Turning lignocellulosic biomass into sustainable fuels for maritime and aviation transport


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ABATE is demonstrating the integration of thermochemical and biochemical processes to convert biomass residues into advanced bio-based refinery intermediates for sustainable transportation fuels

REACHING a climate-neutral energy system requires finding cleaner ways to power sectors that are difficult to electrify, particularly long-distance shipping and aviation. Sustainable fuels derived from renewable resources are a vital part of the solution. However, current commercially available technologies often face barriers due to increased process costs and energy requirements or limited raw materials.

ABATE (Advanced Bio-bAsed refinery inTErmediates) is an ambitious Horizon Europe project that addresses these challenges by developing a novel process to valorise residual biomass into cost-competitive, carbon-neutral advanced bio-based intermediates. These intermediates can directly substitute fossil fuels in conventional oil refineries, helping to reduce emissions without requiring major changes to current infrastructure. Based on current assessments, ABATE technologies could meet more than 55% of the EU renewable marine fuel demand and around 5% of the aviation fuel demand by 2035.

By demonstrating sustainable bio-based carbon capture, utilisation and storage solutions that couple industrial decarbonisation with circular bioeconomy innovation, the project will provide robust policy-relevant evidence supporting the EU Green Deal, Fit for 55, and the Bioeconomy Strategy.

From biomass to sustainable fuels

ABATE focuses on residual lignocellulosic biomass, such as forest residues and agricultural waste. These materials are widely available and do not compete with food production. The project aims to produce fuels that are both economically viable and climate friendly by combining innovative thermochemical and biochemical processes.

The approach builds on research carried out in the Horizon 2020 BioMates project, which successfully validated a two-step valorisation process for lignocellulosic biomass at pilot scale (Technology Readiness Level 5). ABATE now takes the next step by scaling up and intensifying the technology to reach industrial relevance. At full scale, the technology is expected to deliver a GHG emission reduction of 90%-120% – following the revised Renewable Energy Directive (REDIII) methodology – thanks to process optimisation and the use of renewable energy sources within the process.

Major ABATE milestones will be achieved in 2026. The existing demonstration plant has been successfully scaled up to TRL 6 at the RISE facilities in Sweden. In parallel, a new hydrotreatment plant for bio-oil upgrade is being constructed in Greece at CERTH facilities, further improving the industrial relevance and process efficiency. Overall, ABATE introduces five key technological innovations to produce carbon-neutral and cost-competitive advanced bio-based intermediates.

A new era for sustainable fuels: Advancing fast pyrolysis technology and hydrotreatment

One of the ABATE's core innovations is improving fast

pyrolysis – a process that converts biomass into liquid bio-oil, biochar, and gases. A longstanding challenge has been the limited range of usable feedstocks and the variation in bio-oil quality, which complicate large-scale deployment. ABATE addresses these issues by enabling the use of low-value biomass feedstocks, such as forest residues and straw, via a novel hot-gas filtration system.

The project also improves the upgrading stage of fast pyrolysis oil by optimising the catalytic system. Bio-oil is upgraded in a step using a modern catalyst, making it easier to turn into fuels like diesel or jet fuel using existing refinery equipment. The design and construction of a new larger plant at CERTH facilities will allow product recycling and improved heat integration, increasing the overall efficiency.

Crucially, ABATE integrates carbon capture and utilisation (CCU) directly into the fast pyrolysis process using an innovative absorption system. Combined with the use of green hydrogen, this significantly reduces fossil energy demand and aligns the technology with EU climate and decarbonisation targets.

A strategy for full circularity

Circularity is a central goal of the ABATE project. To maximise resource efficiency, CO_2 emitted during the combustion of process gases will be captured, purified, and compressed. This captured CO_2 will be used to demonstrate the potential of the technology for further reducing carbon emissions, including its conversion to methanol.

In addition, the ABATE project aims to treat the entire residual hydrogen stream and convert at least 90% of CO_2 into methane within a biological reactor. The operation of this bioreactor will be demonstrated at TRL 6 within the ABATE project, showing readiness for industrial application.

ABATE also explores benefits beyond fuel production. Following thermal stabilisation, the biochar generated during the fast pyrolysis process will be evaluated for use as a soil improver, with testing to ensure compliance with the EU Fertilising Products Regulation. This can highlight the potential dual role of stabilised biochar as a soil improver and a robust carbon sink, supporting climate mitigation strategies and sustainable agriculture.

ABATE industrial and environmental impact: Increasing renewable content in hard-to-electrify sectors

ABATE is set to deliver significant industrial and environmental advantages. Its innovations are expected to lead to cost-competitive production of biofuels by utilising cheap and available forest and agricultural residues as feedstock.

A key industrial outcome of ABATE is enabling the co-processing of bio-based intermediates in existing refineries. This is a critical step to unlock Annex IX (part A) feedstocks, such as forestry and agriculture residues, under RED III. As a result, refineries will be able to increase renewable content at scale in hard-to-electrify sectors, while continuing to rely on existing infrastructure and expertise to meet growing requirements of RED III, ReFuelEU Aviation, and FuelEU Maritime. At the same time, the integration of carbon capture, renewable energy, and circular use of resources promotes efficient carbon management and contributes directly to EU net-zero climate goals and energy targets.

abate
Advanced Bio-based Refinery Intermediates

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