BIOFIT

Bioenergy Retrofits for Europe's Industry

BIOFIT POLICY RECOMMENDATIONS

This document discusses the special purpose of bioenergy retrofitting and introduces the main challenges for retrofit implementation in Europe. As a key output, it presents recommendations that are relevant for European policy makers and all actors interested in bioenergy.

The document is based on the findings of the EU Horizon 2020 project BIOFIT (NO. 8178999, 2018-2022). For more detailed project results, please see https://www.biofit-h2020.eu/

Introduction

The BIOFIT project, supported by the Horizon 2020 research and innovation programme of the European Union, aims to facilitate the introduction of bioenergy retrofitting in Europe's industry. The **bioenergy retrofits are technical measures applied to existing production plants that support bioenergy utilization as an alternative to fossil energy**. The retrofit measures can result in either of the following:

- Using additional biomass as an input to the production plant for primary bioenergy products or for process energy
- Producing additional output from biomass at the production plant, such as transport fuels, intermediate bioenergy carriers, heat and/or electricity.

Within the BIOFIT project bioenergy retrofitting was studied in five industry sectors: first generation biofuels, pulp and paper, fossil refineries, fossil power, heat and combined heat and power (CHP).

For the **fossil refinery sector**, retrofits provide solutions to reduce the need for fossil feedstock and to help reduce the CO_2-intensity of the final products. Retrofitting can mean either scaling up or converting the existing infrastructure to renewable fuels production. The integration of hydrotreated vegetable oil (HVO) or pyrolysis oil are examples of available solutions. In the long term, solutions are required that fully replace the need for fossil feedstocks.

In the **fossil power, heat and CHP sector** biomass retrofitting supports the phase-out of coal and supports national and EU targets for decarbonisation. Integrating biomass in existing installations means substituting partly ("co-firing") or fully ("repowering") the thermal energy provided by the combustion of a fossil fuel, most commonly coal. For coal power plants, repowering with biomass is a mature, market ready solution that can provide dispatchable renewable electricity on large scale. These conversions can support a just transition in coal-dependent regions. In the future, they may also play a part in negative emissions by coupling bioenergy with carbon capture and storage (BECCS).

Pulp and paper sector retrofits provide multiple opportunities for both replacing fossil fuel consumption and producing additional high-value bioenergy products. Retrofits can aid further decreasing the CO_2 emissions, and improve energy and material efficiency of the mills.

Recently, technical measures in the **1st generation biofuels** sector aimed at increased flexibility of plants and improved quality of the products, and a move towards 2nd generation biofuels.[1] Potentially significant end-uses for biofuels include aviation fuels.

[1] The **1st generation** biofuels sector in Europe involves the production of biodiesel (fatty acid methyl esters - FAME), hydrogenated vegetable oil (HVO) and bioethanol from various food crops. FAME and HVO are produced from oil-bearing crops such as rapeseed. Bioethanol is produced from sugar or starch-containing crops, such as sugar beet, grain and wheat. The **2nd generation** biofuels involve non-food crops such as lignocellulosic feedstocks and waste oils.

Special purpose of bioenergy retrofitting

Bioenergy is an essential form of renewable energy, accounting for almost 60% of the EU's renewable energy production.[2] In the future, bioenergy will remain important. The International Energy Agency (IEA) notes in its recent net-zero roadmap for the global energy sector that bioenergy will play a substantial role, as according to the roadmap, some 20% of the global total energy supply will be provided by modern solid (14 %), liquid (3 %) and gaseous bioenergy (3%) in 2050[3]. The role of retrofitting in the energy system transition in Europe is contributed by all specific retrofitting industries studied in the BIOFIT project, as demonstrated by the examples in this section.

The European electrical grid is still in need of non-stochastic, thermal power generation, with the potential to efficiently interact with variable wind and solar power production, for example. With the coal phase-out (and in some countries nuclear phase-out as well), this role is increasingly played by natural gas, which increases the reliance of the EU on imported fossil energy sources. Biomass can assist in the differentiation of the energy imports or even reduce them if domestic resources are exploited. Moreover, it can produce significant and constant amounts of renewable energy for the grid. Furthermore, the potential of biomass-based combined heat and power production (CHP) for balancing the wider energy system should be acknowledged.

