Doosan Babcock Energy

Biomass firing and co-firing in large coal-fired utility boilers.

W R Livingston

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Biomass materials utilised in large quantities in Northern Europe

- **The solid wastes from agricultural industries, and principally palm oil and olive oil production,**
- **Pellets made from dried sawdusts and other materials,**
- **Dried sludges,**
- **Wood materials in various forms, i.e. sawdusts, forestry residues, wood processing residues, short rotation coppice wood, etc.**
- **Cereal straws and other dry agricultural residues in baled form.**

- **The majority of the biomass material co-fired has been imported from other parts of Europe and from outside Europe.**

Biomass pre-treatment

As with all fuels, biomass material may require significant pre-treatment prior to firing. This may include:

- Chipping or shredding,
- Dewatering and/or drying,
- The removal of tramp material, normally by air classification or magnetic separation,
- Milling,
- Pelletisation or other densification,
- Torrefaction or pyrolysis, with pelletisation.

The infrastructure for the supply and pre-treatment of biomass materials in very large quantities for co-firing is still under development in most countries.

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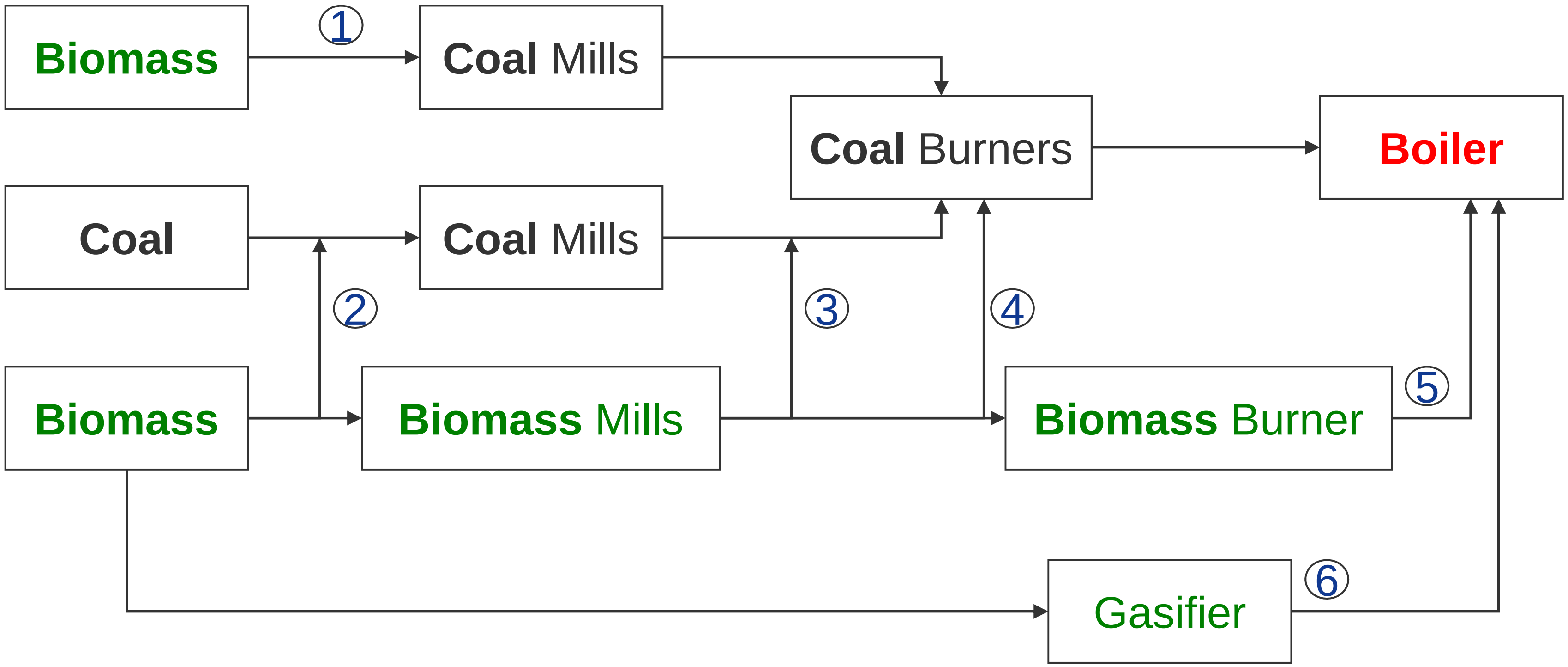
Biomass firing and co-firing options

The principal direct and indirect biomass co-firing options



1. The milling of biomass (pellets) through modified coal mills,
2. The pre-mixing of the biomass with the coal, and the milling and firing of the mixed fuel through the existing coal firing system,
3. The direct injection of pre-milled biomass into the pulverised coal pipework,
4. The direct injection of pre-milled biomass into modified coal burners or directly into the furnace,
5. The direct injection of the pre-milled biomass through dedicated biomass burners, and
6. The gasification of the biomass, with combustion of the product gas in the boiler.

