You can operate wherever you want

WÄRTSILÄ HAS THE MOST COMPLETE RANGE OF ENVIRONMENTAL SOLUTIONS IN THE WORLD

THIS ENSURES ENVIRONMENTAL COMPLIANCE
Wärtsilä and the environment

Whether spurred by tightening regulations, customer demand or enlightened corporate policy, today’s shipowners are constantly looking for ways to have their vessels run leaner and cleaner. Wärtsilä’s environmental offering provides the tools needed to achieve these goals.

Wärtsilä as a company has long been offering technologies for enhanced environmental performance. As one of the marine industry’s leading equipment suppliers, we have a responsibility to supply efficient environmental solutions that can comply with regulations and protect the quality of our seas. Strict environmental legislation has pushed Wärtsilä and other suppliers to develop clean burning engines that minimize exhaust gas emissions, as well as other products to use as secondary means for ensuring compliance.
<table>
<thead>
<tr>
<th>WÄRTSILÄ PRODUCT</th>
<th>BENEFITS TO THE CUSTOMER</th>
<th>BENEFITS TO THE ENVIRONMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrubber systems</td>
<td>• Lower operating costs through access to less costly fuel</td>
<td>• Sulphur oxide gas removal in excess of 98%</td>
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<td></td>
<td>• Avoids fuel switching, storage, availability, and technical issues.</td>
<td>• ECA Compliant</td>
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<td>• IMO / EPA Tier III for the combination of Wärtsilä engine + NOR</td>
<td>• Unparaleled reduction in harmful ship emissions</td>
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<tr>
<td>NOx reducer</td>
<td>• Compact and flexible design for easy installation onboard</td>
<td>• Typical noise reduction for the NOR reactor: 8-12 dB(A)</td>
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<td></td>
<td>• Optimized and validated with Wärtsilä medium speed engines in terms of reliability and size</td>
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<tr>
<td>NACOS Platinum</td>
<td>• Minimizes total energy consumption for the voyage</td>
<td>• Reduced emissions overall with optimized vessel operation</td>
</tr>
<tr>
<td>High Voltage Shore Connection</td>
<td>• To meet the environmental rules and regulations of ports</td>
<td>• Reduced emissions during port docking</td>
</tr>
<tr>
<td>Hybrid Marine System/ Energy Optimisation System</td>
<td>• Optimized energy consumption</td>
<td>• Reduced CO\textsubscript{2}, NO\textsubscript{x} and SO\textsubscript{x} emissions</td>
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<tr>
<td></td>
<td>• Reduced operating and maintenance costs</td>
<td>• Reduced fuel consumption</td>
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<td></td>
<td>• Flexibility to adapt to different operating requirements during vessel lifetime</td>
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<td></td>
<td>• Can be adapted to any energy storage system</td>
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<tr>
<td>Dual-fuel engines</td>
<td>• Maximum flexibility in fuel choice</td>
<td>• IMO Tier III Compliant</td>
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<td></td>
<td>• Most powerful 4-stroke gas engine on the market</td>
<td>• Lowest gas fuel consumption in the industry</td>
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<td>• Long overhaul intervals</td>
<td>• Lowest fuel oil consumption in the industry</td>
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<td></td>
<td>• Minimal operational cost</td>
<td>• Low exhaust gas emissions</td>
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<tr>
<td>LNGPac™ fuel gas handling system</td>
<td>• Integrated gas valve unit</td>
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<td></td>
<td>• LNG cold recovery for HVAC</td>
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<td>• Tailored size and fit</td>
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<td>Sewage treatment systems</td>
<td>• Minimal operational costs</td>
<td>• Med and IMO certified</td>
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<td></td>
<td>• Minimal maintenance requirement</td>
<td>• Safe answer to disposing of waste at sea, maintaining the quality of the world’s oceans</td>
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<td>• Modular construction retrofit plant available (3 modules, easy to install)</td>
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<tr>
<td>Membrane bio-reactor (MBR) technology</td>
<td>• Minimal operational cost</td>
<td>• Exceeds MEPC, USCG, HELCOM and Alaska effluent discharge standards</td>
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<tr>
<td></td>
<td>• Low chemical usage</td>
<td>• MED and IMO certified</td>
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<td></td>
<td>• Smallest footprint</td>
<td>• Fully compliant with the requirements in the 2013 US EPA Vessel General Permit</td>
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<tr>
<td>Ballast water management systems</td>
<td>• Type approved system</td>
<td>• Reduces spread of invasive species across the globe</td>
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<td></td>
<td>• Flexible integration for retrofitting</td>
<td>• Guaranteed compliance with discharge regulations</td>
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<td></td>
<td>• Intelligent PLC control ensuring safe, automatic and economical operation</td>
<td></td>
</tr>
<tr>
<td>Scrubber water treatment systems</td>
<td>• All systems have been fully tested according to all regulated scenarios</td>
<td>• Removes all accumulated impurities from the scrubbing water and clean effluent can safely be discharged into the sea</td>
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<td></td>
<td>• More than 10,000 operating hours with various installations</td>
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<tr>
<td>Oily water treatment systems</td>
<td>• Versatile and flexible enabling it suitable for many different applications</td>
<td>• IMO and US Coast Guard approved</td>
</tr>
<tr>
<td></td>
<td>• More than 10,000 operating hours on various installations</td>
<td>• The amount of oil in water after treatment is less than 5ppm</td>
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<tr>
<td>Water lubricated stern tube solutions</td>
<td>• Reduces lifecycle costs by extending the operational life of the seals and bearings whilst eliminating the cost of lubricants</td>
<td>• Removes all risk of pollution, particularly for vessels operating in environmentally sensitive areas</td>
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<tr>
<td></td>
<td>• Simple and swift installation procedure compared to older traditional methods</td>
<td>• Fully compliant with the requirements in the 2013 US EPA Vessel General Permit</td>
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<tr>
<td>Inert gas systems</td>
<td>• Saves space and weight with a combined burner and scrubber solution</td>
<td>• Lower carbon dioxide emissions than traditional inert gas generators</td>
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<tr>
<td></td>
<td>• Full scale running test available before delivery</td>
<td>• Lower utility consumption reduces both the carbon footprint and energy consumption</td>
</tr>
<tr>
<td></td>
<td>• A choice of custom and standard units available</td>
<td>• Full compliance and control with all IMO Guideline pollutant limits</td>
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</table>

