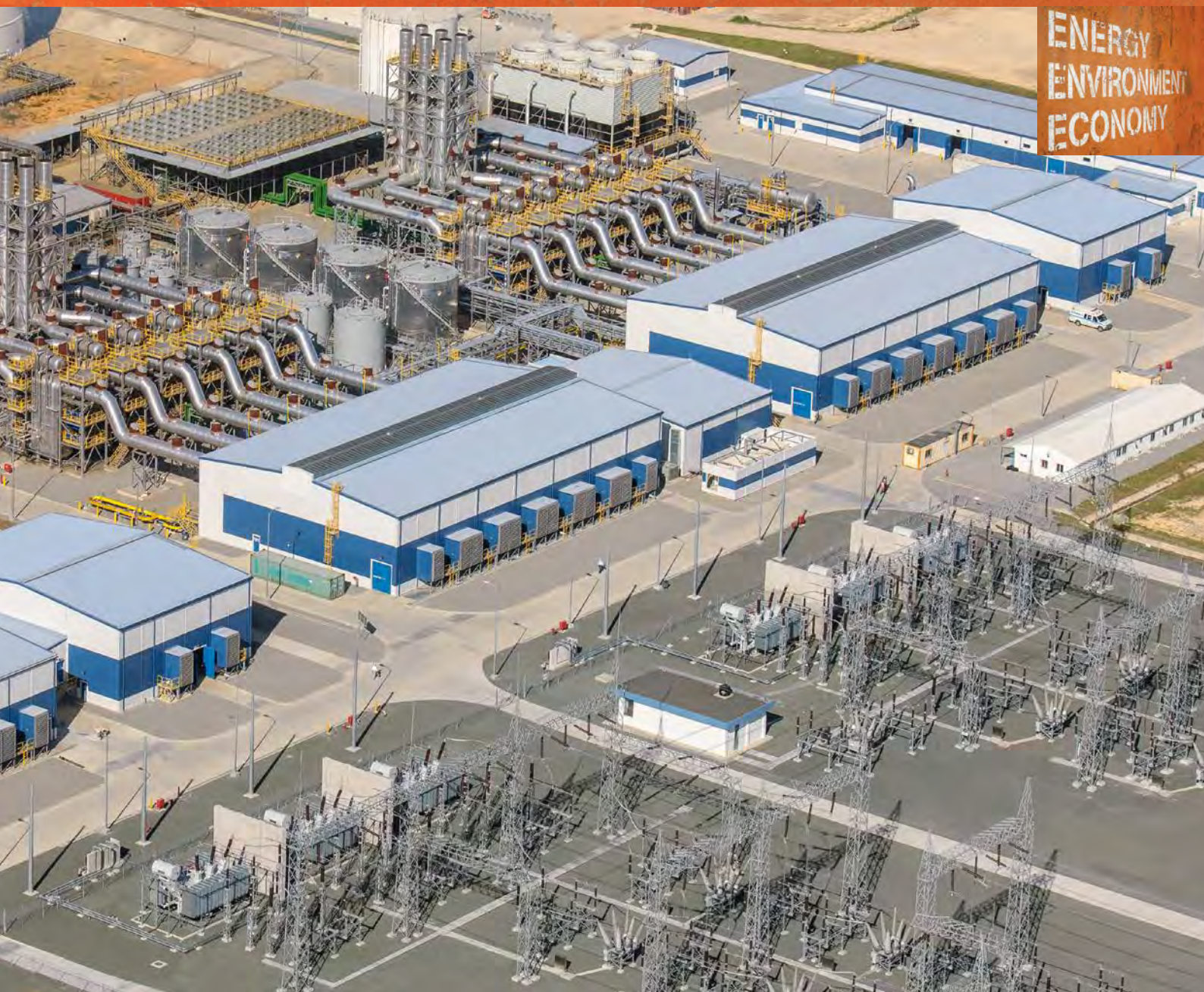
WÄRTSILÄ

GAS AND MULTI-FUEL POWER PLANTS



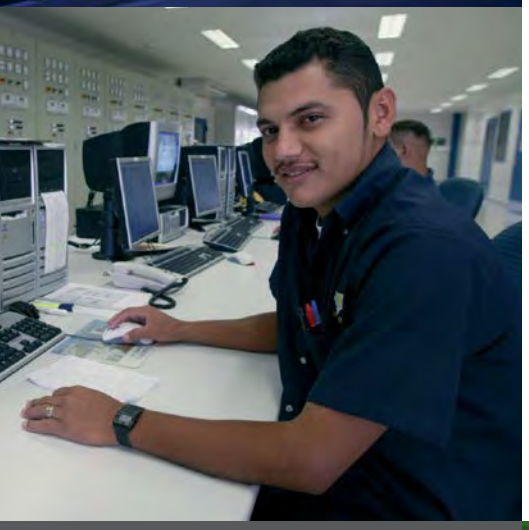
The Sheki power plant in Azerbaijan is equipped with 10 x Wärtsilä 20V34SG engines.

