WÄRTSILÄ

Lifetime Responsibility

ANNUAL REPORT 2004

Sustainability Report

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GRI content index

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1.2 CEO's statement	12-13		4-5	See also the Sustainability Review.
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EC2 Geographic breakdown of markets	3	22	46-47	
EC3 Costs of materials, goods purchased			46-47	
EC4 Percentage of contracts paid by agreed items				Information is not available at the corporate level. Wärtsilä is introducing a new system and is currently assessing the feasibility of reporting the system's key indicators.
EC5 Total payroll and benefits			46-47	
EC6 Distributions to providers of capital			46-47	
EC7 Change in retained earnings			46-47	
EC8 Total sum of taxes			46-47	
EC9 Subsidies received			46-47	
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GRI content	Status/Report/Page			Note
CORE INDICATORS: ENVIRONMENT	**BR**	**FR**	**SR**	BR= Business Review, FR= Financial Review and SR= Sustainability Review
EN1 Total material use			48-57	Information is not available at the corporate level. Only the fuel consumption is reported.
EN2 Percentage of waste material used			52-54	Information is not available at the corporate level. Recycled materials are used in engine and propeller manufacturing.
EN3-EN4 Direct and indirect energy use			48-57	
EN5 Total water use			48-57	EN22 Total recycling and reuse of water. See page 54.
EN6-EN7 Biodiversity-rich habitats, impacts on biodiversity			50-51	
EN8 Greenhouse gas emissions			48-57	
EN9 Ozone-depleting substances			48-57	Not applicable to Wärtsilä.
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LA9 Average training hours			58-61	
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LA11 Composition of senior management and corporate governance bodies	34-39			
HR1 Policies and guidelines (human rights)			58-61	See the social targets on page 58.
HR2 Considerations of human rights in investment				Reportable evidence not available. Wärtsilä assesses its suppliers as described in the Business Review, page 40-41, and companies in connection with mergers and acquisitions.
HR3 Policies and procedures to evaluate human rights			58-61	See the social targets on page 58.
HR4 Global policy preventing discrimination			58-61	See the social targets on page 58.
HR5 Freedom of association policies			58-61	See the social targets on page 58.
HR6 Policy excluding child labour			58-61	See the social targets on page 58.
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PR1 Policy for preserving customer health and safety	11, 41			
PR2 Policy relating to product information and labelling	41			Not applicable to Wärtsilä.
PR3 Policy relating to consumer privacy				Not applicable to Wärtsilä.
PR8 Policy relating to customer satisfaction	42		61	

● Covered ● Partly covered ● Not covered

Wärtsilä's Sustainability Review

Wärtsilä has enhanced its sustainable development reporting. Firstly, the Sustainability Report is now a part of the company's Annual Report, which improves stakeholder communications by reducing the sustainability reporting period to one year. Secondly, the report's coverage is wider than previously.

Wärtsilä continues to work towards achieving its objectives for sustainable development. Improving product environmental performance is a central goal in Wärtsilä's business. The combination of rapid change in the operating environment, the Kyoto Protocol and rising fuel prices require equipment and systems suppliers to focus on solutions offering high efficiency, low emissions and low lifecycle costs. These aspects have top priority in Wärtsilä's product development programme. The selective application of new technology to new and existing products improves the competitiveness of Wärtsilä's products both on land and at sea.

Economic performance

Economic performance means creating added value for Wärtsilä's shareholders and promoting the wellbeing of the local communities in which the company operates. This requires that the company's operations are profitable, competitive and efficient. The results of Wärtsilä's continuous improvement programme and recent restructuring are reflected in the company's improving profitability. Good economic performance establishes a platform for the other aspects of sustainability – environmental and social performance.

Environmental performance

Environmental issues have long played a central role in the company's business environment. The results of Wärtsilä's systematic approach to environmental issues can be seen in both the improved efficiency and lower emissions of our products. Our sustainable development strategy and its goals guide the development of our products and processes. More detailed objectives are defined for each Wärtsilä business and Wärtsilä company. The environmental management systems applied by Wärtsilä companies cover all the activities, such as product design, manufacturing, sales and service, as well as support functions. This provides a solid framework for comprehensive improvement in the companies' performance and for networking within the Group.

The environmental requirements of energy production and the challenges of sustainable development have steered our customers towards adopting increasingly environmentally sound solutions, a good example being the success of Wärtsilä's DF engines as prime movers in LNG carriers. In addition to developing existing technologies, Wärtsilä is working on new technologies for the energy-producing solutions of the future, which will enable us to offer our customers competitive and environmentally sound solutions well into the future as well. In this regard, Wärtsilä's fuel cell project is progressing on schedule and testing of the first trial equipment has been successfully completed.

Environmental legislation has increased at an accelerating pace in recent years, with the focus shifting from regulating operations to the regulation of products. Measures aimed at reducing environmental impacts and improving performance must address the overall impact on the environment instead of individual components. A good example is the propulsion system developed in the Environpax project, in which 10% higher efficiency has been achieved by simultaneous optimization of the hull shape, engines and propulsion system.

Social performance

Wärtsilä's aim is to create and maintain a pleasant and safe working environment for its employees. Wärtsilä needs skilled and motivated personnel to reach its objectives. Employee training and skills enhancement are a central part of the Group's HR policy. Restructuring over the past few years has understandably affected the working atmosphere, especially in the units that were re-organized. In this process Wärtsilä has placed high emphasis on frank dialogue between management and employees to ensure that the reasons for implementing these changes are understood.

The job satisfaction study conducted in 2004 indicated that most Wärtsilä employees are motivated and highly competent. However, the study also showed that employees did not have sufficient knowledge about Wärtsilä's business strategy. Rectifying this situation will need more open and effective communication by management and supervisors.

At the end of 2004 Wärtsilä approved its internal Code of Conduct, which provides the foundation for responsible operation by the company. The code's principles did not result in any major changes in the way we work, but they do help to communicate – both internally and globally – the actions required to ensure we operate as a responsible corporate citizen.

Wärtsilä's occupational health and safety practices are based on the company's Occupational Health and Safety Policy and Directive. Wärtsilä's subsidiaries are required to apply a management system that conforms to OHSAS 18001 requirements.

Active dialogue is one element of the company's responsibility towards its various stakeholders. Wärtsilä encourages open and transparent communication with its stakeholders, and has introduced tools to support its everyday dealings with them. Customer satisfaction, for instance, is now measured for separate projects, which helps us to deal with any discrepancies quickly.

I hope our Sustainability Report meets the expectations of our stakeholders. All feedback is welcome, and indeed is essential to the further development and improvement of our reporting procedures.

Matti Kleimola
Prof., CTO,
Group Vice President
Technology and Environment

Report Scope

Wärtsilä's Sustainability Report 2004 is prepared according to the GRI (Global Reporting Initiative) Sustainability Reporting Guidelines 2002. Wärtsilä reports those core indicators which are of most relevance to its operations, products and stakeholders. The product performance section describes the environmental aspects and impacts of Wärtsilä's products, the measures taken by Wärtsilä to reduce these impacts, and the environmentally advanced solutions that Wärtsilä has developed. The Wärtsilä and Sustainable Development section examines the company's economic, environmental and social performance. The core indicators chosen are of importance at the corporate level.

Coverage of the report

This report covers Wärtsilä's Power Businesses and Imatra Steel. It does not cover Wärtsilä's holding companies, associated companies or supply chain companies.

Wärtsilä's Power Businesses comprise the Group's Ship Power, Power Plants and Service businesses and its Engine division. The first three of these generate external net sales while the fourth is an internal function.

The economic performance data covers all Wärtsilä companies. The data on environmental and social performance covers all Wärtsilä companies except the following:

- Wärtsilä Peru, Wärtsilä Dominicana, Wärtsilä Chile, Wärtsilä Venezuela and Wärtsilä West Africa.
- Wärtsilä-CME Zhenjiang Propeller Company,
- Ciserv Netherlands, Ciserv Europoort, Ciserv Denmark, Ciserv Korea, Ciserv CGL, Ciserv USA and Ciserv Singapore.

These companies will be included in Wärtsilä's sustainable development reporting in 2005 and 2006. The environmental performance data on the Power Businesses and on Imatra Steel is presented separately due to the different nature of these businesses.

Wärtsilä's Sustainability Report is part of its Annual Report and therefore from 2005 Wärtsilä will publish a Sustainability Report annually.

Significant changes in Group structure

The structural changes in Wärtsilä's Power Businesses relate mainly to restructuring of the company's manufacturing operations in France and in Finland, and are described in the Social Performance section.

In Imatra Steel a significant structural change was the sale of the Billnäs Spring Works to the Styria group's owner, Frauenthal Holding AG, in June 2003. The Spring Works has reported its sustainable development data until July 2003.

Coverage of operational data

Operational data	% of Wärtsilä companies			% of personnel			% of product manufacturing		
	00-01	02	03-04	00-01	02	03-04	00-01	02	03-04
Economic	100	100	100	100	100	100	100	100	100
Environmental	14	35	79	64	75	92	100	100	100
Social	12	45	79	53	85	92	100	100	100

Report Profile

Data collection

The data on product environmental performance is based on measured test results. Performance data on the environmental and social aspects of sustainability has been collected from the Wärtsilä companies using a detailed questionnaire. Economic performance data is based mainly on audited financial accounts.

The sustainability data is collected and reported according to Wärtsilä's specific internal reporting guidelines that include all the definitions and instructions necessary for this purpose. Environmental expenditure and investments are reported applying the Eurostat instructions.

Each company has a nominated individual responsible for collection and consolidation of the data, and for its quality and reliability. The management of each company approves the data before it is consolidated at Group level. The companies report their sustainability data using Wärtsilä's CR Profile reporting system. The reported data is checked at both local and Group levels before its consolidation.

The content of this Sustainability Report was reviewed and approved by Wärtsilä's Board of Management on 11 February 2005.

KPMG Oy Ab has independently assessed the completeness, accuracy and consistency of the data in the report. Site audits were carried out in Rubbestadneset, Norway, and in Khopoli, India.

Additional sources of information

Wärtsilä has previously published the following reports:

- Environmental Report 2000
- Sustainability Report 2002
- Imatra Steel Environmental Report 1999
- Imatra Steel Environmental Report 2002.

These reports and their sustainability data are available on Wärtsilä's website: www.wartsila.com.

Sustainability Report Project Team

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Products and the Environment

Investing in operations and technologies that are environmentally sustainable ensures a solid framework for a company's future efficiency and viability. A central objective in Wärtsilä's strategy for sustainable development is reducing the environmental impacts of its products. For the company to meet customers' needs, be prepared for future requirements and remain a frontrunner in the industry, Wärtsilä's product development must be continuously innovative, determined and willing to explore new technologies.

Wärtsilä's product development is aimed at increasing the service life of products, improving their reliability and making the products more environmentally sound. Investing in product development benefits Wärtsilä's customers as well as the environment, both in the short-term and over a longer time span. Growth in the world's energy needs combined with increasingly stricter environmental requirements creates a challenging operating climate for companies in Wärtsilä's line of business. Wärtsilä has responded to these challenges by improving the energy efficiency of its products while simultaneously reducing their emissions.

Wärtsilä first published its Group-wide environmental targets in its Environmental Report for 2000. The first target was to raise sales of gas power plants to one-half of the total volume of Wärtsilä's power plant sales. The second target was to offer Wärtsilä's customers an environmentally advanced product portfolio by the end of 2003. Wärtsilä did not succeed in meeting its first target owing to unfavourable development of the power plant market, changes to the company's power plant portfolio, and the price and availability of natural gas. The second target was reached; Wärtsilä's product range now offers environmentally sound solutions for both ship power and power plant applications.

In 2002 Wärtsilä's Board of Management set new Group-wide targets for Wärtsilä's product development programme. The new targets are even more challenging while also being more tangible in content. The table below summarizes the targets to be achieved by the end of 2005 and reviews their current status.

Product development

Wärtsilä applies new technologies that cross traditional scientific disciplines and conventional industrial boundaries to solve product development tasks, thus producing added value for its customers. Wärtsilä's R&D organization creates the basic elements that make a product both desirable and competitive. Wärtsilä's R&D activities focus on products and applications that are reliable, self-diagnostic, inexpensive to operate and produce minimal environmental impacts throughout their lifecycles. Wärtsilä's research organization collaborates with research institutes and corporate partners in fields that are of crucial importance to the wellbeing of society and conservation of the environment. A substantial proportion of the company's investments in product development is targeted at reducing environmental impacts. R&D expenses are shown in the Financial Review section of the Annual Report 2004.

Lifecycle approach and using results

Since Wärtsilä's products have such a long operational life, identifying the lifecycle impacts of the products is essential to understanding their total environmental impact. Wärtsilä has long focused the thrust of its R&D activities on minimizing environmental impacts. R&D results have also been utilized in existing products by, for instance, upgrading engines. Most of the environmental impacts of Wärtsilä's products arise during the operation of the products. However, Wärtsilä's strategic objective is to ascertain in greater detail the environmental impacts of the company's products during the different stages of their lifecycles by performing lifecycle assessments. The results of the first assessments will enable us to target improvements more precisely on those stages that produce the most significant environmental impacts.

Wärtsilä manages the lifecycle of its products through product design, the selection of suppliers, production methods, optimizing transpor-

Target	Environmental benefits	Status at the end of 2004
Raise the volume of gas and biopower plant sales to 1,000 MW a year.	Lower emissions from gas and biofuels compared to oil.	Sales in 2004 totalled 759 MW.
Raise the volume of O&M agreements to cover 20% of new installations.	Efficient and planned operation of power plants.	The volume of O&M agreements in 2004 covered 30% of new power plant orders and 14% of all engine deliveries.
Provide a comprehensive gas engine portfolio for various engine room installations.	Replace use of steam in LNG carriers. Use of boil-off gas. High efficiency and lower emissions.	First engines supplied for LNG and offshore supply vessels.
Be able to offer propulsion systems with 10% higher total efficiency than is standard today.	Improvement of overall efficiency of ships. Lower fuel consumption and emissions.	The Enviropax project is complete. Its results are described in more detail under Ship Power in this report.
Develop a fuel cell solution prototype with ultra-low emissions and provide the first engines able to run on bio-oils.	Development of alternative environmentally sound solutions.	The test equipment for the first fuel cell prototype has been successfully completed. The first bio-oil engines are in operation.

tation, maintenance and repair during the products' operational lifetime, and by training and advising customers. Product design is an important element in lifecycle management because it is at this stage when the materials to be used are selected, and when the operational parameters, servicing and final decommissioning of the product are planned. Continuous improvement in Wärtsilä's and its suppliers' environmental performance is a cornerstone of Wärtsilä's environmental management system. Training customers and providing them with adequate instructions ensure that products are operated correctly and perform as designed. Wärtsilä's wide range of maintenance services optimizes the performance of its products throughout their operational lifetime.

International legislation and initiatives

In Wärtsilä's business, environmental pollution is regulated at the international level mainly by the IMO (International Maritime Organization) and the World Bank. Wärtsilä's products comply with the requirements of these institutions. Other important environmental restrictions on Wärtsilä's products are the German TA-Luft regulations often applied to gas engine plants and the emission limits on diesel engines set by India and Japan.

Enforcement of the Kyoto Protocol will have a significant impact on the power generation business. Wärtsilä supplies decentralized solutions for power generation that provide high efficiency with relatively low carbon dioxide emissions. The modularity of Wärtsilä's solutions enables our customers to optimize the plant size, while Wärtsilä's multifuel solutions enable customers to switch to cleaner fuels whenever necessary. With respect to greenhouse gases, among the best solutions are power plants running on biofuels as these add no greenhouse gases into the atmosphere.

The EU Commission plans to increase the construction of CHP (Combined Heat and Power) capacity in the EU area. In CHP generation the utilization of fuel energy is highly efficient since much of the residual heat from the combustion process is also recovered and used, for instance in district heating and cooling (DHC), steam production or as heat in industrial processes. The CHP process saves global fuel resources by through efficient use of the energy stored in fuels. The CHP power plants that Wärtsilä supplies offer extremely high efficiencies.

Environmental legislation has increased considerably in recent years and its focus has shifted from regulating operation to regulating the products themselves. Wärtsilä actively monitors legislative initiatives and changes in environmental legislation to ensure the company's ability to respond appropriately to the operating conditions of the future. Wärtsilä's R&D addresses the requirements of the changing operating environment and develops products that give the company a competitive edge.

Future energy solutions

Since 2000, Wärtsilä has developed fuel cell technology for decentralized power generation and marine applications. Today the company's R&D is focusing on developing an SOFC (solid oxide fuel cell) system for both industrial and marine applications. The goal of this programme is to offer Wärtsilä's customers highly efficient and environmentally clean solutions for generating energy.

Wärtsilä believes that fuel cell technology will be one of the most promising energy technologies for decentralized power generation in the future. Wärtsilä is concentrating particularly on fuel cell applications in the 50 kW to 5 MW range for CHP power plants and as an auxiliary power source in ships.

SOFC system

Markets for demonstration and precommercial purposes will develop during this decade.

Wärtsilä is focusing its R&D on the design and manufacture of power generating units based on fuel cells. Integrating the different technologies, including fuel cell systems, is one of the primary areas in which Wärtsilä will exploit its expertise. Wärtsilä's extensive knowhow in combined heat and power generation, marine engine applications and the company's in-depth knowledge of its customers' needs provide a sound basis for developing fuel cell applications.

Wärtsilä's existing SOFC system is based on the use of natural gas or methanol. The fuel is cleaned of sulphur and reformed into methane, carbon monoxide and hydrogen before entering the fuel cells. Some of the gases that do not react in the fuel cells are then directed to a catalytic afterburner, after which the nitrogen oxide and hydrocarbon content of the exhaust emissions is extremely low; in practice less than 1 ppm. The high temperature of the exhaust gases also allows heat to be recovered and used for industrial applications.

Wärtsilä is committed to supplying its customers with environmentally sustainable power generation solutions. Developing the energy generation technologies of the future, such as fuel cells, is a key element in Wärtsilä's strategy for sustainable development.

Wärtsilä's products

Wärtsilä supplies ship machinery, propulsion and manoeuvring solutions for all types of ships and offshore applications. Wärtsilä also supplies power plants for decentralized power generation. The product range comprises gas- and oil-fired power plants with outputs from 1 to 300 MW and biofuelled power plants with outputs from 3 to 25 MW. Wärtsilä offers a range of maintenance and repair services for its products throughout their operational lifetime. Imatra Steel supplies special engineering steels and components to the automotive and mechanical engineering industries.

Products and Environmental Aspects

The environmental aspects of Wärtsilä's products are mainly related to their use. The most significant environmental aspects concern engines, which produce mechanical and thermal energy. In order to produce energy, engines use fuel and lubricants, which results in various kinds of exhaust emissions and waste. Exhaust gases and engine cooling also produce waste heat into the air and water.

The environmental aspects and main environmental impacts of Wärtsilä's products are presented in the table below.

The environmental aspects of Wärtsilä's products are described in more detail in the later sections of this report. Wärtsilä's main solutions for environmental conservation are presented in the sections specific to Wärtsilä's Businesses.

The environmental aspects and main environmental impacts of Wärtsilä's products are presented in the table below

Environmental aspect	Product	Environmental impact	Wärtsilä's solutions
Consumption of raw materials	All products	Depletion of natural resources	Increase product lifecycles, use recycled materials in manufacturing, enhance efficiency in use of materials, improve durability of materials, use of automatic filters
Consumption of fuels and lubricants	Engines, propulsion systems	Depletion of natural resources	Improve energy efficiency, reduce consumption of lubricating oil
Emissions into the air	Engines	Air pollution	Reduce emissions, improve efficiency
Noise and vibration	Engines, propulsion systems	Discomfort	Effective noise mitigation solutions and silencing systems
Solid and liquid wastes	All products	Increased amounts of waste at landfill sites	Recycling of materials, use of automatic filters, extend lifetime of lubricating oils
Heat emissions	Engines	Warming of the Earth's atmosphere	Heat recovery systems
Electrical and thermal energy	Power solutions	Increased wellbeing	Energy-efficient solutions

MATERIALS

Engines

Wärtsilä engines have an extremely long service life, usually well over 25 years. Manufacture of the Sulzer ZA40, for example, started in 1967 and so far 1783 of these engines have been built. Another good example is the Wärtsilä Vasa 32 engine, which entered production in 1978. More than 4500 of these engines have been made. Almost all the engines manufactured of both types are still in use. Long-life products make more efficient use of materials than products with a shorter life. The power-to-weight ratio of the engines has also improved, which means that more energy is generated for the same amount of material in the engine.

Because of their long service life, older engines are often modernized and improved so that they conform to current requirements, and also to reduce their environmental impact. During a normal service life, an engine is used for 100,000 – 200,000 operating hours. Wear components such as valves, piston rings and bearings are normally replaced about every three years and a more thorough engine overhaul is carried out two or three times during the life of the engine. During these, the pistons, cylinder heads, piston liners, connecting rods and turbocharger rotors are replaced or overhauled. Engine components taken out of use are scrapped. Overhauled components are reused, which means their service life is extended. The material from end-of-life components is often used to produce recycled material.

An engine is made up mainly of various metal alloys, so the material used in the engine and its components can be recycled. The most important structural materials in 4-stroke engines are cast iron, alloy and structural steels, and aluminium alloys. The three main elements used in the metal alloys are iron 90.8% m/m, aluminium 2.7% m/m and carbon 2.2% m/m.

Wärtsilä's R&D works systematically to improve the wear resistance and extend the service life of components and materials.

Power plants

Several materials are used in the construction of power plants, steel being the most heavily used material. Concrete is used with steel in the foundations. The building itself usually lasts for the whole working life of the power plant. The goal is always to make optimal use of materials in a power plant, in part to keep costs down. This is achieved through thorough planning that takes into account the conditions at the site.

Most of the power plant components, in some cases even the building, are transported to the site as prefabricated modules. This helps to minimize transportation needs and at the same time makes more effective use of materials by reducing the amount of waste at the building site. Local suppliers are used where possible to minimize environmental impact.

Secondary cleaning equipment for flue gases

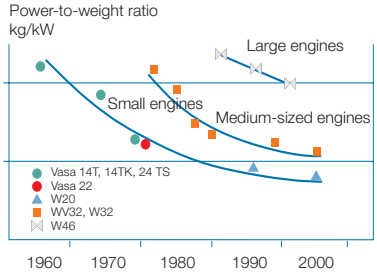
When secondary cleaning equipment is used, the material balance sheet of a plant may contain various reagents. It is then necessary to replace not just the normal spare parts, but also gradually the catalyst materials, for example when using SCR or oxidation catalysts. The catalyst materials that have been replaced are usually returned to the supplier for reprocessing.

Propulsion equipment and seals

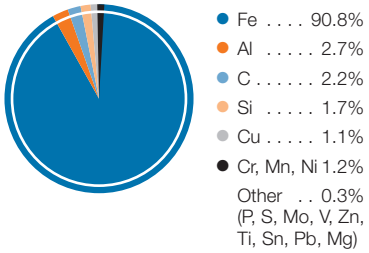
All of Wärtsilä's propulsion products are designed to last the entire working life of a ship, which may be as long as 30 years. Most of the materials are metals, which can be recycled. The products contain non-ferrous metals such as bronze, which is an alloy of copper, nickel and aluminium. Recycled material, such as end-of-life coins and bronze propellers, is used in the casting of new propellers, which reduces the environmental impact of the products. Propulsion products contain few wear parts and these are easy to replace. Lubrication oils or environmentally sound additives are also used in the products.

The sealing systems are optimized to reduce the risk of emissions and the propulsion systems themselves are designed to have minimum emission levels.

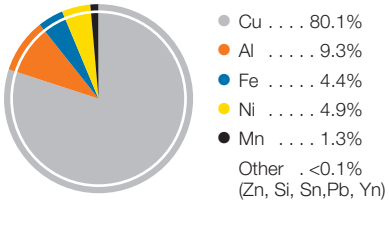
Power-to-weight ratio of Wärtsilä 6-cyl. in-line



Material balance sheet for Wärtsilä 32 engine



Material balance sheet for propulsion products



Total reserves and usage

Until very recently the prevailing view has been that the decline in global reserves of fossil fuels during the coming 10–15 years would not be enough to make significant changes in fuel usage or prices unavoidable. At present, however, the decline in reserves of high-grade crude oil in the North Sea, the reduction in natural gas reserves in North America, and the general shortage of crude oil production and refining capacity, due in particular to the growing demand in China and the USA, all are all pushing up market prices. Some of last year's increase in prices is also due to global instability. If the price increases are permanent, this will speed up the development and introduction of alternative fuels and, through this, will also have an impact on the market for engines. Wärtsilä's R&D activities take this change in the range of fuels into account and the company is prepared to respond appropriately.

Although oil is the most important fuel, and will remain so for a relatively long time, a visible change is the increasing use of natural gas. The supply of natural gas is rising as gas deposits, for example in the sea off northern Norway and Murmansk, are taken into use. In the past, natural gas has been used by onshore power plants, but today marine vessels are making increasing use of liquefied natural gas (LNG) for fuel on environmental grounds. International climate agreements, with their requirements to reduce carbon dioxide emissions, can be expected to boost the use of natural gas significantly in the next few years. Carbon dioxide emissions when using natural gas are 25% lower than in the case of oil and 40% lower than for coal. An even more effective way to reduce carbon dioxide emissions is to adopt renewable energy sources such as biofuels. Increasing the use of biofuels often requires political decisions, which may slow down their introduction. At some point, however, increasing the use of biofuels will become unavoidable.

Fuels used in Wärtsilä engines

The use of different fuels is an important part of Wärtsilä's R&D. Even now multifuel engines offer environmentally sound solutions with low running costs far into the future. Customers have the flexibility to operate the same engine with different fuels. They can, for instance, initially run an engine on heavy fuel oil, and then switch to natural gas later when the distribution network for natural gas has been built, or even switch to biofuel.

