2015

POWER PLANTS SOLUTIONS

WÄRTSILÄ

THE POWER SYSTEM OF THE FUTURE. AVAILABLE TODAY.

Electricity consumption will continue to grow rapidly during the coming decades. At the same time, concerns related to global warming and declining fossil fuel resources have created a need to reduce carbon emissions through renewable power. Nowadays, renewable sources, hydropower excluded, cover a good 3% of total production, but their share is rapidly growing.

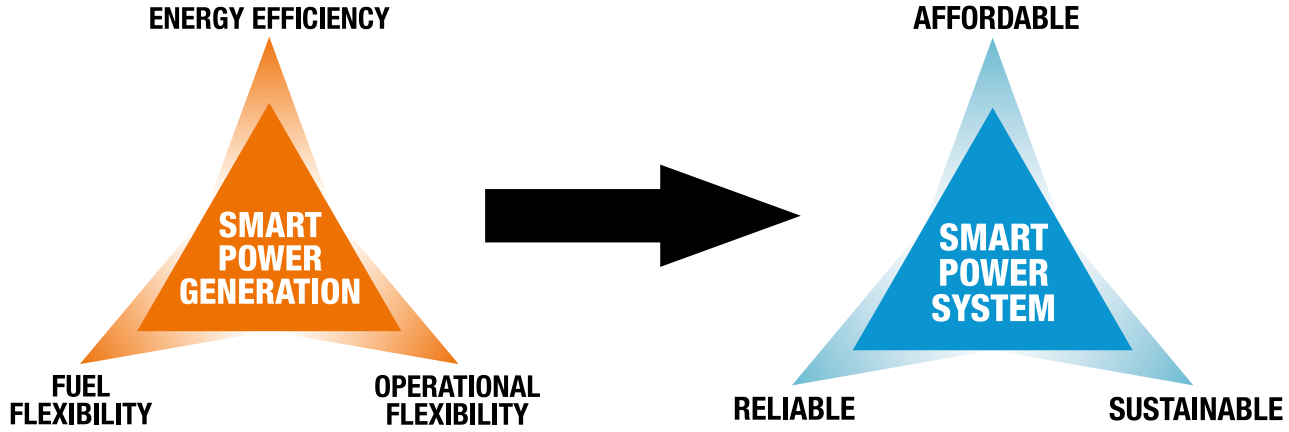
If intermittency problems can be efficiently resolved, wind and solar power offers great potential. Their variability creates new challenges to power systems which cannot be solved by any grid solution. Even small variations in wind speed – which can happen many times per day within time frames of less than 15 minutes – have a dramatic impact on wind power output. In power systems with high shares of installed wind power capacity, this is a challenge which the system is not designed to handle.

The existing power systems need to be complemented by dispatchable, dynamic capacity with the capability of handling frequent fast starts, stops and load ramps. To ensure a sustainable, reliable and affordable power system a dynamic capacity which corresponds to roughly half of the installed intermittent power capacity is required.

BALANCING THE POWER SYSTEM

Wärtsilä's power plants enable the transition to a sustainable, reliable and affordable power system. The main cornerstones are very high energy efficiency, outstanding operational flexibility, and multi-fuel operation. The applications range from stationary and floating base-load power plants to dynamic grid stability and peak load services, balancing large input fluctuations of wind and solar power, as well as serving a wide variety of industrial self-generation needs.

Reservoir hydropower, where available, and smart grids with demand response, assist in the balancing task. When complementing the power system with Wärtsilä's solutions, all balancing challenges can be solved, maximising the use of intermittent renewables.



OPERATIONAL FLEXIBILITY

Being able to operate in multiple modes, from efficient baseload power production to dynamic system balancing in combination with, for example, wind or solar power, Wärtsilä power plants become a key factor in optimising power systems.

They offer ultra fast, zero-emissions, non-spinning grid reserve for any contingency situation or grid black start. They can generate mega-watts to the grid in less than a minute from start-up and reach full load in less than five minutes. They are designed to start and stop – at the push of a button – time after time without impact on maintenance.

The multi-unit configuration allows plant availability and reliability of close to 100%, as well as highest possible firm capacity. They also ensure rapid load following and peak load capability with fast frequency regulation and an efficient spinning reserve.

Wärtsilä's plants are also easy to locate next to critical load pockets, i.e. in cities, thanks to plant size, and low emission and noise levels, and thus reduce the grid investment cost notably. The infrastructural requirements are modest, with little or no water consumption, and lowpipeline gas pressure needed.

ENERGY EFFICIENCY

Power plants based on multiple generating units are far more reliable and fuel efficient than single – or several – large power stations. They also serve efficiently on part load and in demanding ambient conditions, enabling high dispatch even in hot climates and at high altitudes. We also offer the highest available simple cycle energy efficiency of current technologies, 50% or more. With the Flexicycle™ solution the advantages of a flexible simple cycle plant are combined with the superb efficiency of a combined cycle plant.

FUEL FLEXIBILITY

Wärtsilä's multi-fuel plants enable the continuous choice of the most feasible fuel, including solutions for liquid and gaseous fuels as well as renewables. The possibilities gained from multi-fuel plants and fuel conversion solutions represent a hedge for the future. The role of natural gas in power generation is expected to grow significantly over the coming years. Recent technical breakthroughs and the commercialisation of shale gas have resulted in a substantial extension of the perceived depletion time of gas reserves, and have lowered the price of natural gas. With power plants running on gas, the 27% renewable energy share target set for 2030 by entities like the EU is within reach.

WHAT WE DO

We design, build and operate flexible power plants based on multiple large internal combustion engines (ICEs), which can combine gaseous and liquid fuels depending on the available fuel supply. They are tailored to fit the customer´s needs in terms of power output and flexibility.

Thanks to their modular design and a high degree of pre-engineering, they are easy and quick to build, and can later be expanded if the power needs grow.

The above illustration presents a simplified version of all the key mechanical (1-9), electrical (11-17) and auxiliary (21-24) components that make our power plants run, being Wärtsilä engines the heart and soul of the world-class power solutions.

>4700

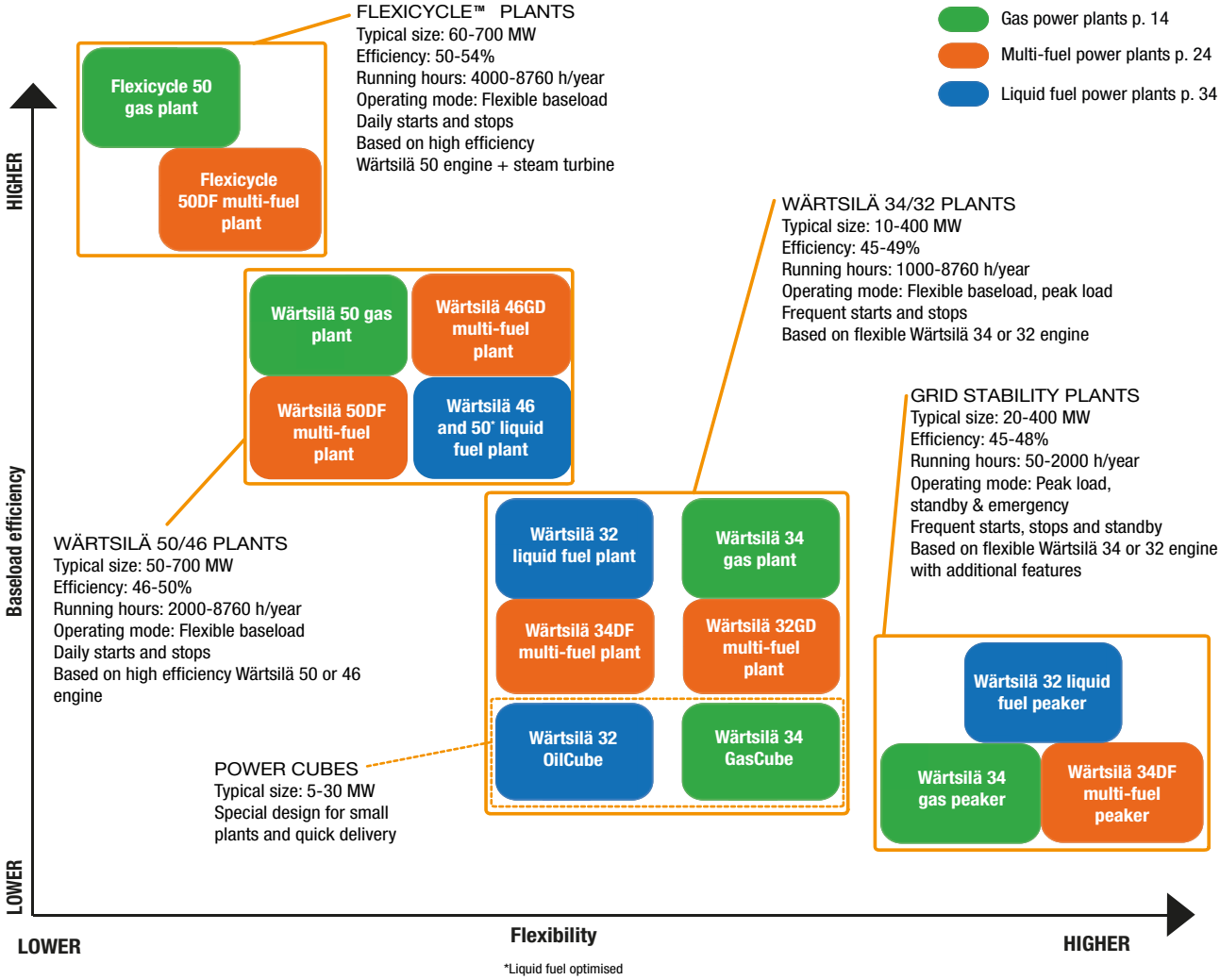
plants worldwide

WORLDWIDE SUCCESS STORIES

more than 10,800 of our engines have been delivered to **over 170** countries worldwide

almost 60 GW installed

A SOLUTION FOR EVERY NEED



*Liquid fuel optimised

KEY FIGURES ABOUT WÄRTSILÄ POWER PLANTS

PLANT OUTPUT (MW)

Typical size of the power plant.

CONFIGURATION

Number and type of gensets that correspond to the typical size of the plant.

MINIMUM LOAD (%)

Lowest plant load that can be maintained for extended periods of time, calculated for a 10-unit plant.

E corresponds to efficiency mode, when load is reduced by turning off units.

S corresponds to spinning mode, when all units are kept online at minimum load.

EFFICIENCY (%)

Plant efficiency based on ISO 3046 conditions and tolerances, excluding auxiliary system losses.

RAMP RATE (%/MIN)

Percentage of the total load that the plant can increase in a minute in order to provide ancillary services.

REGULAR START TIME (MIN)

Start time based on warm standby (preheated or operated in the last 12 hours).

A faster start time translates into the plant being online sooner, thus generating additional power and producing revenue for a longer time.

FAST START TIME (MIN)

Start time based on hot standby (preheated to a higher temperature or operated in the last 6 hours).

If the plant is preheated at a slightly higher temperature, starting times can be cut substantially. This field is the equivalent of the previous one in those warm standby conditions.

ULTRA FAST START TIME (MIN)

Start time based on hot standby plus certain start preparations (preheated and quick start prepared, or operated in the last hour).

Certain plants can be fitted with an ultra fast start capability, which dramatically cuts the starting time even further.

STOP TIME (MIN)

Time it takes to decrease output from 100% to 0%, disconnect from grid and come to a complete stop.

A shorter unloading time adds flexibility to adapt to any load conditions and only being online when it is profitable, saving fuel and reducing emissions.

GAS POWER PLANTS

Wärtsilä gas power plants use natural gas, the cleanest fossil fuel available, in the most economical way, thanks to their high efficiency at any load and unbeatable flexibility to start and stop exactly according to needs. Natural gas is a very valuable resource, let's not waste it!

Besides the combination of efficiency and flexibility, they also offer low emissions, and can provide a great amount of power in a reduced site, making it the optimal solution for locations where minimizing the impact is a priority. As such, they can be placed close to consumption nodes, optimizing the power system.

Wärtsilä gas power plants can run on natural gas, LNG and selected biogases.