WÄRTSILÄ GAS AND MULTI-FUEL POWER PLANTS' BENEFITS:

- Plant electrical efficiency over 53%
- Fast start-up – 2 min from hot standby to full plant load
- Combined heat and power as an option
- Excellent plant availability and reduced need for back-up capacity due to multi-unit installation
- High part-load efficiency
- Low gas pressure requirement
- Maintenance schedule independent of the number of starts, stops or trips
- Full plant output at high altitudes and in hot and dry ambient conditions
- Minimal water consumption due to closed-circuit radiator cooling
- Stepwise investment with smaller risks and optimized profit generation.

ICE-strengths: Relatively high efficiency at small scale; modular; rapid start-up; lower capital cost than OCGT; tolerant of different fuel qualities

Source:
Internal Energy Agency: Energy Technology Perspective – Harnessing Electricity's Potential, 2014



Whether you need baseload, intermediate, peaking or standby power generation, we provide it. WÄRTSILÄ® gas and multi-fuel plants are typically based on modular 4–19 MW internal combustion engine (ICE) units. ICEs are designed for continuous operation on natural gas or in multi-fuel mode (gas/oil).

Our gas and multi-fuel power plants offer high output and efficiency even in the most challenging conditions and locations. In the hottest deserts or high in the mountains, in city centres or jungles, energy output and efficiency is consistent and reliable, throughout the entire load range. And the fact that a negligible amount of water is consumed in the process has obvious advantages, too, particularly in dry locations.

World-class operational flexibility with uniquely fast starts, stops and restarts, ensures perfect control over daily load fluctuations. And as energy demand grows, the high modularity of our products makes it easy to expand your power plant to meet any future changes. You can upgrade your plant at any time without risking operational reliability. After all, several smaller units are, by definition, always more reliable than one large one. Incremental investment also ensures continual competitiveness in today's volatile market.So, just pay for what you need, when you need it.

Finally, our technologies are backed up by world-wide operations and management services that ensure efficiency and optimize equipment reliability throughout its lifecycle.

We offer true flexibility, both in fuel choice and in our ability to respond to operational demand, and this makes Wärtsilä gas and multi-fuel power plants the solid choice in today's power market.

GAS AND MULTI-FUEL POWER PLANTS BY WÄRTSILÄ

- Over 17 GW out there!
- In more than 80 countries

ARUN, SUMATRA, INDONESIA

Customer .. PT Wijaya Karya Persero Tbk (PT Wika) (Utility)
Type.....Wärtsilä 34 gas power plant
Operating mode.....Peak load/stand-by & emergency
Gensets.....19 x Wärtsilä 20V34SG
Total output ..... 184 MW
Fuel ..... LNG (Liquefied natural gas)
Scope ..... EEQ (Engineering & Equipment)
Delivered..... 2015

LIFETIME COMMITMENT

Count on our total commitment and comprehensive range of services – tailored to your requirements – to achieve the best possible performance from your power plant investment throughout its lifecycle.

Wärtsilä carries out deliveries ranging from equipment supply, or equipment and engineering; to complete turnkey projects that include engineering, procurement and construction. Our development and finance group, together with a comprehensive service network, make for a complete project implementation, from concept and financing to construction and beyond.

Our range of services covers everything from rapid spare parts delivery to complete operations and maintenance solutions. By optimizing all aspects of the power plant's operations and minimizing the economic and technological risks involved, we enhance the plant's profitability. Our continuously growing number of Operations & Management (O&M) customers stands as proof.
Wärtsilä currently operates around 500 marine and land-based installations around the world.

If you choose to operate the plant yourself, you can still rest assured that you have the best possible support available when and where you need it – from training and online support to service packages or plant modernization and upgrading. Our global network of 11,000 professionals worldwide stands ready to provide you with the support you need, anywhere at any time.This ensures that your power plant will operate at its highest efficiency and performance levels throughout its lifetime.

We have a track record of providing over 56 GW of power in over 170 countries. Here are just a few examples.

