

MARINE & PORTS | SERVICE

Shore connection solutions

shaping a sustainable world



- Comply to global emission regulations for port calls
- Cutting the pollution in cities surrounding busy harbours
- Safe and simple solution to use in day to day operations

Pollution in cities surrounding busy harbours is largely due to vessels docking to ports. With the ability to connect to shore power the emissions could be cut significantly.

Passenger vessels with the need to keep the hotel load in use throughout the 'port call' are contributing on a high level to the increasing levels of greenhouse gases in cities around the world.

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Shore side infra

integrating with vessel concept

With electrical concept, there is a new design challenge. Ships' operational concept and ships' energy concept are no longer irrelevant for each other.

01 ABB has installed shore connection solution on several Color Line vessels

A century long tradition of bunkering without commitment - to certain location or supplier - will transform. In case emission-free areas will become a standard, the transformation will lead into an electrical charging.

Reasons for connecting the vessel onto the external energy source do vary. Three main purposes for establishing this link are Shore Connection, Shore Charging and Enhanced Shore Power:



Connection



Charging



Enhanced

1. Harbour area emission reduction. Typical approach is to plug on shore power during the stay i.e. Shore connection.
2. On-board energy storage charging i.e. Shore Charging. Usually for emission-free operations.
3. Energy costs (operational expenses) overall reduction by optimizing the energy price with Enhanced Shore Supply.

Some may consider that it is finally the time to happen so, but the infra-structure in many cities is far from being ready. Sailors thought that the electrical revolution will take place onboard, but it is happening on the ports and on infra around us. World is changing, and this makes the change possible for boats and ships as well.

For realizing the drivers behind the change, it is quite practical to study a small – truly old - mechanically driven commuter ferry (length 49m), which consumes 84 l/h on average while in operation (real case example). If we transform this amount of fuel into the equivalent vehicles running on idle while waiting for this ferry to come, the result is eye-opening (as shown below):

1 Ferry = 105 x normal car motor on idle speed. (Idle speed consumption of a modern car is 0.7-0.9 l/h and the average number reduces while hybrid is winning ground.)



105 x

Diesel oil consumption now
84 L/h



21 x

Hybrid fuel consumption
after modernization 17 L/h



0 x

Fully electric after
modernization 0 L/h

Mathematics for CO₂-emission and local air quality are quite easy: this kind of operations at populated areas will be more-and-more under the magnifying glass. In case this ferry is replaced or modernized with electrical concept, the impact on local air quality is equivalent to take out up to 84-105 cars (where 84 is the number after modernization with hybrid concept and 105 with full electrical concept).

Therefore, we need to focus on delivering the energy onboard by means of electrical connection between shore and the ship. This connection is bind to a location, so the ships operational concept needs to be planned for certain route.

Shore side infra will impact on the vessel design process and put up new challenges:

- Ships operators, design houses, shipyards; they all know the ship conceptual design (A) and ship building very well, but when it comes to designing port infra-structures and shore charging lines, they find themselves in new areas.
- As the energy does not drive next to the ship -as it has done in case of bunkering – energy concept (B) needs to be designed from the high voltage network, with necessary politics involved and investments arranged in advance. While bunkering truck was able to move, the electrical network is where it is. Ship must go to the place where connection is possible. (Well, we have fuel trucks now. Maybe in ten years' time, we have battery power trucks.)

- Shore side electrical companies are specialists on electricity, which is not the case in many of the ship operators. Therefore, understanding the investment and operational expenses correctly requires focus and familiarization on both sides. Enhanced solutions are often needed to mix these two parties correctly together.

- The whole system will have the total weight. Weight is distributed between ship and shore. The maximum should be done to minimize the weight onboard. This reduces the consumption of the propulsion, when in operation, reflecting into the overall investment on shore connection.

- Onboard electrical network and propulsion efficiency is vital to improve and reduce the unnecessary consumption and waste use. Starting from propeller (often inefficiency item no.1) all details of consumption should be checked and minimized.

All this will reflect to the new investments. In case the port area infra is already in place, allowing several approaches, the ship owner can evaluate new A and B safely. It creates a commercial backbone, on which to base his/hers transformed the ship concept.



Shore to ship connection

traditional solution as turnkey

ABB can modernize existing vessels and fleets with easy installation during regular operation to ensure sustainable port calls and cutting pollution of cities with busy harbours.

