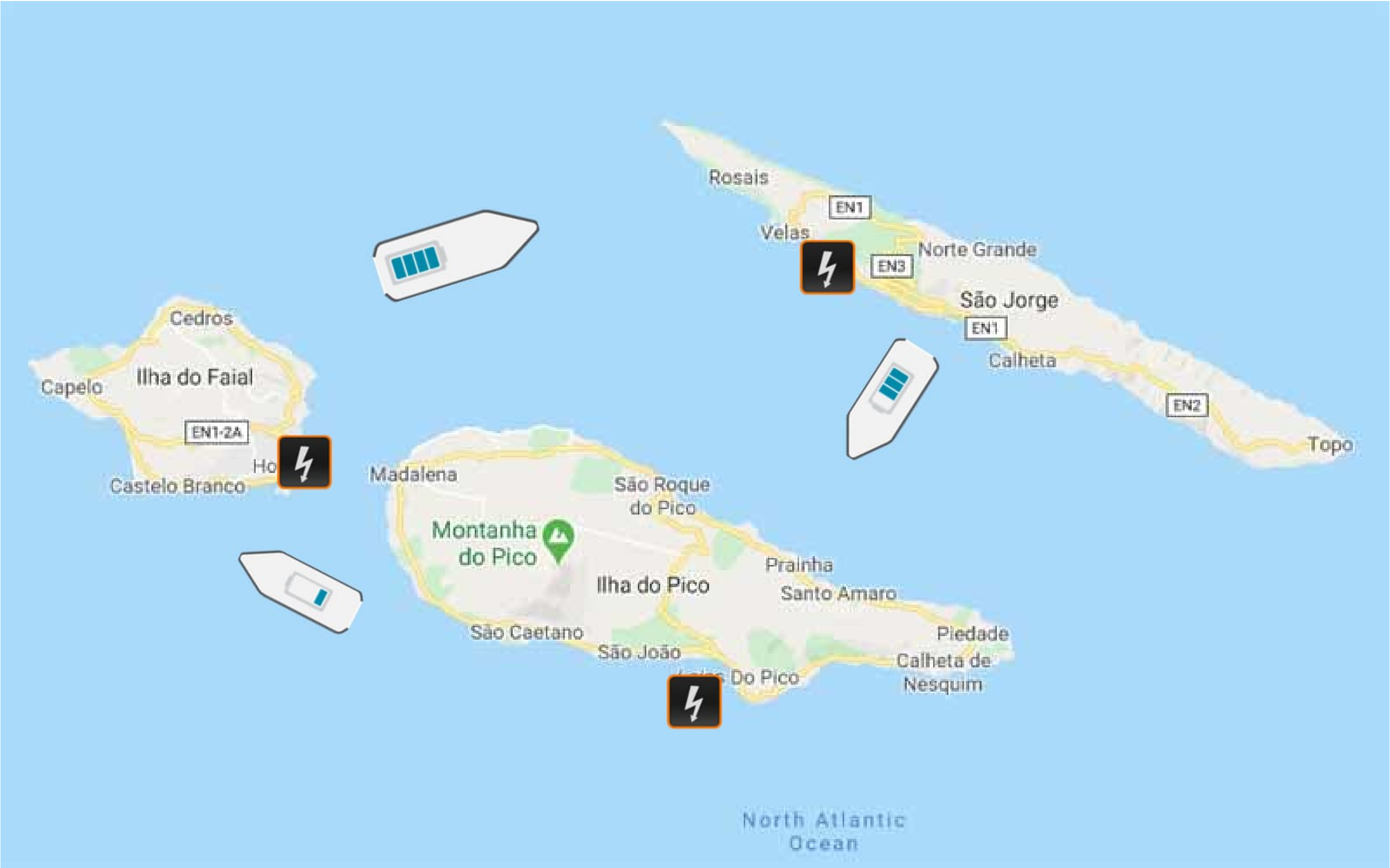
1 CHARGING STATION



Each trip one hour
Uses 2000KW/h
C-rating 2C

6MWH battery pack
Aprox weight 60T
Charging 2MW – 3 hours

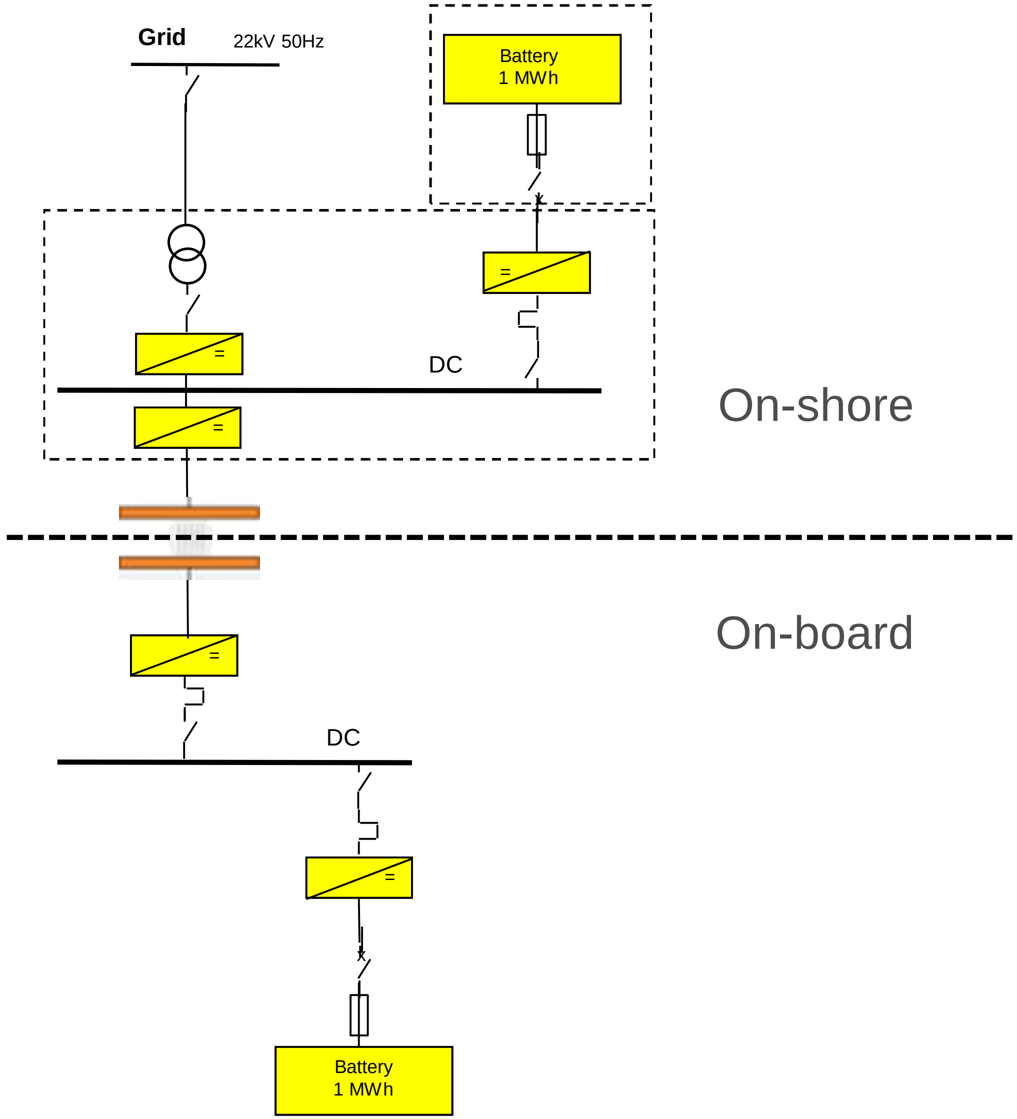
3 CHARGING STATIONS



Each trip one hour
Uses 2000KW/h
C-rating 2C

2MWH battery pack
Aprox weight 20T
Charging 2MW – 1 hour/port

SINGLE LINE DIAGRAM



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- Battery technology and size?
- Propulsion power + hotel?
- Battery C-rating?
- Route vs Installed power vs chargers per island?
- Type of connection wireless or plug (type)?
- Is on shore space for needed equipment available?

WÄRTSILÄ