PEARSALL POWER PLANT (STEC), USA

Customer .....STEC (Utility)
Type..... Wärtsilä 34 gas grid stability
Operating mode..Peak load/stand-by & emergency
Gensets..... 24 x Wärtsilä 20V34SG
Total output .....203 MW
Fuel .....Natural gas
Scope .....EEQ (Engineered Equipment Delivery)
Delivered..... 2009

SEABOARD, DOMINICAN REPUBLIC

Customer .....Seaboard Corporation (IPP)
Type.....Flexicycle 50DF multi-fuel power plant
Operating mode..... Flexible baseload
Gensets..... 6 x Wärtsilä 18V50DF
Total output .....110 MW
Fuel ..... Natural gas, HFO & LFO
Scope .....EEQ (Engineered Equipment Delivery)
Delivered..... 2012

PLAINS END I & II, COLORADO, USA

Customer ..... Tyr (IPP)
Type..... Wärtsilä 34 gas grid stability
Operating mode..Peak load/stand-by & emergency
Gensets..... 20 x Wärtsilä 18V34SG
..... + 14 x Wärtsilä 20V34SG
Total output .....231 MW
Fuel .....Natural gas
Scope ..... ED (Equipment Delivery)
Delivered..... 2001 & 2006

ALIAGA, TURKEY

Customer ..... Çakmaktepe Energy (IPP)
Type.....Wärtsilä 34 gas power plant
Operating mode..... Baseload
Gensets.....28 x Wärtsilä 20V34SG
Total output .....270 MW
Fuel .....Natural gas
Scope:....EPC & EEQ (Engineering, Procurement & Construction and Engineered Equipment Delivery)
Delivered..... 2007, 2009 & 2011

HUMBOLDT, CALIFORNIA, USA

Customer ..... .Pacific Gas & Electric Co (Utility)
Type..... Wärtsilä 50DF multi-fuel power plant
Operating mode..... Baseload
Gensets..... 10 x Wärtsilä 18V50DF
Total output .....163 MW
Fuel ..... Natural gas & LFO
Scope ..... EPC (Engineering, Procurement & Construction)
Delivered..... 2011

BARRICK, NEVADA, USA

Customer ..... Barrick Goldstrike Mines Inc. .....(Industry – mining)
Type.....Wärtsilä 34 gas power plant
Operating mode..... Baseload
Gensets.....14 x Wärtsilä 20V34SG
Total output .....116 MW
Fuel .....Natural gas
Scope ..... EPC (Engineering, Procurement & Construction)
Delivered..... 2005

UTE LORM, LINHARES-ESPIRITO SANTO, BRAZIL

Customer .....Linhares Geração S.A (IPP)
Type..... Wärtsilä 34 gas grid stability
Operating mode..... Peak load
Gensets.....24 x Wärtsilä 20V34SG
Total output .....204 MW
Fuel .....Natural gas
Scope ..... EPC (Engineering, Procurement & Construction)
Delivered..... 2010

SASOLBURG, SOUTH AFRICA

Customer .....SNE (IPP)
Type.....Wärtsilä 34 gas power plant
Operating mode.....Flexible baseload
Gensets.....18 x Wärtsilä 20V34SG
Total output .....175 MW
Fuel .....Natural gas
Scope ..... EPC (Engineering, Procurement & Construction)
Delivered..... 2012

Selective Catalytic Reduction unit (SCR)

Control room

Switchgear room

The generating set

FLEXIBILITY IN SCOPE

Wärtsilä gas and multi-fuel power plants are designed for optimal performance in a wide variety of decentralized power production applications: baseload, peaking power and combined heat & power plants. The plant can be situated whether in the midst of a densely populated area or in a remote area with minimal infrastructural resources. Regardless of the plant's location, it will be just as lean, clean and quiet as it should be.

Modularity simplifies plant configuration to meet each customer's specific needs. Adding features is a matter of adding modules which are pretested for compatibility and reliability. Pre-engineered, integrated solutions speed up the planning and delivery process, quickly creating savings and added revenue.

A typical Wärtsilä gas or multi-fuel power plant consignment consists of:

- generating sets

QUISQUEYA I & II, DOMINICAN REPUBLIC

Customer ..... Barrick & EGE Haina (Industrial & 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

A Wärtsilä GasCube plant is a multiple of engine modules designed to meet a total power need of 6–30 MW. A GasCube based on the Wärtsilä 16V34SG or Wärtsilä 20V34SG, with all the auxiliaries and components needed to make up a working power production unit, provides 7–10 MWe per unit. Due to the self contained design, the GasCube is the optimal solution for agile, streamlined and exceptionally cost efficient project execution.

- **High electrical efficiency**
- **Minimization of the plant's own electricity consumption**
- **Simple and reliable technical solutions**
- **Compact, pre-engineered plant design**
- **Perfect for EPC deliveries even to areas lacking infrastructure.**

Compact auxiliary module

Closed-loop cooling system with radiators

- mechanical auxiliary systems including the fuel system, lubrication, air intake, cooling, exhaust processing and sound-proofing
- electrical systems
- automation
- heat recovery system in combined heat and power plants
- civil works and structures.

