BIOFIT

Bioenergy Retrofits for Europe's Industry

COAL TO BIOMASS CONVERSIONS

SECTORAL RECOMMENDATION PAPER

Retrofitting in terms of the BIOFIT project means the adaption or replacement of a plant characteristic (e.g. equipment, feedstock or auxiliary) to foster the use of bioenergy instead of fossil energy or to improve the overall sustainability of the process. The retrofit measures can result in using (additional) biomass as an input to the production plant or producing additional output from biomass at the production plant.

SECTOR STATUS-QUO

There is a long precedence of using biomass as a co-firing fuel in coal plants in relatively low shares (around 10 to 20 % of the fuel input) and different technical options of doing so: direct co-firing, parallel co-firing, indirect or gasification co-firing. The strong political push for a coal phase-out has prompted several utilities to start replacing coal by sustainably sourced biomass to even greater extent, leading ultimately to the full biomass conversions of several plants in Belgium, Denmark, Netherlands and the United Kingdom.

Although such large biomass power plants - which require sourcing of biomass over long distances – seem to be counter to the "traditional" local character of biomass-to-energy value chains, they offer several advantages. First, it is the only option to produce base load, dispatchable renewable electricity, still needed by electricity grids, currently available today. Secondly, by taking advantage of the advanced steam cycle of the converted coal plant, they offer electrical efficiencies that are unachievable by almost all smaller biomass power plants. Thirdly, being a mature technical solution, it can provide an option for utilities to continue using assets that would have turned "stranded", while also allowing for retaining jobs at power plants that would have otherwise been lost. It should be noted that the specific investment (e.g. in EUR/kW) for a conversion is significantly lower than that of a new biomass power plant, while the implementation time can be reduced compared to a totally new installation; these factors contribute to the competitiveness of the investment and reduce risks. Finally – and in the long run – some cases offer the possibility to become "negative emitters" through the application of Biomass Carbon Capture and Storage technologies.

Smaller coal plants used for district heating, industrial heat or combined heat and power generation may fully switch to biomass through the implementation of appropriate technical measures, such as conversion of the boiler to the Bubbling Fluidized Bed (BFB) technology.

Power plant / Unit	Country	Finalization of retrofits	Installed Capacity (MWe)
ENGIE Max Green (Rodenhuize)	BE	2011	180
Drax Unit 1	UK	2013	660
Drax Unit 2	UK	2014	645
Drax Unit 3	UK	2015	645
Ørsted Avedøre Unit 1	DK	2016	258
Ørsted Studstrup Unit 3*	DK	2016	362
Drax Unit 4	UK	2018	645
Lynemouth	UK	2018	407
RWE Amer 9**	NL	2019	631

* Straw is used as a co-firing fuel

** Fuel mix of 80 % wood pellets, 20 % hard coal

Major biomass conversions of pulverized fuel coal plants in Europe using wood pellets as the main fuel - only units currently in operation shown (Source: Adapted from Rutz et al. (2020).)

COAL TO BIOMASS CONVERSIONS FRAMEWORK CONDITIONS FOR RETROFITTING

Technical Requirements

RED II guarantees that only plants that exhibit a minimum efficiency level are likely candidates for a biomass conversion.

The political frame for large-scale coal to biomass conversions on EU level is mainly set by the Renewable Energy Directive (2018/2001, RED II).

Among others, **article 29 of RED II** introduces specific efficiency requirements for electricity production from biomass fuels. For example, installations with a total rated thermal input above 100 MW require either the application of high-efficiency cogeneration technology, or, for electricity-only installations, a net-electrical efficiency of at least 36 %. This limits the potential candidates for biomass conversions to only fairly modern, high-efficiency coal power plants.

Entrepreneurial Conditions

Reliable biomass supply and operational support are common prerequisites for investment decisions.

A converted coal plant requires the reliable sourcing of large volumes of biomass in order to maintain its operation according to the industry requirements. Wood pellets have lately grown into a commodity fuel and large-scale utilities typically source them from international markets. Plants with somewhat smaller capacities and greater fuel flexibility generally work with local biomass sourcing and require therefore a mature local biomass market.

Despite the growing cost of CO_2 emission allowances in the EU, electricity generation from biomass is in most cases not competitive with fossil-fuel alternatives; therefore, operational support in the form of feed-in premiums or green certificates is required. Such schemes tailored for large-scale biomass power generation have already been adopted by some European countries, such as Belgium, Denmark, the Netherlands and the UK.