The specific benefits for gas power plants include:

- Plant electrical efficiency of up to 50% in single cycle and 54% in combined cycle mode
- Only 5 bar gas pressure requirements for operation, which means no gas compressor is needed at the plant.
- Lean-burn technology guarantees very low emissions by itself, complying with most regulations, including IFC (World Bank group). By adding a selective catalytic reactor (SCR), even the most stringent standards worldwide can be met.

Wärtsilä 50SG gas power plant

High efficiency in a small footprint combined with high reliability and flexibility. Powered by the most efficient gas-driven internal combustion engine in the world.

Perfect for: Flexible baseload

Wärtsilä 34SG gas power plant

Agile and flexible, this plant delivers power with high efficiency and reliability, even in the most challenging ambient and operational conditions.

Perfect for: Peak load, flexible baseload

Wärtsilä 34SG grid stability/emergency gas power plant

Designed for low own consumption combined with ultimate flexibility, gives extremely fast response to emergency situations, and able to supply megawatts in a matter of seconds.

Perfect for: Standby & emergency, peak load

Wärtsilä GasCube

Fully pre-engineered solution for quick installation time with all the great features of the Wärtsilä 34 gas power plant.

Perfect for: Small-sized power plants

WÄRTSILÄ 50SG GAS POWER PLANT

High efficiency in a small footprint combined with high reliability and flexibility makes this solution perfect for flexible baseload applications including daily starts and stops, also providing ancillary services like regulation up&down and tertiary reserves.

- Most efficient single-cycle solution: over 50% efficiency with turbogenerator
- Combined cycle-like efficiency from a single cycle solution
- Full power can be achieved with a wide range of gas qualities, a varying methane number or heating value do not affect the operation
- Robust, reliable genset, proven in the most challenging environments
- Makes the most out of the cleanest fossil fuel available - natural gas
- Minimum area requirement for a given output

KEY FIGURES

See legend on p. 14-15

		SYNC	FULL
		<2	<10 min
50-700 MW	>100 %/min	<2	<5 min
3-36 x 18V50SG	S 30 % E 3 %	n/a	
	50%	<1 min	

RED GATE, Texas, USA	
Customer	STEC (IPP)
Type	Wärtsilä 50SG gas power plant
Operating mode	Flexible baseload
Gensets	12 x Wärtsilä 18V50SG
Total output	224 MW
Fuel	Natural gas
Scope	EEQ (Engineered Equipment Delivery)
Delivered	2014

WÄRTSILÄ 34SG GAS POWER PLANT

Agility and flexibility combined with high efficiency over the whole load range and in any operating profile makes this plant excellent for both flexible baseload and peak load, and supporting the grid with a variety of ancillary services.

- Ultimate combination of efficiency and flexibility. Over 49% efficiency after only 5 minutes from start
- Best up– and down– ramp rates in the industry
- Full power can be achieved with a variety of gaseous fuels, from methane to LPG, without affecting the operation
- Makes the most out of the cleanest fossil fuel available - natural gas
- Genset is easily transported in one piece to challenging locations

The plant is located in an area where temperatures can be as high as 45°C. This, together with demand for high fuel efficiency and lowest levelised cost of electricity, meant gas turbines were not even considered an option. Unlike gas turbines, internal combustion engines (ICEs) do not suffer significant derating at high ambient temperature.

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
	<2	<10 min
10-400 MW	>100 %/min	
	<2	<5 min
1-36 x 20V34SG	S 30 % E 3 %	
	n/a	
49%		
	<1 min	

Wärtsilä has an established track record of delivering high quality, and EDL was impressed by Wärtsilä's proposal to supply an efficient power plant solution on a fast-track basis."

— Shane McLaughlin, Executive General Manager, EDL

MC ARTHUR, Australia

Customer	Energy Developments Ltd (EDL) (IPP)
Type	Wärtsilä 34SG gas power plant
Operating mode	Flexible baseload
Gensets	6 x Wärtsilä 20V34SG
Total output	53 MW
Fuel	Natural gas
Scope	EEQ (Engineering & Equipment)
Delivered	2014

WÄRTSILÄ 34SG GRID STABILITY/EMERGENCY GAS POWER PLANT

Always ready to deliver power to the grid instantly and efficiently in any operating profile makes this plant perfect for peaking and reserve power applications.

- Ultra fast start capability provides megawatts to the grid in seconds and full plant output in 2 minutes
- Able to provide non-spinning secondary reserve thanks to a 30-second ultra fast sync time
- The flexibility of a hydro plant in a gas-fired plant
- Highest efficiency in pulse load (short-time on-off and part-load) operation
- Genset is easily transported in one piece to challenging locations
- Able to provide grid blackstart capability and re-energize a grid even with low gas pressure
- Extremely low standby consumption, <1 kW per MW of installed power

This extremely flexible plant was so successful chasing the winds of the Rocky Mountains that its owner decided to order an expansion and double its capacity only five years after its commissioning, turning it into the largest gas engine-based power plant in the United States.

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
	<2	<10 min
20-400 MW	>100 %/min	
	<2	<5 min
2-24 x 18V34SG	S 30 %	E 3 %
	0:30	1:30 min/sec
	48%	
	<1	min

During breakfast and dinner hours demand increases and the plant follows this perfectly. This is the way. This is the future"

— Kent L. Fickett, Former SVP, PG&E.

PLAINS END, Colorado, USA	
Customer	Tyr Energy (IPP)
Type	Wärtsilä 34SG grid stability/emergency gas power plant
Operating mode	Peak load/stand-by & emergency
Gensets	20 x Wärtsilä 20V34SG 14 x Wärtsilä 20V34 SG
Total output	231 MW
Fuel	Natural gas
Scope	EEQ (Engineered Equipment Delivery)
Delivered	2001 & 2006

WÄRTSILÄ GASCUBE

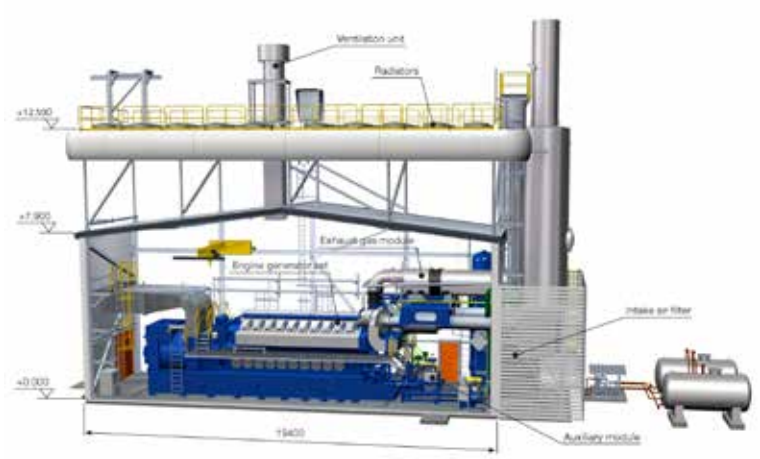
All the great features of Wärtsilä 34SG gas power plant in a compact, ready-to-use pre-engineered package designed for fast delivery time with minimal site work. Consists of a self-contained design with one or several modules, each housing one Wärtsilä 16V34SG or Wärtsilä 20V34SG genset, plus all the auxiliaries needed to make up a working power plant.

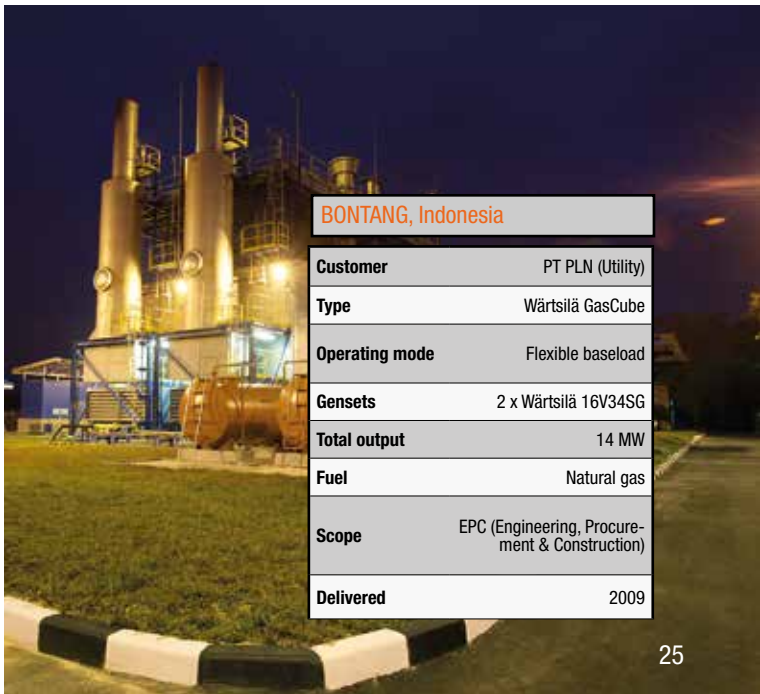
- Easy-to-install, pre-built solution for power needs of 7 to 30 MW
- Ultimate combination of efficiency and flexibility. Over 48% efficiency after only 5 minutes from start
- Same fuel flexibility and low environmental impact as the Wärtsilä 34SG gas power plant
- Easy to expand with additional modules if power need grow with time
- Quickest building and comissioning time
- Perfect for fast-track EPC deliveries.

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
	<2	<10 min
7-30 MW	>100 %/min	
	<2	<5 min
1-3 x 20V34SG	S 30 % E 3 %	
	n/a	
η 48%		
	<1 min	





BONTANG, Indonesia

Customer	PT PLN (Utility)
Type	Wärtsilä GasCube
Operating mode	Flexible baseload
Gensets	2 x Wärtsilä 16V34SG
Total output	14 MW
Fuel	Natural gas
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2009

MULTI-FUEL POWER PLANTS

Multi-fuel power plants make power generation more reliable by being able to adapt to any situations that may occur regarding fuel availability or affordability.

They can even switch fuels while running, for example changing to liquid fuel mode if the gas supply is suddenly interrupted. This capability provides 24/7 security of supply, hedge against fuel price increases and preparation for future fuel infrastructure development.

Wärtsilä's multi-fuel power plants can run in the following operation modes:

- **Gas only** *(with liquid pilot fuel)*
  - Natural gas, LNG, biogas, associated gas *(GD only)*. Insensitive to gas quality
- **Liquid fuel only**
  - Crude oil, diesel, residual oil (HFO), fuel-water emulsions, liquid biofuel
- **Fuel sharing mode** *(in GD plants)*
  - Gas and liquid fuel simultaneously
  - Fuel switch without power decrease
  - Automatic and instant trip to liquid fuel mode in alarm situations (applies also for DF plants)

Wärtsilä 50DF multi-fuel power plant

High efficiency in a small footprint combined with high reliability and flexibility. Can operate equally well on gas, HFO and LFO; and switch between them on the run.

Perfect for: Flexible baseload

Wärtsilä 34DF multi-fuel power plant

Agile and flexible, this plant delivers power with high efficiency and reliability. Starting, stopping and changing fuels is not a problem for this plant.

Perfect for: Peak load, flexible baseload

Wärtsilä 34DF grid stability/emergency multi-fuel power plant

Designed for minimised own consumption and extremely fast response to emergency situations, and able to supply megawatts in a matter of seconds. Adding multi-fuel capability to excellent dynamic features, this plant provides maximum supply security.

Perfect for: Standby & emergency, peak load

Wärtsilä 32GD and 46GD multi-fuel power plants

Especially designed to use low-grade fuels, like associated gas, flare gas or crude oil, optimal for fuel supply varying in quantity and quality.

Perfect for: Flexible baseload, reduction of gas flaring

WÄRTSILÄ 50DF MULTI-FUEL POWER PLANT

Multi-fuel operation with high efficiency combined with high reliability and flexibility makes this solution perfect for flexible baseload applications including daily starts and stops, also providing ancillary services like regulation up&down.

- Most efficient multi-fuel simple-cycle solution, with over 48% efficiency
- Can operate on natural gas or any liquid fuel, including HFO , and switch between them back and forth while delivering power to the grid.
- Full power can be achieved with a wide range of gas qualities.
- Combination of low emissions in gas mode with an efficient liquid fuel mode that can use low-grade fuel oils
- Robust, reliable genset, proven in the most challenging environments

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
GAS	<3	<15
LIQ	<3	<15 min
GAS	<3	<10
LIQ	<1	<10 min

50-700 MW

>100 %/min

3-36 x 18V50DF

S 30 % E 3 %

n/a

GAS 48 % LIQ 45 %

<1 min

The world's largest combustion engine-based power plant, located in Jordan, is a perfect example of the power and flexibility that the Wärtsilä 50DF can offer, even in extremely challenging ambient conditions.

