First-of-its-kind at Skive

Gasification technology has long held the potential to use biomass more efficiently, especially in combined heat and power applications. The potential has come closer to reality with the start-up of a novel demonstration project in Denmark.

"Biomass gasification has now moved from the pilot plant to the real world," says Kari Salo, Managing Director of ANDRITZ Carbona, specialist in gasification technology. At I/S Skive Fjernvarme, a first-of-its-kind installation – where fuel feeding, pressurized gasifier, tar reformer, gas cooler, and scrubber are all operating together outside a laboratory – is now operating in commercial scale. ANDRITZ Carbona provided this technology to produce fuel gas from wood-based biomass for combined heat and power (CHP) production.

A single bubbling fluidized bed (BFB) gasifier and related equipment converts wood pellets to fuel gas for three reciprocating engines in a combined heat and power (CHP) in the CHP plant. The engines generate electrical energy (two MW each) from which the heat is recovered for the community's district heating needs. Two gas boilers in the facility can also utilize the biomass-derived gas providing additional district heat.

The project is financed on a commercial basis, but as it is a demonstration facility, subsidies are provided by the EU, the US Department of Energy, and the Danish Energy Agency.

Gasification is best solution

"Cogeneration of electricity and heat at district heating plants raises our overall efficiency of converting the energy in the fuel," says Jens Ole Skov, Operations Manager for I/S Skive Fjernvarme. "In a smaller scale CHP plant like this, the electrical efficiency must be maximized to make the plant economically feasible. Gasification enables us to produce about 30% more electricity than a conventional steam process. In total, the efficiency of our CHP operation is about 90%."

In addition to being the owner, Skov's company also acted as the general contractor for this EUR 23 million investment project. "This is the biggest project by far that we have ever managed and it has stretched our resources very thin," Skov says. "We have relied very heavily on the technical and engineering expertise of ANDRITZ Carbona."

The scope of ANDRITZ Carbona's supply includes fuel feeding, BFB gasifier, the gas cleaning system, and equipment for gas cooling and distribution. GE Jenbacher AG of Austria supplied the three engines specifically developed for low-calorific gas combustion.

▼ The ANDRITZ Carbona gasifier is a pressurized bubbling fluidized bed (BFB) design.

I/S Skive Fjernvarme in northern Denmark produces 120,000 MWh of district heating and 22,000 MW of electricity for about 8,500 households and businesses. ▼

First-of-its-kind installation.
Fuel feeding, pressurized gasifier, tar reformer, gas cooler, and scrubber all operating in commercial scale.

"Cogeneration of electricity and heat at district heating plants raises our overall efficiency of converting the energy in the fuel."
Jens Ole Skov, Operations Manager for I/S Skive Fjernvarme

Andras Horvath (left), Director of Technology for ANDRITZ Carbona and Jens Ole Skov in the CHP plant.

▲ Two gas boilers at the plant can also utilize the product gas from the gasifier to produce additional district heating.

The plant is expected to produce 6 MW electricity and 11.5 MW district heat from 19.5 MW of wood pellets. The maximum fuel input of the plant is 28 MW, allowing for the generation of additional district heat. Besides providing 70% of the district heating production for 8,500 households in the community, the facility will also produce 40 GWh of electricity annually.

New and exciting work

"This project has given us the opportunity to explore the operational challenges and the lessons to be carried forward," says Andras Horvath, Director of Technology for ANDRITZ Carbona. "We are learning every day."

Gasification itself is a proven technology, according to Horvath. ANDRITZ Carbona originally acquired the BFB technology from the Gas Technology Institute in the USA in 1989. "It was originally used for coal gasification and we modified it for biomass," Horvath says. "We've been developing it ever since."

The technology that is newest is the catalytic reformer which handles the tars developing during wood gasification. "The catalyst is relatively new, and the big unknown is the actual life of the catalyst," Horvath says.

"Also, no one has ever integrated all these systems in commercial scale before. It is all new and exciting, studying the performance of scaled-up equipment."

Skov agrees. "This is by far the most interesting and exciting project I have been involved with," he says. "But as an operations guy, my goal is to get this plant running in auto as quickly as possible."

