BioMates

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Responsible authors:	Rocio Diaz-Chavez and Yara Evans

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1. Introduction

This document reports on the activities and findings of a workshop carried out for the project BioMates, (funded by Horizon2020, Grant Agreement No 727463). The workshop aimed at engaging stakeholders and the public in dialogue, enlisting their views, knowledge, and expertise, and gauging their expectations about factors that may hinder or enable the successful production and commercialisation of hybrid fuels, as envisaged in the BioMates concept. The report first introduces the BioMates project, before discussing aims, organisation, and activities of the workshop. It then moves on to present the workshop results, introducing and discussing the key topics in turn. The report concludes by summing up the key challenges and outlining the prospects for BioMates.

2. Introducing BioMates

2.1. The BioMates Project

The BioMates project aspires in combining innovative 2nd generation biomass conversion technologies for the cost-effective production of *bio*-based inter*medi**ates* (BioMates) that can be further upgraded in existing oil refineries as renewable and reliable co-feedstocks. The resulting approach will allow minimisation of fossil energy requirements and therefore operating expense, minimization of capital expense as it will partially rely on underlying refinery conversion capacity, and increased bio-content of final transportation fuels.

The BioMates approach encompasses innovative non-food/non-feed biomass conversion technologies, including *ablative fast pyrolysis (AFP)* and single-stage *mild catalytic hydroprocessing (mild-HDT)* as main processes. Fast pyrolysis in-line-catalysis and fine-tuning of BioMates-properties are additional innovative steps that improve the conversion efficiency and cost of BioMates technology, as well as its quality, reliability and competitiveness. Incorporating *electrochemical H_2-compression* and the state-of-the-art *renewable H2-production* technology as well as *optimal energy integration* completes the sustainable technical approach leading to improved sustainability and decreased fossil energy dependency. The overall BioMates-Concept is illustrated in Figure 1.

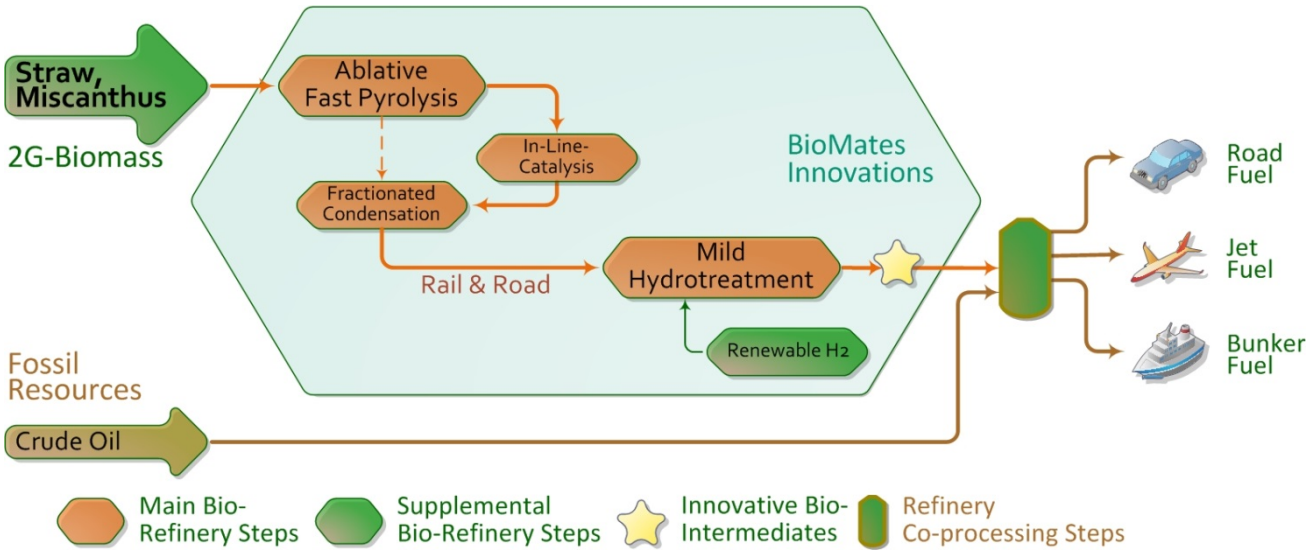

Figure 1: The BioMates-concept

The proposed technology aims to effectively convert residues and non-food/feed plants or commonly referred to as 2nd Generation (straw and short rotating coppice like miscanthus) biomass into high-quality bio-based intermediates (BioMates), of compatible characteristics with conventional refinery conversion units, allowing their direct and risk-free integration to any refinery towards the production of hybrid fuels.

2.2. European Commission support

The current framework strategy for a Resilient Energy European Union demands energy security and solidarity, a decarbonized economy and a fully-integrated and competitive pan-European energy market, intending to meet the ambitious 2020 and 2030 energy and climate targets (EC 2014a, EC 2014b). Towards this goal, the European Commission is supporting the BioMates project for validating the proposed innovative technological pathway, in line with the objectives of the LCE-08-2016-2017 call (EC 2015). This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727463.

2.3. The BioMates team

The BioMates team comprises nine partners from industry, academia and research centres:

- Centre for Research & Technology Hellas / CERTH - Chemical Process & Energy Resources Institute / CPERI, Greece (Project Coordination) - *http://www.cperi.certh.gr/*
- Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany - *www.umsicht.fraunhofer.de*
- University of Chemistry and Technology Prague, Czech Republic - *http://www.vscht.cz*
- Imperial College London, United Kingdom - *www.imperial.ac.uk*
- Institut für Energie und Umweltforschung Heidelberg gGmbH / ifeu, Germany - *www.ifeu.de*
- HyET Hydrogen B.V. / HyET, The Netherlands - *www.hyet.nl*
- RANIDO, s.r.o., Czech Republic - *http://www.ranido.cz/*
- BP Europa SE, Germany - *www.bp.com/en/bp-europa-se.html*
- Research Institutes of Sweden AB, Sweden - *https://www.ri.se/en*

For additional information and contact details, please visit *www.biomates.eu*.

3. The Stakeholders' Workshop

3.1. Aims

Engagement of diverse social actors in proposed projects is now a well-established requirement, both for sustainability purposes and for societal embedment of the bioeconomy (Diaz-Chavez, 2011; Baudry et al, 2017; Lynch et al, 2017, Leibensperger, 2021). It is also increasingly recognised that public perception and social acceptance of new technologies and products play an important role in their market diffusion and full-scale commercialisation, thereby also impacting on their viability and sustainability (Delshad et al, 2010; Chin et al, 2014; Lazini, Testa and Iraldo, 2016; Gracia et al, 2020).

Project partners at Imperial College, with support from other BioMates partners, organised and ran a stakeholders' workshop. The key purpose was to bring together diverse stakeholders to discuss a range of issues around biofuels, hybrid fuel production and commercialisation, as envisaged in BioMates. Gauging stakeholders' views and perspectives on BioMates also helps meet the objectives of tasks across other work

packages in the project, contributing, for instance, to assessment of social sustainability, to policy assessment, to understanding the risks related to social acceptance of the BioMates concept, capturing public perception of hybrid fuels, and determining market and regulatory barriers.

