

# Schwarzheide opens its heart to carbon neutrality

BASF has set its sights on making its Schwarzheide production site one of its first CO<sub>2</sub>-neutral locations. The company recently modernised the power plant, replacing an existing gas turbine with a Siemens Energy SGT-800 and also installing a battery system for black-start capabilities. **Junior Isles** hears how carrying out the upgrade was somewhat akin to open-heart surgery.

As the world's largest chemical producer, BASF has long been taking measures to minimise the impact of its operations on the environment. It is no surprise then that the company has set itself ambitious climate goals, striving to achieve net zero CO<sub>2</sub> emissions by 2050.

In addition, the company wants to reduce its greenhouse gas emissions worldwide by 25 per cent by 2030 compared with 2018. Excluding the effects of the planned growth – which includes the construction of a large Verbund site (a chemical production site with highly interlinked product flows) in South China – this means

cutting CO<sub>2</sub> emissions by around a half in the current business by the end of this decade.

In 2021, BASF Group's worldwide carbon emissions amounted to 20.2 million tonnes of CO<sub>2</sub> equivalent. In 1990, this figure was roughly twice as high. The new 2030 emissions goal represents a reduction of approximately 60 per cent compared to 1990 levels, and exceeds the European Union's target of a 55 per cent reduction.

In a move that is significant in achieving those targets, in 2019 the company engaged Siemens Energy to carry out a brownfield exchange



**Fuchs: We want to become one of the first BASF CO<sub>2</sub>-neutral production sites**



Artist's cutaway of an SGT-800 plant with batteries

project at the combined cycle plant powering its Schwarzheide facility in order to increase power output while cutting emissions.

Commenting on the rationale behind the project, Jürgen Fuchs, Head of the Management Board of BASF Schwarzheide GmbH, said: "We must keep our site competitive in order to grow the business and attract investments. We've already achieved a lot here in the last few months and years.

"When it comes to sustainability, we always talk about the triad of the environment, economy and society. Going forward we can use the opportunities provided by the need to change as a driver for our site's growth. We will use eco-efficient technologies such as modernisation; integrate renewable energies and drive forward the circular economy. We want to do this to become one of the first BASF CO<sub>2</sub>-neutral production sites."

As a growing location that is installing new production systems and technologies, BASF Schwarzheide will need a very flexible energy supply at the site in the coming years.

Julie DeKeyser, Head of Site Services and Infrastructure at BASF Schwarzheide, explained: "On the

one hand, our steam consumption had decreased, but we knew that in the next two or three years we would have an increasing need for electricity. So we wanted to prepare for this by modernising the power plant."

But this would be no regular modernisation. With closing the plant temporarily not an option, Siemens Energy would have to work closely with BASF to carry out the exchange on the live power plant – keeping one power train in operation while carrying out extensive alterations to the other line. It would be sort of an "open heart surgery", as the teams called it. "Working while the plant is in operation presents certain challenges. Any vibration during assembly might cause our gas turbine to stop mid-operation," said DeKeyser.

Commenting on the project's origins, Bernd Künstler, Key Account Manager at Siemens Energy said: "The contract for the project was signed in 2019. But we were engaged in initial talks in late 2017 when they said they would like to replace one of the turbines at the Schwarzheide plant. We figured out that it was a really difficult task, as it would require a lot of changes. It would have been a lot easier to replace the existing turbine with a successor engine from

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that manufacturer but they were still very interested in replacing the turbine despite the huge effort that was needed.”

Siemens Energy therefore began developing the project with BASF and found that despite the level of difficulty, the resulting higher output and greater efficiency still made the project worthwhile in terms of the business case. For a company like BASF, operational expenditure (Opex) over the plant’s lifetime is as much of a consideration as capital cost.

“Opex was certainly one of the major selection criteria for choosing Siemens Energy turbine,” noted Künstler.

The Schwarzheide combined cycle plant has a ‘2+2’ configuration, meaning there are two power trains, each consisting of a gas turbine and steam turbine. The gas turbines were originally GE Frame 6Bs, while the steam turbines are Siemens Energy machines.

Although BASF considered other configurations for the modernisation, the decreasing steam consumption of the chemicals production facility was the main driver in how the modernised

support high maintainability.

The SGT-800’s 15-stage axial compressor has a pressure ratio of 21.8 and has five compressor extractions at stages 3, 5, 8, 10 and 15. The machine’s compressor casing has a vertical-split plane to provide good access to the compressor components for inspection.

Notably, the engine is cold-end driven – unlike the previously existing turbine, which was hot-end driven – and due to certain conditions, BASF stipulated that the existing turbine generator had to remain intact. This meant substantial changes to the generator to accommodate the SGT-800, which consequently called for a new baseplate for the whole train.

