SOLID BIOENERGY IN QUESTIONS

2. CO-FIRING: CLARIFYING A CONCEPT
In Europe, 83\% of the overall final energy consumption on the continent is provided by fossil fuels\(^1\), mainly oil, coal, and gas. Yet despite the uptake of renewable energies over the past decades, as the economic recovery in 2015 has demonstrated, fossil fuel consumption is capable of increasing even further\(^2\).

Worldwide, around 40\% of electricity is produced using coal. By hypothetically replacing just 5\% of coal energy with biomass in all coal-fired power plants, the International Energy Agency (IEA) estimates that fossil CO\(_2\) emissions would reduce by around 300 Million tons CO\(_2\)/year\(^3\).

However, at the opposite of what can be stated in public debates at EU level, “co-firing” remains restricted as several technical and logistical barriers limit its systematic development. Understanding these barriers is key to assessing the potential role of biomass co-firing as well as the measures needed to ensure that the development of co-firing takes place in a sustainable way.

Finally, it is important to highlight that there are two main markets in Europe for biomass co-firing, which differ greatly from a technological point of view but more importantly on their drivers. One of the main decisive factors between the two is whether biomass is used in the boilers as a primary or a secondary fuel.

**WHERE DOES THE CONCEPT OF CO-FIRING COME FROM?**

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**WHAT ARE WE TALKING ABOUT WHEN REFERRING TO “CO-FIRING”?**

The general concept of “co-firing” could seem quite simple to understand at first sight: it basically refers to the use of at least two fuels to generate electricity and/or heat out of a combustion process. However, behind this concept a wide variety of practices and solutions exist, seemingly blurring the scope of a too simple definition:

- **The types of fuel used can be quite diverse**, ranging from fossil fuels such as coal, lignite, and natural gas, to other fuels such as waste (municipal solid waste (MSW), refuse-derived fuel (RDF) and/or solid recovered fuel (SRF)) and biomass (forest-/agri-/aquabased materials). The increased political support for the use of natural gas has also sparked new interest in the market to use it as a fuel when co-firing.

- **From a boiler perspective**, two main options exist for the combustion of biomass in Europe: fluidised bed (FB) technology and pulverised fuel (PF) technology. These types of boilers differ greatly and respond to different needs of the energy producers.

**Pulverised Fuel (PF) technology**

The basic idea of a firing system using pulverised fuel is to use the whole volume of the furnace for the combustion of solid fuels. Coal or-and biomass are ground to the size of a fine grain, mixed with air and burned in the flue gas flow. Due to this requirement of fine grain, the use of biomass in such installations is usually low, between 10\% and 30\%, and required in high quality biomass fuel such as pellets. However, some experiments show that a co-firing level could reach 70\% biomass using adapted technologies and advanced fuels such as torrefied biomass. It is also interesting to notice that Pulverised Fuel technology tend to be used frequently in power only plants.

When compared to conventional power generation (i.e., solely coal or gas-fired plants), co-firing biomass as a secondary fuel has the interesting potential to reduce GHG emissions and to produce power with PF boilers without requiring substantial modification of existing assets and infrastructure.

**Fluidised bed (FB) technology**

In its most basic form, fuel particles are suspended in a hot, bubbling fluidity bed of ash and other particulate materials (sand, limestone etc.) through which jets of air are blown to provide the oxygen required for combustion or gasification. The resultant fast and intimate mixing of gas and solids promotes rapid heat transfer and chemical reactions within the bed able to combust most type of biomass and fossil fuels.

The FB technology is the dominant boiler type used for the combustion of biomass. FB boilers have the technical ability to use up to 100\% biomass as a fuel. Therefore, when biomass is being used as a fuel in FB boilers, this is typically the primary fuel. Another reason that supports using FB technology for biomass is that the biomass fuel only needs to be crushed to pieces smaller than 100 mm; therefore, pelleting is not needed. This means that wood chips and residues can be used, enabling in many cases the use of local fuel. In terms of output, FB technology is typically used for co-generation, i.e. the FB boiler technology-based power plants produce both electricity and heat.

As today, the trend is to have more and more flexibility in the fuel boiler’s portfolio in order to keep fuel-related risks at a minimum, alternative types of FB technology have been developed to answer to this need such as Bubbling Fluidised Bed boilers (BFB) and Circulating Fluidised Bed boilers (CFB).

- **Bubbling Fluidised Bed boilers (BFB)** - BFB boilers are designed to combust fuels with high moisture content and low heating. In BFBs, the primary fuel is typically biomass and the secondary fuel fossil fuel (peat or oil/gas). The driver for BFB co-firing has usually been the need for a support or supplementary fuel due to the low quality of the biomass fuel (high moisture and low heat value). This enables great fuel flexibility, including those not accepted by other industries in their processes. Another driver has been the lack or poor availability of biomass, i.e. mitigation of the risk related to fuel availability.
- Circulating Fluidised Bed boilers (CFB) - CFB boilers are designed to utilize fuels with varying heating values and moisture contents. In CFBs, the primary fuel is typically biomass (forest-based and agrobiomass) and the secondary fuel fossil (coal). However, as CFB boilers are also widely used for the combustion of waste, thus solutions utilizing waste as primary fuel and biomass or fossil fuel as a secondary fuel also exist. The so called “Multifuel boilers” are typically based on CFB technology, and are usually designed to combust biomass and coal (waste/sorted waste) from 0 to 100% or any mixture in between.