The workshop was initially envisaged as a physical meeting, but the onset of the Covid-19 pandemic in the Spring of 2020 led countries in Europe to restrict travelling and impose social distancing rules that in effect precluded a face-to-face event. As a result, the workshop was organised as an online meeting, held as a side event at the 29th European Biomass Conference and Exhibition (EUBCE), a large annual international conference that was also convened online due to the pandemic. BioMates secured a dedicated page within the conference's online platform to disseminate the project, whilst a separate page was set up to publicise the workshop itself, explaining the event, its aims, format and agenda (see Appendix I).

BioMates project partners helped identify stakeholders from their own professional networks to recruit potential participants in the workshop as visitors to the conference, whilst conference attendees were able to sign up for the workshop directly. Upwards of one hundred people showed an interest in the event and registered for it online, including stakeholders invited directly by partners.

3.2. The workshop

The workshop was held on 28th April 2021. A total of 18 stakeholders participated, alongside eight project partners, including those who joined the session to provide extra support to the partners who introduced the project to the audience and those who facilitated the interactive sessions. The stakeholders were mostly based in Europe (Figure 2), representing diverse sectors of interest or activity, although academics and researchers predominated (Figure 3).

Figure 2: Participants' Base Country (N=18)

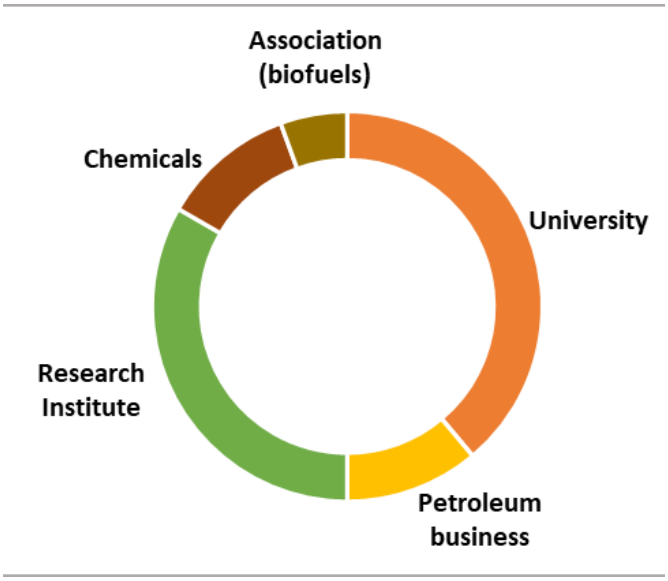

Figure 3: Participants' Sector (N=18)

Source: Stakeholders' Workshop (April 2021)

The workshop opened with an introduction to the key aims and features of the BioMates project. This was followed by two interactive sessions where participants were split into smaller groups in breakout virtual rooms to contribute their views and opinions on the topics under consideration. In the first interactive session, participants discussed risks to the sustainability of BioMates as a hybrid fuel value chain, focusing on risks in

three key stages of the chain: feedstocks, technical processes, and products. In the second interactive session, the focus turned to a discussion of factors that may hinder or enable the market diffusion of BioMates and the hybrid fuel obtained from co-processing with fossil fuel. The discussion focused on price, the role of policy, and factors conditioning social acceptance of the BioMates concept. After each interactive session, participants reconvened in the main virtual room for a brief session reporting and discussing the main findings. Time was also allocated for a final open-floor debate of any of the topics and themes examined before the workshop concluded.

3.3. Risks to BioMates

In the first interactive session of the workshop, participants identified and discussed risks related to three key features of the BioMates value chain, as well as proposing mitigating measures. The risks identified are associated with inputs, conversion technologies, as well as the intermediate product and final hybrid products obtained. Each is discussed in turn next.

3.3.1. Feedstocks

The BioMates project envisages the use of two types of advanced or second-generation biomass feedstocks (i.e., non-food/non-feed), namely straw (from wheat and barley), and the perennial grass miscanthus. These will be converted into the BioMates for further co-processing with crude oil streams in conventional refineries to be commercialised as a hybrid fuel for road, water and air transportation. Figure 4 summarises the risks identified (in red) along with the mitigation measures suggested (in green), relating to both the biomass and the crude oil feedstocks.

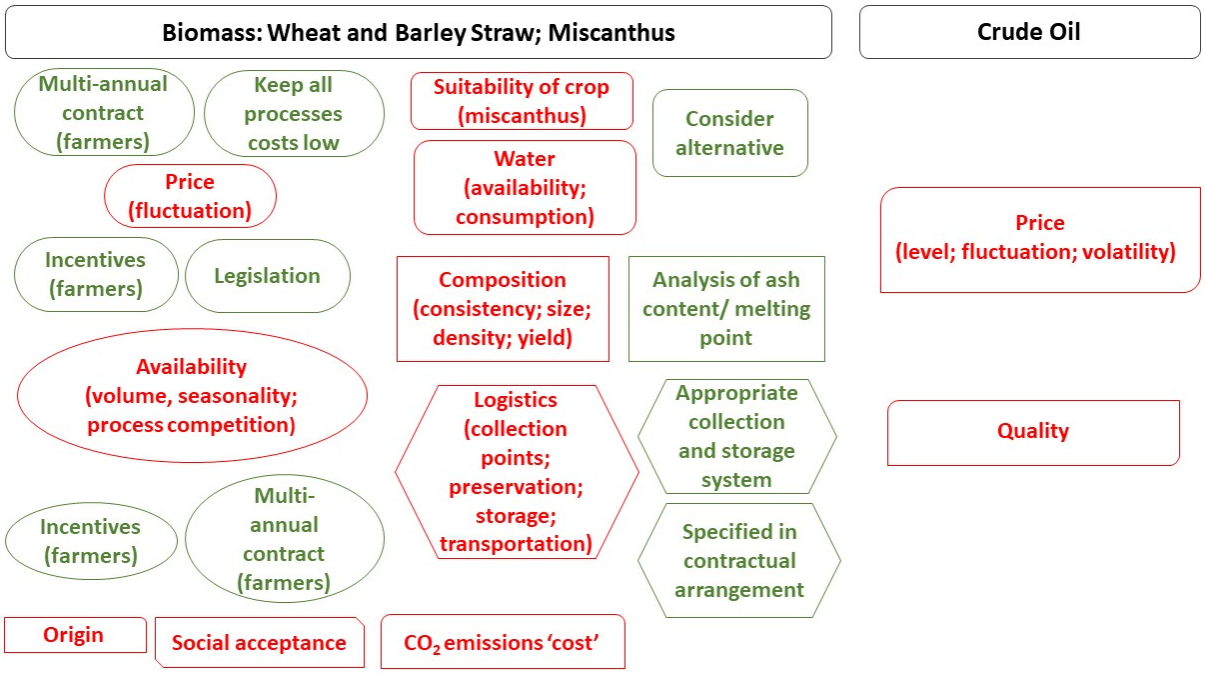

Figure 4: BioMates feedstocks

Source: Stakeholders' Workshop (April 2021)
Note: red is used for risks, green is used for mitigation; similar shapes are grouped together to show a relationship among the topics; different shapes are used for distinct topics

As can be seen in Figure 4, most risks identified are for the biomass feedstocks. Price of biomass feedstocks was seen as a risk due to likely fluctuations that will, in turn, impact along the chain. Amongst the measures proposed, two relate directly to ensuring supply by farmers. Firstly, through state provision of incentives, including subsidies, and secondly, through locking farmers and buyers into long-term (multi-annual) contracts.

Another measure proposed was to keep costs in all other areas (i.e., processes) as low as possible to mitigate against biomass price fluctuation. But legislation was also indicated as a measure to help keep biomass prices stable. Price was also identified as a risk for the co-feedstock crude oil, relating to levels, stability and volatility (i.e., sudden and unpredictable change).

