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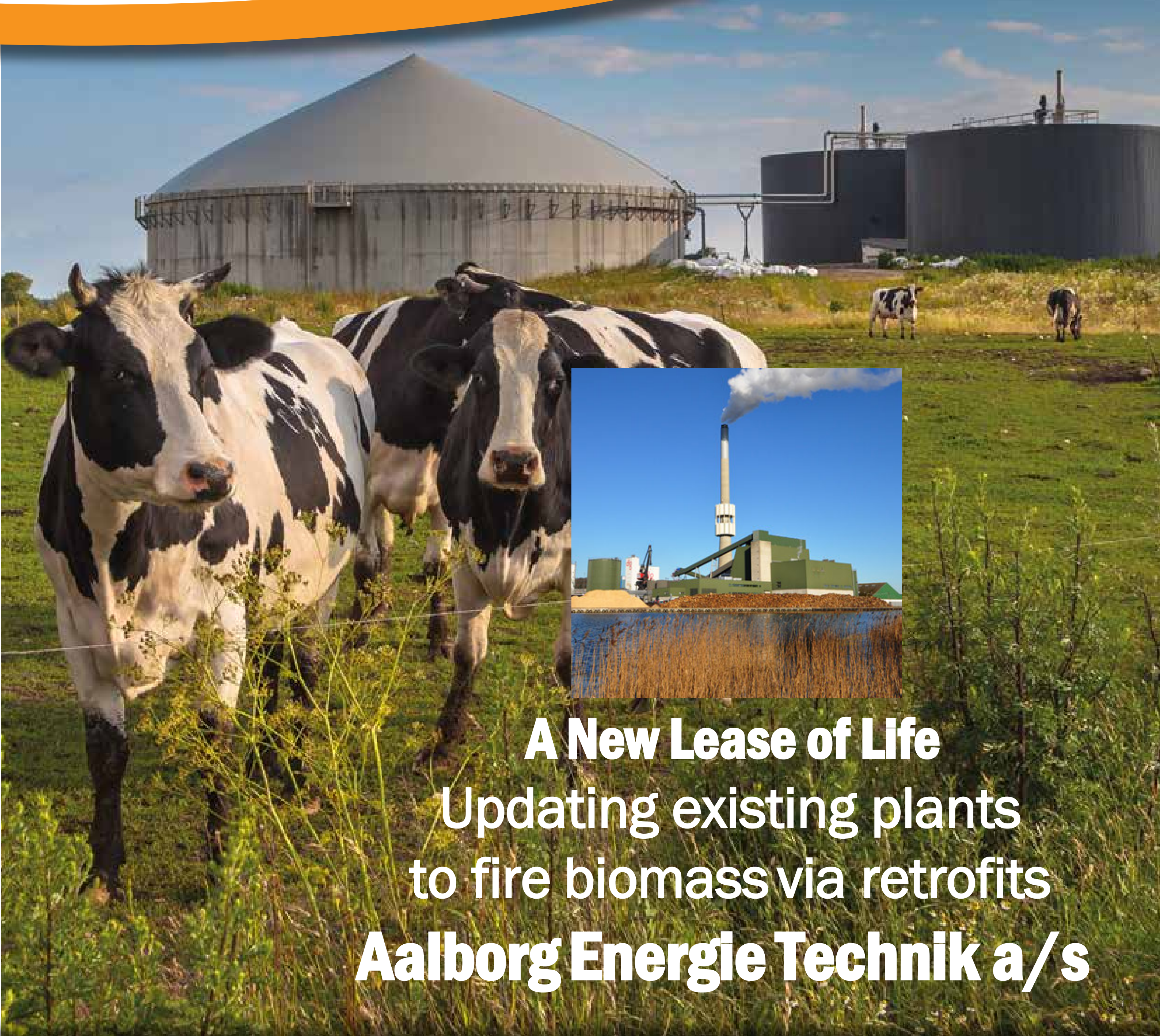


A New Lease of Life
Updating existing plants to fire biomass via retrofits

Aalborg Energie Technik a/s

Regional focus: bioenergy in Europe

The number one source of information internationally for biomass, biopower, bioheat, biopellets and biogas!

