WÄRTSILÄ

Flexicycle™ power plants

Unique operational flexibility with optimal combined cycle efficiency

Combining the advantages of a flexible Wärtsilä engine power plant with the superb efficiency of a combined cycle plant

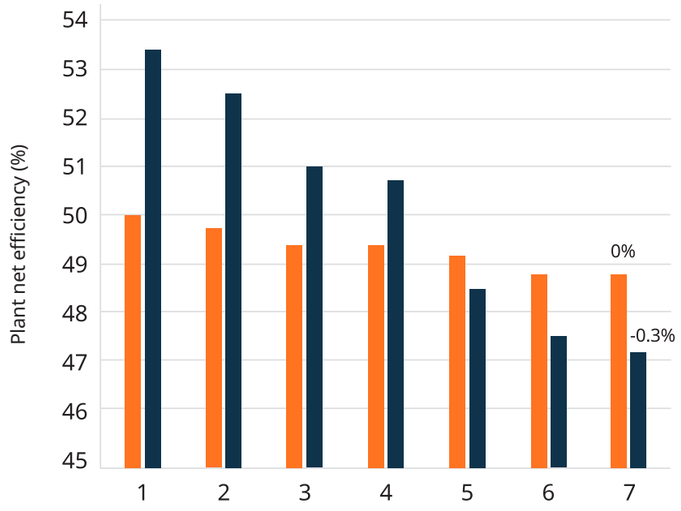
As the share of intermittent renewable energy increases in the power market, fast load-following power is needed to maintain system reliability. The **Wärtsilä Flexicycle™** power plant solution, an engine power plant with steam turbine combined cycle, provides the flexibility needed to facilitate the integration of renewable energy.

The Flexicycle power plant, supported with Lifecycle services, is both agile and highly efficient, which enables competitive performance on both the energy and capacity markets. The combination of flexibility and efficiency makes Flexicycle power plants ideally suited for grid system load following. Depending on the power system, Flexicycle power plants can also be the best choice for efficient flexible baseload power generation. It is a perfect solution for both municipal power generation and for the larger utility market.

Traditionally, baseload generation capacity has consisted of large, centralised coal and/or nuclear power plants alongside combined cycle gas turbine (CCGT) plants, with extended ramp-up and ramp-down times. The intermediate load is often handled by combined cycle gas turbines, while the reserve and peaking capacity is often based on smaller, less efficient generating units, which are expensive to operate.

The Flexicycle power plant solution makes the concept of using different dedicated power plant technologies for different load ranges and operation profiles obsolete. It can operate both in highly efficient combined cycle mode as well as in dynamic and fast simple cycle mode.

Comparison between Wärtsilä Flexicycle and CCGT plants: cumulative impact of defined conditions on plant net efficiency. Case 7 Flexicycle plant 48.7% vs CCGT net efficincy 47.2%.

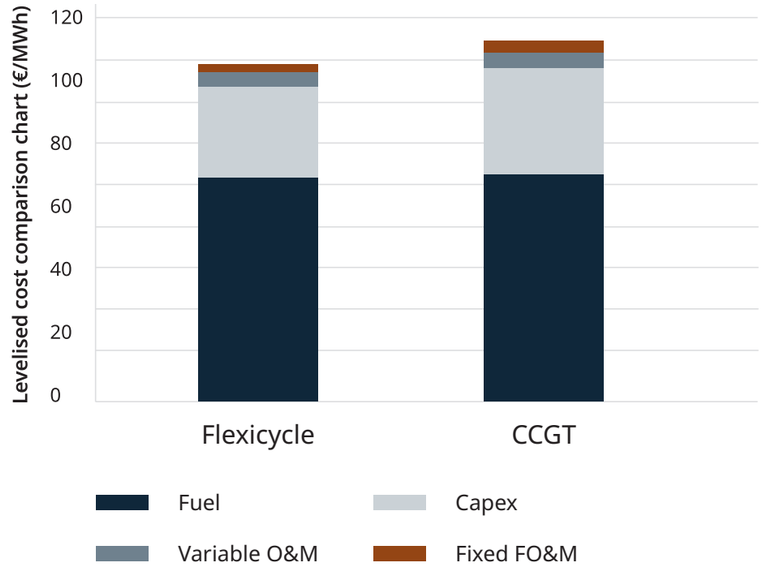


1. ISO conditions sea water cooling
2. Ambient temp 30°C
3. Cooling with ACC
4. Gas compression paracitic load
5. Average load 80%
6. Degradation after one year of operation
7. Effects of 100 starts/year

Flexibility in fuel choice

The Flexicycle solution is based on a gas, multi-fuel, or liquid fuel engine power plant in combination with a steam turbine combined cycle.

