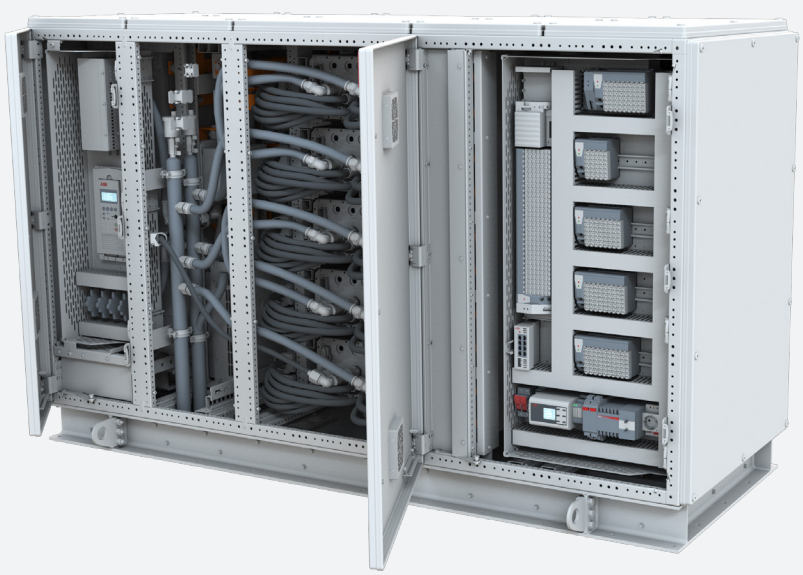
5.8 Onboard Microgrid - Compact electric propulsion system

Onboard Microgrid always contains the propulsion system, it has the capability to generate the ship's electrical network, and it contains at least one power source.

Experience tells us that reaching small is even more challenging than making large system. This is because choosing correctly becomes important when space is limited. By opening new markets, like fluvial transportation and communal traffic for electrical system solution, we were only increasing the challenges in design criteria targeting simplicity.

The system is small enough to be in the control bridge of a water bus or the engine space of a sailing yacht.

Despite the size, all electrical power plant and propulsion systems elements are included. Onboard Microgrid always contains the propulsion system, it has the capability to generate the ship's electrical network, and it contains at least one power source, in form of diesel generator, battery, and in the future other types of energy sources such as fuel cells. In addition, it provides space for connection for up to three more consumers or power sources. In a vessel powered by Onboard Microgrid, up to two Onboard Microdrive cabinets can be installed where they operate independently. In the case of unlikely event of failure, the DC bus in the two Onboard Microdrive can be connected manually to provide reduced power safety functionality, such as take-me-home.



— Onboard Microdrive cabinet

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Onboard Microgrid is best suited for small ships in need of a compact system

This is sufficient number of available connections for all main consumers and power sources into the system. The power of each connection is at range of 100 – 650 kW. Components utilized are marine approved and representing .maximum. Deliveries are planned for non-classified and classified market.

The outcome was not only the compact unit. It also releases the vessel general arrangement (GA) for practical re-arrangement, where engines may be selected according to size and emissions criteria and placed freely in locations, which allows:

- Short funnelling, minimized cooling ducting
- Reduced number of engines and installed power (tank capacity may be reconsidered)
- Arrangement to support widest possible cargo/ passenger space
- Weight distribution
- Variety of propulsion concepts made possible
- No need to build electrical rooms or spaces

Operational design also did gain several new elements for small ships:

- Minimum running engine capacity always in use
- Emission free operation modes made possible for small ships operating close to urban areas
- Propeller protection functions
- Power utilization intelligence
- Deeply providing user interface and data transfer possibility to office

As the legislation and regional operational laws become in force, the world is changing rapidly. Initiatives in European waterway transport have already taken the first steps, when NRMM-emission requirements (Non-road mobile machinery regulation 2016/1628) came in force. This development will proceed even faster, as many of the big cities are taking the role of decision making in their own hands. Similar development is ongoing around the world. Together with our global service network, Onboard Microgrid is a well-needed solution where the future of the small segment ships is projected to be hybrid or electrical, as it provides the possibility to utilize smaller size engines or other power sources onboard.