**OUR ENVIRONMENTAL OFFERING**

**AIR POLLUTION**

**GAS AS A FUEL**

**SEA POLLUTION**
Air pollution

We are all aware of the environmental and health problems caused by air pollution; global warming, acid rain and lung cancer being the most obvious. Rules and legislation concerning emissions to air have been enforced to put pressure on ship owners to become more environmentally conscious. When it comes to ship engine emissions, most of the regulatory focus is currently on sulphur oxides (SOx) and nitrogen oxides (NOx). Wärtsilä offers some tried-and-true technologies to tackle both.

EXHAUST GAS CLEANING

Whenever primary methods for minimizing air pollution from ships are not possible, secondary methods can be considered. A secondary method means that emissions are removed after they have left the source, in this case the engine. Wärtsilä has been working with exhaust gas cleaning since the early 90’s, during which time the company has accumulated valuable experience and extensive know-how. This has resulted in a wide range of products that are fully certified and which guarantee legislative compliance.
SCRUBBER SYSTEMS
Wärtsilä scrubber systems have been developed to efficiently remove Sulphur Oxides (SOx) from the exhaust gas, but additionally they also remove significant levels of particulate matter. Low sulphur fuel, on the other hand, doesn’t automatically mean fewer particles. In fact, running on MGO will mean releasing small particles (also called black carbon) into the air, which are especially harmful to people. Wärtsilä has developed a full wet scrubber portfolio that can cover a wide range of specific needs for our customer’s installations. Great effort has also been put into reducing the environmental impact of our scrubbers. This includes not only cleaning the exhaust gas, but also the wash water from the scrubber system. With over 200,000 running hours, Wärtsilä has the longest experience in the marine scrubbing market today.

NOX REDUCER
A marine diesel engine installed on a ship constructed on or after 1 January 2016, and operating in the North American ECA and the United States Caribbean Sea ECA, must comply with the Tier III NOx standards. The same rule applies in the North Sea and Baltic Sea for ships with keel laying on or after 1 January 2021.