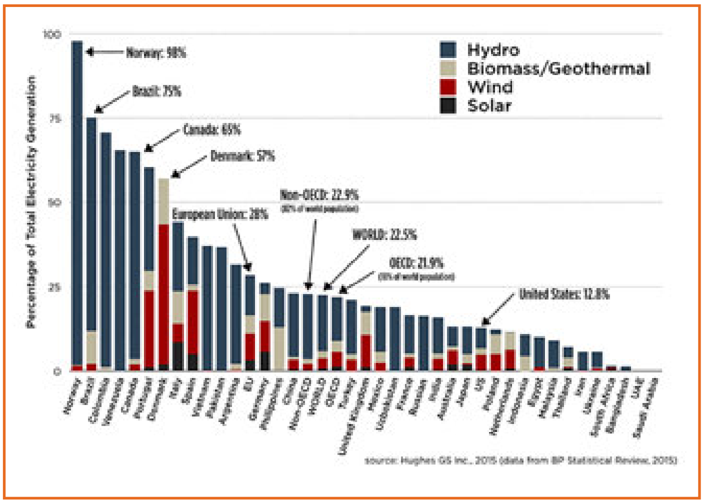
Updating existing plants to fire biomass via retrofits and fuel conversions

A new lease of life

In Europe, renewable energy targets are in place for 2030, with more long-term goals still to be set. Every European nation is different. Denmark, for example, has one of the highest percentages of electricity generated by renewables, and with no natural resources like hydropower, Denmark is switching away from fossil fuels using primarily biomass and wind.

Many district heating plants and process industries are being converted into biomass-fired facilities since they will be able to supply continuous steam and power, no matter if the wind is blowing or the sun is shining.

Optimisation of conceptual design of a biomass-fired plant can be done in various ways. One way is to analyse whether an existing fossil-fired boiler installation can be converted to burn biomass, typically at a cost of 20-50% of a new plant. This article will demonstrate where and how fuel conversions have been successfully carried out.



Percentage of electricity generated by renewables (by country in 2014)

Clean wood and coal

On the Danish island of Bornholm, a 35MW district heating plant called Østkraft was built in 1995. It is owned by the regional municipality of Bornholm and supplies district heating to the 16,000 residents living in the city of Rønne. Østkraft features a heavy fuel oil/coal-fired boiler (up to $106MW_t$, 85 bar, 525˚C), which was supplied by Vølund, and a steam turbine ($37MW_e$).

The base load for district heating and power is supplied when burning with coal ($74MW_t$). During normal operation, the power to Bornholm comes partly through a subsea cable from Sweden. However, this supply is sometimes interrupted and in these cases the combined heat and power (CHP) plant can switch to combust heavy fuel oil to boost the power output ($10MW_t$).

In order to minimise the plant's emissions, however, the boiler will be converted to biomass combustion during 2016. Any combination of biomass, coal, and oil in the boiler will be possible, while the coal and heavy oil firing systems will be maintained as a precaution.

The total installation includes fuel handling, changes to the boiler, and a flue gas condensation system. Aalborg Energie Technik (AET) will be responsible for changing the boiler and, among other things, supplying the combustion system, which comprises the AET Combi Spreader Stoker to secure a flexible fuel mix between coal and biomass.

The AET Combi Spreader Stoker creates a uniform fuel injection into the furnace through an adjustable distribution plate, pulsating air supply, and adjustable spreader air pressure. The advantage of this system is a better fuel distribution on the grate (fully covered grate surface), which ensures a high degree of fuel burnout and lower emissions.

Clean wood, dust and coal

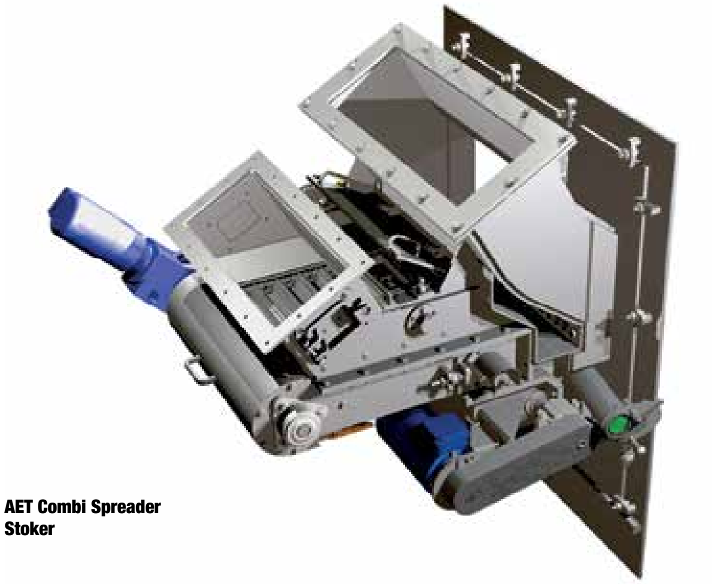
Verdo's district heating plant, which is located in the Danish city of Randers, was built in 1982. It comprises two coal-fired steam boilers (2 x $95MW_t$, 111 bar, 525˚C) from Aalborg Boilers in addition to a common steam turbine ($52MW_e$). The advantage of this configuration is the option of part-load in the spring, summer, and autumn months. The CHP plant supplies hot water and electricity to Randers (approx. 60,000 citizens).