Operation with Marine Environment System MES
Controller modularity and modern programming style do enable Onboard Microgrid to be an open platform for future development of new operational modes. This is needed as new forms of energy sources are emerging to the market.
Another important feature of Onboard Microgrid is that its control philosophy is simple, yet proven, allowing various types of energy sources to be connected parallel in the DC-link. This simplicity is possible, leveraging from the long experience of ABB.

Operation of Onboard Microgrid is made through a control interface, which is designed according to its purpose of use. All this may be operated through an HMI-panel or through hardwired control options. In this case ABB provides a pre-engineered signal interface for external control systems.

Alarm and monitoring functions may be presented in the HMI-panel as well, or in external automation system, through Ethernet (Modbus TCP/IP) communication.

Operational modes of system are divided into two categories: power generation modes and propulsion modes. These modes are independent from each other. All power generation modes are available for all propulsion modes.

Power generation modes
Supported power source types are synchronous generators, shore connection and batteries. A generator may be an externally excited synchronous machine or a permanent magnet machine. Its engine may be diesel- or gas engine operating at constant or variable speed.

Future product releases bring support for additional sources, such as shaft generator (PTO/PTI), fuel cells and solar panels.

Control system allows the operator to select an optimum operating mode depending on vessel status. Available modes depend on actual hardware configuration and e.g. availability of power sources.

In Engine-mode the system operates as a traditional electric propulsion machinery, utilizing optimum number of generators by load dependent start and stop functions and operator configurable running priority. Variable speed engines can be used to further increase operational flexibility.

Hybrid-mode is available in systems with battery energy storage. Onboard Microgrid control system can be configured to operate in Peak shaving- or Optimum loading modes. The first one uses energy storage to minimize effects of fast load transients to engines but allows engine load to vary with load. Optimum DG load in turn uses battery energy storage to maintain constant load of engines. Change over between the modes occurs automatically based of battery energy level and engine loading condition.

Electric mode utilizes only batteries as far as possible, enabling zero emission operation. The mode may be selected manually, or system can be configured to switch automatically between electric and hybrid mode.

The supply connection from shore AC-network into the Onboard Microdrive cabinet is considered equivalent to an onboard generator input. In case of multiple AC-network supplies to same Onboard Microdrive cabinet, the AC supply needs to be galvanically isolated (=supply transformer with individual secondary windings required.)