Selective Catalytic Reduction, or SCR, is today’s primary technology for NOx abatement. The NOx Reducer (NOR) is available for all Wärtsilä medium speed engines in a wide range of sizes and shapes to fit any vertical or horizontal space regardless of width and length constraints. Wärtsilä engines delivered with NOR are equipped with exhaust gas temperature control to ensure the correct temperature for SCR operation (ON/OFF). The NOR can be used for various applications and different fuel qualities (HFO / MDO / MGO) and can be operated together with other exhaust gas equipment including scrubbers, silencers, exhaust gas boilers etc.
High Voltage Shore Connection
The Wärtsilä High Voltage Shore Connection is a solution for reducing emissions during port docking. The system design is essentially based on meeting port needs while also conforming to ICE/ISO/IEEE 80005-1 requirements. A typical configuration comprises the key components, such as the cable reel, a medium voltage switchboard, and a control and monitoring facility that includes an interface between ship and shore. A complete assembly can either be installed separately onboard the vessel, or containerised for siting at a specific onboard location. Upon request we can develop tailor made solutions for all vessel types.

NACOS Platinum
The NACOS Platinum ECDIS incorporates route planning assistance, thereby providing the operator with information that can minimize the vessel’s total energy consumption during the voyage.

By taking into account the most relevant parameters such as route, schedule, speed limits, traffic rules and environmental data, an optimal rpm profile from an energy point of view will be generated. The NACOS Platinum ECDIS presents a transparent overview of the optimization results, and the execution of the optimized route can be simulated at the ECDIS. Online execution is carried out by Trackpilot and Speedpilot which are integrated sub-systems of NACOS Platinum.

This scalable solution can be adapted for all kinds of propulsion systems and generates significant fuel savings and environmental benefits. The optimization framework is easy to extend for weather routing and geometrical route optimization.
Gas as a fuel

One primary method for reducing emissions from a marine engine is to run on cleaner fuel. Operating with LNG is an effective way to comply with current exhaust emission legislation, since LNG is one of the few fuels pure enough to meet even the strictest regulations. In addition to enabling compliance with NOx and SOx restrictions, particulate matter (PM) is minimized. Wärtsilä has led the way in developing technologies that make running on gas more available than ever, providing a range of solutions, including the Wärtsilä dual-fuel engines and the Wärtsilä LNGPac™ fuel gas handling system. We offer the LNG fuel system on its own, as well as part of a complete propulsion system.

DUAL-FUEL ENGINES
Fuel flexibility gives owners and operators the possibility to select the most suitable fuel, depending on such factors as local environmental restrictions, fuel price variations and fuel bunkering availability. Dual-fuel engines will automatically and instantly change to diesel operation, if there is an interruption to the gas supply; a safety and operational feature that does not cause any loss of speed or power.

A unique feature of Wärtsilä dual-fuel engines is their ability to run on natural gas, marine diesel oil, heavy fuel oil and bio fuels, thus providing maximum flexibility in fuel choice.

LNGPac™
The Wärtsilä LNGPac™ is a complete fuel gas handling system for LNG fuelled ships and includes the bunkering station, LNG tank and related process equipment, as well as the control and monitoring system. Wärtsilä can deliver LNG fuel gas systems for propulsion and power generation for any applicable type of ship or engine. The standard Wärtsilä LNGPac™ uses an IMO type C LNG storage tank. Bunkering takes place from the bunkering station to the LNG tank via an insulated pipe. The main process equipment inside the tank connection space ensures the correct gas temperature for the engines and maintains sufficient pressure inside the LNG tank.
Pollution at sea

We are slowly but surely destroying our seas; waste water from ships and from land cause eutrophication, leaving the bottom of the sea lifeless. Oil leaks and solid waste destroy entire ecosystems. Species are wiped out by unfamiliar predators that have been introduced to local ecosystems by humans. Sea creatures die from having eaten plastic items that get lodged in their digestion system. Fortunately, many of these problems can be avoided thanks to the introduction of cleaning technology, safety measures, and basic common sense. Here again, legislation plays a major role when it comes to ensuring a safe and sound environment for both humans and nature alike.

WASTEWATER TREATMENT
Wärtsilä is the world’s leading manufacturer of marine sewage treatment systems.

