ISSUE 2 | MAY 2025

PROJECT NEWSLETTER

Fuel-Up

Powering a Greener Future for Aviation and Marine Transport

We are pleased to share the second issue of FUEL-UP newsletter, keeping you up to date with the latest updates and activities implemented by the project. FUEL-UP – *Production of advanced biofuels via pyrolysis and upgrading of 100% biogenic residues for aviation and marine sector, including full valorisation of side streams* – is a Horizon Europe Innovation Action aimed at transforming biogenic waste into advanced biofuels to enable the green transition and the decarbonisation of the aviation and the marine transport sectors.

CONTENT

1. Powering a Greener Future for Aviation and Marine Transport

Advanced biofuels are crucial for meeting Europe's climate objectives and addressing global warming. By 2050, they have the potential to supply **14% of the world's transport fuel** and **45% of the aviation fuel required globally**. When produced sustainably, these biofuels could cut CO_2 emissions by approximately 21 gigatons (Gt) annually, leading to a significant **reduction of greenhouse gas emissions**.

FUEL-UP project, funded by the European Union, aims to advance **bio-oil conversion** into **sustainable biofuels**, specifically targeting the aviation and maritime sectors. The project focuses on the transformation of bio-oils produced from **fast pyrolysis** (FP) into advanced

biofuels through intermediate process steps (**stabilization and deoxygenation**) combined with refining at refinery scale to ensure transformation of all streams to the **key aviation and marine fuels sectors**. FUEL-UP will, therefore, validate, at demo scale, a route to produce sustainable liquid biofuels from lignocellulosic streams with more than **45% aviation fuel,** about **35% in the marine diesel** and **20% heavy naphtha** at **technology readiness level 6-7 (TRL 6-7)**.

FUEL-UP will provide aviation and shipping markets with two new advanced, **drop-in biofuel products** meeting the market needs in terms of quality, specifications, environmental performance and certifications. The **SAF and marine diesel** will be fully aligned with needs of marine and aviation engine manufacturers and certification pathways. SAF produced in FUEL-UP will be continuously analyzed, tested and optimized to de-risk the ASTM D4054 evaluation process. FUEL-UP will then perform ASTM D4054, Tier 1 and Tier 2, testing for the final fuels and start the D4054 evaluation. Additionally, combustion tests will be performed to get valuable performance/safety metrics and support the evaluation process. The aim is to achieve an ASTM specification by 2030 facilitating commercialization.

The fuel will be a drop-in fuel and in consequence compatible with 100% of aircraft (already existing and future), facilitating its market uptake and replacement of fossil fuels.

FUEL-UP will develop a route for producing advanced biofuels from abundant available and unused resources, through a technology that can be adapted to the different types of feedstocks available across Europe. It will increase **EU leadership in advanced biofuels production** that provides solutions for decarbonizing the energy and transportation sectors, as well as the industry. It will demonstrate the cost-effective conversion of biomass into biofuels through pyrolysis and further upgrading of pyrolysis oils into SAF and marine diesel and scenarios of deployment, and the further valorization of these components in a circular economy approach.

Although advanced biofuels could strongly contribute to solving European climate challenges, their deployment is hampered by their cost, the fact that refineries are not adapted to deal with such products, and the fact that no certification exist for high co-feeding rate providing the highest impact. By providing adapted conversion pathways allowing the synthesis and deployment of advanced biofuels in existing plants, FUEL-UP will reduce the dependence on current fossil-based resources and will allow the economic exploitation of remote biomass resources.

The FUEL-UP project will utilise and contribute to the **Key Enabling Technologies of advanced materials and advanced manufacturing** though the development of new sustainable-by-design tailor-made catalysts and linked reactors and process. The full value chain of advanced biofuels production will be demonstrated at TRL 6-7.

The FUEL-UP process will improve energy efficiency as its adoption will contribute to valorising diverse feedstock available in Europe in industrial infrastructures with clean and environmentally sound technologies (**Sustainable Development Goal - SDG 9**). Once adopted, the new processes of conversion of biomass could make it possible to reduce the use of fossil fuels (**SDG 12**) and put in place value chains for advanced biofuels production and usage by involving multiple sectors (chemical, power, energy and other industries) and enhancing cross-sectoral cooperation (**SDG 17**).