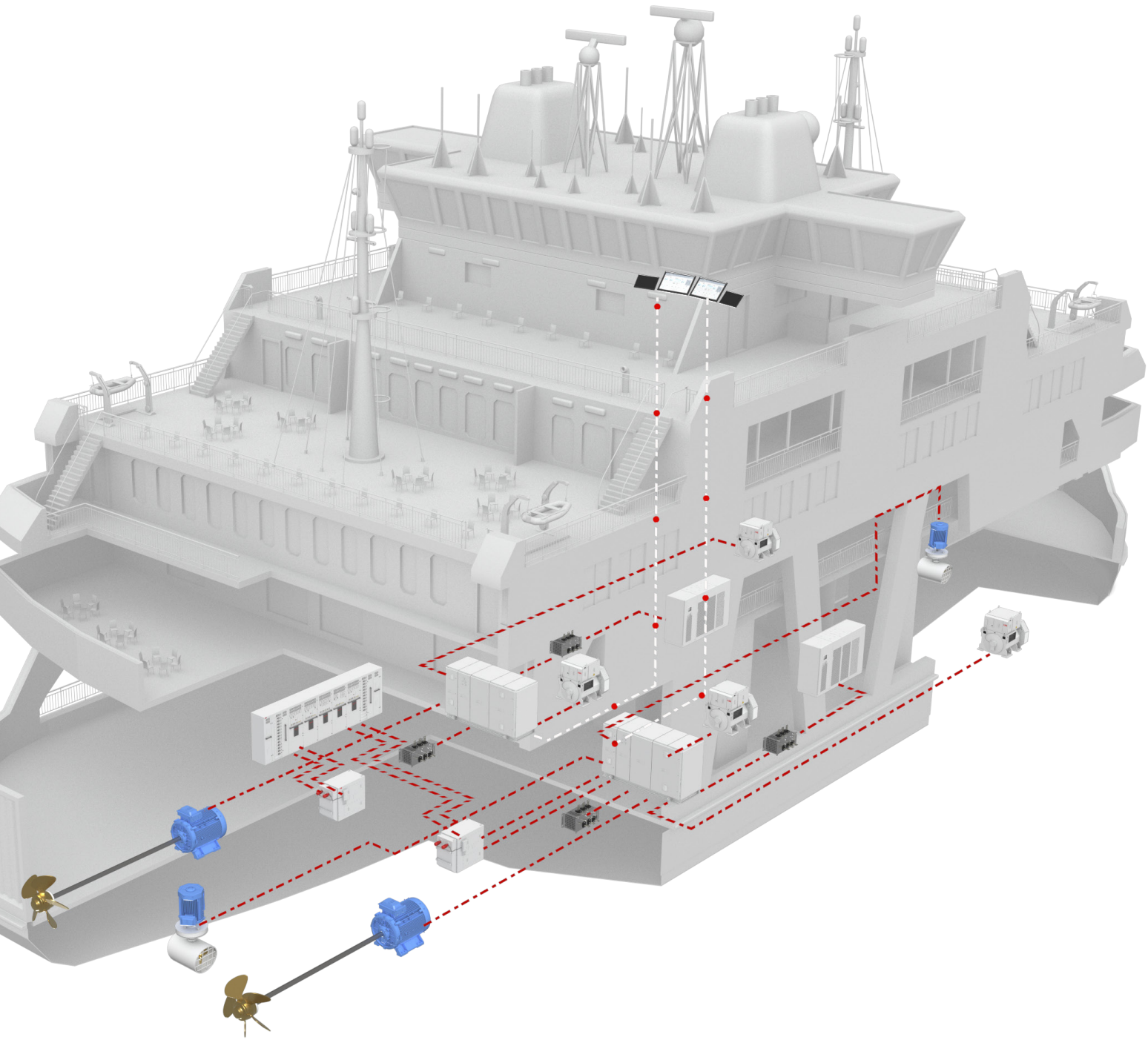
In case the available shore power is not enough for onboard load, Onboard Microgrid Control will automatically keep necessary number of engines running parallel to shore connection.

Propulsion modes
Propulsion motor connected to the Onboard Microdrive may be an asynchronous (induction) motor or a permanent magnet synchronous motor. Other types of electrical motors, such as reluctance assisted permanent magnet motors or synchronous motors are not supported.

One Onboard Microdrive supports one propulsion drive, which may consist of one or two its inverters.

In simplest for the propulsion drive consists of one inverter and one single winding motor. Higher power or redundancy may be achieved using two inverters to supply power of propulsion. This may be achieved by using two motors coupled to a common gear. Alternatively, it is possible to use a motor with dual stator winding configuration.

The motor / inverter configurations above can be coupled to propeller shaft directly or though a gearbox, to an azimuthing mechanical thruster or tunnel thruster.



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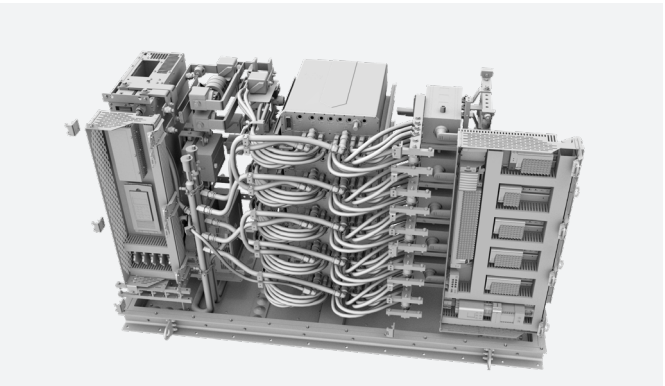
Onboard Microgrid, power and propulsion system onboard a small ferry