For over four decades the Wärtsilä Hamworthy Super Trident sewage treatment plant has been widely regarded as standard specification on all types of vessels.

For a more advanced wastewater treatment process, the Wärtsilä Hamworthy MBR technology is based on biological degradation and membrane separation that allows for the treatment of black and grey water to satisfy the most stringent standards. The process produces the highest quality discharge without requiring any addition, or generation, of chemicals that are hazardous to the environment or the ship’s operation. The technology has been scrutinised by the Alaskan authorities, the USCG and the USEPA. In every case its performance was deemed to be outstanding.

BALLAST WATER MANAGEMENT
To avoid whole ecosystems being destroyed by the introduction of alien organisms, new rules regarding ballast water have been introduced. As from September, 2017 the Ballast Water Management (BWM) convention means that every ship above 400 gross register tonnes (GRT) will have to install a type-approved ballast treatment system at its next mandatory International Oil Pollution Prevention (IOPP) survey.

Wärtsilä has developed a portfolio of ballast water management systems that enable compliance with these regulations, while at the same time helping to avoid the collapse of fragile marine ecosystems across the globe. The main function of the Wärtsilä systems is to eliminate any living organisms that are transported together with the ballast water. To achieve this, the Wärtsilä Aquarius® ballast water management systems are based on two different technologies: UV irradiation and electro-chlorination, both which have been approved by the IMO in accordance with the global G8 guidelines. Both products currently have USCG Alternate Management System (AMS) and are in the process of achieving USCG type approval.
Wärtsilä Hamworthy MBR technology

Wärtsilä Hamworthy sewage treatment plant

Wärtsilä Aquarius® ballast water management systems

Wärtsilä oily water and scrubber water treatment

**SCRUBBER WATER TREATMENT**

Wash water is generated from all types of scrubber systems and if not treated may have serious environmental impact on our oceans.

The Wärtsilä Scrubber Water Treatment system removes accumulated impurities from the scrubbing water in accordance with legislation and clean effluent can safely be discharged into the sea. The system uses the same highly effective method as the Wärtsilä OWS. The technology is versatile and flexible, making it suitable for many different applications. The systems have been fully tested according to all regulated scenarios and have to date more than 10,000 operating hours on different installations.

**OILY WATER TREATMENT**

Oil spills can be devastating to marine environments, which is why discharges are strictly regulated, even in small amounts.

Wärtsilä’s series of water treatment units are based on dissolved air flotation (DAF), where chemicals are added to the contaminated/oily water, after which dissolved air is used to separate the contaminants from the water. Our OWS systems are built on the same platform as the other oily water products, and provide the most effective oily water, bilge and sludge treatment on the market, outperforming current IMO regulations and meeting future marine customer expectations.

**WATER LUBRICATED STERN TUBE SOLUTIONS**

The installation of Wärtsilä’s water lubricated stern tube solutions removes all risk of pollution, particularly for vessels operating in environmentally sensitive areas, and reduces lifecycle costs by extending the operational life of the seals and bearings. At the same time, the cost of lubricants is eliminated. We have a proven record of supplying water lubricated systems to the marine market for over 60 years, thereby establishing their reliability, flexibility and operational excellence. Our oil-free, water lubricated stern tube solutions, are fully compliant with the requirements of the 2013 US EPA Vessel General Permit.

**INERT GAS SYSTEMS**

By installing a Wärtsilä inert gas system, protection is provided to the vessel, the personnel, and the environment. Wärtsilä is a market leader in the development, design, manufacture and servicing of advanced inert gas and nitrogen solutions for marine and offshore oil and gas applications. We have more than 50 years’ experience, system deliveries to more than 2500 vessels, and are certified by ISO 9001:2000, ISO 14001:2004 and OHSAS 18001:2007.
The future of environmental shipping

Environmental considerations will be a central element of the shipping industry in the future. In fact, in certain vessel sectors and in many areas of the globe, it is already. Green shipping is here now, it is here to stay, and it will get even greener in the years to come.

This is why Wärtsilä is taking the lead in developing the technologies that enable environmentally sustainable operations, while at the same time focusing on efficiency as a means for controlling costs. When Wärtsilä introduced the first dual-fuel engines to the marine industry some 30 years ago, the use of clean burning LNG became viable as a marine fuel. Today, LNG fuelled propulsion is widely accepted as a means of complying with emission regulations, and this trend is gaining momentum at a rapid pace.