Finally, FUEL-UP will contribute to the **Green Deal** achievements by decreasing GHG emissions and providing greener energy.

2. Aviation Regulation - How does it contribute to achieving EU's climate targets?

Globally, aviation accounted for **2.5% of all carbon dioxide emissions in 2023**, and its growth in recent decades has outpaced that of rail, road, and shipping.

The International Energy Agency (IEA) reported that as international travel recovered after the COVID-19 pandemic, aviation emissions neared **950 million tonnes of CO2 in 2023**, about **90% of pre-pandemic levels**.

The International Civil Aviation Organisation (ICAO) projects that international aviation emissions could **triple by 2050** compared to 2015. Within the EU in 2022, direct aviation emissions made up 3.8% to 4% of total greenhouse gas emissions and 13.9% of transport emissions, making it the **second-largest contributor in the transport sector** after road travel.

Addressing this trend requires a combination of strategies, including sustainable aviation fuels, aircraft and engine improvements as well as operational efficiencies.

The EU is addressing the aviation industry's high CO2 emissions through the **ReFuelEUAviation Regulation**, a key component of the Fitfor55 package. This regulation mandates the progressive adoption of **Sustainable Aviation Fuels (SAF)** at EU airports, aiming for a **55% emissions reduction by 2030**. From 2025 onwards aviation fuel suppliers must ensure that all fuel made available to aircraft operators at EU airports contains a minimum share of SAF (and a minimum sub-share of synthetic aviation fuels from 2030 onwards), which will increase over time.

What is a SAF according to ReFuelEU Aviation?
ReFuelEU defines SAF as "drop-in" fuels compatible with existing infrastructure, including synthetic aviation fuels from renewable hydrogen and captured carbon, advanced biofuels from waste and residues notably, biofuels produced from oils and fats notably as well as recycled carbon aviation fuels.

The success of ReFuelEU relies on collaboration between fuel suppliers, airports, and airlines, covering over **95% of EU air traffic**. Increased SAF production is anticipated to lower costs and create jobs across the EU.

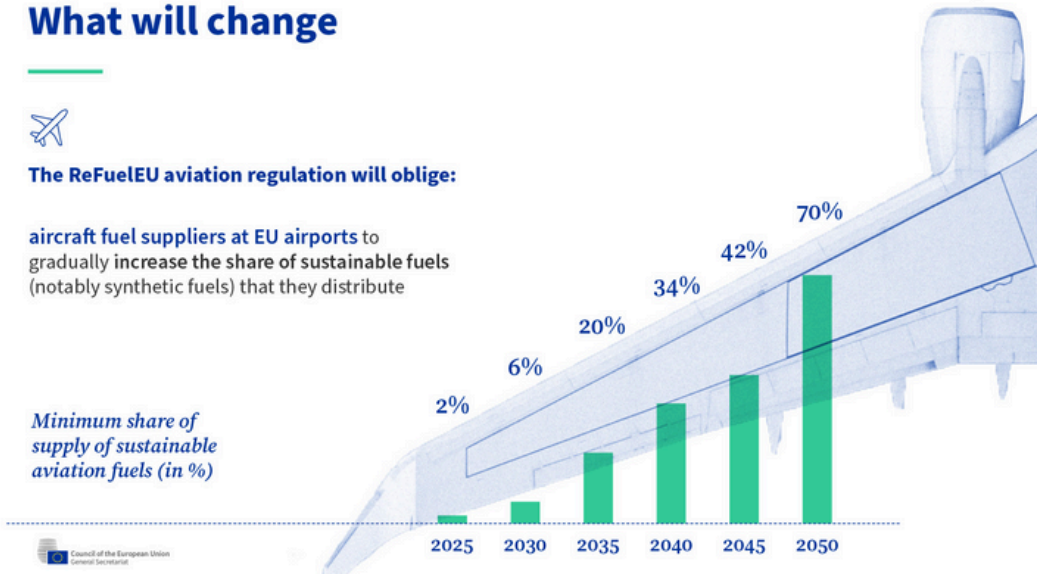

Figure 1: ReFuelEU Aviation Regulation. Photo credit: European Commission

In addition, the European Union is supporting the ReFuelEUAviation initiative by other worth mentioning actions:

- **International Collaboration**: Working with International Civil Aviation Organization to promote global ambition on SAF adoption.
- **Global Development**: Funding projects like **ACT-SAF** in 13 African states and India to foster SAF production.
- **Industry Partnerships**: Facilitating cooperation through the **Renewable and Low-Carbon Fuels Value Chain Industrial Alliance**.
- **Streamlining SAF Development**: Accelerating SAF pathway qualification through the **EUSAF Clearing House** and simplifying plant construction via the **Net Zero Industry Act**.
- **Enhanced Transparency**: Utilizing the **EU taxonomy** and environmental labeling (**Flight Emissions Label**) to guide investment and consumer choices, supported by the **CountEmissionsEU** initiative.
- **Financial Support**: Providing funding via **Horizon Europe**, the **Innovation Fund**, and **InvestEU** to reduce SAF production risks, and enabling Member State aid under the **Guidelines on State aid for climate, environmental protection and energy** (**CEEAG**).
- **Price Incentives**: Offering financial assistance through the Emissions Trading System (ETS), **SAF allowances and preferential tax treatment** via the revised Energy Taxation Directive to bridge the price gap between SAF and fossil kerosene for aircraft operators.

3. Maritime Regulation – How does it affect the maritime sector?

The second edition of the **European Maritime Transport Environmental Report**, released by the **European Maritime Safety Agency (EMSA)** and the **European Environment Agency (EEA),** highlights that while Europe's maritime sector is making headway in sustainability, significantly greater effort is needed to meet EU climate and environmental goals. These goals target reductions in energy use, pollution, and greenhouse gas emissions, alongside improved biodiversity protection. The report underscores the crucial role of maritime transport in the economy but points out its considerable environmental impact, including rising methane emissions and persistent air and water pollution.

While the use of alternative fuels is increasing, substantial scaling and international cooperation are required for a truly sustainable future. EU leaders emphasize the urgency of this transition, supported by initiatives like the **FuelEU Maritime Regulation** and the **EU Emissions Trading System**.

In 2023, the European Union adopted the **FuelEUMaritime initiative**, as a key part of the **EU's Fitfor55 package** with the aim to increase the demand and use of renewable and low-carbon fuels and reduce the greenhouse gas emissions from the shipping sector. Starting in 2025, vessels over 5,000 gross tonnage calling at EU ports will face **mandatory limits on the greenhouse gas intensity** of their onboard energy. GHG intensity' is a measure of the total CO_2-equivalent emissions onboard a ship between January and December in any given year. Measurements are based on reported fuel consumption and the emission factors of the fuels used, including emissions from production to transportation, bunkering and end-use.

The regulation aims for a progressive reduction in carbon intensity, reaching an **80% decrease by 2050 compared to 2020 levels**.

Ships will be required to connect to **onshore power supply (OPS)** in ports, or utilize **alternative zero-emission technologies**.

These vessels account for **55% of all ships** and a staggering **90% of CO2 emissions** from the maritime sector.

FuelEU is a crucial step towards achieving the EU's 2030 and 2050 climate goals, aligning maritime transport with the EU climate targets.

The regulation aims for a progressive reduction in carbon intensity, reaching an **80% decrease by 2050 compared to 2020 levels**.

Ships will be required to connect to **onshore power supply (OPS)** in ports, or utilize **alternative zero-emission technologies**.

The FuelEU Maritime regulation will work in conjunction with other EU initiatives like the **EU Emissions Trading System (ETS)**, the **Energy Taxation Directive**, and the **revised Alternative Fuels Infrastructure Directive** (formerly 2014/94/EU).