We trust Wärtsilä to professionally and competently lead the EPC consortium in this successful project"

— Mr Young Jin Bae, CEO, AAEPC

IPP3, Jordan	
Customer	AAEPC (IPP)
Type	Wärtsilä 50DF multi-fuel power plant
Operating mode	Flexible baseload
Gensets	38 x Wärtsilä 18V50DF
Total output	573 MW
Fuel	Natural gas, HFO & LFO
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2014

WÄRTSILÄ 34DF MULTI-FUEL POWER PLANT

Multi-fuel operation with full agility and flexibility combined with high efficiency over the whole load range and in any operating profile makes this plant excellent for both flexible baseload and peak load, and supporting the grid with a variety of ancillary services like up– and down– regulation.

- Ultimate combination of efficiency, operational flexibility and fuel flexibility
- Can operate on natural gas or any liquid fuel, including HFO , and switch between them back and forth while delivering power to the grid.
- Full power can be achieved with a wide range of gas qualities,
- Combination of low emissions in gas mode with an efficient liquid fuel mode that can use low-grade fuel oils
- Genset is easily transported in one piece to challenging locations

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
GAS	<3	<10
LIQ	<1	<6 min

10-400 MW

>100 %/min

	SYNC	FULL
GAS	<2	<6
LIQ	<1	<3 min

1-36 x 20V34DF

S	E
30 %	3 %

n/a

GAS	LIQ
48 %	45 %

<1 min

Wärtsilä came up with a special engine configuration to enable the power plant to efficiently meet a highly variable baseload demand.

This is my third project with Wärtsilä and I've again appreciated Wärtsilä's focus and support for their customers as their number one goal during both construction and operations."

— Tony Warnett, Power Station Superintendent, Grande Côte Operations

GRANDE CÔTE, Senegal	
Customer	Grande Côte Operations SA (Industrial)
Type	Wärtsilä 34DF multi-fuel power plant
Operating mode	Flexible baseload
Gensets	4 x Wärtsilä 20V34DF + 1 x Wärtsilä 9L34DF
Total output	36 MW
Fuel	HFO & LFO (Natural gas)
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2013

WÄRTSILÄ 34DF GRID STABILITY/ EMERGENCY MULTI-FUEL POWER PLANT

The most flexible power plant in all aspects, always ready to deliver power to the grid instantly and efficiently, on any fuel. This makes the plant perfect for peaking and reserve power applications in any current or future fuel supply environment.

- Ultra fast start capability provides megawatts to the grid in seconds and full plant output in 2 minutes
- Able to provide non-spinning secondary reserve thanks to a 30-second ultra fast sync time
- Highest efficiency in pulse load (short-time on-off and part-load) operation
- Able to provide grid blackstart capability and re-energize a grid on diesel or low-pressure gas
- Extremely low standby consumption, <1 kW per MW of installed power
- Genset is easily transported in one piece to challenging locations

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
GAS	<3	<10
LIQ	<1	<6

min

20-400 MW

>100 %/min

GAS	<2	<6
LIQ	<1	<3

min

2-36 x 20V34DF

S	E
30 %	3 %

0:30 **1:30** min/sec

GAS	LIQ
48 %	45 %

<1 min

Elering, the Estonian Transmission System Operator, recently added 250 MW of reserve capacity to the national grid by means of a Wärtsilä 34DF Grid stability/emergency multi-fuel power plant. Operating mainly on natural gas but capable of using LFO as a backup, it ensures the national grid is safe and sound at all times.

We had end results that needed to be met and Wärtsilä's engines simply offered an unrivaled solution"

— Ilo Toom,
Project Manager, Elering

KIISA, Estonia

Customer	Elering (Utility/TSO)
Type	Wärtsilä 34DF grid stability/emergency multi-fuel power plant
Operating mode	Peak load/stand-by & emergency
Gensets	27 x Wärtsilä 20V34DF
Total output	250 MW
Fuel	Natural gas & LFO
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2013 & 2014

WÄRTSILÄ 32GD MULTI-FUEL POWER PLANT

Seamless operation regardless on fuel make this plant great for flexible baseload and industrial self-generation. Especially designed to use low-grade fuels, like associated gas, flare gas or crude oil, it is optimal for fuel supply varying in quantity and quality.

- Ultimate fuel flexibility
- Can operate on natural gas or any liquid fuel, and switch between them back and forth while delivering power to the grid.
- Unique fuel-sharing mode: adjust the fuel mixture according to the availability of gas and top up with liquid fuel
- Genset is easily transported in one piece to challenging locations

KEY FIGURES

See legend on p. 14-15

		SYNC	FULL
10-400 MW	>100 %/min	<1	<6 min
		<1	<3 min
1-24 x 20V32GD	S 30 % E 3 %	n/a	
	45%	<1 min	

WÄRTSILÄ 46GD MULTI-FUEL POWER PLANT

- Same fuel flexibility as Wärtsilä 32GD multi-fuel power plant
- A step further in terms of performance: a bigger unit size allows the engine to be even more efficient

GD OPERATION: Original gas-diesel operation mode, where gas is the main source of energy, and pilot fuel oil injection is used to ignite the combustion. Available at any point between 30-100% of rated load, the plant can transfer to and from GD operation within this same range.

FUEL SHARING: Available between 30-100% of rated load. Simultaneous combustion of gaseous and liquid fuel, in a ratio that can be adjusted flexibly. The fuel share set point can be adjusted online. The operator may also change the set point at any time during operation.

FUEL OIL OPERATION: Regular Diesel-principle combustion. Available for the whole load range and for any of the mentioned liquid fuels.

LIQUID FUEL POWER PLANTS

Liquid fuel power plants make power available anywhere, anytime. Proven long-term reliability makes these plants suitable for stationary and floating baseload, and for stand-by applications.

Wärtsilä liquid fuel power plants bring great value to the table, such as

- Tremendous fuel flexibility, with the possibility of running on heavy fuel oil, light fuel oil, crude oil, emulsified fuels or liquid biofuel
- Great dispatch ability, ability to supply megawatts to grid within seconds, and reach full plant load in minutes
- Utilising heavy fuel oil (HFO) in the most efficient way possible

Wärtsilä 46 & Wärtsilä 50DF* liquid fuel power plants

High efficiency combined with high reliability and flexibility. Able to use any kind of fuel oil, excellent for covering larger and stable power demands. Powered by the most efficient diesel combustion engine in the world.

Perfect for: *Baseload, Flexible baseload*

Wärtsilä 32 liquid fuel power plant

Agile and flexible, this plant delivers power with high efficiency, even in the most challenging ambient and operational conditions. Based on the Wärtsilä 32 genset with more than 100 million cumulative running hours.

Perfect for: *Flexible baseload, peak load*

Wärtsilä 32 grid stability/emergency liquid fuel power plant

Based on the Wärtsilä 32 genset, the fastest response in the whole market is the main feature of this plant.

Perfect for: *Standby & emergency, peak load*

Wärtsilä OilCube

Fully pre-engineered solution for quick installation time with all the great features of the Wärtsilä 32 liquid fuel power plant.

Perfect for: *Small-sized power plants*

* Liquid fuel optimised

WÄRTSILÄ 46 & WÄRTSILÄ 50DF* LIQUID FUEL POWER PLANTS

High efficiency and power on any liquid fuel combined with high reliability and flexibility make this solution perfect for flexible baseload applications including daily starts and stops, also providing ancillary services like up– and down– regulation.

- Most efficient simple-cycle liquid fuel solution, up to 47% efficiency
- Can operate on any liquid fuel, including HFO, LFO, liquid biofuel, crude oil or fuel-water emulsions
- Robust, reliable genset, proven in the most challenging environments
- Most compact HFO power plant in terms of footprint

***This Wärtsilä 50DF plant is optimized for liquid fuel operation, providing the same features as the Wärtsilä 46 plus the option to switch to gas when it becomes available.**

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
	<3	<15 min
50-700 MW	<1	<10 min
3-36 x 18V46	n/a	
	<1 min	

>100 %/min	S	E
	30 %	3 %
47%		

BETANO, East Timor

Customer	Govt of Timor Leste
Type	Wärtsilä 46 liquid fuel power plant
Operating mode	Flexible baseload
Gensets	8 x Wärtsilä 18V46
Total output	137 MW
Fuel	HFO
Scope	EEQ (Engineering & Equipment)
Delivered	2011

WÄRTSILÄ 32 LIQUID FUEL POWER PLANT

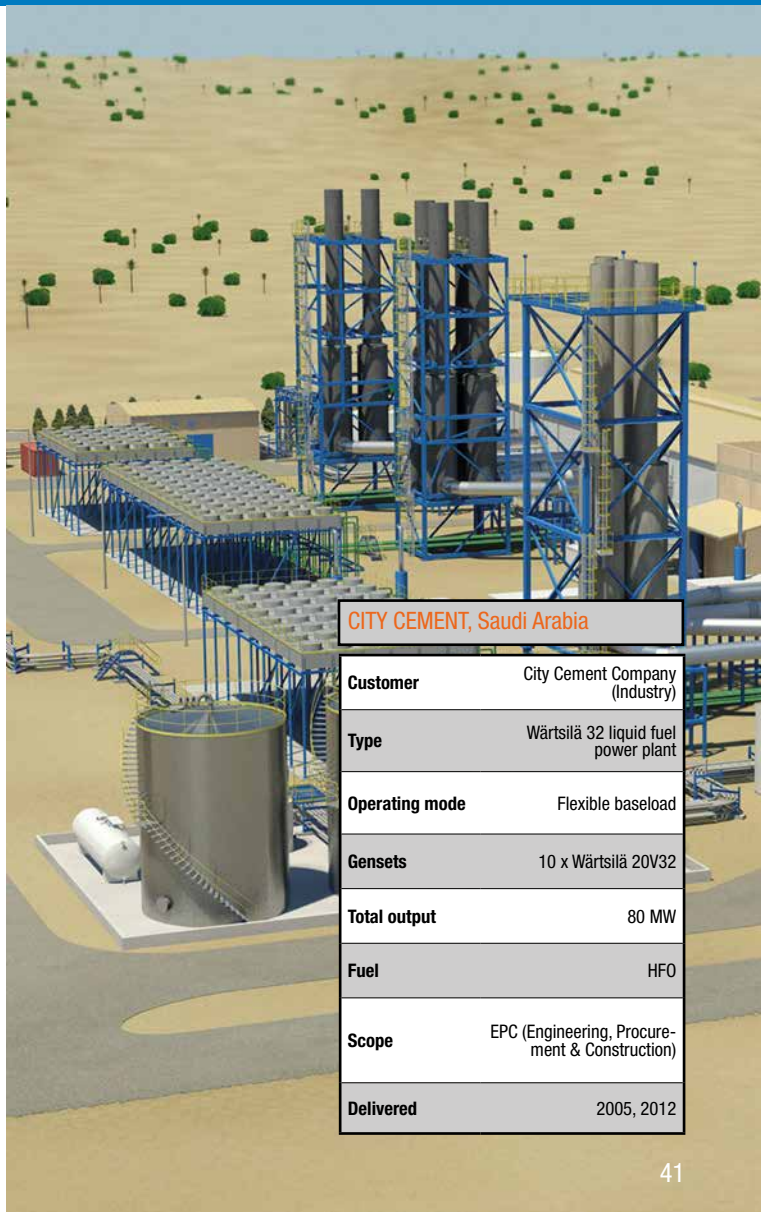
Agility and flexibility combined with high efficiency over the whole load range and in any operating profile makes this plant excellent for both flexible baseload and peak load, and also for supporting the grid with a variety of ancillary services.