In the early noughties, it was decided that some of the industrial waste in the surrounding areas, such as meat and bone meal, olive stones, shea nuts, sunflower pellets, and wood pellets, was to be reused in the plant.

AET retrofitted the cogeneration plant in 2002-2003 with its Dust Firing System. The plant was then able to operate in co-firing mode with a minimum of 50% coal and maximum 50% biomass fuel or 100% coal in single mode, and any combination in between. The AET Dust Firing System was added on to the existing boilers for even greater fuel flexibility.

Another retrofit was then carried out between 2008 and 2009, enabling the plant to fire 100% biomass and introducing flue gas condensation as well. A new separate woodchip firing system was implemented, while the option to fire coal was maintained. The plant was then able to fire 100% biomass, 100% coal, or any combination in between, e.g. 70% biomass and 30% coal via the AET Combi Spreader Stoker.

The Østkraft plant on Bornholm island



AET Combi Spreader Stoker

While the initial co-firing project (in 2002-2003) did not involve major modifications of the furnace and heating surfaces, the conversion to 100% biomass required an extension of the furnace in each boiler in order to keep full load on the boilers. Some of the existing heating surfaces were re-designed and a new economiser tube-bank added. The existing grates were moved accordingly and the secondary/tertiary air system was further extended with six additional injection levels.

The transition from coal to biomass is not without problems. Biomass can cause corrosion and slag build-up. Computational fluid dynamics (CFD) modelling was made of the combustion, furnace and heating surfaces to identify the temperature profile and concentration of potassium chloride (KCl). After this modelling, it was decided to change the material for the hanging superheaters (SH2 and SH3) to stainless steel. The CHP plant is now able to burn uncontaminated woodchips as well as dusty fuels using AET's Dust Firing System.

Henrik Bøgh Nielsen, production director at Verdo, says: 'The two retrofits have given us a large fuel flexibility to utilise what fuel is available on the market at a low price.'

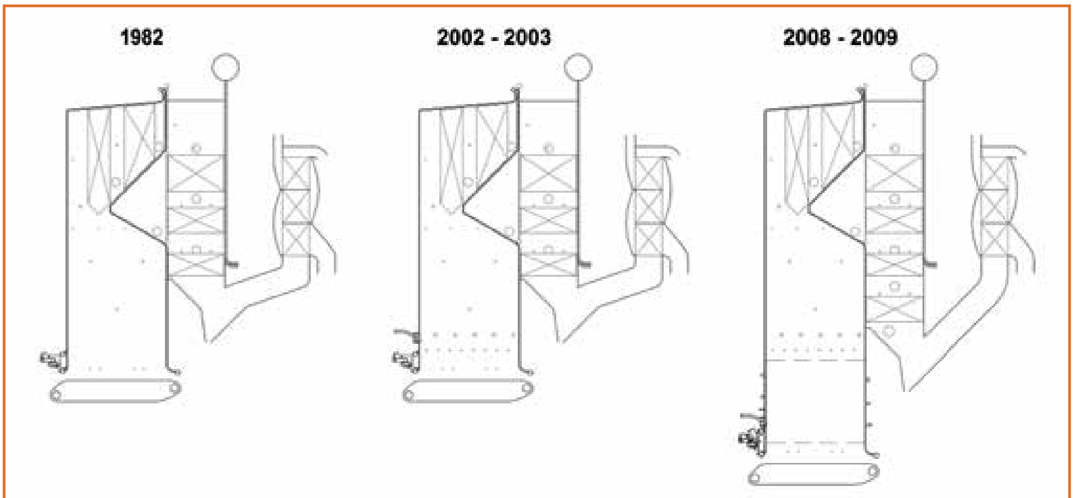
Waste wood

In 2004, German pharmaceutical company Boehringer Ingelheim Pharma wanted to change the fuel in its existing boiler plant, located in the city of Ingelheim, from coal to waste wood. The CHP plant was originally built in 1983 with a coal-fired travelling grate boiler ($63MW_t$, 76 bar, 525˚C) supplied by Lentjes and a steam turbine for the supply of electricity and process heat to the pharmaceutical site.

