THE ICING ON THE CAKE

Stockholm's Environmental Masterpiece

One of the world's largest biomass projects has recently started up right in the centre of Sweden's capital, Stockholm, helping it on its way to become Europe's most environmentally friendly city. ANDRITZ played a major role in creating Fortum Värme's showcase Värtaverket biomass CHP plant.

The locals call it the "Wedding Cake" due to its multi-tiered form sitting quietly and unobtrusively along the cityscape of Stockholm. Carefully built around three protected ancient oak trees, the uniquely impressive design of the boiler house at the Värtaverket site was recently shortlisted in two categories at the prestigious global MIPIM architectural awards.

While certainly impressive on the outside, this terracotta clad masterpiece of design also holds something truly remarkable within – one of the world's largest biomass boilers, which, along with some of the most modern technology available, ranks it among the most productive and efficient facilities to be found anywhere today.

And this growing city certainly needs a large, efficient, and productive boiler; Scandinavia in the winter can be a very cold place and Stockholm's 1.5 million residents need full on, 100% reliable district heating to enable them to live and work in the city. The new biomass CHP plant at Värtaverket will play its part by delivering heating to some 190,000 households, as well as generating valuable green electricity that goes into the national grid.

AIR QUALITY – A BIG ISSUE IN STOCKHOLM

What is even more impressive is that the new plant is fuelled entirely by biomass, which comes in chip form from all over Sweden and further around the Baltic region. The chips are fed into the boiler from a dedicated railhead and harbor via a complex subterranean conveyor system down to 40 meters below the sea level through tunnels cut into solid rock. Mats Strömberg, Senior Project Manager for the KVV8 project says, "Not only is this one of the largest biofuel projects in the world, but we have built it in a tight space, right in the heart of the city, with a lot of the main moving parts and supply systems situated way underground."

All of the ash from the plant is transported back through the same tunnels to silos at the harbor through a completely closed loop conveying system.

The authorities in Stockholm have long been working on reducing environmental impact, with clean air becoming an increasingly important issue in the city. District heating through pipes was first introduced to Stockholm in the 1950s, which initially got rid of a lot of emissions into the air from coal fires being used in individual homes. The Värtaverket heating and power plant first started in 1969, and now the distribution grid covers most of central Stockholm's heating needs. The heat distribution grid here has a total length of around 330 km with an average diameter pipe of 261 mm. The system holds approximately 32,200 m^3 of water (40,000 m3 including the accumulator).

What makes the environmental aspects at Värtaverket even more challenging is that the plant is right next to a residential area as well as very close to Ekoparken, the world's first city national park.

Strömberg says, "The target in this city is to get rid of fossil fuels completely well before 2030. We will do this by building plants such as KVV8, but also using waste-to-heat plants for district heating and generating electricity in other ar-

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The conveyor carrying wood chips from the harbor to the boiler.

"To get the capacity we needed, we had to install a very large boiler. That meant height as well as width when it came to capacity."

MATS STRÖMBERG
Senior Project Manager, KVV8

eas. In fact, Fortum has recently announced that coal plants in the city will be completely closed by 2022."

Clearly the Värtaverket KVV8 project has become a substantial milestone in the Fortum-Stockholm city strategy of reduced emissions – the new facility has reduced CO_2 emissions by an incredible 126,000 tonnes per year and 650,000 tonnes per year including the impact from the electrical production.

GOING UNDERGROUND – THE KVV8 PROJECT

The decision to start the procurement of the biomass plant to supply the city with district heating was made in February 2011, and ANDRITZ experts were called in from the outset due to the long experience the company has in biomass projects. Strömberg says, "We brought in ANDRITZ and the other large boiler suppliers right from the beginning; we needed to discuss technical solutions and logistics with companies that knew how to place boilers, big boilers, in difficult positions. In the case of the Värtaverket site, we not only had high demands in the capacity of the boiler, we also had major local city planning restrictions when it came to height and space. We needed suppliers who understood how to work with this.

