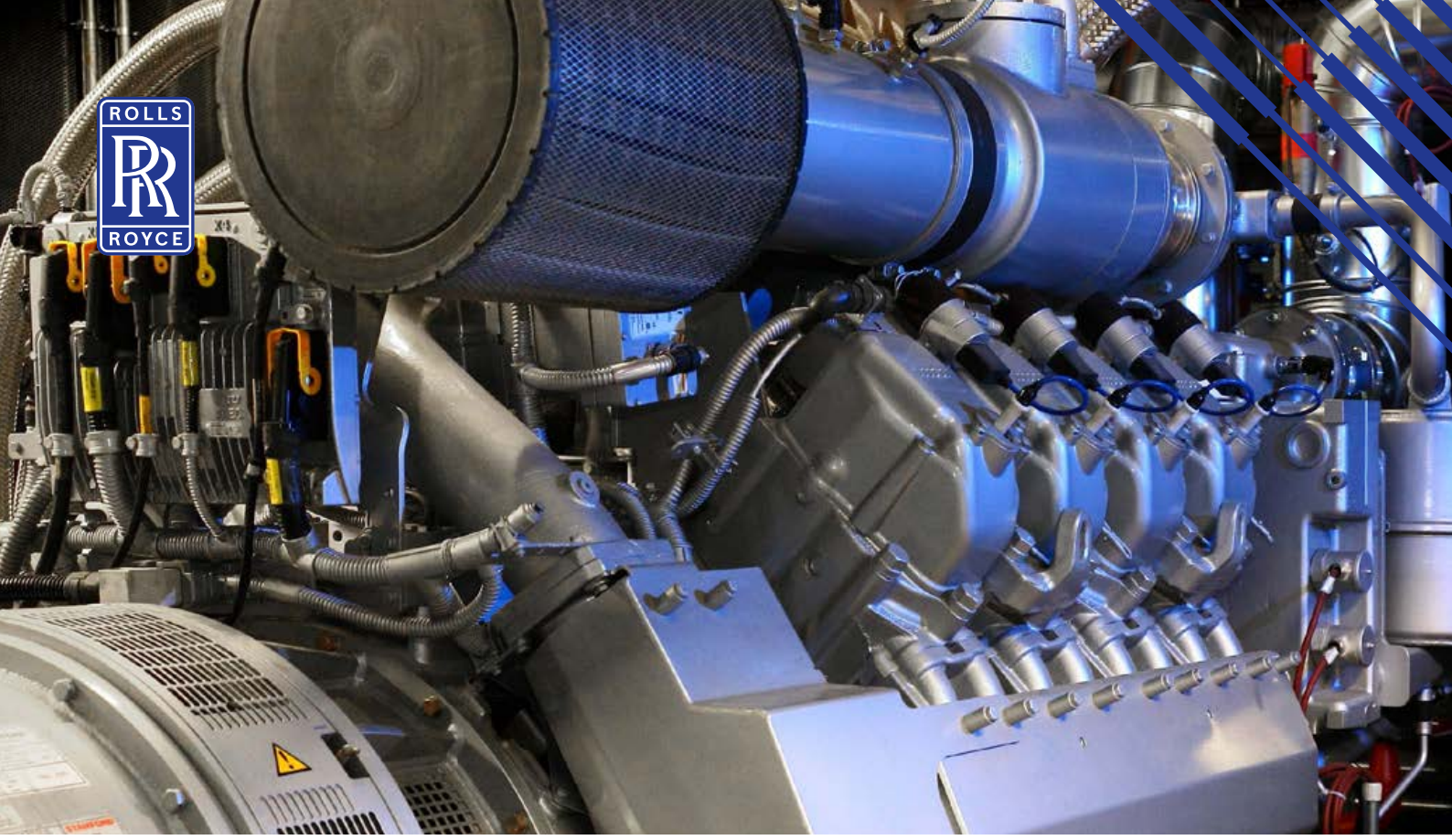

Cogeneration with the Series 4000

COGENERATION POWER PLANT IN VAUBAN ACHIEVES EFFICIENCY OF 96 PERCENT

Who	badenovaWÄRMEPLUS
What	Cogeneration power plant module GC 849 N5
Where	Freiburg suburb of Vauban, Germany

The cogeneration power plant module GC 849 N5 from Rolls-Royce replaced a repair-intensive steam engine at the Vauban combined heat and power (CHP) station in spring 2011. Since then, the CHP station has been operating more reliably than before and, thanks to a sophisticated heat extraction system and the use of an electrical heat pump, 96 percent of the energy used can be converted into electricity and useful heat.

