The new cogeneration plant from Vattenfall Wärme in Berlin-Marzahn proves that industrial facades do not have to be dreary: With the day's changing light, the CHP plant also changes its appearance Source: Siemens Energy

District Heating for Berlin

Vattenfall Wärme Berlin has not only achieved its goal of halving CO_2 emissions by 2020, but even exceeded them. A milestone in the concept of reducing emissions: one of Europe's most modern combined heat and power plant in Berlin-Marzahn that as general contractor, Siemens Energy built – in just over three years.

The history of the Marzahn cogeneration plant is closely intertwined with that of the city of Berlin. The city intends to be CO_2-free by 2050. No easy undertaking. This is why the power company Vattenfall Wärme Berlin committed itself in a climate protection agreement to the city Berlin to halve its CO_2 emissions – compared to 1990 – in the German capital by 2020. Today, this has been achieved. Vattenfall's next target is phasing out coal by 2030. An important step in this direction was the construction of one of the most efficient combined heat and power (CHP) plants in Europe in Berlin-Marzahn – with Siemens Energy as general contractor. In May 2020 Siemens Energy handed over the new cogeneration plant on a turnkey basis after only a little over three years construction time. Soon thereafter it went into commercial operation.

The plant has an electrical output of around 273 MW and a thermal output of around 232 MW. The heart of the plant is an SGT5-2000E gas turbine manufactured at the Siemens Energy workshop in Berlin-Moabit – a proven and reliable turbine with low capital costs and long-term advantages in maintenance and repair. Together with the Klingenberg CHP plant (also gas-fired), the plant in Marzahn is important to the supply of district heating in eastern Berlin area. Combined, the two plants serve around 450,000 households – only in the eastern part of the city, by the way, as underground the city is still divided. The eastern part has a two-pipe system, while West Berlin has a three-pipe system for district heating.

Successful bid for international tender process

Marzahn represents a power plant for the future: It has a maximum fuel efficiency of over 90%; it is flexible with short start-up and shut-down times and can quickly switch between full and partial loads. This

enables it to balance fluctuations, which repeatedly occur when feeding renewable energy into the electricity grid – a necessary component for energy transition. At the same time, it reliably secures the needs of urban heating customers. Also, the gas turbine is flexible enough to use hydrogen – ideally produced with green energy – in the coming years. Still, this development was certainly also helped by subsidies paid by Germany for cogeneration plants. They are to be paid out over the duration of 30,000 full-load hours and are supporting to amortize Vattenfall's investment costs.

Following an international tender process Siemens Energy was awarded the contract as general contractor in December 2015. For the company, it was a given to pursue this commission. After all, power plants are part of the core business of Siemens Energy (in 2015 still part of Siemens AG). Also, the plant is located in Berlin, where the company has its gas turbine workshop and other production facilities. "We were convinced by Siemens Energy's technology, important components of which came directly from Berlin", says Vattenfall's project manager for the power plant, Jochen Ludwig. "Of course, Siemens Energy not only supplied technology, the company also acted as general contractor. And we were right to expect them to handle a project of this complexity very well".

Flexibility thanks to high degree of automation

Various specifications by Vattenfall and the plant's location framed Siemens Energy's design in important ways. First and foremost technology. As part of Germany's energy transition, a gas-fired CHP plant was required, as natural gas is a fuel producing low CO_2 emissions that can be a bridge to hydrogen and other sustainable fuels.

The power plant also had to be flexible. In case of low heat demand – as in summer – it is important to be able to run the power plant at low partial load without stopping district heat production. After all, heat is also needed on warm days – most people want to be able to take a warm shower any day of the year. This is enabled by a high degree of automation and fast controls of all components of the plant, such as: the gas and the steam turbine, the heat recovery steam generator, or the air condenser.

High degree of prefabrication was necessary

The plant's flexibility also allows Vattenfall to take advantage of attractive electricity prices – and, if necessary, to compensate for fluctuations in other district heat supply plants or in the output of wind and solar power within minutes, thus helping to make renewable energies suitable for base load.

