District Heating with the Flexibility of the KA26 Combined Cycle Power Plant

CONFERENCE PAPER

POWER

We are shaping the future | ALSTOM
District Heating with the Flexibility of the KA26 Combined Cycle Power Plant

Christian Bohtz, Mark Stevens, Hans-Jürgen Sackmann, Andreas Ruedt
1 Abstract

For Combined-Cycle Cogeneration Power Plants in district heating applications, a high degree of flexibility between power and heat production, to accommodate for seasonal and daily demand variations, is as important as high efficiency and fuel utilisation.

The strengths of the KA26 combined-cycle power plant, high efficiency at baseload and at part-load, are a particular advantage in district heating application. Extraordinary operational flexibility is provided based on the large operation range with low emissions from 100% load down to 40% and below and additional Low Load Operation capability at approx. 20% load.

Alstom has adapted the KA26 for district heating applications, to provide the KA26 ecoHEAT™ for ecological and economical heat production, based on high operational flexibility and high fuel utilisation. Extraction of steam at low pressure from the steam turbine is most efficient, as the steam can be used twice – first for power production and then to supply heat. Up to 300 MWth can be supplied to the district heating system with a compact plant arrangement based on a floor-mounted, single-shaft design. 30% of the heat can still be supplied in Low Load Operation at very low power production, as often required during the night. Based on the OEM know-how and Plant Integrator™ capability, Alstom can customise the power plant and integrate it with the district heating system.

This paper highlights the benefits of the KA26 ecoHEAT™ for district heating applications and gives an overview over most recent KA26-based district heating projects.
2 Introduction

2.1 Cogeneration: CO\textsubscript{2} reduction and efficient use of natural resources

Combined Heat and Power (CHP) or cogeneration produces both electricity and thermal energy at the same time. It achieves a very high fuel utilisation of up to 90% and above, given that the fuel is used twice – first to produce power at high efficiency and then a second time in the form of heat for district heating or industrial use.

CHP significantly reduces CO\textsubscript{2} emissions through greater energy efficiency. The efficient system recovers heat that would in electricity generation normally be wasted. It saves fuel that would otherwise be used to produce heat or steam in a separate unit. An additional benefit can come from replacement of coal with natural gas, a clean fuel with lower emissions and only half of the coal CO\textsubscript{2} production. New Combined-Cycle Power Plants (CCPP) with Cogeneration can therefore reduce CO\textsubscript{2} emissions by 65%, compared to existing separate power and heat production facilities relying on coal.

2.2 ecoHEAT™ for efficient and flexible cogeneration

Cogeneration of power and heat achieves a very high fuel utilisation. However, power and heat are not always required at the same time due to
- seasonal and ambient temperature driven changes in heating demand
- changes during the day in power demand

![Figure 1 - Heating is mainly required in winter, power is mainly required during daytime](image)

In order to meet both power and head demand, cogeneration requires a high operational flexibility, including flexibility between power and heat production.

Alstom’s ecoHEAT solutions consider these requirements by providing optimised concepts for all CHP applications to achieve ecological and economical power and heat production.

<table>
<thead>
<tr>
<th>ecological HEAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o High fuel utilisation</td>
</tr>
<tr>
<td>o High part-load efficiency</td>
</tr>
<tr>
<td>➔ Reduction of natural gas consumption</td>
</tr>
<tr>
<td>➔ CO\textsubscript{2} reduction up to 65% using natural gas as a clean fuel, compared to existing separate power and heat production facilities relying on coal</td>
</tr>
</tbody>
</table>
3 KA26 ecoHEAT™ plant components

Alstom’s KA26 CCPP achieves a high efficiency and high flexibility. It is therefore the first choice for cogeneration applications. The power plant maximises the efficiency and inherent flexibility of its main components, including the GT26 gas turbine, Heat Recovery Steam Generator (HRSG), steam turbine and generator that are explained in this chapter in more detail.

3.1 GT26 Gas Turbine

The GT26 type gas turbine is Alstom’s largest gas turbine, designed for 50 Hz operation. It consists of a solid welded rotor with 22 compressor stages, one high-pressure (HP) turbine stage and four low-pressure (LP) turbine stages. Heat input is performed by two annular combustion chambers.