Biomass availability was also identified as a risk, linked to volume, seasonality (i.e., whether available year-round), and competition with other uses (e.g., straw left on the ground post-harvest as soil cover for replenishment) and processes (e.g., other biorefinery uses). As with prices, state incentives to farmers and engaging farmers through long-term contracts were seen as measures to ensure biomass availability. A further risk noted was the origin of the biomass, linked to a concern with whether it would entail importation (i.e., cross-boundary movement) and all associated costs (e.g., financial, environmental, social) and whether it might displace other activities and the implications of that (i.e., indirect-land use change). The type and origin of biomass, in turn, are linked to a wider risk of social acceptance, although the fact that they are second generation (i.e., not edible crops nor animal feed) already helps mitigate it. Biomass feedstocks were also seen to be at risk of imposing a CO_2 emission 'cost' (i.e., not emission-free).

Regarding biomass characteristics, the suitability of miscanthus for conversion was questioned because of its own specificities, and because the crop requires large volumes of water for growing and processing, which in turn, raised the risk of water availability, leading to the suggestion that miscanthus will be replaced with an alternative, more appropriate crop. More generally, the composition of both types of biomass raised risks relating to size (i.e., volumes required for conversion), consistency and density (i.e., whether reliable for processing) and yield (i.e., volumes obtained), which could be addressed through technical procedures (e.g., analysis of ash content and melting points). The quality of the crude oil used for co-processing was also identified as a risk, since it will determine the refinery entry point for co-processing (i.e., 'sweet spot').

A final risk associated with the biomass feedstocks relates to logistics. Concerns were raised about the possible dispersal of collection points away from refineries and thus issues about transportation costs, and about storage conditions and measures to ensure preservation (e.g., straw decays rapidly). The design and implementation of appropriate collection and storage systems were suggested for addressing these risks, along with their specification in contractual agreements.

3.3.2. Processes

The main processes employed by BioMates are the AFP and single-stage mild catalytic hydro-processing (mild-HDT), which are complemented by fractional condensation, electrochemical hydrogen compression with state-of-the-art renewable hydrogen production, fine tuning of BioMates properties and optimal energy integration (Figure 5). In combination, these processes aim to ensure the quality, reliability, competitiveness, and efficiency of BioMates.

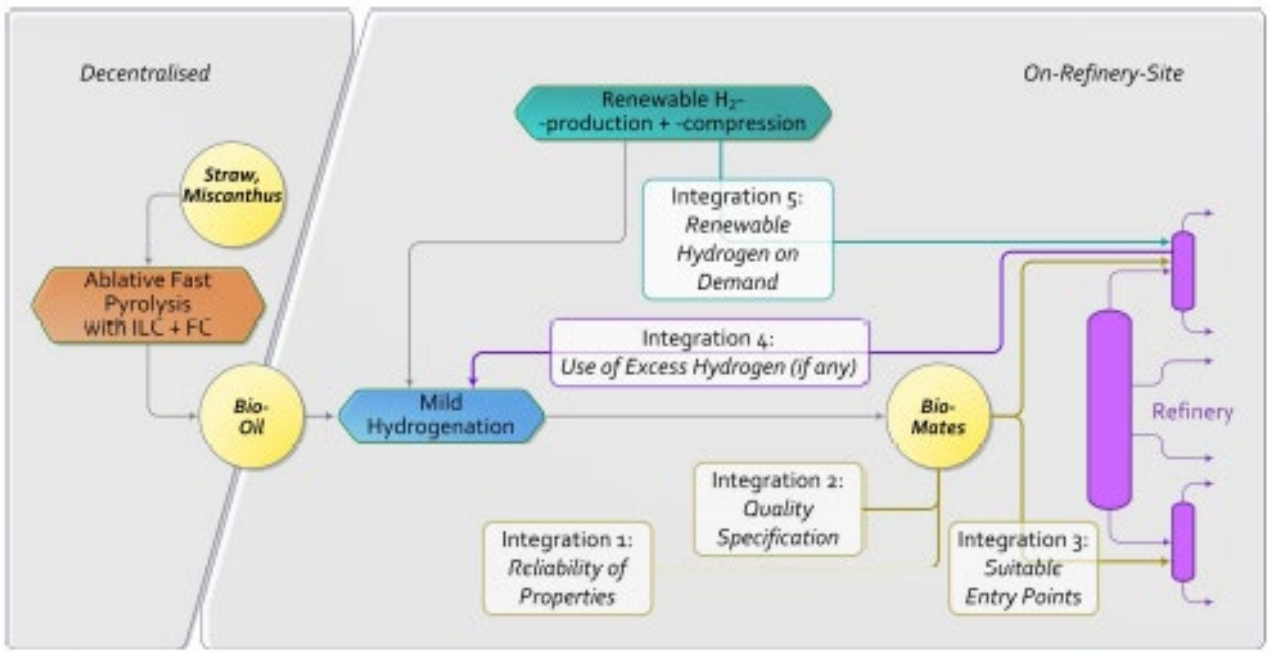

Figure 5: BioMates integration into conventional refineries

Source: Stakeholders' Workshop (April 2021)

The risks and mitigating actions relating to the different technological processes employed in BioMates identified by workshop participants are illustrated in Figure 6.

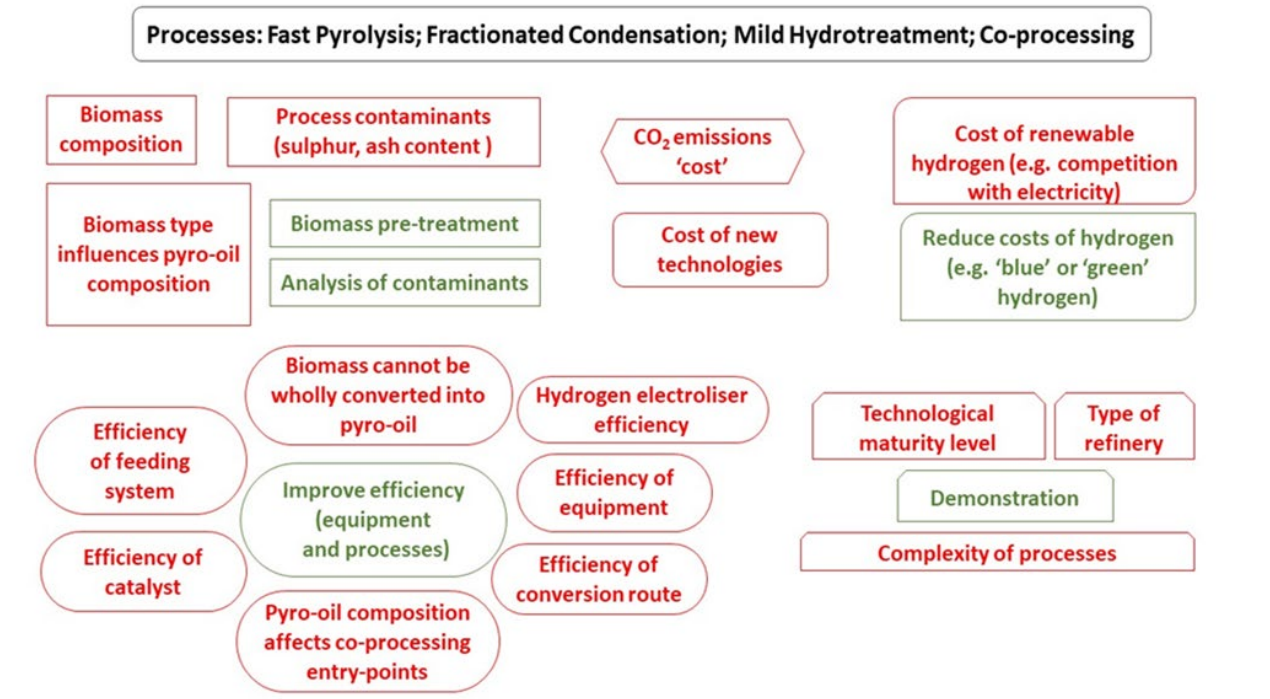

Figure 6: BioMates processes

Source: Stakeholders' Workshop (April 2021)
Note: red is used for risks, green is used for mitigation; similar shapes are grouped together to show a relationship among the topics; different shapes are used for distinct topics