The entire plant had to fit into a very compact package as the designated site was not large. At the beginning of the 1970s, the first CHP plant had been built in Marzahn, which supplied energy to parts of eastern Berlin and Marzahn industrial plants. In the beginning, it was fired with Soviet crude oil, later also with waste. The waste incineration plant closed in 1990 and the remaining power generation plant was taken off the grid in 2010. The power plant was to be built on this site – to be precise, at Allee der Kosmonauten at the corner of Rhinstraße. But with a total size of only 55,300 m^2 this was certainly a challenge (figure 1) – and it was clear that a high degree of prefabrication would be necessary. Regardless, Siemens Energy was happy to take on the challenge.

Making sure the site is secure

While already had been worked intensely on the detail engineering, Siemens Energy also took control of the site in spring 2017. Various plant components on the site had already been dismantled in 2011 and 2012 by Vattenfall. As general contractor, Siemens Energy was responsible to ensure that the site was secured before the cornerstone was laid in October 2017. Before taking over the site a soil survey and an explosive ordnance detection was conducted. This was followed by a grid sampling to identify any soil contamination, which showed the ground only to be moderately contaminated.

The plant's most important buildings, which have no basement, are the engine buildings for the gas and the steam turbine, the boiler building with a 67-meter-high stack for flue gases, the feed water pump house and the switchgear building. In addition, it had to have a site for the control room, buildings for ancillary systems, a gas compressor building, as well as administration, storage and workshop buildings.

High level of fuel efficiency

The SGT5-2000E turbine weighs around 200 t and is about 10 m long. It is mounted on a concrete turbine table weighing around 1,000 t at ground level. The hot flue gas from the turbine is fed into a heat recovery steam generator. It also contains catalysts in order to minimize nitrogen oxide and carbon monoxide emissions, which makes it possible to keep emissions low even when the plant is operated at low gas turbine load. The water evaporating in the heat exchanger tubes of the heat recovery steam generator is then fed into the steam turbine

Figure 1. All tightly put together: The CHP Plant in Berlin-Marzahn was built on a small site due to clever planning und plenty of prefabrication

Source: Siemens Energy

SST5-800, which in turn produces additional electricity.

This is where cogeneration comes into play: An essential part of the steam from the steam turbine is fed into heating condensers, releasing its heat to water for the district heating network. The water is heated up in the plant to a maximum of 135 °C and in turn supplies customers with energy for heating and hot water at a maximum pressure of up to 15 bar. Taken together, this ensures a high level of fuel efficiency: Up to 92% of the energy available in natural gas is converted into electricity or heat.

The perfect tie-in point for district heating

As said, the system can switch quickly between partial and full load. One can compare this to a car with a turbo engine. The electrical output can be increased by at least 8 MW within one minute and the thermal output by at least 5 MW. Therefore, it is not surprising that Marzahn is one of the most flexible CHP plants in Europe today.

Another special feature of the plant is that hydraulically it is placed at the optimal tie-in point for district heating for eastern Berlin. But since there is no freshwater cooling at the site, today there is an air condenser to be used at ambient temperatures above approx. 5 °C. This air condenser helps with condensation for excess steam that cannot be condensed in the district heat exchangers when the district heat demand is low.

A table with a steam turbine at 18,5 meters height

What made all of this a smooth process was the basic and detail engineering which was closely coordinated with the customer. Siemens Energy commissioned components with design specifications such as dimensions, performance data and load capacity, which in turn came back with all required data to develop detailed 3D models down to small bore piping. Furthermore the BIM (Building Information Modeling) methodology was set up during construction to efficiently coordinate the site activities like piping installation. Siemens Energy also insisted on having almost everything enclosed – for work safety, energy efficiency, maintainability and soundproofing with special focus on ensuring high plant availability.

A particular challenge was the building that was to house the steam turbine. It had to be designed in a way to integrate not only the steam turbine, but also its steam piping, the district heaters and the entire district heat system – and, of course, taking into account all process requirements. With a close eye on ensuring safety, a turbine table was built, also weighing approximately 1,000 t, which was supported by six reinforced concrete columns. The turbine table is dynamically decoupled from the columns with spring elements reducing possible vibrations and oscillations to a minimum. And since the available space had to be used in the best possible way, then this table was lifted to a height of 18.5 m.