“This wasn’t part of Siemens Energy’s work, noted Künstler. “But they had to dig out the old massive concrete baseplate, do a forming structure onsite for the new one and lift it in place with a big crane. Doing it this way saved them time, since it allowed other work to be done in parallel.”

This was just one of several tricky changes that were needed. Künstler added: “With our machine being a cold-end drive, as opposed to hot-end, the generator had to be moved from



Finspång, Sweden, plant from November 2020 to January 2021. After customer acceptance tests were completed, installation work for the

development that BASF saw as innovative. So this is another opportunity for us to demonstrate and prove the technology,” said Künstler. “Also CO<sub>2</sub> emissions are a lot lower [than from a diesel genset].”

The SIESTART system is designed to provide the maximum loads of the turbine start motor and of the auxiliary equipment (1.8 MW for the starter motor and 0.4-0.5 MW for auxiliary equipment) to perform at least three sequential black-starts. It is designed to operate for ten years but a capacity extension at the end of its designed lifetime is possible to compensate for the ageing and capacity degradation.

In addition to ticking the environmental box, battery systems have several advantages over diesel engines. According to Siemens Energy, battery storage black-start systems require less maintenance than diesel gensets and are more reliable when needed. A diesel generator requires fuel feed lines; space for fuel storage; it has to be started monthly; and fuel needs to be changed annually if not used.

Künstler noted: “Diesel engines often have starting problems when they are needed, so they figured that batteries could be a good option. They also realised that there is the potential to increase their use in the future beyond black-start.”

**Model of the BASF Schwarzheide plant**



**Battery energy storage at the BASF plant will provide black-start capability**

plant would be configured. BASF therefore decided the best option was to replace one of the gas turbines to increase power output, while lowering fuel consumption.

Künstler added: “They also worked on the boiler; wherein the exhaust boiler behind the gas turbine was modified along with the plant distributed control system. These tasks were carried out by BASF.”

Due to key differences in design, the biggest undertaking in the project was the replacement of the existing gas turbine with a Siemens Energy SGT-800 industrial gas turbine.

The new turbine has a maximum power output of 57 MW, although BASF will operate the unit at 52 MW. This compares to 40 MW from the old machine. The SGT-800 has a gross efficiency of 40.1 per cent, which according to Künstler is currently the best-in-class in the 50-60 MW range. According to Siemens Energy, its design efficiency is up to 10 per cent higher than its nearest competitor.

The single-shaft engine is composed of a 2-bearing rotor with a 15-stage compressor and a 3-stage turbine. First- and second-stage blades and vanes are cooled, third-stage blades and vanes are uncooled, all three turbine disks are cooled. The turbine section is designed as a module to

one end of the drive train to the other. This resulted in a change in direction of rotation of the generator rotor.

“Another change that was needed, was that the exhaust pipe of the gas turbine also had to be modified as the original machine had a vertical exhaust, while the SGT-800 has an axial exhaust.”

As the old generator was from another OEM, manufacturing drawings had to be scanned and understood by the engineering department, said Künstler. “It was an engineering task but they were up for the challenge. The risk is that you have some overview drawings and ideas of what it might look like inside but you don’t know the truth until the patient is lying on the table. That was what we discovered when we disassembled the generator.”

Once the generator was opened up, engineers were able to perform reverse engineering so that the necessary modifications could be made. According to Siemens Energy, the generator is now in better condition than before and can now be taken to its performance limits.

Following dismantling of the old gas turbine and generator around the end of October/beginning of November 2020, construction of the gas turbine was carried out in the

gas turbine was carried out between April and October 2021. This was followed by hot commissioning and first fire in November.

The expansion of the BASF Schwarzheide power plant will see the chemical facility produce more materials for use in batteries for e-mobility. This was one of the drivers behind the decision to install a Siemens Energy SIESTART battery system for black-start of the power plant. The battery system has been designed for an output power of 2.4 MW and an installed battery capacity of 1.7 MWh.