As Figure 6 shows, the characteristics of the biomass feedstock (i.e., composition) pose risks to processes as contaminants (i.e., sulphur and ash content) which in turn bear on the composition of the bio-oil obtained and can be addressed by treatment of the biomass prior to conversion and analysis of contaminants. Various risks identified related to the efficiency of equipment and processes (i.e., catalyst, feeding system, conversion route, co-processing entry point, hydrogen electrolyser), that should be addressed by their overall improvement, even though, as was observed, not the whole of biomass can be converted, again, because of their own characteristics.

Risks related to costs were raised for new technologies, and hydrogen, particularly as it may compete with electricity, which could be addressed by using 'green' hydrogen (i.e., from electrolysis powered by renewable electricity; P2G), or still 'blue' hydrogen (i.e., from fossil sources).

Further risks to processes were identified for the technology itself, relating to the type of refinery, complexity of processes, and maturity (i.e., technological readiness level) which was also seen by some as an opportunity as they offer more options (i.e., different types of biomass, more conversion routes), although some also thought that high complexity means that technical malfunction or failure may impact on more processes. A final risk was identified as the cost of CO_2 emissions from chemical transformations of biomass.

3.3.3. Products

BioMates refers to the intermediate product obtained from the conversion of the biomass feedstocks, which will then be co-processed with crude oil to obtain the final product, a hybrid fuel that is ready for use as a transportation fuel on road, air and water vehicles. Figure 7 shows the risks identified for the bio-oil and hybrid fuel.

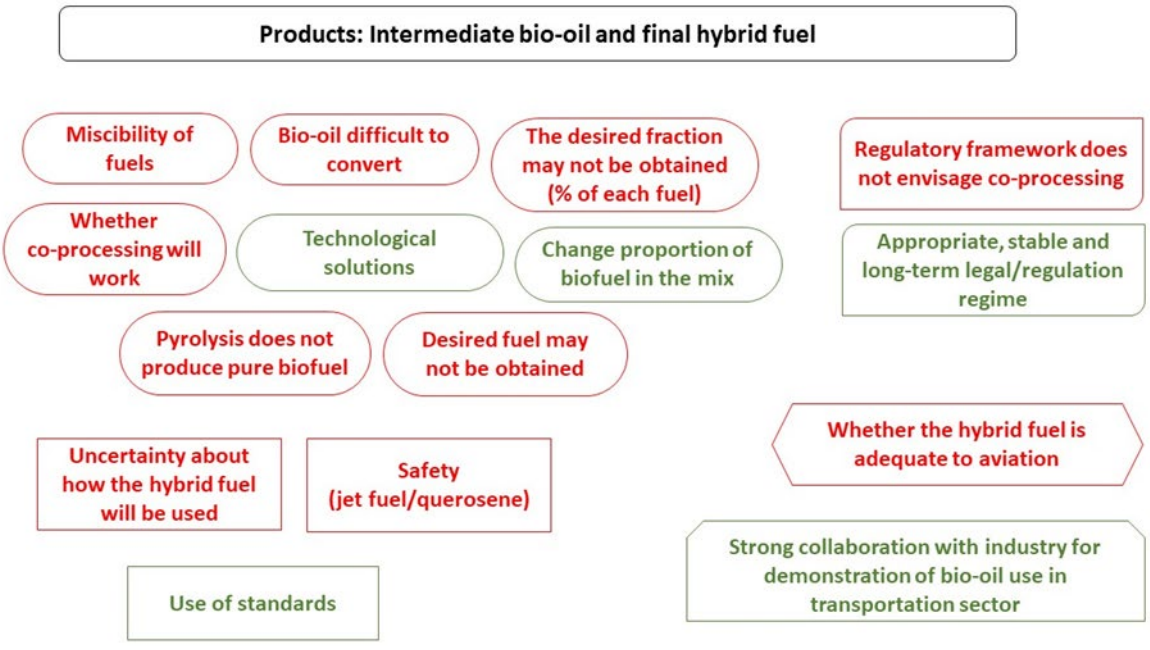

Figure 7: BioMates products

Source: Stakeholders' Workshop (April 2021)
Note: red is used for risks, green is used for mitigation; similar shapes are grouped together to show a relationship among the topics; different shapes are used for distinct topics

Some of the risks identified in Figure 7 relate to the actual characteristics of the bio-oil (i.e., difficult to convert further, may have impurities not eliminated by AFP), which, in turn, link to other risks. These relate the characteristics of the hybrid fuel, to miscibility and the proportion of fuels obtained in the final product, and, ultimately, to the effectiveness of co-processing of these two types of fuel (i.e., whether it works). Changing the proportion of biofuels in the mix and generally adapting processes are proposed as mitigating measures.

Other risks noted are associated with safety, particularly in relation to use as aviation fuel, but also uncertainly about potential misuse, although the adoption of standards and certification could help mitigate. But there were also questions as to whether this hybrid fuel is suitable for use in air transportation. This could be addressed through demonstration to the transportation sector in general, in collaboration with industry, thus underscoring the value and benefits of co-processing BioMates with fossil fuel for transportation, to help ensure the viability of the proposed hybrid fuel.

Risks were also noted in relation to the lack of provisions in existing regulations for co-processing (perhaps more pertinent in the context of the EU), which need to be included in appropriate and long-term regulatory regimes.

3.4. BioMates in the Market

In the second interactive session of the workshop, participants examined the barriers to market diffusion of BioMates and the hybrid fuel, as well as noting the factors that may enable it. The barriers identified are associated with price, policy and society's perception and acceptance. Each of these is discussed in turn next.

3.4.1. Price

Price is amongst the most important factors conditioning the market diffusion of technologies and products. Figure 8 shows the barriers to market diffusion related to prices that stakeholders identified at the workshop.

The availability of feedstock was noted as a barrier that has a knock-on effect on feedstock price itself. Other cost factors also impinge on feedstock availability and price, as for instance, water consumption and weather conditions.

High capital and operating costs may also slow down market penetration, including the costs of obtaining the technology and costs arising from technological drawbacks or problems.

Competition with crude oil prices, along with the volatility of fossil fuel prices may also discourage the market take-up of BioMates by refineries and other parties, as well as hindering the consumption of the hybrid fuel by end-users, not least because final prices to consumers may be higher than those for fossil fuels, resulting from compounding costs along the chain.