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02 Shore-to-ship power flow from ports' main incoming station to on-board vessel installation

Usual reason for installing shore connection is to avoid utilization of heavy fuel oil in the harbour. Vessel normally stays in the quay for longer period (hours), as the connection process requires port services and 5-20 minutes of time for arranging the cable connection.

Solution is utilized throughout the power range (0-15MW). Low voltage solution is widely used, for example in ferries and high voltage solutions is a typical solution for cruise vessels and container ships. All these ship types use shore connection for providing electricity to ships electrical consumption during harbour stay.

Shore connection solutions are many, but as defined in the IEC-standards, manually connected, interlocked cable connection operation with automated synchronization is most used way to perform it without blackout on the transfer process. Commonly used plugging via blackout does not require any synchronization and due to a low capital costs needed, this solution has been tradition when possible.

ABB Marine has several solutions with references for shore connection. Low voltage (<1000VAC, <1500VDC) solutions according to IEC 80005-3 General requirements and High voltage (typically 6.6-11kVAC) solutions according to IEC 80005-1 General requirements. IEC continues developing the standards and updates are expected.

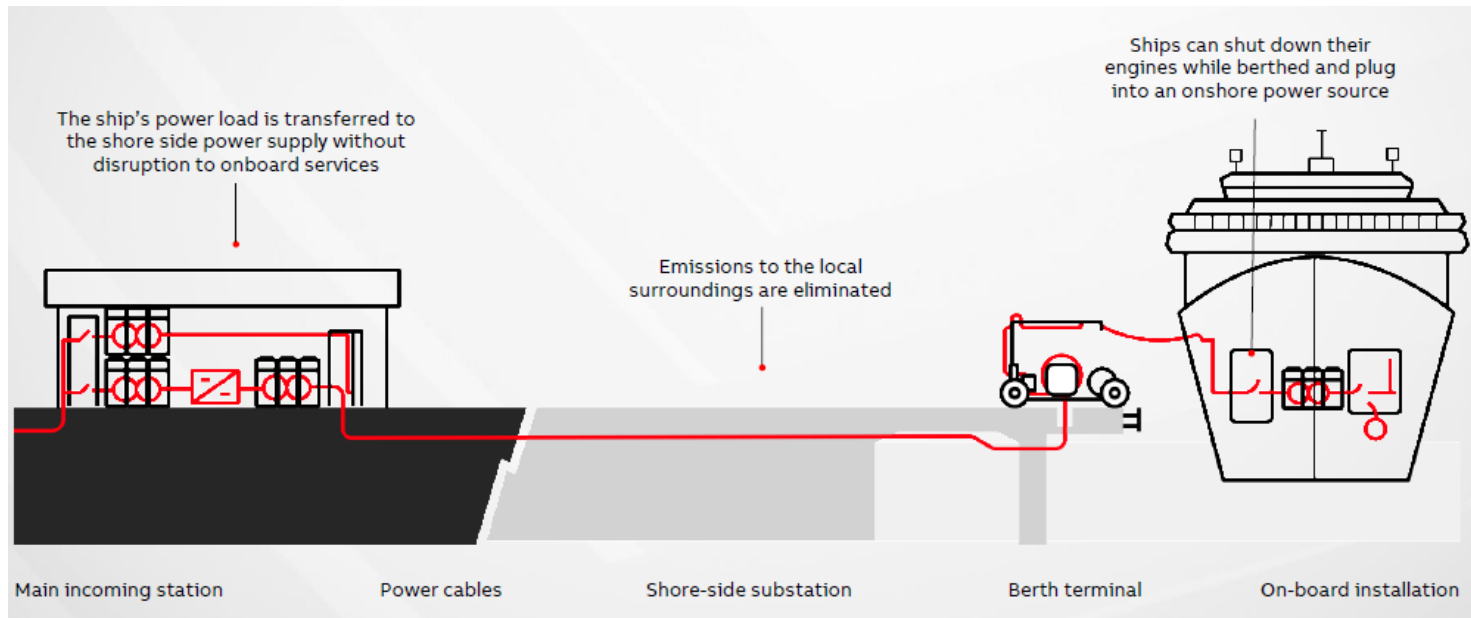
Ships electrical load defines the power factor of the utilized power. Typically the powerfactor of a ships boardnet is between pf.=0.7 and pf.=0.8, which means that the powerfactor may be lower than defined in the electricity supply contract. Then the consequence is that vessel owner must pay extra on reactive power consumption (kVAr's). This is sometimes very expensive, even ten times the price of efficient kW. Enhanced shore supply should be considered in such cases.

