# BIOMASS CO-FIRING

## PROCESS AND TECHNOLOGY, EFFICIENCY, POTENTIAL AND IMPACT

Biomass co-firing reduces greenhouse gas (GHG) emissions from coal-fired power and enables high efficiency power generation from biomass in modern, large-size coal fired plants—much higher than the efficiency of hundred per cent dedicated biomass power plants.

Co-firing in combined heat and power plants is currently the most competitive option to exploit the biomass energy potential for both electricity and heat production.

Biomass co-firing consists of combusting biomass and fossil fuels, mostly coal but also natural gas, in the same power plant. In most cases, biomass co-firing in coal power plants takes place by mixing biomass with coal before burning, but biomass can also be gasified and burned in separate burners, after which the gaseous fuel or steam is mixed with the boiler streams of the coal-fired power plant. The advantage of biomass co-firing is that it reduces greenhouse gas (GHG) emissions from coal-fired power and enables power generation from biomass with the high efficiency achieved in modern, large-size coal-fired power plants, which is much higher than the efficiency of dedicated, 100 per cent biomass power plants. The other advantage of biomass co-firing is that the incremental investment for burning biomass in coal-fired plants is significantly lower than the cost of dedicated biomass power. At present, co-firing projects in coal-fired power plants exceed the biomass capacity of dedicated biomass plants. The Clean Development Mechanism (CDM) recognises biomass co-firing as a way to reduce $CO_2$ emissions in developing countries. The indicators developed by international organisations to measure the sustainability of bio-energy (including protection of soil and water resources, bio-diversity, land allocation and tenure, and food prices) need to be integrated into the relevant policy measures. The costs of biomass acquisition and transportation determine to a large extent the economic feasibility of co-firing. The acquisition costs depend on possible competition with other biomass energy uses (e.g. biofuels) or non-energy applications. In developing countries, the use of waste streams from agriculture and forestry may also create additional value and job opportunities while contributing to rural development.

## CO-FIRING TECHNOLOGIES

**Direct co-firing** is the simplest, cheapest and most common option. Biomass can either be milled jointly with the coal (i.e. typically less than 5 per cent in terms of energy content) or pre-milled and then fed separately into the same boiler.

**Indirect co-firing** is a less common process in which a gasifier converts the solid biomass into a fuel gas that is then burned with coal in the same boiler. Though more expensive because of the additional technical equipment (i.e. the gasifier), this option allows for a greater variety and higher percentages of biomass to be used. **Parallel co-firing** requires a separate biomass boiler that supplies steam to the same steam cycle. This method allows for high biomass percentages and is frequently used in pulp and paper industrial facilities to make use of by-products from paper production, such as bark and waste wood.

## PROCESS AND TECHNOLOGY STATUS

Biomass co-firing consists of burning biomass along with coal in coal-fired power plants. Compared to power plants burning 100 per cent biomass, co-firing offers several advantages, including lower capital costs, higher efficiency, improved economies of scale and lower electricity costs due to the larger size and the superior performance of modern coal power plants. At present, some 230 power and combined heat and power (CHP) plants use co-firing, mostly in northern Europe and the United States, with a capacity of 50-700 MW. Co-firing in CHP plants is currently the most competitive option to exploit the biomass energy potential for both electricity and heat production.

## PERFORMANCE AND COSTS

The net electric efficiency of a co-fired coal/biomass power plant ranges from 36-44 per cent, depending on plant technology, size, quality and share of biomass. While a 20 per cent co-firing (as energy content) is currently feasible and more than 50 per cent is technically achievable, the usual biomass share today is below 5 per cent and rarely exceeds 10 per cent on a continuous basis. A high biomass share means lower GHG emissions. It is estimated that 1-10 per cent biomass co-firing in coal power plants could reduce $CO_2$ emissions from 45 million to 450 million tonnes per year by 2035, if no biomass upstream emissions are included. However, high biomass shares involve technical issues, such as securing sufficient biomass, as well as potential combustion problems, such as slagging, fouling (which reduces heat transfer) and corrosion. The overall cost of co-firing is sensitive to the plant location and the key cost element is the biomass feedstock. The investment cost for retrofitting a coal-fired power plant for co-firing is in the range of 430-500 USD/kW for co-feed plants, 760-900 USD/kW for separate feed plants and 3,000-4,000 USD/kW for indirect co-firing. These costs are still significantly lower than the cost of dedicated 100 per cent biomass power plants.

AT PRESENT, SOME 230 POWER AND COMBINED HEAT AND POWER (CHP) PLANTS USE CO-FIRING, MOSTLY IN NORTHERN EUROPE AND THE UNITED STATES, WITH A CAPACITY OF 50-700 MW.

In May 2012, Drax Power Limited awarded Alstom a contract to build the main processing works for what is believed to be the largest biomass co-firing project in the world – the 4,000 MW Drax power station in North Yorkshire (UK)

## SUSTAINABILITY, POTENTIAL AND BARRIERS

The substitution of 10 per cent of the global coal-fired capacity by co-firing would result in about 150 GW biomass capacity. In comparison, today's co-firing capacity is estimated at between 1-10 GW (the variability being associated with the actual biomass share in co-firing plants), and the total installed biomass capacity amounted to some 62 GW in 2010. Therefore, a large co-firing potential exists, but a substantial increase would pose problems regarding the availability of biomass, which can also be used for biofuels and biomaterials production.

## GHG EMISSIONS AND ENVIRONMENTAL IMPACT

Biomass co-firing offers a comparatively low-cost way to reduce greenhouse gas (GHG) emissions. While the combustion of biomass can be considered carbon neutral, the overall GHG balance of the biomass provision (i.e. pre-combustion supply chain) depends on many factors, such as processing, transport modes and distances, and in the case of dedicated energy crops on cultivation/harvesting, and possible land use change effects.