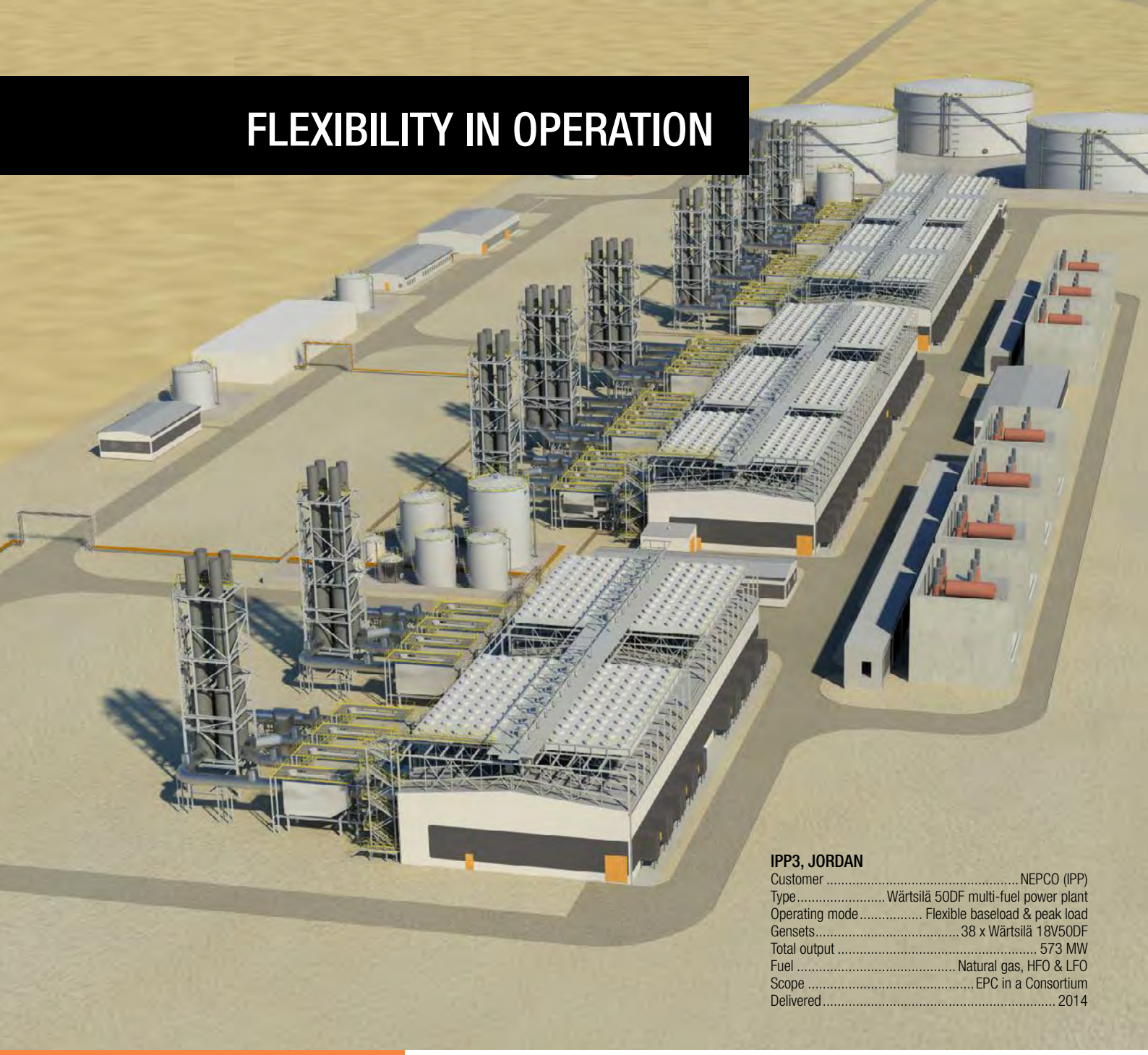
Installing a steam boiler to drive a steam turbine will increase the power production by close to 10%. The steam cycle option can either be included in the initial design, or added at a later date. In CHP applications for hot water production the total efficiency can reach 95%. This lowers the production cost of electricity and increases the economic attraction of these plants.

The environmental impact of a Wärtsilä gas or multi-fuel plant is low. NO_X emission levels fulfill the majority of global emission requirements today without any secondary cleaning methods. To further reduce environmental impact, effective oxidation and/or NO_X catalysts and other advanced equipment can be installed.