- Ultimate combination of efficiency, operational flexibility and wide range of liquid fuels capability
- Two-stage turbocharging applied to the Wärtsilä 20V32TS engine maintains efficiency and power regardless of challenging ambient conditions, like high altitudes or hot temperatures
- Can operate on any liquid fuel, including HFO, LFO, liquid biofuel or crude oil
- Genset is easily transported in one piece to challenging locations

KEY FIGURES

See legend on p. 14-15

			SYNC	FULL
			<1	<6 min
10-400 MW	>100 %/min		<1	<3 min
1-24 x 20V32TS	S 30 %	E 3 %	0:30	1:30 min/sec
	47%		<1 min	



CITY CEMENT, Saudi Arabia

Customer	City Cement Company (Industry)
Type	Wärtsilä 32 liquid fuel power plant
Operating mode	Flexible baseload
Gensets	10 x Wärtsilä 20V32
Total output	80 MW
Fuel	HFO
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2005, 2012

WÄRTSILÄ 32 GRID STABILITY/EMERGENCY LIQUID FUEL POWER PLANT

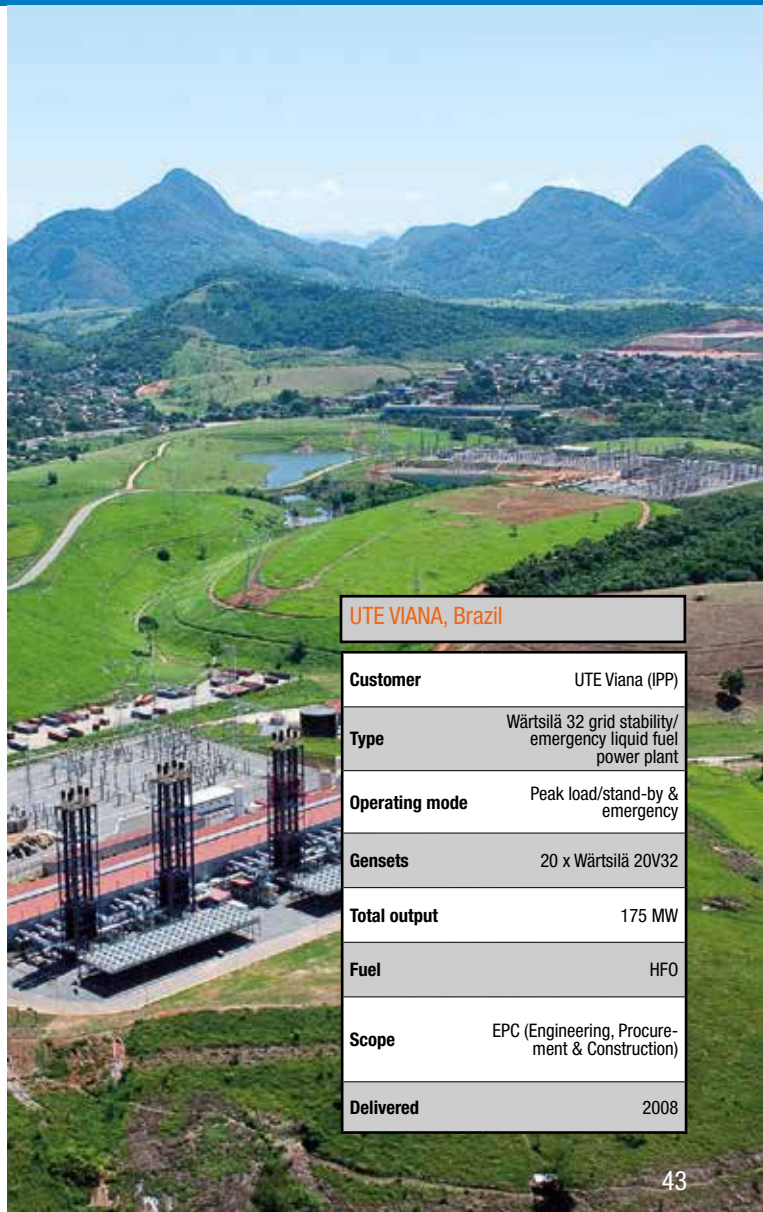
Always ready to deliver power to the grid instantly and efficiently in any operating profile makes this plant perfect for peaking and reserve power applications.

- Ultra fast start capability provides megawatts to the grid in seconds and full plant output in less than 3 minutes
- Able to provide non-spinning secondary reserve thanks to a 20-second ultra fast sync time
- Able to provide grid blackstart capability and re-energize a grid
- Extremely low standby consumption, <1 kW per MW of installed power
- Genset is easily transported in one piece to challenging locations

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
	<1	<6 min
20-400 MW	>100 %/min	<1	<3 min
2-24 x 20V32	S 30 % E 3 %	0:20	1:00 min/sec
46%		<1 min



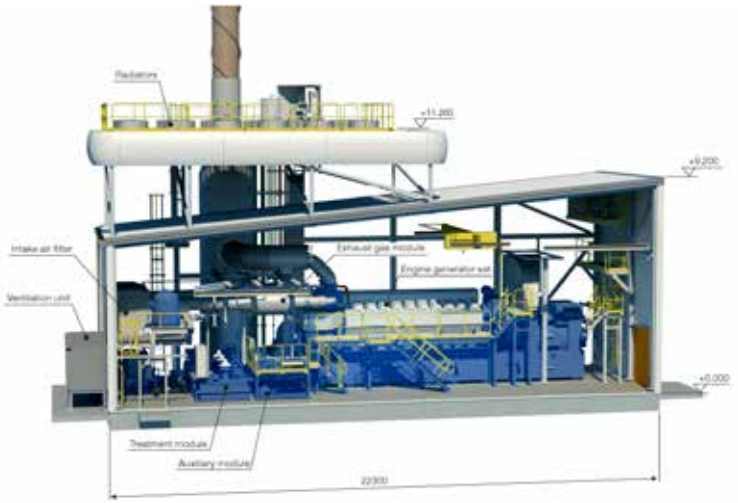
UTE VIANA, Brazil

Customer	UTE Viana (IPP)
Type	Wärtsilä 32 grid stability/ emergency liquid fuel power plant
Operating mode	Peak load/stand-by & emergency
Gensets	20 x Wärtsilä 20V32
Total output	175 MW
Fuel	HFO
Scope	EPC (Engineering, Procure-ment & Construction)
Delivered	2008

WÄRTSILÄ OILCUBE

All the great features of a Wärtsilä 32 plant in a compact, ready-to-use pre-engineered package designed for fast delivery time with minimal site work. Consists of a self-contained design with one or several modules, each housing one Wärtsilä 12V32, 16V32, 20V32 or 20V32TS genset, plus all the auxiliaries needed to make up a working power plant.

- Easy-to-install, pre-built solution for power needs of 5 to 30 MW
- Great fuel flexibility like the Wärtsilä 32 liquid fuel power plant
- Easy to expand with additional modules if power need grow with time
- Quickest building and comissioning time
- Especially designed for environments where infrastructure may be challenging
- Perfect for fast-track EPC deliveries.



KEY FIGURES

See legend on p. 14-15

			SYNC	FULL
			<1	<6 min
5-30 MW	>100 %/min		<1	<3 min
1-4 x W32	S 30 %	E 3 %	n/a	
	46%		<1 min	

WÄRTSILÄ FLEXICYCLE™

Flexicycle™ is an innovative concept trademarked by Wärtsilä, which combines the excellent dynamic capabilities of combustion engines with the superb efficiency offered by combined cycle solutions.

By adding a waste heat recovery system to the plant, consisting of a heat recovery steam generator for each engine and a common steam turbine and condenser for the plant, total efficiency can be improved by a very significant 3-4 percent units. The plant can switch between single or combined cycle modes upon request, getting the best of both worlds.

When the steam cycle is equipped with a dry condenser connected to the radiator cooling circuit, the total water consumption of the plant is negligible, making it also suitable for areas where water is a crucial resource.

With 2.7 GW delivered to this day, Flexicycle™ represents the ultimate solution for flexible baseload plants, in either its gas-fired or multi-fuel configuation.

One configuration, two switchable operational modes, and the advantages of both single and combined cycle: excellent flexibility and unmatchable efficiency.

FLEXICYCLE™ 50SG GAS POWER PLANT

Adding a flexible steam cycle (Flexicycle™) to the highly efficient Wärtsilä 50SG engines makes this solution perfect for flexible base-load or even pure baseload applications. Due to the flexibility of the Wärtsilä 50SG engine, this solution can provide all desirable ancillary services.

- Most efficient flexible baseload solution: up to 54% efficiency without compromising flexibility
- Suited for a larger amount of running hours per year, it can serve large power needs with a very high efficiency
- Can start up quickly and inexpensively with extremely high efficiency
- Can switch between two operation modes:
  - **Dynamic single cycle (SC)** (with all the benefits from a Wärtsilä 50SG gas power plant) with up to 50% efficiency
  - **Combined cycle (CC),** reaching up to 54% efficiency

KEY FIGURES

See legend on p. 14-15

60-700 MW

>100 %/min

3-36 x 20V50SG + steam turbine

S **30** % E **3** %

SC **50%** CC **54%**

	SYNC	FULL
SC	<2	<10
CC	<40	<60 min
SC	<2	<5
CC	<30	<45 min
	n/a	
	<1 min	

FLEXICYCLE™ 50DF MULTI-FUEL POWER PLANT

Adding a flexible steam cycle (Flexicycle™) to the highly efficient Wärtsilä 50DF engines makes this the ultimate solution for flexible baseload, with complete fuel flexibility.

- Most efficient multi-fuel flexible baseload solution: up to 52% efficiency without compromising flexibility
- Suited for a larger amount of running hours per year, it can serve large power needs with a very high efficiency
- Can operate on natural gas or any liquid fuel, including HFO , and switch between them back and forth while delivering power to the grid
- Can start up quickly and inexpensively with extremely high efficiency
- Can switch between two operation modes:
  - **Dynamic single cycle (SC)** *(with all the benefits from a Wärtsilä 50DF multi-fuel power plant)* with up to 48% *efficiency*
  - **Combined cycle (CC),** reaching up to 52% efficiency

KEY FIGURES

See legend on p. 14-15

	SYNC	FULL
SC	<3	<15
CC	<40	<60 min

60-700 MW

>100 %/min

	SYNC	FULL
SC	<3	<10
CC	<30	<45 min

3-36 x 20V50DF + steam turbine

S	E
30 %	3 %

n/a

SC	CC
48%	52%

<1 min

Barrick and EGE Haina teamed up to build twin Flexicycle™ 50DF multi-fuel power plants in the Dominican Republic, providing efficient and reliable power to a new gold mine and the local community at once.

We can vary the dispatch to match the load without sacrificing efficiency or suffering maintenance impacts"

— Bernerd L. Grill , Commercial Mgr, Barrick

QUISQUEYA, Dom. Republic	
Customer	Barrick (Industrial) + EGE Haina (Utility)
Type	Flexicycle™ 50DF multi-fuel power plant
Operating mode	Flexible baseload
Gensets	12 + 12 x Wärtsilä 18V50DF
Total output	430 MW
Fuel	Natural gas & HFO
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2013

FLOATING POWER PLANTS

Wärtsilä's floating power plants integrate our expertise in marine technology with the many benefits of flexible, decentralised power generation.