A Rolls-Royce solution

Freiburg-Vauban, Germany – The Freiburg suburb of Vauban has undergone massive change in recent years. Whereas the 0.4 km² area was used as barracks by the French army up until 1992, the suburb now has living space for some 5000 citizens of Freiburg, most of whom live in low-energy and passive houses. Many of the houses use photovoltaic systems to generate electricity, thus helping to protect the climate. Heating is also environmentally friendly thanks largely to a 14 km long local heating grid operated by badenovaWÄRMEPLUS GmbH & Co. KG, Freiburg.

The Vauban combined heat and power station went into service shortly after the turn of the millennium – initially with a wood-fired cogeneration plant supported by two peak load boilers for natural gas or oil. Whereas the wood chip heating system continues to work perfectly, the steam engine/generator combination has suffered from frequent failures. The reciprocating engine operated using hot steam at 250 °C and 26 bar often broke down, while the planned power production didn't materialize due to the teething problems and frequent malfunctioning of the steam engine.

Instead of continuing to refurbish the repair-prone steam engine, badenovaWÄRMEPLUS opted for a reliable solution: an MTU gas-engine cogeneration power plant based on the 4000 Series engine for the main supply, supported by the existing 2.5 MW wood chip heating system and the gas/oil peak load boilers, each with an output of 2.5 MW, when the demand for heating is high. Because of the low amount of heating required by the houses, hot water consumption accounts for a high share of the total heating demand, meaning that the cogeneration power plant can cover over 50 percent of the entire heating demand (in this case 14,000 MWh/a) on account of its thermal output and the planned number of operating hours.

To make optimum use of the energy used, the consulting engineers Eser, Dittmann, Nehring & Partner GmbH in Tamm and the heating experts at badenova devised a plant concept offering a level of efficiency several percentage points higher than that of conventional cogeneration power plants. At the heart of the solution is the machine from Rolls-Royce in Augsburg. The MTU eight-cylinder 4000 Series engine operating in the cogeneration power plant module GC 849 N5 achieves such a high output that the generator at the shaft end supplies around 850 kW of power, meaning that some 40 percent of the energy contained in the fuel is made usable.

"Tapping" of the coolant, the oil circuit and the exhaust gas is optimized in order to extract around 1150 kW of heat. For this, two exhaust gas heat exchangers are installed in Vauban. The second exhaust gas heat exchanger cools the exhaust gas again from around 120 °C to below 66 °C whilst using the additional thermal energy in the exhaust gas. The heating water arriving at the grid return at a temperature of around 62 °C is thus initially pre-heated by a moderate 1.3 K by the low-temperature exhaust gas heat exchanger. Subsequently, the heat from the mixture cooler, the engine oil and the engine coolant increase the temperature to around 67.5 °C. Finally the heating water flows through the first exhaust gas heat exchanger (as viewed in the exhaust gas flow direction), which heats it to the target temperature of around 90 °C. The additional low-temperature exhaust gas heat exchanger increases the overall efficiency of the cogeneration power plant by around three percentage points (compared to conventional power plants) to 93 percent.

In order to further improve the overall efficiency, the waste heat from the cogeneration power plant – especially that from the generator and the engine block – does not simply flow into the atmosphere via a ventilation system. Instead, an electric heat pump cools the area where the cogeneration power plant is erected and the second stage of the mixture cooler before forwarding the heat obtained to the district heating grid. In this way, up to 140 kW of additional output is mobilized and supplied to the district heating grid. If the available useful energy, power and heat is added together and then divided by the sum of the power and fuel used, the plant achieves the possibly record-breaking efficiency level of over 96 percent. To ensure that operation is heat-controlled, badenovaWÄRMEPLUS has backed up the cogeneration power plant module with a 100,000-litre stratified heat accumulator. Hence the cogeneration power plant can operate at full load for one to three hours and charge the accumulator.

The cogeneration power plant team is satisfied: the MTU module operates reliably and with low emissions. It is also possible to use bio-energy with the machine designed for natural gas. badenova, the parent company of badenovaWÄRMEPLUS, has been operating biogas plants since 2010, their gas being supplied to the gas grid following conditioning as "bio natural gas". This enables green energy to be obtained based on the same principle as the supply of eco-power. The Vauban combined heat and power station therefore provides an ecofriendly solution which meets the ecological requirements of the citizens – and saves heating customers money thanks to its high level of efficiency.

In order to handle the cogeneration module's higher electrical power, a 0.4/20kV transformer (seen in front) was set up in the combined heat and power station. (Picture: MTU/Ralf Dunker)

The low-temperature exhaust gas heat exchanger (right) boosts fuel efficiency by an additional three percent. (Picture: MTU/Ralf Dunker)