

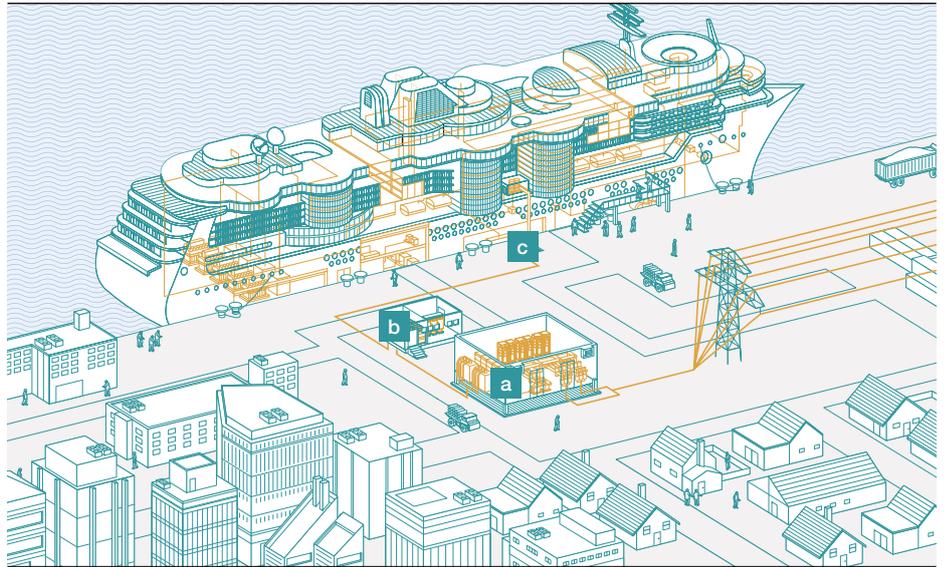


Onshore and onboard

Looking at the shore-side and shipside technologies and the case for standardization in shore-to-ship power

LUTZ THURM, ISMIR FAZLAGIC, THORSTEN HARDER, KNUT MARQUART – The environmental footprint of port areas is under scrutiny. Governments, port authorities and shipowners have explored different solutions to reduce emissions from ships while they are engaged in port operations. One solution to this problem has been identified as connecting ships in port to an onshore power supply, where electricity from the shore-based grid is used to power ships' infrastructure used for hosting crew and passengers while docked, and for cargo-handling activities. With the impending standardization of shore-to-ship power, implementation of the solution is sure to expand, helping port authorities and shipowners to reduce portside emissions.

1 General overview of shore-to-ship power supply



1a Transformer and switchgear

1b Converter

1c Connector

A case has been made for shore-to-ship power supply → 1: The environmental profile of electricity generated by power plants on land versus ships' diesel engines running on bunker fuels is one of the main advantages of this technology. Through shore-based power¹, regulators can respond to a specific, local problem (pollution) with a specific, local solution (power connection from shore). For ports, the ability to supply power to ships at berth enables them to establish a more efficient and powerful overall electrical supply as a utility. In addition, the investment in infrastructure is sustainable over decades with long-term revenues. For the port area community, there is an additional benefit of reduced noise and vibration in harbor areas. And with standardization of shore-to-ship power supply, investment in the technology becomes more worthwhile.

Shoreside technology

The technology required to provide onshore power to ships at berth is not novel equipment. Engineers today can use proven technology in order to develop a reliable infrastructure to transfer the power, with rigorous technical attention to issues such as safe cable management. Costs for the equipment vary widely, depending on the specific needs

of the port and the power it will provide. Additional investments stem from construction and installation at the quay and potential needs related to strengthening the port's electricity grid.

Power supply in ports is typically equivalent to that of a small factory, with electricity needed to power shoreside loading and unloading infrastructure such as cranes, belts and gantries, cooling, heating as well as incidentals. Most ports have access to enough power to run these consumers, with an additional 2 to 3 MW for secondary needs. Given that a vessel's power needs while in port may be as much as 10 MW depending on the type of vessel, the electrical infrastructure at many ports will be insufficient to handle significant shore-to-ship power connections without a major improvement to their grid. This may involve investing in a new substation or installing a new incoming power line with more power; both of these actions would involve negotiation with the port's power provider.

Onshore power solutions often comprise the entire chain from the incoming substation and include transformers and frequency converters to match the grid power voltage and frequency to the ship's

onboard power system. These allow several vessels to be connected simultaneously and enable the supply of 50 and 60 Hertz power regardless of the local grid frequency. They also comprise the connecting cables and berth terminals.