**The advantage of fuel flexibility**

As FB boilers are not demanding when it comes to fuels, they offer energy producers flexibility that other solutions cannot offer on the same scale. The driver for CFB/multifuel co-firing is the ability to optimize fuel costs and to mitigate risks regarding fuel price and availability. It should be noted that as CFB boilers offer the possibility for great fuel flexibility, the ability to co-fire is typically not the result of a conversion but original design. Fuel flexibility is an important component that the energy producer is looking at when making the original investment. However, it should be noted that the cost of this ability also renders the cost of the CFB boiler to a slightly higher level compared to a boiler that uses only one fuel. Therefore, the return on investment (ROI) of these investments are also reflected in demands of high efficiency of the solution, and in practice, using low quality less expensive fuels to fully utilize CFB boiler properties.

Besides the fuel mix and co-firing technology, different pathways are also considered as co-firing practices: in a same boiler (direct co-combustion) or in separate boilers.

**Direct co-combustion in fluidised bed (FB) boilers, called co-injection, with parallel crushing and combustion. The dominant solution for co-firing when biomass is the primary fuel.**

**Direct co-combustion in pulverised coal (PC) boilers, with parallel milling and burner system. The dominant solution when biomass is the secondary fuel.**

In the case of parallel combustion, it is fair to question whether this really constitutes co-firing. In these installations, both biomass and other fuels are consumed on the same site but in different units (e.g. a power plant with different units, some running 100% on biomass and complementary units running on coal, oil or gas, in case of peak load).

This is the case of Drax in the UK that is not classified as co-firing as the coal and biomass are combusted in different boilers.

As a result, it should be noted that at EU level, no clear and precise definition of co-firing exists. It is usually defined as simultaneous combustion of different fuels in the same boiler, without further technical definition. Without a precise definition and with the absence of an impact assessment on co-firing, proposing to set regulations may have negative consequences for a wider range of applications, thus creating legal uncertainty for operators. In fact, while the intention of the legislator may be to target the use of co-firing when coal is the dominant fuel, the current attempt by the EU legislator to limit the role of co-firing could impact negatively co-firing installations using (often low quality) biomass as the primary fuel.
Reporting the exact amount of installations that co-fire biomass in Europe is not an easy endeavour mostly because of the lack of harmonisation in the definition.

However, one can get a general idea by looking at the statistics of sold boilers in recent years. According to McCoy’s Power Boiler Report (2017), over a total of 300 new biomass-utilising boilers sold in the EU between 2008 and 2017, 21 were designed to be co-fired. The McCoy data contains only new boilers or large-scale boiler rebuilds (e.g. conversion from PC to FB). However, it does not contain conversions, where only fuel feed or burners have been modified (e.g. in majority of PC power plant conversions to cofiring or wood pellet firing).

Besides the number of newly installed boilers, considering their energetic capacity gives a better idea of their actual contribution to the EU energy mix. In general, the 300 newly installed boilers generated 10.7 GW electricity. Majority of them, 222 units, are cogeneration units which generate also thermal power. There are no official statistics for the thermal capacity, but in cogeneration units thermal capacity is always higher than the electric capacity.

It is also interesting to notice that 77% of all biomass firing FB boilers were able to cogenerate, while of other biomass firing boilers only 57% were able to do so.

Considering the geographical distribution of installations is similarly disclosing relevant information on co-firing practices. One can see in the below map, that when considering installations with biomass as dominant fuel, FB technology dominates, and the locations are focused in forest-rich regions with mature forest-based industries. These regions traditionally use wood chips, residues and other low-quality biomass that is locally produced for energy production. On the contrary, when considering installations with coal as dominant fuel, as one can see, PF technology dominates, and the locations are focused in the UK and the central part of Europe. These regions typically use pellets for energy production. We can therefore clearly see that co-firing is not one single technology but rather two different realities creating two different markets. Putting them in the same basket would be a mistake. The realities and advantages of both technologies should be accounted for when willing to limit the use of “co-firing”.

"Biomass" is a term used to refer to organic matter that can be converted into energy. Theoretically, most types of biomass sources can be used as a fuel when co-firing, and numerous tests have been conducted by companies and research laboratories to analyse solid biomass feedstock characteristics. However, most commercial co-firing plants in operation prefer woody fuels as they are naturally low in ash, sulphur, and nitrogen. Other biomass feedstocks are co-fired depending on their local availability including straw, switchgrass, corn stover, rice hulls and olive cake. Today, new advanced fuels such as torrefied pellets are considered (but not used yet) for their promising specificities.
Biomass co-firing with residues and wastes has been recognised by the United Nations Framework Convention on Climate Change (UNFCCC) as a technology to mitigate GHG emissions. As biomass is considered carbon neutral (the net CO₂ from the combustion of biomass is reduced to zero when the effects of photosynthesis are considered), the share that is co-fired in power plants reduces the amount of emissions of the whole combustion process.

