FUEL-UP Project Hits Mid-Point Milestones, Accelerating Sustainable Aviation Fuel (SAF) and Marine Diesel Development

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The global urgent need to reduce greenhouse gas (GHG) emissions and combat climate change is driving a fundamental transformation in energy and industrial sectors. **Biomass** has emerged as a central pillar in this transition, offering pathways to replace fossil feedstocks and support a low-carbon, circular economy through the production of fuels and added-value products. **Sustainable aviation fuel consumption** is expected to expand from 1 billion litres in 2024 to 9 billion litres in 2030, meeting 2% of total aviation fuel demand in the main case. Mandates in the European Union and United Kingdom, incentives in the United States and blending targets in Japan drive most of this growth. **Maritime biofuel demand** is projected to double to 1.6 billion litres (0.05 EJ) by 2030, making up near 1% of total maritime fuel demand. The primary region for growth continues to be Europe, where fuel suppliers are required to meet GHG intensity reduction targets of 2% by 2025 and 6% by 2030 and are subject to carbon pricing under the EU ETS[1].

The EU-funded **FUEL-UP project**, launched in January 2024, aims to produce sustainable, drop-in **Sustainable Aviation Fuel (SAF)** and **marine diesel** from lignocellulosic streams. The project validates a demonstration-scale route (**TRL 6-7**) to convert bio-oils from fast pyrolysis into a target fuel mix (**45% aviation fuel, 35% marine diesel, 20% heavy naphtha**) using intermediate steps and refinery-scale upgrading.

Key objectives include:

- Providing advanced, market-ready SAF and marine diesel.
- Achieving an ASTM specification for SAF by 2030 through D4054 evaluation, making the drop-in fuel compatible with all aircraft.
- Developing cost-effective, adaptable conversion technology to enhance EU leadership.
- Overcoming deployment barriers (cost, refinery adaptation) by creating pathways for existing plants, reducing fossil fuel dependence.
- Supporting the Green Deal and contributing to the circular economy and SDGs (9, 12, 17).

FUEL-UP project has successfully completed its initial two years, by confirming the technical feasibility and by setting the stage for the demonstration-scale production of advanced drop-in biofuels, specifically SAF and marine diesel. The project's collaborative efforts have been instrumental in optimizing catalysts, validating processes, and embedding circularity into the biofuel production chain.

Advancing the Core Biofuel Conversion Pathway

BTG, with the support of BTG-neXt, Ranido, Avecom and Sintef, focused on the activities required to produce and characterize **Stabilized Deoxygenated Pyrolysis Oils (SDPO)** as intermediates for the production of **Hydrotreated Pyrolysis Oil (HPO)**, by using optimized catalysts and processes, while also addressing the environmental aspects through the treatment and potential valorization of the aqueous byproducts. Extensive research and testing were conducted by Tüpraş, DLR, Ketjen and BTG to identify and optimize the **best catalyst**

[1] https://www.iea.org/reports/renewables-2025/renewable-transport

and process conditions for upgrading the kerosene fraction of HPO into SAF. The successful optimization phase will enable the process to transition to a more realistic TRL 6 demonstration scale.

De-Risking Certification and Fuel Quality

DLR, with the support of Tüpraş and BTG, contributed with its expertise in aviation fuel specification and ASTM D4054 evaluation to FUEL-UP. Its role spans from rapid, data-driven assessment of the produced synthetic blending component samples using DLR's aviation fuel prescreening method, up to combustion tests. During the first two years, DLR prescreened initial samples, using detailed GCxGC compositional analysis coupled to machine-learning property prediction, they explored compositional design spaces to identify promising pathways for improved fuel quality, and performed numerical blending studies. These activities provide fast, specification-oriented feedback to the producing work packages, supporting process optimisation and reducing risk for later D4054 qualification steps.

Achieving Circularity Through Waste Valorization

In these first two years of the project, AristEng, with the support of Sintef, Tüpraş, BTG, BTG-Next and Avecom, developed and assessed innovative pathways to utilize pyrolysis off-gases and aqueous streams resulting from the hydrotreatment steps of pyrolysis oil, performing conceptual process design and calculating mass and energy balances for various alternative processes. The most promising options - based on carbon recovery, carbon footprint and economic performance - were integrated into the complete FUEL-UP value chain. In addition, in the upcoming months, AristEng together with LIST defined the boundary limits of FUEL-UP, which will serve as the basis for the project's life-cycle assessment (LCA).

Commercial Viability and Scaling-Up Assessment

Under the management of BTG-Next, supported by all partners, the project established a strong foundation for commercialization:

- Conceptual Plant Design (FEL-1): The team defined the conceptual design for a commercial-scale plant, including plant boundaries, a preliminary equipment list, and risk identification. This included designing a scaled-down demonstration unit to aid de-risking.
- Techno-Economic Assessment (TEA): A preliminary TEA was prepared, estimating production costs of the fuel products and conducting a sensitivity analysis to understand the impact of key parameters (e.g., pyrolysis oil costs, hydrogen price, catalyst lifetime).

Pyrolysis Wastewater Becomes a Source of Energy and Clean Water

Avecom successfully completed trials with its new Aqueous Phase Treatment Pilot Plant (ATPT) on hydrotreated pyrolysis oil. This advanced biological system ran for three months with promising results. The tests confirmed that the upstream hydrotreatment effectively broke down the complex and sometimes toxic compounds into readily biodegradable ones. Subsequently, the anaerobic stage efficiently converted these compounds into significant volumes of biogas:

- High Yield: 0.4 NL biogas per gram COD (Chemical Oxygen Demand).
- High-Quality Fuel: The produced biogas had a high methane content of 80%.

Furthermore, the aerobic post-treatment resulted in purified effluent (< 1 g COD/L). This treated water is now perfectly suitable for reuse, for example, as dilution water in the anaerobic process or for other pyrolytic demands.

All these achievements position FUEL-UP project strongly as it enters its third year, which will focus on the execution of the full TRL 6-7 demonstration and the final push towards commercial readiness.

Figure 1: FUEL-UP Team during third Consortium Meeting

Partners

FUEL-UP project is coordinated by SINTEF Industry (Norway) and has a consortium of 12 partners from 8 different EU countries: SINTEF Ocean (Norway), B.T.G. Biomass Technology Group (The Netherlands), BTGNext (The Netherlands), Tüpraş (Türkiye), RANIDO (Czech Republic), AVECOM (Belgium), German Aerospace Center (Germany), AristEng (Luxembourg), ETA-Florence Renewable Energies (Italy), LIST (Luxembourg), Ketjen (The Netherlands).

Contacts

Duncan Akporiaye (Project Coordinator – SINTEF): Duncan.Akporiaye@sintef.no
Nikolaos Tsakoumis (Project Management – SINTEF): Nikolaos.Tsakoumis@sintef.no
Chiara Benetti (Communication and Dissemination – ETA-Florence): chiara.benetti@etaflorence.it
Website: www.fuelup-project.eu
Mail: info@fuelup-project.eu
LinkedIn: http://www.linkedin.com/company/fuel-up-project

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