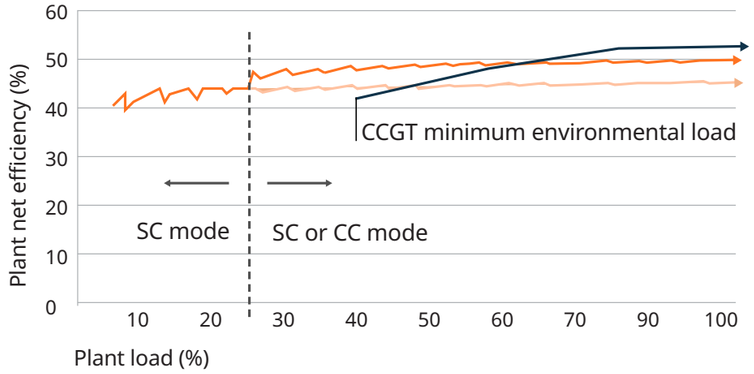
The fuel flexibility of our solutions enables the choice and utilisation of the most feasible fuels, including natural gas and many other gases, as well as most fuel oils. The customer can also choose to run their plant on multiple fuels.



Levelised cost of electricity comparison on 6000 running hours & 100 annual starts. Wärtsilä Flexicycle is outperforming the CCGT plant in the intermediate operation. The higher on-site efficiency is resulting in lower fuel costs. Savings with Wärtsilä gas engine power plant 8 €/MWh, approximately 4.7 M€ per year.

Wärtsilä Flexicycle in cyclic and part-load operation, 0% tolerance.

Sources: GTPro & Wärtsilä



The combination of flexibility and efficiency

The Flexicycle solution combines the advantages of a flexible simple cycle plant with the superb efficiency of a combined cycle plant in a unique way. The combined cycle mode, with an optimum efficiency in excess of 54% (ISO conditions), is ideal for baseload operation.

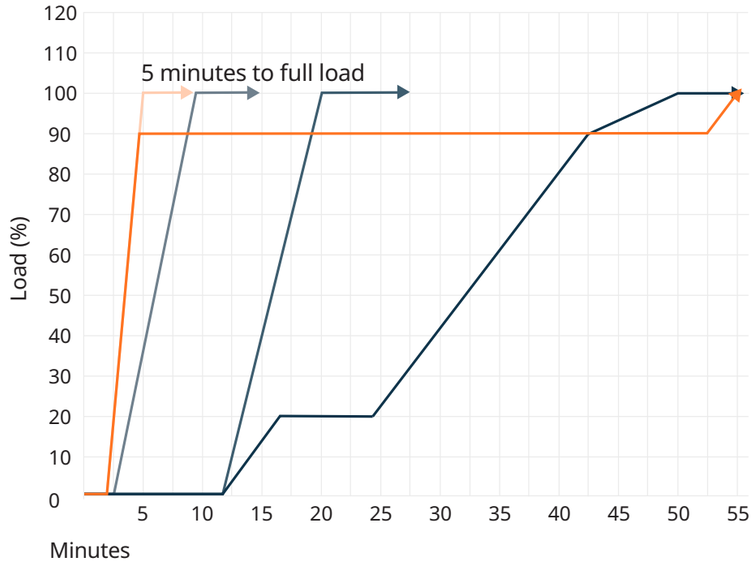
In the Flexicycle concept, the dynamic features of simple cycle combustion engines are maintained as the steam production can be turned on and off individually for each generating set. With quick synchronisation and start-up to full engine power in less than five minutes, without restrictions or impact on maintenance schedules, the Flexicycle plants can be dispatched immediately when an imbalance between supply and demand begins to occur.

The multi-unit design of ICE power plants offers optimised flexibility for dynamic load following with independent units, high efficiency at any plant load (by switching units on and off), as well as optimised plant sizing throughout the lifecycle.

Quick start-up of the Wärtsilä engine power plant.