Milling pelletised biomass in coal mills

- The milling of wood pellets in coal mills, and the firing of the mill product through the existing pipework and burners, is done at a small number of power stations in Europe, including Hasselby in Sweden.
- The coal mills are very robust, and have high availability/low maintenance requirements.
- At best, the coal mill breaks the pellets back to the original sawdust size distribution.
- The mill has to be modified to operate with cold primary air.

Biomass co-firing by pre-mixing with coal and co-milling

- Co-firing by co-milling has been the preferred approach for stations embarking on co-firing for the first time.
- The capital investment can be kept to modest levels, and the expenditure is principally on the biomass reception, storage and handling facilities.
- The project can be implemented in reasonable time.
- This approach is particularly attractive when there are concerns about the security of supply of the biomass materials, and the long term security of the subsidy payments for co-firing.

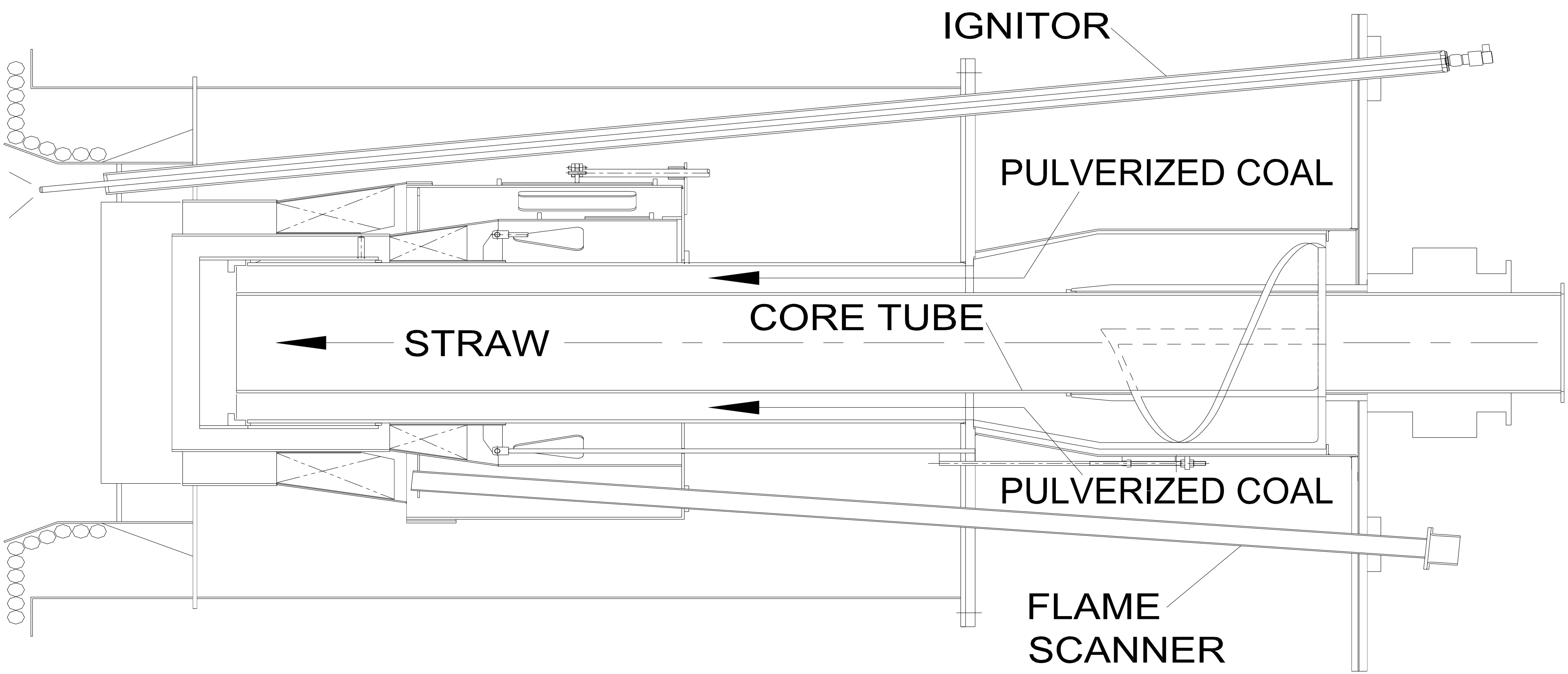
Direct injection co-firing systems for biomass basic options

- The biomass can be pre-milled either off-site or on-site.
- All direct injection co-firing systems involve the pneumatic conveying of the pre-milled biomass from the fuel reception and handling facility to the boiler house.
- There are three basic direct injection co-firing options:
  - Direct injection into the furnace with no combustion air,
  - New, dedicated biomass burners, and
  - Injection of the biomass into the pulverised coal pipework or through modified burners.