The engine cooling arrangement using closed-circuit radiator cooling reduces plant process water consumption to almost zero, minimizing the effect on local water resources.

The hall design and low building profile help the plant to blend in with its surroundings. Effective sound-proofing allows the plant to be operated even in densely populated areas, where the actual loads are, which effectively prevents possible transmission and distribution bottlenecks.

FLEXIBILITY IN OPERATION



IPP3, JORDAN

Customer	NEPCO (IPP)
Type	Wärtsilä 50DF multi-fuel power plant
Operating mode	Flexible baseload & peak load
Gensets	38 x Wärtsilä 18V50DF
Total output	573 MW
Fuel	Natural gas, HFO & LFO
Scope	EPC in a Consortium
Delivered	2014

An ICE is today's most efficient means of converting liquid or gaseous fuels into energy. Wärtsilä gas power plants can run on low-pressure gas. The multi-fuel option gives even more flexibility when the gas supply is unreliable.

Wärtsilä gas engines operate on most natural gas types. They are also available as multi-fuel engines, operating on natural gas as well as on diesel fuel. When the gas supply is uncertain or prices are volatile, it is possible to switch over from gas to diesel or vice versa during continuous operation if necessary. The option to run on diesel as a backup fuel can considerably improve reliability in case of gas shortages.

In emerging gas markets it is possible to build a fast track plant operating on liquid fuel, and later expand and convert the plant to operate on gas as the supply becomes more readily available. This also works the other way around: existing power plants with gas conversion possibilities create a good base for investments in gas infrastructure.

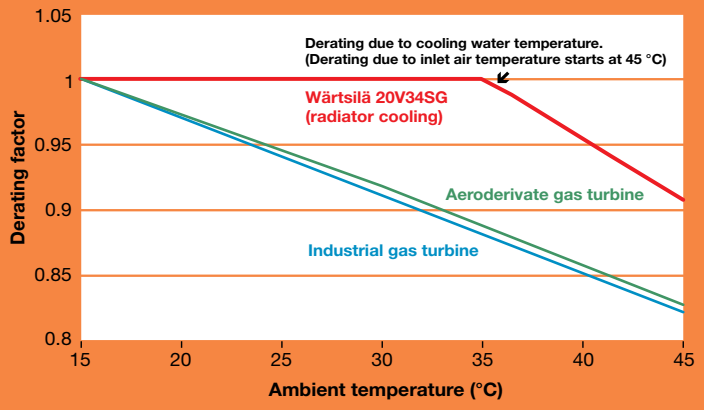
Wärtsilä gas engines with modern lean-burn technology reach over 50% electrical efficiency. The heat recovery option does not affect the electrical efficiency of the generating set. High efficiency translates into considerable savings in fuel costs compared to other technologies.

Multi-unit configuration creates a part-load profile that enables you to optimize the entire output range of the plant. For a given total plant load, you simply operate as many individual generating sets as required at their optimal efficiency.

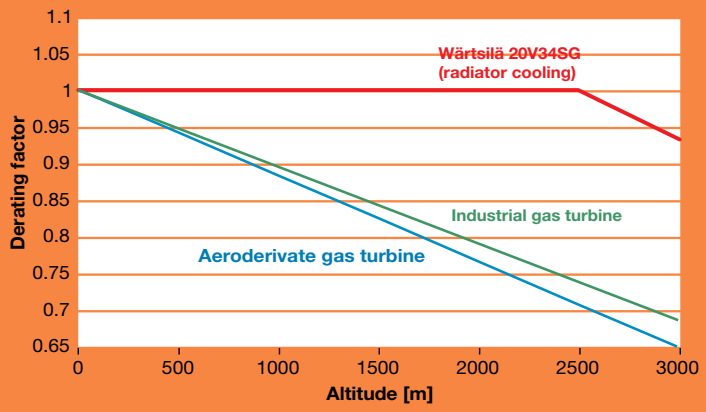
Wärtsilä gas and multi-fuel power plants withstand extreme conditions, with only

minimal heat rate and output derating at high altitudes or in hot temperatures. Furthermore, Wärtsilä gas and multi-fuel power plants can be located virtually anywhere due to the fact that our plants run on low gas pressure and their air cooled system does not consume any process water.

