Flexible combined heat and power & trigeneration solutions
Combined benefits of distributed cogeneration

Wärtsilä’s development of distributed engine power plant solutions is based on the demand for alternative energy sources, the need to shorten transmission distances, and the increasing stipulations for fuel efficiency. With increased deregulation and the liberalisation of energy markets, the trend in many countries is towards decentralised systems. Power, heat and cooling need to be generated closer to consumers.

Flexibility within the power system will be increasingly required in order to integrate growing shares of wind and solar energy in a cost-efficient and secure manner, while adhering to environmental requirements. Energy markets in many parts of the world have to balance distinct needs, but fluctuating demand combined with variations in the renewable energy output can make such balancing difficult.

Wärtsilä’s CHP plants technology, with its fast starting and stopping capabilities, is an ultra-flexible complement to power production from wind and solar sources.

Wärtsilä’s combined heat and power (CHP) and trigeneration plants use fuel in the most efficient way and help to reduce carbon emission levels. Total plant efficiencies can exceed 90%. Our CHP plants are capable of running on various liquid, gaseous and bio fuels, while maintaining low emissions and high efficiency. Wärtsilä engine plants comply with national and local environmental requirements, and with the World Bank guidelines for power plants.

Thanks to the hang-on heat recovery system, Wärtsilä CHP plants maintain 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 from just one power plant. This is possible without compromising the high reliability and superb flexibility of the Wärtsilä power plants.

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 Wärtsilä CHP and trigeneration solutions.
Environmentally friendly and efficient solution with a small CO₂ footprint.

- Dynamically able to respond to electricity price variations.
- The most flexible power plant in the thermal power industry supports intermittent wind and solar energy.
- Flexibility can be further improved with heat storage.
- Multiple engine units with fast start and ramp rates enable dynamic operation at high efficiency during low heat demand.
- High efficiency and flexible operation over a wide load range. Typical plant sizes: 6-200 MWₑ.
- Multi-unit design enables optimised plant size with step-by-step investment.
- Flexible operation responds to changes in power, heat and cooling demands.
- On-site maintenance without production downtime.
- Lifecycle solutions optimises the efficiency and performance of the plant.

Low capital and operational costs per output unit ➔ high profitability.

**Typical specific CO₂ emissions from different power plant types**

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>CO₂ emissions in g/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal fired steam boiler</td>
<td>800</td>
</tr>
<tr>
<td>Gas turbine fuel oil single cycle</td>
<td>750</td>
</tr>
<tr>
<td>Gas turbine natural gas single cycle</td>
<td>600</td>
</tr>
<tr>
<td>Diesel engine fuel oil single cycle</td>
<td>600</td>
</tr>
<tr>
<td>Gas engine natural gas single cycle</td>
<td>450</td>
</tr>
<tr>
<td>Gas engine natural gas CHP (gas/gas)</td>
<td>340</td>
</tr>
<tr>
<td>Gas engine natural gas CHP (gas/steam)</td>
<td>240</td>
</tr>
<tr>
<td>Coal fired chilling plant</td>
<td>400</td>
</tr>
<tr>
<td>Diesel engine fuel oil DCAP</td>
<td>260</td>
</tr>
</tbody>
</table>

Electricity production only

Electricity and heat production

Electricity and chilling production
Wärtsilä CHP and trigeneration plants are powered by large internal combustion engines (ICE). They offer exceptional flexibility and uncompromising performance wherever power, heat and/or cooling are required.

The heat recovery systems between the prime mover and the customer’s equipment, are typically “hang-on” solutions, ensuring both optimised heat production and effective engine cooling and operation. Wärtsilä’s heat recovery design takes into account all the seasonal, monthly, weekly and daily variations in the customer’s heat/cooling production conditions. Heat production does not affect the electrical output or the electrical efficiency of the prime mover.

Gas engine plant start-up times are very short – 100% electrical output is reached in 2 minutes and 100% heat output in less than 15 minutes.