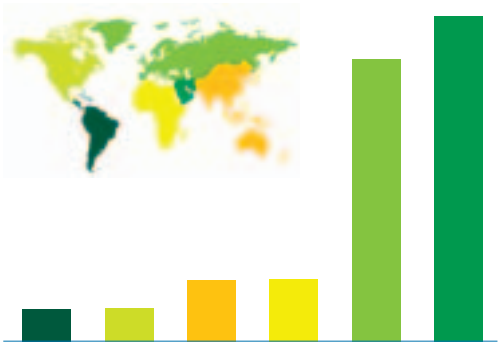
Multifuel technology, which permits the use of different types of fuel such as liquid fuels based on crude oil, gaseous fuels and biofuels, allows customers to choose the optimal fuel in each situation. Fuel flexibility also ensures that an engine is available for continuous operation, even if there are problems in obtaining a certain fuel.

Proved oil and natural gas reserves at end 2003

Thousand million barrels

- Asia Pacific 47.7
- North America 63.6
- Africa 101.8
- South & Central America . . 102.2
- Europe & Eurasia 105.9
- Middle East 726.6

Trillion cubic metres



- South & Central America . . . 7.19
- North America 7.31
- Asia 13.47
- Africa 13.78
- Europe & Eurasia 62.30
- Middle East 71.72

Source: BP Statistical Review of World Energy 2004.

Range of fuels for Wärtsilä engines

Liquid, oil-based fuels	Gaseous fuels	Biofuels (examples)
Liquid fuel oil (LFO)	Natural gas (NG)	Rapeseed oil
Heavy fuel oil (HFO)	Liquified natural gas (LNG)	Palm oil
Crude oil (CRO)	Compressed natural gas (CNG)	Coconut oil
High-viscosity base oils	Associated gas	Biodiesel (B100)
Orimulsion®	Coal bed gas (methane)	
Water-fuel emulsions		

Many fuels in a wide range of grades can be used in most Wärtsilä engines, but the suitability of certain fuels, such as the special gases and biofuels listed in the table, must be established separately for certain engine types.

Natural gas is today often the primary fuel option in power plants on land if it is available. However, many countries do not yet have a distribution network for natural gas and the use of liquid fuels is then the main option.

Wärtsilä's DF engines can run simultaneously on liquid light fuel oil and natural gas. If there is a need to run an engine on liquid fuel over an extended period, the DF engine can be easily modified to operate with cheaper heavy fuel oil.

If crude oil is available, it is often a practical option for the engine fuel, especially in isolated areas. Pumping stations for crude oil pipelines and oil processing units at crude oil fields are typical examples of places where it is used.

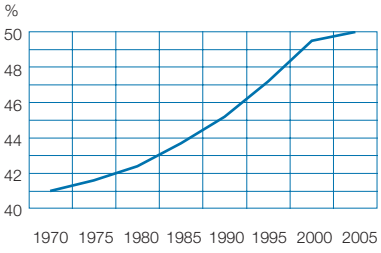
The continual fluctuations in heavy fuel oil prices have also created the need to develop new alternative oil-based fuels. These are fuels such as Orimulsion® and the high-viscosity bottom oils obtained from oil company refining processes.

The use of biofuels is another focus area for R&D. Over the past few years, fuels derived from different plants that have been processed in different ways, such as rapeseed oil, palm oil and coconut oil, as well as commercially available products such as Biodiesel (B100), have been successfully tested on Wärtsilä engines.

ENGINE EFFICIENCY

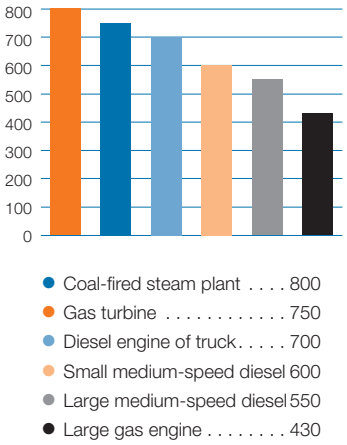
The efficiency of an engine is the ratio of the engine's power output to the energy in the fuel fed into the engine. Hence high engine efficiency is fundamental to low fuel consumption and to savings in costs and emissions. Sulphur and carbon dioxide emissions, for example, are directly proportional to fuel consumption and to the content of carbon and sulphur in the fuel. Large diesel and gas engines typically run at very high efficiencies and for this reason they also display the lowest specific SO_2 and CO_2 emission levels when comparing different engine types running on the same fuel quality.

Thermal efficiency development of Wärtsilä engines



The shaft efficiency of Wärtsilä diesel and gas engines is in the range of 42 – 50% depending on the engine type. Unlike gas turbines, reciprocating internal combustion engines achieve high efficiency over a broad load range; moreover, their high efficiency and power output remain virtually unchanged over a wide range of intake air temperatures. This feature, unique to reciprocating engines, is important with respect to both marine vessels and onshore power plants. In ships, the engine's load range varies between 30% and 85% for most of the time, while the intake air temperature varies considerably due to the time of year and geographical location of the vessel. Where onshore power plants with reciprocating engines

Typical specific CO_2 emissions of various processes in g/kWh



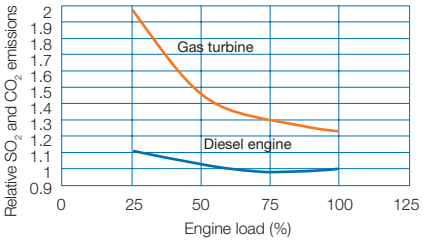
are concerned, the need to overrate the engine due to a higher intake air temperature is minimal. Again, compared to a large gas turbine, a multi-engine installation offers the advantage of being able to run at optimal efficiency simply by choosing the right number of engines for the required load.

The total efficiency of large power plants can be raised by converting part of the waste heat from the exhaust gases into electricity. This requires a steam boiler and steam turbine connected in what is called a "combined cycle", which can raise the plant's electrical efficiency to approximately 55%. Another method is to use some of the waste heat from the exhaust gases to produce heat in the form of steam or hot water using a waste gas boiler. This system, called "combined heat and power" (CHP), can raise the plant's total efficiency to 75 – 90%.

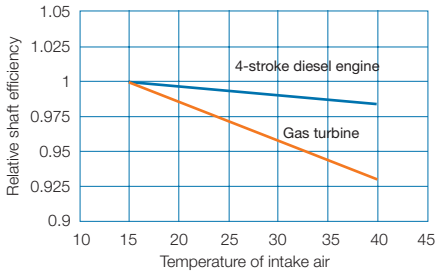
Over the past three decades, the efficiency of Wärtsilä's most energy-efficient engines has risen from roughly 41% to about 50%. This has been achieved through a variety of methods such as increasing the cylinder pressure, raising the compression ratio, reducing the fuel injection period, optimizing the valve timing, and improving the combustion process. The pace of improvement in efficiency has fallen off somewhat in recent years owing to the increasing restrictions placed on nitrogen oxide emissions. As to engine performance values, the most important priorities in Wärtsilä's R&D programme include raising efficiency and reducing emissions. The same trend will continue in the years ahead; to maintain its competitive edge, Wärtsilä will need to raise the efficiency of its engines further despite the ever more stringent nitrogen oxide limits.

Raising engine efficiency and lowering emission levels can significantly reduce environmental load because large diesel and gas engines have a long lifecycle, typically 25 – 50 years.

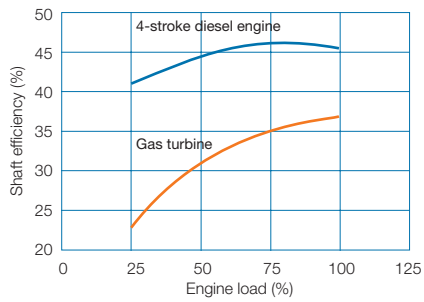
Typical relative SO_2 and CO_2 emissions: 4-stroke diesel engine and gas turbine with same power output



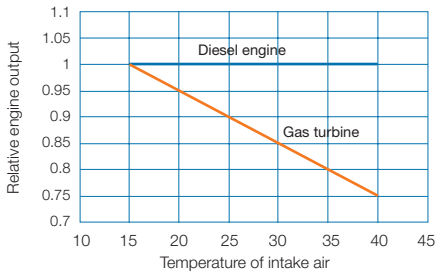
Impact of intake air temperature on shaft efficiency: 4-stroke diesel engine and gas turbine with same power output



Example of shaft efficiencies at 25 °C: 4-stroke diesel engine and gas turbine with same power output



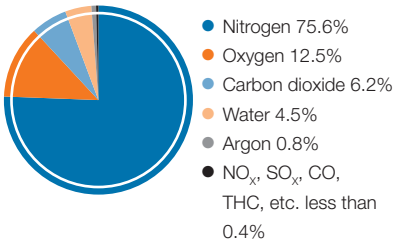
Impact of intake air temperature on power output: 4-stroke diesel engine and gas turbine with same power output



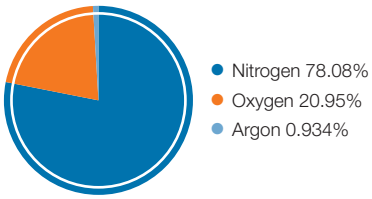
EMISSIONS INTO THE AIR

Typically, more than 99.5% of the exhaust gases of diesel and gas engines have the same components as the outside air. In addition to the above components, exhaust gases also contain the following hazardous substances:

Typical composition of the exhaust gas of a large diesel and gas engine



The composition of dry outside air



Typical composition of the exhaust gas of large diesel and gas engine

Component	Typical content range of component in exhaust gases[1]	Content of component in clean, dry outside air[1]
Nitrogen N_2	75 – 77% (v/v)	78.08% (v/v)
Oxygen O_2	10.5 – 15.5% (v/v)	20.95% (v/v)
Carbon dioxide CO_2	4 – 6.5% (v/v)	about 0.035% (v/v)
Water H_2O	4 – 11% (v/v)	
Argon Ar	0.8% (v/v)	0.934% (v/v)

Typical content range of component in exhaust gases without exhaust gas cleaning [2,3]

Component	Diesel engine	Gas engine
Nitrogen oxides NO_x	700 – 1.500 ppm (v/v)	60 – 130 ppm (v/v)
Sulphur oxides SO_x	30 – 1.000 ppm (v/v)	0 – 3 ppm (v/v)
Carbon oxides CO	20 – 150 ppm (v/v)	200 – 500 ppm (v/v)
Hydrocarbons THC	15 – 100 ppm (v/v)[4]	1.000 – 2.200 ppm (v/v)[4]
Particulate mater PM	20 – 100 mg/nm^3	

[1] % v/v: volume fraction
[2] ppm (v/v): parts per million by volume
[3] mg/nm^3: milligrams per nominal cubic metre (temperature=0 ºC and pressure: 101.3 kPa)
[4] Measured as methane equivalent

The following tables list the compositions of the exhaust gases emitted by large diesel and gas engines, their environmental impacts, formation mechanisms and the possibilities available for reducing the emission components.

About carbon dioxide and sulphur oxide emissions

General

- Alongside water, carbon dioxide (CO_2) is an end-product of the complete combustion of hydrocarbons
- CO_2 is a colourless, odourless and non-toxid gas
- CO_2 is exhaled by humans
- CO_2 is a naturally occurring component of the atmosphere
- Sulphur oxide (SO_2) and sulphur trioxide (SO_3) are grouped together under the general term sulphur oxides (SO_x)
- Sulphur oxides are corrosive toxic gases with a pungent smell.

Environmental impacts

- CO_2 is the most important “greenhouse gas”; its increasing presence in the atmosphere is believed to cause climate warming
- SO_x emissions increase acid rains and acidification
- SO_x have an unfavourable effect on vegetation and human health, and a corrosive effect on buildings
- Estimates disagree on the negative impact of SO_x emissions into the oceans because seawater is alkaline and the importance of the long-range transboundary atmospheric transport of SO_x is not fully understood.

Formation in engines

- The carbon and sulphur in the fuel oxidizes in the engine’s combustion chamber into CO_2 and SO_x. Hence, in practical terms the emissions levels of CO_2 and SO_x can be considered directly proportional to the carbon and sulphur content of the fuel
- Comparisons of different combustion processes show that the diesel engine has the lowest CO_2 and SO_x emission because the diesel process has the highest efficiency
- The typical ratio of SO_2 to SO_x is 0.95
- The typical ratio of SO_3 to SO_x is 0.05.

Emissions reduction methods in engines

- Raising the engine’s efficiency, i.e. reducing its fuel consumption
- Using low-sulphur fuels, e.g. changing from heavy fuel oil with a high-sulphur content to low-sulphur heavy or light fuel oil, or moving over entirely to the use of natural gas
- Changing to fuels with a lower carbon-to-hydrogen ratio. Changing from fuel oil to natural gas, for example, reduces CO_2 emissions. Correspondingly, adopting the use of biofuels essentially eliminates net CO_2 emissions altogether.

Feasible emissions reduction technologies

- No commercial technology exists for reducing CO_2 emissions
- Several alternatives are available for reducing SO_x emissions.

About nitrogen oxide emissions

General

- Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) are grouped together under the general term nitrogen oxides (NO_x)
- NO is a colourless gas
- NO_2 is a dark brown, toxic gas
- Nitrous oxide (N_2O) is a colourless gas heavier than air and one of the greenhouse gases.

Environmental impacts

- NO_x emissions generally increase acidification and eutrophication (overrich nutrients in water systems and soil)
- NO_x emissions promote the formation of ozone and smog in the lower atmosphere in heavily populated urban areas. Ozone in the lower atmosphere is harmful to vegetation and human health.

Formation in engines

- The N_2O emissions of reciprocating engines are typically low
- The NO_x emissions of a diesel engine are relatively high owing to the high combustion temperatures in the diesel process
- The NO_x emissions of a gas engine are relatively low because this engine's combustion process is based on premixing of the fuel and air.
- The formation of NO_x emissions in an engine is thermal; the primary source of nitrogen is the nitrogen in the combustion air
- The combustion termperature, the degree of fuel/air premixing and the duration of the fuel in the cylinder all strongly affect the formation of NO_x. NO_x formation is highest with a high combustion temperature, low degree of premixing and long fuel duration
- NO_x formation in an engine is an extremely complex process comprising hundreds of different chemical reactions and many intermediate products
- The typical NO/NO_x ratio in a diesel engine's exhaust gases is 0.95, and for NO_2/NO_x 0.05
- After being released as exhaust into the atmosphere NO oxidizes into NO_2 typically within a few hours.

Methods of reducing emissions in the engine

- Delayed fuel injection and ignition, which reduces the in-cylinder duration of the combustion gases at high temperatures
- In a diesel engine, lowering the fuel injection pressure; this reduces the formation of droplets and also the combustion efficiency and temperature
- Raising the degree of premixing, and in a gas engine increasing the amount of air
- Advancing the closing time of the inlet valve to lower the final combustion temperature ("Miller valve timing")
- Reducing the temperature and pressure of the combustion air fed into the cylinders
- Optimizing the geometry of the combustion space and the compression ratio
- In a diesel engine, optimizing the fuel injection method
- Introducing water to the combustion space to reduce the temperature, e.g. using a water-fuel emulsion or saturating the intake air (Combustion Air Saturation System, (CASS); Direct Water Injection (DWI); Water-in-Fuel Emulsion (WFE))
- Many measures aimed at reducing NO_x emissions also increase fuel consumption and the formation of particulates. Optimization of an engine's emission levels therefore requires that all these factors are taken into account.

Feasible emissions reduction technology

- A Selective Catalytic Reduction (SCR) catalytic converter.

About emissions of particulates and smoke

Environmental impacts

- Apart from the visual nuisance caused by smoke, particles are regarded as being harmful to human health
- Particles below 0.2 µm in diameter are considered to reach the lungs. Some of the particles arising from the combustion process belong to this category
- Larger particles are considered to be less of a health hazard as they are efficiently captured in the airway before reaching the lungs
- Since small particles are easily air-borne, their detrimental effects on health are often visible far from their source.

Formation in engines

- Particles form in the combustion space as a result of locally low quantities of excess air. Some of the particles do not have time to burn completely but pass out into the atmosphere in the exhaust gases. The amount of particles in the exhaust depends on the amount of hydrocarbons in the fuel and lubricating oil and on the amount of sulphur and ash in the fuel
- When using heavy fuel oil, typically more than 50% of particles in the exhaust come from the ash and sulphur components in the fuel
- When using light fuel oil, most of the particles consist of carbon or hydrocarbons and only a very small proportion comes from the ash and sulphur components in the fuel
- Particles smaller than about 0.4 µm are considered to be invisible. A proportion of the particles produced by an engine fall below this size
- Gas engines have very low levels of particle emissions.

Reduction methods in engines

- In diesel engines, raising the fuel injection pressure as this improves droplet formation and combustion efficiency
- Raising the temperature of the intake air
- Optimizing the geometry of the combustion space, the compression ratio, and the fuel injection method
- Many measures taken to reduce particle emissions also tend to increase NO_x emissions.

Feasible emissions reduction technology

- Of the commercial technologies available today, only the electrostatic precipitator is suitable for diesel engine power plants but its investment costs are high. Sometimes, in conjunction with desulphurization equipment, bag filters are used to reduce particle emissions.

About carbon monoxide emissions

General
- Carbon monoxide (CO) is a colourless, odourless and toxic gas.

Environmental impacts
- In large quantities CO is toxic and reduces the ability of the lungs to absorb oxygen
- In the atmosphere CO oxidizes to CO_2 within a few hours.

Formation in engines
- CO is a result of incomplete combustion
- The formation of CO in the combustion space is local; it is the result of absent combustion air and low temperatures
- In diesel engines, CO emissions are low compared with other emission sources due to effective combustion and high excess air quantities
- In gas engines, CO emissions are relatively high due to premixing and relatively low combustion temperatures.

Reduction methods in engines
- Optimizing the geometry of the combustion space, the compression ratio, and the fuel injection method.

Feasible emissions cleaning technology
- Oxidation catalyst.

About hydrocarbons

General
- Hydrocarbons are a group comprising hundreds of organic compounds, to which carbon, hydrogen, nitrogen, oxygen and sulphur may be bound
- Given the complex nature of hydrocarbon emissions, it is difficult to define the risks they pose to human health
- Hydrocarbon emissions are generally divided into two categories: total hydrocarbons (THC) and non-methane hydrocarbons (NMHC)
- Another term used is volatile organic compounds (VOC), which is generally understood to mean all hydrocarbons from which either methane or both the methane and ethane have been removed.

Environmental impacts
- THC are instrumental in the formation of ozone and smog in the lower atmosphere in densely populated urban environments
- The other hydrocarbons are considered to be carcinogenic
- Of the hydrocarbons that fall within the category of greenhouse gases, methane in particular is strongly instrumental in climate warming.

Formation in engines
- THC and VOC emissions form in the combustion chamber as a result of the local absence of combustion air, as well as low combustion temperatures and the evaporation of lubricating oil from the combustion chamber towards the end of firing period
- In diesel engines, THC and NMHC emission levels are low compared to other emission sources due to the efficient combustion process and high excess air quantities
- Hydrocarbon emissions when burning heavy fuel oil are generally at a low level compared to the use of light fuel oil as evaporation is lower
- In gas engines, THC emissions are relatively high due to premixing and the relatively low combustion temperatures in these engines.

Feasible emissions reduction technology
- Diesel engine: no commercial technology is available when using heavy or light fuel oils
- Gas engine:
  - o Oxidation catalyst for NMHC and VOC emissions
  - o No commercial technology currently available for THC.

NOISE AND ITS SUPPRESSION

Noise from engines consists of air-borne noise, structure-borne noise and exhaust noise. Compliance with the IMO regulations is a basic criterion in engine design. Wärtsilä has ongoing programmes aimed at reducing the noise level of engines. Structure-borne noise is transmitted through the hull structure and radiated throughout the ship. Structure-borne noise can typically be reduced by 90%, but in special applications a reduction of more than 99% can be achieved. Exhaust noise disturbs communication on smaller ships and is a nuisance factor both onboard and in harbours. The installation of exhaust gas silencers can reduce exhaust noise levels.

Noise control is also an essential element in the design of Wärtsilä's power plants. Wärtsilä's standard power plant products are designed to meet set minimum criteria. Very often the solution selected is suitable without modification for projects where the power plant is situated in an industrial area, or an area in an environment that does not contain sites detrimentally affected by noise.

The requirements set for noise vary according to the location of the plant. The noise criteria for a power plant situated in or near a residential area, for instance, are much stricter than the normal requirements for a power plant in an industrial area. In such a case the starting point is often a standard solution, to which different technologies and noise mitigation methods are then applied to achieve an acceptably low overall noise level.

It makes little sense to design power plants for industrial areas to the noise suppression standards required in residential areas because the background noise level is already relatively high. This avoids the need to build unnecessarily costly power plants.

Power plants are designed primarily to meet local legislation and regulations on environmental noise, but in many cases also to comply with international criteria on environmental noise such as the World Bank's guidelines. Wärtsilä's responsibility for environmental noise depends on the scope of the delivery, reaching its maximum in "turnkey" projects. Wärtsilä guarantees the noise level of a power plant at a specified distance from the site.

Power plant noise impacts can be estimated during the environmental impact assessment, which evaluates the background noise of the area surrounding the power plant and addresses the potential disturbance to facilities in the proximity such as residences, schools and hospitals. After this the noise levels of the power plant are simulated, using Wärtsilä's input values, to produce a sound chart that covers the boundaries of the property and the facilities located in its surroundings. The purpose of modelling noise levels at the power plant and in the surrounding area is to optimize the methods used to reduce the impact of noise. If the standard solution proves to be inadequate, the design of the power plant is modified to meet the case-specific demands, and the noise levels are simulated again.

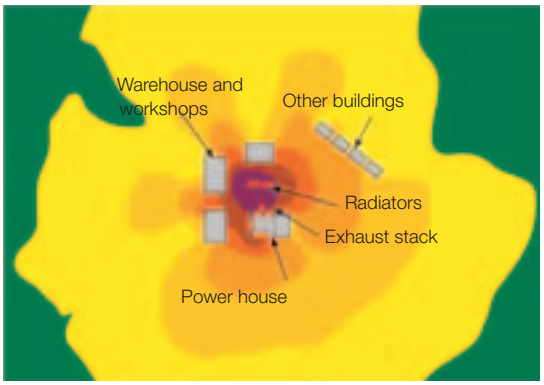
The following aspects are addressed in noise engineering for power plant applications:

- Power plant building design: wall structure and thickness, ventilation
- Dampening of the charge air intake and exhaust outlet
- Engine cooling system: type and location of the radiator
- Relocating the layout of noise-producing components.

WASTE

A continuous target of product design has been the optimal use of materials. This is reflected in the development of power-to-weight ratio and increased time between overhauls as well as the improved lifetime of the components.

Example of the typical noise level of an engine driven power plant as simulated with special noise modelling software



- < 50.00 dB(A)
- 50.00 – 55.00 dB(A)
- 55.00 – 60.00 dB(A)
- 60.00 – 65.00 dB(A)
- 65.00 – 70.00 dB(A)
- 70.00 – 75.00 dB(A)
- > 75.00 dB(A)

The cost of fuels can be a major component in the operating costs of a ship, which highlights the importance of reducing fuel consumption when considering costs and emissions levels. One way of reducing fuel consumption and thus the amount of waste created is to raise the engine's combustion pressure. Development of the piston–ring–liner combination has achieved low lubricating oil consumption and long change intervals, supplemented by systematic co-operation with oil companies to extend the useful life of the lubricating oil. Minimal waste during operation has been Wärtsilä's aim when designing the lubricating and fuel treatment system. To do this, Wärtsilä has moved away from using disposable insert filters to self-cleaning automatic filters.

Waste is generated during the construction of a power plant, mostly soil and rock derived from earthworks, wastes created while building the foundations, or packing materials. Since the components, including the wall and roof structures, for Wärtsilä's turnkey power plants are delivered in the specified sizes as ready-to-install elements, power plant construction does not create significant amounts of other wastes. The waste that is generated is sent to a local waste disposal site for disposal or utilized according to local conditions.

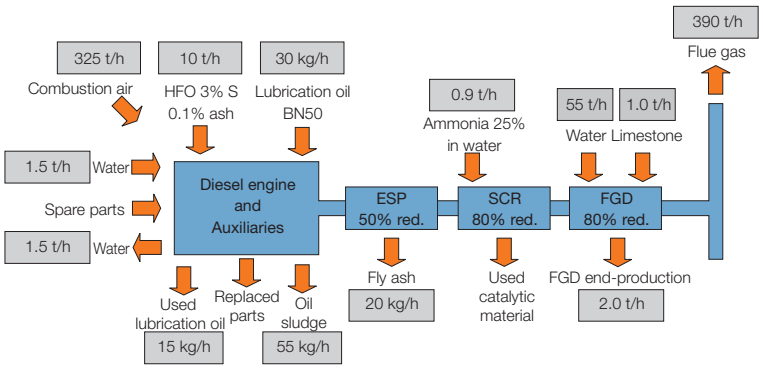
Most of the environmental impact of a Wärtsilä power plant during its lifecycle comes from the operation of the plant. Operation of an engine-driven power plant normally generates only small amounts of waste. Most of the materials classified as waste are replaced spare parts, used lubrication oil and oily sludge from the fuel. Other wastes include small quantities of replaced filters and wear parts as well as normal office wastes.

Replaced metal parts are normally reprocessed to produce metal products locally. Procedures for oily wastes, including used lubrication oil and oily sludge, vary considerably. One option is to incinerate them, whether at the site or at an external facility. Another is to send them to the oil supplier for producing new oil products, or to local industry for energy production according to legislation and local regulations.