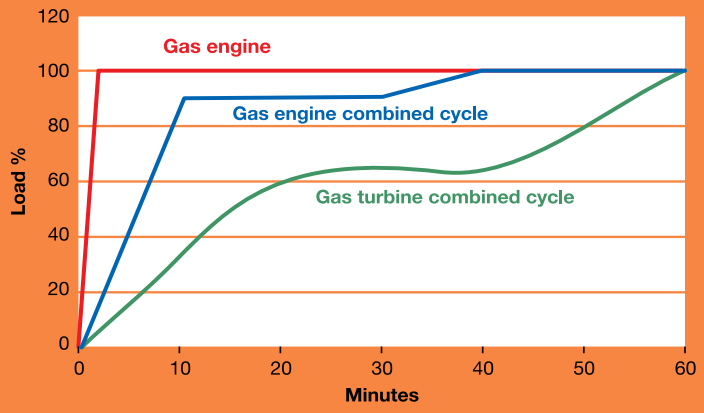
The multiple genset concept ensures high reliability and availability. All maintenance can be performed on-site one unit at a time, leaving the remaining units available for duty. The use of several identical engines also reduces the cost of on-site spare parts stock.



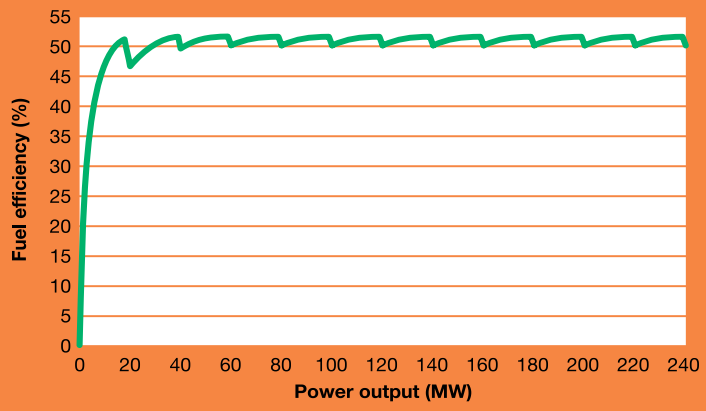
Wärtsilä gas combustion engines offer stable output and high performance in hot and dry conditions. No water consumed for plant cooling = arid area suitability!



Wärtsilä gas ICEs offer stable output and high performance at high altitudes as well.



Wärtsilä 50SG fast start up and load & turbine start up and load



Wärtsilä 50SG multi-unit gas engine power plant has very high part-load efficiency.

FLEXIBILITY IN FUEL

The engine generating sets used in Wärtsilä power plants are driven by heavy-duty medium-speed four-stroke ICEs. These generating sets consist of an engine connected directly to a generator via a flexible coupling. The generator and engine are rigidly mounted on a common baseframe.

LEAN-BURN GAS ENGINES (SG)

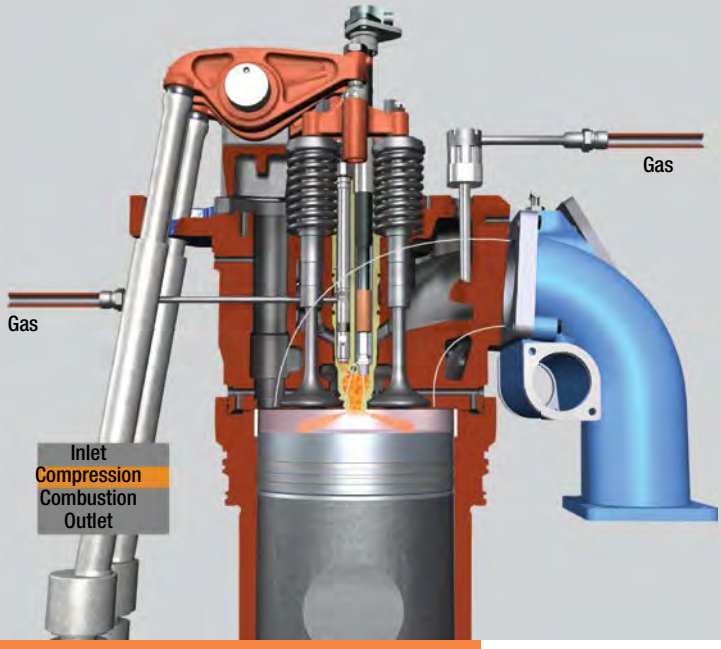
The SG engines are spark-ignited lean-burn engines. In this process, the gas is mixed with air before the inlet valves. During the intake period, gas is also fed into a small prechamber, where the gas mixture is rich compared to the gas in the cylinder. At the end of the compression phase the gas-air mixture in the prechamber is ignited by a spark plug. The flames from the nozzle of the prechamber ignite the gas-air mixture in the whole cylinder. Combustion is fast. After the working phase the cylinder is emptied of exhaust and the process starts again.

