TECHNOLOGY DEVELOPMENTS IN THE COFIRING OF BIOMASS

Cofiring biomass with coal started in Europe and North America in the late 1990s. It is proven to offer a relatively quick and cost-effective way to partially decarbonise coal-based electricity generation in the short to medium term. Cofiring in some coal-fired power plants can contribute towards achieving some of the UN Sustainable Development Goals. Cofiring with biomass also helps to extend the life of coal-fired power plants during the transition to other low carbon generation. Although Canada and much of Western Europe are phasing out coal-fired power which will reduce opportunities for cofiring biomass, coal remains an important fuel for power generation in Asia and Eastern Europe. There is increasing cofiring activity in these regions, so work continues on developing cofiring technologies.

Biomass and its pretreatment

The properties of biomass are significantly different from coal and there is also a significant variation among the types of biomass, which has impacts on the selection of technology and fuel for cofiring, the deactivation of catalysts, corrosion, and ash deposition and the utilisation of ash from cofiring. In response, a variety of biomass pretreatment methods have been developed to improve the physical and chemical properties of biomass and make it more 'coal-like'. Pretreatment of biomass such as pelletisation, densification, steam explosion and torrefaction improve its characteristics for transportation, handling and combustion. The majority of biomass for cofiring is pelletised wood and forestry by-products. Steam explosion is currently at the industrial demonstration scale (April 2020) while wet torrefaction is still at the laboratory stage. Torrefaction is an increasingly popular method to improve the energy density of biomass and make it more brittle to increase its grindability. The technology has been commercialised. Issues related to the chemical composition of biomass can be reduced by leaching and washing. Biomass weathering outdoors is a common practice, but leaching treatment is only at the pilot scale. Two or more technologies are often combined to maximise the benefits of biomass pretreatment.

Cocombustion

As direct cofiring in pulverised coal (PC) boilers has dominated the sector for the last 20 years, the technology is mature. It remains the most popular method for cofiring in countries such as Japan and South Korea. However, in China co-gasification indirect cofiring is preferred as it is easier to measure the amount of biomass used in this process.

Fluidised bed combustion (FBC) boilers are most suitable for cofiring and coal-fired FBC units can be adapted readily to cofire. In general, FBC boilers can cofire higher ratios of biomass, and cope with biomass with a higher moisture content and larger particle size than PC boilers. FBC cofiring can result in the discharge of less ash and the consumption of less limestone than PC cofiring. However, with FBC there is an increased likelihood of bed agglomeration occurring.

Oxyfuel combustion as part of a carbon capture system can be combined with cofiring to maximise emissions reduction of CO_2. Cofiring coal and biomass in oxyfuel fluidised beds is a promising technology for CO_2 capture. The drawbacks of oxyfuel combustion are the high cost of retrofitting and the energy efficiency; however, it has the potential to create negative emissions of CO_2. Some bench and pilot scale experiments have been carried out.

Cofiring a high ratio of biomass can increase CO_2 emissions reduction but the main concerns are the availability of biomass fuel, storage and handling, milling, slagging, fouling, corrosion and ash disposal. Much work has been carried out in Europe on high ratio biomass cofiring. In particular, Drax power plant in the UK tried various biomass cofiring ratios over several years before converting four 660 MW units to 100% biomass. Work is underway in Japan to increase and optimise the cofiring ratio.

Operational issues

Biomass transport, storage and handling at coal-fired power plants requires extra care due to the increased risks of fire and dust explosion.

Although biomass is not necessarily ground as fine as coal due to its fast burning characteristics, operators of utility boilers prefer to feed the boiler biomass particles as small as coal particles, or at least of a comparable size, for transportation through coal pipes and combustion in a PC burner. However, it is more difficult to grind and pulverise biomass than coal, although pretreatment of biomass can improve its grindability. Co-milling biomass with coal is the cheapest option for direct cofiring of a low ratio of biomass. But, dedicated mills are often used for biomass grinding.

Some biomass fuels, such as herbaceous crops, have high alkali and/or chlorine contents, which increase the tendency of slagging, fouling, and corrosion within the boiler system. Washing and leaching can reduce water soluble potassium, chlorine and sulphur components of biomass. Torrefaction has also proved effective. Alkali carbonates can be used as sorbents to reduce HCl. Combustion additives, can be used to change the ash composition and further reduce the presence of volatile alkali species. Fouling can also be controlled by on-line cleaning systems. Cofiring herbaceous biomass with coal with a low tendency to foul, such as lignite, can reduce slagging. The use of more corrosion resistant high alloy tube materials and chromium and nickel rich surface coatings can be applied.

Impacts on environment

In general, cofiring has positive impacts on emissions of SOx, NOx, particulate matter, and trace metals due to the inherent properties of biomass. Although there may be issues with NOx emissions control. Although the overall volume of ash produced from cofiring is reduced, cofiring biomass changes the chemical properties of the fly ash and bottom ash and impacts ash utilisation when cofiring at a high ratio.

Key messages

Cofiring biomass with coal has been practiced for over two decades, first in Western Europe and North America and now in Asia. The technology is mature. Recent developments have focused on the pretreatment of biomass. Cofiring biomass is more expensive than firing coal alone due to its low thermal efficiency and boiler efficiency, high cost of fuel transportation and handling, and various operating issues. Retrofitting and modification power plant also incur capital investment. Although progress continues to be made to facilitate cofiring, there has been no major technology breakthrough to reduce the cost significantly. Cofiring remains unable to compete on an economic basis with coal. Hence government support, and favourable regulatory and environmental policies are required for the deployment of cofiring.

Each executive summary is based on a detailed study which is available separately from www.iea-coal.org. This is a summary of the report: Technology developments in the cofiring of biomass by Xing Zhang and Simone Meloni, CCC/305, ISBN 978-92-9029-628-7, 80 pp, August 2020.