BIOFIT

Bioenergy Retrofits for Europe's Industry

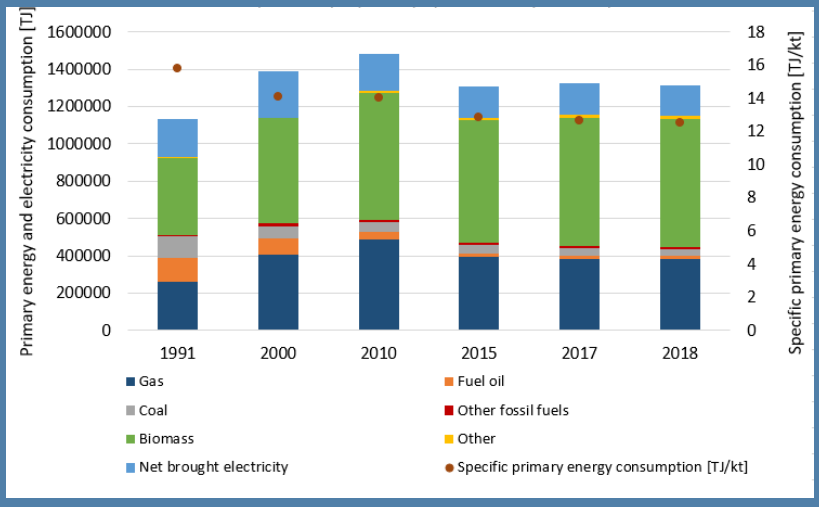
PULP AND PAPER

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

In Europe, there exist 151 pulp mills and 740 paper and board mills, which produce annually 38.1 million tons of pulp and 89.9 million tons of paper and board (2019). The number of the mills has steadily decreased since 1990's, while the production has stayed relatively stable. In addition to traditional products, the industry has shown ample interest in widening their product portfolios by developing and producing new high-value products, such as biofuels, bio-composites and bio-based plastics, and in revising their business models. Digitalization, sustainability and energy and material efficiency are some of the drivers steering the development of the sector. Urgent need for climate change mitigation increases the demand for energy, fuels and products from renewable sources, while the role of forests as carbon sinks is getting more important and may limit the direct use of virgin wood.



Primary energy and electricity consumption and specific primary energy consumption in pulp and paper industry in Europe (Source: Modified from Cepi Key Statistics 2019)

The pulp and paper industry in Europe already covers 60.0% of their total fuel consumption and 52.5% of their total primary energy consumption by biomass, while fossil fuels represent 38.9% of the total fuel consumption (2018). Energy efficiency measures have steadily decreased the specific primary energy consumption within the sector, and the share of biomass used for energy has increased over the years. However, the sector is in different positions regarding availability of biomass. Biomass consumption is high and the consumption of fossil fuels is close to zero in the Nordic countries, where the mills have good access to forest resources. However, stand-alone paper mills especially in the Central and Southern Europe face challenges regarding access to bio-based feedstock, and the main fuel in these mills is typically natural gas. The pulp mills using forest residues as a feedstock have good prerequisites for bioenergy retrofits.

Pulp mills that are no longer integrated to paper mills use less energy than before, which opens up opportunities for producing high-value bioenergy products from their side streams. Since the mills are often net producers of energy and close to being fossil-free, bioenergy retrofits often lead to production of additional bioenergy products.

PULP AND PAPER FRAMEWORK CONDITIONS FOR RETROFITTING

Political conditions

Stable and long-term policies with clear targets are important for new investments.

The political frame affecting the P&P sector on the EU level is mainly set by the Renewable Energy Directive (2018/2001, RED II) and the Fuel Quality Directive ((EU) 2015/1513, FQD). The aim of these Directives is to increase the share of renewable energy in the final energy consumption, to increase the share of renewable fuels in the transport sector, to limit the use of critical feedstock (e.g. food and feed crops and feedstock with risk for indirect land-use change), and to reduce the greenhouse gas intensity of transport fuels.

Bioenergy retrofits in the P&P sector relate to both substitution of fossil fuels at sites and production of new bioenergy products, mainly for the transport sector. The dedicated targets for advanced biofuels in REDII further drive towards converting side streams into biofuels. Additionally, use of side-streams and waste have interfaces with the waste legislation and initiatives related to circular economy.

Future raw material availability and acceptability of bioenergy create uncertainty in the sector. Raw material availability is affected by the tightening sustainability criteria and concerns related to carbon sinks and potential impacts to biodiversity. Long-term political support and consistency in the development of the regulatory framework would be important to support the investments and the scaling-up of the retrofit technologies that typically require high upfront investments.