The look and feel of a steam power plant

Most of the piping equipment for the district heating is constructed around the steam turbine hall. This means steam pipes coming from the steam turbine or steam pressure reducing stations with diameter of up to 1.8 m. There are also district heating pipes with diameters of up to 1.4 m in the building, district heating circulation pumps, booster pumps, heaters, etc.. Usually, in combined cycle plants, some of these would be housed in separate buildings. But in this particular case there was no space. So most were put into the machine house and some into the feed water pump house.

This also meant that the assembly sequence of the various components and piping had to be figured out before starting construction – this was achieved with the help of a constructability study. And it was learned that large components and pipes had to be installed while raising the building around them (figure 2). Today, the finished machine house gives the impression of a small steam power plant.

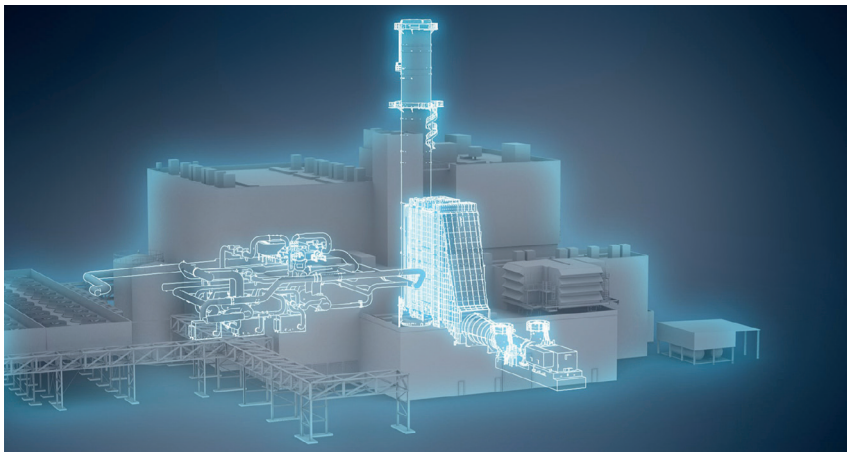

Figure 2. All at the same time: large components and pipes were installed while the building was raised around them

Source: Siemens Energy

It worked better than ever guaranteed

All the effort was certainly worth it: In May 2020, Siemens Energy was able to officially hand over the plant. By then, of course, it had already successfully passed the performance test and the trial run operation – working better than ever guaranteed.

It's particularly gratifying to note that the plant's most important building blocks were manufactured by Siemens Energy in Berlin or within a radius of around 300 km. The SGT5-2000E gas turbine in Berlin-Moabit, switching components such as the vacuum circuit breakers and the generator switchgear in Berlin-Siemensstadt. The steam turbine came from Görlitz, the generators from Erfurt, the oil-cooled transformers from Dresden and the low-voltage switchgear from Leipzig. Only the medium-voltage switchgear travelled a longer way: from Gebze in Turkey.

Hydrogen on the horizon

The power plant is designed to run for at least 40 years. During this time, however, the plant can still be modified – and actually should be. If the burners are converted accordingly, the gas turbine can be fired with hydrogen at up to 40% by volume. Tests for this purpose have already been carried out at the Siemens Clean Energy Center in Ludwigsfelde. Vattenfall also is working on gaining more experience in operating its CHP plants with hydrogen and natural gas mixtures. Therefore, it is no surprise that Vattenfall is exploring to install an electrolyzer in Marzahn for the hydrogen required.

HSSE Performance

Siemens Energy implemented its Zero Harm program on the Marzahn site to support compliance with HSSE (Health, Safety, Security and Environment) among all employees across all hierarchies and all companies working onsite. The Zero Harm program specifies the following principles:

- Zero incidents – it is achievable,
- Health, safety and environment – no compromises,
- We take care of each other.

The implementation of the Siemens Energy Zero Harm Program, in combination with the safety behaviour regulations, Vattenfall's Golden Rules program and the close collaboration of Siemens and Vattenfall on a daily basis onsite, achieved good results with respect to HSSE. There were no serious incidents during the construction phase or during commissioning leading to a good total recordable incident frequency rate.

Joachim Metzner
General Project Manager for the Marzahn CHP plant, Siemens Energy, Erlangen/Germany
joachim.metzner@siemens-energy.com
www.siemens-energy.com