DUAL-FUEL ENGINES (DF)

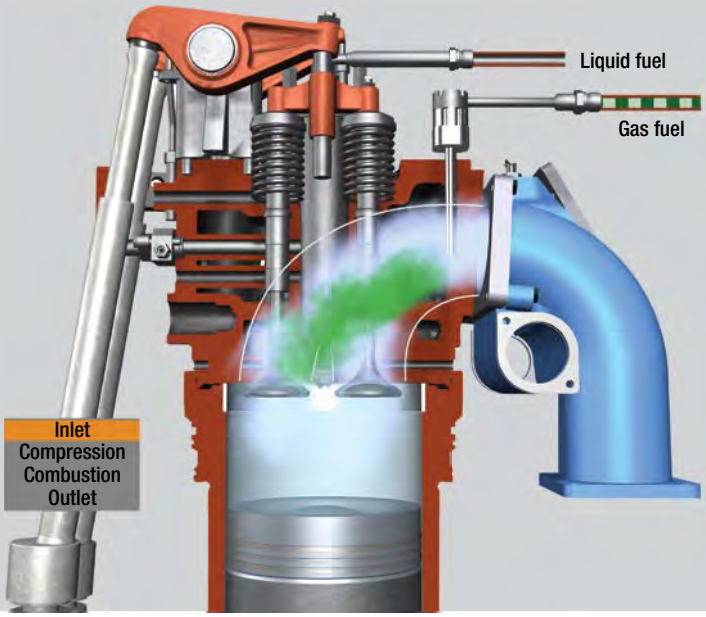
The dual-fuel engine utilizes a “lean-burn” combustion process when operating on gas. Here, the gas is mixed with air before the intake valves during the air intake period. After the compression phase, the gas-air mixture is ignited by a small amount of liquid pilot fuel. After the working phase the exhaust gas valves open and the cylinder is emptied of exhaust gases. The inlet air valves open when the exhaust gas valves close, and the process starts again.

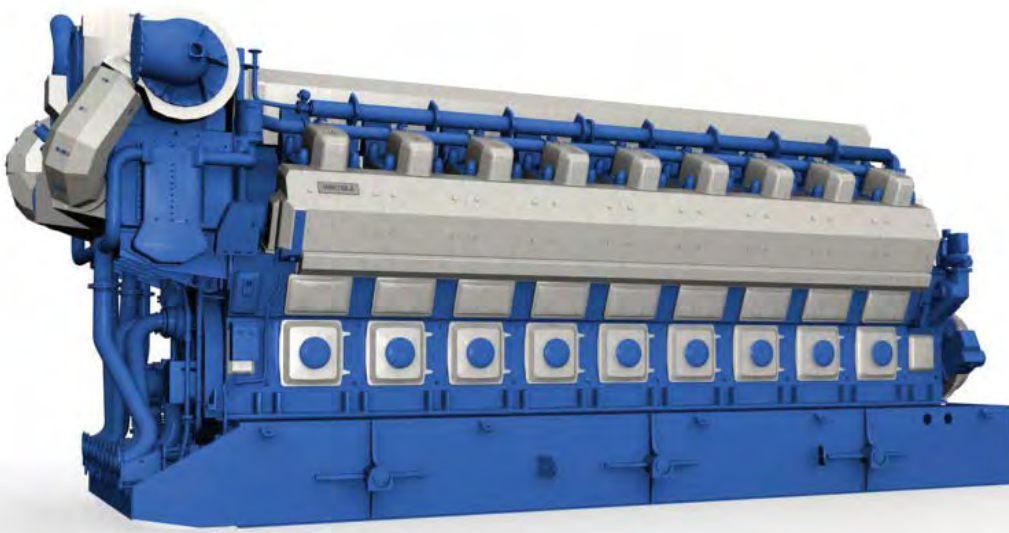
The dual-fuel engine is also equipped with a back-up fuel system. This is a normal diesel process with camshaft-operated liquid fuel pumps running parallel to the process and working as a stand-by.