“There is a huge installation currently going on to build a production plant for battery materials at the site,” said Künstler. “As they are expanding in this direction, the plant is going to get a perfect reference for an entire battery value chain from end-to-end – battery materials, battery technology and even battery recycling. So it’s not just talk, BASF lives it”

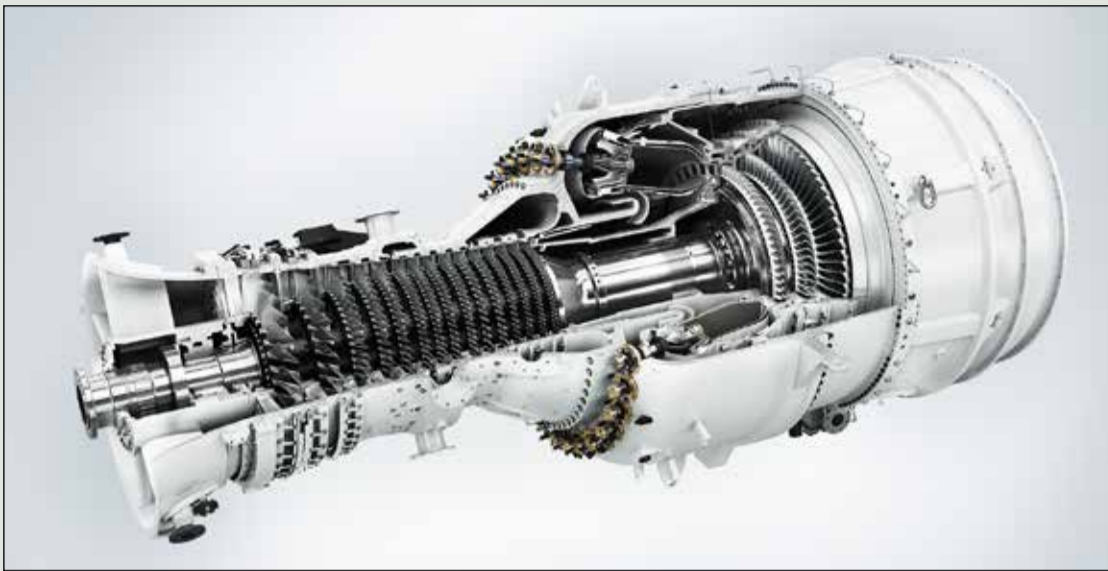
Black-start capability was a requirement for the power plant, and the battery system will be used to perform the duty of what would typically be handled by a diesel generator. As an innovative company, BASF was open to the idea.

“This is not completely new but it’s also not standard [practice]; it’s a



**Künstler: We figured out that it was a really difficult task, as it would require a lot of changes**

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**The SGT-800 has a maximum power output of 57 MW**

Batteries are certainly more versatile. Wherein a diesel genset is “bound capital” in terms of fuel, the electricity from a battery storage system can also be used to generate revenue. The battery could in future be used alongside the gas turbine to cover load variations, provide fast frequency control, and potentially gain revenues from participating in the ancillary service markets.

With the SIESTART system, the gas turbine would operate at a specific, optimised output level, i.e. in load following mode. When the required level of plant output is below the output of the gas turbine, the extra output could be used to charge the batteries. When the required level of plant output is above the output of the gas turbine, the batteries would provide the additional output required. This improves the overall efficiency of the power plant and therefore lowers emissions, while improving operational flexibility.

“When thinking about using it in future for ramp-up for load changes, it might get interesting but it depends on the operating value: how often you will need it; how big is the battery capacity, etc.,” said Künstler. “Of course the battery [at the site] is too small for this at the moment. But if a battery is already installed and connected to the grid, it’s easier to enlarge the system to provide more capacity for this type of operation. So it offers flexibility for the future.”

Although modernising a power

plant while it is operating is not unheard of, it was the first time that Siemens Energy would carry out such an operation with this kind of turbine and technology.

Künstler said: “Currently we are

working on another project with BASF, which will be similar but it’s not a gas turbine project. Projects like Schwarzheide are becoming more frequent. In the future we will have to work much more on existing power plants and modify them to meet future needs.”

Having successfully handed the gas turbine over for commercial operation earlier this year, Siemens Energy believes the brownfield exchange could become a blueprint and key reference not only for BASF but also for other industrial customers looking at tackling similar issues.

“What we did at Schwarzheide is perfect proof that it’s possible to do it like this; and that we can use the turbine in this way,” said Künstler. “The project was executed within the timeframe and is running as planned. It’s also a perfect reference for the market – for the chemical industry and the power plant industry. There are other engines of the same type as at Schwarzheide that we can exchange successfully.”