Exchangeable filters, oily rags and similar waste containing oil or solvents are either incinerated along with other oily waste or delivered to an external facility for appropriate treatment or final disposal. Flue gas cleaning creates its own challenges for waste management at power plants. The catalyst material of an SCR and the oxidation catalyst must be changed at intervals. These elements can contain hazardous and even dangerous compounds that are damaging to health and the environment. On the other hand, they also contain precious metals that can be re-used if suitably processed. They are normally sent back to the supplier of the unit for reprocessing to produce new catalytic material.

The re-usability and final disposability of the end-product created when reducing particulate and sulphur emissions must be evaluated as precisely as possible during the environmental impact assessment of a power plant. Wärtsilä has conducted studies of the typical composition of these end-products, applied a range of accepted methods and performed standard-compliant tests in order to help its customers evaluate such issues. These tests can determine the basis for classification of wastes into hazardous or normal wastes. The figure below illustrates the reduction achieved in sulphur and particulate emissions in the end-products when operating a 50 MW power plant using a certain fuel.

Material balance of diesel engine power plant



Typical material balance when operating a 50 MW diesel power plant equipped with radiator cooling, consumption boilers and flue gas control system.

Ship Power Solutions

Wärtsilä's engine room and propulsion solutions for marine applications are reliable, economical and environmentally sound. Wärtsilä tailors its solutions to the precise needs of its customers by optimizing the entire ship machinery, propulsion and control system. This approach is encapsulated in Wärtsilä's concept The Ship Power Supplier. Wärtsilä also provides lifetime support to ensure the high availability and reliability of the vessel throughout its service life. Wärtsilä's service portfolio includes training, spare parts, technical support, and continuous technology upgrades and improvements. Wärtsilä also maintains a global network of service professionals competent and equipped to carry out maintenance and repair tasks in a timely manner.

Wärtslä's Ship Power products and services cover a broad range of marine vessels from containerships, bulk carriers and tankers to RoRo ferries, cruise liners, car ferries and LNG carriers as well as vessels for special markets such as naval vessels, dredgers, coastal fishery vessels, harbour tugs and offshore installations.

The comprehensive product range comprises main and auxiliary engines with outputs from 60 kW to 80,080 kW, as well as generating sets, reduction gears, propulsors, steerable thrusters, rudders, control systems, seals and bearings. Together, these allow Wärtsilä to optimize the ship's entire propulsion system for excellent environmental performance.

Ship Power fact

The DF engine is a 4-stroke combustion engine able to run on both natural gas and light fuel oil, as well as on heavy fuel oil with minor modifications. The engine can also be switched instantaneously between gas and light fuel oil, and vice versa, during operation.

The DF engine family covers power outputs in the range 1400–17100 kW and the thermal efficiency of these engines is max. 47 %, which is higher than for any other gas engine.

More information on Ship Power products in the Annual Report, Business Review, page 16.

Wärtsilä's ship machinery products are marketed under the brand names WÄRTSILÄ®, SULZER®, LIPS®, Auxpac™, Propac™, Deep Sea Seals and JMT.

Optimizing total ship efficiency

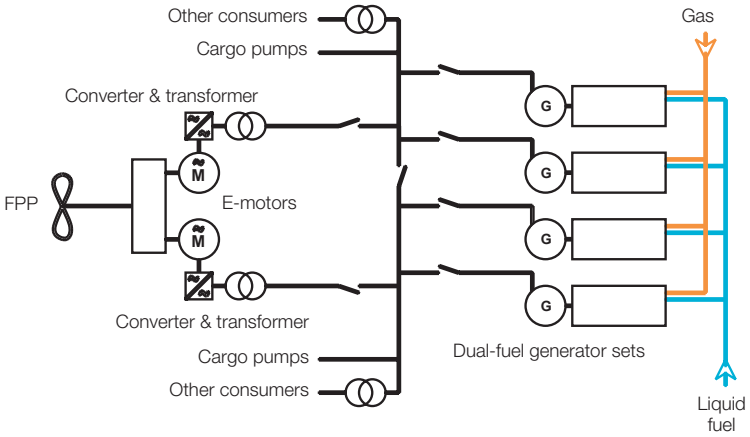
Wärtsilä has gained promising experience working with its partners in the design of various vessel types. Examples include the world's newest liquified natural gas (LNG) vessels equipped with Wärtsilä DF dual-fuel engines and the environmentally advanced Enviropax RoPax vessel. In both cases the main emphasis was given to enhancing their propulsion efficiency through the use of speed-adapted propellers, HR nozzles and a new hub for controllable pitch propellers coupled with advanced propulsion control.

CASE – OPTIMIZATION OF LNG GAS CARRIER

Background to research

LNG carriers are traditionally equipped with machinery based on steam turbines although diesel en-

Safe, reliable and redundant



gines, with their higher efficiency, have long been the preferred choice of prime mover for other types of vessel. The main reason for this has been the opportunity to utilize the boil-off gas that evaporates from the LNG vessel's gas cargo by burning it in a steam boiler. LNG vessels are typically equipped with 23 MW steam turbines, and the size and operating speed of these vessels has largely been determined by the limited efficiency of this technology.

The recent development of a diesel engine able to run on low-pressure gas and connected to an electrical propulsion machinery is encouraging the industry to completely re-evaluate the size and operating parameters of LNG vessels. The result is the opportunity today to design and build vessels with decisively better size and sailing characteristics.

New machinery concept

Since the gas engine (DF) operates at higher efficiency than the steam turbine, fuel consumption is also lower, which means that smaller fuel tanks can be used. Similarly, using several DF engines rather than one steam turbine leads to more flexible engine load as the engines can be run at their optimum efficiency.

It is also considerably easier to locate gas engines in the ship's engine room compared with a steam turbine power plant due to their smaller size and weight. This, in turn, reduces the overall volume of the engine room, freeing space for a larger payload.

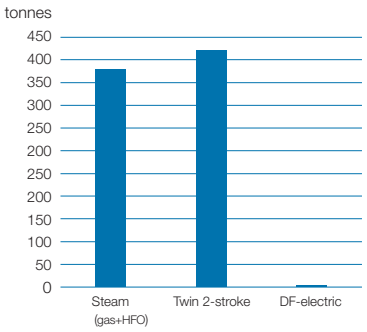
Since the DF engines run on gas (and 1% marine diesel oil) and have a higher thermal efficiency, their exhaust emissions are also lower than for a steam turbine.

Comparision of SO_x, CO_2 and NO_x emissions of DF engines, steam turbines and 2-stroke engines.

[1] The results are based on calculations, model tests and simulations. The results have been used in the engine deliveries.

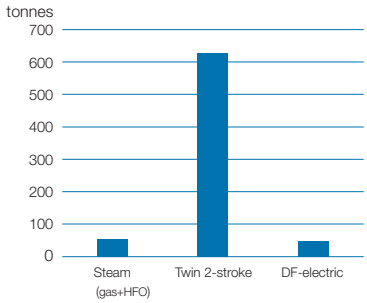
Total SO_x emissions of round trip[1]

(excluding harbour operations)



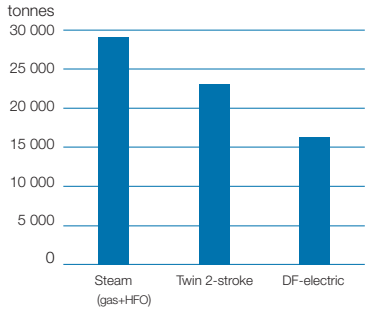
Total NO_x emissions of round trip[1]

(excluding harbour operations)



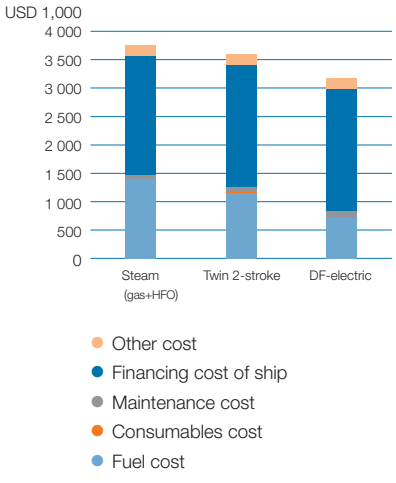
Total CO_2 emissions of round trip[1]

(excluding harbour operations)



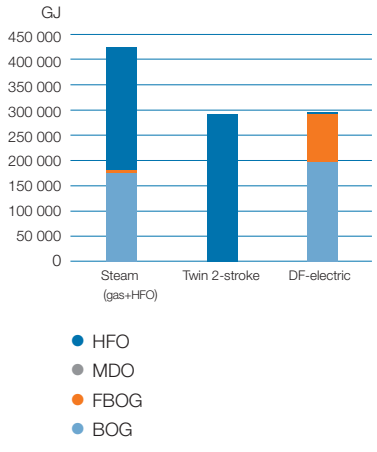
Total operating cost of round trip[1]

(excluding harbour operations)



Total energy consumption of round trip[1]

(excluding harbour operations)



Designing a new vessel

Since the LNG carrier's design need no longer be determined by the standard size of the steam turbine plant, the vessel's designers have greater flexibility. Calculations show that the economics of this vessel type can be optimized by a new design based on lower total resistance coupled with greater length and faster engines, leading to substantial increases in cargo capacity and operating speed. The bottom line is lower cost and emissions per transported ton.

CASE ENVIROPAX – ENVIRONMENTALLY ADVANCED ROPAX VESSEL

Project goals and methods

Enviropax is a joint project involving Wärtsilä, ABB and Kvaerner Masa-Yards (Aker Finnyards). Its purpose was to design a new RoPax vessel concept with better overall economy and environmental performance. The shape of the vessel's hull, its machinery and propulsion system are optimized to reach these goals. All three companies collaborated on the design and the vessel's design values have been verified using independent model tests. Resistance, propulsion and cavitation tests were performed by two research institutions (VTT[1] and Marin[2]).

[1] The Technical Research Centre of Finland

[2] The Maritime Research Institute (The Netherlands)

Project execution

Wärtsilä's task was to design and develop the machinery and propellers for the vessel. The result is a new combined diesel-electric and diesel-mechanical machinery concept called CODED which employs the best characteristics of both propulsion systems. Compared with conventional diesel-mechanical machinery, the new combined concept offers lower power demand, optimum engine load and greater flexibility in the use of the installed power. Despite these advantages the costs of this concept are lower than for a diesel-electric machinery.

To make the machinery as environmentally sound as possible, Wärtsilä designed the Enviropax to be used with the Wärtsilä Enviro-Engine™. This features common-rail technology for minimum fuel consumption and Compact SCR units to ensure minimum smoke and NO_x emissions.

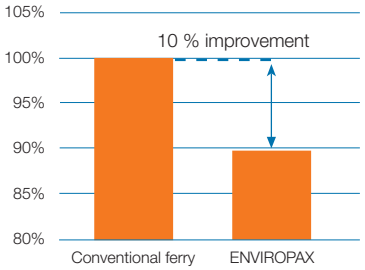
The new propulsion system features one contra-rotating propeller (CRP)pair. The forward propeller is a conventional mechanically driven Lips controllable pitch propeller (CPP) powered by two diesel engines via a reduction gear. The other, mounted directly aft of the CPP, is an electric pod (Azipod) with a smaller fixed pitch propeller that rotates in the opposite direction, thus utilizing part of the rotative energy left in the slipstream of the forward propeller. Research also investigated the power distribution of the propeller pair and identified the factors affecting the dimensioning of the propellers.

Benefits and results

Compared to a conventional twin-screw vessel, the new design achieves a reduction in fuel consumption of 6–10%, depending on the power distribution of the contra-rotating propellers. The investment costs of the Enviropax are 0.8–1.3% higher but annual savings as high as €1.0 million can be achieved in machinery related operating costs alone compared to the conventional design. Moreover, the combined machinery allows more flexible use of the engine room, providing scope for increasing the cargo space.

Enviropax vessel with podded CRP propulsion and CODED machinery.

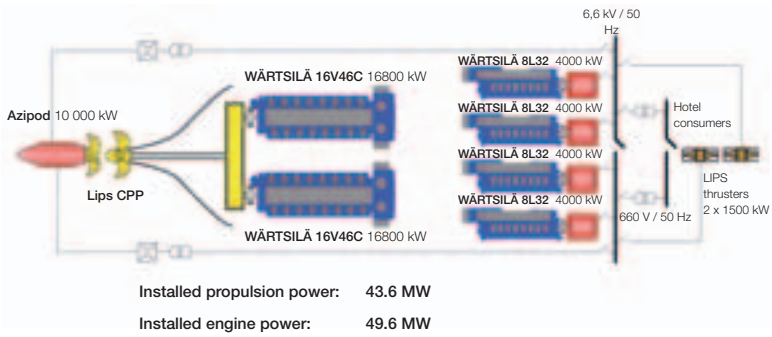
The CODED machinery with podded CRP gives clear improvements in fuel consumption compared to conventional solutions



Enviropax prospects

The first RoPax vessels designed to the joint project's new specifications have now entered commercial operation in Japan. Wärtsilä has supplied the ship machinery for these vessels.

CODED machinery with podded CRP propulsion



Total propulsion system efficiency

The propulsive efficiency of a propeller is affected both by the open-water efficiency of the propeller and, on the other hand, by the interaction between the hull and the propeller. Overall propulsion efficiency, therefore, can be improved by improving the efficiency of the propeller, the hull, or both.

The total efficiency of a propeller is a maximum value that represents an ideal level of efficiency based on a theoretical analysis. In practice a propeller's open-water efficiency is always lower than its ideal figure owing to friction and to axial and rotational losses. A large propeller leads to better ideal efficiency and for this reason increasing the propeller diameter will improve the propeller's open-water efficiency.

The propulsive efficiency of a moderately loaded propulsor (a propeller or similar device such as a waterjet or steerable thruster) is typically 62%. Losses in operation (38%) fall into three categories:

- Axial kinetic energy losses 20%
- Rotational kinetic energy losses 8%
- Frictional losses 10%.

To reduce axial losses, a larger-diameter propulsor should be used. A large diameter is used especially in the case of a speed-adapted propeller or "slow-runner". Propellers with the largest diameters have been successfully retrofitted to vessels which are then operated at reduced power and propeller speed than originally. Although the hull efficiency of the vessel is now slightly reduced, the improvement in open-water efficiency raises the vessel's total propulsive efficiency.

Wärtsilä has supplied more than 30 speed-adapted propellers which have raised vessel propulsive efficiency by 5–14%.

The Efficiency Rudder

Wärtsilä offers the Efficiency Rudder to improve a vessel's propulsive efficiency and steering characteristics. The unique feature of its design is a fixed "torpedo" placed in the rudder horn immediately behind the propeller. The torpedo can be removed to allow easy removal and servicing of the propeller shaft. An additional flap can be installed on the trailing edge of the rudder blade to improve manoeuvrability.

The Efficiency Rudder offers at least three significant benefits:

- The propulsive efficiency of the vessel is higher than when using a conventional rudder.
- Full-scale trials have confirmed engine power savings of 5 – 8% for single-screw vessels and 2 – 5% for a twin-screw vessels.
- The pressure pulses on the hull, which generate vibration and noise, are lower than in the case of a conventional propeller-rudder combination. Full-scale tests indicate a reduction of 20 – 40% in pressure pulses.

The HR nozzle

Nozzles are aerofoil-shaped rings placed around the propeller to increase the thrust on the propeller and therefore its efficiency. The HR high-efficiency nozzle differs from conventional nozzles with its S-shaped outer surface and a specially rounded leading edge. Several hundred of these have been installed in vessels of all descriptions since the launch of the small-diameter nozzle-propeller combination. Full-scale tests on several vessels confirm that the HR nozzle gives a 7–10% greater bollard pull, which translates into an improvement of up to 13% in open-water conditions, compared to a conventional nozzle.

Given these good results, Wärtsilä recommends the use of the high-efficiency nozzle for a number of applications. These include harbour tugs, offshore vessels, dredgers and semi-submersibles among many others.

Controllable pitch propellers

Wärtsilä has reviewed its portfolio of controllable pitch propellers (CPPs) based on recent market requirements, particularly the facts that ships today are required to have more power, operate at higher speeds and demonstrate better fuel efficiency with lower noise levels.

The use of CPPs has grown steadily since introduction of this design some 40 years ago. Today this propeller type is in wide use, especially in vessels which benefit from high-output 4-stroke engines.

CPPs offer many operational benefits for several ship types. Ship operators normally choose a CPP for one of the following reasons:

- The use of shaft generators for higher operational efficiency
- Good manoeuvring characteristics
- The wide range of thrusts required
- Their fast response to different thrust requirements
- Lower operational costs
- Optimal engine load characteristics.

The E-hub

The E-hub has been specially developed for applications requiring high strength such as RoPax vessels and ice-strengthened propellers. The hub contour is flush (cylinder-shaped) and so particularly suitable for high-ship speeds.

The first E-hubs are expected to enter operation at the beginning of 2005. The concept utilizes the strong points of the earlier hub designs. The blade bearing, the blade seal and the solutions used are based on proven design technology. Optimized construction and the minimum number of parts gives reliability and reduced cost. The hub can also be used with environmentally sound water-soluble lubricants, although this requires a lower bearing pressure.

The contour of the E-hub significantly improves the cavitation properties in the following ways:

- The blade bolts have been tilted so that the blade root can be easily faired on the blade foot

E-hub construction.

- No flow disturbances are caused by the blade bolt holes
- The blade bolts themselves are level with the surface of the blade foot.

A special feature of the E-hub concept is the blade foot sealing. This seal was developed for the CPS hub for the heaviest wear conditions (sandy waters) and has shown excellent operating performance. The basic feature of this seal is double sealing capacity at the blade foot for the same number of parts. This gives longer life while minimizing leakages.

The new design makes the outer dimensions of the new E-hub smaller than for previous types, leading to better hydrodynamic performance: 1% in the case of fast RoPax vessels (heavily loaded conditions).

Remote control system

The use of a remote control system can considerably reduce a vessel's operational costs. The system must of course be reliable, safe and available at all times. Operational costs can be reduced by other factors including:

- Less fuel consumption by optimum scheduling of pitch and shaft speed. The LIPSTRONIC 7000 system easily allows for optimum schedules, one for manoeuvring and one for open-water conditions, to ensure environmentally sound operation in different conditions.
- Avoiding over-fast loading and unloading of the engine when increasing or decreasing the engine speed. Optimized operation reduces maintenance costs and extends the lifetime of the equipment.

These features can yield significant savings in fuel costs as well as less service and repair due to reduced thermal stress and emissions.

Protecting the marine environment

Any oil loss to the environment from the ship's sealing system is unacceptable. Wärtsilä's CoastGuard EnviroSeal pollution-free sterntube sealing system offers an environmentally sound alternative and is available in different designs for retrofitting to existing vessels or for use in new tonnage. The CoastGuard sternseal system is a non-polluting option designed in particular for cruise vessels, bulk carriers and RoRo vessels. Similarly the Airguard 3AS antipollution sterntube seal provides an environmentally sound option by preventing the spilling of lube oil from the seal.

These sealing systems prevent both the leakage of bearing oil into the seaway and the ingress of water into the bearing system. They ensure continuous operation between planned maintenance periods, with no unplanned dry-dockings for emergency repairs.

Reducing emissions

Smokeless engines: Common-rail injection

Most harbours in the world are located close to densely populated areas and for this reason the demand for no visible smoke under any circumstances has become increasingly important in recent years. State-of-the-art common-rail injection technology now makes it possible to provide smokeless engines. Wärtsilä has the widest range of products available with common-rail technology for heavy fuel operation.

Efficiencies

Steam turbine		2-stroke		Dual-fuel electric	
Fuel / Boil-off gas	100%	Fuel / Boil-off gas	100%	Fuel / Boil-off gas	100%
Boiler	89%	2-stroke	49%	DF engines	46%
Steam turbine	34%	Shafting	98%	Alternators	96%
Gearbox	98%			Transformers & converter	98%
Shafting	98%			Electric motor	98%
				Gearbox	98%
				Shafting	98%
Propulsion machinery efficiency	29%	**Propulsion machinery efficiency**	48%	**Propulsion machinery efficiency**	41%
Fuel / Boil-off gas	100%	Fuel	100%	Fuel / Boil-off gas	100%
Boiler	89%	Auxiliary engines	43%	DF engines	46%
Steam turbine	30%	Alternator	96%	Alternators	96%
Gearbox	98%				
Alternator	96%				
Electric power generation efficiency	25%	**Electric power generation efficiency**	41%	**Electric power generation efficiency**	44%

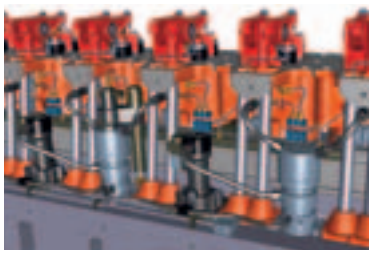
Common-rail injection: 4-stroke engines

By keeping the fuel's injection pressure high and stable throughout the load range, common-rail technology ensures that the engine operates without visible smoke throughout its operating range. Optimal engine operation has been achieved at all speeds and loads. The common-rail system is designed for new engines but it can also be retrofitted to existing installations.

Benefits of the Sulzer RT flex engines

The Sulzer RT-flex engines offer distinct benefits to shipowners and ship operators such as smokeless operation at all vessel speeds and reduced running costs owing to longer service intervals and lower part-load fuel consumption. Precise control of the injection, high injection pressures at low engine speeds and the sequential shut-off of the injectors combine to give steady running at very low running speeds without smoking, down to 10–12% of nominal speed. Particular attention has been given to making the RT-Flex system reliable.

Common-rail injection: 4 stroke engines



Reducing NO_x emissions

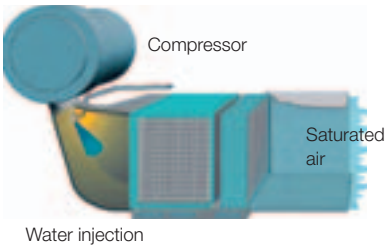
Air humidification technologies

The use of water is an effective way of reducing temperature peaks during the combustion process and thus limiting the formation of NO_x emissions.

CASS

The newest technology developed by Wärtsilä for reducing NO_x emissions is called CASS –Combustion Air Saturation System. CASS technology is based on the principle of introducing pressurized water into the combustion process to dampen NO_x formation. The pressurized water is added to the intake air after the turbocharger compressor. Due to the high temperature of the compressed air the water evaporates instantly and enters the cylinders as steam, reducing the combustion temperature and thus NO_x formation by as much as 50% when the water consumption is approximately two times the fuel oil consumption.

Working principle of CASS



DWI

Direct Water Injection (DWI) reduces NO_X emissions by 50 – 60% without adversely affecting power output. The solution is a DWI valve, through which the water and fuel is injected typically in a water-to-fuel ratio of 0.4 – 0.7.

Existing engines can also be modified with NO_x reduction technologies such as DWI and CASS.

SCR

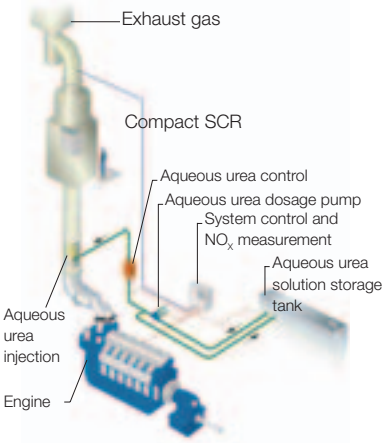
SCR is currently the only method capable of reducing NO_X emissions by 85 – 95%. A reducing agent, such as an aqueous solution of urea, is injected into the exhaust gas at a temperature of 290 – 350 °C. The urea in the exhaust gas decays into ammonia, which is then put through a catalysing process that converts the NO_X into harmless nitrogen and water.

A typical SCR plant consists of a reactor which contains several catalyst layers, a dosing and storage system for the reagent, and a control system. The SCR reactor can also be designed as part of the exhaust silencer – a solution called Compact SCR.

The lifetime of the catalyst elements is typically 3 – 5 years for liquid fuels and slightly longer if the engine is operating on gas. The main running costs of the catalyst come from urea consumption and replacement of the catalyst layers. The urea consumption is about 15 – 25 g/kWh of 40% m/m urea.

SCR technology can be fitted on all Wärtsilä engines, both those already in operation and new 2- and 4-stroke engines. Many ferries sailing in the Baltic Sea are equipped with SCR technology.

Compact SCR



Tallink Victoria has a Compact SCR system.

COMPLIANCE WITH REGULATIONS

The minimum environmental requirement set by Wärtsilä for its Wärtsilä and Sulzer brand marine engines is compliance with the regulations of the IMO (International Maritime Organization). Wärtsilä has developed, and continues to develop, NO_X reduction technologies that will make it possible to comply with the strictest national or regional legislation in the future. Activity in this area is increasing around the world.

IMO MARPOL Annex VI

Following a ratification processing lasting several years a sufficient number of states have now signed the IMO MARPOL 73/78 Annex VI which will come into effect on 19 May 2005. This requires that every engine with a power output above 130 kW installed in a vessel built (keel laid) after 1 January 2000 must comply with the NO_X emissions limits stipulated in MARPOL 73/78 Annex VI.

Annex VI contains a global cap of 4.5% m/m on the sulphur content of fuel oil and calls on the IMO to monitor the worldwide average sulphur content of fuel. Annex VI also contains provisions allowing for special "SO_X Emission Control Areas" to be established with more stringent controls on sulphur emissions. In these areas, the sulphur content of the fuel oil used on board ships must not exceed 1.5% m/m. Alternatively, ships must fit an exhaust gas cleaning system or use any other technological method to limit SO_X emissions. The Baltic Sea Area is designated as a SO_X Emission Control area in the Protocol.