The EU is the second largest producer of petroleum products with a crude refining capacity of about 660 million tons per year, representing 13% of total global capacity. The fossil refinery sector itself has set climate neutrality in 2050 as their target[4], and the transport sector in the EU is currently fuelled (95%) by liquid (fossil) fuels. As the production volumes for biofuels in Europe were 11.5 million tons of biodiesel in 2015, and 1.9 million m^3/a for bioethanol,[5] the call for climate neutral solutions is clear. Here, bioenergy retrofitting can provide solutions needed meeting the demand for renewable fuels.

The decarbonisation of the power sector is a serious challenge both at the European and at the national level, but also on the regional level. For coal regions in transition, the closure of coal mines and power plants results in severe socio-economic pressure. Retrofitting existing plants and establishing local biomass value chains could help to maintain industrial expertise and jobs in these regions. In addition to electricity, repowered power plants can create significant amounts of heat for local networks, providing an important local service, even if such plants might not match the efficiency of CHP plants.

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[2] Scarlat, N., Dallemand, J., Taylor, N. and Banja, M., Brief on biomass for energy in the European Union, Sanchez Lopez, J. and Avraamides, M. editor(s), Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-79-77234-4, doi:10.2760/49052, JRC10935

[3] IEA, Net Zero by 2050: A Roadmap for the Global Energy Sector, Int. Energy Agency. (2021).

[4] https://www.fuelseurope.eu/clean-fuels-for-all/vision-2050/

[5] https://www.biofit-h2020.eu/publications-reports/BioFitHandbook-2020-03-18.pdf

It seems evident that the future production of bioenergy will be based on a diverse set of technologies and feedstocks. Here, retrofits can play a role, as also demonstrated in the BIOFIT project case studies and analyses. Compared to other options, bioenergy retrofits have particular advantages in the short term due to their potential to use the existing infrastructure.

Challenges to bioenergy retrofitting

Rapidly changing policy framework and market conditions

Frequent changes in policy frameworks and related support mechanisms create uncertainty in the markets and hinder investments in technologies for bioenergy retrofitting. While bioenergy retrofits can be both technically and economically feasible, some retrofits require subsidies, green premiums or other financial support mechanisms to become economically feasible. Support schemes that enable long-term planning are needed to secure investments since the market conditions for both the feedstock and the end-products can change rapidly.

Long-term planning is challenging, since although new targets for greenhouse gas emissions savings and advanced biofuels' shares are proposed in the Fit-for-55 package, even the targets set in REDII may not be reached in time. According to Bioenergy Europe, most of the Member States are still working on REDII transposition.[6]

Complex and interconnected regulation

Regulations in bioenergy and related industries are interconnected, e.g., waste management, agriculture, energy production, food industry, air emissions and transport, creating a complex system to manage. As an example, many interlinking directives are listed in the REDII. Despite the regulation aiming at being consistent, in practice, efficient adoption of the vast, evolving documentation poses a challenge to actors in the field.

To ensure the contribution of bioenergy retrofits to climate goals, biomass fuels and biofuels need to be as sustainable as possible and substitute as much fossil fuels as possible. However, compliance with the requirements arising from the Emissions Trading System ETS and RED may create a large administrative burden for many small-scale operators. For example, in the proposal for REDIII, it is foreseen to lower the exemption threshold for the application of sustainability criteria in the case of solid biomass fuels to 5 MW of thermal capacity. In comparison, the exemption threshold in REDII was set to 20 MW. Additional challenges are foreseen due to the plans related to retroactive application of GHG emission savings criteria to existing plants.

[6] https://bioenergyeurope.org/artciles/322-fit-for-55-package-which-future-for-renewables-in-europe.html

The definition of waste materials varies between the Member States

Conflicting and overlapping legislation (e.g., waste legislation vs. circular economy objectives and renewable energy legislation) may cause bottlenecks for valorising and/or using waste and residues. Currently, each Member State can define the materials that are considered as waste. If the definition of Annex IX waste streams of the RED II is not uniform in Member States, submarkets per country may be created, leading to increased competition and confusion due to differing definitions and support schemes.

For example, some Member States do not promote all pulp and paper (P&P) production residues as renewable energy sources, although European legislation defines a "biodegradable fraction of products, waste and residues from forestry and related industries" as such. The use of some P&P production residues is restricted in the Waste Incineration Directive 2000/76/EC and require specific permits.