The gas turbine is designed to run on natural gas, although fuel oil can be used as backup. The combustion system allows for wide range of natural gas compositions to be burned including natural gases with large high hydrocarbon content.

Sequential combustion

The GT26 uses the concept of sequential combustion, or reheat cycle concept. Compressed air is heated in a first combustion chamber (EV or EnVironmental combustor) by adding about 50% of the total fuel (at baseload). After this, the combustion gas expands through the single stage HP turbine, which lowers the pressure by about a factor of 2. The remaining fuel is added in the second combustion chamber (Sequential EV combustor, SEV), where the combustion gas is heated a second time and finally expanded in the 4-stage LP turbine.

Table 1 - Advantages of Alstom ecoHEAT solutions for cogeneration

<table>
<thead>
<tr>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>High flexibility, also between power and heat production</td>
</tr>
<tr>
<td>The right amount of power and the right amount of heat at the right time</td>
</tr>
<tr>
<td>Two separate revenue streams from power and heat</td>
</tr>
<tr>
<td>Lower risk for owner/operator, compared to dependence on power or heat only</td>
</tr>
<tr>
<td>Lower cost for owner/operator due to reduction of natural gas consumption</td>
</tr>
<tr>
<td>More natural gas available for export due to reduction of domestic consumption</td>
</tr>
<tr>
<td>Certificates of Origin for produced power in the EU (EU Cogeneration Directive)</td>
</tr>
<tr>
<td>Incentives for Cogeneration in many countries</td>
</tr>
<tr>
<td>CHP-capability facilitating permitting (e.g. EU Efficiency Directive)</td>
</tr>
</tbody>
</table>

Figure 2 - GT26 thermal block and cross-section, with sequential combustion and four variable guide vanes for efficient cogeneration
Loading is carried out in several phases: the initial ignition of the EV burners; the subsequent ignition of the SEV burners; and then loading of the GT by opening the four rows of variable compressor guide vanes to allow a greater air mass flow through the GT. During part-load above 25% gas turbine load, the turbine controller maintains the exhaust gas temperature at the maximum part-load temperature by opening the VGV and increasing fuel injection to both combustors.

For cooling and sealing purposes, air is drawn off the compressor at a number of stages. Two airflows are cooled externally to the gas turbine. These coolers are producing additional steam, which result in additional power produced by the steam turbine.

Based on Sequential Combustion and the four variable compressor guide vanes, the GT26 gas turbine offers unique operational flexibility with a large operation range and high combined cycle efficiency, both at baseload and at part-load.

With more than 85 units sold and exceeding 2.5 million fired hours, the GT26 is a well-proven gas turbine to supply reliable power and heat. Increased availability is achieved with the possibility of longer maintenance intervals as a result of this proven experience.

### 3.2 Heat Recovery Steam Generator (HRSG)

In the HRSG, the exhaust energy from the Gas Turbine is used to produce steam. For the KA26 CCPP, a horizontal type, triple pressure reheat HRSG operates typically in natural circulation mode. Heat discharged from the gas turbine as hot exhaust gas serves as the heat source to produce superheated HP, IP and reheat steam and superheated LP steam.

The feedwater flows are pre-heated in the respective economizers and admitted via control valves into the HP, IP and LP drums. Saturated steam is generated at the HP, IP and LP evaporators.

The HP steam is led to the multi-stage HP super-heater, the IP steam to the IP super-heater and subsequently to the re-heater. The LP steam is also super-heated. At the outlet of the HRSG, the HP and re-heat steam are atemperated with feedwater extracted from the HP economizer feedwater line and IP economizer section.

The HRSG of the KA26 is optimised for cyclic operation, as often needed in co-generation applications.

Improved features include single row harps to reduce cycle fatigue (see Figure 3), stepped component thickness to reduce thermal stress, an optimized drain system and a high level of pre-fabrication in Alstom workshops requiring minimal site welding. Altogether, this leads to less leakages and higher availability.

![Alstom OCC™ Design](image1)

![Conventional Technology](image2)

Figure 3 - Alstom HRSGs with single row harps are optimised for cycling operation.
3.3 Steam turbine

For the steam turbines, Alstom can select from a large portfolio of steam turbines optimised for use in combined cycle power plants, ranging up to 400 MW. Several configurations with single and two casing turbines, for backpressure and condensing-extracting operation are available.