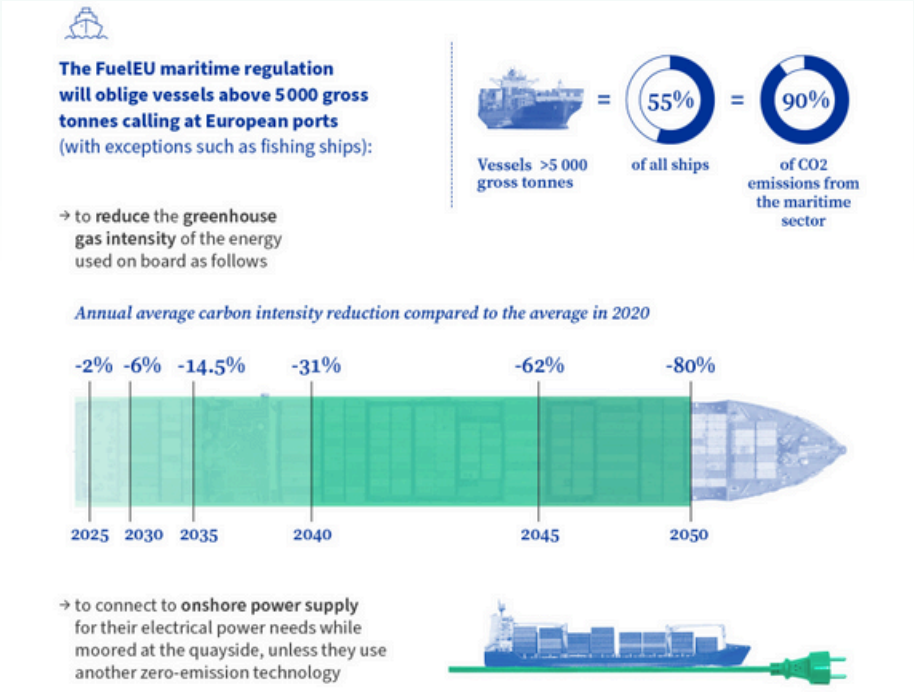

Figure 2: FuelEU Maritime Regulation. Photo credit: European Commission

The **ETS** employs a "**cap and trade**" mechanism, limiting emissions within a specific region and allowing companies to trade allowances.

Additionally, the **Energy Taxation Directive** will introduce taxes on marine fuel for intra-EEA (European Economic Area) voyages, gradually increasing over ten years.

Finally, the revised **Alternative Fuels Infrastructure Directive** aims to ensure EU-wide access for ships to **clean electricity and liquified natural gas (LNG) refueling** through coordinated national policies and infrastructure improvements.

On a global scale, the **4th International Maritime Organization GHG Study** revealed maritime transport's contribution of 1,056 million tonnes of CO2 in 2018, underscoring the urgency to reduce GHG emissions from ships. In response, the **IMO's 2023 Revised GHG Strategy** has significantly strengthened its ambitions. Key targets include:

- **A 40% reduction in carbon intensity by 2030** (compared to 2008).
- **5-10% adoption of zero/near-zero GHG fuels by 2030**.
- **Net-zero emissions by or around 2050.**
- Indicative checkpoints of **20-30% reduction by 2030 and 70-80% reduction by 2040 in total annual GHG emissions** from international shipping.

These are not just goals; they are a call to action for the entire maritime sector.