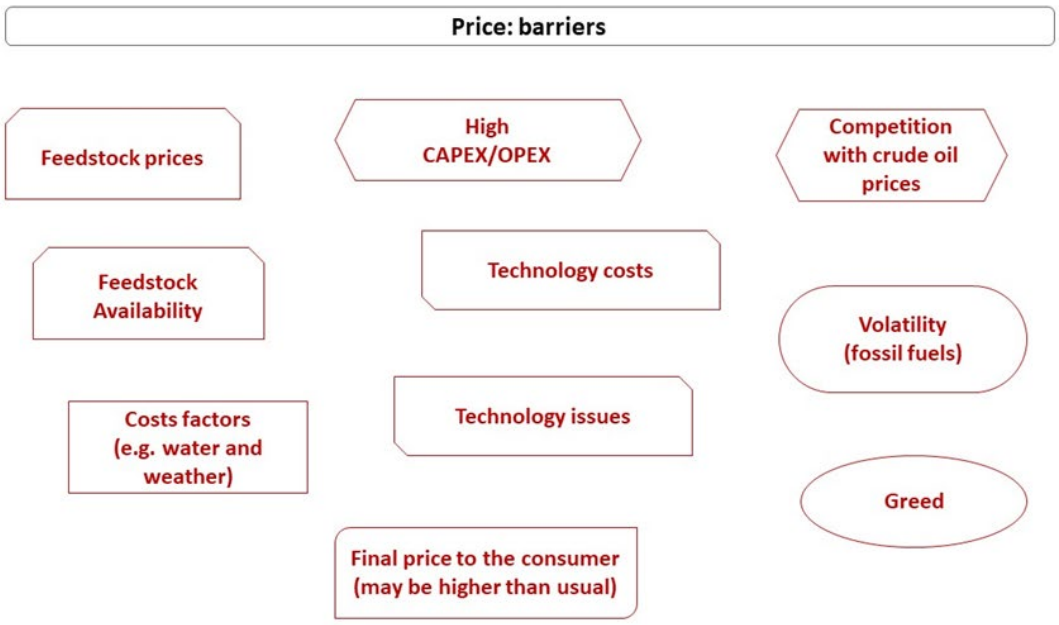

Figure 8: Price as barrier to market diffusion

Source: Stakeholders' Workshop (April 2021)

Factors related to price that may enable greater market diffusion of BioMates and the hybrid fuel could be actions to bring down the barriers identified, which are included amongst the various factors identified at the workshop as enablers of market expansion, shown in Figure 9. Thus, improving processes and technology was seen as important to reduce capital and operational costs and put prices in check, whilst also ensuring prices become competitive against fossil fuels, which may translate as prices that consumers find affordable.

Government support, including through public incentives, were also noted as enablers of market expansion for the intermediate bio-oil and the final hybrid fuel. Such incentives could help put in place the necessary procurement systems and anchored in regulations that need to be consistent, coherent and mandatory. The use of labels (for instance, for quality assurance) may also help raise the market share, and leverage it further if the proportion of the bio-oil in the hybrid fuel increases in the future, such increase being itself another enabling factor for increased consumption.

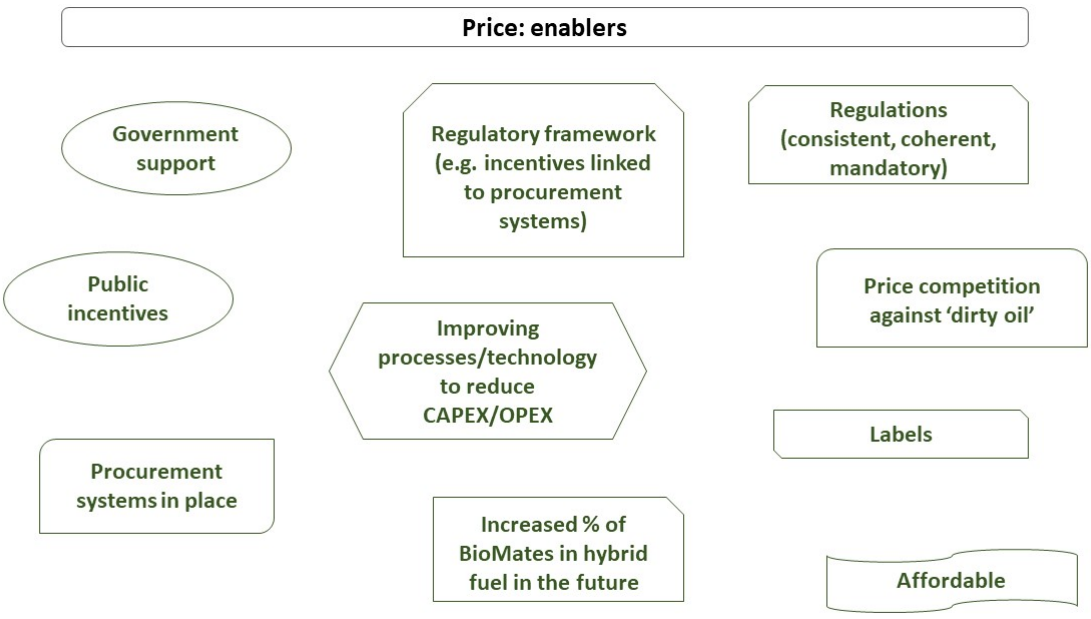

Figure 9: Price as enabler of market diffusion

Source: Stakeholders' Workshop (April 2021)

3.4.2. Policy

Figure 10 shows the policy hurdles to market diffusion of BioMates and the hybrid fuel discussed at the workshop. Existing policies in the EU were seen to offer no real incentives currently for the market take-up of either bio-oils or hybrid fuels. Policies that ban the use of particular types of crops or biomass also act as market barriers, as do strict policies that focus mostly on specific hybrid fuels (e. g., petrol and electricity) and these may further discourage diversification in road transportation modes (e.g., priority of private vehicles and combustion engines over public transport and all-electric engines). Policy focus on quotas, rather than on quality, was also highlighted as a barrier, although some participants also thought that the enforcement of quality regulations and standards may hinder market expansion (e.g., added costs). In the context of the European Union, the uneven implementation of regulations for renewable energy (Renewable Energy Directive/RED) across the region was seen as a key hurdle.

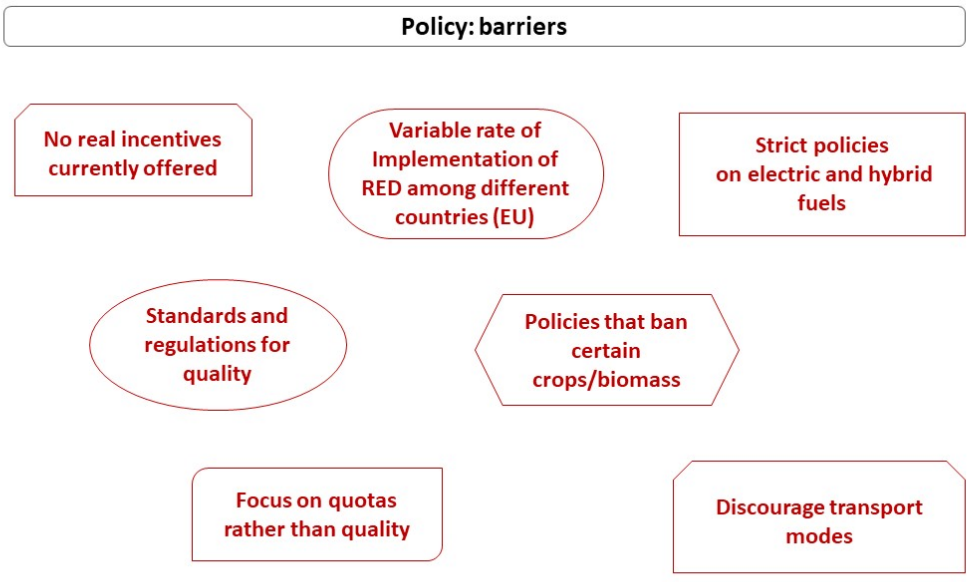

Figure 10: Policy as barrier to market diffusion

Source: Stakeholders' Workshop (April 2021)