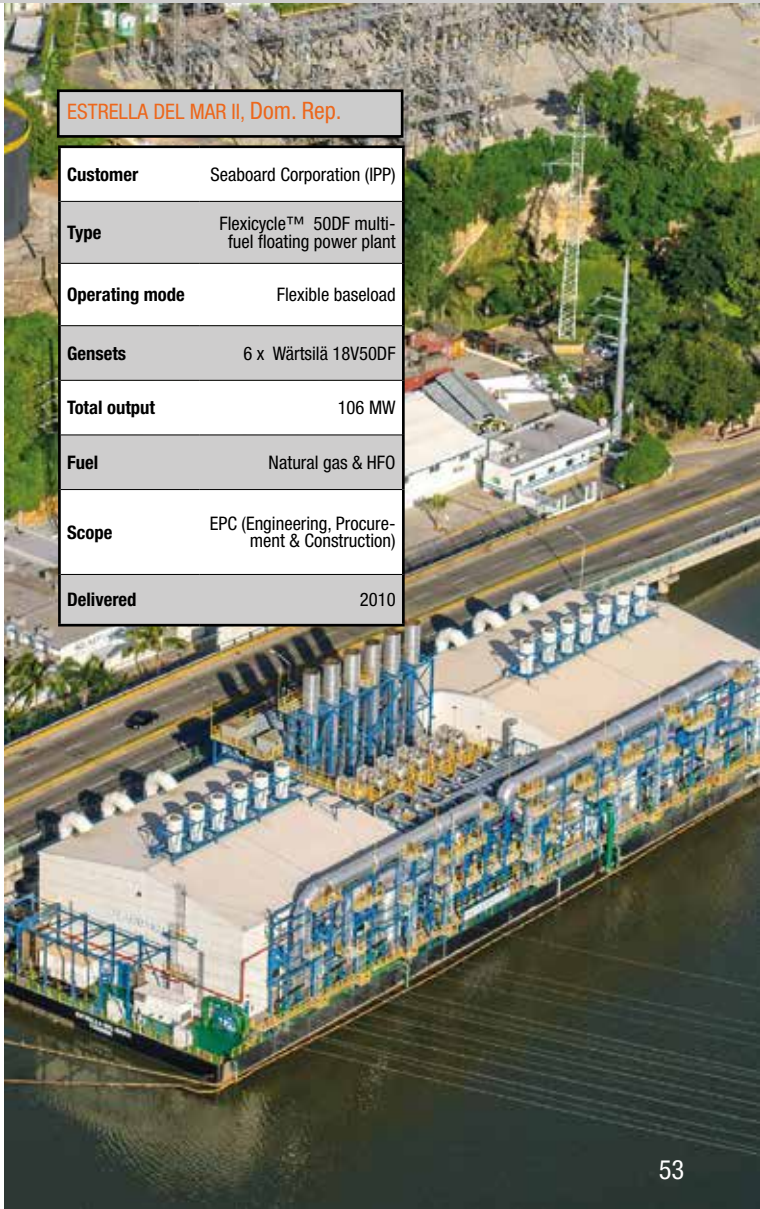
Floating power plants are based on tested components and system solutions. They are constructed cost-effectively and rapidly in a well-controlled industrial setting. When towed into place and connected to the grid, the plants are fully functional, providing a fail-safe option even in the remotest locations and under the most challenging ambient conditions.

Floating power plants can also provide a rapid answer to an increase in power demand in advance of new, land-based plants. Our turnkey solutions include site preparation and operation and maintenance services, according to customer needs. The lead time from contract to start-up of commercial operations is short, guaranteeing a quick return on investment.

Wärtsilä offers floating power plants based on any of the gensets reviewed previously in this catalogue.

Why a floating power plant?

- Provides fast supply of electricity to areas with limited infrastructure
- Is a mobile asset, possible to relocate or trade
- Does not require a large site
- Is not dependent of soil quality
- Provides secure power supply in the event of an earthquake or flood



ESTRELLA DEL MAR II, Dom. Rep.

Customer	Seaboard Corporation (IPP)
Type	Flexicycle™ 50DF multi-fuel floating power plant
Operating mode	Flexible baseload
Gensets	6 x Wärtsilä 18V50DF
Total output	106 MW
Fuel	Natural gas & HFO
Scope	EPC (Engineering, Procurement & Construction)
Delivered	2010

COMBINED HEAT AND POWER & TRIGENERATION

Combined Heat and Power (CHP) and trigeneration plants use fuel in the most efficient way and at the same time help to reduce carbon dioxide emissions. Total plant efficiencies can reach over 90% depending on the application. Wärtsilä's CHP plants can run on various liquid, gaseous and bio fuels, while maintaining low emissions and high efficiency.

Thanks to a hang-on heat recovery system, the plant will maintain the same high electrical efficiency and output, regardless of the heat production and ambient conditions. The products can be steam and hot or cold water.

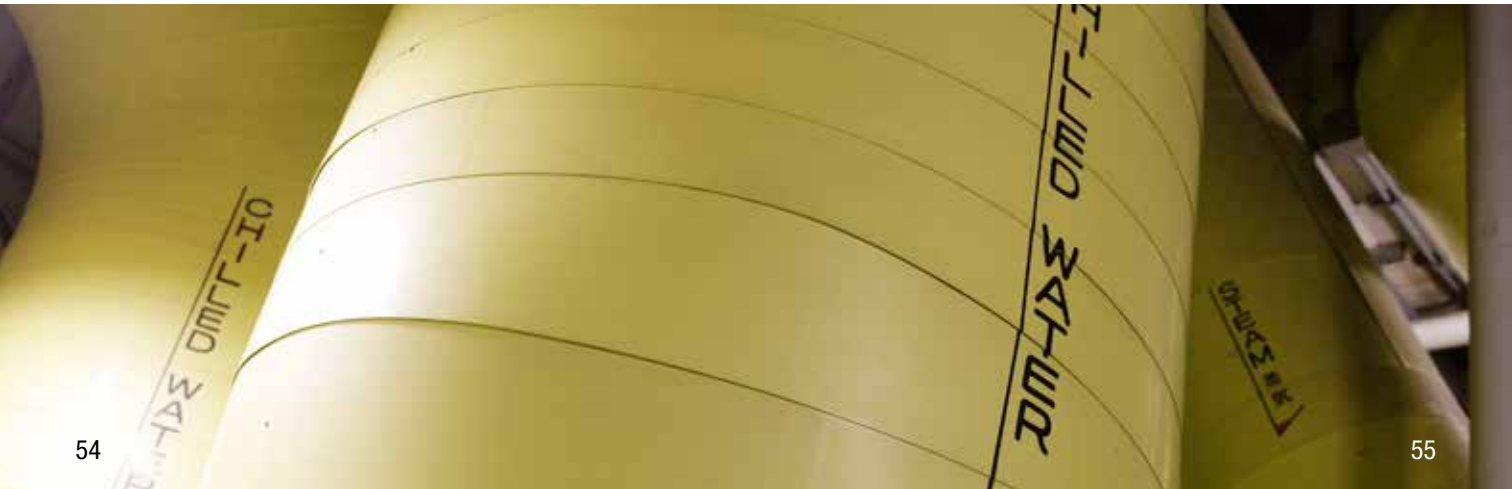
In trigeneration power plants, Wärtsilä can deliver three valuable products for the customer; electricity, heating and cooling - all this in just one power plant. This is possible without sacrificing the high reliability and superb flexibility of an ordinary Wärtsilä power plant.

Wärtsilä offers CHP solutions to all customers with substantial heating demands such as utilities and municipalities. Also large facilities such as airports, shopping centers and other building complexes can utilize the Wärtsilä CHP and trigeneration solutions.

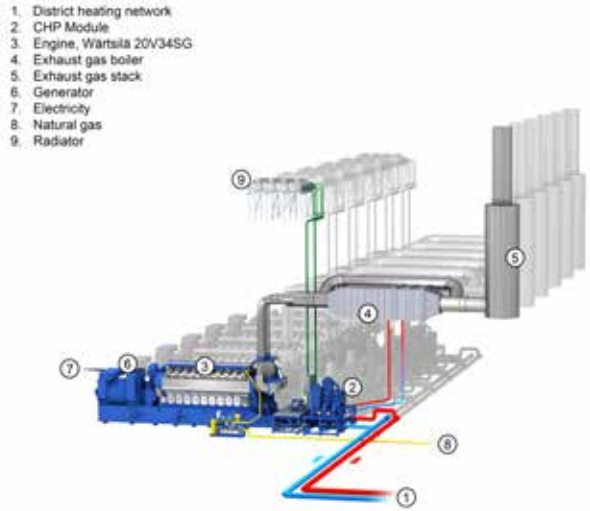
Wärtsilä offers CHP & trigeneration power plants based on any of the gensets reviewed previously in this catalogue.

Benefits of Wärtsilä CHP solutions:

- An efficient plant with a high power-to-heat ratio enables more electricity production
- Multiple units with fast start and ramp rates enable dynamic operation during low heat demand seasons at high efficiency
- Good dynamic capabilities (multiple units) enable opportunities in ancillary services
- CHP plants are optimized for maximizing the customer's profitability in any existing DH network
- High efficiency and flexible operation over a wide load range
- Dynamically able to respond to electricity price variations and to support intermittent, inflexible generation
- Flexibility can be further improved with heat storage.
- Proven track record of more than 11 GW of installed Wärtsilä CHP plants



Total attainable efficiency for a Wärtsilä CHP system depending on hot water supply and return temperatures.



Coupling of the hang-on CHP system, which enables the extremely high total efficiency of the plant without affecting its electrical output.

MAKUHARI, Japan

Customer	Energy Advance Co. (Utility)
Type	Wärtsilä 34SG gas trigeneration power plant
Operating mode	Flexible baseload
Gensets	1 x Wärtsilä 20V34SG + 1 x Wärtsilä 16V34SG
Total output	15.7 MWe + 10.85 MWth
Fuel	Natural gas
Scope	EEQ (Engineered Equipment Delivery)
Delivered	2007

LNG SOLUTIONS

Besides building Power Plants, Wärtsilä now have the capability to develop and plan the entire LNG/LEG/LPG/LBG fuel supply chain together with our PP customers and other gas consumers.

We help our customer to develop concepts arong the fuel supply chain and supporting them with our broad experience in Project Development & Financing. (see p. 66 for more information)

We are also utilizing Wärtsilä Marine divisions experience, knowhow and network when developing the LNG/LEG/LPG/LBG fuel supply chain. Thanks to this we can also plan & develop the shipping side of the fuel logistics.

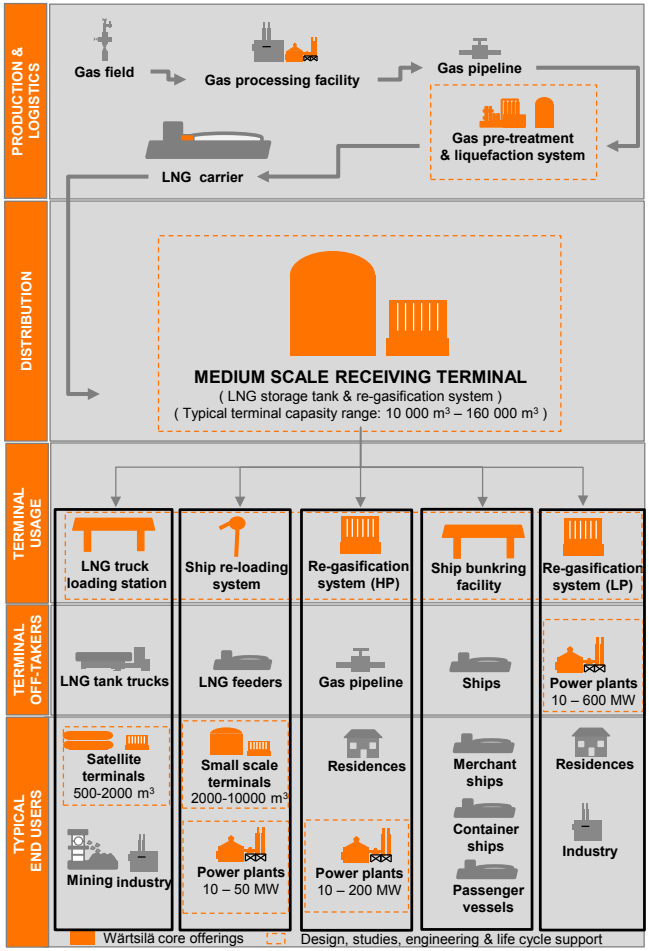
For Terminals and Liquefaction projects we are able to provide the same full range of project and life cycle support services, as we provide in the Power Plant deliveries. Scope of supply can be anything from engineering & equipment deliveries to full EPC (see p. 70-71 for more information) with guaranteed performance and delivery time. Regarding the life cycle support we are capable to run & maintain the facilitities during their entire life time.

Combining our Project and Lifecycle management capabilities with the gas processing knowledge and proven marine experience makes Wärtsilä the most valued business partner you can have when it comes to LNG Solutions.

LEGEND:

LNG	Liqufied Natural Gas
LEG	Liqufied Ethane Gas
LPG	Liqufied Petroleum Gas
LBG	Liquified Bio Gas
EPC	Engineering, Procurement & Construction

Wärtsilä in the LNG value chain



NOTE ! Aditional information of Wärtsilä's LNG solutions is available on request.