Fast reaction to changing dispatch conditions

No fuel wasted during starts

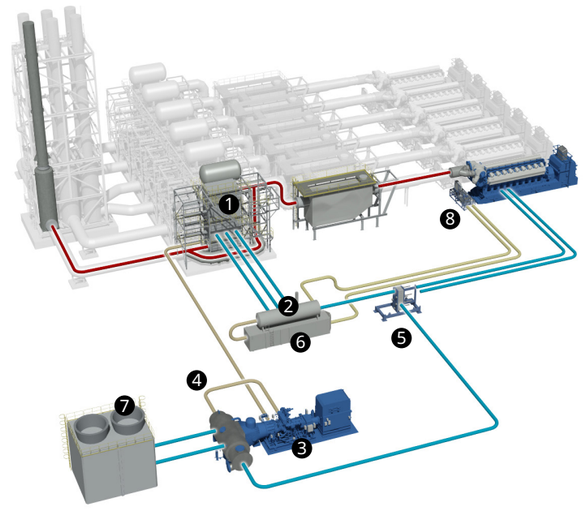


Flexicycle combined cycle system

Two-in-one

The Flexicycle power plant solution's two-in-one characteristic makes it a very competitive solution for handling a grid system's intermediate load. Thanks to its high combined cycle efficiency, the Flexicycle power plant can also be the best choice for flexible baseload generation, depending on the power system's capacity mix.

Features such as fast synchronisation and ramp times, as well as the flexibility of multiple independent units, make these power plants outstandingly well suited to supporting grid systems that require flexibility because of daily load fluctuations, or that have a significant installed base of wind or other non-dispatchable power.



1. Exhaust gas boiler
2. Feed water tank
3. Steam turbine
4. Water cooled condenser
5. Condensate preheater
6. Heat recovery container including auxiliary boiler
7. Cooling tower
8. Engine preheater

Flexicycle™ with radiators

The Flexicycle with radiators solution reduces the acquired footprint of the power plant by placing the entire cooling system on the roof. A Flexicycle power plant with radiators is particularly well suited for cold and moderate climate conditions.

Features and benefits

- Smaller plant footprint
- Early power – the plant can be started by running it in open cycle mode, thus generating revenue while the combined cycle system is still under construction
- No or minimal water consumption
- Maximum efficiency over a wide load range
- Decentralised production
- High reliability
- Superb load-following ability
- Reduced environmental footprint
- Easy plant operation

Features

Two operating modes: operationally flexible simple cycle and highly efficient combined cycle

Efficiency in dynamic simple cycle mode can exceed 50% (ISO conditions)

Highly efficient combined cycle operation extends the plant's electrical efficiency past 54% (ISO conditions)

Multi-unit plant can operate on a wide load range maintaining high plant net efficiency. Similar features can be maintained in Flexicycle™ concept as the steam production can be switched on and off individually for each generating set

Quick start and shut down as well as fast ramp-up capability without restrictions or influence on maintenance schedules and costs

Low water consumption

Proven EPC track record and plant performance

Fuel conversion capability as well as possibility to convert existing power plant to Flexicycle™ power plant

Capability to operate on different electricity markets (energy, capacity & ancillary services)

Lifecycle performance guarantees

Benefits

Wide load range with high efficiency at any plant load

Capable of immediate dispatch while maintaining predictable operation and maintenance costs

Lower fuel consumption and, thus, carbon emissions in Flexicycle™ operation compared to simple cycle mode

Can be operated even in areas where water is a scarce resource

Lifecycle solutions and services

Our range of services covers everything from rapid spare parts delivery to complete long-term operation and maintenance solutions. By optimising all aspects of the power plant's operations and minimising the economic and technological risks involved, we ensure the plant's performance and competitiveness.

With Wärtsilä operation and maintenance solution, the aim is always to maximise the productive lifetime of the installation and optimise the return on investment. The solution is always customised to meet the specific needs and operating profile, including for example, performance and lifecycle cost guarantees.

For self-operating customers there is also the best possible support available – from long-term service agreements to maintenance and spare parts, and plant modernisation and upgrading.

Our global services network of 11,000 professionals provides services and 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 life.

Flexicycle™ upgrade solution

Wärtsilä's Flexicycle Upgrade solution minimises the ecological footprint and maximises the efficiency of existing simple cycle power plants. This solution improves power plant efficiency by up to 10% by producing additional electricity using waste energy from the exhaust gas. By implementing the Flexicycle Upgrade solution, heavy industries with large amounts of waste heat can achieve very high efficiency while lowering the emissions per MWe produced.

Selected Wärtsilä Flexicycle™ references.

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About Wärtsilä

Wärtsilä leads the transition towards a 100% renewable energy future. We help our customers to decarbonise by developing market-leading technologies. These cover future-fuel enabled balancing power plants, hybrid solutions, and energy storage and optimisation technology, including the GEMS energy management platform. Wärtsilä Energy's lifecycle services are designed to increase efficiency, promote reliability and guarantee operational performance. Our portfolio comprises 76 GW of power plant capacity and more than 110 energy storage systems delivered to 180 countries around the world.

www.wartsila.com/energy