2nd stakeholder engagement events and results' evaluation report

Unravel -Project
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Summary

This deliverable report describes the engagement and exploitation activities towards the diverse groups of UNRAVEL stakeholders carried out within the framework of the project in the period M33-M48, and describes the initial results (described in D7.3) that emerged from the activities. The work has been performed within WP7 and is linked to the progress achieved in the technical work packages (WP2, WP3, WP4, WP5 and WP6).

To achieve maximum impact of UNRAVEL, the target groups and potential users of project results have to be fully known and their needs have to be understood. The stakeholder engagement activities carried out within the UNRAVEL project are designed to maximize the project's impact and to facilitate the uptake of results and newly generated knowledge by all stakeholder groups. During project period, Soprema filed one patent on the production of polyols from lignin using ethylene carbonate and several scientific papers were published.

Based on the stakeholder engagement activities performed and based in the evaluation of preliminary results and knowledge outputs as well as existing knowledge gaps and potential risks and future market barriers that are of relevance, we have come to the conclusion that the topic of securing a solid biomass supply chain and sound feedstock logistics is one of the most important areas for intense stakeholder engagement.

The stakeholder engagement activities have also revealed valuable input and opinions from industry on the product applications. It was concluded that the lignin valorisation in PUR foams was definitely a good application with sufficient technical and economic viability. However, the sugar (C5 and C6) valorisation routes are not yet optimal and some additional applications were brought in by the stakeholder panel members. An initial SWOT analysis was performed by Polybridge to explore potential additional valorisation routes.

The importance of both above-listed topics to support a strong bio-based economy and the necessity to engage with relevant stakeholders has lately been confirmed by the BBI JU in their Annual Work Plan (AWP) 2021. In line with the Strategic Innovation and Research Agenda (SIRA), the AWP 2021 confirms the commitment to strengthen the participation of biomass feedstock suppliers in the value chain. BBI JU further will encourage partnerships with end-market actors to create a market pull for bio-based products. In UNRAVEL, based on our stakeholder engagement strategy and hands-on action, we strongly contribute to these strategic goals as set out by BBI JU.

Contents

1. Introduction

Aim of this document is to report on the engagement and exploitation activities towards the diverse groups of UNRAVEL stakeholders carried out within the framework of the project in the final period M34-M48, and to describe final results that emerged from the activities. This deliverable report is the follow up of Deliverable 7.3 that described the initial engagement and exploitation activities in the first project period (M1-M33).

The reader is referred to Deliverable 7.3 for the overall strategy and knowledge evaluation that is described there. The current deliverable report builds on that and provides an update of the stakeholder engagement and exploitation activities for the final part of the project.

2. Stakeholder engagement activities – Progress towards objectives

The specific objectives of UNRAVEL's stakeholder engagement activities during the first phase of the project (M1-M33) had been to enhance the project visibility at local, national and international levels and to connect with the scientific community to discuss the progress achieved in research and the technological development in the fields of lignocellulosic biorefinery, biomass processing via the FABIOLA organosolv fractionation process and the conversion to high quality lignin, (hemi)-cellulose and extractives resulting from the separate ELEANOR pre-extraction step performed as part of the UNRAVEL cascading process. The overall project strategy for targeted stakeholder engagement and the activities performed during that phase as well as the formats chosen were discussed in deliverable report *D7.3 1st Stakeholder engagement events and results' evaluation report* and further details can be found therein.

UNRAVEL's overall goals, specific objectives and activities during the final phase of the project (M34-M48), which is covered in this report, responded to the increasing maturity of concepts, technologies and results and aimed at:

- Demonstrating in more detail how UNRAVEL results and outcomes could be relevant to society at large, e.g. by helping to address the challenges of replacing fossil-based resources and to decarbonise specific industrial sectors, by utilising sustainable feedstocks, by improving the competitiveness of biorefinery and by creating jobs and positive environmental impacts.
- Maximising the support and public acceptance and minimising the risks of public resistance towards the upscaling of UNRAVEL technologies and concepts.
- Discussing expectations, hopes and concerns of the industry and especially of end users of UNRAVEL products (lignin, cellulose) towards future commercial lignocellulosic biorefinery, especially considering product specifications and economic feasibility and the sustainability of UNRAVEL value chains.
- Contributing to the European knowledge base on bio-based products from lignocellulosic feedstocks, sustainability performances, challenges and opportunities and so far underused feedstocks that can help to avoid the risk of competition over certain feedstocks that already see growing demands (e.g. hardwood chips).
- Ensuring that UNRAVEL results are taken up by decision-makers to influence policymaking, by industry to secure market uptake and sustainable growth as a segment of the bioeconomy.
- Paving the ground for a successful project follow-up, either via demonstration-level projects or via technology upscaling and investment by the private sector.