Several research works have been carried out to evaluate the effect of biomass co-firing by adopting various approaches. A recent publication released in 2016 reported over 20 studies concluding the overall positive GHG balance following the introduction of co-firing in plants. However, one should notice that the net reduction of CO₂ emissions is strongly influenced by the origin and supply chain of the biomass feedstock as well as the final proportion of the biomass in co-firing. In the near future, experts estimate that this impact could be even amplified by the adoption of carbon capture and storage (CCS) or carbon capture and reuse (CCU) technologies combined with the use of advanced biomass fuels.

Co-firing biomass with coal or gas generally represents a very cost effective and efficient way to shift to renewable energy technology. In the case of FB boilers designed for co-firing, one investment allows the boilers flexibility with different fuels, thus enabling the energy producer to avoid double infrastructure, to optimise fuel costs and to mitigate risks related to fuel availability and cost. In the case of PF boilers, co-firing allows for the addition of a second fuel stream into the boiler through a conversion with limited investment needed. Co-firing with biomass allows to progressively shift to renewables while keeping energy price affordable for final consumers. In addition, with biomass often being a local fuel, its use in co-firing increases the energy security of the energy producers. Co-firing also creates opportunities in other biomass industries located within a close proximity around the installation, such as forestry, agriculture, construction, manufacturing, food processing and transportation industries.

More than technical limitations, one of the most important limitation for utilities in deciding whether to introduce co-firing practices is the security of the biomass supply throughout the year, the transportation costs and the availability of raw materials. In fact, the cost of biomass acquisition and transportation determines to a large extent the economic feasibility of co-firing projects. A stable, sustainable and economical flow of biomass is therefore needed to sustain a biomass co-firing project. This is why co-firing plant are mostly located in European countries where long forestry traditions exist, forest residue mobilisation is well developed and sustainable supplies of biomass exist. Imposing restrictions on biomass power only and co-firing installations, as proposed by the EU legislator in the recast of the Renewable Energy Directive (RED II article 26.8) is not taking local specificities into account and imposes a top-down approach not fit for the purpose. It is up to Member States to evaluate if the technical and logistical parameters are present to use co-firing technology and increase the share of renewables in their energy mix.

In addition, it does not take into account the difference between technologies; pulverized fuel (PF) where the fossil fuel is the dominant fuel and refers usually to retrofitting coal power plants, and fluidized bed (FB) technology where biomass is usually the dominant fuel and brings an important advantage to the energy producer in terms of fuel flexibility. These are two different technologies where a “one size fits all” approach would have unintended consequences.
Co-firing is a complex topic which is often misunderstood or evaluated without taking into account its full scope. Several reasons may exist which drive the need to co-fire biomass and fossil fuels, and various technologies may enable operators to do so. Co-firing as a principle has the benefit of giving power plant operators a multifuel option. This is of crucial importance to increase flexibility when fuel supplies are uncertain, while keeping the energy price affordable for end consumers. In a context of international climate actions to keep the temperature rise levels under $2^\circ C$, co-firing offers quick and affordable CO2 emissions reductions. As an example, 30% biomass co-firing would make specific CO2 emissions of a newly built highly efficient coal plants (having a net efficiency of 45%) equal to CCGT power plants operated with natural gas (with an efficiency of 57%). Due to a lack of clarity in the definition of co-firing and not taking into account the different technologies involved, restrictions on biomass power only and co-firing installations as proposed in the recast Renewable Energy Directive (RED II article 26.8) may have non-anticipated effects on several operators and lead to the simple continuation of fossil installations. Member States should be able to use their local available fuel to switch away from fossil dependence, provided the level of efficiency of the installation is in line with the Best Available Technology associated efficiency levels (BAT-AEELs) as defined in the Commission Implementing Decision (EU) 2017/1442. In addition, the price of carbon being currently very low in the ETS sector, economic operators do not have sufficient incentives to totally switch fuel. Meanwhile, the economic attractiveness of co-firing is a step in the right direction.

SOURCES

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DEFINITIONS

Solid biomass
A source of energy from materials including wood, sawdust, and to a lesser extent, crop waste, which can be used directly or processed into briquettes and charcoal. It is called solid because it is used in its solid form unlike other bioenergy (biogas or liquid biofuels). (Source: Practical Action)

Bioenergy
The conversion of biomass resources such as agricultural and forest residues, organic municipal waste and energy crops into useful energy carriers including heat, electricity and transport fuels. It can be in solid, gaseous or liquid state. (Source: FAO)