In district heating applications of the KA26 CCPP, for example, typically the Alstom STF15C steam turbine is used. This ST consists of one reheat type single flow HP cylinder, one single flow IP cylinder and one double flow LP cylinder. The turbines are rigidly coupled. HP live steam enters the HP turbine through a single valve block, consisting of a stop and a control valve, and is expanded to reheat pressure. The cold reheat steam is mixed with the IP steam, generated in the HRSG, and reheated. The hot reheat steam enters the IP turbine via two intercept valve blocks, each equipped with a stop and control valve. The LP steam enters the IP turbine through a stop and a control valve. The outlet steam of the LP turbine is discharged to the water-cooled condenser.

The IP steam turbine is equipped with extractions for district heating operation to supply low-grade steam to the district heaters, where the water for the district heating system is heated. Steam for the first district heater (DH1) is drawn off from the IP exhaust. The second district heater (DH2) receives steam from the IP steam turbine at an intermediate stage.

As this steam turbine is designed for maximum and controlled steam extraction, maximum level of flexibility between power and heat production can be achieved.

3.4 Generator

In a multi-shaft arrangement, the GT26 and the steam turbine are each driving an Alstom air-cooled TOPAIR generator. In the single-shaft configuration, both the GT and ST drive the same, hydrogen cooled TOPGAS generator. Both generator types are of a two-pole, three-phase synchronous design. The hot air or hydrogen is re-cooled in heat exchangers located in the generator housing. The heat is transferred into cooling water and rejected to atmosphere through a remote cooling system. In particular the large, hydrogen cooled TOPGAS generator is characterised by high efficiency also during part-load, further supporting the high part-load efficiency of the single-shaft power plant.

The generator is equipped with a static frequency converter for using the generator as a synchronous motor to start-up the gas turbine.

3.5 District Heaters

Alstom manufactures heat exchangers for many applications, including heating condensers that can be used to heat up the district heating water. Typically surface heat exchangers with U-shaped heat exchanger tubes are used. Water passes through the tubes on the inside of the condensing section, while the extraction steam condenses on the outer surface. In an optional second zone, the condensate is subcooled.
District Heating with the Flexibility of the KA26 Combined Cycle Power Plant

4 KA26 ecoHEAT™ plant integration for district heating

The KA26 ecoHEAT™ is an adaptation of the KA26 CCPP for cogeneration, e.g. district heating.

The operational flexibility of the KA26 is mainly based on Sequential Combustion and the four variable compressor guide vanes of the GT26 gas turbine. It is characterised by:
- High operation range from 100% down to 40% combined-cycle load and below
- High efficiency, both at baseload and part-load
- Low NOx emissions at full load down to 40% part-load
- Fuel flexibility regarding gas composition
- High GT exhaust gas temperature maintained during part-load operation for efficient combined cycle operation with steam extraction
- Low Load Operation capability to produce 30% of the heat at minimal power production of about 12%

The Water Steam Cycle is optimised for each CHP project, in order to achieve optimum performance with a tailor-made solution. The WSC below shows an ecoHEAT solution for the KA26 in district heating application.

Figure 6 - Water Steam Cycle of the KA26 ecoHEAT for district heating - with controlled steam extraction feeding two district heaters for flexible and efficient cogeneration
4.1 Compact plant arrangement

Aside from the large operating range, Alstom has also optimized the KA26 plant arrangement for district heating applications. The KA26 ecoHEAT plant is arranged in a very compact single-shaft arrangement – including the gas turbine, generator, clutch and steam turbine. Even the district heaters are oriented in the shaft-line for easy access to the single-shaft for maintenance. This solution is well suited for narrow sites and requires less space than a multi-shaft arrangement. A common hydrogen-cooled TOPGAS generator from Alstom with superior part-load efficiency raises the high part-load efficiency of the CCPP even further.

Alstom-proprietary steam extraction at the top of the steam turbine allows a standard, ground mounted arrangement of the single-shaft - even with highest possible amount of steam extraction. The standard shaft height of 5.5 m can be maintained, avoiding an expensive table-mounted design, where the steam turbine, generator and gas turbine need to be lifted several meters higher with a heavy concrete structure.
4.2 District Heating (DH) System

For optimum efficiency, the water of the district heating system is heated in two stages. As mentioned before, the two heaters are located in the extension of the single-shaft for easy access and maintenance of the plant.