The multitude of objectives highlights the wide variety of stakeholder groups that needed to be targeted by UNRAVEL during the final phase of the project to meet the engagement objectives. The stakeholder groups that have been targeted by UNRAVEL between M34 and M48 of the project are listed in Table 1.

Table 1: Stakeholder groups targeted in Year 3 and 4 of UNRAVEL.

Scientific and technology community – Lignocellulosic Biorefinery (incl. related projects)	Industry – Lignocellulosic Biorefinery
Scientific and technology community – Lignocellulosic products (lignin, (hemi)cellulose, extractives), incl. related projects)	Industry – Valorisation lignin, (hemi)-cellulose, extractives
Biomass suppliers – Hardwood; pulp; agricultural & forestry residues, roadside grass (and other underused feedstocks)	End Users - Lignin, (hemi)-cellulose, extractives
Policy makers – Bioeconomy, environment, decarbonisation, biomass, forestry & agriculture, sustainability	Civil society – NGOs, environmental organisations, active citizens

The project's updated Advanced Dissemination and Exploitation Plan/DEP (last updated version submitted as part of the Technical Periodic Report RP2) during the final phase of the project provided the basis for UNRAVEL's stakeholder engagement activities by (i) outlining the updated UNRAVEL dissemination, exploitation and communication strategy and objectives for that phase, by (ii) providing the updated results of our in-depth stakeholder analysis, by (iii) refining the roles and responsibilities and (iv) by providing a work plan at task and stakeholder level, which had been specified for the period covered in this report after the finalisation of D7.3 (M33) and refined after RP2 (M36), making it the most current working document for stakeholder engagement.

Based on the work carried out, and as demonstrated by the outputs presented in this document, UNRAVEL met the objectives of the stakeholder engagement strategy. The detailed activities performed by UNRAVEL during the final phase of project year 3 and during project year 4 (2021 and 2022) per target stakeholder group are described in detail in the following chapters.

3. Stakeholder engagement activities – M34-M48

3.1. Stakeholder engagement activities towards specific stakeholder groups

As already performed and described in the 1st Stakeholder Engagement report (D7.3), also for the final phase of UNRAVEL knowledge generated within the project was screened for the potential to be shared with relevant stakeholders that are related to UNRAVEL' concepts and outputs. Consolidated knowledge that has been generated during the project term and especially between M30 and M48 that has been cleared from IP protection and therefore could be shared with a wider community comprised topics in biomass sustainability, availability and resulting risks and/or opportunities, results in biomass pre-extraction and fractionation, lignin application tests and performance results, the environmental impacts of lignocellulosic biorefinery as well as the techno-economics, social and regional aspects and the overall sustainability of the lignocellulosic value chains targeted by UNRAVEL.

In parallel to identifying newly generated knowledge that was of interest for sharing with relevant stakeholder groups, knowledge gaps and critical issues that require further knowledge exchange and discussions have been assessed. Here, the need for knowledge exchange was identified especially in the

areas of biomass supply, more precisely in possibly damaging competition over certain feedstocks in the future, and promising scale-up scenarios as well as product portfolios of future commercial lignocellulosic biorefinery, resulting national or regional strategies for scale-up and biomass sourcing and required strategies to guarantee the sustainable sourcing and use of biomass. Furthermore, a need for knowledge exchange has been identified for possible integrative scenarios for lignocellulosic biorefinery for biomaterials and biofuels and possible synergies that may arise from such combined approaches. A need for intense exchange with actors in biorefinery (science, technology and industry) has been identified as priority after the project has ended, as basis for technology scale-up and further exploitation of the overall biorefinery concept.

3.1.1. Engaging with the scientific and technology community via conferences and publications

Table 2 summarises the conferences at which UNRAVEL partners engaged with the science and technology community (incl. industry active in technology research and innovation) and the scientific publications that resulted from the project March 2021 and May 2022.

Table 2: Overview of conferences, events and publications as part of UNRAVEL's engagement with the science and technology community.

Conference	Target	Participant(s)
2021		
EUBCE conference 2021 (online)	Science Industry	Fraunhofer – poster presentation and pitch: "Unravelling an efficient fractionation of complex mixed lignocellulosic feedstocks in a pilot scale biorefinery"
2022		
EUBCE conference 2022 (online)	Science Industry	IFEU – keynote presentation: "Four questions to consider in LCA studies to identify bio-based products that are compatible with a defossilised economy"
UNRAVEL final conference 2022 (side event at EUBCE 2022)	Science Industry Policy	TNO, IFEU and Soprema presented results of UNRAVEL. EURIDA and TNO organized an additional panel discussion with industry and policy stakeholders.
Lignocost conference 2022 (Wageningen, NL)	Science Industry	TNO – Presentation on lignin characterization for bio-based products (UNRAVEL results and additional lignin depolymerization results outside of UNRAVEL)
Lignocost conference 2022 (Wageningen, NL)	Science Industry	Soprema – Presentation on PUR foams applications from UNRAVEL lignin