The modular design of Wärtsilä CHP and trigeneration plants enables rapid delivery anywhere in the world. Prefabricated, functionally pre-tested modules guarantee consistent quality and performance, and make on-site installation a matter of assembling and connecting the modules.

Another benefit of Wärtsilä’s modular plant concept is the unique flexibility of the cascading multi-engine structure of the plants. Multi-unit installations provide high plant efficiency at any load: at times of low demand, some of the generating sets can be turned off, while the plant continues to run at peak efficiency with as many units running as required.

If demand increases over the longer term, the plant can be easily extended by adding new engines. This also allows a smaller initial investment, with the option to expand later if required.
The two-floor plant lay-out allows a small and compact footprint. The generating set and auxiliaries are on the first floor and the ventilation, exhaust gas heat recovery, and emission reduction equipment on the second floor.
The high efficiency of Wärtsilä’s CHP plants translates into considerable savings in fuel costs compared to other technologies. For optimised profitability, the plants are customised to the customers’ specific needs.

A distributed combined heat and power plant increases reliability in the supply of energy. Energy production is local and close to the point of consumption. Local heat generation ensures quick response to changes in capacity or temperature in the industrial process or the district heating network.

To optimise the balance between thermal and electrical energy production, each plant is customised to suit the needs of the end user. Wärtsilä provides a design that ensures maximum efficiency and the best possible operational flexibility. The automation system not only controls all the internal processes in the Wärtsilä CHP plant, but is also carefully integrated with all necessary signals and connections to the existing systems, thereby guaranteeing a fully compatible plant.

For industrial applications (e.g. textile industry, food processing, refineries, etc.) steam can be produced for the processes. Fuel efficiency can be increased with steam production. Should the electricity grid be subject to failures, Wärtsilä engines with lifecycle solutions guarantee a reliable supply of energy at all times.

Typical total plant efficiency as a function of the DH supply and return temperature.
Steam generation for industrial applications.
In the past, the main role of CHP plants was to produce heat, while electricity was produced as baseload and often sold to local utilities at flat prices. It was done based on baseload operations during the heating season. This is now changing as a result of the evolving electricity market.

Wärtsilä’s Dynamic District Heating (DDH) concept is based on the utilisation of CHP plants according to the demands of the national power system. The DDH plant supports the power grid, while continuing to fulfil its primary mission of heat generation.

The DDH solution is designed to handle variabilities in the generation of thermal power. With a highly efficient gas engine power plant, asset owners achieve more economic benefits and greater value. The excess heat from engine cooling and exhaust gases are harnessed for district heating needs.

Plant configuration
A Wärtsilä DDH power plant is a multi-unit CHP plant that includes the engines, boilers and pump modules. DDH plants are capable of high efficiency and flexible operation over a broad range of plant loads, and are thus able to respond to the demand for heat, and to fluctuations in the price of electricity. This flexibility can be further enhanced with thermal storage of the produced heat.

Thermal storage
Due to volatility in electricity prices, power generated during peak hours is typically more profitable than power generated during the night. In a DDH plant, the generated thermal energy can be stored in thermal storage tanks, also known as heat storage tanks, in order to decouple heat production from electricity production.
By combining the efficiency and flexibility of Wärtsilä engine technology with a tailored and optimised CHP process, a DDH plant can efficiently operate in electricity markets anywhere.

With a Wärtsilä DDH power plant and thermal storage, the variations in power prices and heat demand can be utilized to maximize the value of the heat and power generation. This is achieved by operating the engines during these peak hours and feeding the heat produced into the district heating network or to the thermal storage tank. With a thermal storage tank tightly integrated into the Wärtsilä DDH power plant, the benefits can be utilized completely.

Such benefits include:
- The heat output from the engine and thermal storage will substitute other investments in heat generating capacity
- The power plant’s power output will be at maximum load during periods when energy prices are high
- The engine/accumulator will decrease the operation of heat only boilers
- Eventually the value of the generated power may be boosted by selling the capacity on the balancing market.
Trigeneration solutions

While in many countries, district heating system technology is well established, in warmer climates the need is different. Here, where the yearly demand for heat is much less and the summer temperatures are high, cooling generation is essential.