For each shore-based power connection point, the port or terminal must have a dedicated transformer, which serves two purposes. First, it provides the required galvanic separation (a nonmetallic direct

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connection between the onshore power supply grid and the ship's internal system), so that an earth fault in the ship's electrical system will not endanger the port grid or vice versa. Second, the transformer steps down the power supply from a voltage level optimized for distribution (eg, 20 kV) to one of the two voltage levels standardized for shore-to-

Footnote

¹ Shore-to-ship power is also known as cold ironing, onshore power supply, alternative maritime power (AMP) or shore connection, among others.



a ABB's PCS100 static frequency converter



b ABB's PCS6000 static frequency converter

ship power connections: 11 or 6.6 kV as required by the ship.

Each shore-based power connection point also requires medium-voltage (MV) switchgear with an automated earthing switch. In essence, the switchgear interrupts the power supply and the switch ensures that there is absolutely no power in the cables between the ship and shore while they are being handled and connected. As the highest risk associated with shore-based power connections is injury to personnel manipulating the cables and systems, this switchgear is critical.

A static frequency converter is required for most shore-based power connec-

sion with one converter may serve multiple ships and berths. Thanks to their small footprint, the converters can fit into any substation building or container along with the compact switchgear and transformers. In addition, the frequency converters improve the overall power quality of the port grid by improving the power factor and stabilizing voltage and frequency. Depending on the project requirements, low-voltage PCS100 or medium-voltage PCS6000 converters are used → 2.

Finally, the shoreside infrastructure for a shore-to-ship power connection must include an automation and communications system, which allows personnel to coordinate the connection of cables and synchronize the ship's electrical load to the shoreside supply. This is possible with two RTUs (remote terminal units) – one onboard and one onshore – that have Ethernet communication via a fiber-optic cable.

The shore-based power connection system need not occupy much precious quayside space. The incoming substation can be conveniently located as far as 10 km from the quayside transformer and MV panels that directly supply the vessel with electricity. At the quayside,

there is only a small and secure room-sized container that houses the power transformer, the MV switchgear with an automated earthing switch, protection and control devices, and the operator interface. The major benefit of a compact shoreside infrastructure is that it ensures smooth dockside operations and can also be made mobile.

Shipside technology

To use power from the shore-based electricity grid, ships must be either built or retrofitted with equipment that enables the connection to shore, synchronizes the power changeover from shore to ship and connects the incoming power supply to the ship's auxiliary power system. Ships can be safely retrofitted in a relatively short time while in operation or dry docking, without major interruption of operations.

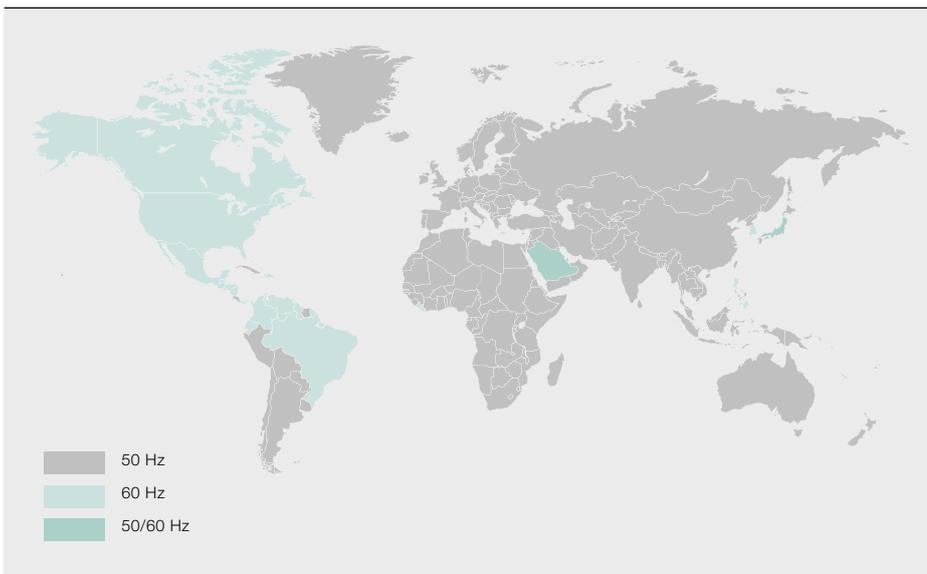
First, the shore-based power must get onboard via cables → 4, 5. In some cases, particularly with container ships and roll-on/roll-off car carriers, the cable is installed on the ship and lowered via a spool or drum to the quay, where it is connected. On cruise ships, the cable is always shoreside, with a small integrated hydraulic arm to guide it.

