CFB and biomass, a winning combination

The circulating fluidised bed boiler has a number of significant advantages in biomass applications, not least its high degree of fuel flexibility, ability to make use of locally sourced cheap but low quality fuels, and insensitivity to big variations in fuel properties.

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When reduction in CO_2 emissions, and emissions in general for that matter, is given priority, biomass fuel, co-fired with coal or used in a dedicated 100% biomass facility, can be an attractive option. However, the term "biomass" necessarily describes a broad range of organic materials. Biomass fuels may include clean wood chips from harvested trees, agricultural residue, salvaged wet forest residues, and manufacturing wood wastes that are very difficult to reliably burn, as well as mixtures of products. Also, the properties of the biomass vary substantially depending on seasonal mixtures, moisture content, and the region where harvested, as well as any fuel pre-processing necessary prior to firing. Biomass can have a wide range of chemical and physical properties and is a much more diverse fuel than coal.

A pulverised coal (PC) boiler that is modified to co-fire biomass will certainly increase its fuel flexibility, but the gains may be relatively limited. For example, a PC boiler that was originally designed to burn coal can be constrained in terms of the amount and type of biomass that can be co-fired due to limitations such as boiler volume and combustion control systems. Retrofitted PC boilers are generally limited to 20% or less biomass by weight, often less than 10%, according to the US Department of Energy (although some PC conversion projects have achieved much higher percentages, up to 100% in some cases, eg Drax in the UK). Co-firing biomass in an existing PC boiler adds complexity to the plant, such as adding a duplicate fuel handling system and other auxiliary equipment. The PC boiler also requires a relatively clean and homogeneous biomass fuel supply, particularly with respect to moisture content, which means fuel must be pre-processed.

New build plant developers demand maximum fuel flexibility so that new facilities can have full access to arbitrage in the global fuel market, maximise use of inexpensive local (but often very poor-quality) fuels, as well as have the ability to co-fire a wide range of locally produced biomass fuels.

The decided trend has been towards using circulating fluidised bed (CFB) technology when fuel-flexibility and utilisation of local fuels (for economic, environmental, and fuel security advantages) are paramount.

The fuel-flexible CFB is able to co-fire biomass with coal in any proportion up to 100% biomass, when sufficient quantities are available. The CFB is also insensitive to biomass fuel type and moisture content and generally requires no preprocessing prior to firing.

An integrated fuel-flexible CFB plant can deliver a number of significant advantages for those considering replacing aging coal-fired power generating plants, particularly district heating plants.

For example, a CFB plant configured as a combined heat and power plant can co-fire a locally sourced brown coal with many forms of locally procured biomass mixtures and bio-sludge. This approach often addresses a multitude of regional environment and energy efficiency problems, such as increasing the overall scale and energy efficiency of a district heating network. In addition, the plant can be sized to meet peak electricity and heat demand thereby producing, at certain times, surplus dispatchable electricity for the local power grid. This approach ensures regional CO_2 emissions are reduced and, if the plant is built within the EU, it will help regional authorities meet refuse derived fuel (RDF) reuse requirements designed to reduce the amount of landfilled material. Depending on the location of the plant, there may also be CHP production and renewable energy system financial incentives available.

The fuel flexibility of CFB technology allows the utilisation of a wide range of renewable and waste fuels and fuel mixes to reduce carbon dioxide emissions compared to conventional generation. The technology also offers high efficiency and significantly increased flexibility in plant operations because a CFB plant can efficiently and reliably burn a broad spectrum of biomass fuels, with or without coal.

The five brief case studies shown on these pages illustrate the advantages.

These five biomass-fired combined heat and power plants are significant in terms of their heat and power production capacity as well as also providing major environmental and fuel security benefits. However, there have been fairly tight limits on the size of CFB plant considered capable of burning 100% solid biomass fuels, until now, that is.

MGT Teesside Ltd is building the £650m Tees Renewable Energy Plant, a 299 MWe 100%-biomass-fuelled CHP plant at Teesport, UK (pictured below, source of picture, **Sumitomo SHI FW**).

When completed, it will be the largest dedicated biomass power plant in the world. Construction of the Tees Renewable Energy Plant (to be featured in the next issue of *Modern Power Systems*) began in August 2016 and commissioning is scheduled to begin in 2019 with full commercial operation expected in early 2020. MPS

Case study 1: Zabrze CHP plant, Poland

Source: Sumitomo SHI FW

The Zabrze CHP project (see *MPS*, August 2017, pp 28-30) illustrates how CFB technology was deployed to meet the EU renewable energy mandate (20% by 2020) and the Waste Framework Directive (WFD), which requires materials with a heating value greater than 6000 kcal/kg to be used as a refuse derived fuel (RDF) and no longer landfilled. An existing 60-year-old coal-fired district heating system had reached the end of its useful life.