Annex VI prohibits deliberate emissions of ozone depleting substances, which include halons and chlorofluorocarbons (CFCs). The Annex also prohibits the incineration onboard ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

The EU

The EU Commission has submitted a proposal for a directive to reduce the sulphur content of marine fuels in the EU area. The main provisions of this directive are:

- A 1.5% sulphur limit on fuels in all vessels sailing the Baltic Sea, the North Sea and the English Channel
- The same 1.5% sulphur limit on fuels used by passenger vessels on regular services between EU ports
- A 0.2% sulphur limit on fuels used by inland vessels and seagoing ships at berth at EU ports, with some exceptions.

The proposal will still be put before the European Parliament before the Council can give its final approval.

All Wärtsilä and Sulzer engines are already designed and optimized to run on fuels with any sulphur content.

Local regulations

Alaska enforces regulations governing the permitted smoke levels from ships. Wärtsilä has demonstrated its compliance with these regulations in a number of projects.

Economic control mechanisms have been widely adopted in certain countries. A system of environmentally differentiated fairway dues was introduced in Sweden in 1998, while in Norway an environmental tax based on tonnage was introduced in 2001. Reductions in port dues based on environmental performance are offered by many ports in Sweden as well as in Maarianhamina (capital of the Åland Islands between Sweden and Finland) and the port of Hamburg in Germany.

INSTALLING EMISSIONS REDUCTION TECHNOLOGY

Most of the marine applications supplied by Wärtsilä with emissions reduction systems can be found in the Baltic Sea but some also operate in Caribbean and Alaskan waters. The following table summarizes the exhaust emissions reduction technologies either already in use or on order from Wärtsilä (January 2005):

	Engines	Output (MW)
CR	43	363
DWI	53	515
RT-flex	132	5,830
SCR	68	376
CASS	3	12

SHIP POWER SERVICE

Prime movers, propulsion systems and auxiliary equipment including emissions reduction technology give their best performance with high reliability, availability and low emission levels when maintained as planned and operated correctly. For this reason Wärtsilä offers its customers a full range of complementary lifetime support services.

The history of each product including assembly and adjustments is recorded and updated to ensure that the appropriate service and repair action can be taken and the right spare parts supplied. Wärtsilä supplies the spare parts for its core products and auxiliary systems through its worldwide network of service companies either from its product factories or from HUB stocks; the latter hold the most important components closer to the customer.

Recycling – reconditioning and product upgrades

Wärtsilä workshops recondition used parts that are still in working condition. Customers can also trade in these parts for reconditioned exchange parts. Complete engines can be reconditioned as well and thus restored to their design parameters. The newest technologies can be retrofitted to existing engines. The purpose of engine upgrades is to improve the economic and environmental performance and safety of older engines in service.

Training

Wärtsilä Land & Sea Academy provides general and product-specific training to customers covering all operation, maintenance and safety issues. The Academy also offers accredited training courses for IMO/STCW-95 certificates, and it has the capability and capacity to deliver both ship handling and engine room training courses.

WLSA training centres are located at the product factories and also in major shipbuilding and ship operating areas.

Technical service

Wärtsilä provides 24-hour technical support for its customers whenever the need occurs, from advice and troubleshooting, to repairs and ordering and supplying spares. Wärtsilä's specialists also perform various verification and tuning measurements for the purposes of the IMO regulations or port regulation limits, etc.

Technical feedback from customers is collected, evaluated and utilized in product development as well as for maintenance recommendations and other support. Results obtained from using such feedback include extended intervals between overhauls, reduced oil consumption, and improved monitoring of engine parameters.

Technology advances are applied as much as possible to products already delivered and even products removed from the range. In other words, Wärtsilä makes available numerous product modifications, upgradings, tools and agents, and supporting software products. These include:

- On-screen guidance and management applications for finding spares or for performing maintenance tasks, etc.
- Diagnostic applications for preventive maintenance
- Remote monitoring and diagnostic support, enabling specialists to perform analyses and give advanced support whenever needed
- A combination of manual inspections and online monitoring of equipment and system efficiency data makes it possible to predict maintenance needs for condition-based maintenance (CBM). Combining traditional methods with preventive maintenance, CBM allows operators to optimize maintenance tasks by scheduling them with harbour stops, for example, thus maximizing operational availability and safety.

Service agreements

Wärtsilä guarantees basic lifecycle support for all the equipment it supplies. A broad range of Service Agreements is offered that give customers the option of further extending their equipment lifetime and even optimizing the total lifecycle productivity of an installation, should they require this. The following are the main types of agreement:

- Supply Agreement: increases parts supply reliability and information on upgrades. A Spares-on-Line connection allows the customer to order needed spares directly to the ship's next destination port.
- Support Agreement: provides onboard support and participation in daily routines
- Maintenance Agreement: includes regular overhauls with reports and recommendations
- Operation & Maintenance Agreement: ensures full performance and operational responsibility for the installation.

Plains End power plant (111 MW) uses ULE-type SCR (Selective Catalytic Reduction) and oxidation catalysts.

Power Plant Solutions

Wärtsilä's product portfolio includes a range of power plants utilizing either oil or gas as fuel. Wärtsilä BioPower, a range of boiler plants fired using mainly solid biofuels, adds an extra dimension to the portfolio. In decentralized energy production, Wärtsilä's Power Plants business focuses on the decentralized power generation market, supplying mostly power plants for baseload operation, as well as plants for intermediate load and peak shaving applications in certain market areas.

Wärtsilä supplies power plants to utilities or independent power producers (IPPs) for conventional electricity generation. The company also has industrial customers who want to safeguard their production with a reliable source of power. An increasingly important market segment is oil and gas extraction, in which power is needed for drilling, transportation and refining. The diesel engines that power the oil pumping stations, for instance, also run on the crude oil pumped through the pipeline.

Wärtsilä offers complete customer support covering the entire lifecycle of the plant for all of the power generation solutions it delivers.

Applications	Customers	Fuels
Baseload	Utility	NG, LNG, CNG
Peaking	Industry	Special gases
Standby	IPP	LFO, HFO
Pumping	Oil & Gas	Orimulsion®
		Bio-oils

This is achieved through sophisticated service products and service and maintenance agreements developed in collaboration with the company's global network of subsidiaries and service companies.

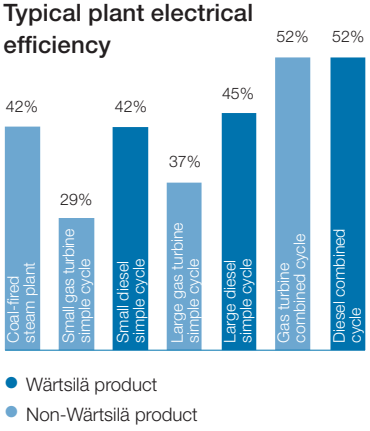
In addition to reducing emissions, Wärtsilä's Power Plants business places high priority on developing diversity and flexibility of emissions reduction techniques in order to find solutions that are competitive and easy to deploy in different market areas where the requirements for emissions and the fuels used differ widely. Wärtsilä focuses on fewer types of engine in order to achieve solutions that are more environmentally sound and have improved overall reliability and cost-efficiency.

Energy efficiency

Wärtsilä's engine-driven power plants offer certain benefits in energy economy compared to many other types of plants. Energy efficiency is an important aspect, not only in terms of energy economy but also because it reduces the use of limited natural resources as well as the emissions produced per unit of energy. Specific emissions of sulphur and carbon dioxide per unit of energy produced with the same fuel depend purely on efficiency. The shaft efficiencies of engines in Wärtsilä® power plant engines can be close to 50%, and remain high even at low outputs.

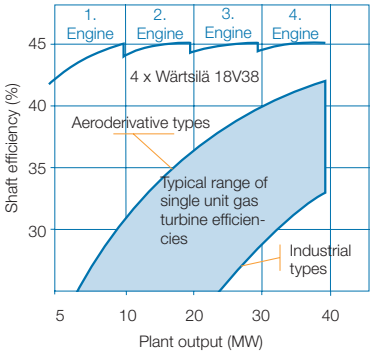
Typically engine-driven power plants contain several engines, thereby fully exploiting the efficiency advantages in different oper-

Typical plant electrical efficiency



ating ranges. The output of a power plant can be regulated, mainly by the number of engines operating and by optimizing the output of individual engines, thus maintaining very high overall efficiency even at low turndown ratios (loads). Availability also increases in a multi-engine installation because an individual engine can be serviced while the others are in operation.

Shaft efficiencies of gas turbine and engine-driven power plant versus power output



In combined heat and power (CHP) generation, or cogeneration, the residual heat from the engine cooling water and flue gas is used to produce steam or hot water. This thermal energy is typically used in a district heating network, an industrial process or a chiller.

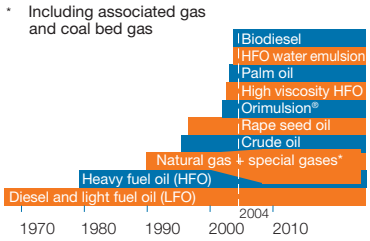
A solution that would maximize energy efficiency and versatility in many applications is trigeneration, in which the thermal energy produced in addition to electricity is used for either heating or cooling, depending on the need, or for both simultaneously in different proportions. Cogeneration typically achieves 75 – 90% overall efficiency, thereby significantly reducing emissions levels per unit of energy.

Decentralized power generation means using small energy production units that are located close to the centres of energy consumption. The spread of decentralized power generation is a result of electricity market deregulation and the radical changes this caused in the energy sector. The business environment of today's electricity markets clearly favours decentralized power generation as opposed to the conventional model, which is based on centralized generation in large installations. The short delivery times for small plants combined with the ability to increase their production capacity in stages, and often to easily combine heat and power generation, are definite advantages compared to the inflexible model of centralized power generation. Decentralized power generation also allows problems such as transmission losses caused by long transmission lines, and land reservations for the lines, to be minimized by locating the power generating plants close to consumers. Wärtsilä power plants are well suited to decentralized power generation.

Reducing emissions at a single large source is more cost-effective than reducing them at a number of small plants. On the other hand, to ensure the same ambient air quality the emissions level at a large plant should be much lower than in the case of several decentralized plants. Replacing a large coal-fired plant, for example, that has 35 – 40% efficiency, with small gas-fired CHP plants that can have 90% efficiency, would produce appreciable environmental benefits because with the same emission content the relative emission per unit of energy generated would be more than halved. Furthermore, burning natural gas at the same efficiency would produce only 60% of the quantity of carbon dioxide produced by burning coal.

Multifuel solutions

Types of fuel used in Wärtsilä's engine-driven power plants

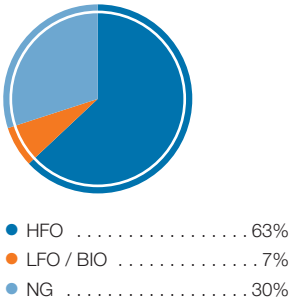


Most of the power plants that Wärtsilä has delivered recently use heavy fuel oil, but the proportion of plants using natural gas is increasing. Also, the use of crude oil – for instance, at oil pumping stations and in other power generating applications in the oil industry – has considerably boosted Wärtsilä's power plant deliveries.

The use of bio-oils is progressively increasing in Wärtsilä's deliveries of engine-driven power plants. One example is the Pentesilea project in Italy, which is nearing the commissioning stage. The plant will use palm oil as fuel in two Wärtsilä 18V32 engines, which generate an electrical out-

Relative sales of different types of Wärtsilä's engine-driven power plants

(June 2003-May 2004)



put of 16 MW. Although the emission requirements set for the plant can mostly be met by means of the clean combustion process achieved by the engine technology, both engines have also been equipped with SCRs to reduce NO_X emissions.

The Pentesilea plant (16 MW) in Italy is fired using bio-oil, such as palm oil.

Wärtsilä's dual-fuel solutions for power plants are extremely flexible. One solution is to select a diesel power plant that operates during the first few years on heavy fuel, for instance. When natural gas later becomes an option, the engines can be converted to gas-powered engines. Another more flexible solution is to select a dual-fuel engine – e.g. a Wärtsilä DF or GD engine – that can switch seamlessly between operating on gas or fuel oil depending on availability, prices or other such criteria.

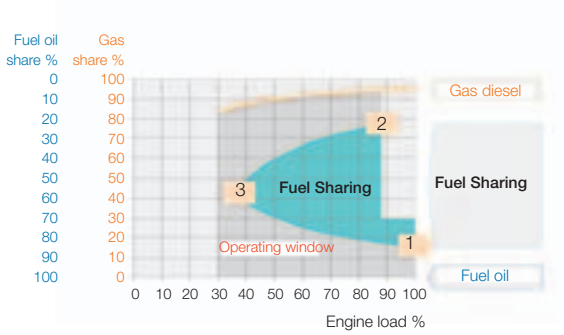
One of the latest achievements in this field is the fuel sharing concept, developed especially to meet the needs of the oil industry, in which a Wärtsilä GD engine uses gas and liquid fuels simultaneously in different proportions. This kind of power plant can use gas or fuel oil simultaneously over a very wide operating range. If, for example, the gas available allows only 30% of the rated output to be reached, the engine will use fuel oil for the remaining 70%. The operator can freely change the setpoint of the fuel share within a specified operating window. Of course, the operator has the choice of running the engine in conventional gas or fuel oil operation as well. The principle was tested originally in 1999 with a Wärtsilä® 4R32GD engine designed for the needs of LNG tankers. In 2002 the oil company Dygoil identified a need for such an installation because the volume of gas available fluctuated strongly at one of their plants. Wärtsilä carried out further development and delivered a fully-operational power plant to Dygoil in March 2004.

Reduction of emissions

Primary methods are mainly used to control emissions of nitrogen oxides (NO_X). When developing and optimizing engines it is necessary to look at the whole picture because reducing emissions of nitrogen oxides can result in higher fuel consumption and increased emissions of other substances. In Wärtsilä power plants dry primary methods – i.e. optimizing the engine – are mainly used to reduce emissions, which promotes Wärtsilä's goal of supplying power plants in which water consumption is minimized.

In certain applications, however, wet primary methods achieve the best overall result because the reduction efficiencies achieved with dry methods are limited when fuel consumption and other emissions are factored in. Wärtsilä is developing, and plans to commercialize, certain wet technologies for the power plant sector in the near future. These chiefly comprise humidification of the combustion air using water or steam, and the use of water-in-fuel emulsions. The latter already has a track record in commercial applications, such as Orimulsion® fuel (bitumen-water emulsion).

Operating windows of fuel sharing concept



The two Wärtsilä 18V32GD engines in the Dygoil plant in Ecuador use the fuel sharing principle.

Secondary methods are an important element in Wärtsilä power plants as well. Their use and the need for them depend very much on the location of the plant and the type of fuel used. Wärtsilä has actively engaged in co-operation with different equipment suppliers aimed at reliably deploying various methods in engine-driven power plants. Secondary methods can successfully eliminate many different emission components.

Flue gas emission control equipment delivered or currently on order from Wärtsilä (January 2005) for power plant applications

	No. of engines	Output (MW)
SCR	153	972
Oxidation catalyst	247	1,075
ESP	10	160
FGD	59	683

Reducing nitrogen oxides

SCR (Selective Catalytic Reduction) systems are used in many Wärtsilä power plants to remove nitrogen oxides (NO_X). SCR can be used in both diesel and gas engine applications. Typical reduction efficiencies are 80–90%, but increasing the catalyst material and improving the control system can achieve improved reduction efficiencies, although this increases costs. The basic principle of SCR is that the use of an ammonia or urea solution at a suitable temperature reduces the nitrogen oxides on the surface of the catalyst to completely harmless molecular nitrogen (N_2) and steam.

Wärtsilä's goal has been to develop an ultra-low-emission (ULE) version of an SCR for gas-fired engines, especially for the US market. This engine which would achieve a NO_X emission level of below 10 ppm (15% O_2). Power plants fitted with this solution have been delivered to the USA over the past few years. Emissions have been below requirements both in the commissioning stage and during normal operation of the power plant. The emission guarantees for corresponding power plants designed today can be set at approximately 5 ppm (dry, 15% O_2). The largest remaining challenges for reducing NO_X emissions are controlling the rise in costs and limiting ammonia slip.

Another significant development area has been applying SCR techniques in power plants that use poor-quality fuels. One problem in the use of conventional SCRs has been the increase in pressure loss caused by blockage of the catalyst reactor when poor-quality fuels are used. Tests conducted in 2002 showed that an SCR with a different catalyst structure and improved automatic soot blowing equipment was an effective solution. The change in pressure loss throughout a full 3,600 hours of testing, using mainly Orimulsion®, was insignificant. Since Orimulsion® has a high sulphur and ash content, soot emissions were higher than normal, making the testing conditions extremely demanding. This high-dust SCR system is now ready for the first commercial application.

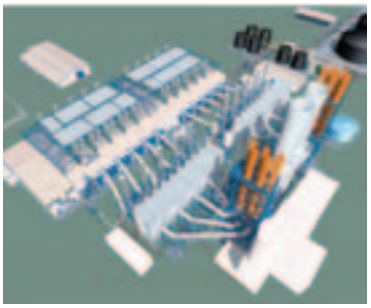
Reducing sulphur dioxide

Various types of flue gas desulphurization (FGD) systems have been delivered to Wärtsilä's diesel power plants in different parts of the world. Typically two types of FGD systems are used in Wärtsilä power plants: wet sodium hydroxide (NaOH) and wet limestone ($CaCO_3$) FGD systems. The first is better suited to small plants using low-sulphur fuels because the initial investment cost is relatively low, even for smallish plants, although sodium hydroxide is expensive and results in high operating costs. A wet limestone FGD system is more suitable for large power plants and cheap high-sulphur fuels. Dry desulphurization systems have also been installed in Wärtsilä power plants, but their feasibility is restricted by, for instance, the maximum permissible temperatures of the flue gas, which are not optimal for standard engine-driven power plants.

The conventional limestone FGD system has been used in boiler plants all over the world for many decades now. Since there are always risks attached to deploying a technology in a new environment, Wärtsilä conducted a project for thoroughly monitoring its first plant. The Manisa power plant in Turkey, in which Wärtsilä's first limestone FGD system was installed, has been operating for three years now and the monitoring period is nearing its end. Measurements taken at start-up and each year since show that this FGD system meets its performance targets.

Reducing particulate emissions

The electrostatic filter is a very old invention that has been used in countless applications, such as boiler plants and cement factories. Wärtsilä started R&D activities aimed at using ESP (electrostatic precipitator) technology with diesel engines in 1997, which have so far covered pilot testing in Finland at the end of 1997 and a demonstration in Guatemala in 1999-2000. One result of this R&D is an electrostatic precipitator that can achieve particulate emission levels of 40–50 mg/nm^3 (dry, 15% O_2) with extremely poor-quality fuels. The first commercial project in which ESP is used was ready for installation in early 2004. Two preliminary measurements of emission levels at the Guatemalan plant have already been taken and the results indicate that the performance targets will be achieved.



150/160 MW diesel power plant using water-in-fuel emulsion, in which electrostatic precipitators and wet limestone flue gas desulphurization systems have been installed.

Stricter emission limits in the future will necessitate even higher reduction efficiencies. ESP development with one of Wärtsilä's suppliers is ongoing, aimed at achieving lower particulate matter levels (<30 mg/nm^3 (dry, 15% O_2)). The testing, scheduled for 2003 in the original plan, was postponed until 2004. So far two particulate matter (PM) emission measurements have been taken of this enhanced ESP version, and the preliminary results indicate that achieving the target level is feasible.

Reduction of carbon monoxide and hydrocarbon emissions

With the exception of SCR, the techniques listed above are not normally used with gas engines. Instead, a substantial part of reducing

emissions in gas-fired power plants is performed by oxidation catalysts, which remove either carbon monoxide (CO) or hydrocarbons (HC), or both. Numerous different types of oxidation catalysts have been supplied to Wärtsilä's gas-fired power plants over the years, ranging from small catalysts for removing carbon monoxide through to the highly efficient ULE (ultra low emission) versions for the US market with high CO and HC reduction efficiencies but costing many times more than the small units.

Normal oxidation catalysts can reduce emissions of many hydrocarbon components, but removing methane (CH_4) with catalytic oxidation is especially demanding because proper operation of today's catalytic materials requires much higher temperatures than those in the flue gases from gas engines. Wärtsilä is monitoring the development of methane reduction methods in the market to find a cost-effective solution.

Economic impact of flue gas emission control

One consequence of rising fuel prices, especially the sharp rises recently, is that the price and efficiency of a fuel is of even greater importance with regard to the overall cost of the electrical power a plant generates. This has made the use of cheaper and lower-quality fuels more attractive. Conversely, fuel quality has an appreciable impact on flue gas quality, and therefore also on the need to scrub flue gases, the type of scrubber used and the scrubbing efficiency needed. A poor-quality fuel, high in sulphur and ash, may need flue gas desulphurization (FGD) and particle reduction systems while a low-sulphur, low-ash fuel does not necessarily need any treatment.

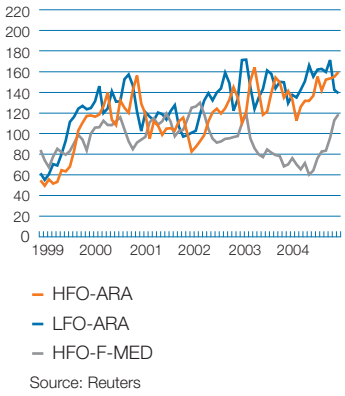
A poor-quality fuel may result in lower fuel costs but the cleaning technology on the other hand requires additional capital investments and additional operating costs. The customer will make the investment decision based on the total lifecycle cost corresponding to a certain electricity price. The main aspect is that cleaning equipment generally has an appreciable impact on the cost of generating electricity, and therefore there must be a large enough price difference between high- and poor-quality fuel to make it economically viable to use poor-quality fuel.

Monitoring emissions

Monitoring emissions is a natural follow-on to reducing emissions. A plant's emissions can be monitored on-site in two ways; either by measuring the levels of emission components and other parameters in the flue gas with automatic equipment, or with a secondary method relying on scheduled measurements of the flue gas and periodic on-site inspection of certain process parameters and fuel quality.

Prices of fuel oils in recent years

US$ / tonnes



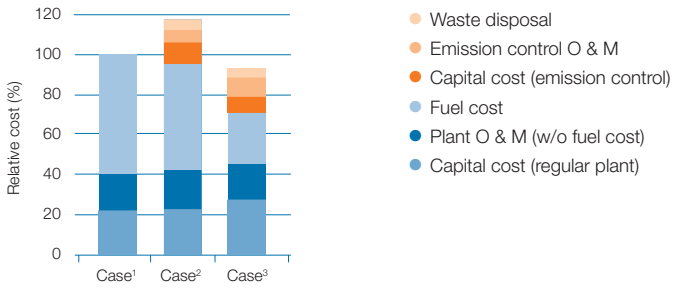
Source: Reuters

The use and maintenance of automated equipment to ensure reliable operation requires a high level of know-how from the personnel. This is not necessarily adequate or available in all cases and can mean that the emission data reported is unreliable. Often, therefore, it is considered sufficient to carefully monitor the process parameters and to call in a specialized consultant to perform regular measurements. Normally this produces adequately reliable results.

The legislation of some countries makes the use of automatic emission monitoring equipment mandatory for plants of a certain type or size. These systems are often called CEMS (Continuous Emission Monitoring System) or AMS (Automated Measurement System). In India, for example, it is mandatory for large (> 50 MW) diesel power plants to use this type of equipment for monitoring NO_x emissions.

The proportion of Wärtsilä power plants equipped with CEMS or AMS systems will probably grow in future. The challenge here is that Wärtsilä power plants are normally provided with individual exhaust ducts and flue gas stacks – each en-

Power plant electricity production costs as a function of fuel quality and cleaning techniques



Case 1. Good-quality HFO, no emission control
Case 2. Low-cost HFO, particle control with ESP, flue gas desulphurization
Case 3. Low-cost emulsified fuel, particle control with ESP, flue gas desulphurization

gine has its own stack. That means numerous individual components will be needed even if a time-shared system is used, i.e. a single analyser serves a number of stacks. As the number of components increases, the reliability of the equipment declines. Furthermore, the use of different fuels also presents a challenge for equipment design.

Based on experience in India and on laboratory tests, Wärtsilä has developed a system for measuring the gaseous components of emissions from diesel plants fired by heavy fuel oil. The system can also be adapted to plants fired by gas or light fuel oil. The system has not yet reached the long-term objectives for simple, reliable and easy to use equipment, and therefore one of Wärtsilä's key projects in 2004 and 2005 is the development and testing of a new, innovative solution for automated flue gas measurement.

Water consumption

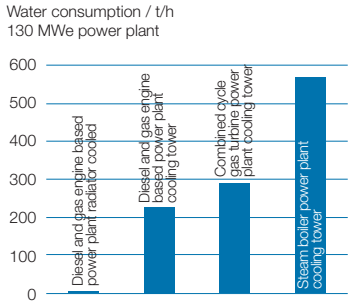
Water is a critical resource in many parts of the world and is becoming increasingly important to economic and social development year by year. It is estimated that only 2.5% of all the Earth's water resources is fresh water and only 0.26% of this amount is easily available. Furthermore, some of these scarce water resources are becoming polluted and in many areas they vary considerably, both locally and seasonally.

Water consumption is also an important environmental aspect of energy generation. Minimizing water consumption and wastewater is one of Wärtsilä's design principles. Compared to many other methods, an air-cooled engine-driven power plant in closed circuit is unrivalled in terms of low water consumption.

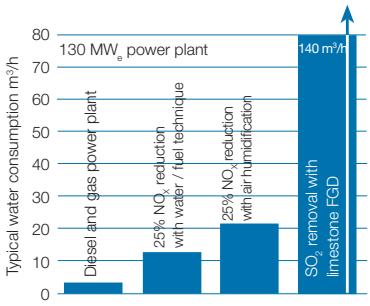
Water consumption is an important factor that should be considered when evaluating emissions reduction techniques. Wet primary methods for reducing emissions of nitrogen oxides, for example, considerably increase water consumption. On the other hand they offer savings in fuel consumption and therefore lower emissions of carbon dioxide.