Shore to ship power supply

The auxiliary engines of ships that are kept running whilst in port, produces SOX, NOX, CO2 and particle discharges. Sometimes noise to local environment is also considered as pollution. All these have a negative health and environmental impact on the surrounding communities.

With ABB Shore-to-ship power supply solutions, ships can shut down their auxiliary engines while berthed and plug into an onshore power source, thereby eliminating emissions into the local surroundings. The ship's power load can be seamless transferred to the shore-side power source, in a secured and automated manner, without disrupting the onboard services.

This solution covers all necessary electrical and automation infrastructure on ships, and can be used for retrofits or new builds. ABB Shore-to-ship power supply solutions are delivered on a turnkey basis, including procurement, project management, system studies and calculations, engineering, installation, commissioning and testing (ie. from the procurement till the first S2S connection).



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Benefits

ABB Shore-to-ship power supply solutions enable customers to comply with the environmental requirements set by regulatory authorities such as the IMO, California Air resources Board (CARB) European Union and individual states and governments.

The ABB Shore-to-ship power supply solution for ships in port is a practical and effective means of reducing pollutants and noise for the crew and the local community. In some cases, the solution also provides energy savings and maintenance cost reductions.

- Turnkey supply of complete system – including port side.
- Safety based on ABB's long experience, know-how and crew training.
- Type approved equipment provides high reliability.
- Flexible arrangement for most vessel types.
- Fast installation – minimal disruption to ship services.
- Availability of ABB worldwide service network.

This fully integrated system helps to reduce emissions in ports, by connecting ships to the port's electricity grid via a shore-to-ship power connection. A seamless automated power transfer of the ship load is secured, from the onboard power plant to the onshore source and back. This enables vessels to shut down their diesel-generator sets, used to create onboard electric power, and plug into an onshore power source while berthed.

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03 Shore to ship power eliminates emissions during port calls

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04 MS Eurodam is retrofitted with ABB Shore Connection (image courtesy Holland America Line Holdings)

ABB Shore-to-ship connections comply with international standards

After years of participation in the IEC committee, and effective technical guidance work within the related work group, ABB is one of the first companies on the market to supply a high voltage shore connection compliant with international rules.

This is crucial due to the nature of the shipping industry, in which the ship to be connected up is constantly on the move.

International regulation requirements for the system

- High Voltage Shore Connection (HVSC) by IEC, ISO and IEEE
- IEC ISO IEEE 80005-1
- The ABB Shore-to-ship concept complies with all major ship classification societies:
 - Lloyds, released 2009, rules for onshore power supplies
 - DNV, RINA, GL, ABS

Typical solution with Azipod® electric propulsion

The shore connection system has an incomer on the main switchboard and a shore connection panel located in the shore connection room. Cable sockets are mounted in the front of the cabinet.

Typical solution with shaftline on a Container vessel

The shore connection system has an incomer on the main switchboard and a shore connection panel located shore connection room. An onboard cable drum lowers the cable down to the quay for onshore termination. This is a typical solution for container vessels.