## POWER GENERATION EMISSIONS

If combined with carbon capture and storage (CCS) technologies, biomass co-firing results in negative GHG emissions (i.e. net removal of $CO_2$ from the atmosphere), also referred to as 'biogenic carbon sequestration'.

## CURRENT COSTS AND COST PROJECTIONS

At present co-firing in state-of-the-art CHP plants is considered the most cost-effective option of producing electricity from biomass. Determining the overall cost for biomass co-firing in coal-fired power and CHP plants requires analysis of several components, particularly the costs related to investment, operation, maintenance and fuel. It must be noted that the actual costs are very sensitive to the specific site and the existing installation (if any), which determine the investment costs, as well as costs of the coal and biomass to be used. The fuel cost is the most important factor when considering the additional costs for co-firing. The investment cost depends on the plant capacity and service (i.e. power generation only or combined heat and power), as well as the type of the biomass fuel to be used and the quality of the existing boiler (if any). The operation and maintenance (O&M) costs are likely to be similar to coal-fired power plants (5-10 USD/MW) since co-firing increases fuel handling costs but reduces de-sulphurisation and ash disposal costs. The biomass fuel cost consists of two components: the cost of the feedstock and the cost of transportation, preparation and handling. Feedstock costs vary greatly with the biomass origin (e.g. dedicated cultivation or agriculture and forestry waste), type and composition (i.e. energy and moisture, taxes, fees, etc.).

## SUSTAINABILITY, POTENTIAL AND BARRIERS

While co-firing currently seems to be one of the most efficient options to exploit biomass for energy use, its sustainability and potential are closely linked and depend on the overall sustainability of the biomass resources. A substantial increase in biomass co-firing poses the question of sustainability and availability of the feedstock supply, which could also be used for the production of biofuels and bio-ethylene. Depending on assumptions about agricultural and forestry residues, future crop yields, land availability for energy crops, demographic expansion and diet, estimates of the bio-energy resource potential vary over a wide range.

## POTENTIAL FOR DEVELOPING COUNTRIES

Co-firing offers advantages for emerging and developing countries since the use of waste from forestry and agriculture will increase the economic value of these sectors, which are usually strong components of the economy in these countries. Instead of being burned on the fields, as is commonly done, agricultural waste could be used profitably in co-firing power-plants. However, international cooperation is needed to ensure the environmental and social sustainability of biomass exploitation (e.g. guarding against land-grabbing or deforestation, biodiversity loss in connection with large-scale monocultures). Of key importance is the fact that biomass co-firing has been recognised as a mitigation technology by the UNFCCC and that countries can sell carbon credits associated with their co-firing projects. Also important is biomass trading, which is increasing swiftly, driven by high fossil fuel prices and policies to reduce GHG emissions.

## SUSTAINABILITY GUIDELINES AND CERTIFICATION

The Global Bioenergy Partnership (GBEP) has recently completed a set of 24 indicators to measure the sustainability of bioenergy. These indicators cover environmental, social and economic aspects (e.g. soil protection, water resources, biological diversity, land allocation, food prices, energy access, infrastructure, workforce training). Similarly, the World Bioenergy Association (WBA) uses sustainability criteria as the basis for their verification scheme of biomass sustainability. The Bioenergy and Food Security Criteria and Indicators project (BEFSCI) of the United Nations Food and Agriculture Organisation (FAO) has made a compilation of bioenergy sustainability initiatives. Certification schemes can help safeguard against unsustainable practices (e.g. in the energy forestry sector). The IEA Bioenergy Implementing Agreement has produced an overview of bioenergy certification initiatives. On the industry side, the European Pellet Council, in collaboration with the Wood Pellet Buyers Initiative, recently launched its 'ENplus' certificate to support standardisation for pellets used in Europe, both locally produced and imported. More than 30 producers and 40 traders have so far been certified, with several others in the pipeline (as of 13 December 2011). The scheme is expected to expand and also include the sustainability criteria. Similar wood pellet certification schemes are being developed in the United States and by the Technical Committee on Solid Biofuels of the International Organisation for Standardisation (ISO).

## POLICIES AND INCENTIVES TO SUPPORT CO-FIRING

Considering current prices for coal and biomass, co-firing is generally more expensive than solely coal-based power generation or CHP. The competitiveness of biomass co-firing can be improved through measures to make coal-based energy more expensive, particularly carbon pricing through emission cap-and-trade schemes or carbon taxation. Based on current carbon prices, the incremental cost of co-firing cannot be fully recovered by selling emission permits, but the new European Union Emissions Trading System (EU ETS) in 2013 is likely to increase co-firing competitiveness and pellet use in Europe as large emitters (e.g. coal power plant owners) are subjected to auctioning of their $CO_2$ allowances. Other measures to increase the profitability of biomass co-firing include the removal of specific fossil-fuel subsidies, incentives for the conversion of power plants into CHP plants, government support to biomass supply infrastructure and dedicated R&D funding for co-firing. Governments can also establish mandatory use of biomass co-firing by quota obligation schemes. Policies should seek the most efficient use of the given biomass potential by encouraging co-firing in CHP plants where district heating systems are available and in connection with industrial facilities.

***Inputs from IEA-ETSAP and IRENA Technology Brief E21 – 2013***

**IN DEVELOPING COUNTRIES, THE USE OF WASTE STREAMS FROM AGRICULTURE AND FORESTRY MAY ALSO CREATE ADDITIONAL VALUE AND JOB OPPORTUNITIES WHILE CONTRIBUTING TO RURAL DEVELOPMENT.**