To reduce water consumption, air-cooled radiators are used in many Wärtsilä power plants. Wärtsilä also gives high priority to developing engines that enable dry methods for reducing nitrogen oxides.

Water consumption of different types of power plants



Effect of emissions reduction on water consumption



Legislative requirements

A core principle applied by Wärtsilä in the development of its power plants and equipment is to meet the requirements of the World Bank. Wärtsilä makes every effort in designing its power plants to ensure that the World Bank's stack emission guidelines are met with a sufficiently good quality of fuel without using wet primary or secondary methods in cases where the plant is located in a non-degraded airshed.

Current World Bank Guidelines for the NO_x, SO_2 and PM emissions of the new power plants

Secondary or wet primary cleaning methods make it possible to use lower-quality fuel and reach lower emission levels, or to achieve better fuel economy.

Ambient air quality is an essential factor in the World Bank's emission guidelines. The compliance of a power plant with the relevant ambient air quality guidelines or regulations is the responsibility of the plant owner. The resulting ambient air quality is a combination of the effects of various sources, including traffic, natural sources, other industrial plants and households, and it also depends on the local momentary and seasonal weather conditions. Every effort should be made to establish the ambient air quality, and changes in it, with thorough studies and atmospheric dispersion modelling, both of which are important elements in the environmental impact assessment of the plant.

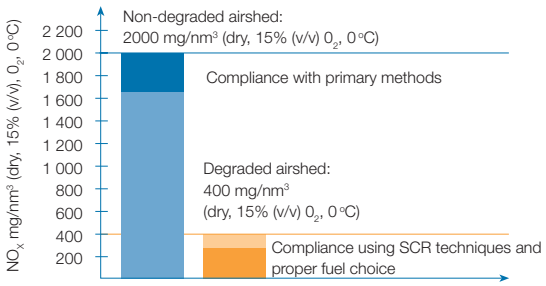
TA-Luft limit values for NO_x

German TA-Luft regulations have been widely applied to engine-driven plants in other European countries apart from Germany. The latest TA-Luft 2002, released in 2002, sets stricter limits on dust and CO emissions. Wärtsilä's strategy for lean-burn gas engines, including its dual-fuel engine (DF) in gas mode, is to comply with the TA-Luft regulation using primary techniques as far as practicable. The use of a CO oxidation catalyst is normally required for compliance with the TA-Luft regulations today.

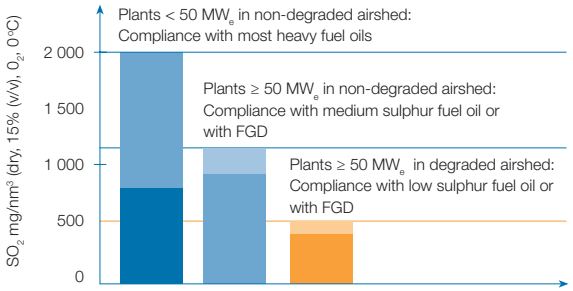
Other limits

India has long been an important market for Wärtsilä diesel power plants. In 2002 India launched new regulations for diesel engines which set stricter emission limits on plants commissioned after June 2005 than for plants delivered before that date. Wärtsilä has fo-

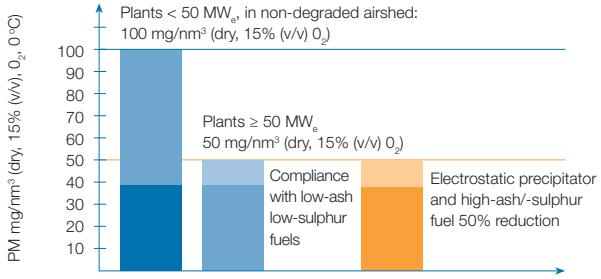
NO_x emissions compliance of Wärtsilä diesel engine power plants with World Bank Guidelines



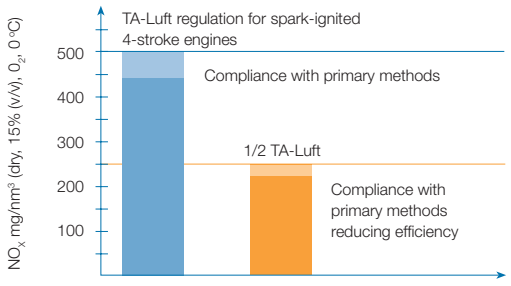
SO_2 emissions compliance of Wärtsilä diesel engine power plants with World Bank Guidelines



Particle emissions compliance of Wärtsilä diesel engine power plants with World Bank Guidelines



NO_x emissions compliance for gas engine power plant (TA-Luft)



cused considerable R&D resources on developing and launching engines that meet the 710 ppm (dry, 15% O_2) NO_x requirement in order to minimize the need for wet reduction methods and the consequent increase in water consumption. This goal is a demanding one for diesel engines using heavy fuel oil, for which there is strong demand in India – especially for small (< 20 MW_e) power plants.

The goal has been partly achieved in that some types of engine meet the new requirements, and in that unfortunately engines using heavy fuel oil will often have slightly higher fuel consumption and CO_2 emissions. Wärtsilä is continuing its engine development programme and progressive improvements are expected from advances in turbocharging technology. Wärtsilä diesel engines can meet the other emission limits India has set, such as those for CO, NMHC and PM, using fuels that are generally available in the country.

The principle in the US market for specifying emission limits for individual power plants differs from the practice in many other countries in its diversity. The permit process in the USA applies a number of different regulations, and often total annual output (tonnes per year) of a certain emission component is set as a threshold value for a power plant. In other words, the maximum permitted content in the flue gas is determined according to the plant's annual power output.

This being the case, the permitted maximum content depends very much on the size and annual utilization of a power plant. It is often important, for instance, that HAP (Hazardous Air Pollutants) emissions are less than 25 tonnes a year, and that individual HAP components are less than 10 tonnes a year, for the plant to avoid being classified in the Major Source category and consequently subjected to considerably more complex licensing and monitoring.

Generally speaking, limitations on emissions are in a permanent state of flux. Certain parameters are used across the board today while others are just being introduced, and the rate of change varies in different market areas.

Installations of emission reduction technologies

Although most Wärtsilä gas-fired plants are delivered without SCR, this technology is now deployed in many plants delivered to the USA. These plants are often equipped with highly effective oxidation catalysts as well. Wärtsilä calls this power plant solution the ULE (Ultra Low Emission) concept, an example of which is the 111 MW_e Plains End, Colorado, plant commissioned in 2002 – 2003. The plant contains 20 Wärtsilä® 18V34SG engines, each fitted with SCR equipment and an oxidation catalyst. The NO_X emission level guaranteed for the plant was 8 ppm (dry, 15% O_2), and emissions from the plant's units have consistently been below this figure both during commissioning and in subsequent scheduled measurements.

The use of cheap fuels with a high sulphur and ash content usually necessitates desulphurization of the flue gases and PM reduction. The 150/160 MW diesel plant Wärtsilä delivered to Guatemala uses water-in-fuel emulsion, which requires ESPs and desulphurization because of the sulphur dioxide and particulate emissions produced during its combustion. Each of the ten Wärtsilä® 18V46 engines in the plant is connected to its own ESP unit, after which the flue gases are cleaned in two parallel wet limestone FGD systems. The goal for this solution is to achieve a reduction efficiency of 90% for SO_2 and a PM emission level of below 50 mg/nm³ (dry, 15% O_2). Initial measurements indicate that these targets will most likely be achieved.

A limestone FGD system has definite advantages when the plant is big and the fuel has a high sulphur content. The CPT-Lungtan power plant in Taiwan, due for commissioning during 2005, is a good example of another type of desulphurization need. Altogether seven Wärtsilä 18V32 engines will be installed in this plant, which will use fuel with a maximum sulphur content of 0.5%. Despite this, desulphurization was a requirement for the plant. In this case a wet sodium hydroxide FGD system was by far the most economically viable option because of its low investment cost. The desulphurization unit also contains a flue gas reheater, which uses hot air to raise the temperature of the flue gas to some 10 degrees above the condensation point. The purpose of the reheater is to minimize the visible flue gas after the scrubbing process, which is made visible by the steam it contains.

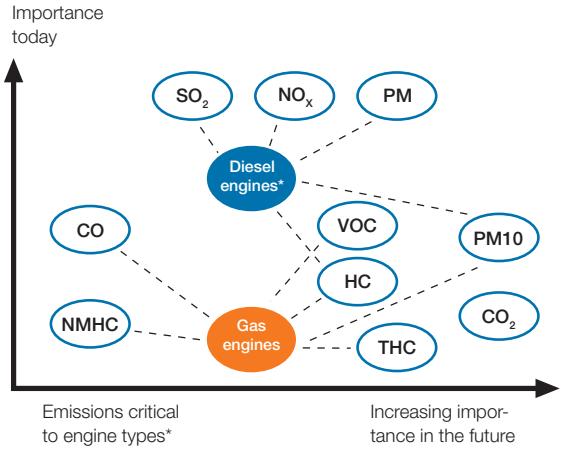
India's emission limits for diesel power plants

	1 July 2003 - 30 June 2005	1 July 2005 -
NO_X (ppm) Big cities ≤ 75 MW and other areas ≤ 150 MW	970	710
NO_X (ppm) Big cities > 75 MW and other areas > 150 MW	710	360
NMHC (as C, mg/nm³)	100	100
PM (mg/nm³), light fuel oil	75	75
PM (mg/nm³), heavy fuel oil	100	100
CO (mg/nm³)	150	150
S content of fuel oil (%) big cities	2	2
S content of fuel oil (%) other areas	4	4
Reference oxygen concentration 15 % O_2, nm³ 25 °C / 101.3 kPa		

Plant servicing

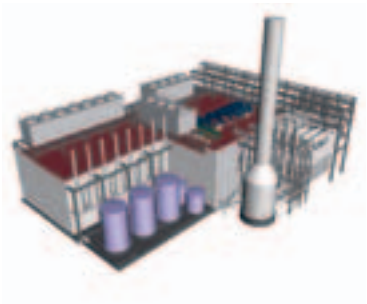
Any power generation unit will perform best in terms of production, availability, emissions and long service if it is operated and maintained according to plan using professional expertise and high-quality spare parts. The nearest subsidiary of Wärtsilä's global network participates in a power plant delivery, examines the logistics, safety and environmental aspects of the delivery, provides the customer with post-commissioning support, and conveys the customer's feedback and needs to the organization throughout the operational lifetime of the installation – and often after it.

Focus on air emissions from engine-driven power plants



Abbreviations:
NO_X = oxides of nitrogen
SO_2 = sulphur dioxide
PM = particulate matter
PM10 = particulate matter with diameters below 10 micrometres; in the future also PM2.5 will probably appear
THC = total hydrocarbons
NMHC = non-methane hydrocarbon
CO = carbon monoxide
VOC = volatile organic compounds, typically means non-methane non-ethane hydrocarbons
HC = individual hydrocarbon compounds (e.g. formaldehyde) or group of hydrocarbons (e.g. PAH)
CO_2 = carbon dioxide

The CPT-Lungtan plant in Taiwan will be delivered with a wet sodium hydroxide FGD unit.



Optimized logistics

Wärtsilä ensures the prompt availability of original spare parts not only with global transport contracts but also by maintaining HUB warehouses in Singapore and Florida that store the parts most frequently needed. That means critical parts for both engines and auxiliary systems are only a reasonable distance from the installation.

Recycling, reconditioning and modernization

Wärtsilä's servicing workshops recondition components, spare parts or complete engines for a customer. Wärtsilä also stocks and sells reconditioned components and engines, giving a discount for reconditionable parts returned by the customer. Exploiting technological advances to modernize and modify installations helps older production units to meet stricter environmental requirements by reducing fuel and lubricating oil consumption, or by enabling the use of a more environmentally sound fuel.

Operation and service training

The Wärtsilä Land & Sea Academy (WLSA) provides extensive training programmes covering operation, service and safety issues for power plant personnel. With a focused training strategy and qualified teachers, the WLSA provides a thorough understanding of how to optimize lifecycle costs and environmental performance while also meeting production targets. General or plant-specific training is given in one of Wärtsilä's training centres or on-site prior to commissioning a plant. WLSA also provides remote training and e-learning wherever this is practical.

Technical support

Wärtsilä offers its customers 24-hour phone support, giving practical advice on a range of technical questions. A customer can immediately receive instructions by phoning the nearest Wärtsilä call centre, thus avoiding potential machine breakage, emissions or accidents. Wärtsilä's technical experts also perform measurements and analyses, and publish servicing recommendations. This helps customers to solve problems and to modify and optimize operating performance.

Wärtsilä's expert-manned service provides remote monitoring and diagnostic support through remote analyses of problems occurring in an installation. A combination of manual inspections and online monitoring of equipment and system efficiency data is used for Condition-Based Maintenance (CBM) to accurately determine the overall system status and thus predict and optimize maintenance needs and maximize plant availability and operational safety.

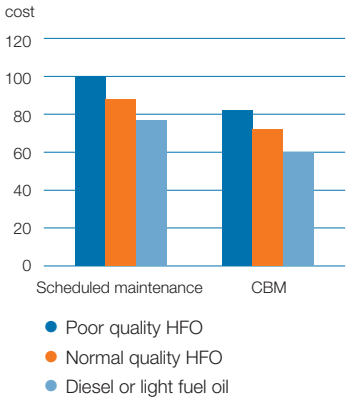
Operations & maintenance agreements

Wärtsilä's service agreements are comprehensive in scope and tailored to precise needs, letting customers choose from different levels of partnership agreements, or a day-to-day business relationship. Agreements cover all aspects of lifecycle optimization, including parts supply and daily assistance, inspection and maintenance. Wärtsilä's Operations and Maintenance (O&M) agreements include complete operation with implementation of agreed performance targets and maintenance for an installation. Over 140 plant owners around the world enjoy the benefits of Wärtsilä's O&M agreements.

Wärtsilä has a 5-year O&M agreement with Plains End power plant, which started operating commercially in May 2002. The fixed-price contract guarantees stack emissions, heat rate and plant availability. The plant differs from many others in that it is provided with a remote monitoring system that enables effective

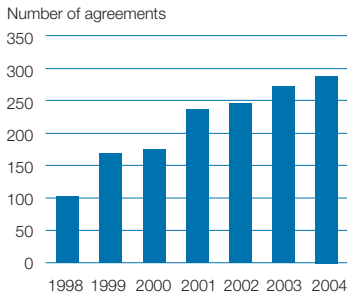
Cost comparison of maintenance systems

Maintenance cost, parts and work for 50,000 operating hours on different fuel qualities at year 2002 price level.



Service agreements in force

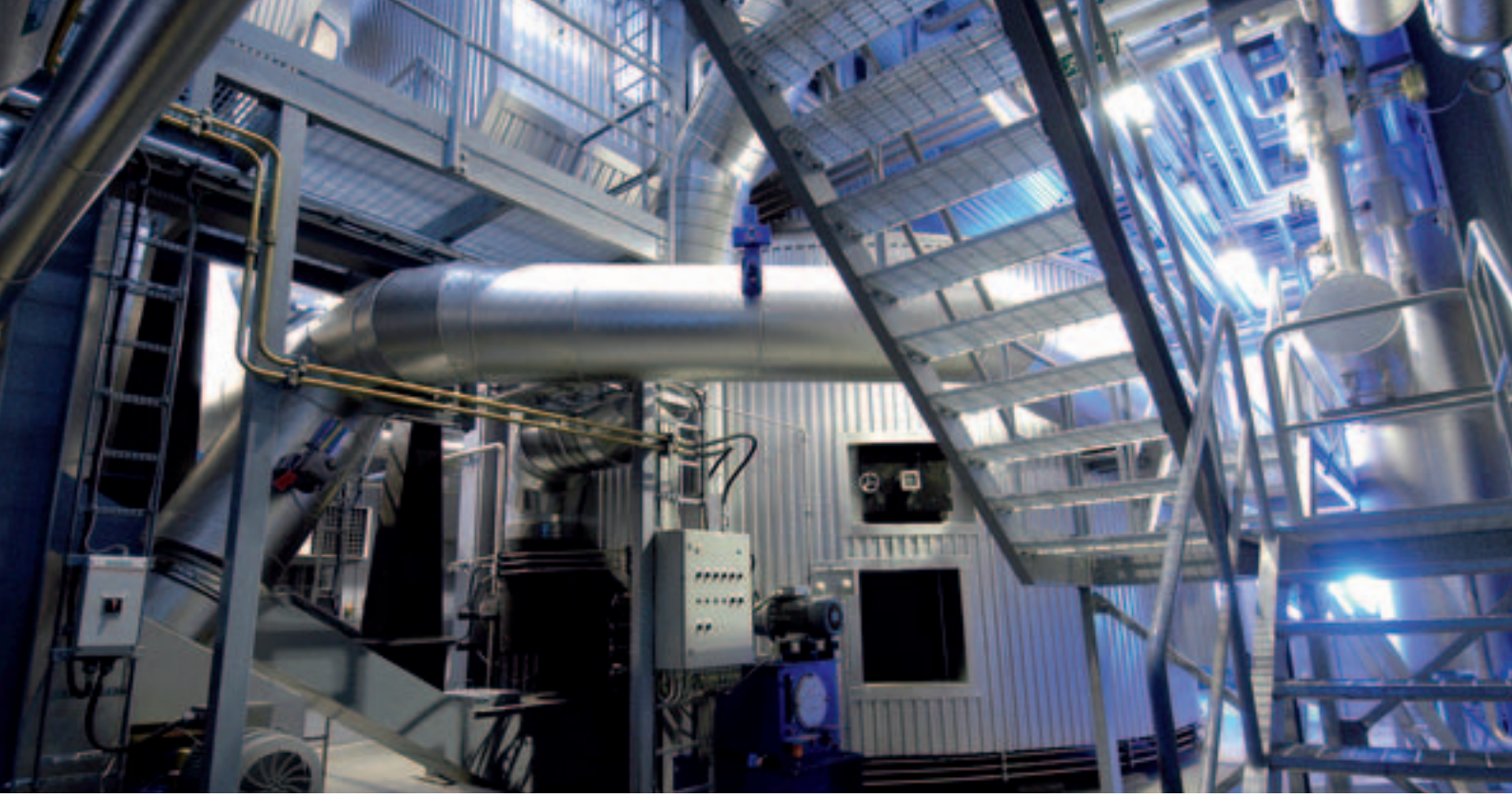
Number of agreements



operation with minimum personnel. Six Wärtsilä employees work at the plant, which can be monitored from Fort Lauderdale, over 3,000 kilometres away, or even from Vaasa, Finland. More extensive servicing is provided by the nearest Service Office.

The Public Service Company of Colorado, a regional utility, needs not only peaking power to meet fluctuating summer and winter loads but also standby power that can quickly be used if the operation of baseload plants is interrupted. The technology Wärtsilä offers is a unique solution for generating standby and peaking power because of the excellent heat rate of the plant in exceptional ambient conditions. The plant is located 1,875 metres above sea level with outdoor temperatures as high as +37 °C. Local residents have easily accepted the plant because of its physical appearance and low emission levels.

Operating the plant at its design values optimizes performance, avoids overloading the engines mechanically or thermally, and thus keeps gas consumption optimal during each period of operation. Continual monitoring of operating parameters and computation of operational trends reduces the number of unscheduled stops. That allows maintenance to be properly scheduled according to need. Wherever practical, all maintenance and service activities are performed at the same time in order to minimize the number of stops and maximize availability. Operating the plant with optimal gas consumption and correctly scheduled maintenance minimizes operating costs.



Boiler Plants

Wärtsilä Biopower manufactures and supplies boiler and power plants that use biofuels, oil and gas for fuel. Boiler plants operating on biofuels have a capacity of 2–17 MW_{th}. Boiler plants that operate on oil and gas have a unit size of 1–15 MW_{th}. With these fuels the plants can produce hot water, steam and electricity according to the customer's needs. In 2004 Wärtsilä Biopower supplied plants with a combined capacity of 72 MW_{th} / 6.03 MW_e.

Biopower has focused on biomass-fired boiler and power plants which it supplies to selected market areas. Wärtsilä's patented BioGrate technology enables the power plants to use various wood-based biofuels such as bark, sawdust, wood chips and also peat as their source of energy. BioEnergy (BE) plants produce hot water and steam. BioPower (BP) plants produce heat and electricity. The boiler plant systems are installed and the building is assembled in modules in the Wärtsilä factory. For larger boiler plants, prefabricated modules are used as far as possible to obtain optimal results, and these are assembled on site to form the boiler plant. At present more than 76 BioEnergy and BioPower plants are in use around the world.

Plant manufacture and material

The materials used in the plants consist of various steels and masonry materials. Tubular structures, rolled steel and cast steel that withstand high temperatures are used in the boiler and combustion equipment. In plants where the flue gases are condensed, corrosion-resistant steels are used. The main material used in the building is usually concrete. Steel is used for load-bearing structures and normal materials are used for thermal and noise insulation. Safe, standard materials are used in electrical equipment for electricity transmission and protection.

Deliveries 2004

Products	MW_{th}	MW_e
BioEnergy	18	
BioPower	34	6
Oil / gas	20	

Energy production

Wärtsilä's bioboilers are designed for wood-based fuels that are typically generated as flows of residues from forest industry processes.

Distinctive characteristics of biofuel:

- Variable, high moisture content, up to 65% m/m
- Variable heat value on arrival at the plant, at its lowest only 5 MJ/kg
- Fairly low, variable energy density: 0.5 $MWh/m^3 < q < 1.2$ MWh/m^3
- Low sulphur content < 0.05% m/m dry
- Low ash content 0.5 – 3% m/m dry
- Low chlorine content < 0.05% m/m dry.

Boiler plants are usually dimensioned for fuel with a heat value of 6 – 9 MJ/kg on arrival. A separate drying plant for the fuel is not needed, since Wärtsilä's grate design can utilize wet biomass efficiently.

The biofuel may have picked up impurities such as pieces of metal, sand or stones during handling or

transportation. If these are not removed from the fuel, they may reduce the availability of the plant and increase the need for auxiliary energy. The impurities can be removed with magnetic separators or various screens.

Energy efficiency

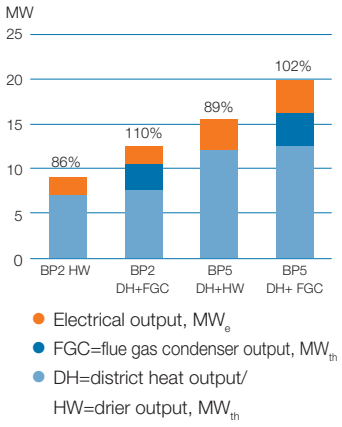
The main factor affecting the efficiency of the boiler is the level of flue gas losses, in other words the proportion of the combustion energy lost with the flue gas. The size of the losses is affected by the volume of flue gas emitted from the boiler and in particular its temperature.

The adjacent figure shows typical boiler plant efficiencies as a function of the boiler load and moisture content of the fuel. The energy efficiency varies between 85% and 91%. The drier the fuel used, the greater the efficiency. Using a system to recover the condensation heat in the water vapour contained in the flue gas, cooling the flue gases to the dew point, the plant's total energy efficiency (boiler and heat recovery system) can improve by up to 20 percentage points. In this way a high energy efficiency can be achieved even with wet fuel.

In BP plants, electricity is generated with a steam turbine generator and the low-pressure exhaust steam from the turbine is used to produce hot water in a steam condenser. The combined heat and power (CHP) generation process optimizes production to the heat requirements with electricity generated as a byproduct. Given what is financially and technically feasible in each case, BP products are dimensioned for relatively low steam pressure and temperatures (23 – 52 bar and 450 – 480 °C). The total energy efficiency is then 85 – 86%.

A BP plant can produce just electricity, in which case the energy efficiency in electricity generation is 25%. The low-pressure exhaust steam from the turbine is then condensed using either air or water. The energy efficiency of oil-fired boiler plants varies between 85% and 92% and when gas-fired it is 95%, if a preheater is used for the feed water.

BP plant output and efficiency



Emissions to the air

The flue gas emissions from bio-boilers consist mainly of NO_x, SO_2, CO, CO_2 and particle emissions. The carbon contained in biofuel originates in the carbon dioxide in the atmosphere. When the fuel is burnt, its carbon is released back into the atmosphere mainly in the form of carbon dioxide, but when the biomass decomposes the carbon is also released back in the form of methane (CH_4) and other hydrocarbons. The burning of biomass does not in the long term alter the level of carbon dioxide in the atmosphere, nor does it increase the level of greenhouse gases.

Greenhouse gases

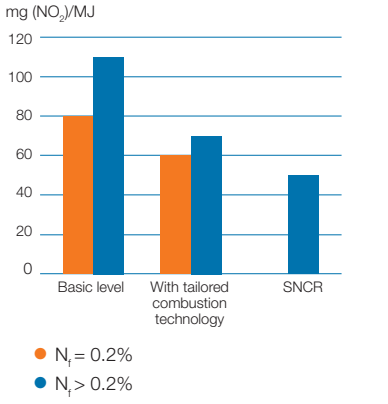
Greenhouse gases comprise several gaseous compounds such as carbon dioxide, methane and nitrous oxide. The Kyoto Protocol, part of the UN Framework Convention on Climate Change, will restrict the greenhouse gas emissions of the parties to the agreement. The EU's internal emissions trading scheme (EU ETS) is also based on the Kyoto Protocol and is starting at the beginning of 2005.

The Kyoto Protocol contains not only emission restrictions but also various flexible mechanisms for achieving emission reductions. Joint Implementation (JI), for example, makes it possible to finance investments in emission reductions in connection with projects carried out in countries that have ratified the Kyoto Protocol. In the period 2001 – 2004, Wärtsilä Biopower has delivered district heating plants with a combined output of 12.5 MW_{th} in JI projects in the Baltic countries.