The factors related to policy identified at the workshop as enabling market expansion of BioMates and the hybrid fuel are shown in Figure 11. The regulation of prices was called for, as was the provision of subsidies for achieving policy targets (i.e., renewable energy quotas), and parity in the provision of incentives (i.e., the same levels and types of incentives to be given to hybrid fuels are they are for electricity). Policies should also be flexible to allow for the accounting of bio-content in all energy products, and discounting should also apply for use of hybrid fuels. There was also a need for policies that encourage demand for hybrid fuels (such as that resulting from co-processing of BioMates and crude oil) and greater support to investment in production and commercialisation of hybrid fuels. More engagement from different industry segments with biofuel producers was also seen as important, along with interconnection and better articulating among oil companies, biofuel producers and all different segments within the transportation sector.

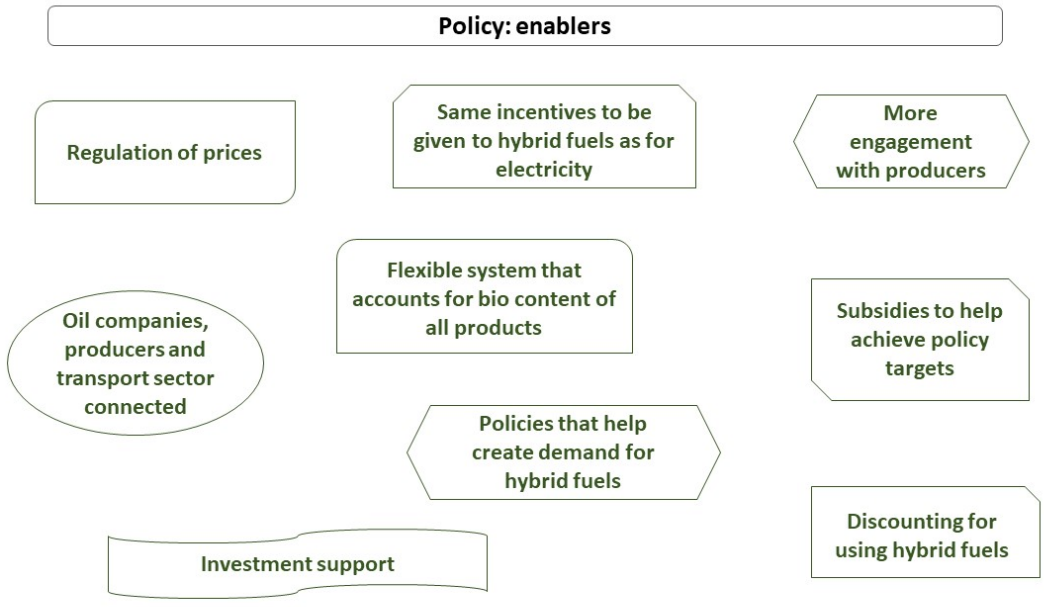

Figure 11: Policy as enabler of market diffusion

Source: Stakeholders' Workshop (April 2021)

3.4.3. Societal barriers and enablers of market diffusion

Figure 12 shows the societal barriers to market diffusion of the BioMates concept, that is, acceptance of inputs, processes and intermediate and final products, identified at the workshop. Amongst these was the perception that wider society lacks understanding and knowledge of biofuels and hybrid fuels. Awareness-raising campaigns focused on new biotechnologies and bioproducts were proposed to break down these barriers.

It was also discussed whether the fact that BioMates is co-processed with fossil fuels rather than being used on its own as entirely as a renewable transportation fuel (e.g., biodiesel) might not hinder market take-up, and whether the focus on hybrid fuels might not also discourage the use of other modes of transportation (e.g., electric vehicles). Proposed actions to clarify these issues involve the demonstration of the benefits of technologies and products through pilots, to highlight, also, their contribution to the reduction of CO_2 emissions, and the wider role in mitigating climate change through the emission of Green House Gases.

Price was also seen as a potential barrier for the market expansion of BioMates, that is, the price of the intermediate bio-oil for purchase by oil refineries and distributors, and the final product, the hybrid fuel to the final consumer. The most obvious measure touted is for prices to be made affordable (the 'right price') to help ensure market insertion and expansion.

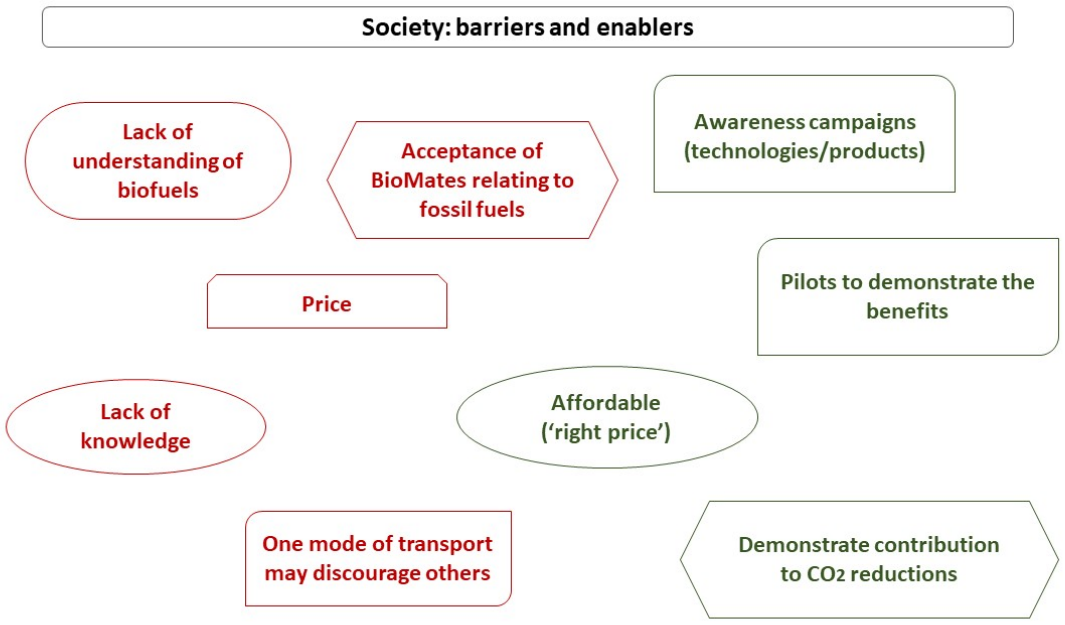

Figure 12: Social factors as as barriers and enablers of market diffusion

Source: Stakeholders' Workshop (April 2021)

3.5. Prospects for BioMates

The risks to the BioMates concept were discussed separately at the workshop, according to specific key topics relating to the production side, whilst the discussion on barriers to market expansion hinged on key factors affecting commercialisation and consumption. Yet, the various risks are interlinked, as are the different types of barriers. Together, they configure important challenges to the successful implementation of BioMates as a vialbe and sustainable commercial venture for energy production for the transportation sector. These linkages are shown in Figure 13, through a range of symbols.

