Efficient engines with natural gas and biogas

One of the main questions currently asked of energy generation concerns its efficiency. Particularly when fossil fuels are used to generate energy, it is absolutely essential that the maximum benefit is obtained from the limited resources. There is also a frequent demand for regenerative energy suppliers to improve cost efficiency. This is why the principle of cogenerating heat and power has long been used in energy generation. Cogeneration power stations use engines from MAN to utilise gas, whether natural or biogas, to not only generate electricity but also to make use of the generated heat. This is how it is now possible to achieve overall efficiency levels above 90%. The German law for the maintenance, modernisation, and expansion of combined heat and power generation (Kraft-Wärme-Kopplungsgesetz) came into force on 1 April 2002 "in the interests of saving energy, environmental protection and achieving the federal government’s climate protection objectives, making a contribution to increasing energy generation from the cogeneration of heat and power in the Federal Republic of Germany to 25% by the year 2020 [...]".

In Germany, the principle of cogenerating heat and power is therefore a key factor in fulfilling the stipulated climate objectives. In fact, the application areas are varied and stations now come in all sizes.
 sizes. The engines from MAN Engines can be found in plants with outputs of 37 kW to 550 kW and provide electricity, heating and cooling to homes, hotels, hospitals, research institutions and industrial companies.

The cogeneration power stations are operated either with natural gas or biogas. The engines were developed specifically to operate with natural gas or biogas because, in contrast to diesel engines, they can be subjected to higher temperatures and lower pressures. The materials used for this ensure long service lives, and by using mature standard parts they achieve high reliability. For operation with biogas, harmful elements such as siloxane and sulphur must be filtered out of the fuel gas.

Combined heat and power – it depends on the application

However, making cogeneration power stations both environmentally friendly and profitable requires not only an efficient engine – the whole concept must be right. Cogeneration power stations with MAN engines are built by the most varied of companies. These combine and match up the individual parts, such as the engine, generator, heat exchanger and control unit. In the next step, the module still needs to be adapted to the customer's energy concept.

A good example that clarifies these individual steps is found at Rohde AG in Nörten-Hardenberg. Two power stations of type GG 140 S with separate high-temperature and calorific value waste-gas heat exchangers from Sokratherm GmbH, Hiddenhausen, have been installed with 140 kW electrical and 235 kW thermal output each. These are each operated with a natural gas engine from MAN of type E2876 E312. With revolutions at 1500 rpm and 50 Hz the engine achieves a mechanical efficiency of 39.2% based on DIN ISO 3046-1. Sokratherm states the module’s overall efficiency level at 91.3% (36.2% electrical; 55.1% thermal). The planners from Geese – Beratende Ingenieure, Hagedsken, integrated the cogeneration power stations into the energy concept of Rohde AG, which specialises in surface refinement and manufacturing industrial handles.

The electricity produced via the generator covers around 55% of the company's electricity requirements. Heat for the necessary process temperatures and heating is tapped via heat exchangers at two points. Hot water at 80°C is obtained from the engine and oil cooling and guided to a hot water stratified store. The engine exhaust gas is guided through a downstream high-temperature exhaust gas heat exchanger and heats water to 110°C, and therefore to the maximum temperature that is required in the company to heat the eloxal reservoir. Downstream of the hot water store, which is 8m high and has a 43 m³ capacity, is a sophisticated heat cascade. In addition, the recirculation temperatures can be set such that a calorific value heat exchanger could be installed downstream of the high-temperature exhaust gas heat exchangers. This opti-
mal exploitation of the heat produced by the engine during combustion achieves a 60% thermal efficiency; the overall efficiency level is around 96%.

For this efficiency and the elaborate implementation the project, which represents a 48% energy cost saving for the company, was presented by the specialist magazine “Energie und Management” as the cogeneration power station of the month for January 2014, and a jury from Bundesverband Kraft-Wärme-Kopplung (B.KWK) selected it as the cogeneration power station of the year 2014.

This example emphasises the potential in cogeneration that can be achieved using cogeneration power stations. Over the past ten years a total of six stations with MAN engines were awarded the title “cogeneration power station of the year”. They are all individual solutions that demonstrate the variety of potential applications.