NO_x emissions

Nitrogen oxide emissions from boiler plants running on biofuel mainly derive from the nitrogen in the fuel. NO_x emissions have been reduced using combustion technology by increasing the phasing of the combustion air and increasing the duration of the combustion gases in the combustion zone. BioPower and BioEnergy plants normally have NO_x emission levels of below 90 mg/MJ (when the fuel has a nitrogen content of less then 0.2% m/m). To meet customer requirements, tailored solutions can be implemented that conform to even stricter emissions criteria.

Specific nitrogen oxide emissions



CO emissions

The carbon monoxide content of flue gas is kept low by maintaining a sufficiently high combustion temperature throughout the boiler's capacity range. This is done with multiphase air distribution, with grate structures that effectively control

the movements of the fuel layer, with the specially designed brick walls of the combustion chamber, and by mixing the flue gases and combustion air effectively. A steady frequency-controlled fuel feed to the furnace and a large fuel stock that balances out variations in fuel quality are further factors in achieving clean combustion.

Sulphur emissions

Sulphur dioxide emissions (SO_2) to the air are also extremely low, since clean biofuel does not normally contain significant amounts of sulphur (< 0.02% m/m in dry fuel). Typical SO_2 emissions are less than 20 mg/MJ, so no separate system is needed for extracting sulphur dioxide from the flue gases in order to meet the emissions standards.

Particle emissions

The level of a boiler's particle emissions is affected by fuel properties such as the ash content, particle size and impurities. Clean biomass usually has a low ash content (0.5–3% m/m dry) compared to other solid fuels. The grate separates some of the ash, which helps to reduce the load on the particle separator. The separation efficiency of different particle collection systems depends on the load on the separator (particle concentration, distribution and amount of gas) and the fuel properties. An electrostatic precipitator typically achieves particle emission levels of 10–50 mg/MJ, whereas a multicyclone may achieve 100 mg/MJ.

Emissions into the air from oil- and gas-fired boilers

Emissions into the air from oil and gas boilers are reduced using efficient combustion technology (modern burner with an appropriate boiler structure) and with precise, advanced regulation of the combustion air.

The following are typical emission levels from boilers fired using light fuel oil and gas:

- CO < 20 mg/MJ
- NO emissions < 60 mg/MJ
- SO_x < 10 mg/MJ
- C_xH_x < 7 mg/MJ
- Particle emissions < 10 mg/MJ.

Noise emissions

Noise disturbs those in the neighbourhood, and increasing attention is being paid to this when designing structures. Noise emissions within the plant must be below 85 dB(A) at a distance of one metre from machinery and outside below 50 dB(A) at a distance of 50 – 100 metres from the wall of the plant. To meet the strictest noise emission requirements, tailored solutions can be implemented that meet requirements for lower noise levels.

Ash, water and lubrication oil

Ash is a typical byproduct of BE and BP plants. The solid matter in biofuel includes 1 – 3% ash. Ash is mainly recovered in two separate systems. Bottom ash is recovered after it has been extinguished (wet) under the grate. Dry bottom ash has a particle size of 50 µm – 10 mm. Fly ash is recovered dry either from the multicyclone or the electronic precipitator, depending on the cleaning method, and it can be kept separate from the grate ash. Fly ash has a particle size of 1 µm–1 mm. The ash can usually be recycled. It can be used as a soil improvement agent, as a fertilizer in forests, and as an additive in the concrete industry.

Roughly three-quarters of a BP plant's need for extra water is determined by the quality of the raw water, the process circuit and the type of plant; where BP2 and BP5 plants are concerned a further factor is the need for water treatment. The remainder is determined mainly by the ash treatment requirements.

The calculated water consumption varies in BP (CHP) applications running on typical fuels between 15 g/MJ_f and 25 g/MJ_f provided there is no steam consumption in the process. Monitored results of operating power plants are in short supply but these correspond to the above values.

Water consumption in BE plants relates principally to ash treatment unless there is other water consumption in the process. Consumption varies typically in the range 3 – 7 g/MJ_f depending on the ash content of the fuel.

Lubrication oil is used in BP and BE plants in the fuel handling systems and in the hydraulic system in the grate. Some 500 l/a of oil is needed. BP plants also consume 500 l/a of lubrication oil in the turbine.

Compliance with legislation

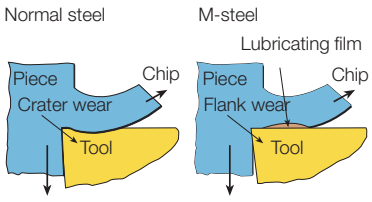
Wärtsilä's BioEnergy and BioPower plants are designed to meet all local emission requirements. These are usually set for:

- Non-combusted gases such as CO
- Nitrogen oxides
- Sulphuric oxides
- Particle emissions
- Noise emissions
- Water separated by flue gas condenser
- Condensate from the steam boiler.

Imatra Steel Products

Imatra Steel supplies low-alloy engineering steels and steel products to the automotive and other advanced sectors of the mechanical engineering industry. Imatra Steel's operations are founded on full cooperation between its business units, Imatra Steel works, Imatra Kilsta Forge and Scottish Stampings Forge, ranging from product and process development to internal sales.

Lubrication effect of M-steel



Steel bars

Imatra's steel bars, available as round bars, squares and flats, are predominantly delivered to automotive applications through a diversified supply chain. Typically, long bars supplied by Imatra Steel Works first enter a forging process in which they are forged into a component with roughly the final shape. This is followed by possible heat treatment, machining and finishing in a separate machine shop into a final forged steel component. The component is then delivered to an assembly line for installation into a specific subassembly, e.g. a car or truck engine. This subassembly is then assembled in a car or truck.

The automotive supply chain has offered several possibilities for Imatra's R&D to find and maintain environmentally advantageous solutions both for the manufacturing process and through the whole service life of an engineering part.

Direct quenching steel, IMAFORM™, allows the forged component to be quenched in water from the forging temperature without the need for further conventional energy-consuming heat treatment. This decreases environmental impacts and costs.

Machining of steel forgings requires energy and causes toolbit wear. That is why one of Imatra's main product development targets over the years has been to improve the machinability of the steel it produces. This has led to the product concept called M-steel, where M stands for improved machinability. M-steels offer better machinability than conventional steels without a trade-off with mechanical properties. Better machinability means that the workshop can either use a higher machining speed or alternatively lengthen toolbit life, both of which have a positive impact on machining costs and the environment.

From the standpoint of the steel manufacturer the important environmental aspects in the development of cars and trucks are safety, lightness and recyclability.

Safety requires that the steel components are of high quality and meet strict mechanical requirements, one of the most important of which is fatigue strength. To achieve sufficient fatigue strength properties, the cleanliness and careful inclusion control of the inner structure of the steel play an important role. This is an R&D area that is being given high priority at Imatra Steel Works.

The lightness of a vehicle is a design target that aims for better utilization of the net load of the car or truck. This in turn reduces fuel consumption and hence the risk of pollution over the vehicle's service life. One way this objective can be achieved is to use high-strength steels with advanced properties. Imatra Steel's R&D works in close and intensive co-operation with vehicle designers to extend and further improve the use of high-strength steel grades in customers' products.

Motor vehicles are mainly made of steel or other ferrous materials. At the end of vehicle's lifecycle, it becomes an important source of raw material for steel producers that use scrap steel for raw material, a factor that emphasizes the recyclability of a vehicle. Steel as such can be regarded as 100% recyclable. However, some metallic components, manufactured from so-called free cutting steels contain lead to improve machinability, are therefore not favoured as recyclable materials. Imatra has developed steel called IMATRA GreenCut™ to provide customers with an opportunity to replace leaded steel with an unleaded alternative offering equal machining properties.

The same arguments applied to the automotive industry above also apply to the steel deliveries to mechanical engineering industry although in this case the machinability of steel is even more important.

Die-forged products

Imatra Kilsta AB is one the world's leading manufacturers of die-forged products, particularly for the heavy vehicle industry. Imatra Kilsta specializes in heavy crankshafts, front axle beams, steering knuckles and other steering components.

Imatra Steel's position in the supply chain

Material supplies

The raw material used in Imatra Steel's production chain consists almost entirely of recycled steel.

Imatra Steel Works

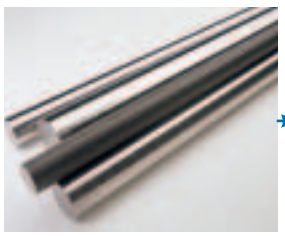
The Imatra Steel Works produces low-alloy round, flat and square bars for demanding customers in the automotive and mechanical engineering industries. Deliveries go to the Kilsta Forge and to other automotive and mechanical enginering companies.

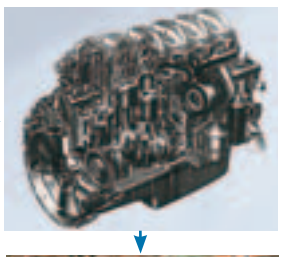
Kilsta Forge

The Kilsta Forge specializes in forged engine and front axle components for heavy commercial vehicles. Deliveries are shipped directly to customers' engine and axle factories.

The system supplier

Engines and axles are assembled in specific factories into complete systems for final assembly.





The recycler

Metal recycling companies recycle disused vehicles and other capital goods for further processing and reuse. The scrap returns to the steel works, completing the circle.

The user

The user purchases a safe, reliable and pleasant-to-drive vehicle that gives efficient service for years. Nonetheless its useful life will one day come to an end.

The OEM manufacturer

Systems and components are assembled into complete vehicles.

The forge is equipped with the latest technology both in the forging presses and ancillary equipment in order to meet the high demands of the automotive industry with regard to quality, tolerances, drafts and design. Among other equipment, Imatra Kilsta possesses the most powerful and fully computerized forging press in the world. This is used to produce heavy diesel engine crankshafts and front axle beams for trucks and buses.

Imatra Kilsta's subsidiary, Scottish Stampings, is the leading European manufacturer of forged and machined front axle beams for the commercial vehicle industry. Its dedicated production process includes some of the latest technologies to ensure that beams of the highest industry standards are supplied to customers. With a product weight range of 30 – 180 kg Scottish Stampings has the flexibility to supply low-to high-volume series in a variety of materials, heat-treated and in finished conditions including fully machined.

Wärtsilä and Sustainable Development

Operational performance

Wärtsilä's mission, vision and sustainable development strategy provide the framework for developing the company's activities and products. They are supplemented by Wärtsilä's Operative Excellence System (OpExS), a tool for continuous improvement. Wärtsilä harmonizes its operations worldwide through its global environmental, quality and occupational health and safety policies and the company's operating principles (Corporate Manual, Code of Conduct).

Wärtsilä's sustainable development is based on three closely interrelated pillars: economic, environmental and social performance.

Economic performance

Economic performance involves meeting the expectations of shareholders and contributing towards the wellbeing of society. This requires that the company's operations are efficient, profitable and competitive.

Good economic performance establishes a foundation for the other aspects of sustainability

Environmental performance

Good environmental performance means sound management of natural resources and operating on the environment's own terms. Protecting the air, soil and water as well as combating climate change and using natural resources in a sustainable way are all important objectives. This applies to both Wärtsilä's operations and to the use of its products.

Manufacturing is the major element in operational performance. The main environmental aspects of manufacturing relate to the use of energy and natural resources, and thus also to the emissions that manufacturing produces. Achieving energy efficiency and reducing emissions are central goals for all Wärtsilä companies and factories.

Social performance

Social performance involves following good practices and procedures in stakeholder relations. This includes such aspects as the wellbeing and skills development of the company's employees, product safety, and smooth co-operation within Wärtsilä's network. Good social performance also requires continuous co-operation with suppliers, partners and local communities.

Wärtsilä service worldwide

Economic Performance

Economic performance involves meeting the expectations of shareholders and contributing towards the wellbeing of society. This requires that the company's operations are efficient, profitable and competitive.

Good economic performance establishes a platform for the other aspects of sustainability – environmental and social responsibility.

Creating economic value-added

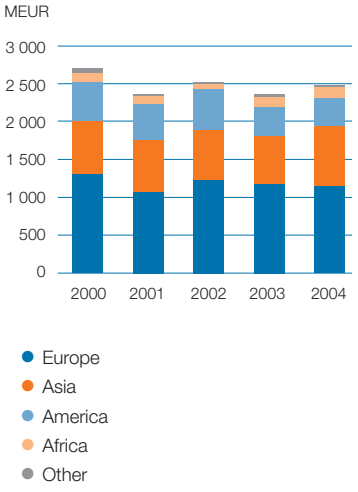
Wärtsilä's purpose is to create value for its various stakeholders. The focus is on profitability and generating a good long-term return on investment for shareholders. Achieving this depends on Wärtsilä's ability to satisfy the expectations of its other stakeholders as well. This includes providing customers with high-quality products, solutions and services, building long-term partnerships with suppliers, offering employees competitive compensation and working conditions, and contributing to the wellbeing of the local communities in which Wärtsilä operates.

Customers

Wärtsilä creates value for its customers by providing products, solutions and services that fulfil their needs and expectations. The development of high-quality, reliable and environmentally sound solutions depends on long-term collaboration and continuous interaction with customers. Wärtsilä provides its customers with service throughout the product lifecycle, thus ensuring optimal performance during the product's lifetime. The modernization of installed products can also extend their service life.

Wärtsilä's net sales totalled EUR 2,478.2 million in 2004. Europe contributed 46%, Asia 32%, the Americas 15% and Africa 6% to Wärtsilä's overall net sales.

Geographical breakdown of markets

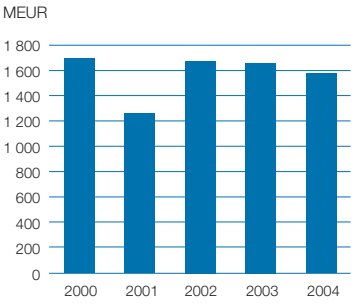


Suppliers

Suppliers play a significant role in Wärtsilä's delivery process. Wärtsilä aims to deepen the partnerships with its suppliers in order to ensure that both parties have a mutual understanding of Wärtsilä's strict process and product requirements. Apart from financial benefits, partnerships create added value for suppliers through the knowledge and development support Wärtsilä offers them. Successful partnership can also assist a local supplier in expanding internationally by becoming a part of Wärtsilä's global supply chain. Structural changes in recent years have had an impact on local supply chains. Wärtsilä has collaborated with its suppliers in minimizing these impacts.

In 2004 the value of goods, materials and services purchased by Wärtsilä was EUR 1,580.9 million. Wärtsilä has more than 7,000 active suppliers, most of whom are located in Europe where Wärtsilä has its main production units. Wärtsilä also has a significant number of suppliers in Asia.

Cost of all goods, materials and services purchased



Value-added distributed to Wärtsilä's shareholders

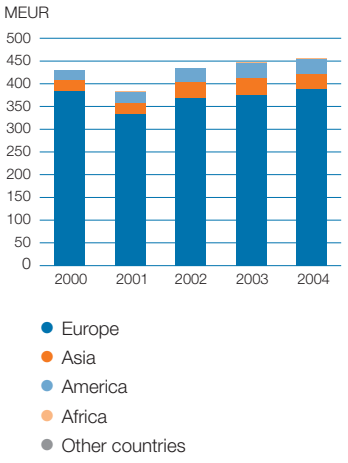
MEUR		2000	2001	2002	2003	2004
Customers	Net sales	2,706.8	2,358.7	2,519.0	2,357.5	2,478.2
Suppliers	Cost of goods, materials and services purchased	-1,708.7	-1,227.1	-1,676.7	-1,666.4	-1,580.9
	Value-added	998.1	1,131.6	842.3	691.1	897.3
	Distributed to stakeholders					
Distribution of value-added						
Employees	Wages and salaries	429.5	382.5	434.2	447.7	456.6
Public sector	Taxes and social dues	221.3	302.2	162.2	110.8	191.7
Creditors	Interest on debt and borrowings	31.0	15.2	18.5	15.9	3.3
Shareholders	Dividends	143.6	237.8	104.1	106.4	83.3
For business development		172.6	193.9	123.2	10.3	162.4

Employees

At the end of 2004 Wärtsilä had 12,475 employees worldwide. Wärtsilä also employed thousands of people indirectly through its supply chain. In order to be able to recruit competent and motivated people, Wärtsilä endeavours to offer employees competitive salaries, opportunities for continuous personal development and a good working environment. Developing employee skills and competences is of critical importance both for Wärtsilä's business performance and for the development of the company's employees.

Salaries totalled EUR 456.6 million in 2004. This sum includes basic salaries as well as payments based on various incentive schemes, which cover some 60% of the total personnel.

Geographical breakdown of wages and salaries

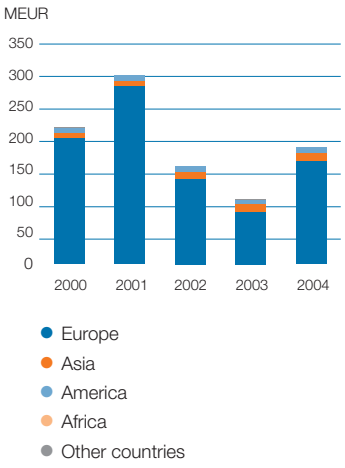


Public sector

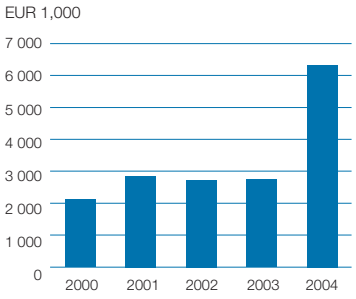
Wärtsilä pays various social dues and taxes to the governments of various countries. Income taxes and social dues in the financial period 2004 were EUR 191.7 million. The social costs for employees that Wärtsilä pays in most countries contribute to the funding of pensions, unemployment and other social benefits that provide security and improve the quality of life for the company's employees and their families.

Wärtsilä companies also receive subsidies from the public sector. The value of the subsidies received in 2004 was EUR 6.3 million and they were mainly related to R&D projects.

Geographical breakdown of taxes and social dues



Subsidies received from public sector[1]



[1]The 2000-2002 figures include the data from 10 major Wärtsilä companies and the 2003-2004 figures from 12 major Wärtsilä companies.

Creditors and shareholders

In 2004 Wärtsilä's net financial items totalled EUR 3.3 million. Dividends totalling EUR 83.3 million were paid to the company's shareholders. Wärtsilä's dividend policy is to pay a dividend equivalent to 50% of its operational earnings per share. In recent years the company has distributed an extra dividend based on the sales of certain non-core business interests. The dividends paid per share are presented in the financial statements.

Community support

At the national level, Wärtsilä provides financial support for a number of national, cultural and social activities. The Board of Directors has supported activities focused on children and young people, national defence, disabled war veterans, and medical and technical research. Wärtsilä's Board of Directors contributed altogether EUR 77,000 to these activities in 2004.

Financial contributions by the Board of Directors[1]

EUR 1,000	2002	2003	2004
	64.5	55	77

At the local level, Wärtsilä has provided financial support to cultural, educational, sports and other activities as shown in the table below.

Financial contributions to local organizations

Total EUR 1,000	2002	2003	2004
	512.8	306.8	385.0

Environmental Performance – Power Businesses

Wärtsilä's strategy is to be a leading global supplier of power solutions. Operational development in line with the principles of sustainable development is a key aspect of the company's operating environment. In all activities associated with developing its activities, processes and products, Wärtsilä aims to use the latest technology available for improving efficiency in materials and energy consumption, and for reducing and managing emissions and wastes. Wärtsilä's targets to the end of 2005 are presented in the table below.

Wärtsilä's principle is to apply certified Environmental Management Systems based on ISO 14001 in all Group companies. The company's environmental system focuses especially on compliance with legal requirements, identifying and reducing environmental aspects, impacts and risks, training personnel and clearly defining their responsibilities, full documentation of activities and procedures, action in emergencies, and continuous improvement of environmental performance.

Wärtsilä's main environmental aspects relate to the use of materials and natural resources, energy consumption, and emissions and wastes generated by the company's operations. The company's environmental records cover production, maintenance and sales units.

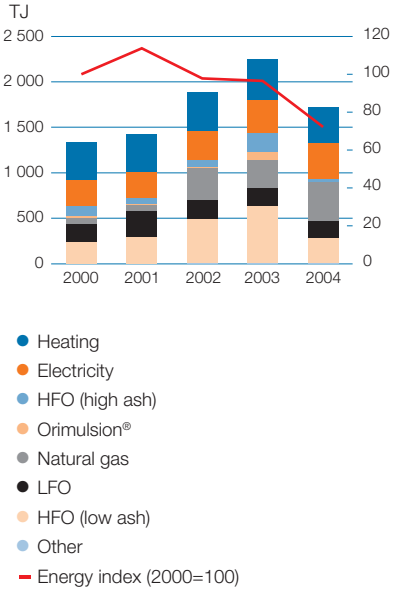
The coverage of environmental reporting has changed since the 2002 Sustainability Report. The figures for 2003 and 2004 include a higher proportion of Wärtsilä companies than in earlier years. Consequently, the figures in this report show an absolute increase in the figures for those years.

ENERGY

Total energy consumption

The total energy consumption (in terajoules, TJ) presented below includes the electricity, heat and fuels used in Wärtsilä companies in recent years.

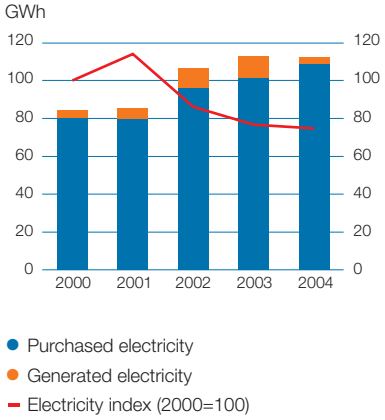
Annual energy consumption



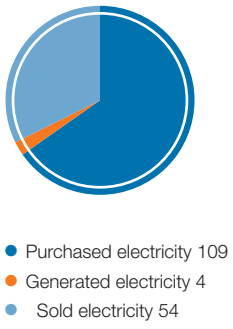
Electricity

Wärtsilä uses electricity in its manufacturing operations – for example, in machining components – and in service workshops and offices. Both the electrical and the heat energy generated during engine test runs can be utilized. Wärtsilä's aim is to use the electrical energy for its own purposes while also selling part of this electrical energy to a local power company. Due to the nature of engine test runs, the production of electricity and the company's electricity demand are not equivalent; this allows the surplus energy to be sold to a local power company.

Annual electricity consumption



Electricity balance 2004, GWh

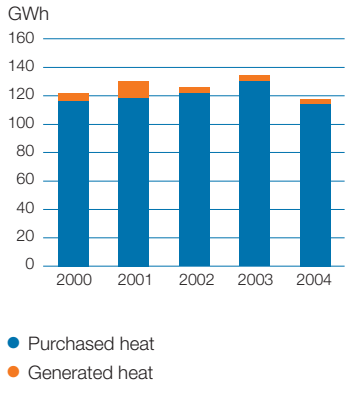


Target	Environmental benefit	Status at end of 2004
To perform energy analyses and improvement programmes in all factories.	Reduced consumption of primary energy, more efficient use of natural resources, and reduced emissions.	Some factories have performed energy analyses and improvement programmes.
To perform a lifecycle assessment for one Ship Power application and one Power Plant.	A deeper understanding of lifecycle environmental impacts.	The lifecycle assessments are ongoing.

Heat

Heating for factories and offices accounts for most of Wärtsilä's consumption of heat energy. In several factories the heat generated in engine test runs is used for heating. Some factories and offices are connected to a local district heating network, some have their own heating plant, and some use electricity for heating.

Annual heat consumption



Water

The water consumed by Wärtsilä can be divided into two categories: domestic use and cooling use. Domestic water is used mainly for sanitary purposes and by industrial equipment such as machine tools and washing machines. Some factories also use water to produce moulds.

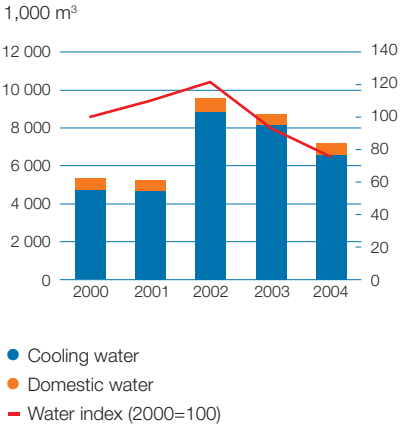
Heat emissions into water systems arise from engine cooling and process cooling water. Wärtsilä companies use water from the local watercourse for their engine and process cooling needs. In such cases, the cooling water system is kept separate so that only heat is released into the natural water system. Wastewater is sewered and piped to the local wastewater treatment plant. If effluent is not suitable for sewage treatment, it is taken to a special treatment plant for hazardous wastes.

Emissions to the air

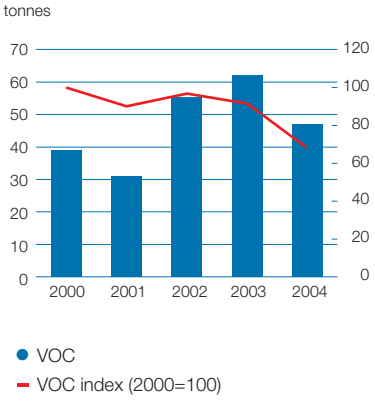
The primary source of manufacturing noise is engine test runs and ventilation machinery on factory roofs. This noise is mostly low frequency and is therefore not easily detected by the human ear. Wärtsilä has specifically addressed the issue of noise protection using technical means and we have succeeded in lowering noise levels considerably. However, noise abatement is a continuous need and requires regular monitoring.