Automatic operation is a must, according to Skov. He supervises the operations of eight district heating facilities for the company and all run attended overnight and weekends. "So, we are testing, measuring, optimizing, and automating – all at the same time!"

Commissioning of the plant started in late 2007 and, using one gas engine, operations began in the summer of 2008. The second and third gas engines were installed in 2008 and are now all in operation. In the summer, district heating requirements are minimal, so the engines were not needed. By regulations, the plant cannot be used solely for electricity generation (even though the plant would profit from the green energy credits), so cold weather is welcome to fully test the system.

Aerial view of Thorsvej district heating plant (I/S Skive Fjernvarme) in Denmark. ▼

"What we know so far is that there is very low tar content in the product gas compared to circulating fluidized bed technology," Horvath says. "There are no heavy tars which might condense in the system."

Integrated design

The Skive plant can utilize wood pellets or chips. Currently, pellets are fed through two lock hopper systems into the lower section of the gasifier's fluidized bed. The air-blown gasifier is operated at a maximum of 3 bar over pressure and 850° C temperature. Dolomite is used as the fluidized bed material.

Before the gas can be used as fuel in the engines, several steps must be completed. First, is the gas cleaning step which uses a novel catalytic technology to reform the tar compounds in the gas to hydrogen and carbon monoxide. The product gas contains about 22% carbon monoxide, 20% hydrogen (H_2) and 5% methane (CH_4) by volume, and has a heating value of about 5 MJ/kg. By way of comparison, natural gas has a heating value of about 40 MJ/kg.

Next, the gas is cooled and passed through filters to remove dust. The gas is then scrubbed with water to cool it further. "The maximum gas temperature for the engines is about 40° C," Skov says, "so the gas must be cooled considerably. The heat removed from the gas in the gas cooler and scrubber is used to generate district heat."

Now the gas is ready for use in the engines or in the two gas boilers, or flared off in a possible emergency situation. The heat from engine cooling (lubrication oil and jacket cooling) and the exhaust gas is recovered for the production of district heat.

Commissioning, start up, and operations

Hot start-up of the ANDRITZ Carbona gasifier occurred late in 2007. The start-up was performed in a stepwise fashion, according to Horvath, with the gasifier, gas cooler, filter, and gas boiler processes operated independently to verify the integrity of gas production. Once the systems were supplying gas to the boilers and delivering district heating to the hot water network, the tar reformer and scrubber were added to the gas cleanup line and commissioned.

Product gas quality was measured in detail to ensure it met all the criteria for impurities and contaminants specified by engine supplier. The first engine achieved full load, grid-connected operation after a few days.

"The results show that the system design is highly suitable for this type of application," Skov says. "The raw gas quality and heating value corresponds well with the original design requirements. The gas cleaning system has been tested and the required gas quality has been achieved."

Demonstration plant challenges

Still, the path from a pilot plant to a commercial scale plant is a difficult one. "The team from I/S Skive Fjernvarme has worked extra hard on this project and it has been great to cooperate with them," Horvath says.

"We are meeting the technical and operational challenges one by one," Skov says. "We knew there would be obstacles since this is a first-of-its-kind facility. As owners, we want to produce cheap electricity and heat for our stakeholders. ANDRITZ Carbona wants to demonstrate and prove new technology. Together we are managing to overcome our challenges and demonstrate the feasibility of this new technology."

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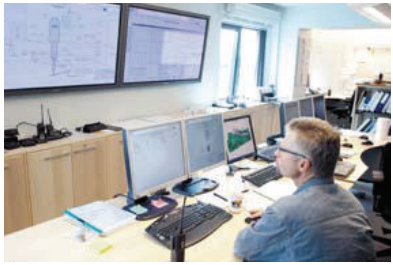
▲ The engine room: three reciprocating engines operate on the biomass-derived fuel from the ANDRITZ Carbona technology.

Operators in control room. The facility is designed to run on auto-pilot nights and weekends, so there is a high level of instrumentation and control. ▼



▲ Denmark is aggressively applying renewable energy solutions and was the first in the world to start up this CHP plant with biomass gasification.