The district heaters consist of surface heat exchangers. Integration of the heaters in the Water Steam Cycle is shown in Figure 6. District heating water enters the inlet water box of the first heater, flows through the tubes and exits the heater via the outlet water box. It then passes through the second district heater in much the same way.

Steam extraction is adapted to the required district heating temperature. For a maximum supply temperature of 110 degC, condensing heater DH2 is fed with steam extracted before the last stages of the IP steam turbine, while the condensate drains into DH1 through an expansion device. The condensing and sub-cooling heater DH1 is fed with cascade condensate from DH2, steam discharged from the IP steam turbine and additionally with hot feedwater from the HRSG.

The condensate from the heater DH1 leaves the heater via the heater condensate extraction pumps and fed directly to the deaerator at the feedwater tank.

4.3 Power and heat output in different operation modes

The operation modes can loosely be divided into ‘Condensing’ and ‘Condensing / District Heating’ modes. The operation of the whole plant is highly automated, providing the required power and heat at an optimum overall efficiency.

Condensing Mode for power production

In this operation mode the district heat extraction system is shut down: The steam turbine is in operation, but the extraction valves and the DH water control valve are closed.

The exhaust steam from the HP steam turbine is reheated in the reheater section of the HRSG and directed into the IP steam turbine, passing the crossover line into the LP steam turbine and finally condensed in the condenser.

The load of the power plant is controlled according to the grid requirements (electrical load and frequency control). The range is shown in blue on the horizontal axis in Figure 9.

Condensing / District Heating Mode

In this operational mode the plant is providing both power and heat for district heating. The steam turbine is in operation; with the steam extraction valves open in controlled position and hot circulated feedwater from the HRSG is fed into DH1.

The district heating network operator determines the water flow and the reference value for the district heating temperature in accordance with the required heat load. The Steam extraction is controlled automatically by the CCPP to meet the required district heating temperature.

The power plant is continuously adjusting the gas turbine operation within the operation range to meet the demand from the grid (electric load and frequency control) while supplying the required heat. Therefore power and heat demand can be met at the same time over a wide operation range, as shown in red in Figure 9.
With optional bypasses, the operation range can be extended to the light red area in Figure 9. The steam can be fed directly to the heaters, bypassing the steam turbine. In full bypass operation, the steam turbine is shut down and the required district heat determines gas turbine operation, including GT power production.

The KA26 ecoHEAT CCPP provides unique flexibility between power and heat production. The plant can provide 468 MW\textsubscript{e} with a net efficiency of 59\% in condensing mode. In condensing-heating mode, up to 300 MW\textsubscript{th} heat can be supplied with a fuel utilisation of up to 90\% and above, with only a small reduction in power of about 50 MW\textsubscript{e}.

Such a high heat output is even possible for a single-shaft arrangement. For ambient conditions below ISO conditions, the power output is further increasing. In condensing-heating mode, the plant can be operated from baseload down to 40\% load and below, corresponding to around 190 MW\textsubscript{e}, while still supplying up to 150 MW\textsubscript{th}. The red area in Figure 9 shows the large condensing-heating operation range, where any power and any head demand can be met at the same time.

**District Heating in Low Load Operation**

In Low Load Operation, only the first combustion chamber of the gas turbine (EV) is used. The second, sequential combustor (SEV) is shut down and the compressor guide vanes are partially closed. Therefore low emission limits can be maintained even at around 20\% load. The steam turbine remains in operation, ready for fast loading up. The Low Load Operation concept has proven profitability versus a start/stop operating regime. A further advantage is the fast availability of 350 MW additional power that can be provided within 15 minutes, as a quick response to sudden power demand responses to sudden power demand such as in case of an unplanned outage of other plants serving the grid.