The new Zabrze CHP plant is built around a fuel-flexible Sumitomo SHI FW circulating fluidised bed boiler. When commissioned, by the end of 2018, ZCP will supply electricity and steam heat for about 70 000 households in the municipalities of Zabrze and Bytom. The €200 million CHP plant will produce 145 MWt of heat and 75 MWe of electricity. The plant is initially configured to burn 0-100% domestic hard coal with 0-40% RDF, which translates into burning about 200 000 tons of RDF each year. There are also provisions in the plant design to add the capability to burn up to 100% locally sourced biomass in the future. By combusting these locally sourced residential and industrial wastes, the facility reduces the region's CO_2 emissions. In addition, the plant's SO_2 and NOx emissions will remain well below the statutory requirement of 150 mg/Nm³ when burning design coal and biomass mixes using only furnace limestone injection and SNCR, respectively, while concurrently reducing the amounts of waste products.

Case study 2: Kaukaan Voima Oy, Finland

Source: Kaukaan Voima Oy

The 125 MWe CFB facility at the Kaukaan Voima Oy plant in Kaukas, Finland, which entered commercial operation in 2010, is one of the world's largest 100% biomass-fired CFB installations. The plant produces process steam and electricity for a pulp and paper mill and district heating for Lappeenrannan Energia, a city-owned power company.

The plant provides 125 MWe, 110 MWt of district heat, and 150 MWt of process steam. It supplies about 85% of the total district heating needs of residents and businesses in the city of Lappeenranta.

The biomass fuel is locally sourced and consists of bark and wood pieces from wood handling at the Kaukas mill (40%), bark and wood pieces from other forest industry plants (within a 100 km radius, 20%), stumps, branches, and logging refuse from the forest (within a 100 km radius, 20%), and peat from within a 50 km radius (20%).

Case study 3: Lahti Energia, Finland

Source: Lahti Energia Oy

In March 2017, Lahti Energia Oy, a municipality-owned energy supplier, awarded a contract to Sumitomo SHI FW for its new 60 MWe/158 MWt CFB bio district heating plant, Kymijärvi III, located in Lahti, Finland. The multi-fuel CFB plant is designed to burn up to 100% biomass, which will consist mainly of woodchips from forest residues and forest industry byproducts, as well as peat and coal as alternative fuels. The new plant will replace the aging coal-fired Kymijärvi I plant, which will be retired. The plant is now under construction and plant testing is expected to begin in mid-2019.

Case study 4: Jyväskylän Energia, Finland

Source: Jyväskylän Energia

The Jyväskylän Energia power plant is owned by the City of Jyväskylä, the local electricity, water and district heat provider. The plant produces up to 200 MWe and 240 MWt of district heat for the city of Jyväskylä. The plant is fuelled by milled peat and biomass (mostly logging chips) with clean wood chips providing up to 70% of heat input. The biomass is sourced mainly from central Finland, bringing regional economic benefits. SHI FW supplied the CFB boiler and auxiliary equipment as well as carrying out the erection and commissioning of the boiler island.

The CFB boiler is equipped with an electrostatic precipitator and ammonia injection both in the furnace and the separator (SNCR). There is also limestone injection in the furnace for enhanced SO_2 removal.

The plant meets EU emissions standards (150 mg/Nm³ NOx, 200 mg/Nm³ SO_2, 200 mg/Nm³ CO, and 30 mg/Nm³ particulates, all at 6 % O_2, dry).

The boiler contract was awarded in August 2007 and the plant entered commercial operation in the summer of 2010.

Case study 5: Igelsta CHP plant, Söderenergi AB, Sweden

Source: Söderenergi AB

The Igelsta CHP plant is owned by the municipalities of Södertälje, Botkyrka and Huddinge. The plant produces 200 MWt of district heating and 85 MWe. The boiler is designed to fire a fuel mixture of up to 25% RDF pellets and 75% biomass, principally forestry waste, mainly tree branches and tops but also wood chips, bark and shavings. In addition, energy crops such as willow (salix) and reed canary grass are extensively used. Recovered waste fuels are also burned, such as quality-controlled scrap paper, wood and plastic that cannot be recycled into other materials. The CFB is also designed to combust up to 70% demolition wood with 30% biomass.

Sumitomo SHI FW signed the supply contract for the CFB island of the co-combustion plant with the municipal utility Söderenergi AB in June 2007. The plant entered commercial service in December 2009.