MODULARITY

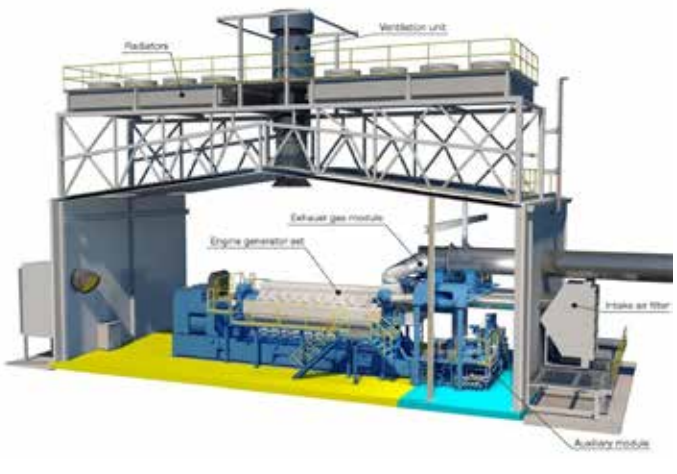
A module is a self-contained component of a system, which has a well-defined interface to the other components. Something is modular if it includes or uses modules, which can be interchanged as units without disassembly of the module. As energy demand grows, the high modularity of Wärtsilä's products makes it easy to expand a power plant to meet increasing future demand.

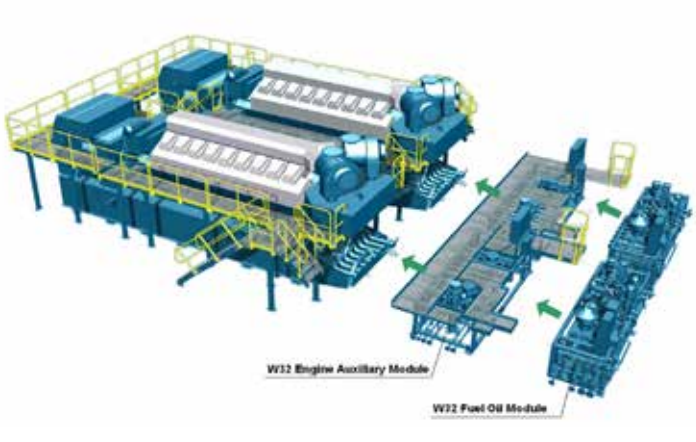
The common interfaces and flexibility of Wärtsilä's modular design, fulfilling a range of specifications and recommendations, addresses both the demand of today's customer and potential future needs. The focus of modularisation is around the engine and inside the power house, even though modules are also used elsewhere, starting with the unloading of fuel, lubricating oil and other process-related items. By using predefined modular solutions, Wärtsilä can ensure that set performance targets are reached.

Rapid installation time is one of the main benefits. Prefabrication also ensures consistent high quality. Other benefits include the compact and predefined design for container transportation, and the use of well-proven components from well-known suppliers. The use of portfolio modules leads to higher documentation quality during the tender phase. When compared to carrying out such work on site, the controlled manufacturing, cleaning, and painting processes associated with modularisation, have a positive environmental impact. For our customers, modularised design means higher return of their power plant investment.

Some of the benefits of modularisation are:

- A **pre-designed solution** that can be customised to suit specific needs
- **Fast and easy installation** on site
- **Proven design**
- **Reliable and thorough** quality control
- **Optimised piping** layout
- **Compact assembly**
- **Standardised connection** interfaces
- **Optimised transport** dimensions





ELECTRICAL & AUTOMATION

The Wärtsilä Power Plant Electrical and Automation concept provides a complete plant management solution with standardised modules, generators, switchgears and transformers, which can be tuned to the customers or utility requirements. Wärtsilä Power Plant Automation is based on the following building blocks. All these systems have been developed with complete integration, and have clear and easy user interfaces providing a uniform interface and logic for the operators.

- **WOIS** (Wärtsilä Operators Interface System) is the operator's workstation, for process displays, control actions, trends, alarm and event lists
- **WISE** (Wärtsilä Information System Environment) is the workstation for reports, logbook, electronic documentation and 3rd party interfaces
- **UNIC** is the engine embedded control system, handling all the control, monitoring and protection functions of the engine, together with the PLC
- **PLC** based process control system handles all the control, monitoring and control functions of the genset and plant equipment
- **Remote connection** provides a secure internet or satellite link, to give remote access to the information in the WOIS and WISE systems
- Condition Based Maintenance (**CBM**) reporting system, is a subscriber based condition evaluation and reporting system created by Wärtsilä experts.
- An optional **Archiving Station** enables a lifelong storage of the plant's operational data

AUTOMATED OPERATION MODES

Operational flexibility is applied in the same package supporting either baseload, intermediate, peak load or stand-by power generation. Thanks to the intelligent controllers, the Wärtsilä solution provides:

- True MW control with embedded frequency support and power factor control for easy plant power management and import/export control
- Isochronous load sharing of both active and reactive power for island mode operation support
- Droop mode as a backup and traditional operation mode.

All these operating modes are inbuilt and transfer between the modes is automatic and smooth.

EMISSIONS REDUCTION AND MONITORING

Wärtsilä Power Plants maintains a high level of expertise in emission cleaning methods for power plant effluents and stack emissions, in order to offer a variety of proven reduction technologies for different market needs.

EMISSIONS REDUCTION FOR GAS POWER PLANTS

Sulphur dioxide (SO_2) and particulate matter (PM) emissions are insignificant for power plants running on natural gas. Nitrogen oxide (NO_x) emissions are also low.

DRY METHODS (PRIMARY)

Wärtsilä gas engines use a lean-burn combustion process. In this process, natural gas and air are premixed in a low air/fuel ratio (lambda 2-2.5) before being fed into the cylinders. The lean-burn process efficiently reduces NO_x emissions due to a lower combustion temperature. Another advantage with the lean-burn process is the increased output and efficiency of the engine. Wärtsilä gas engines have sufficiently low NO_x emissions to comply with most national/local regulations using lean-burn primary method only.

SELECTIVE CATALYTIC REDUCTION (SCR)

In areas with more stringent control of NO_x emissions the engines can be equipped with SCR units. In the SCR, NO_x is reduced by a catalyst, combined with a reagent that is either an aqueous solution of urea or ammonia.

OXIDATION CATALYSTS

Gas (SG) engines and multi-fuel (DF) engines can be equipped with oxidation catalysts for the abatement of carbon monoxide (CO) and/or hydrocarbon (HC) emissions, if required by national regulations.

WÄRTSILÄ IOXI

The Wärtsilä IOXI (Integrated Oxidation Catalyst) is a compact, cost efficient solution for moderate CO and formaldehyde (CH_2O) reduction from gas engines. Gas engines equipped with IOXI ensure compliance with most stack emission limits.

COMBINED SCR AND OXIDATION CATALYST

In some areas efficient multi-component emissions reduction is required. The combined catalyst system comprises SCR for NO_x emissions and oxidation catalyst for CO and/or HC emissions.

Humboldt, Eureka, California (10 x Wärtsilä 18V50DF, 162 MW)
The multi-fuel DF engines can operate on light fuel oil as back-up. The plant is equipped with combined SCRs and oxidation catalysts and meets the strict Californian emission requirements both in gas and liquid fuel mode.

EMISSIONS REDUCTION FOR LIQUID FUEL POWER PLANTS

NO_X, SO_2 and particulate matter are the main emissions of interest regarding stationary liquid fuel engines. SO_2 and PM emissions are mainly related to the quality of the liquid fuel. Wärtsilä liquid fuel engines have low carbon monoxide (CO) and hydrocarbon (HC) emissions thanks to their high thermal efficiency.

Wärtsilä's liquid fuel power plants are designed to meet the stack emission limits set by the World Bank/IFC Guidelines for liquid fuel power plants up to 300 MWth (~140 MWe) in non-degraded airsheds by using dry primary methods. Secondary flue gas treatment methods are available for more strict regulations, or when only low grade liquid fuels are commercially available.

DRY METHODS (PRIMARY)

The primary method (Low NO_x combustion process) used in Wärtsilä liquid fuel engines is designed for the best overall emissions performance, while maintaining the good thermal efficiency of the engine. The main elements of the low NO_x combustion process are:

- Late fuel injection start
- High compression ratio
- Optimised combustion chamber and fuel injection rate profile
- Early inlet valve closing (Miller concept) together with high boost pressure.

These are the key elements for suppressing the combustion peak temperatures, resulting in reduced NO_x formation.

SELECTIVE CATALYTIC REDUCTION (SCR)

Wärtsilä's liquid fuel power plants can be equipped with SCR units to reduce NO_x emissions if required.

NO_x emissions are typically reduced by up to 80–90% by using a reagent that is either an aqueous solution of urea or ammonia. The composition and structure of the catalyst element are selected based on fuel properties. At high reduction rates, the size of the SCR reactor increases and more complicated premixing and reagent injection systems are needed. In addition the control system becomes very critical due to operation within a narrow window.

FLUE GAS DE-SULPHURISATION (FGD)

Several FGD types are available for the power plant market. The most feasible methods in stationary engine plants have generally been proven to be wet sodium hydroxide (NaOH) FGD in smaller plants, and wet calcium carbonate ($CaCO_3$) FGD in larger plants. Wet FGD systems are typically capable of removing up to 90% of the SO_2 emissions. All wet FGD solutions require large quantities of water and reagents.

The FGD end products, either liquid or solid depending on the chosen FGD technique, need to be disposed of in an environmentally acceptable way. The composition of the end product depends on the fuel oil used, lubrication oil, process water and reagents. The disposal and utilisation options available for the end product should be examined in the environmental assessment of the project.

ELECTROSTATIC PRECIPITATOR (ESP)

A dry ESP unit can be used to reduce PM emissions. The ESP technique provides a stable, low pressure-loss option to reduce PM emissions. ESP's dry end product, fly ash, needs to be disposed of in an environmentally acceptable way. The composition of the end product depends on the fuel and lubrication oil used. The disposal and utilisation options available for the end product should be examined in the environmental assessment of the project.

CONTINUOUS EMISSIONS MONITORING (CEMS)

In cases where continuous data on emission levels is required, indicative or parametric emissions monitoring systems will provide robust, good quality and cost efficient emissions monitoring. In these systems, emissions are calculated based on process data, such as engine parameters, fuel composition and ambient data. In some installations, continuous emissions monitoring systems (CEMS) based on analysers are required.

There are many different CEMS on the market and the choice of system needs to take into careful consideration the installation's specific features, such as measured components, fuel and stack configuration. The integration of emissions data handling and reporting into the plant system is a crucial part of a successful emissions monitoring system.

REDUCING CONTAMINATED WATER

The oily water collection and treatment system is an essential part of the engine power plant. The system is designed to collect water from areas that are potentially contaminated with oil and other impurities for treatment. Before discharge from the plant, contaminated water can be either treated on-site by the Wärtsilä oily water treatment (OWT) unit or transported for proper treatment. In areas that are subject to stringent effluent limits, biological treatment might also be required. Wärtsilä Senitec Biosys is a biological treatment system for grey water, treated oily water and/or similar effluents from power plants.

WÄRTSILÄ DEVELOPMENT & FINANCIAL SERVICES

A global team of power plant project developers and finance professionals in Wärtsilä Development & Financial Services (WDFS) offers expert services to Wärtsilä's customers worldwide.

FINANCIAL SERVICES

WDFS supports clients with advice and assistance in deal structuring and financing. Through its strong relationships with both local and international financing institutions, including export credit agencies (ECA), commercial banks and development banks, WDFS is well positioned to structure financing to suit each customer's requirements. A manufacturing presence in several countries provides a competitive advantage for accessing ECA guarantees and funding, especially through Finnvera (Finland) and SACE (Italy). WDFS also offers financial advisory services including financial modelling and feasibility studies.

PROJECT DEVELOPMENT

WDFS develops independent power producer (IPP) projects based on Wärtsilä ICE technology and know-how with a focus on environmentally responsible power projects with sound financing structures. With a proven track record since 1991, WDFS has successfully developed and closed over 30 highly feasible IPP projects (approx. 3500 MW) around the world. WDFS structures and negotiates project financing for IPP projects on a limited recourse or non-recourse basis. WDFS has over the years proven its ability to mobilize capital from multilateral and bilateral institutions, local and international commercial banks, and equity investors.