As energy storage systems become more efficient with greater capacities and lower costs, hybrid and electrically powered shipping is the industry’s next frontier. Wärtsilä’s hybrid solutions combine conventional diesel or dual-fuel engines with batteries and offer high efficiency by running the engines at optimal load and absorbing many of the load fluctuations through batteries, thus significantly reducing emission levels.

With hybrid propulsion concepts, the control system is crucial to achieving high efficiency and economic fuel consumption. The Integrated Automation System (IAS) provides the platform for all information and operation of the vessel, while the Energy Management System (EMS) controls and monitors the different energy systems and delivers essential information to the operator.

As part of the Wärtsilä HY, the company’s groundbreaking hybrid power module for ship propulsion, Wärtsilä has developed a new, highly sophisticated, and fully integrated EMS. This is the overall ‘brain’ controlling the energy flows between the different power sources. It also adds performance optimisation features with respect to emissions, trim and route, as well as monitoring the long-term performance of the vessel. Furthermore, it creates an entirely new level of interaction with the ship’s onboard systems, thereby providing enhanced operability and greater predictability.

Digital transformation is one of the most important megatrends that will impact the marine industry in the future, and Wärtsilä is already investing in an advanced digitalisation programme. The industry is moving towards a time when autonomous shipping will move from being a concept into operational reality. Digitalisation is critical to this trend, and to many other initiatives that will make shipping cleaner, more efficient, and environmentally sustainable.
Experience and recent successes

HARMONY OF THE SEAS
Owner: Royal Caribbean International
Yard: STX France
Scope of supply:
• 2 x Wärtsilä hybrid scrubber systems
• 4 x 12 cylinder Wärtsilä 46F engines
• 2 x 16 cylinder Wärtsilä 46F engines
• 4 x Wärtsilä CT3500 transverse thrusters
• Wärtsilä NACOS platinum navigation and dynamic positioning systems
• Houselight dimming system for all public venues, - dimming system for all suites, a low resolution LED wall for the theatre from Wärtsilä FUNA

ROBIN HOOD
Owner: TT Line
Yard: Finnyards OY
Scope of supply:
• 4 x Wärtsilä hybrid scrubber systems designed to reduce harmful sulphur oxide (SOx) and particulate emissions from the ship’s exhaust
• Turnkey delivery responsibility covers full engineering, pre-fabrication, installation, classification, project management, and construction site management
• Integrated automation system (DAMATIC)
• Integrated navigation system (Wärtsilä NACOS Platinum)
• Diesel electric propulsion drive system
• Power generation and distribution

CROWN PRINCESS
Owner: Princess Cruise Line
Yard: Fincantieri
Scope of supply:
• 3 x Wärtsilä Hamworthy MBR16 membrane bioreactor plants capable of managing up to 947m³/day of wastewater for 4,620 people on-board. The system exceeds even the most demanding standards and achieved outstanding performance in Alaska.
• Diesel engines
• Integrated navigation system (NACOS-XX5)

TARBIT BIT VIKING
Owner: Tarbit Shipping AB, Sweden
Scope of supply:
• 2 x 500m³ LNG fuel storage tanks (LNGPacs) on the ship’s deck
• Conversion of two existing Wärtsilä 46 engines to Wärtsilä 50DF engines
• 2 x LNG bunkering stations
• LNG and gas piping onboard
• Updating the vessel’s automation system and gas detection system
The vessels emissions of CO₂ have been reduced by some 25%, while emissions of particulates and NOx have been dramatically lowered. When using LNG fuel, SOx emissions are eliminated entirely.
At Wärtsilä we strive constantly to do what is best for you. This includes optimising the lifecycle value of your installations by offering precisely what you need; a promise we can deliver on since we provide the marine industry’s most complete portfolio of products, integrated solutions and global services.

By prioritising operational efficiency, environmental excellence, fuel flexibility and 24/7 support, we work with you to find your shorter route to robust growth, greater profitability and regulatory compliance. This is why today, every third vessel in the world has a Wärtsilä solution onboard.

www.wartsila.com