The boiler was redesigned and the AET Combustion System was implemented to burn demolition wood (class A1-A4) in accordance with the requirements of the German WID (today substituted by IED).

Converting the facility to fire waste wood was extremely challenging. Particular issues included high temperature corrosion and slagging due to the alkali content in the fuel, and the low melting temperature of the fuel.

A ChlorOut system was



An overview of the different phases of Verdo's plant conversion, with the development in boiler layouts from 1982 to 2009

Extensive retrofit opportunities

IN EUROPE alone there are more than 5,000 major boilers and more than 1,000 major biomass boilers. While some of these operate efficiently, others operate with high emissions, low capacity, and low efficiency.

The optimisation potential of a plant can be difficult to predict by desk research alone, so a first inspection is preferable in order to identify expectations, emissions progression throughout, and first estimates of boiler and plant performance. This is followed by a deeper analysis with a thermodynamic calculation of the boiler and the whole plant, which can be followed by:

- **Boiler efficiency improvement:** Primarily by combustion optimisation. There may be opportunities to lower the operating oxygen content of a biomass boiler from 6-10% to 1.6-2.2%. The increase in efficiency can be from 86-88% to 92-93%.
- **Plant efficiency improvement:** By looking at the efficiency of each component (turbine, condenser, pre-heaters) and identifying design/operating parameters, pressure losses, pinch points.
- **Emission reduction:** Slashing CO and NOx emissions, for example, by more than 50% is typically possible only by primary means like combustion improvements. Further improvements are possible with SNCR, SCR, ChlorOut, etc.
- **Capacity increase:** By thermodynamic and potential CFD calculation of the boiler, and by heat balance calculation of the water/steam cycle, it is possible to identify potentials to be realised. Capacity increase of up to 40% has been realised.
- **Improvement of availability:** In-depth analysis of current availability, downtime, and potential change of equipment as well as a preventive maintenance plan can be performed. An availability of between 8,400 and 8,550 hours per year is realistic, which can be interpreted as unique, since some biomass plants are only able to operate 7,000-7,500 hours per year.
- **Upgrade of PLC control and SCADA:** When the plant is 10-20 years old and the mechanical parts still have many years to operate, it is often difficult to get spares and support for the IT systems. It can be a good idea, therefore, to change the PLC control and SCADA/DCS).

Today, Boehringer Ingelheim Pharma's boiler plant fires waste wood

implemented via the AET SNCR DeNOx System in order to minimise fouling and corrosion at the last stages of the superheaters. The ChlorOut system is a two-step injection system with dedicated sulphate liquids (ammonium sulphate and iron sulphate) in order to reach a certain KCl level and reduction of NOx emissions as well as NH3 slip. The KCl level is monitored by an in-situ alkali chloride monitor (IACM). As the superheaters were kept in the original material (10Cr and 13Cr), it was decided to reduce the steam temperature to 490°C.

The ChlorOut system has increased the plant's lifetime and minimised slagging.

Other fuel conversions

When BSE, commonly known as mad cow disease, broke out in the UK in the late 90s, more than 4 million cattle had to be slaughtered. The bodies were partly buried and partly sent to rendering plants, which resulted in a great surplus of meat and bone meal (MBM).

UK power plant EPR Glanford was built as an EPC by Aalborg Industries in 1992. The power station consists of fuel handling equipment, a poultry litter-fired boiler ($50MW_t$, 67 bar, 450˚C), a steam turbine, and an air-cooled condenser. However, the BSE epidemic and leftover MBM saw EPR Glanford converted to burn MBM solely by introducing a new combustion system based on AET's Combustion System with Dosing Bin and Dust Firing System, as well as modification on the lower part of the furnace.

'A new fuel [MBM] made this conversion quite challenging for us,' remarks Frank Scholdan Lund, AET's sales manager.

The secret

Since its inception in 1996, AET decided it would not only develop its own design of biomass boiler, but would also develop in-house designed combustion components.

The AET Combustion System today encompasses dosing bin, rotary valve, fuel chute, spreader stoker, travelling grate, over-fire air system, fly ash re-injection, and dust firing system. The company has also designed its SNCR deNOx plant, air pre-heaters, control software for the boiler, and a full biomass-fired plant. This has resulted in advantages for its customers, including:

- Higher performance and lower in-house consumption
- Lower emissions
- Higher availability and lower operational as well as maintenance costs
- One service company to solve the challenge quickly and efficiently.

For more information:
Visit: www.aet-biomass.com