Thus, for instance, risks to feedstocks such as availability, price, logistics, and origin all interrelate (i.e., high demand for biomass feedstocks, volatility of fossil fuel prices, costs with logistics, and costs deriving from the sourcing of biomass). They, in turn, interrelate with costs associated with the different conversion processes (i.e., part of OPEX and CAPEX), as well as products (i.e., BioMates and final hybrid fuel). They also link to price as barriers to market diffusion (i.e., type and volume of feedstock, competition with fossil fuels, price volatility, price to the consumer, cost of technology, cost of resources (e.g., water), and the effects of weather impacts on such resources (e.g., water scarcity, contamination, etc), along with barriers to social acceptance (i.e., affordability). In addition, the risk of social acceptance of feedstocks links to a lack of knowledge about types of feedstocks (i.e., biofuels and fossil fuels) which may hinder increased consumption. Many other linkages can be established across risks and barriers, helping delineate a complex picture regarding the actions, measures and policies needed. Indeed, a holistic approach that accounts for all of these interlinakages and the challenges they pose is imperative to understanding the prospects for the BioMates concept.

Whilst several of these challenges may be specific to the BioMates concept due to the combination of types of feedstocks used, the conversion processes, and the intermediate and final products obtained, most have been perennial issues in the wider context of biofuels value chain development, being extensively documented, alongside with their possible solutions, which also largely reflect the measures proposed by

stakeholders at the workshop (e.g., Diaz-Chavez, 2011; McCormick and Kauto, 2013; Hodgson et al, 2016; Goetz, German and Weigelt, 2017; Hassan et al, 2018; Panoutsou et al, 2021).

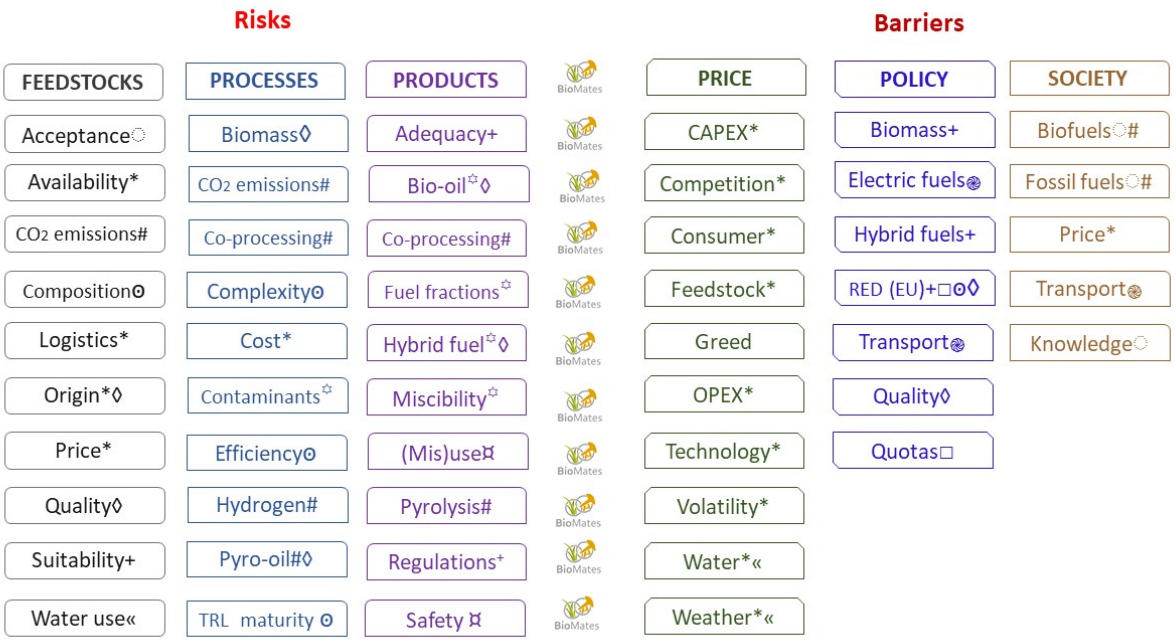

Figure 13: Risks and barriers to BioMates

Source: Stakeholders' Workshop (April 2021)

BioMates offers clear advantages over extant renewable fuel alternatives. For instance, it is converted from advanced, second-generation biomass feedstocks, which averts the 'fossil versus fuel' dilemma, and complies with the European Union Renewable Energy Directive (RED), a policy instrument that aims to enable the EU to comply with the 2015 Paris Accord on Climate Change (Gracia et al, 2020). In its latest review (Article 29 of the 2018 recast of the RED, EC2018a;b), the RED stipulated new binding targets for Green House Gas savings requirements for the transport sector, setting the mandatory share of renewable energy in the transport sector to 14% by 2030, with advanced biofuels contributing 0.2% in 2022, 1% in 2025 and 3.5% by 2030, and their contribution to carbon saving being double-counted in the calculation of the renewable energy mix for the sector (Cadillo-Benalcazar et al, 2021; Gracia et al, 2020).

BioMates is also being developed at a time when internal combustion engines in the EU are set to remain the main technology in road transport into the next decade, comprising around ¾ of the total light vehicle fleet, hence biofuels remain the most realistic renewable option for most transport vehicles up to 2030, and thus a key component in technology mix to address GHG emissions from transport, which have continued to increase, from 20% of the total GHG emissions in 2010, to 27% in 2016 (Gracia et al, 2020). The hybrid fuels derived from BioMates can be used directly in these conventional engines, without modification, and be supplied through existing fuelling stations (Chin et al, 2014). The hybrid fuels derived from BioMates will also contribute to the portfolio of fuels that incorporate biofuels being developed for shipping (Bach et al, 2020) and aviation (Filimonau, Miroslaw and Pawlusiński, 2018; Kim, Lee and Jaemyung, 2019). Hence, BioMates novel energy production technology has an important role to play in helping the EU meet its commitments to reducing carbon emissions from transport through increased use of renewable energy. Indeed, as Panoutsou et al (2021) note, advanced biofuels can make a substantive contribution to efforts to decarbonise road, air and water transportation in the short to medium term, so long as the challenges besetting their value chain

(including those identified by the stakeholders and reported here) are addressed to help speed up production and market uptake.

Stakeholders broadly accepted the BioMates concept, acknowledging that synthetic fuels have a role to play in the decarbonisation of the transportation sector in the immediate future, and that use of hybrid fuels may become a standard practice in the sector. But they also noted the following: that more investment is needed for overcoming technological 'bottlenecks' and improving processes; that greater use should be made of waste and residue rather than crop cultivation; that more 'green' energy sources should be used (e.g., electricity); that processing routes that emit less CO_2 be prioritised; and that production costs need to be kept as low as possible. Other issues noted were the need for much better integration of the supply chain, with greater efforts to ensure the sustainability of the whole chain, and stakeholder collaboration and synergy as essential to widening the market for BioMates, particularly among feedstock producers, biofuel suppliers, and companies and agencies operating in the transport sector.

Overall, from the point of view of the stakeholders at the workshop, the prospects for the BioMates concept are promising, as it is seen to offer a suitable interim solution to the seemingly intractable challenge of achieving zero carbon emissions through the phasing out of fossil fuels from the transportation sector. However, the evolving landscape for sustainable transportation fuels face long-standing challenges that need to be overcome through better articulation among all stakeholders, greater commitment to decarbonistion of the transport sector by business and government, effective state support, and stable and coherent policy frameworks.