Sourcing of unexploited feedstocks to secure raw material availability

BIOFIT sectors compete for sustainable raw materials with each other and with other uses. Currently in many Member States, biomass fuel is substantially sourced from international markets. The implementation of the cascading principle for forest biomass will increase the interest towards the use of waste and residues and may cause uncertainty in raw material markets for bioenergy. The availability of sustainable biomass for both energy and non-energy purposes should be secured at the national level and included in long-term planning.

Some of the retrofits can exploit raw materials with no other local uses (e.g., bark gasifiers in the P&P sector) and can be recommended as such. The sufficiency of sustainable raw materials for certain bioenergy retrofits can be improved by developing the sourcing and supply chains (e.g., collection of used cooking oil (UCO) for the biofuels sector), by enabling the use of waste materials (e.g., by removing legislation obstacles or developing technologies for side stream exploitation) and by targeting actions for specific local feedstock sourcing (e.g. the cultivation of energy crops on marginal land).

Need for technology-neutral legislation

The potential of large-scale production of renewable jet fuels is restricted by the lack of low-cost feedstock. Options being investigated for cost-effective alternative pathways and feedstock include a diverse range of technologies with the potential to upgrade alcohols, to convert ligno-cellulosic feedstock, and to make effective use of low-cost sources of biomass. A clear comparison of the commercialization status of the aforementioned alternative pathways is often hindered by the absence of a common technology terminology and lack of transparency regarding competing claims by companies to promote their own proprietary technology. Instead of pre-defined lists of specific technologies, legislation should be technology-neutral to ensure that development of promising new solutions for renewable fuel production remains attractive in future.

Fossil fuels are still promoted

Continued subsidies for fossil fuels and the exclusion of related external costs results in low prices for fossil-based energy. For electricity, the external costs for fossil fuel technologies have been estimated as 68-177 €/MWh[2], and the prices of CO_2 emission allowances in the EU may not be sufficient to make biomass-based power production competitive with fossil-fuel alternatives. Additionally, fossil fuel subsidies in the EU-27 reached approximately €50 billion in 2018.[7] This discourages investments in bioenergy retrofits, even though it must be remembered that the industry itself may be eligible to subsidies and have some external costs as well. To even out the playing field, an efficient portfolio of mechanisms such as subsidies, green premiums, or carbon tax, is to be determined in order to ensure development of cost-efficient green technologies.

International competition

While tackling the greenhouse gas emissions at the EU-level, most industries are exposed to international competition. According to The European Green Deal [17], "*The commission will propose a carbon border adjust mechanism, for selected sectors, to reduce the risk of carbon leakage*." This is of importance to the pulp and paper industry sector, for example, to avoid problems with intercontinental competition. The mechanism will allow a level playing field in Europe for certain EU sectors and will allow to reduce the free allocations under ETS. Furthermore, the competition can also be tackled by targeting the R&D funding as well as investment support for innovative technologies.

Lack of information, cooperation and general awareness

Optimal operation of a bioenergy or biofuel producing plant requires a constant supply of feedstock with a certain quality and quantity, and at a reasonable cost. The applied technology should be selected so that it will meet local energy and fuel requirements and will be able to convert locally available raw materials. Therefore, the size of the plant and the technology applied are critical factors from both an economic and an environmental perspective.

The BIOFIT TOTAL case study[8] showed that the suitability of pyrolysis technology to produce bio-oil was higher when using sawmill residues as feedstock, since they were already sized, uniform and available in large quantities. The relevant costs were also lower than the corresponding ones related to other biomass feedstocks (e.g. wood processing industry residues). To find solutions that are optimal for local conditions, regional cooperation and knowledge exchange between industrial actors should be encouraged.

In addition, the public acceptance of bioenergy is currently fragile and varies between the studied sectors. The study in four selected European countries (Bosnia and Herzegovina, Germany, Spain, and Sweden), with 800 respondents in each country showed that the

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[7] Directorate-General for Energy (European Commission), Trinomics, Final Report Summary: Energy costs, taxes and the impact of government interventions on investments, European Commission, Rotterdam, 2020. https://doi.org/10.2833/827631.

[8] https://www.biofit-h2020.eu/total-refining-and-chemicals/

respondents have a certain level of confidence in technologies enabling bioenergy production.[9] However, some level of scepticism related to bioenergy installations as mere greenwashing was also recognised. It is recommended that when bioenergy production technologies have positive effects—potentially and/or actually—these consequences must be communicated to contribute to citizens' acceptance of bioenergy production in general.