Still around one third of the heat can be supplied in Low Load Operation: Starting from condensing mode with ca 70 MW\textsubscript{e}, up to 90 MW\textsubscript{th} can be supplied, with 50 MW\textsubscript{e} only. A fuel utilisation of 75\% can still be achieved. This is the ideal operation when heat is required, but electricity prices are low, as usual during the night.
With an optional bypass of the steam turbine, the steam turbine can be taken out of operation and additional heat (up to 140 MW\textsubscript{th}) can be supplied to the district heating system at around 25 MW\textsubscript{el} only. Figure 9 above shows power and heat production in Low Load Operation.

### 4.4 Options for project specific optimisation

Several options are available to provide optimum project specific solutions:

- Anti-icing and air pre-warming system with water-air heat exchanger for efficient air pre-heating at extremely low ambient conditions. Well suited for residential areas with stringent noise requirements
- Bypass of steam turbine for additional heat
- Fuel oil as backup-fuel
- Different cooling types (including direct cooling or cooling towers)
- Integration with district heating system

![Figure 10 - GT filter house with integrated anti-icing and air pre-warming system based on a heat exchanger](image)

**Optional multi-shaft arrangement with a clutch between IP and LP steam turbine**

For a KA26 power plant in a multi-shaft arrangement, a synchronous coupling can be included in the ST shaft between the IP and LP turbine. This allows an operation of the HP and IP Steam Turbine in a back-pressure mode to supply steam to the heating condensers, while the LP turbine is shut down. Figure 11 illustrates such a configuration.

![Figure 11 – Optional coupling between IP and LP steam turbine allows taking the LP ST out of operation during longer periods with high heat demand](image)
During start-up of the ST, the coupling engages automatically as soon as the LP Turbine has reached the speed of the HP/IP Turbine. The coupling automatically remains locked with a positive torque. In case a negative torque results during transient operation, disengagement of the coupling is prevented by a hydraulically controlled locking device.

The synchronous coupling solution is the preferred choice to further increase fuel utilisation. In District Heating Operation mode, fuel utilisation above 90% can be achieved.

Four operation modes are possible with such a configuration:

- **District Heating Operation**
  In this operation mode the LP ST is disconnected. The condensation and main cooling water systems are out of operation. The GT load is controlled according to the heat load required by the district heating system.

- **Mixed Operation**
  In this operation mode the LP ST is connected and the condensation and main cooling water systems are in operation. Control valves adjust the steam flow from the IP to the LP ST in the condenser and therefore also the remaining steam that is supplied to the district heaters. The load of the Power Plant is controlled according to grid requirements, with the GT in electrical load or frequency control.

- **Condensation Operation**
  In this operation mode the district heaters are separated from the ST by blocking the non-return flaps in the extraction lines. HP/IP and LP ST are connected and all the steam is condensed in the cold condenser. The load of the Power Plant is also controlled according to grid requirements, with the GT in electrical load or frequency control.

- **District Heating Peak Operation**
  In this operation mode the ST is out of operation with the turning gear in operation and all the steam produced in the HRSGs is fed into the district heaters by means of the steam bypass systems. The condensation and main cooling water system are out of operation. The GT load is controlled according to the heat load required by the district heating system.
4.5 Possibility for steam extraction of the KA26 CCPP

The KA26 CCPP can provide a large range of steam quality from several extraction points and meets heat requirements of all major CHP applications.

The steam massflow in the table below can typically be extracted from a KA26 plant.

<table>
<thead>
<tr>
<th>Source of steam</th>
<th>Typical Pressure</th>
<th>Typical Temperature</th>
<th>Steam Massflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP steam</td>
<td>70 – 140 bar</td>
<td>500 – 580 degC</td>
<td>40 – 80 kg/s</td>
</tr>
<tr>
<td>IP steam</td>
<td>15 – 33 bar</td>
<td>500 – 580 degC</td>
<td>40 – 80 kg/s</td>
</tr>
<tr>
<td>Cold Reheat steam</td>
<td>15 – 33 bar</td>
<td>~380 degC</td>
<td>Up to 20 kg/s</td>
</tr>
<tr>
<td>LP steam (Cross Over or extraction from IP turbine)</td>
<td>&gt; 3.8 bar</td>
<td>~ 300 degC</td>
<td>Up to 100 kg/s</td>
</tr>
<tr>
<td>LP steam</td>
<td>3.1 – 4.6 bar</td>
<td>~ 290 degC</td>
<td>Up to 8 kg/s</td>
</tr>
<tr>
<td>LP steam (extraction from LP turbine)</td>
<td>0.3 – 0.4 bar</td>
<td>Saturated</td>
<td>Up to 10 kg/s</td>
</tr>
</tbody>
</table>

Table 2 – Ranges of possible steam extraction from KA26-1 CCPP, in multi- or single-shaft configuration

Alstom as an OEM of the Gas Turbine, Steam Turbine and HRSG has the capability to provide customised power plants solutions for any specific, even larger heat demand.