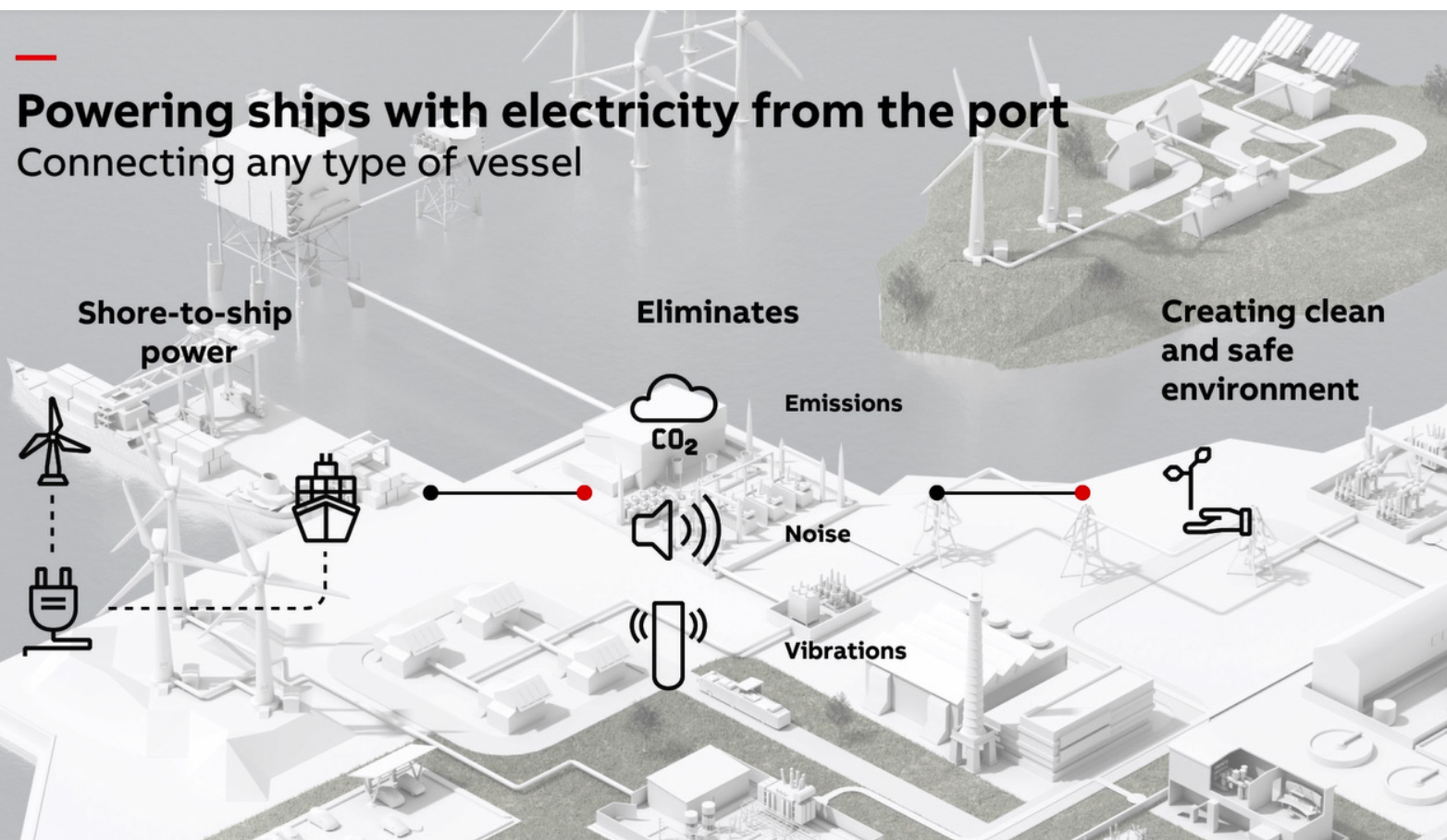
Typical solution with shaftline for a Ro-Ro / Ro-Pax

The shore connection system has an incomer on the main switchboard and a shore connection panel located in the shore connection room. An onboard transformer steps down the power from high to low voltage. This is a typical solution for ferries, Ro-Ro/Ropax vessels.

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Powering ships with electricity from the port

Connecting any type of vessel





Connection- and disconnection sequence (generic)

The full sequence for connecting or disconnecting a vessel to shore power includes the following steps:

- Vessel arrives in port.
- Power cables and control cables are connected.
- The last running engine is synchronized with the shore power grid.
- After the shore connection circuit breaker is closed, the generator is off-loaded and the engine is stopped.
- Before the vessel departs from the port, the first engine is started and synchronized with the shore power grid.
- After the load is transferred to the generator, the shore connection opens.
- Power cables and control cables are disconnected and the vessel is ready for departure.

Main components

The High Voltage shore connection consists of the following main components:

- High voltage shore connection panel with or without socket(s) for connecting the portable or fixed power cable(s) from the shore side.
- Necessary control and protection equipment.
- Automation interface between the shore and ship installation.
- The existing main switchboard is equipped with

(an additional cubicle and) circuit breaker, including the necessary control and protection devices.

- Safety circuits
- Incomer panel

Options

- Power management system with integrated shore to ship power system.
- Step down transformer to match the shore voltage level with the ship's voltage.
- HMI to operate the shore to ship power system.
- Cable management system (typical for container vessels).
- AVR (automatic voltage regulator), i.e. Unitrol 1020.
- Governor system, i.e. DEGO IV.
- Protection coordination study upgrade.