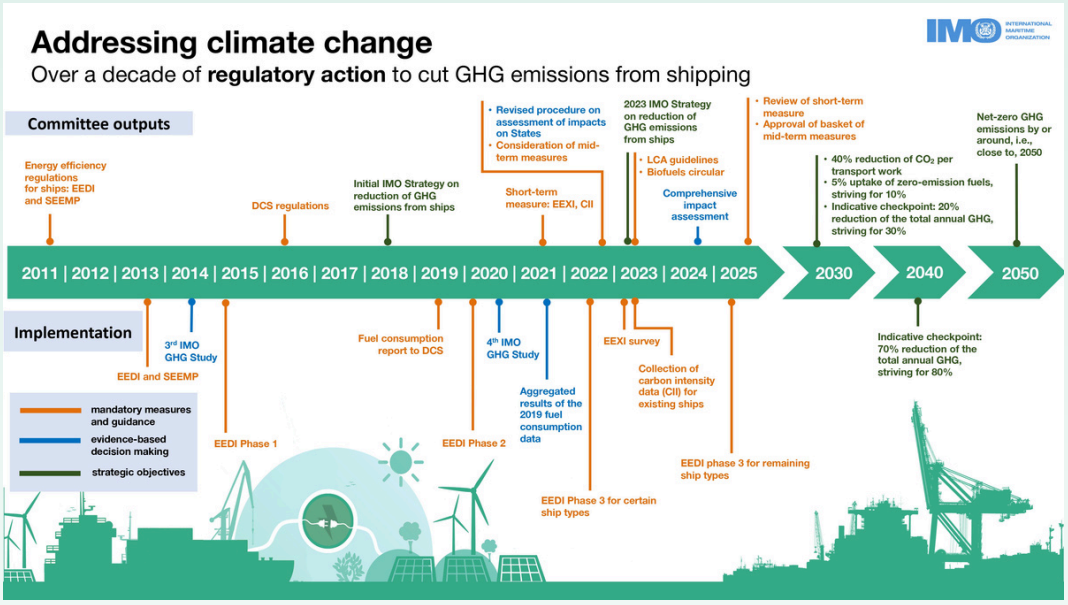

Figure 3: Regulatory actions to cut GHG emissions from shipping. Photo credit: IMO

4. Project Activities Updates

FUEL-UP is approaching month 18, marking the conclusion of several project work packages, including:

- **WP2**: **Supporting Activities for the Production of Stabilized Intermediates**
- **WP8**: **Carbon Management and Process Side-Stream Valorization Evaluation**
- **WP10**: **Preliminary Process Design, Feasibility Study and Techno-Economic Assessment**
- **WP12**: **Plans and First Communication Activities**

Work Package 2, managed by BTG, with the involvement of Ranido, Avecom and Sintef, has been 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 by-products.

In essence, WP2 has laid the groundwork by producing the necessary intermediate oil streams (SPO and SDPO) using **optimized catalysts** and **processes**, while also addressing the environmental aspects through the treatment and potential **valorization of the aqueous by-products**.

Work Package 8, managed by Aristeng, with the involvement of Sintef, BTG, Tüpraş, Sintef Ocean, Avecom , BTG-Next, List and DLR, has been

focused on determining the best ways to utilize the by-products of the biofuel production process, specifically **pyrolysis off-gases and aqueous phase streams**.

WP8 's goals has been to maximize the utilization of carbon from biomass by exploring various ways to valorize the side streams, ultimately selecting the most environmentally sound and economically viable options for integration into the overall biofuel production process.

Work Package 10, managed by BTG-Next with the involvement of all partners, has been focused on the initial steps towards understanding the commercial viability of the project. The main activities have been:

- **Conceptual Design of a Commercial Plant** (FEL-1) including defining plant boundaries and constraints, creating a preliminary design basis, an initial equipment list, and potentially a 3D plot plan as well as identifying and quantifying potential risks and performing a scale-down study and cost estimate for a conceptual design of a demonstration unit to assess de-risking.

- **Scoping/Screening Study**: Conducting a broad evaluation of the entire value chain, assessing product applications, including the main fuels and by-products like HPO naphtha and methane from aqueous phase treatment as well as performing an initial evaluation of the fuel market to guide further development.

- **Preliminary Techno-Economic Assessment (TEA):** Using the outputs from the conceptual design and the screening study to prepare a preliminary TEA, estimating the production costs of the fuel products as well as including a sensitivity analysis to understand the impact of key parameters such as pyrolysis oil costs, hydrogen price, and catalyst lifetime.

In essence, WP10's aim has been to provide an early-stage understanding of the technical feasibility and economic potential of the FUEL-UP project by developing a conceptual commercial plant design, evaluating the broader context of feedstocks and markets, and conducting a preliminary techno-economic analysis.

Work Package 12, managed by ETA-Florence, with the involvement of all partners, has been focused on establishing the **project's communication, dissemination, and exploitation strategies** and implementing initial activities. The main activities are:

- Mapping relevant scientific, industrial, and policy **stakeholders**, engaging target groups, defining **key messages**, and detailing the tools and timeline for dissemination.

- **Visual Identity and Dissemination Materials**

- **Online Presence**: Launching a project website with detailed information, resources, news, and international cooperation aspects, as well as establishing and maintaining a presence on various social media channels and publishing periodic e-newsletters.

- **Events:** Holding introductory presentations to raise awareness about FUEL-UP's objectives and to initiate interaction with other projects and stakeholders.

- **Publications**: Issuing a project press release at the beginning of the project and producing factsheets, digital brochures, or policy briefs for the project's main deliverables.

- **Exploitation**: Conducting internal workshops to identify **Key Exploitable Results (KERs)**, determining ownership and **IPR measures** and pathways to ensure the uptake of these results by project partners and third parties.