5 Recent district heating projects with the KA26

Alstom is an OEM of all main power plant components (including GT, ST, Generator, HRSG, transformers, heat exchangers and control system) and can integrate them in tailor-made, optimised cogeneration solutions. The plant can be built on full turnkey basis (including Engineering, Procurement and Construction) and Operation and Maintenance services can be provided as required by a customer, up to a carefree solution with full operation and maintenance.

In the last 70 years, Alstom has installed more than 100 GW of combined-cycle plants on a turnkey basis. This includes plants in all fields of CHP applications, like desalination, chemical and petrochemical plants, refineries, pulp and paper, and district heating. The KA26 combined cycle power plant, for example, is being used recently at two district heating plants in Russia and Germany.

5.1 Moscow TPP-26, Russia

Russia has the world’s largest district heating system, with district heating plants providing more than 70 percent of the heat supply. In large cities, between 70 and 95 percent of the homes are connected to a network of district heating pipes, whose total length amounts to 200 000 km. Around 30 percent of the heat is produced by nearly 500 CHP plants. The rest is generated from more than 65 000 mainly gas-fired boilers.
In 2010, a new KA26 CCPP was completed in Moscow at the TPP-26 generating facility owned by OJSC Mosenergo. The new TPP-26 cogeneration unit is one of a number of new combined-cycle power plants to be built in Moscow. Mosenergo has 17 thermal power plants located in and around the municipality of Moscow, historically designed and developed to provide combined heat and power for the harsh Russian winter conditions.

The plant, known as unit 8, is designed to operate principally on natural gas, with oil as back-up fuel. It increases the total installed power generating capacity of TPP-26 from 1400 MW to 1820 MW and is an important project in Russia’s drive to reduce domestic fuel gas consumption by modernizing its district heating plants.

The ability to achieve an electrical efficiency of 59 percent makes this the most advanced combined-cycle plant in Russia. Meanwhile, the additional use of the waste steam to provide district heating brings the overall fuel utilisation of the plant to more than 85 percent.

The GT26 gas turbine and the steam turbine at this plant are arranged in a multi-shaft configuration. The steam turbine consists of one reheat type HP turbine section, an IP turbine and one double-flow LP turbine. The IP steam turbine is equipped with extractions to supply two steam/water heat exchangers for district heating. Steam for the first heater is drawn off from the IP exhaust. The second heater receives steam from the IP steam turbine at an intermediate stage.

The CCPP is designed to accommodate daily load variations. It can also handle daily start-up and shut-down cycles. The facility is capable of operating over a very wide ambient temperature range of -42°C to 35°C.

In power production mode, TPP-26 Unit 8 is providing 420 MWe. In condensing-heating mode, it is providing up to 265 MWth heat to the district heating system with a fuel utilisation above 85 percent.
5.2 Niehl 3, Cologne, Germany

In December 2012, Alstom signed a contract with the German utility RheinEnergie for the turnkey construction of a 450 MW combined-cycle heat and power plant (CHP) in Cologne, Germany. The plant is located next to the river Rhine, in the northern part of the city.

The Niehl 3 CHP power plant is based on Alstom’s gas-fired KA26 combined-cycle plant design. All the major equipment will be supplied by Alstom: This includes a GT26 gas turbine, a hydrogen cooled TOPGAS generator and a COMAX steam turbine, Heat Recovery Steam Generator (HRSG), condenser and the district heaters, as well as the ALSPA power plant control system. With Alstom’s Plant Integrator™ concept, maximum value can be provided for the customer based on in-house components and optimum integration. For example, it was possible to integrate the plant in the desired but very restricted location due to the compact plant arrangement.