Recommendations

- Due to increasing competition for biobased raw materials, **research and funding should be allocated for studying the possibilities for broadening the feedstock base for bioenergy and biofuels production, including biomass from marginal, underutilised, contaminated (MUC) lands.** There are still many under-utilised waste streams due to various challenges such as high variation in composition, contaminants, high water contents, many streams of low amounts and varying availability throughout the year. Potential means could include support for technological solutions that can convert a variety of complex waste streams into energy carriers or building blocks for fuels, investments in energy efficiency and other new technological solutions that could help to decarbonise the sectors.

- Many of the potential residue and waste streams applicable for biofuel production are scattered and difficult to mobilize. **New collection systems for residues and waste should be established** in order to improve availability of these streams for biofuel and bioenergy production.

- **National and EU legislation should be revised in order to remove obstacles for and/or promote the sustainable collection of agricultural and forestry residues** for the bioeconomy, including bioenergy applications. Bioenergy retrofitting could be promoted also by removing legal obstacles regarding the co-processing of fossil and biobased feedstocks and developing the related standardisation. Coal to biomass repowering projects that require large volumes of biomass currently mostly coming from imported wood pellets, would benefit from developing supply chains and technologies for sustainable agro-biomass exploitation.

- Biomass feedstock supply for refineries could be promoted by stimulating technologies related to intermediate bioenergy carriers, IBCs (IBCs include pre-treated biomass, such as torrefied pellets and bio-oil) so that the required volumes of IBCs become available, and they can be traded like a commodity. Trade centers for IBCs could further be beneficial to stimulate market uptake.

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[9] Taufik, D., Dagevos, H. (2021). Driving public acceptance (instead of skepticism) of technologies enabling bioenergy production: A corporate social responsibility perspective. Journal of Cleaner Production, vol. 324. https://doi.org/10.1016/j.jclepro.2021.129273.

- Regulations and governance should set economic incentives and construct a step-by-step supply chain system that will **enhance the collection of UCO and animal fats**. A certification/control system for the collected UCO should be developed. The collection data should be tracked and published to prevent fraud. Furthermore, establishing municipal logistic centres would aid this development, since the authorities' role is important in starting the activity.

- For 1st generation bioethanol production, the transition to 2nd generation biofuel production is currently not cost competitive. **Support for further research of alternative pathways towards a cost-effective and sustainable advanced bioethanol production** (such as retrofitting 1st generation biofuel plants with 2nd generation biofuel add-ons) is still needed. The retrofitting approach could result in synergies and cost savings. The transition from 1st to 2nd generation biofuels in the biodiesel sector is already state of the art and well documented with numerous positive examples (see BIOFIT factsheet Volos Biodiesel Plant, Greece[10]).

- **Biorefineries allow putting the cascading principle into practice** by simultaneously producing both biobased products, fuels, and energy. However, such investments have **high risk and high capital expenditures that need to be tackled with a stable and long-term policy framework**.

- In order to facilitate the market uptake of emerging technologies for bioenergy retrofitting in the pulping industry, **R&D funding as well as investment support should be targeted at new technologies that allow efficient side-stream utilisation and increase overall energy-efficiency**. These include many commercially mature technologies such as bark combustion, bark gasification, biogas production from sludge, ethanol production from black liquor in sulphite mills, tall oil conversion into transportation fuels and lignin separation from Kraft black liquor.

- **Standard calculation formulas should be developed and implemented to quantify the renewable content of all transport fuels**. Current work on a Europe-wide definition should be conducted with diligence, speed and in cooperation with renewable fuel producers.

- Renewable aviation fuels have the potential to deliver a major contribution to achieving increased EU climate targets for 2030.[11] This requires **developing a supportive technology neutral policy environment for the successful deployment of renewable jet fuel technologies**, and internationally consistent sustainability certification procedures that take into account regionally specific contexts.

- **Careful and transparent communication and information to the public is needed** to maintain and strengthen public trust in industrial activities to implement bioenergy technologies.

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10 https://www.biofit-h2020.eu/files/pdfs/190318%20-%20Biofit%20-%20Factsheet%20-%20Greece_low.pdf
11 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52021PC0561

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