5. Upcoming Presentations and Consortium Meetings

FUEL-UP Project partners met for the **third consortium meeting** in February 2025 in Istanbul and spent two action-packed days delving into the first 14-month project progress.

On the first day the project partners kicked off with in-depth work package presentations, showcasing the significant milestones achieved. The evening ended with a delicious dinner at **Banyan Istanbul**, with breathtaking views of the **Ortaköy Mosque** and the majestic **Bosphorus** – a perfect setting for fostering collaboration and inspiration.

Figure 4: Consortium Meeting in Istanbul, Feb. 25. Source: ETA-Florence

On the second day we had the privilege of visiting **Tüpraș's R&D Center** and **Izmit Refinery**, witnessing first hand their cutting-edge demo-scale hydroprocessing efforts.

Tüpraș's vital role in FUEL-UP involves enhancing wood-based oils and charting a course for their seamless integration into biofuel production.

Targeted dissemination and communication activities have been planned for the upcoming months in order to discuss the project goals, advancements and results within large platforms, initiatives and conferences.

On 9-12 June 2025 FUEL-UP will participate with a poster presentation as well as with a parallel presentation at the **33rd European Biomass Conference and Exhibition** in Valencia, Spain. The European Biomass Conference and Exhibition is one of the largest biomass conferences and exhibitions in the world with the aim of accelerating research and market uptake across the globe.

With the visual presentation "***Recovery of alcohols in Aqueous Stream from Stabilized Pyrolysis Oil Process***", on Tuesday 10th June afternoon, Sintef Industry will introduce a feasibility assessment study conducted as part of their activites for

Figure 5: Visit to Tüpraș's R&D Center. Source: ETA-Florence

FUEL-UP project, to recover specific key chemicals from aqueous streams from stabilized pyrolysis process (SPO_aqueous) and stabilized deoxygenated pyrolysis process (SDPO_aqueous).

FUEL-UP project, in fact, leverages **fast pyrolysis (FP) technology** to produce **bio-oils**, which are further processed through stabilization and deoxygenation steps to produce high-quality fuels and chemicals. These steps are integrated within large-scale refining to ensure efficient transformation of all streams into advanced biofuels and chemicals.

FUEL-UP's objectives and first results will also be presented during the Parallel Event "***Innovation and Sustainability for Maritime Biofuels***" on

Tuesday 10th June afternoon, dedicated to EU projects accelerating the deployment of sustainable biofuels and renewable energy solutions into the maritime transport sector.

From August 31 to September 5, 2025, FUEL-UP will be present at **EuropaCat 2025** in Trondheim, Norway. The event gathers scientists and students from academia and industry to discuss successful **catalyst development** and innovative solutions to tackle future resource and environmental challenges. It will explore catalysis service to society and the environment as well as looking into its fundamental scientific questions and solutions.

FUEL-UP will be also participating in the **2025 AIChE® Annual Meeting** in Boston, USA in November 2025 with the presentation "***Re-parametrization of NRTL model for C1+ organics and alcohols recovery from aqueous phase in biofuel production***" by Sintef.

AIChE Annual Meeting is the premier educational forum for **chemical engineers** seeking innovation and professional development.

At AIChE 2025 Sintef will describe in detail FUEL-UP's **aqueous phase valorization** process resulted from liquid-liquid separation with pyrolysis oil withdrawn to recover alcohols and other relevant chemicals such as acetic and formic acid. The main advantage introduced by this technology is the opportunity to replace fossil fuels with renewable carbon sources and wastes, leading to reduced emissions and improved circularity.

All partners will meet again in **June 2025** at **DLR's premises in Stuttgart, Germany**, for the **project's fourth consortium meeting**.

Figure 6: EUBCE 2024 in Marseille, France. Source: ETA-Florence

Figure 7: 2025 AIChE Annual Meeting. Source AIChE

info@fuelup-project.eu

www.fuelup-project.eu/

FUEL-UP Project

Project Coordinator

SINTEF

AristEng · Avecom · btg · btg-neXt · DLR Deutsches Zentrum für Luft- und Raumfahrt · etaflorence renewable energies · Ketjen · LIST · Tüpraş · Ranido

Funded by the European Union

This project has received co-funding from the European Union's Horizon Europe Research and Innovation Porgramme Under Grant Agreement N° 101136123. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.