While generating electric power, a substantial amount of cooling energy can be generated from the exhaust gas and engine waste heat by applying absorption chiller technology. Wärtsilä has designed its trigeneration plants to optimally meet the demand for both power and cooling.

Many industrial facilities and public buildings, such as airports, hospitals, shopping malls and large factories, have heating and cooling needs that can be efficiently met by a trigeneration plant. To maximise the total efficiency of a trigeneration plant, its location should ideally be close to the consumers.

Ambient conditions

Both electric power and cooling consumption are dependent on seasonal and daily demand variations. Cogeneration plants have to follow the load accordingly. These variations can be very large, with ambient temperatures reaching 50 °C in the summer. Therefore, the fluctuations in electrical power consumption are also considerable. For example in the Middle East, 70% of the electricity produced is used for air conditioning.

DCAP solutions

The Wärtsilä District Cooling and Power (DCAP) system has been developed for hot areas where no heat is required, but only power and chilled water for district cooling and air conditioning.

These systems can be designed for 50,000 TR. The optimal solution is always based on the correct design and sizing. The entire chilled water demand should not be covered solely by absorption chillers. Instead, electrically driven chillers and/or chilled water storage tanks should be utilized to cover demand peaks, thereby minimizing...
Case: Typical variation curves for a two engine trigeneration plant supplying electricity, heat and chilled water according to customer needs. Heat from the engines is utilized for heating during the winter period, and as an energy source for chillers during the summer. Thus, the plant’s heat recovery is efficiently used throughout the entire year.

DCAP reduces primary fuel usage by two thirds

The DCAP plant can obtain 0.6 kWe/TR with a storage tank and 0.7 kWe/TR without the tank. Compared to conventional centralised power plants or electrically driven compressor cooling plants installed on rooftops, this represents primary fuel savings of more than 60%.

The total investment cost of the chiller capacity. The plant can provide both the required electricity and cooling, even during the hottest time of the year. When the engines feed electricity to the grid, all available waste heat is used efficiently for cooling. In case the chilled water cannot be utilized right away, the plant is able to run in pure electricity mode or charge the storage tanks so that no capacity is wasted.
Project execution

Wärtsilä has the resources and capabilities to fulfill contracts ranging from engineered equipment delivery (EEQ) to complete turnkey projects including engineering, procurement and construction (EPC). We have a proven track record of 4900 projects in 177 countries.

With experienced and certified project execution personnel and more than 30 years of experience in delivering complex projects around the world, Wärtsilä understands the requirements for power plant projects and is fully capable of handling and managing the complete range of contracting arrangements.

Capabilities:
- Inter-disciplinary team of more than 250 project managers and project engineers with 100+ PMI-certified professionals.
- Certified HSE Management System OHSAS 18001 & ISO 14001
- Quality Management System ISO9001
- Proven engineering solutions and reliable engineering partners
- Modern and efficient project systems and collaboration tools
- Efficient procurement and logistics process and well established global supply chain
- Experienced construction management and commissioning teams of 400+ engineers
- Qualified subcontractors and sustainable construction methodology.
Our range of services covers everything from rapid spare parts delivery to complete long-term operation 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.

Wärtsilä frequently enters into operation and maintenance (O&M) solutions with customers such as independent power producers (IPP), captive power plant operators, and baseload plant owners. These solutions are also suitable for balancing power plants, peaking/intermediate plants and utilities. They aim to maximize the productive lifetime of the installation and the return on investment. The solution is always tailored to the specific needs of the customer, including performance and lifecycle cost guarantees.

Wärtsilä currently operates more than 1000 marine and land-based installations (34 GW of generating capacity) around the world.

If the customer chooses to operate the asset themselves, the best possible support is available – from other long term lifecycle solutions to maintenance and spare parts or plant modernisation and upgrading.

Our global services network of 11,000 professionals stands ready to provide support for our customers, anywhere at any time. This ensures that the power station will operate at its highest efficiency and performance levels throughout its lifetime.