Technical data for Onboard Microdrive cabinet



Degree of protection	IP54
Ambient design conditions	Air 0°C - 50°C, Water 10 °C. - 45°C, no condensation
Overall dimensions	Height 1294mm, Depth 827mm, Length 2154mm
Service space	Front 600 mm, above 200 mm, behind 20 mm, sides 200 mm
Weight	OMD880LC unit 900 - 1200 kg (excluding transformer, filter parts, motor(s) and power source(s))
Cooling	Liquid cooled, interfaced for external dedicated closed loop cooling circuit
Basic configuration:	Off-grid converter and distribution transformer with LCL-filtering, DC-link 750VDC, propulsion motor interface, power source interface(1pc)
Optional configurations:	Three configurable HES-module slots for use as power source, 2nd propulsion system, consumer
System configuration – external active parts:	• Propulsion drive braking resistor (1 pc/OMD880LC – when needed) • Battery inductance (1pc / battery),Power source filtering (1pc/source - when needed) • Distribution transformer (1 per OMD880LC)
Voltage	500VAC, 750VDC (230-500VAC)
Ratings	• DC-link 1360A, Transfer DC-link 400A • 5 pcs HES-module branches 100-650kW • Electrical network supply 500VAC 330kVA, 600 A for 3s

HES Module sizes and current ratings in in Onboard Microgrid

	Generator AAC	Motor AAC	Shore AAC	Battery ADC
S	318	350	350	383
M	545	600	600	600
L	800	800	800	900

Control HW platform	ABB (B&R) X20-system
Control system interfaces	• HW interface to engines, generators, motors, shore connection, battery management system and remote-control system. Can bus interface to battery management system. • Modbus TCP to automation system (statuses, measurements, alarms) • Internal ethernet control network
HMI	• 1 or 2 graphical operator panels and hardwired propulsion essentials panels • Local start / stop-control for AC- and DC-power generation

Power generation modes	Engine	Electric	Hybrid	Shore
	Engines only	Battery only	Battery & engines	Battery charging & AC network supply from shore

San Cristoforo

A modernization reducing emissions and increasing overall energy efficiency.

The ferry, owned and operated by Gestione Navigazione Laghi, carries up to 450 passengers and 27 vehicles. Following the conversion, San Cristoforo passengers will benefit from a quieter, smoother ride along the lake with less onboard vibration, noise and exhaust fumes.

"This modernization will allow San Cristoforo to operate in the most environmentally-responsible way, and we are delighted to work with ABB on this project, given the group's extensive experience in developing, project managing and supporting shipboard hybrid systems."

Alessandro Acquafredda, General Director, Gestione Navigazione Laghi.

San Cristoforo has been originally powered by a pair of conventional 310 kW diesel main engines driving twin shaft lines propellers. The comprehensive retrofit project will bring additional operational efficiencies by reducing the shaftline components and basing the new propulsion solution on a direct shaft line at both ends of the vessel. Following the conversion, the controllable pitch propellers will be replaced with a simpler, more efficient fixed pitch propellers that will help improve the overall fuel economy of the ferry.

ABB's scope of supply will include new propulsion motors, diesel-generator sets, transformers and switchboards. Additionally, the modernization project marks a debut order for Onboard Microgrid, a compact DC grid platform recently launched by ABB to help smaller vessels optimize their fuel efficiency by making the best use of available power.

Onboard Microgrid will allow the vessel to optimize energy efficiency by pooling hotel and propulsion power sources via a DC-link, so that generator sets or batteries can be called on based on user needs, in either diesel, hybrid or electric modes.

San Cristoforo is retrofitted with Onboard Microgrid system with batteries enabling hybrid operations