PROJECT MANAGEMENT SERVICES

The Power Plants Project Management organisation plans, leads, manages and executes projects for our customers. We support our customers with cost estimates, scheduling and project planning. The projects are managed by our personnel using professional project management methodology and best practices, which have been developed over the years within Wärtsilä Power Plants.

We have broad experience in building power plants in challenging geotechnical locations, including areas where earthquakes, landslides, swelling soil and liquefaction may occur.The project locations range from the African jungle to the Siberian tundra.

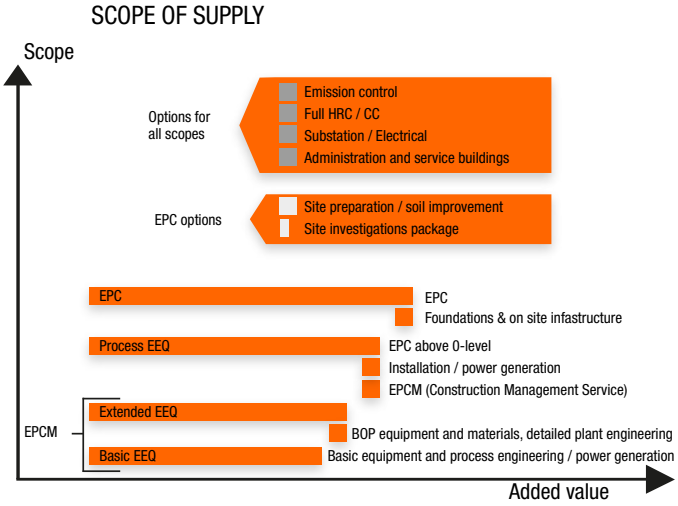
The properties of foundations and structures are selected individually to ensure the best possible outcome taking all the ambient conditions into consideration. The buildings mainly consist of high-quality prefabricated structures to ensure shorter construction time and improved risk assessment. By choosing the right materials, even the energy efficiency can be improved, while the plant's environmental impact is significantly reduced.

Our aim is also to enhance safety and offer the best possible working conditions for the plant operators.

Wärtsilä's civil engineer teams have conducted more than 500 projects over three decades with an unbeatable track record. Our services include everything from pre-planning inspections to installation.

Wärtsilä offers the following options of scope of supply & contract types:

Basic EEQ *(Basic Engineered Equipment Delivery)* is the most basic service where only the main equipment and related auxiliaries are engineered and supplied. The service includes configuration and engineering for supplied equipment and materials, transport, and technical advisory for installation and commissioning.



Extended EEQ *(Extended Engineered Equipment Delivery)* is a complete supply solution for defined scope including detailed engineering for total solutions, all materials and equipment plus technical advisory services for installation and commissioning. The customer needs to hire a contractor to perform installation and civil works on site.

EPCM *(Engineering, Procurement, Construction & Management)* is a service contract adding Construction Management services to the scope. It includes construction and site management, project and construction scheduling, sub-contracting, site supervision and documentation services for site works and subcontracts. It includes assistance to customers in local work, monitoring and reporting on the performance of subcontractors. This service contract is made in connection with extended EEQ contracts.

EPC *(Engineering, Procurement & Construction)* is a solution where the customer has only one point of contact, thereby minimising their risks. The contract covers project management, site management and supervision, engineering, materials and equipment, civil works, foundation and site infrastructure works, transport and installation, and commissioning, as well as schedule and performance guarantees for the entire solution.

Process EPC includes the same features as EPC, but installation is only done above floor level. Subsoil and foundation works, underground materials supply and site works are performed or subcontracted by the customer.

POWER PLANT LIFECYCLE

Optimising your operations and preventing the unexpected is our shared passion – we serve you whenever, wherever.

With nearly 7 GW of power plants under asset management agreements and close to 5 GW under maintenance agreements, Wärtsilä is recognised by customers as their preferred service supplier in ensuring the availability and cost-efficient operation of their installations. They benefit from having their entire power system fully serviced by one global supplier.

Wärtsilä serves and supports customers in improving and optimising their operational efficiency throughout the whole lifecycle of the installation. Our Services organisation currently features more than 11,000 dedicated professionals in almost 70 countries.

Our Services solutions cover everything from product support with parts, field service and technical support, to service agreements, performance optimisation including upgrades and conversions, environmental solutions, training, and online support.

The choice available extends from parts and maintenance services to a variety of comprehensive, customised long-term service agreements, including performance and asset management agreements.

On the basis of our experience in operating and maintaining around 500 marine and land-based installations located in almost 70 different countries, and through the know-how and support of Wärtsilä's worldwide organisation, a Wärtsilä service agreement has become established as a proven and reliable instrument for both parties.

Wärtsilä adds value to your business at every stage in the lifecycle of your installations. With us as your service partner, you receive many measurable and guaranteed benefits, such as availability and performance, productivity gains and cost benefits. Above all, you have peace of mind in the knowledge that your installation is being serviced by the most experienced partner you could have.

A variety of comprehensive, customized long-term service agreements, including performance guarantees, and operations & management are available for our power plant customers. Based on our experience in operating and maintaining hundreds of installations all over the world, we can offer you unique know-how and the support of our global organisation.

Asset Management
- Full responsibility for operations & maintenance
- Lifecycle cost guarantee
- Risk management
- Performance guarantee
- Extending lifetime of asset

Maintenance Agreements
- Responsibility for maintenance
- Financial predictability
- Partnership with common goals
- Ensured performance
- Online operational support
- World class technical expertise
- Global and local coordination

Technical Management
- Classification society approved concept
- Maintenance planning
- Maintenance cost prediction
- Condition evaluation
- Condition monitoring
- Periodical inspections

Supply Agreements

Consisting of one or more of the following
- Manpower
- Spare parts
- Workshop services
- Online services
- Competence development and training

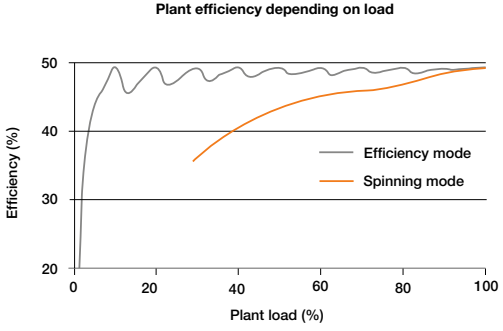
OPERATION OF A MULTI-UNIT POWER PLANT

There are often significant seasonal, weekly and daily variations in power demand. In a multi-unit power plant the units can be started and stopped as per demand. It is possible to optimise the usage of each single unit by choosing to either provide spinning reserve or to run it flat-out to obtain maximum efficiency.

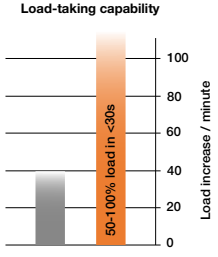
A multi-unit power plant can be run in various ways dependent on the situation at hand. Basically, there are two main operating principles:

In **spinning mode**, the gensets are synchronized and running, but at a reduced load. This way the plant is fully ready to take large, immediate load increases just in seconds.

In **efficiency mode**, the minimum amount of gensets are running at full load to meet the current load demand, thereby allowing them to operate at their best thermal efficiency. Still, the remaining gensets, which are in stand-by mode, can come online and reach full load in a matter of a few minutes to meet any unforeseen load increases.



Plant features in the two different operation modes



INTERNAL COMBUSTION ENGINE MAINTENANCE

Maintenance of gas, dual-fuel and liquid fuel engines is easy. Keeping strategic spare parts for exchange purposes on site considerably reduces the downtime required for maintenance. All maintenance can be effectively performed on site. One engine at a time can be maintained, without affecting the operation of the other units of the plant.

The multi-unit setup means that the annual average unit running hours, depending on the actual load profile, can be considerably lower than the annual plant running hours. In a multi-unit plant the units can be dispatched, so that the running hours are unequally spread on each unit. This allows for scheduling the maintenance one unit at a time, thereby maximising the available power generation capacity at any given time. Ideally, the maintenance is scheduled at periods of lower power demand.

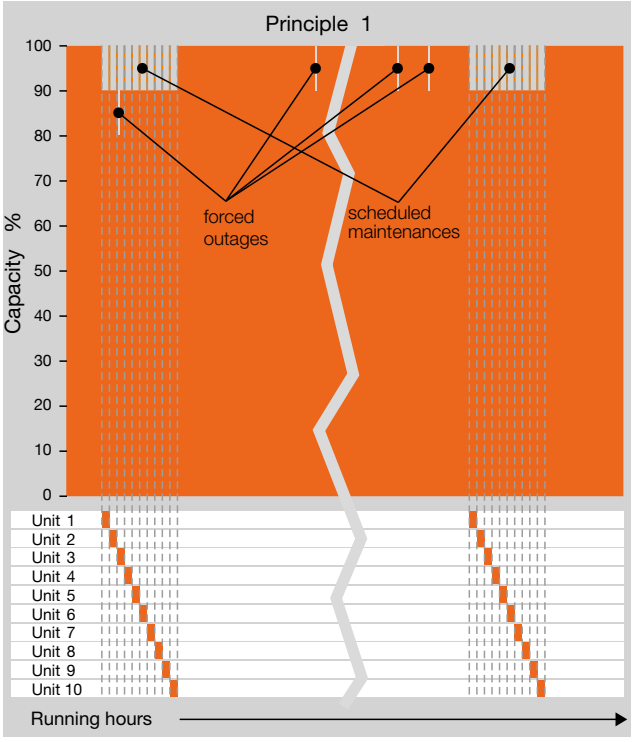
For Wärtsilä's internal combustion engines (ICEs) there is no equivalent operating hours (EOH) calculation. This means that the maintenance schedule is not affected by the number of starts and stops.

MAINTENANCE SCHEDULING

Thanks to condition-based, flexible maintenance, engine servicing can be performed when it best suits the customer´s operations. The following figures illustrate three different scheduling principles for the maintenance of a Wärtsilä power plant.

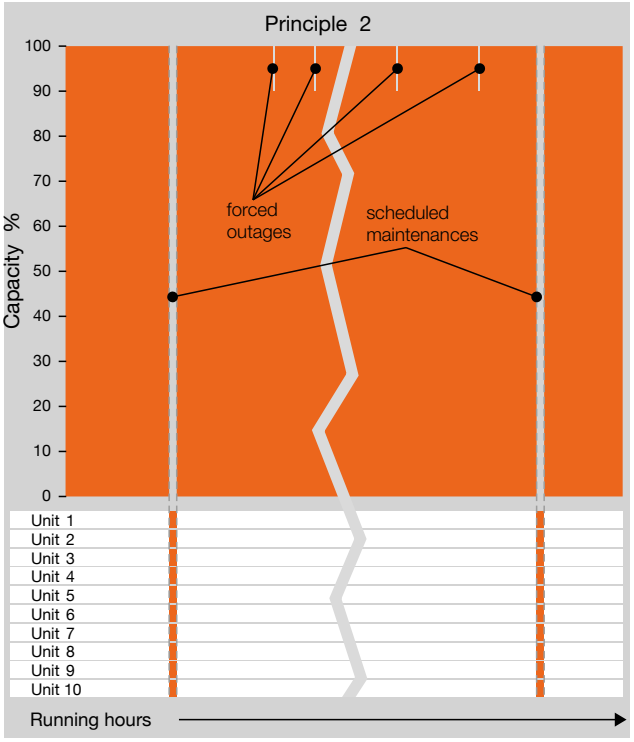
Principle 1: One at a time

- Maximum firm capacity due to sequential maintenance of one unit at a time
- High reliability and unsensitiveness to unscheduled maintenance outages thanks to multiple units