Direct injection into modified burners

- This has been achieved successfully for both wall-fired and corner-fired furnaces.
- Modification of the existing coal burners involves additional cost and risk compared to injection into the pulverised coal pipework.
- This approach may be necessary in some cases, depending on the nature of the biomass, particularly if there is a risk of blockage of the fuel supply pipework at splitters, e.g. with chopped straw at Studstrup in Denmark.

Modified Doosan Babcock Mark III Low NOx burner for firing chopped straw at Studstrup power station, Denmark



Direct injection into the pulverised coal firing system

- Direct injection into the existing coal firing system is relatively simple and cheap to install.
- The mill air and fuel flow rates can be reduced in line with the biomass conveying air flow rate, and the heat input to the mill group from the biomass.
- Both the mill and the burners can be maintained within their normal operating envelopes for both the heat input and primary air flow rate.
- The maximum heat input from the mill group is not affected, and can be increased in some cases.
- There are new interfaces between the mill and biomass conveying system controls, covering permits to operate, biomass system shutdowns, start-ups and trips, etc.
- There is a recent demonstration of a prototype direct firing system at Drax Power Station in Britain. The system has been in successful operation since summer 2005, firing a wide variety of pre-milled biomass materials.
- This system has now been extended to all boilers.

Fuel Specification for high level co-firing or 100% biomass firing

The physical properties of the biomass materials must be considered. This includes:

- Physical form- i.e. loose material or pellets
- Moisture content
- Ash content

Excessive levels of sulphur, chlorine and nitrogen should be avoided in most cases.

The principal risks of negative impacts on the boiler performance and integrity after conversion are ash-related.

- **Most biomass materials have low ash contents (<5%), compared to most power station coals.**
- **The biomass ashes are very different chemically from coal ashes, i.e. they are not an alumino-silicate system, but a mixture of simple inorganic compounds, of Si, K, Ca, P and S.**
- **There are concerns about increased rates of deposition on boiler surfaces and the surfaces of SCR catalysts.**
- **There are concerns about increased rates of high temperature corrosion of boiler components, with high chlorine biomass materials.**
- **Biomass co-firing tends to increase the level of submicron aerosols and fume in the flue gases, and may impact ESP collection efficiency.**
- **There may be utilisation/disposal issues with mixed coal/biomass ashes.**

The control of ash deposition

- The **careful design of the furnace and boiler convective section**, which recognises properly the characteristics and behaviour of the fuel ash, is of prime importance. The incorporation of specific furnace and boiler design features to minimise ash deposition, and to aid the removal of ash and the avoidance of ash accumulation.

- Very careful specification of the **fuel ash characteristics** is essential.

- The correct design, operation and maintenance of the **combustion equipment and of the on-line cleaning systems** are important issues.

- **Intensive cleaning** of the furnace and boiler surfaces during outages can be very effective in increasing the operating times between outages.

- There are **specialised on-line deposition monitoring and sootblowing control systems** that are commercially available and that can assist significantly with the optimisation of the sootblower operations and the control of ash deposition.

Conclusions

- Large scale biomass co-firing is one of the most efficient and cost effective approaches to generating electricity from renewable sources.
- Biomass co-milling is being practised successfully, as a retrofit to existing plants, by a number of coal plant operators in Britain and continental Europe.
- Direct injection co-firing projects are currently being implemented as a means of increasing the co-firing levels.
- Injection of the biomass into the pulverised coal pipework is the preferred direct firing solution for both retrofit and new build projects.
- To date, the impacts on boiler plant operations have been modest but this will increase with increasing co-firing ratios and with higher ash biomass materials.
- A number of the new build coal power plant projects have a biomass co-firing requirement.
- There is current interest in the conversion of coal-fired utility boiers to 100% biomass firing.

Thank you for your attention

W R Livingston

Doosan Babcock

blivingston@doosanbabcock.com

Doosan Babcock Energy