"To get the capacity we needed, we had to install a very large boiler. That meant height as well as width when it came to capacity. There was no way around it; we had to go underground. To do this, we had to blast through solid rock, build the boiler down to 14 meters below ground and the tunnels down to 40 meters below sea level – we created a very big hole, all within a stone's throw of local residents. We also excavated the tunnels underground from the harbor to the plant for the biomass conveyors and in March 2014 we were ready."

With a total investment of 500 MEUR, ANDRITZ was awarded the contract for the boiler and all automation at the plant in December 2012. Bernhard Haimel, Project Manager for ANDRITZ, explains, "We were delighted and proud to win this order; there was a lot of work involved in the quotation process. Our aim was to convince Fortum that we were the right supplier for the job.

"This was a unique project in many aspects, particularly the manufacture and installation of one of the world's biggest boilers, with a biofuel fed Circulating Fluidized Bed (CFB) and an output of 345 MWth. What was particularly difficult in this case was that we had to fit the boiler into a limited space at the same time as apply the very best technology for efficiency, including the need for fuel feeding via six spouts to ensure even distribution of the biofuels, one of the prerequisites for the lowest possible flue gas emissions."

ANDRITZ also delivered the flue gas cleaning system. Both, SNCR and high dust SCR technology is used to ensure lowest NOx and NH_3 emissions. For primary desulfurization of the flue gases, limestone is injected into the furnace. For dedusting, bag house filter technology is used with the possibility to add bicarbonate upstream the filter.

Another prime element of the boiler supplied by ANDRITZ was the Lexor Bed Material Heat Exchangers, which allow the installed superheaters highly advanced steam parameters of 560°C at 147 bar without the normal corrosion risk.

Being a typically demanding customer, Fortum was seeking the highest possible performance it could obtain. During the sales phase, the company insisted that the demand of the thermal output increased from 300 to a peak load of 345 MWth which was further increased to a peak load of 375 MWth during the project. "Fortum communicated its demands well and clearly, and we knew that if we could meet all those challenges the result would be a plant that is unique in the world," adds Haimel.

As the contracted suppliers began their work at the plant, communication was absolutely key. Strömberg says, "It is common in Sweden to divide a project such as this into many different contracts and contractors. In this case we had 30 packages, so the coordination of these was a massive undertaking in itself. There were numerous meetings and lots of different, experienced consultants involved working on various aspects of the project. It was quite a task, but there was a really good and open culture of communication that made things continue smoothly when things went wrong or unexpected challenges came along."

Says Haimel, "Due to the fact there were so many different suppliers and subcontractors, and simply so much equipment – which was

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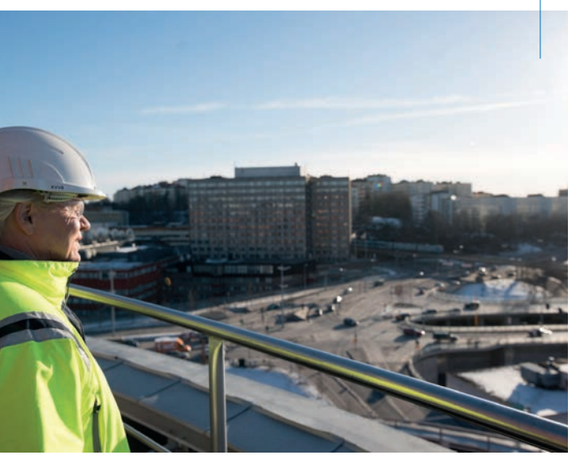

Overlooking central Stockholm.

Much like catching and using the steam generated from a boiling kettle, the technology at the Värtaverket site has been designed for maximum output, and to use and reuse any steam, heat or power to achieve extra efficiency wherever possible.

Carefully built around three protected ancient oak trees, the uniquely impressive design of the boiler house at the Värtaverket site has recently been shortlisted in a global prestigious design awards.

arriving on a just-in-time basis because of limits on space and transport restrictions in the city – we had to think in a very detailed way about the erection sequence and what it would finally look like. One big aid for us at this stage was the use of 3D modelling, which really helped us when it came to situating all the many kilometres of pipework used in the plant."