As pressure increases to cut emissions, Siemens Energy anticipates there are plenty of opportunities for

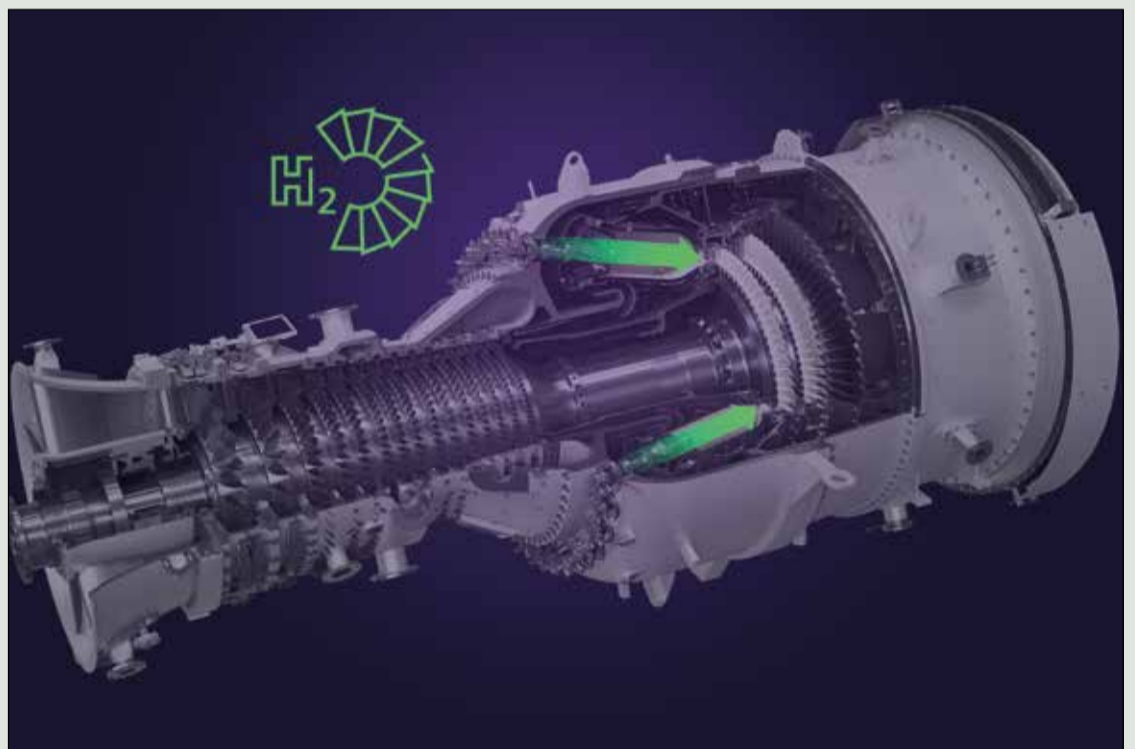
adapting its gas turbines to run on hydrogen for a number of years now, and has released a hydrogen blending capability with natural gas in DLE (dry low emissions) mode between 30 and 75 per cent by volume, depending on the gas turbine model. The company has set out a roadmap for achieving a 100 per cent hydrogen capability in DLE mode by 2030 at the latest.

This could be a consideration for BASF in the future as it moves towards its net zero goal.

“Although it’s currently not foreseen that the turbine will run on hydrogen due to still outstanding availability, we are investing in the technology already so that we are prepared for the future,” said Künstler. “But of course BASF were interested in what hydrogen capabilities we have, and it was investigated as an option for future use.”

DeKeyser added: “We are very pleased. For this kind of project, you really need a partner that is capable to keep coming up with their own ideas and keep re-thinking things.”

Summing up the project, Künstler said: “The collaboration with BASF



**Siemens Energy is already looking ahead with a programme to allow its units to run on hydrogen**



**The SGT-800 package is at the heart of the modernised plant**

the SGT-800 at industrial sites.

The SGT-800 operates on natural gas with low emissions. The NO<sub>x</sub> emission levels will be 15 ppm for the gas turbine while operating in the range of 60-100 per cent load. This will see nitrogen oxides from the plant reduce by 50 per cent.

Most, notably, however, in line with BASF’s drive to cut carbon emissions, the new installation will substantially reduce CO<sub>2</sub>. At the operating load at Schwarzheide, power plant efficiency is 4 per cent higher, thus reducing CO<sub>2</sub> by 16 per cent.

And as gas turbine operators look to zero CO<sub>2</sub>, Siemens Energy is already looking ahead with a programme to allow its units to run on hydrogen. The company has been working on

Schwarzheide was really excellent; it was always a real partnership. The project was challenging but working at an experienced level with the customer was really beneficial – the professionalism we had in exchanging information. It’s always a pleasure when technical discussions could be held on a high level due to the knowledge of all related engineers. BASF’s Center of Expertise departments are a perfect example – their engineers understand the discussions at a high level.

“There was always open communication even during the challenges, which you get with projects of this size. We always found a good solution; there was always great teamwork and team spirit throughout the execution period.”

### SCC-800: Performance data for 1x1 combined cycle power plant

	62 MW rating	57 MW rating
Gross plant output (MWe)	89	81.5
Gross plant efficiency (%)	95.6	58.5
Gross plant heat rate (kJ/kWh)	6040	6154
Number of gas turbines	1	1



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