CHP plant runs on syngas at Schwarze Pumpe

A recently commissioned plant at Schwarze Pumpe looks set to provide a commercially viable option for delivering combined heat and power from biomass gasification.

Junior Isles

Producing syngas from biomass gasification and then using this gas to generate power using a reciprocating engine is not a new concept, yet it is a technology that has not yet seen widespread commercial application at industrial scale.

However, US-based technology company, ZeroPoint Clean Tech Inc., is now introducing a combined heat and power (CHP) package that could be a viable option for users looking to install decentralised, renewable-based CHP systems. The company recently completed commissioning of an engine that runs on biomass-derived syngas at a plant in Schwarze Pumpe, Germany.

ZeroPoint has been in operation for six years, during which time it has developed various working prototypes and a beta unit but Schwarze Pumpe represents its first full scale commercial unit to be shipped and commissioned.

David Pitt, ZeroPoint's EVP of International Operations said: "This is significant in the world of gasification because the market has been looking for an industrial scale unit, something bigger than a few hundred kilowatts. A unit like ours, which generates in the 1.5-2 MWe range by producing sufficient high quality gas to run a modern gas engine genset has arguably been the holy grail of biomass gasification and as with most things the devil's in the detail. Our learning curve has been all about how to understand the nuances of the process and to optimise its control."

ZeroPoint believes that the real differentiators between its technology and other technologies lie in the high energy conversion efficiency from solid biomass to gas and its associated cleanliness and chemical stability. The company says the thermal efficiency of the process is more than 85 per cent.

Pitt explained: "Most people in the industry talk about a conversion rate of about 1 tonne of biomass to 1 MW of power. From 1 tonne of dry biomass, we produce 1.5-1.8 MW, with the remainder of the energy available as waste heat. I believe our technology is at least 25 per cent better than anything else that's out there at the moment."

The three most common process technologies used for gasifying biomass are the updraft, downdraft and fluidised bed methods.

"If you are looking for a process that produces the cleanest gas, the science leans towards downdraft gasification, however, historically it has been considered to have limited scalability with most applications being less than 500 kW. Updraft gasification has been the conventional approach for high volume gas production although it inherently produces gas, which requires significantly more cleaning than the downdraft approach hence it is generally used in boiler applications. We believed the problems related to cleaning the dirty gas from the updraft process to the quality needed for a gas engine could be commercially insurmountable and hence we decided to focus our development efforts on techniques to scale the downdraft process.

"This enables us to deliver industrial gas volumes that are capable of being cleaned to the quality required for a modern gas engine using relatively straight forward scrubbing technology." said Pitt.

ZeroPoint began developing its technology in mid-2006 with lab-scale modelling of dispersion in its proprietary downdraft gasification process. Promising results enabled the company to secure financing later that year to build a half-scale pilot plant in Potsdam, New York, USA, the following year. This facility was used to develop and validate its process designs and prove all of the basic control configurations and flow dynamics. "This gave us a decent handle on how to actually scale up to our 2 MW objective," noted Pitt.

The company secured a commercial development contract with a US waste operator in 2007 to build the first full size beta plant. The plant was designed to help the operator learn how gasification would work with engineered fuels from waste.

Pitt commented: "This occupied us for 2008 and most of 2009. It was a big learning curve, particularly in engineering a robust gas cleaning system and developing the controlling algorithms to optimise flows and achieve process stability in the reactor." As a consequence, ZeroPoint secured a contract with Kedco Power to supply gasifiers for a CHP project development in Ireland. The first unit for this plant was shipped in 2009.

The contract for the gasifier just commissioned at Schwarze Pumpe was signed with Blue Planet Bio Energy Deutschland in 2010. The gasifier unit was shipped in December 2010 and following weather delays and the completion of the formal approvals by TÜV, began commissioning in June of 2011.

> "The economics of gasification can stack up in island communities that rely on diesel."

The plant consists of a gasifier, a genset that runs on the syngas produced from biomass, and all associated balance-of-plant equipment.