Three modules have been in use since 1996 at Allweiler AG in Radolfzell, the most recent one since 2004. They provide electricity to such plants as the electric melting furnaces at the pump manufacturer and avoid costly load peaks through the use of a load management system.

In 2006, a project in Bersenbrück that generates biogas in an agricultural business won the award. The gas was transported via a pipeline to the town centre 1.5 km away where two CHP 400 modules by Lindenberg-Anlagen GmbH, each with an MAN E2842 LE312 gas engine, provide 347 kW of electrical and 409 kW of thermal output. The generated power and heat supply two schools and a swimming pool in the town, amongst other buildings.

In 2009, the Maritim Hotel in Braunlage decided to exchange a defunct cogeneration power station. The hotel has over 300 beds, an outdoor and indoor swimming pool as well as a spa area with a sauna and solarium, and now covers 40% of the heating requirements with the Sokratherm system that generates 130 kW of electrical and 201 kW of thermal output. The electricity generated is also used within the hotel itself.

At the end of 2009, a biogas/natural gas cogeneration power station was commissioned for the then Berlin head office of solar energy company Solon (the station is operated with natural gas, but the consumed volume is restored to the gas network elsewhere with prepared biogas). The station’s overall supply concept has been designed for sustainability, which is why the building was designed to be energy efficient, with a photovoltaic system and a cogeneration power station with 89.7% efficiency. This not only provides electricity and useful heat but also cooling for the air-conditioning via a one-stage absorption refrigeration system.

The cogeneration power station of 2011 is at the Wilhelm Brandenburg meat fac-
tory in Dreieich. They had reached the limits of the local power network due to growth. To avoid extending the network, two GTK 140 cogeneration power station modules with Lambda 1 gas engines from MAN, each with 140 kW of electrical and 207 kW thermal output, were installed by Kuntschar + Schlüter GmbH.

**Climate objectives in sight**

All of these systems not only stand for a significant increase in profitability for the operators’ energy supplies, but also enable CO2 savings, in some cases of a significant order. The savings are clearest where biogas is used for electricity and heat generation, because this gas is generally considered to be CO2-neutral. The carbon dioxide released was previously removed from the air by plants, which are the basis for the biomass. Depending on the type of substrate production and the design, biogas stations can even have a negative emission balance. This is, however, usually better than with natural gas and significantly better than with brown and hard coal. According to the Federal Ministry for Economic Affairs and Energy (BMWi), in 2013 the share of greenhouse gas emissions avoided by biogas through the use of renewable energies in Germany was 43.9%. This is the same percentage as solar and wind energy combined. Specifically, the savings through the use of biogas are stated as 64.1 million tonnes of CO2 equivalent compared with 146 million t CO2 equivalent from all renewable energies. A comparable figure exists for CO2 emissions saved through cogeneration for 2012. The Öko-Institut e.V. states coal, oil, gas and biomass as energy sources that have saved 38.8 million tonnes of CO2 through the use of cogeneration, compared with uncombined electricity and heat generation. Around 18% of generated heat and power is generated from biomass.

The figures show the approximate scale and importance that consistent use of cogeneration has for the fulfilment of climate objectives and protecting the environment. Cogeneration power stations play an important role and are designed optimally for each application. Packages that address individual customer requirements with flexibly configurable MAN engines improve the efficiency.

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**MAN gas engine range for cogeneration power stations**

MAN offers low-pollution gas engines for cogeneration power stations with outputs ranging from 37 kW to 550 kW for natural gas and from 68 kW to 550 kW for special gas (biogas, landfill gas, sewage gas). The MAN engines developed especially for use with natural and special gas are characterised by maximum reliability and energy efficiency. As a result of their optimal combustion process they achieve overall efficiency levels above 90%. With the wide range of low-maintenance induction and Lambda 1 engines, it is possible to achieve the lowest emission levels through the use of a three-way catalytic converter. The MAN gas engines have proven their robustness, combined with high operating hours in peak load and ongoing operation, for agriculture and local authority use, in hotels and hospitals as well as numerous other industries. Long maintenance intervals and the high lifetimes of MAN gas engines ensure a low total cost of ownership for the stations.