**Guaranteed asset performance**

Guaranteed asset performance is a solution where Wärtsilä guarantees reliability and availability of the power plant with fixed cost. Customers can manage the operations and outsource the maintenance and its management to Wärtsilä.

The onsite support engineer, online data and remote monitoring enable advanced support and immediate response from Wärtsilä’s experts to ensure the safe operation of the power plant.
Broad experience on a global scale

Wärtsilä has a track record of 70 GW of installed power generation capacity in 177 countries around the world. Our installed capacity of CHP plants totals approximately 13 GW.

Here are some examples.

<table>
<thead>
<tr>
<th>Location</th>
<th>Customer</th>
<th>Fuel</th>
<th>Prime movers</th>
<th>Electrical power</th>
<th>Heating power</th>
<th>Application</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainz, Germany</td>
<td>Kraftwerke Mainz-Wiesbaden AG</td>
<td>Gas</td>
<td>10 x Wärtsilä 20V34SG</td>
<td>100 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>93 MW&lt;sub&gt;th&lt;/sub&gt;</td>
<td>Hot water</td>
<td>2019</td>
</tr>
<tr>
<td>Aktau, Kazakhstan</td>
<td>KazAzot LLP</td>
<td>Gas</td>
<td>4 x Wärtsilä 20V34SG</td>
<td>39 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>13 MW&lt;sub&gt;th&lt;/sub&gt;</td>
<td>Steam</td>
<td>2017</td>
</tr>
<tr>
<td>Cheon Ahn City, South Korea</td>
<td>JB Enertek Co., Ltd</td>
<td>Gas</td>
<td>3 x Wärtsilä 20V34SG</td>
<td>25.4 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>21.3 MW&lt;sub&gt;th&lt;/sub&gt;</td>
<td>Hot water</td>
<td>2010 &amp; 2015</td>
</tr>
<tr>
<td>San Donato Milanese, Italy</td>
<td>Enipower SpA</td>
<td>Gas</td>
<td>2 x Wärtsilä 20V34SG</td>
<td>19.4 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>9 MW&lt;sub&gt;th&lt;/sub&gt;</td>
<td>Hot water</td>
<td>2014</td>
</tr>
</tbody>
</table>
**SASOLBURG**

Customer: Sasol New Energy (SNE)
Fuel: Gas
Prime movers: 18 x Wärtsilä 20V34SG
Electrical power: 175 MW\textsubscript{e}
Steam power: 41.6 MW\textsubscript{th}
Application: Steam
Delivery: 2012

**LINATE AIRPORT**

Customer: Malpensa Energia Srl
Fuel: Gas
Prime movers: 3 x Wärtsilä 20V34SG
Electrical power: 24 MW\textsubscript{e}
Heating power: 17.5 MW\textsubscript{th}
Cooling capacity, total: 14.0 MW\textsubscript{C}
Application: Trigeneration
Delivery: 2007

**ÚJPALOTA**

Customer: CHP Invest Kft.
Fuel: Gas
Prime movers: 3 x Wärtsilä 20V34SG
Electrical power: 29 MW\textsubscript{e}
Heating power: 19 MW\textsubscript{th}
Application: Hot water
Delivery: 2004

**BARAJAS AIRPORT**

Customer: AENA
Fuel: Gas, LFO
Prime movers: 6 x Wärtsilä 18V32DF
Electrical power: 33.6 MW\textsubscript{e}
Heating power: 24 MW\textsubscript{th}
Cooling capacity, total: 37.4 MW\textsubscript{C}
Application: Trigeneration
Delivery: 2004
Wärtsilä Energy Business is leading the transition towards a 100% renewable energy future. As an energy system integrator, we understand, design, build and serve optimal power systems for future generations. Wärtsilä’s solutions provide the needed flexibility to integrate renewables and secure power system reliability. Our offering comprises engine-based flexible power plants – including liquid gas systems – hybrid solar power plants, energy management systems and storage and integration solutions. We support our customers over the lifecycle of their installations with services that enable increased efficiency and guaranteed performance. Wärtsilä has 70 GW of installed power plant capacity in 177 countries around the world.

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