SG PRINCIPLE



DF PRINCIPLE





Wärtsilä 18V50SG

- **The world’s largest gas-fired ICE**
- **The world’s most efficient single cycle prime mover**

GAS-DIESEL ENGINES (GD)

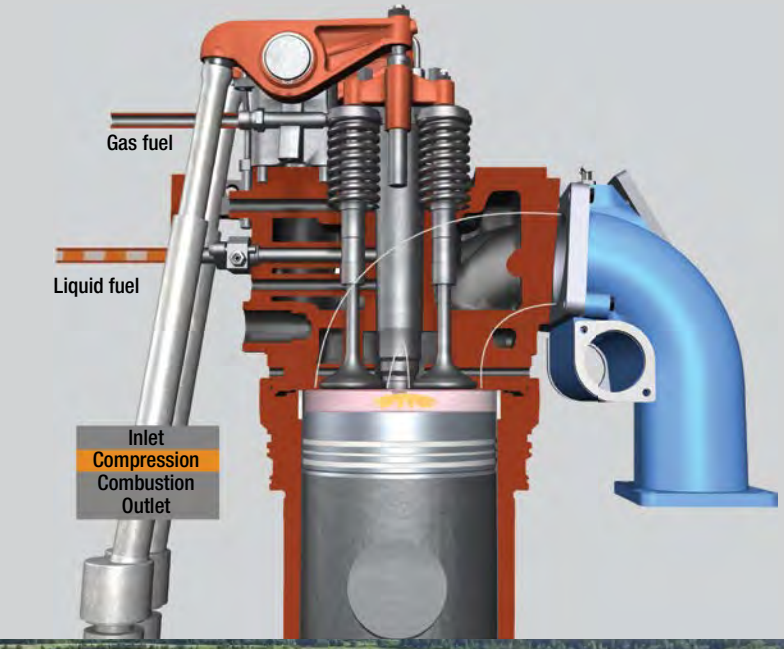
The GD engine utilizes the diesel combustion process in all operational modes. In **gas mode**, the gas is injected at high pressure after the pilot fuel and is ignited by the flame from the pilot fuel injection. The amount of pilot fuel is equivalent to approximately 5% of the fuel energy input at full engine load.

The gas-diesel engine can be switched over instantly to **liquid fuel mode** operation. The liquid fuel can be light fuel oil, heavy fuel oil or crude oil. In this case, the process is the same as the conventional diesel process.

In **fuel sharing mode**, the ratio between liquid and gas fuel amounts can be controlled and varied during operation. The operating window for the fuel sharing mode is 30 to 100% load and the gas/liquid fuel ratio can vary according to the fuel sharing window.

The gas-diesel process can tolerate big variations in the gas quality and is especially suitable for “non-pipeline quality gas”, such as associated gas in oil fields.

GD PRINCIPLE



GAS GENSETS

Wärtsilä 50SG	18V50SG
Power, electrical (50 Hz/500 rpm) kW	18 320
Power, electrical (60 Hz/514 rpm) kW	18 760
Genset dry weight (tonne) ±5%	365
Reduced transport weight (tonne) ±5%	293

Wärtsilä 34SG	9L34SG	16V34SG	20V34SG
Power, electrical (50 Hz/750 rpm) kW	4340	7740	9730
Power, electrical (60 Hz/720 rpm) kW	4170	7430	9340
Genset dry weight (tonne) ±5%	77	120	130

MULTI-FUEL GENSETS

Wärtsilä 50DF	18V50DF
Power, electrical (50 Hz/500 rpm) kW	16640
Power, electrical (60 Hz/514 rpm) kW	17080
Genset dry weight (tonne) ±5%	369
Reduced transport weight (tonne) ±5%	297

Wärtsilä 34DF	9L34DF	16V34DF	20V34DF
Power, electrical (50 Hz/750 rpm) kW	4340	7740	9730
Power, electrical (60 Hz/720 rpm) kW	4170	7430	9340
Genset dry weight (tonne) ±5%	79	120	134

Wärtsilä 46GD	12V46GD	18V46GD
Power, electrical (50 Hz/750 rpm) kW	11380	17080
Power, electrical (60 Hz/514 rpm) kW	11380	17080
Genset dry weight (tonne) ±5%	272	370
Reduced transport weight (tonne) ±5%	209	298

Wärtsilä 32GD	6L32GD	9L32GD	12V32GD	16V32GD	20V32GD
Power, electrical (50 Hz/750 rpm) kW	2640	3970	5300	7120	8920
Power, electrical (60 Hz/720 rpm) kW	2580	3890	5180	6970	8730
Genset dry weight (tonne) ±5%	58	79	93	120	131

KIISA ERPP I & II, ESTONIA

Customer ..... Elering (Utility/TSO)
Type ..... Wärtsilä 34DF multi-fuel grid stability
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

SANGACHAL, AZERBAIJAN

Customer ..... AzerEnerji (Utility)
Type ..... Wärtsilä 50DF multi-fuel power plant
Operating mode ..... Baseload
Gensets ..... 18 x Wärtsilä 18V50DF
Total output ..... 308 MW
Fuel ..... Natural gas
Scope ..... EPC (Engineering, Procurement & Construction)
Delivered 2009

WÄRTSILÄ

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. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

10.2014 / Bock's Office