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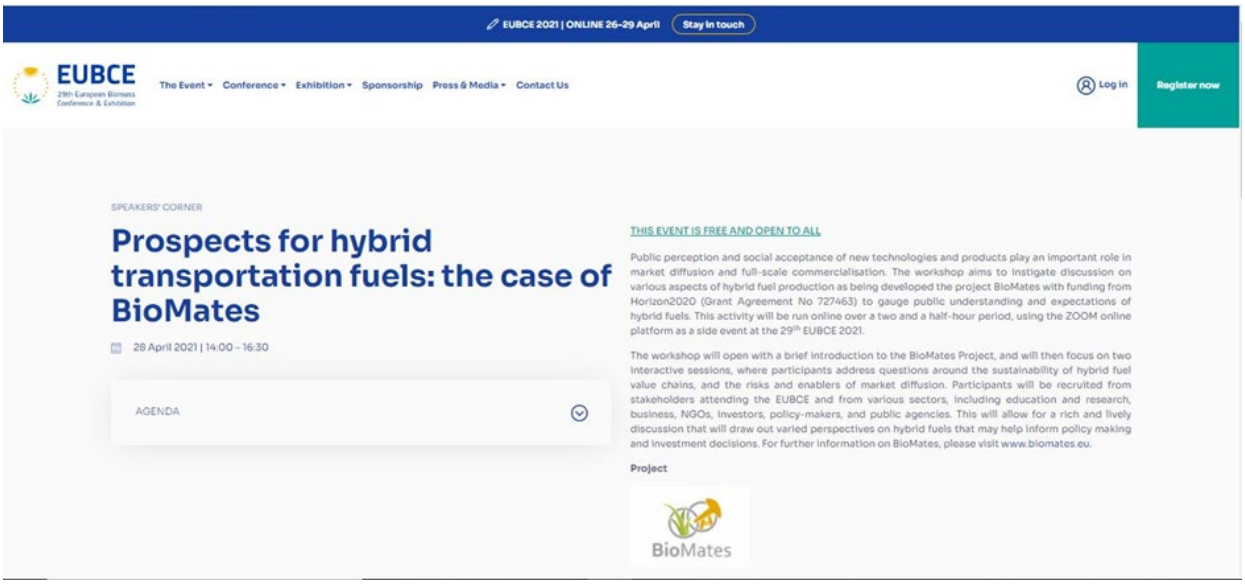
5. Disclaimer

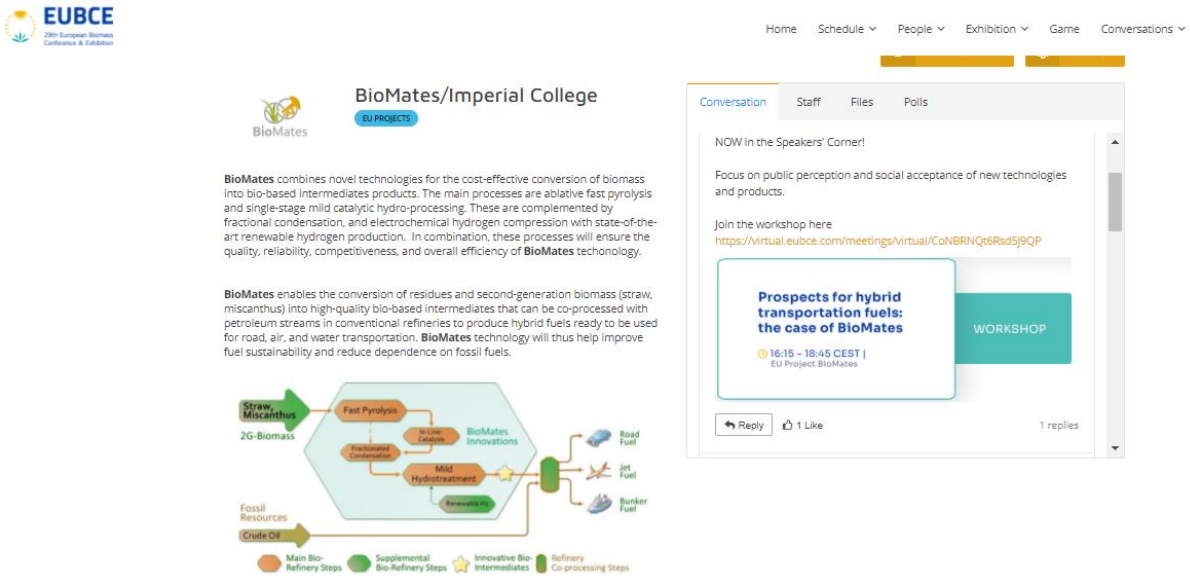
This report reflects only the authors' view. The European Commission and its responsible executive agency, CINEA, are not responsible for any use that may be made of the information it contains.

Annex I



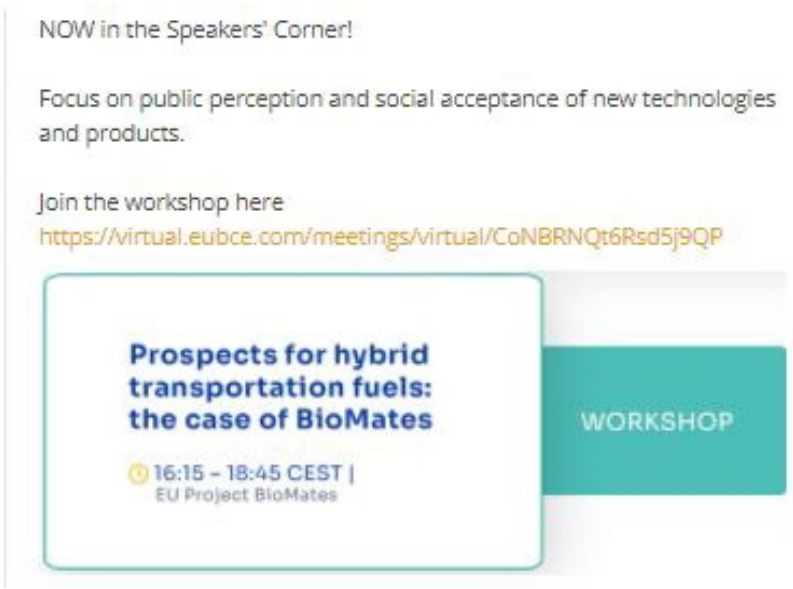
Source: EUBCE (2021), with detail enlargement

Annex II



BioMates combines novel technologies for the cost-effective conversion of biomass into bio-based intermediates products. The main processes are ablative fast pyrolysis and single-stage mild catalytic hydro-processing. These are complemented by fractional condensation, and electrochemical hydrogen compression with state-of-the-art renewable hydrogen production. In combination, these processes will ensure the quality, reliability, competitiveness, and overall efficiency of **BioMates** techonology.

BioMates enables the conversion of residues and second-generation biomass (straw, miscanthus) into high-quality bio-based intermediates that can be co-processed with petroleum streams in conventional refineries to produce hybrid fuels ready to be used for road, air, and water transportation. **BioMates** technology will thus help improve fuel sustainability and reduce dependence on fossil fuels.



Source: EUBCE (2021), with detail enlargements