AUTOMATION – THE MOST ADVANCED IN EUROPE

The plant has an extremely high degree of automation, also supplied by ANDRITZ. Haimel explains, “The DCS system at Värtaverket is very sophisticated and one of our most challenging tasks was to integrate the various technological areas into the common control system supplied by ANDRITZ. Now the entire plant can be operated or at least monitored from several control rooms located in different areas of the power station, both in the newly built part as well as in the existing buildings. Safety, availability, and efficiency were the key requirements throughout the design of the electrical and automation system and for the selection of suppliers for this project. Consequent observation of these requirements has resulted in one of the most advanced power boilers in Europe.”

In order to achieve the demanded high level of automation, first class instrumentation was required in the plant. ANDRITZ supplied all the automation, control, and the measuring instruments within its technological scope of supply as well as most of the instrumentation and control in technological areas supplied by Fortum itself.

A further significant part of the scope of delivery was the supply and installation of the electrical power distribution with twelve power transformers, switchgears, and numerous drive systems up to several MWth. ANDRITZ also supplied the uninterruptable power supply (UPS) system for critical components and systems with safe power.

RUNNING AT 100% EFFICIENCY AND BEYOND

The first firing in the boiler at Värtaverket was in November 2015, with commissioning based on biomass in February 2016, some four years after conception of the ambitious, ground-breaking project. Strömberg says, “We reached what you could say was full commercial production in April 2016. Before that we had to make thousands of safety-related checks as the site is so close to the city. We had to push the boiler to the absolute limit, and then kick it out, to make sure that all the fail safes we had in place worked, and only then we could think about stable operation.”

Much like catching and using the steam generated from a boiling kettle, the technology at the Värtaverket site has been designed for maximum output, and to use and reuse any steam, heat or power to achieve extra efficiency wherever possible. Strömberg explains, “The boiler has been designed for maximum output, which is largely based on a well-designed combustion process with high efficiency. But there are also added extras, which allow us to maximize efficiency at the plant by reusing heat and steam. For instance, a so-called heat shift system is implemented in the boiler back pass that cools the flue gas temperature further down after the boiler. The system allows flexibility, switching over heat to incoming combustion air and/or condensate water after the turbine condensers.”

Haimel adds, “The heat shifting system also allows for a lot of flexibility in reusing waste heat and ensures lowest boiler outlet temperatures. This increases the efficiency of the boiler itself by far. Furthermore the boiler has varying needs going from winter to spring and autumn to winter. The ANDRITZ PowerFluid technology for power boilers allows for the boiler to go quickly and smoothly from a maximum load of 345 MWth up to overload operation of 375 MWth and down to 80 MWth allowing for a wide operation range, which is unique for a biomass application of this size.”

And there’s more, Stromberg continues, “The recovery of district heat from flue gas is maximized by combustion air humidification upstream of the boiler and a flue gas condensation downstream of the boiler. While spraying water into the combustion air, the concentration of vapor water in the flue gas is maximized through the boiler. The efficiency of the flue gas condensation after the boiler becomes higher while increasing the condensation effect so that more heat can be recovered. The outgoing flue gas to the stack has a temperature around 40° C. This makes the overall efficiency of the plant very high – and certainly more than 100%.”

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On SPECTRUM’s visit to Värtaverket on a cold winter’s day in February 2017, the plant was running very quietly at maximum load in the center of Stockholm, delivering heat to tens of thousands of homes and businesses in the city.

A large ship from Finland was unloading chips by the great crane bucket into the crane hopper on the pier in the harbor, and the conveyors in the tunnels underneath the plant were smoothly delivering biomass at a rate of 416 m^3 per hour (10,000 m^3 per day).

From the outside of the plant, there were barely any emissions to be seen coming from the stack, and what there was, was harmless steam. The completely closed loop emissions system makes sure of that.

And the icing on the cake? “The environmental data from this plant is very, very good,” concludes Strömberg. “The contract we made with ANDRITZ stated that the emissions need to be much lower than government regulations, and they have achieved this and more. The success of the Värtaverket KVV8 project means we are a big step on the way to creating a fossil fuel-free city.”

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A hole was blasted out of the rock to a depth of 40 meters.