The high voltage shore connection panel

- Finished cabinet solution, with both a power module and a control module.
- Developed in accordance with the rules of major classification societies.
- It may be supplied with cable sockets located in the front, or with openings for cable entry through the cabinet floor.

Sockets and plugs are standardized for the following vessel types

- Cruise vessels (11 and 6.6 kV)
- Container vessels (6.6 kV)
- RoRo and RoPax vessels (3.3 kV / 11 kV)

The main switchboard feeder panel

- The shore connection feeder will be a part of the vessels main switchboard.
- Alternatively, an additional feeder can be installed within an existing spare position inside the vessels main switchboard.
- Or, a finished cabinet solution equipped as a complete, so called, «generator panel» can be connected to the vessels main switchboard by fixed cables or bus bars.
- Installation has to be tailored case by case.

Cable management systems are standardized for the following vessel types

- Cruise vessels.
- Container vessels.
- RoRo and RoPax vessels.

Automation solutions

- Standardized solution based on the ABB platform
- Operator interface by ABB Marine
- Hardware
 - AC800M controller
 - S800 remote I/O units
- Low end interface solution based on the AC500 controller
 - Interface between the existing ship's automation and shore-to-ship systems
 - AC500 controller
 - S800 remote I/O units
- Both solutions are in accordance with all major classification societies

ABB supplies also shore side power to ports in order to keep ships powered during their port call, and to reload the energy storages onboard.



CUSTOMER: CORSICA LINEA

Corsica Linea has three Ro-Pax vessels upgraded with ABB Shore Connection to receive shore power in the port of Marseille - following port specific emission regulations.



Shore charging for fully electric vessel operations

Shore charging supports shore distance ships to operate on solely battery power between ports where the vessels can power up by connecting to the shore side power.

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05 ForSea's Aurora
electric ferry (image
courtesy of ForSea)

Shore charging is installed, when vessel operation is made from an energy storage i.e. from battery and vessels operational concept is designed in a manner that requires external energy feed from shore.

Shore charging is a wide topic covering from low rated manually connectable charge lines to huge automatic, robotic power connections. When referring to the automotive industry, both AC- and DC-charging will be considered on the market during the transition period, maybe permanently.

Roughly, the time reserved for making the connection is defining the connection type. This goes together with investment, which increases when power raises and when required connection time reduces. It is important to design vessel operation correctly to avoid unnecessary investment on power need or the time definition. This links to battery size selection, which is another main parameter in investment sheet.

Manual cable connection is considered when overall concept does not require high rate fast battery charging as a part of normal operations. This operation is a simple approach if crew is

present in the cable connector area.

Low voltage, manual plug connection solutions are available on a power range 0-600A, which typically allows transfer power up to 450kW. This power range is commonly divided between

- Night charging power, which is designed to charge battery full before the daily operation starts

- Day-time charging power, which is short term fast charging during the operations.

Operational combination of these two power levels defines the dimensioning of the battery capacity and the charging transfer line components.

Increasing the day-time charging current, often increases the transfer line dimensions, component size and the battery size (explanation: when battery manufacturer offers the solution with a certain life time, he takes the cyclic charge/discharge current into account and oversize the battery accordingly). Lengthening of the charging time reduces the maximum rating.

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Reducing the day-time charging increases also the battery total capacity need and/or creates need for hybrid operation mode, where batteries are used parallel to the generators. Popularity of electrical hybrid concept is a result of this optimization process.

When need for fast charging increases up to the level that connection time is seconds, instead of minutes, automatic connection process is needed.

Automatic shore charging is available throughout the power range (0-15MW). Both low and medium voltage solutions are possible. Main purpose is to provide automatically maximum charging electricity to ships battery charging at high rate (and to electrical consumption during harbour stay) during short harbour stop.

Automatic cable / plug connection solution is considered to maximize the charging time during the short stop and/or to keep crew involvement in minimum.

Automatic connection increases the investment drastically, especially in case the plug position seeking area is wide. Combination of heavy cable load and moving plugging target easily requires careful analyse if connection is possible in the ramp or in the floating element to minimize the target seeking machinery.

Shore charging solution is a vital part of ships electrical concept. It needs to be designed and delivered together with a rest of the system and considered as a part of battery space approach, where passenger and crew safety is in important role.