Industrial Conditions

New innovative bio-based products allow the P&P companies to widen their product portfolios and to create new businesses. Barriers related to potential market uptake of the new technologies are economic rather than technical. Investments are typically aligned with existing bioeconomy and circular economy strategies.

Many of the retrofit options for the P&P industry are technically proven and commercial, but currently applied only in a few mills in Europe. Low number of existing retrofits leads to uncertainty in assessing their economic feasibility. Another challenge is that retrofit technologies are not directly replicable from one mill to another, but the implementation depends on the applied pulping technology, the local operational environment and the markets. Unestablished markets for some of the potential products from the retrofits may create additional barriers for implementation.

The main feedstocks for retrofit products are residues, such as bark, black liquor and sludge. Thus, the volume of the residues limits potential amount of final products.

PULP AND PAPER TECHNICAL OPTIONS FOR RETROFITTING

Pulp and paper sector produces several different side streams, which offer multiple retrofitting possibilities. Retrofits can be divided to those applicable to energy supply in the pulping process, sulphate pulping process and sulphite pulping process.

Option I -Retrofits for energy supply in pulping process

In a Nordic pulp mill, limekiln is typically the only part using fossil fuels (mainly natural gas or fuel oil). This fossil fuel consumption can be replaced with biogas, synthesis gas from bark gasification, wood powder, lignin or tall oil pitch. A huge bioenergy retrofitting potential lies at the stand-alone paper mills in Central and Southern Europe, where part of the fossil fuel consumption could be substituted by biogas from anaerobic wastewater treatment.

Option II - Retrofits for sulphate pulping process

Sulphate pulp mills have several possibilities for production of additional biofuels from black liquor, lignin extracted from black liquor, bark, sludge from wastewater treatment, crude tall oil and methanol separated from the evaporation. Lignin and part of hemicelluloses end up in black liquor, which is typically combusted in the recovery boiler to generate bioenergy. Lignin is an easily transportable energy carrier, which can be used as a feedstock for multiple products, used as fuel or further processed to bioenergy products.

Black liquor can be converted to DME, biomethanol or Fischer-Tropsch biofuels through gasification or to bio-oil through hydrothermal liquefaction. Sludge from the wastewater treatment plant can be valorised either as biogas through anaerobic fermentation or as hydrochar through hydrothermal decarbonization.

Renewable diesel production, bark gasification, anaerobic fermentation of sludge, biomethanol production and lignin extraction are technically proven and commercial technologies, while black liquor gasification, hydrothermal liquefaction and hydrothermal carbonization are in the demonstration phase.

Biomethanol plant at Södra's pulp mill in Mönsterås, southeast Sweden. (Source: Linus Sandvide Lindmark & Partner/ Södra)

Domsjö Fabriker's, Sweden. Main products are cellulose, lignin and bioethanol. Bioethanol is sold to SEKAB for further refining or resale. (Source: Domsjö Fabriker).

Option III – Retrofits for sulphite pulping process

In the sulphite pulp mills, lignin is typically obtained as a product (lignosulphonates), and therefore, less bioenergy is produced compared to sulphate mills. External fossil fuels might be needed. Part of the hemicellulose sugars can be used for bioethanol or biogas production. Bioethanol production is already commercial technology. Brown liquor gasification and synthesis to DME, biomethanol or Fischer-Tropsch biofuels are also possible. Bark can be used for bioenergy or biofuel production.

Retrofits in the P&P sector provide valuable products for the energy and transport sectors and support the achievement of the European climate and energy targets.

CONCLUSIONS

Retrofits provide multiple opportunities for both replacing fossil fuels consumption and producing additional high-value bioenergy products. While the pulp and paper mills in the Northern Europe are already highly relying on bioenergy for primary energy consumption, retrofits can aid further decreasing the CO_2 emissions originating from the sector. Legislation at the EU level is supportive towards production of advanced biofuels for the transport sector and increasing the share of renewable energy in energy production.

Retrofits allow the P&P industry to diversify their product portfolios and to further improve energy and material efficiency. Compared to stand-alone plants, retrofits are often considered as more cost-efficient options for biofuel production.

Though many retrofit technologies are mature the total number of retrofits has remained low. Critical points for successful retrofitting are related to either efficiently using existing value chains or establishing new ones, the amount of available residues and to the case specific implementation potential. As the investment costs are typically high, policy framework supporting long-term investments and alignment of national policies with EU-level policies is important.

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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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