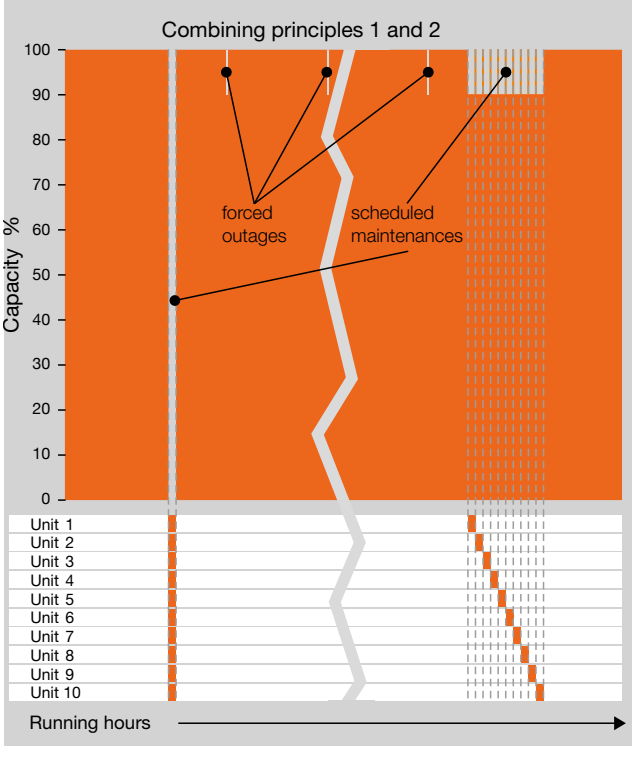
Principle 2: All at once

- Availability of the full plant output when it is most needed, by concentrating all maintenance in the off-season
- Minimised maintenance costs
- High reliability and unsensitiveness to unschedule maintenance outages thanks to multiple units



Combining principles 1 and 2:

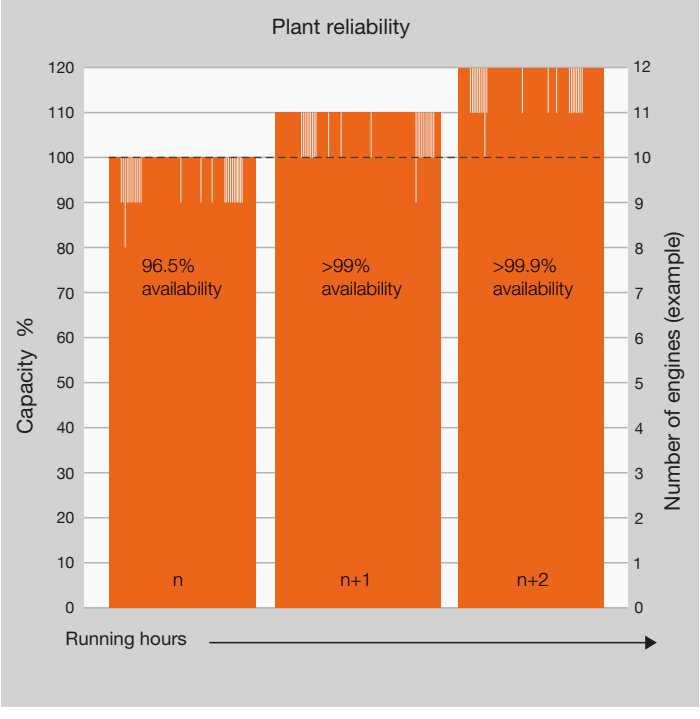
- Adjustable maintenance schedule suitable for seasonal operating variations
- Allows fluctuating business to switch between the maintenance profiles as needed



RELIABILITY & AVAILABILITY

Thanks to the multi-unit configuration, the highest availability and reliability targets can be achieved.

The below figure illustrates the typical operational availability of a Wärtsilä power plant. If the plant capacity matches the actual maximum load (corresponding to the power generated by *n* units), the availability of the plant capacity is above 96.5%. By adding a stand-by unit, the availability can be increased to >99%, and a second stand-by unit further raises the availability to >99.9%.



APPROVED FUELS

Wärtsilä power plants are able to run on a wide selection of fuels, ranging from natural gas to fuel-water emulsions. Detailed specifications for the approved fuels are available upon request.

GASEOUS FUELS & LNG

NATURAL GAS

Natural gas consists mainly of methane plus small quantities of heavier hydrocarbons, carbon dioxide and nitrogen. Commercial gas is processed to meet specifications for heating value, Wobbe index and cleanliness.

LIQUEFIED NATURAL GAS (LNG)

LNG is natural gas that has been converted to liquid form for easier transport and storage. LNG takes up about 1/600th of the volume of natural gas in gaseous state.

COAL BED NATURAL GAS

Coal bed natural gas is found in underground coal layers. It contains methane, water and carbon dioxide in varying proportions. Coal bed gas contains more heavier hydrocarbons than conventional natural gas, but no natural gas condensate.

SHALE GAS

Shale gas is natural gas trapped in fine-grained sedimentary rock, particularly quartz and calcite. Together with coal bed gas and methane hydrates, shale gas is an unconventional source of natural gas.

BIOGAS

Biogas is the result of treating organic matter in digesters or through other decomposing processes. The resulting gas consists mainly of methane and carbon dioxide.

ASSOCIATED GAS

Associated gas is separated from crude oil in field degassing equipment. The methane content is lower than in natural gas, but the concentration of heavier hydrocarbons is higher, normally yielding a higher energy density. GD engines are very suitable for burning associated gas, also when operating in fuel sharing mode.

LIQUEFIED PETROLEUM GAS (LPG)

Liquefied petroleum gases, also referred to as simply propane or butane, are flammable mixtures of hydrocarbon gases. LPG, vaporised at atmospheric pressure, has a higher calorific value (94 MJ/m3 equivalent to 26.1kWh/m3) than natural gas (methane) (38 MJ/m3 equivalent to 10.6 kWh/m3).

Gas					Liquid				
	Natural gas (/LNG)	Biogas	LPG (>97% propane)	Associated gas	Crude	LFO/diesel	Liquid biofuel	HFO	Fuel-water emulsion
Density (kg/m3)	0.7-0.8	~ 0.8	1.3-1.4	1.3-2.5	835-1002	810-900	~ 910 - 930	920-1010	1005 @30% water
Viscosity (cSt)	N/A	N/A	N/A	N/A	2-70@50°C	~ 2 -11@40°C	~ 26@50°C	100 - 700@50°C	350-450@50°C
Wärtsilä 34SG	●	●	●						
Wärtsilä 50SG	●	●							
Wärtsilä 34DF	●	●				●	●	●	
Wärtsilä 50DF	●	●				●	●	●	
Wärtsilä 32GD	●	●		●	●	●	●	●	●
Wärtsilä 46GD	●	●		●	●	●	●	●	●
Wärtsilä 32/32TS					●	●	●	●	●
Wärtsilä 46					●	●	●	●	●
Wärtsilä 50DF[1]					●	●	●	●	●

[1] liquid fuel optimised

LIQUID FUELS

LIGHT FUEL OIL

Light fuel oils or diesel oils are high value distillates that have traditionally been used to fuel diesel engine power plants, both for standby operation and baseload applications. Light fuel oil is typically used in backup power plants and installations in islands or arctic conditions where cheaper alternatives are not available.

HEAVY FUEL OIL

Heavy fuel oils are blended products based on the residues from refinery distillation and cracking processes. They are black viscous liquids which require heating for storage and combustion. Heavy fuel oils are used for diesel engines in power plant and marine applications.

CRUDE OIL

Crude oil is a highly complex mixture of hydrocarbons and other components. The flash point of crude oil is low, typically below the ambient temperature. Crude oil can also be used as fuel in power plants with diesel engines, for example in oilfield power production. Another application is for pumping stations located along a crude oil pipeline, where fuel from the pipeline can be used for the prime movers.

LIQUID BIOFUELS

Liquid biofuels are derived from biological material and can be produced from a variety of carbon sources. Common liquid biofuels approved for use in Wärtsilä engines include oils from various oilseeds, such as palm oil, palm stearin, rape seed oil, sunflower oil and jatropha oil. Liquid biofuels can also be of non vegetable origin, i.e. oils or fats from fish, poultry and animals. Refined biofuel qualities, such as transesterified biodiesel or hydrogenated renewable diesel, can also be used.

FUEL-WATER EMULSIONS

An oil-in-water type emulsion is one way of utilising the residue coming from a refinery as fuel in a diesel power plant. By making an emulsion with water the viscosity is dramatically reduced, enabling it to be pumped at ambient temperature in warm countries. Using it in the diesel engine requires only a fraction of the heating needed for heavy fuel oil.

Gas					Liquid				
	Natural gas (/LNG)	Biogas	LPG (>97% propane)	Associated gas	Crude	LFO/diesel	Liquid biofuel	HFO	Fuel-water emulsion
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Wärtsilä 34DF	●	●				●	●	●	
Wärtsilä 50DF	●	●				●	●	●	
Wärtsilä 32GD	●	●		●	●	●	●	●	●
Wärtsilä 46GD	●	●		●	●	●	●	●	●
Wärtsilä 32/32TS					●	●	●	●	●
Wärtsilä 46					●	●	●	●	●
Wärtsilä 50DF[1]					●	●	●	●	●

[1] liquid fuel optimised

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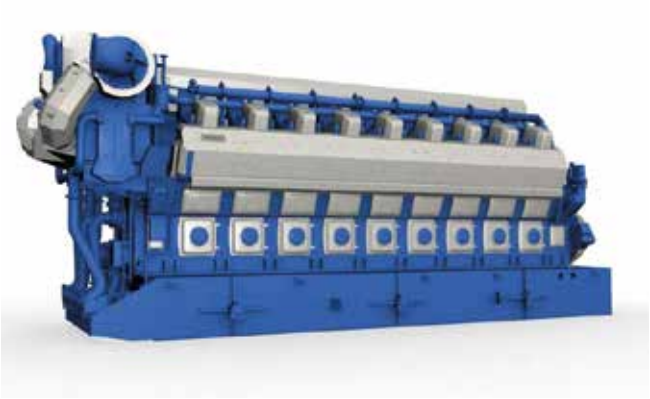
POWER PLANT GENSETS

The core of a power plant solution is the genset. Wärtsilä gensets consist of a four-stroke medium-speed engine, connected to a generator via a flywheel and coupling, mounted on a common baseframe. The genset is aligned, fine-tuned and pre-tested in the factory, fully ready for installation with minimal work at site.



Small and medium sized gensets (based on Wärtsilä 32/32TS/32GD/34DF/34SG) are normally transported as complete gensets. If required by the logistics of the project, the gensets can also be delivered split into two blocks: engines mounted on the baseframe and generators shipped separately.

Larger gensets (based on Wärtsilä 46/46GD/50DF/50SG engines) are normally delivered in two blocks: engine and generator mounted on its own base frames, ready to be bolted together at site. This allows a considerably reduced transportation weight.

Fuel	Engine (speed, 50/60 Hz)	Cylinder configuration	Power, electrical (kW, 50Hz)	Power, electrical (kW, 60Hz)	Genset dry weight (tonne), ±5%	Reduced transport weight (tonne), ±5%
Gas	Wärtsilä 50SG (500/514 rpm)	18V50SG	18320	18760	365	210
		9L34SG	4340	4170	77	-
	Wärtsilä 34SG (750/720 rpm)	16V34SG	7740	7430	120	50
		20V34SG	9730	9340	130	65
Multi-fuel	Wärtsilä 50DF gas opt. (500/514 rpm)	18V50DF	16640	17080	369	215
		9L34DF	4340	4170	79	-
	Wärtsilä 34DF (750/720 rpm)	16V34DF	7740	7430	120	50
		20V34DF	9730	9340	134	65
	Wärtsilä 46 GD (500/514 rpm)	12V46GD	11380	11380	272	209
		18V46GD	17080	17080	370	298
	Wärtsilä 32GD (750/720 rpm)	6L32GD	2640	2580	58	-
		9L32GD	3970	3890	79	-
		12V32GD	5300	5180	93	-
		16V32GD	7120	6970	120	-
		20V32GD	8920	8730	131	-
Liquid fuel	Wärtsilä 50DF liquid opt. (500/514 rpm)	18V50DF	18320	18320	369	297
	Wärtsilä 46 (500/514 rpm)	12V46	11380	11380	269	207
		18V46	17080	17080	368	296
	Wärtsilä 32 (750/720 rpm)	6L32	2640	2580	53	-
		9L32	4340	4170	78	-
		12V32	5790	5560	92	-
		16V32	7740	7430	117	-
		18V32	8730	7380	128	-
		20V32	9730	9340	130	-
	Wärtsilä 32TS (750/720 rpm)	20V32TS	10120	9730	151	-

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers.

In 2014, Wärtsilä's net sales totalled EUR 4.8 billion with approximately 17,700 employees. The company has operations in more than 200 locations in nearly 70 countries around the world. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

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