Special note needs to be raised for shore side part of distribution, which is typically not marine approved. Shore side delivery is an own project inside the main project. In case charging in the port is not ready, the battery-ship is not sailing.

Charging energy taken from the network is typically with high power factor, as the battery charging is made with converters. This means that power factor is >0.93 , which is a high standard value and amount of kVAR's does not lead to excess invoices from electrical company.



CUSTOMER: FORSEA

Automated shore charging

is supporting fully electric vessel operations of two ForSea ferries: Aurora and Tycho Brahe.

"It's important as a company to be modern, and to be modern is that you think about the whole economy, and the economy is also how much you pollute."

Johan Röstin
CEO, ForSea

image courtesy: ForSea



Enhanced shore supply

for intelligent shore connection

To comply with demanding requirements set on port emissions, both ship owners and ports need innovative technologies. Shore-to-ship power is an investment reducing the environmental burden.

Intelligent shore connection solutions are winning ground on the market, mainly driven by the price rating of the energy and differences between ship design and shore side design. Sometimes updating the usual shore connection to enhanced, pays back in months. This is the case in the networks, which are unable to take more reactive load and electrical company tries to avoid this kind of load to increase. Then pricing may be very aggressive for reactive load.

Tools and methods to consider improving the connectivity of the vessels:

- Effective power (P) and reactive power (Q) are having different price rating, depending on the local electricity supplier. In some cases, the power factor (vector ratio of P and Q) may be beneficial to correct and reduce the energy price by power factor compensation. When reactive power is reduced, energy becomes cheaper. Natural ships electrical network is often poor in this sense and may be corrected with short payback investment. Compensation may be done with
 - medium voltage compensation on shore
 - frequency converter on shore
 - frequency converter on board
 - compensation on board (in case static calculated compensation is possible. Active compensation on board is problematic, in case network construction varies a lot)
 - overall improvement of network power factor by utilizing the frequency converters on motor load (speed control also reduces kilowatts, so double effect)

- Frequency difference: Ships onboard equipment are smaller if designed for higher frequencies. Therefore, many vessels are coming out from shipyard with 60Hz equipment. This means that there is a frequency difference between shore (in Europe 50Hz) and ship. Then needed component is a static drive, providing the frequency matching.

- In case possible to arrange, the shore / shore charging connection may get its energy from local energy storage. This allows reduced connection size towards the supply network and reduces the energy amount paid for the supplier company. Such a solution may be:
 - Short term network stability improvement (case in many islands, where electrical network stability is poor) by adding batteries on shore side drive
 - Local energy production solution in case fuel cells, wind, gas, solar is available in the harbour or close-by.

CUSTOMER: SEREC (END CUSTOMER: PORT MARTINIQUE)

ABB is delivering an enhanced shore supply drive to Martinique in cooperation with SEREC.

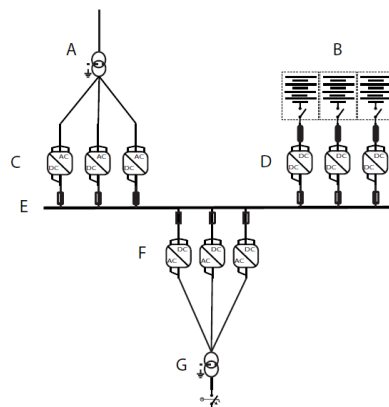
SEREC is working on this project as an integrator responsible of "Quai aux Huiles"-projects electrical installation. Company is working on product and project deliveries related to electrical switchboards and power plant / distribution products. They are currently celebrating 40 years in business. SEREC is present in Guadeloupe, Martinique and French Guyana.

ABB Scope of deliveries included the following:



ABB ACS880 – off grid converter:

- capable to create onboard 60Hz (island network 50Hz)
- 3 x 700kVA inverter supply module for island network connection (C)
- 3 x 700kVA DC/DC-converters for battery connection (D) (with standard ABB battery signal interface) in common DC-link (E)
- 3 x 700kVA inverter supply module for ship supply network (G)
- interfaced with 3 x 500kW, 3 minutes batteries (B) which are used in case island network of Martinique disappears.
- designed for 1000kW distribution capability in case of failure in one component in drive or in batteries
- high power factor towards the electricity supplier (>0.93)



Distribution transformers:

- acting as a voltage matching and EMC-barrier between the drive and both directions



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