Air emissions are mainly caused by test runs and the painting of completed engines or other Wärtsilä products. Test run emissions consist of nitrogen oxides, sulphur dioxide, carbon dioxide and particles, as well as small amounts of other emission components.

Annual water consumption



Annual VOC emissions



The painting of engines and other Wärtsilä products generates VOC (volatile organic compounds) emissions.

Monitoring environmental impacts

Within Wärtsilä, environmental impacts caused by operational activities are monitored as follows:

- Participation in the monitoring of air quality with other local stakeholders
- Measurement of air emissions
- Charting of noise levels
- Periodical effluent analysis
- Soil analysis.

In addition Wärtsilä Finland Oy has participated in the following surveys: nitrogen fallout patterns, bio-indicator surveys, and NO_x and SO_2 diffusion surveys.

Compliance

The operations of Wärtsilä's production companies require a valid environmental permit. Wärtsilä companies have the required environmental permits, the terms of which are generally met. Incidents of non-compliance are described below.

Environmental disturbances and complaints

The number of disturbances, complaints and incidents of non-compliance are presented in the figure. Reported disturbances cover incidents in which the Wärtsilä company concerned has generally been obliged to report the disturbance to the authorities.

The following main environmental disturbances occurred at Wärtsilä's business locations in 2004:

- 6 fires
- 2 fuel leaks
- 2 lubricant leaks
- 5 chemical leaks
- 1 oily water leak
- 1 leak in an effluent system
- 1 small gas explosion during a test run
- 1 breakdown in the monitoring system.

All the above disturbances were investigated and appropriate corrective action was taken in each case.

Most complaints were received from occupants of neighbouring sites. The main cause for complaint was noise. All complaints were investigated and appropriate corrective action was taken wherever necessary.

Cases of non-compliance

At Wärtsilä Finland Oy there was one case of exceeding the conditions set by the permit relating to emissions of methane from the LNG storage facilities. Consequently, Wärtsilä Finland Oy has applied for an amendment to its environmental permit. The authorities are currently reviewing the matter.

Wärtsilä Iberica SA had three separate incidents of non-compliance relating to:

- Deficient classification of hazardous wastes
- Delay in submitting reports to public authorities
- Deficient maintenance of a cooling tower.

These non-compliances were rectified during 2004.

At Wärtsilä Propulsion Norway AS, an audit of the environmental management system identified deficiencies in the procedures for monitoring compliance with permit conditions. The matter is being investigated and the necessary corrective action will be taken when the solution is found.

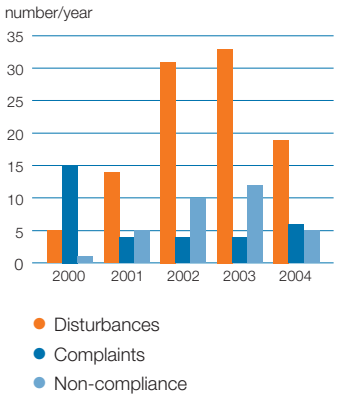
Non-compliance cases presented in previous reports

An internal review conducted by Wärtsilä France identified needs for corrective action, most of which has been taken. The remaining non-compliances related to the height of the stacks and the treatment of wastewater. Action in both cases is still ongoing. Because of the structural changes involved, the measures necessary to rectify these non-compliances, and others that were identified, must be re-evaluated with the authorities.

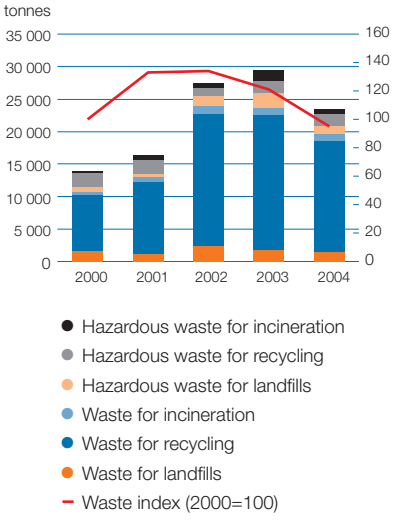
Waste management

Manufacturing activities causes various wastes. These are divided into two main categories: hazardous and non-hazardous. Hazardous wastes include cutting fluids,

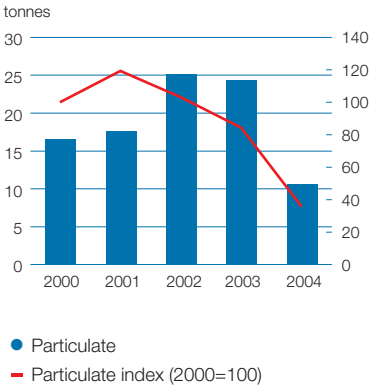
Disturbances, complaints and non-compliance



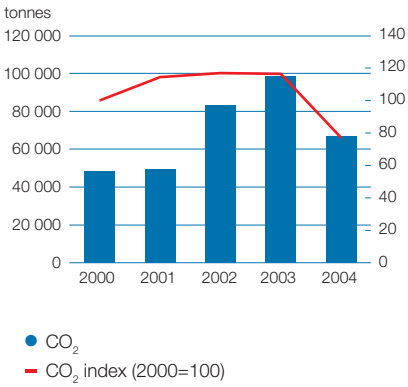
Annual waste



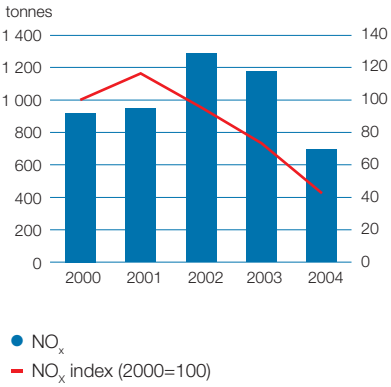
Annual particulate emissions



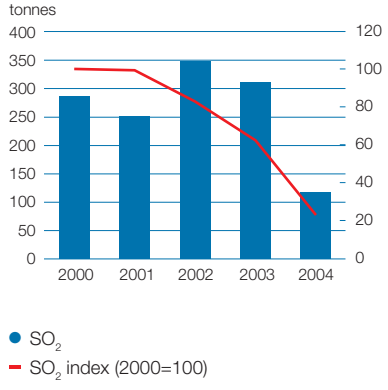
Annual CO_2 emissions



Annual NO_x emissions



Annual SO_2 emissions



Environmental capital expenditures and operating expenses

MEUR	2000	2001	2002	2003	2004
Environmental capital expenditures	3.0	5.2	1.8	2.1	2.8
Environmental operating expenditures	2.4	2.3	4.0	4.9	2.8

various types of waste oil, paints and solvents, oily wastes and solid wastes, etc. Hazardous wastes are taken to a hazardous waste disposal facility for appropriate treatment.

All Wärtsilä companies sort their waste according to local municipal regulations. However, generally speaking the main sorting categories are: waste to be incinerated, crude waste for landfills, clean cardboard, and waste paper. Waste wood, scrap metal and metal chips are collected separately. Only coarse waste and in some cases waste wood are removed for landfill disposal. Other wastes are used either as raw materials or for energy.

Waste management in Wärtsilä has four aims:

- To reduce the amount of the waste generated in Wärtsilä processes
- To use the waste as a material
- To use the waste as energy
- To dispose of the waste in an environmentally sound way.

ENVIRONMENTAL COSTS

Environmental capital expenditure and operating costs are difficult to separate from normal operating costs in our operating environment. It is equally difficult to define capital expenditure as an exclusively environmental investment or as a machine or equipment investment in the production process.

Concerning Wärtsilä's operations, we have defined expenditures as environmental expenditures if they are related to soil, water and air pollution control, waste management, environmental management or noise control.

Wärtsilä's real estate and environmental liabilities

The real estate that Wärtsilä owns is mainly located in urban areas. The company is not aware of any properties that are situated in the biodiversity-rich habitats.

Environmental risks and liabilities are identified and reviewed as a part of overall risk management. In Wärtsilä's operations, potential liabilities are primarily related to the company's real estate. Environmental liabilities are systematically scrutinized in conjunction with every acquisition or sale of real estate. Wärtsilä has recognized certain cases where potential environmental liabilities may exist but these are not expected to have a significant financial impact on Wärtsilä.

Environmental Performance – Imatra Steel

The Imatra Steel Group consists of Imatra Steel Works, the Imatra Kilsta Forge and Scottish Stampings. Imatra Steel's business units work together in close collaboration.

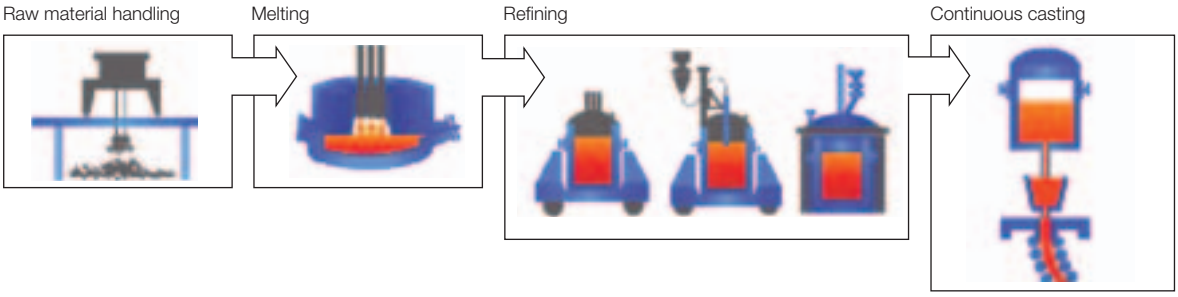
Imatra Steel Works is Europe's leading supplier of long special engineering steels. The plant uses recycled steel scrap as its raw material. The scrap is melted in an electric arc furnace, cast, hot-rolled and further processed according to the customer's needs and specifications into round, square, flat or threaded bars. Steel for forging is delivered hot-rolled and finished. Further processing of the steel bars comprises various forms of heat treatment and a wide range of mechanical treatments and inspections.

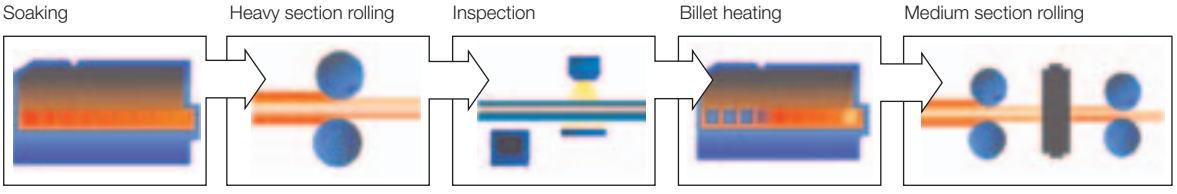
Imatra Kilsta AB is one of the world's leading manufacturers of die-forged products, particularly for the heavy vehicle industry. The factory specializes in heavy crankshafts, front axle beams, steering knuckles and other steering components. Its subsidiary, Scottish Stampings, supplements the product range with its forged and machined front axle beams for trucks and other heavy vehicles.

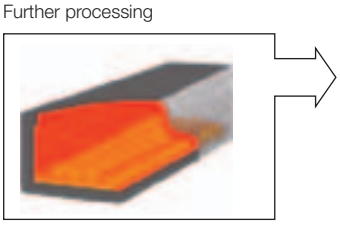
During forging, the steel bar supplied by Imatra Steel Works or another supplier is heated, cut and forged into the form of the forging die. The forged pieces are heat treated, machined, finished and inspected. In some cases the part is ready for its final intended use at this stage, but many customers wish to finalize the process in their own workshops.

Main environmental aspects

Imatra Steel Works has conducted a lifecycle assessment (LCA), in cooperation with the Finnish Environment Institute, to evaluate the most important environmental impacts of steel production. The inventory conducted prior to the LCA covered the production of the raw materials needed for steel production, energy production and the actual manufacturing of steel. The results showed that carbon dioxide emissions contributing to climate change and the oxides of nitrogen and sulphur that cause acidification account for more than 85% of all the large-scale environmental impacts of manufacturing steel bars. All these emissions are related to the use of fossil fuels.







The other production units of Imatra Steel use steel bars as their raw material and consume large amounts of energy. Consequently, the main environmental aspects to address are common to the whole Group: the efficient use of energy and raw materials.

LCA is a suitable method when evaluating wide-scale environmental impacts on air and water, but it is very difficult to link local impacts and waste to LCA.

A survey conducted in August 2002 showed that residents in Imatra Steel's neighbourhood considered the intermittent noises from the smelter scrap yard as the most irritating environmental nuisance, especially during summer nights when noise carries long distances. Scottish Stampings is also located near populated areas, and the response of neighbouring residents in these areas is broadly the same as at Imatra.

The results of lifecycle assessments of waste seldom match the guidelines given by the EU's waste policy. The manufacture of steel and steel products produces large volumes of wastes. Therefore continuous efforts are needed to minimize the generation of waste and to increase recycling.

Environmental management

Environmental matters within the Imatra Steel Group are managed locally in accordance with Group guidelines. Each unit appoints a person who is responsible for monitoring legislation, assisting with compliance and coordinating matters that concern the whole mill or forge. Any environmental action needed is taken by the line organization in each case. The Imatra mill and the Kilsta forge have certified environmental systems in place. Scottish Stampings is currently implementing its own environmental system.

Permits and other legal matters

Implementation of the Integrated Pollution Prevention and Control (IPPC) Directive

The aim of the IPPC Directive is for all industry in the EU area to use the Best Available Technology (BAT) from the environmental viewpoint by the end of 2007. The directive requirements apply to all of Imatra Steel's production sites and will be implemented by incorporating them in the environmental permits for Imatra Steel's operating sites. The schedules for these permits vary slightly from country to country. Scottish Stampings and Imatra Steel Works received their renewed permits in December 2004, while Imatra Kilsta will submit a permit application to the authorities in 2005.

Both Imatra Steel Works and the Environmental Centre of South-Eastern Finland, the supervising authority in this case, appealed to the Administrative Court concerning the terms and conditions of the permits. Imatra Steel Works did not accept the condition limiting the total emissions of particulate matter because this cannot be achieved by applying BAT. The Environmental Centre felt that the provisions on slag and slag products were too open to interpretation. The estimated time for handling the appeals is between eight and ten months.

Imatra Steel Works currently has modern production processes as a result of the large investment programme implemented over the last 15 years. The production equipment, processes and minimal environmental impacts of the Works clearly fulfil the BAT requirements. Therefore, the terms and conditions of the permit are reasonable from Imatra Steel Works's standpoint and do not require large investments. Many of the terms and conditions support the principle of continuous improvement already embodied in the ISO 14001-compliant environmental system that Imatra Steel Works uses. The new environmental permit is valid until the end of the year 2013.

The European Union's Emissions Trading Scheme

Imatra Steel Works falls within the scope of the Emissions Trading Directive and will thus participate in the Emissions Trading Scheme between 2005 and 2007. Imatra Steel Works has been granted an emissions permit and emissions rights for that period. It is estimated that the direct effects on Imatra Steel's financial performance will be quite minor because of the factory's current low level of emissions. However, the indirect effects caused by electricity price changes are as yet unknown. A number of reports forecast a sharp rise in the cost of electricity, especially during years of low rainfall in the Nordic countries.

Material consumption

Steel can be produced from iron ore or steel scrap. Imatra Steel Works's raw material is solely scrap, which consists mainly of industrial cutting and machining wastes, steel from demolished buildings and structures, as well as machines, vehicles and other objects rejected in industrial, commercial and private activities.

Using scrap saves large amounts of iron ore, as well as lime and other raw materials. The amount of energy required in the electric arc furnace process is only 25% of that needed in the ore-based process, which in turn means less carbon dioxide emissions to contribute to the greenhouse effect.

Imatra Steel's processes provide a good example of the environmental benefits of using materials effectively. Manufacturing steel parts with complex shapes by forging produces much less scrap than other methods, such as machining. Although the metal chip produced in machining is re-used as raw material, forging makes the environmental impacts caused by manufacturing the steel chip unnecessary.

Monitoring environmental impacts

All Imatra Steel companies monitor the efficiency of their material usage and energy consumption as an essential part of managing their production costs. Environmental impacts are monitored according to the terms and conditions of the environmental permits.

ENERGY CONSUMPTION

Total energy consumption

The production of steel and steel products is highly energy-intensive. Energy consumption is the third highest production cost after raw materials and labour costs. Consequently, the need to use energy effectively pre-dates environmental concerns in the steel industry and has always been an important factor in developing and operating production processes.

Imatra Steel Works is committed to energy conservation and aims to increase energy efficiency in all its processes through systematic reviews and critical evaluation of the results, and by development programmes for enhancing energy efficiency.

Electricity

The electric arc furnace and adjoining processes use roughly 75% of the electricity consumed at Imatra Steel Works to produce raw steel from scrap. The hot rolling of steel bars and various forms of pumping also consume high volumes of electricity. Pumps are used for pumping cooling water and hydraulic fluids, fans for combustion air and flue gases, and compressors to produce compressed air. Other processes play a minor role in terms of electricity consumption. Most of the electricity consumed by the forges is used to heat the steel bars for hot forging and heat treatment.

Fuels

Half of the total energy used in Imatra Steel is produced from fossil fuels, mainly natural gas, LPG, and heating oil. Most of this energy is used for direct heating of material to the temperature of 1,200 – 1,300 °C that is required for hot forming processes, mainly rolling or forging, and to lower temperatures for the heat treatment of steel and steel products in order to give them the mechanical properties that steel parts for machine components need. Other types of processes use fuels for, among other things, heating ladles and producing steam for vacuum pumps. Fossil fuels are also used for heating factory buildings and offices, and for internal transport.

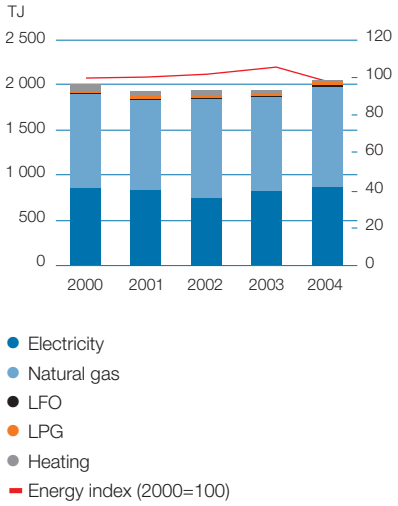
Heat recovery

The main aim in designing production equipment for a particular process must be the overall internal efficiency of that process; in other words, the energy output of the process must ideally be re-used in the same process. Thus the hot flue gases from the electric arc furnace at Imatra Steel Works are used to preheat scrap, and the billet reheating furnaces are equipped with recuperators that use the flue gases to preheat the combustion air. Recuperative burners are also used in some smaller units for the same purpose. The heat contained in the cooling water of the bloom reheating furnace, the largest heating unit in Imatra Steel Works, is used externally to heat some factory buildings and office blocks.

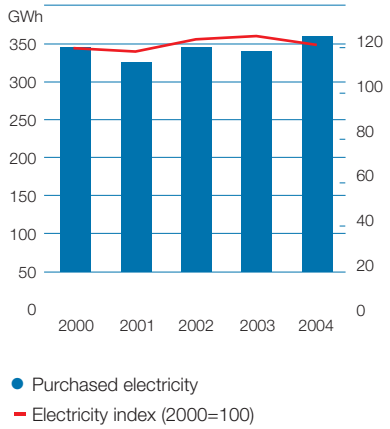
Water consumption and discharges of sewage

Tools and production equipment – and sometimes the product itself – require large volumes of cooling water since steel production involves high temperatures. A total of 12.6 million cubic metres of river and rainwater were used for this purpose in 2004.

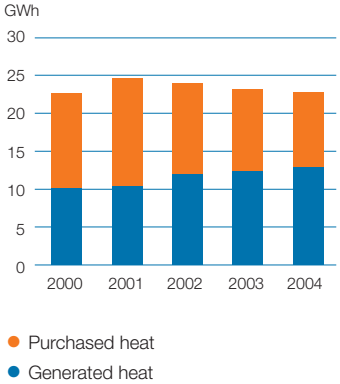
Annual energy consumption



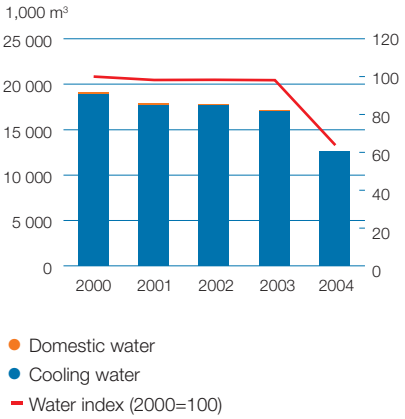
Annual electricity consumption



Annual heat consumption



Annual water consumption



Discharges to the watercourse

Imatra Steel uses several technologies to reduce flows of water and emissions to the watercourse:

- Cooling water flows in a closed circulation system and heat is evaporated in cooling towers (total flow not reported)
- Clean cooling water is kept separate from other water, so that heat is the only emission into the watercourse (10.5 million cubic metres)
- Contaminated process water is treated and cooled enough to be recycled for purposes that do not set high requirements on water quality (10.6 million cubic metres).

Imatra Steel Works and Imatra Kilsta have their own sewage treatment plants. The discharged water (2.8 million cubic metres in 2004) contains oils and suspended solids. The oil originates from lubrication used in the bearings of the rolls and other machine components as well as occasionally from hydraulic fluid leakage. Most of the suspended material is fairly harmless iron oxide from hot rolling and forging, but the water also contains small amounts of metals used as alloying elements in steel production. Discharged water also contains zinc and lead from the scrap used as raw material but generally these metals are bound to the suspended solids and are efficiently removed during the treatment of wastewater.

The provisions of the permits for both production sites set limits on the emissions of suspended solids and oil. Imatra Steel Works monitors its emissions of copper, lead, nickel and zinc as a part of the mill's normal procedures for monitoring environmental impacts.

All Imatra Steel sites have separate sewage systems for taking sanitary discharges to municipal sewage treatment plants.

EMISSIONS TO AIR

Carbon dioxide

Emissions of carbon dioxide are calculated from material balances. Most emissions originate from the burning of fuels. The remainder, some 15,000 tonnes a year, is produced by metallurgical reactions in the manufacturing process for liquid steel. The carbon dioxide emissions monitoring programme that Imatra Steel uses complies with the regulations of the European Union's Emissions Trading Scheme.

Sulphur and nitrogen oxides

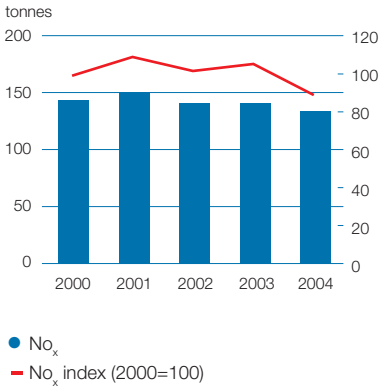
The majority of oxide emissions originate from the use of fuels, and emission volumes are calculated using general emission factors. The production of liquid steel generates the remainder of the emissions, which are calculated according to measured emission factors.

Particulate matter and metals

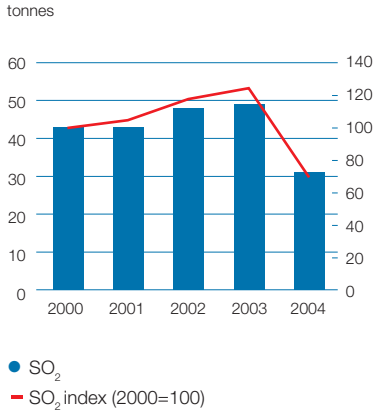
The methods for estimating volumes of particulate matter and metal emissions and the reliability of the estimates vary, depending on the emission source. For emissions typical for one ducted source, such as the stack for the EAF flue gas filtering system, the emission factors are determined using standardized measuring procedures. Generally, estimates based on these procedures are highly accurate. When there is a single emission source for several pollutants, such as mercury, lead and zinc, the annual estimates for the volumes of these pollutants are also reliable.

However, the situation with regard to diffuse emissions of particulate matter including dust-bound metals, such as iron and alloying elements, is entirely different. Most processes in the production of steel and steel products are dusty and require high temperatures. Even though the major sources of dust are isolated and the evacuated air is effectively cleaned, some dust is always present throughout the process environment. Many process

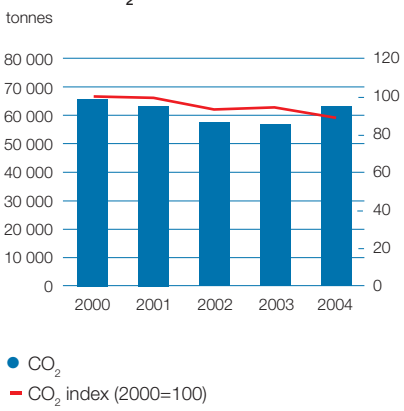
Annual NO_x emissions



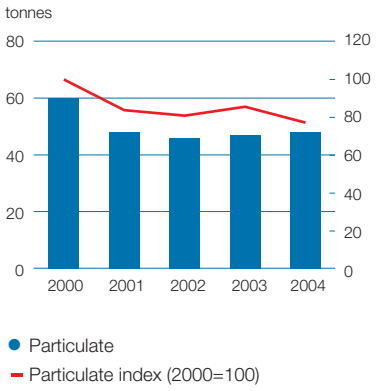
Annual SO_2 emissions



Annual CO_2 emissions



Annual particulate emissions



steps require very large volumes of ventilation air to maintain acceptable working conditions because of the heat. Despite the low dust concentration of the evacuated air, these emissions of air are the major source of dust emissions at all of Imatra Steel's production sites. There is no reliable method for determining the amount of these diffuse emissions. Therefore estimates of the total amount of dust emissions cannot be very accurate.

Volatile organic compounds (VOC)

All Imatra Steel sites emit VOC emissions due to solvents used in the washing of machine components during servicing. The emission factor for Imatra's electric arc furnace was measured for the first time in 2004, which explains the increase in VOC emissions compared to previous years.