COAL TO BIOMASS CONVERSIONS TECHNICAL OPTIONS FOR RETROFITTING

Option I -Full biomass conversion of pulverized coal plants

Large-scale coal power plants typically employ the pulverized fuel combustion technology. When converting to biomass, the firing principle remains the same, but new mills and burners, suited to biomass fuels, substitute with the coal ones. The biomass demand for such converted plants is huge – a single unit may require more than one million tons per year – and these quantities are generally secured through imports. Currently, wood pellets are the standard biomass choice in such conversions, since their high energy density and good fuel properties offer both economic and technical advantages. Other biomass fuels may also be considered as part of the fuel mixture and utilities are looking more and more into alternative assortments as a way to reduce fuel costs. Wood pellets are hydroscopic, meaning that – unlike coal - they have to be protected from moisture. That is why large storage domes are a typical feature of converted plants. Upgrades and modifications in other biomass handling facilities are also required – including appropriate safety precautions against fires and explosions.

View of Drax Power Station at Selby, UK (Source: Drax)

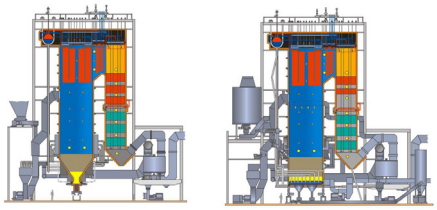
Option II
Substitution of coal by thermally treated biomass

Steam exploded Arbacore pellets (Source: Arbaflame)

Thermal pretreatment is a general term to describe technologies (torrefaction, steam explosion) that aim to transform a biomass fuel to become more coal-like in its properties. Essentially, the idea is to "retrofit" the fuel - instead of the facility – so that it can serve as a drop-in replacement for coal, with minimal investments and modifications. Co-firing of thermally pre-treated biomass with coal has been demonstrated in trials at several coal plants and in the commercial retrofit of Thunder Bay Unit 3 in Canada. At the moment, the market for thermally treated biomass fuels is in early stages of development, but this option offers the possibility of a very quick substitution of coal with minimal investments.

Option III – Conversion of boiler to Bubbling Fluidized Bed (BFB)

A conversion into a Bubbling Fluidized Bed (BFB) boiler is possible for a wide range of furnaces (grate, pulverized fuel, oil, recovery) and solutions are typically available up to 300 MWth output. A key advantage of a BFB boiler is that it is capable of combusting a wide range of "traditional" biomass fuels (e.g. wood chips, forest residues, sawdust, etc.) and it may even co-fire – in smaller percentages – some more challenging fuels (e.g. agrobiomass, recycled wood, tire-derived fuel / TDF, etc.). Minimal pre-treatment requirements compared to pulverized fuel systems and fuel flexibility can help the establishment of local biomass supply chains. A BFB conversion can have a lower investment by 50-70% compared to a new installation; limitations and challenges related to boiler derating, reduced efficiency or fuel suitability should be checked.



Conversion of pulverized fuel coal boiler of Elektrociepłownia Białystok S.A. to a multi-fuel biomass (wood chips, forest residues, agrobiomass) BFB boiler (Source: Valmet)

Coal to biomass conversions are mature, market-ready, large-scale bioenergy plants that can provide today base load, renewable electricity under strict sustainability requirements, while also supporting the transition of coal regions.

CONCLUSIONS

The quick coal phase-out taking place in several EU member-states has undeniable climate benefits but also poses several challenges, ranging from the technical (e.g. grid stability) to the socio-economic (loss of employment in coal regions). The conversion of coal plants to biomass is not the silver bullet for all these challenges, but it is a technically mature option that should be considered as part of the wider decarbonisation strategy when conditions are favourable. Existing industrial schemes and REDII establish suitable sustainability criteria for the operation of such large-scale plants. Beyond being part of the solution today, a biomass repowered plant may also be the pioneer in the mobilization of underutilized biomass feedstocks or even pave the way for delivering negative emissions through the applications of BECCS (Bioenergy Carbon Capture and Storage) technologies.

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BIOFIT Best Practice Factsheet: Retrofit of Thunder Bay Generating Station – Unit 3, Canada: www.biofit-h2020.eu/files/pdfs/190318%20-%20Biofit%20-%20Factsheet%20-%20Canada_OPG_low.pdf

BIOFIT Best Practice Factsheet: Retrofit of Avedøre Power Station – Unit 1 (Denmark): www.biofit-h2020.eu/files/pdfs/190318%20-%20Biofit%20-%20Factsheet%20-%20Denmark_Avedore_low.pdf

THE BIOFIT PROJECT

This sectoral recommendation factsheet was prepared within the BIOFIT project. The project aims to facilitate the introduction of bioenergy retrofitting in Europe's industry. Target industries are first-generation biofuels, pulp and paper, fossil refineries, fossil firing power and combined Heat and power (CHP).

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