When the cable-management system is onshore, the electrical connection is received shipside by a shore connection panel → 6. This panel must generally be located close to the hull and in convenient reach of the heavy shoreside

Many of today's ships with shore connection equipment have been retrofitted rather than built with the equipment installed.

tions → 2. The majority of ships operate with a 60 Hz supply, whereas local power grids in many parts of the world use 50 Hz → 3. As a result, most shore-based power connections will require a frequency conversion. Static frequency converters provide an economical solution to connect any ship to any grid independent of the required frequency. Depending on the port's layout, a centralized

3 Frequencies throughout the world. Such differences necessitate frequency converters for shore-to-ship power.



4 Connection cables on Holland America Line's Vista-class ms Oosterdam vessel



cables. The shore connection panel contains a circuit breaker, a protection relay, the physical electrical connection (plugs and grounding cable), and a control interface with the ship's integrated automation system, or power management system. These systems allow the incoming power to be synchronized with the ship's diesel auxiliary engines before the load is transferred. ABB shore connection panels include two cabinets, the dimensions of which vary depending on the power rating. This MV equipment must be installed in a dedicated room.

On ships that use conventional mechanical propulsion (in which the diesel engines directly power the ship's propellers, as opposed to diesel electric propulsion), the ship's low-voltage auxiliary power system – typically 400 to 690 V – requires a transformer to receive the 11 or 6.6 kV power supply from shore. This transformer is relatively large and bulky, but – unlike the shore connection panel – it can be installed in the engine room or any other suitable location onboard.

The process of connecting and disconnecting a ship to the shore-based power supply takes between five and 30 minutes. Onboard, the chief engineer or a trained staff member experienced with the ship's power management system handles the power transfer. Cable management can be done either by ship or shore personnel with adequate training in handling MV equipment. At least one company has begun investigating an automated system for plugging the

cables into the ship to improve safety and save time.

Currently, the majority of ships equipped with the infrastructure to receive shore-based power are container vessels, and many ship designers are either including this infrastructure in their designs or are setting aside space for it. Many of today's ships with shore connection equipment have been retrofitted (ie, the equipment is added to an existing vessel), rather than built with the equipment installed.

While little of the technology installed onboard ships for onshore power supply is new, usually the entire system must be engineered on a case-by-case basis for each installation. Even if the connection is standardized, ship design is not, meaning that questions of space, accessibility, interfacing with the power management system and the diesel engines all need to be surveyed and assessed prior to installation. ABB has developed turnkey solutions covering the entire scope of delivery, with minimal interruption of ship operations.

Standardizing shore-to-ship power connection systems

In order for shore-to-ship power supply to make sense for ports and shipowners, the nature and arrangement of power connections must be standardized. Neither a port owner nor a shipowner can justify investment in expensive equipment to enable a shore connection system without assurance that such a system will be functional across many

The IEC, ISO and IEEE joined forces to create a standard that will enable onshore power connections to effectively have a water-tight global basis.



jurisdictions and for a defined period of time.

Work on a common standard for onshore power supply for ships at berth began early in 2005. Major players in this effort have included technology suppliers, governments, port authorities, shipowners (particularly cruise line, tanker and container ship companies), classification so-

Through shore-based power supply, regulators can respond to a specific, local problem (pollution) with a specific, local solution (power connection from shore).

cieties and others. The IEC, ISO and IEEE² joined forces to create a standard that will enable onshore power connections to effectively have a water-tight global basis.

The standard applies to the specification, installation and testing of onshore power systems and plants and addresses:

- The onshore distribution system

Footnote

- ² IEC is the International Electrotechnical Commission; ISO is the International Organization for Standardization; IEEE is the Institute of Electrical and Electronics Engineers.



- The shore-to-ship connection
- Transformers/reactors
- Semiconductor converters and rotating converters
- Ship distribution systems
- Control, monitoring, interlocking and power management systems

The purpose of the standards work was to define requirements that “support, with the application of suitable operating practices, compliant ships to connect quickly to compliant high-voltage shore power supplies through a compatible shore-to-ship connection” [1]. This should eliminate the need for ships or port operators to adapt or adjust their infrastructure to enable connections.

The initial goal of creating a single, global connection standard for all ships at all ports was abandoned out of necessity. The power needs and capacities of ships differ so much that a single standard would be unfeasible. As a result, four separate, but linked, standards were created – one for ro-ro ships, one for container ships, one for cruise ships and another for tankers. In addition, there are two main standard voltages for connection – 11 kV and 6.6 kV.

With a global standard in place, investment in shore-to-ship power connection systems by ports and shipowners is due to take off. The final standard is on the verge of ratification.

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Further reading

- Marquart, K., Haasdijk, T., Ferrari, GB, Schmidhalter, R. Shore-to-ship power: ABB's turnkey solution is effectively reducing portside emissions. *ABB Review* 4/2010, 56–60.
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- [1] IEC/PAS 60092-510. Edition 1.0 (2009, April). Electrical installations in ships – Part 510: Special features – High-voltage shore connection systems. Retrieved September 20, 2010 from http://webstore.iec.ch/preview/info_iecpas60092-510%7Bed1.0%7Den.pdf.

Title picture

The Holland America Line cruise ship ms *Zuiderdam* (page 36) is equipped with shore-to-ship power technology, helping to make residential life in harbors more liveable.