Other emissions into the air

The melting of scrap in the electric arc furnace generates a variety of organic compounds, which then mix with the flue gases. Imatra Steel Works monitors the emissions of three major compound groups: polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB) and polychlorinated benzo-p-dioxins and -furans (dioxins). All of these compounds persist in the environment and tend to accumulate in food chains. Some of them are toxic or highly toxic to human beings and animals. These emissions are monitored, partly for reporting purposes but mainly to verify to the authorities that the emissions are kept at an acceptable level.

Noise

As almost all Imatra Steel's units are located close to population centres, noise management issues are highly important.

Several Imatra Steel works has performed several studies to reduce noise levels. Basic noise abatement measures were taken when building the smelter and scrap yard at Imatra. A noise barrier has since been installed in the scrap loading area for the electric arc furnace to reduce the noise produced by handling scrap. These measures, combined with annual training sessions, have yielded excellent results. Nevertheless, in addition to a subdued but steady rumbling, the factory emits occasional banging noises that some people find disturbing. However, the factory's noise level does not exceed the limits set by the environmental permit.

The situation is broadly the same for Scottish Stampings. In 2004, the company planned a noise management programme which will be tested during the summer.

Waste

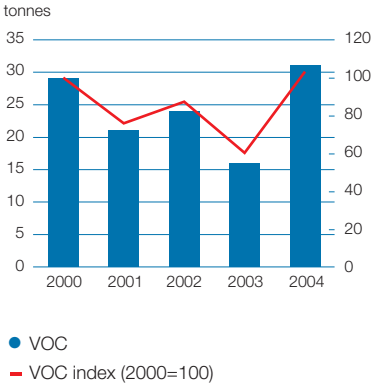
In this report, Imatra Steel follows the practice of classifying untreated steel slag from the electric arc furnace as waste, and steel scrap as a secondary raw material.

Steel slag, rolling scale (oxidized iron) and used refractory materials constitute over 90% of Imatra Steel's non-hazardous waste. Steel slag is processed into a byproduct used in road construction aggregate, and rolling scale is used as raw material in the cement and iron industry. The use of refractory waste (some 2,500 t/a) in the EAF process was fully implemented in 2004 although some of the waste, roughly 20%, is not suitable for use and is transported to landfills.

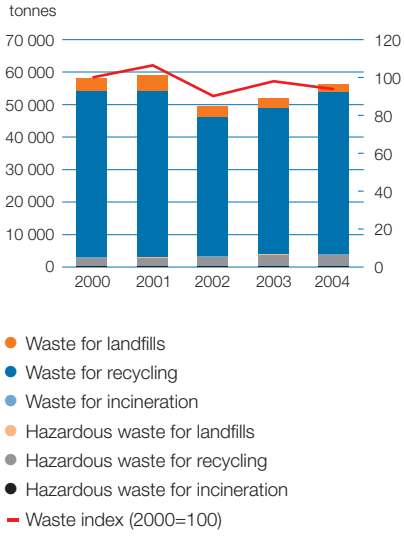
The dust separated from the flue gases of the electric arc furnace accounts for over 90% of the total amount of hazardous wastes produced by Imatra Steel. Over 35% of the dust is zinc originating from galvanized and electroplated steel scrap. The dust is transported to a treatment plant, where more than 1,000 tonnes of zinc per year is separated. The profits generated in this way significantly reduce the otherwise high transport and treatment costs of the dust.

Apart from the EAF dust, there are some 15 designated hazardous wastes that originate mainly from service functions. In terms of weight, these mainly consist of various grades of waste oil and oily solid wastes.

Annual VOC emissions



Annual waste emissions



Compliance with legislation, environmental permits and other requirements

The operation of Imatra Steel's production sites complied with environmental laws, permits and agreements in 2004, and there were no disturbances or accidents that required reporting to the authorities.

Recorded complaints

There was one complaint to Imatra Steel Works concerning the dust generated by the treatment of slag. Corrective action to avoid excessive dust generation in future consisted of a meeting with the subcontractor responsible for the slag treatment at which the agreed rules and the importance of following them were discussed.

Scottish Stampings received four complaints about environmental noise in 2004. The sources of the nightly banging noises were charted and in the autumn a programme was designed to reduce the noise. The practical effectiveness of the programme will be assessed over the summer.

Environmental costs

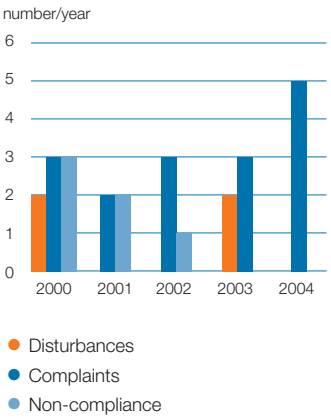
Imatra Steel's operating costs for environmental conservation in 2004 amounted to a net EUR 1.93 million. Corresponding capital expenditure totalled EUR 0.23 million.

Environmental liabilities

During their evaluation of environmental risks, Imatra Steel Works and Imatra Kilsta assessed the environmental impacts of their past activities in the areas that are suspected of being contaminated. Scottish Stampings has conducted a similar assessment as demanded by the authorities, and the results have been approved. The contamination is mainly related to oily soil. Because the contaminated areas are relatively small and the associated liabilities are limited, the remediation will be conducted progressively as a part of normal operations.

A systematic assessment based on taking samples and covering the entire factory area and all potential pollutants has not been conducted at any of Imatra Steel's production plants.

Disturbances, complaints and non-compliance



Social Performance

Wärtsilä's social performance strategy defines the central objectives for Wärtsilä's operations. Wärtsilä's intention is to act as a good corporate citizen, to offer an interesting, motivating and hazard-free workplace to its employees, and to enhance employee skills and supply chain management. In 2004 Wärtsilä approved its Code of Conduct for achieving these goals. Each Wärtsilä employee is required to act in compliance with the Code of Conduct and each Wärtsilä subsidiary must verify compliance locally.

Wärtsilä's Board of Management has approved the following objectives for the company's social performance:

- Verification of compliance with the Code of Conduct, and the creation of monitoring procedures and reporting practices in 2005-2007
- Review and update of supplier requirements so that they conform with the Code of Conduct in 2005
- Introduction of Occupational Health and Safety Systems in all subsidiaries.

Structural changes in the company

In 2004 Wärtsilä continued implementing measures to match production to the prevailing level of demand. In January the company announced its plan to close down production of Wärtsilä 46 engines at the Wärtsilä factory in Turku, Finland, and to centralize production instead at the company's factory in Trieste, Italy. Trieste was selected as the manufacturing location for large engines because its premises were more suitable and because no significant investment was needed to increase the factory's manufacturing output.

After negotiations with personnel, as required by Finnish legislation, it was decided to continue manufacturing Wärtsilä 46 engines in Turku until the end of 2004, after which service and support activities, and certain other functions, would remain in Turku, generating employment for some 200 people. The net result was a loss of 407 jobs, although about 130 employees included in this figure could be entitled to various pension benefits. Wärtsilä's aim in this difficult restructuring was to act responsibly by, for instance, offering longer periods of notice than normal and making special arrangements for senior employees.

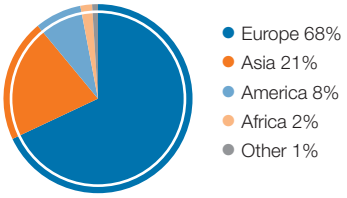
In Wärtsilä France, measures started the previous year to cease production of high-speed engines were completed. This will result in the loss of about 305 jobs. Of these, 43 employees have been re-located within the company. Wärtsilä prepared a comprehensive social plan to safeguard personnel benefits.

Wärtsilä's Service division has expanded strongly in recent years and the Ciserv units, in particular, have grown in number. Wärtsilä recruited altogether 385 skilled employees in 2004 to meet the growth in the Service business. This figure also includes corporate acquisitions.

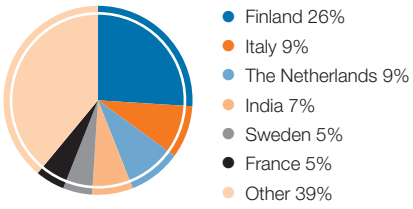
Personnel

Wärtsilä's personnel mainly comprises full-time employees with permanent employment contracts. The number of temporary and part-time employees is relatively low. The number of Wärtsilä's employees has remained fairly stable over the past few years, despite restructuring. In addition to direct employment, Wärtsilä also uses subcontractors in its factories, accounting for altogether 1,170 man-years of work in 2004.

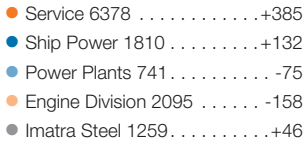
Personnel by market area



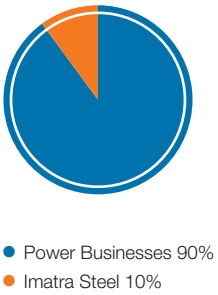
Personnel by country



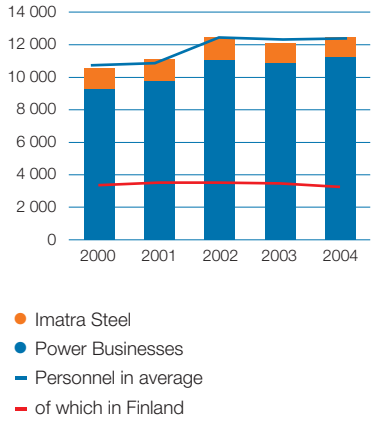
Change in number of employees per business



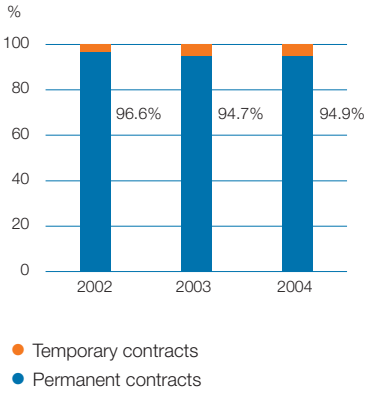
Personnel by business



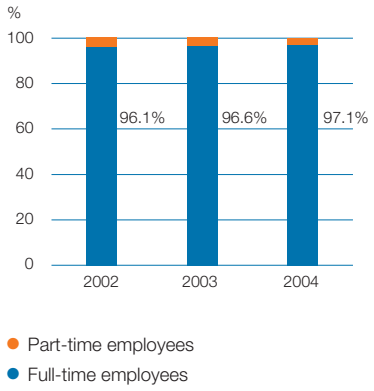
Personnel by business



Permanent/temporary employees



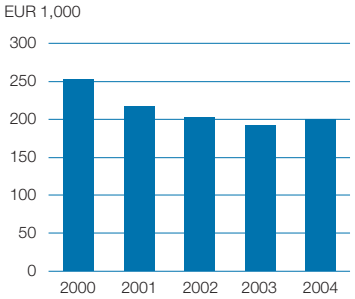
Full-time/part-time employees



Personnel in figures 2004

Total	12,475
Nationalities of personnel:	68
Change in number of employees (net employment creation):	+177
Average age of personnel:	34.8 years
Total payroll costs:	EUR 573.3 million
Aggregate coverage of different bonus systems:	60%
Development discussions held annually:	58%

Net sales/person



In many European countries almost all employees fall within the scope of collective bargaining agreements, with the exception of senior management. The proportion of personnel belonging to trade unions ranges between 70% and 100%. In other countries the proportions vary so much that a Group-wide average would not give a true picture. Matters affecting personnel are also reviewed in the Annual Report.

Consulting and informing in Group companies

Wärtsilä's procedures for consulting and informing within the Group are arranged in each country according to local legislation. Wärtsilä's Code of Conduct calls for ongoing and open dialogue between the company's management and employee representatives through co-determination bodies, and employees are kept informed of both the Group's situation and that of their particular company. Company management and personnel engage in open discussion also in those countries where there are no formal co-determination bodies as such. Regular briefings for personnel are an integral part of the operating procedures of Wärtsilä companies. Employee participation in decision-making also extends to occupational health and safety (OHS). Most Wärtsilä units have an OHS committee with representatives from all personnel groups.

In addition to Wärtsilä's procedures for consulting and informing employees at the local level, the European Works Council (EWC) handles issues that affect the whole Group. The EWC and its working committee play an active role in considering and pursuing Group-wide issues. Employee satisfaction surveys are reviewed in the Stakeholder Engagement section of the Annual Report.

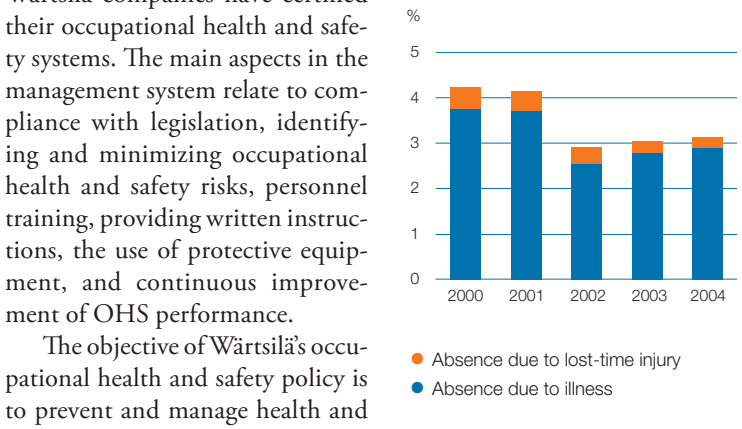
Occupational health and safety

Wärtsilä's occupational health and safety principles are defined in the company's policy and directive on occupational health and safety (OHS). Wärtsilä's subsidiaries must have a management system in use that conforms to the OHS policy and directive. Although certification is not a requirement, 11 Wärtsilä companies have certified their occupational health and safety systems. The main aspects in the management system relate to compliance with legislation, identifying and minimizing occupational health and safety risks, personnel training, providing written instructions, the use of protective equipment, and continuous improvement of OHS performance.

The objective of Wärtsilä's occupational health and safety policy is to prevent and manage health and safety risks to personnel and stakeholders. In addition to the management system, Wärtsilä companies apply OHS programmes required by local legislation, which are normally implemented in OHS committees consisting of representatives of the companies' management and personnel. Accidents are recorded and investigated in the manner required by local legislation. Altogether 60% of Wärtsilä companies have an occupational health and safety committee.

The indicators used to measure occupational health and safety performance include the number of injuries, the amount of absence due to illness and the frequency of injuries. There were no fatal injuries in Wärtsilä's factories or offices during the review period.

Absence rate

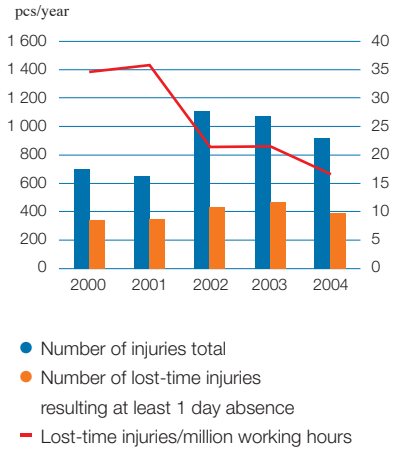


Training and personal development

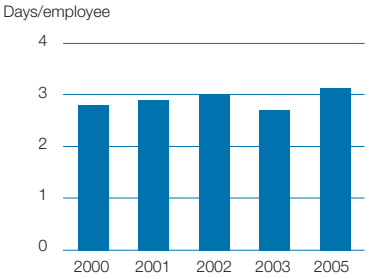
Wärtsilä has a comprehensive personal development programme, the aim of which is to continuously improve the skills, motivation and co-operation of the company's employees and managers. The target is 5 training days per person per year. Management skills programmes, such as Lead and Energo, focus on enhancing supervisory and management skills. The programmes also emphasize the importance of Wärtsilä's values in everyday management work. Wärtsilä provides training for senior management in co-operation with the London Business School.

Wärtsilä's training organization arranges a variety of open courses for employees as well as numerous courses tailored to the special needs of individual departments.

Injuries



Training days



Trainin days

Days/employee	2003	2004
Managers	3.2	2.5
Technical employees	3.5	3.4
Administrative employees	2.2	2.4
Blue-collar employees	2.6	3.3

Human rights

In line with the Code of Conduct approved at the end of 2004, Wärtsilä supports and respects basic human rights as outlined in the UN's Universal Declaration of Human Rights. Wärtsilä expects its suppliers to operate in compliance with the same ethical standards with regard to human rights.

Wärtsilä's employees represent almost 70 different nationalities, and the company supports equal treatment of all its employees irrespective of race, colour, nationality, gender, age or religion. The company's employees are selected on their qualification and competence for each specific job.

Wärtsilä supports the work-related rights defined by the International Labour Organization (ILO) and therefore works to ensure there is freedom of association and the right to collective bargaining in the company. In those countries where local legislation does not recognize these rights, Wärtsilä endeavours to give employees other channels for expressing their opinions. Wärtsilä does not accept the use of forced labour or child labour in any form.

These commitments have been an integral part of Wärtsilä's way of working, which were codified in the Code of Conduct that Wärtsilä endorsed at the end of last year. Wärtsilä's Board of Management has also decided on practical implementation of the Code of Conduct during 2005 – 2007. The first step in the implementation plan is a wide-scale campaign to disseminate information internally through the company's magazines and intranet. The Code of Conduct will also be a

topic at all levels of Wärtsilä's internal training programmes. Wärtsilä's compliance programmes, internal audits and OpExS management systems will be used to monitor the effectiveness of these measures.

Since Wärtsilä expects its partners and suppliers to act in compliance with its Code of Conduct, similar measures will also apply to them. The company sets common requirements for its suppliers and regularly monitors conformance with these requirements through numerous performance indicators and audits. All the main suppliers are required to comply with Wärtsilä's requirements in order to gain Approved Supplier status.

Impacts on communities

The guiding principle of Wärtsilä's Code of Conduct is to promote openness and good interaction with our stakeholders locally. This applies as much to the families of personnel, our neighbours, educational institutions and the media as to local authorities and officials. The methods we have used towards this end include Open Door days, press briefings and different modes of communication for different target groups. Wärtsilä's activities for charitable purposes are described in the Economic Performance section of this report.

Wärtsilä collaborated closely with local authorities on a daily basis concerning the closure of production activities at Turku (Finland) and Mulhouse (France) in order to find new jobs and minimize the detrimental effects of these closures. Suppliers Days were arranged in both Turku and Trieste for suppliers of the Turku factory to review the impacts caused by the change and create a framework for continuing supplier relationships into the future.

Wärtsilä as an employer

In 2004 Wärtsilä Brazil was named one of the 100 best employers in Brazil. This was the 8th time that Great Place to Work® Institute Brazil evaluated companies operating in the country, and altogether 460 companies participated in the competition. In 2003 Imatra Steel's Steel Works won Technology Industries of Finland's award for the best work environment among Finnish metal refining companies.

Bribery and corruption prevention

Wärtsilä's Code of Conduct expressly prohibits the company and its employees from accepting or offering any kind of benefit considered to be a bribe. Only normal business gifts of nominal value may be given or accepted. The instructions, which make it compulsory to comply with anti-bribery provisions and to report any cases of bribery, also make reference to the OECD's anti-bribery legislation and principles. The company updated and clarified its agent agreements and Broker Guidelines during 2004 in response to claims of bribery in certain project which Wärtsilä considers to be groundless.

Political lobbying

Wärtsilä's policy is engage in open dialogue and discussion with both local and international public authorities and officials. An important area of co-operation in this forum is the reduction of emissions from energy production. Stakeholder co-operation with public bodies is a part of Wärtsilä's business operations and not a political activity.

Competition regulations

Wärtsilä has a compliance programme for managing risks relating to competition law, and the company's corporate management are strongly committed to implementing this programme. Wärtsilä's various subsidiaries conducted reviews of compliance with competition regulations when formulating the programme and during the course of mergers and acquisitions. No infringements of competition regulations were identified. The programme documentation includes a manual of competition law, which provides information about competition regulations and instructions for the company's internal procedures. Wärtsilä has also arranged training in competition law for key personnel.

Product liability

Wärtsilä's occupational health and safety policy defines procedures for ensuring product safety. Further information about issues relating to product safety is given in the Policies and Management System section of the Annual Report.

Customer satisfaction

Wärtsilä conducts customer satisfaction surveys, as described in the Stakeholder Engagement section of the Annual Report. The results for 2004 are based on a new measurement system and are as follows:

- Ship Power 7.5
- Service 7.8
- Power Plants 8.0.

Summary of Key Figures

Performance indicators[1]	2000	2001	2002[2]	2003[3]	2004[3]
ECONOMIC					
R&D expenses [EUR mill.]	81	82	88	70.2	59.4
Environmental investments [EUR mill.]	3.02	5.19	1.83	2.23	3.05
Environmental operating expenses [EUR mill.]	2.45	2.25	6.02	6.93	4.71
ENVIRONMENTAL: Power Businesses					
Total energy consumption [TJ]	1,340	1,348	1,923	2,251	1,723
• Electricity consumption [MWh]	84,315	85,193	106,617	112,806	112,324
• Heat consumption [MWh]	121,746	130,179	126,294	134,944	117,684
• Light fuel oil [t]	4,691	4,872	4,866	4,862	4,474
• Heavy fuel oils [t]	8,353	8,571	13,552	20,146	7,169
• Natural gas [t]	1,366	1,365	7,611	6,785	9,625
• Other fuels [t]			242	146	188
• Orimulsion® [t]	797	342	232	3,275	0
Total water consumption [1000 m^3]	5,357	5,222	9,570	8,710	7,207
• Consumption of domestic water [1000 m^3]	609	530	727	576	606
• Consumption of cooling water [1000 m^3]	4,748	4,692	8,843	8,134	6,601
Emissions of nitrogen oxides [t]	919	947	1,287	1,174	696
Emissions of carbon dioxide [t]	48,492	49,155	83,232	98,419	66,586
Emissions of sulphur oxides [t]	286	252	348	310	117
Particulates [t]	17	18	25	24	11
VOC [t]	39	31	55	62	47
Non-hazardous waste [t]	10,622	12,921	23,887	23,608	19,587
Hazardous waste [t]	3,320	3,533	3,644	5,835	3,913
ENVIRONMENTAL: Imatra Steel					
Total energy consumption [TJ]	2,001	1,915	1,917	1,942	2,047
• Electricity consumption [MWh]	297,000	279,000	298,000	291,299	313,462
• Heat consumption [MWh]	22,600	24,600	24,000	23,256	22,643
• Light fuel oil [t]	88	100	320	364	247
• Natural gas [t]	17,083	16,715	15,118	16,522	17,442
• Liquified petroleum gas [t]	1,080	973	948	423	25
Total water consumption [1000 m^3]	19,056	17,853	17,754	17,113	12,591
• Consumption of domestic water [1000 m^3]	156	153	154	158	44
• Consumption of cooling water [1000 m^3]	18,900	17,700	17,600	16,955	12,547
Emission of nitrogen oxides [t]	143	150	139	139	133
Emissions of carbon dioxide [t]	66,500	62,900	58,900	57,558	62,309
Emissions of sulphur oxides [t]	43	43	48	49	31
Particulates	60	48	46	47	48
VOC [t]	29	21	24	16	31
Non-hazardous waste [t]	55,260	56,040	46,600	48,336	52,677
Hazardous waste [t]	2,700	2,790	2,960	3,686	3,645
SOCIAL					
Training days [days/employee]	2.9	3.0	3.0	2.9	3.1
Number of lost-time injuries	348	356	422	467	382
Lost-time injuries [number/million working hours]	34.6	35.8	21.4	21.5	16.6
Absence rate [% of total working hours]	4.24	4.14	2.92	3.04	3.13

[1] The operational performance data in this report has been compiled from the economic, environmental and social records of the Wärtsilä companies. Whilst every effort has been made to ensure that the information is neither incomplete nor misleading, it cannot be considered as reliable as the financial information published in the Financial Review.

[2] The 2002 figures include the second-phase companies, which are presented in the previous report.

[3] The 2003 and 2004 figures include the third-phase companies, which are presented in the previous report. The third reporting phase includes all Wärtsilä companies except those mentioned in the Report Scope section.

Assurance Statement

At the request of Wärtsilä Corporation, we have reviewed the sustainability reporting of Wärtsilä Corporation consisting of the economic, environmental and social data and statements presented according to the GRI content index in the Business Review and Sustainability Report of the Annual Report 2004 of Wärtsilä Corporation for the years 2003 and 2004. We have also reviewed the systems and methodologies behind the data. The data presented is the responsibility of and has been approved by the Board of Management of Wärtsilä Corporation. The inherent limitations of completeness, consistency and accuracy of the data are set out in the Business Review and Sustainability Report of the Annual Report 2004 of Wärtsilä Corporation.

This engagement was conducted in accordance with the International Standards for Assurance Engagements. We planned and carried out our work to provide reasonable, rather than absolute, assurance on the reliability of the data presented that was subject to assurance.

Our review consisted of the following procedures:

- a discussion with management responsible for compiling the report;
- an examination of relevant supporting information for the data presented;
- a review in more detail of the systems for gathering and processing data at the operating level at one site in Norway and one site in India, selected by us.

Sustainability reporting presented in the Business Review and Sustainability Report of the Annual Report 2004 of Wärtsilä Corporation has been prepared in accordance with the 2002 GRI Guidelines. Based on our activities, nothing has come to our attention that causes us to believe that the data presented according to the GRI content index in the Business Review and Sustainability Report of the Annual Report 2004 of Wärtsilä Corporation would not have been gathered and processed according to the internal reporting guidelines and would not describe the present state and progress of the issues presented in the Business Review and Sustainability Report of the Annual Report 2004 of Wärtsilä Corporation.

Helsinki, 14 March 2005

KPMG OY AB

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