The biomass or wood for the plant is supplied in chipped or pellet form with excess dust or fines already removed along with any other foreign materials such as stones and metals. "Feedstock preparation is critical to the process as it has a big impact on gasifier efficiency over time," noted Pitt.

The overall footprint for the gasifier with its cleaning system is approximately 30 m long, 4 m wide and 7 m high at its tallest point. Fuel and air are fed in to the top of the reactor where the biomass settles on a stratified grate. This creates a biomass bed, which is progressively transformed from a solid to a synthesis gas as a consequence of the gasification chemistry. Temperatures in the reactor range from about 150ºC to 900ºC.

Solid residue is separated from the syngas and collected at the bottom of the gasifier in the form of a bio-char. This bio-char can be used as a high-grade soil conditioner.

The hot syngas exiting the gasifier is initially cooled and then scrubbed before being conditioned to meet the requirements of the gas engine. Waste heat is recovered in the cooling process which can generate steam to support the gasification process along with plant specific waste heat applications such as biomass drying, chilled water production and district heating.

"We aim to produce a gas that has a calorific value well in excess of 5 MJ/m^3, which is about the minimum level a gas engine needs to operate. It is a relatively lean gas because air is used as the oxidant. The gas has a stable composition, being about 45 per cent nitrogen, 20 per cent carbon monoxide, 20 per cent hydrogen and small amounts of carbon dioxide and methane," said Pitt.

At Schwarze Pumpe, the syngas drives a GE Jenbacher 320 engine. Another project under way in Ireland will use a Jenbacher 620 engine. "Our customers have opted for Jenbacher engines as they have a reputation for being able to run on syngas. This is probably by virtue of the fact that there aren't many syngas engines running but as more of these plants are deployed, many of the major vendors will see the new market opportunity and will inevitably offer competitive options," commented Pitt.

Although just a single engine is in operation at Schwarze Pumpe, the site has the potential to run more engines. "This year will be about continuing to operate with one or two engines; we may test another engine there. It will also be about refining the process so we can invest in more lines, ultimately scaling it up to five engines or maybe well beyond," said Pitt.

Pitt believes expansion is quite possible. "German tariffs are very favourable, so the project economics stack up," he noted. And while there appear to be no real technical challenges to commercial rollout of the technology, economic incentives will be important in regions such as the EU.

Pitt said: "Gasification isn't the lowest capital cost technology; you need a sympathetic regulatory environment to enable it to get moving or an environment where the cost of power generation is inherently very high. Over time as equipment is manufactured in volume, capital costs will come down. Whether it will come down to the point where it can compete with the conventional fossil and hydrocarbon technologies is debatable."

Ultimately success will depend on fuel costs as well as biomass availability. Pitt believes that a country such as the UK will progressively move towards waste wood, as it is in good local supply and with pressure to reduce landfill, its availability is pretty much guaranteed for the foreseeable future. He therefore sees good potential for installing small 2-6 MW decentralised CHP plants in local communities that use local fuel sources.

In other parts of Europe, where biomass can come from sustainable forests, Pitt says there will be a different set of economics, which will focus more heavily on the utilisation of virgin woods.

Nevertheless the company is confident that its package will find a place in the market. In addition to the Schwarze Pumpe and Ireland projects, ZeroPoint is now looking at projects in the UK, Germany and a "host of initiatives around the equatorial belt". Pitt says the company has been working with people to look at ways of optimising the use of major agricultural waste such as palm waste.

He concluded: "We see major potential over time for using gasification in the palm industry. The economics of gasification can stack up in island communities that rely on diesel. Diesel generation can be significantly more expensive than gasification in those types of areas because the biomass is relatively cheap. We have been getting a number of enquiries from companies in Central America, Asia and the Far East assessing the potential of converting diesel engines to run on syngas produced from biomass."

Although just a single engine is in operation at Schwarze Pumpe, the site has the potential to run more engines