The GT26 gas turbine and the steam turbine will be installed in a single-shaft arrangement, both turbines driving the same generator. From the three-casing steam turbine, steam can be extracted from the last stages of the IP turbine and from the cross-over line to the LP turbine to feed the two district heaters in the optimum and most efficient way. The heaters are located axially of the turboset, which results in minimal requirement for additional space.
The clutch between the generator and the steam turbine allows a fast start-up of the gas turbine and the start-up of the steam turbine independently. This way, the entire plant can be started up in short time and will reach efficiencies over 60% net when only producing power, probably the best efficiency for an F-class plant ever achieved. Direct cooling is used for the condenser with water from the river Rhine, with an additional discharge cooling tower that can be used in summer to limit the discharge temperature.

The ALSPA plant control system will be integrated in the existing control room, making it even possible to operate both the new and the existing Niehl 2 combined-cycle power plants from the same operating station.

By providing up to 265 MW heat, enough to heat 50,000 homes, the plant will reinforce Cologne’s district heating networks and reach a fuel utilisation of more than 87%, making it one of the most effective plant in the world. With the ecoHEAT adaptation, the plant is designed for highest operational flexibility and provides the flexibility to meet power and heat demand at the same time. The plant achieves fuel efficiencies of around 70% even at low load. At less than 15% plant output, still up to 80 MW\textsubscript{th} heat can be supplied when the steam turbine is in operation. When the steam turbine is shut down, feeding the steam directly to the district heaters, even 120 MW\textsubscript{th} can be supplied with 25 MW power.

The German power market is extremely volatile, so being able to turn down the plant to very low loads whilst still generating thermal power with the ecoHEAT™ system is a unique advantage.

Commissioning of the power plant is scheduled for 2016. The plant will have to fulfil very stringent noise emission requirements due to the residential area close by. The project includes fifteen years of planned maintenance, as well as remote monitoring from the Alstom Plant Support Centre on a 24/7 basis.
6 Summary: Benefit of the KA26 ecoHEAT™ for district heating

Alstom has adapted the KA26 combined cycle power plant for district heating applications, to provide the KA26 ecoHEAT™ for ecological and economical heat production, based on high operational flexibility and high fuel utilisation. Extraction of steam at low pressure from the steam turbine is most efficient, as the steam can be used twice – for power production first and then to supply heat.

The 468 MWₑ rated plant provides very flexible heat production. It can provide up to 300 MWₘₗ at baseload, and still up to 150 MWₘₗ at partload with 190 MWₑ.

In the unique Low Load operation mode, up to 90 MWₘₗ can be provided. With 50 MWₑ only, this is the ideal heat production mode in case of low electricity prices, typically during the night. Additional heat can be supplied with bypasses of the steam turbine.

With a compact single-shaft design, the plan is well suited even for narrow sites. The district heaters are oriented in the direction of the shaft to allow for easy access to the entire single-shaft for maintenance. Extraction of steam at top of the steam turbine enables a ground-mounted design, avoiding a table-mounted design, where the entire single-shaft needs to be lifted with a heavy concrete structure.

With the fuel utilisation of up to 90% and above and only half of the CO₂ production from gas than coal, combined heat and power from the KA26 ecoHEAT can play an important role towards decarbonising the power sector.

Two recent projects in Russia and Germany demonstrate that the KA26 is well suited for district heating.
7 Appendix

References


[2] Experience from Alstom’s TPP-26 Project in Moscow - District Heating with the KA26 Combined Cycle Power Plant
Christian Bohtz, Stefan Jeken, Thomas Wunsch
Paper presented at Russia Power 2010 in Moscow

[3] District Heating with the Flexibility of the KA26
Christian Bohtz, Hans-Jürgen Sackmann, Thomas Wunsch, Andreas Rüdt
Paper presented at the Power-Gen Europe 2011 in Milan

Abbreviations

CCPP Combined-Cycle Power Plant
CHP Combined Heat and Power
DH District Heating / District Heater
EPC Engineering, Procurement and Construction
GT Gas Turbine
HP High Pressure
HRSG Heat Recovery Steam Generator
IP Intermediate Pressure
LP Low Pressure
MW \(e\) MW electric
MW \(th\) MW thermal
OEM Original Equipment Manufacturer
ST Steam Turbine
VGV Variable Guide Vane (of the GT compressor)