Note: Due to the COVID-19 restrictions and the related cancellations or postponements of relevant events the participation in scientific conferences by the UNRAVEL consortium has been very limited.
Scientific Publications (peer-review)
Pisano, I., Gottumukkala, L., Hayes, D.J., Leahy, J.J. (2021): *Characterisation of Italian and Dutch forestry and agricultural residues for the applicability in the bio-based sector. Industrial Crops & Products. DOI: 10.1016/j.indcrop.2021.113857* The article was published on the 27th July 2021.
Duval A., Vidal, D., Sarbu, A., René, W., Avérous L. (2022): *Scalable single-step synthesis of lignin-based liquid polyols with ethylene carbonate for polyurethane foams. Materials Today Chemistry. DOI: 10.1016/j.mtchem.2022.100793* The article was published on the 17th February 2022.
Smit, A.T., van Zomeren, A., Dussan, K., Riddell, L.A., Huijgen, W.J.J., Dijkstra, J.W., Bruijnincx, P.C.A. (2022): *Biomass Pre-Extraction as a Versatile Strategy to Improve Biorefinery Feedstock Flexibility, Sugar Yields, and Lignin Purity. ACS Sustainable Chemistry & Engineering. DOI: 10.1021/acssuschemeng.2c00838* The article was published on the 27th April 2022.
Smit, A.T., Verges, M., Schulze, P., van Zomeren, A., Lorenz, H. (2022): *Laboratory to pilot-scale fractionation of lignocellulosic biomass using an acetone organosolv process. ACS Sustainable Chemistry & Engineering. DOI: not available yet* The article was accepted on the 15th July 2022.

3.1.2. Inter-project knowledge exchange and engagement with related initiatives

During the final project period knowledge generated within UNRAVEL was shared and discussed with relevant EU knowledge and stakeholder platforms as well as projects that are related to UNRAVEL' topics and planned outputs. The transfer of knowledge and results will be continued after the end of UNRAVEL. The knowledge selected for knowledge transfer due to its relevance for wider target groups is listed in Table 3 below.

Table 3: Topics selected for targeted knowledge exchange.

Topic	Action	Target Groups
Topic #1: Overall UNRAVEL cascading concept for lignocellulosic biorefinery. **Subtopic #1.1**: Future integration of UNRAVEL processes in sustainable industry-scale plants and biorefineries **Subtopic #1.2**: Improving the overall sustainability of lignocellulosic biorefinery	A. Meetings for knowledge exchange and for developing future concepts with relevant projects and initiatives B. Develop public fact sheets and open databases for wider stakeholder groups	Biorefinery Biotechnology sectors Climate and sustainability community
Topic #2: Biomass supply chains, logistics and improved access to feedstock and wood resources for lignin applications; **Subtopic #2.1**: Type of resources and feedstocks deployed for the UNRAVEL value chains; **Subtopic #2.2**: Outlook on environmental, socio-economic and overall sustainability performance **Subtopic #2.3**: How can novel lignin value chains and the valorisation of extractives and biorefinery side-streams improve overall biomass use and forestry and agricultural management concepts	A. Meetings with relevant projects and initiatives B. Include biomass suppliers and experts in UNRAVEL for systematic knowledge exchange	Biomass suppliers Logistics experts in bio-based value chains Sustainability community
Topic #3: Results and recent developments on high quality lignin, extractives and hemi-cellulosic sugars as biorefinery products and high value applications **Subtopic #3.1**: Novel applications from high quality lignin, esp. in the construction sector (bitumen, polyols, PU/PIR) **Subtopic #3.2**: Valorisation of extractives, e.g. botulin, for the pharmaceuticals and green chemistry sectors **Subtopic #3.3**: Valorisation of hemi-cellulosic sugars for bio-ethanol	A. Meetings with relevant projects and initiatives B. Include industrial stakeholders and end users for systematic knowledge exchange	Manufacturers bio-based products Chemical sector Pharmaceutical and cosmetics sector (esp. for betulin as extractive from birch)

The topics and results that have been identified to be of strongest interest for targeted knowledge exchange, as listed above, further built the basis for inter-project communication. UNRAVEL initiated contacts with coordinators and/or partners from related projects (see Table 4), building the fundament for continuous knowledge exchange during the final phases of the project.

Table 4: UNRAVEL Inter-Project Exchange – Topics and action performed.

Topic	Target Project(s)
Topic #1: Future integration of FABIOLA™ in LIBERATE project's pilot scale electrochemical plant concept for zero CO_2 processing and improving the overall sustainability of lignocellulosic biorefinery	LIBERATE (funded by Horizon 2020/SPIRE) www.liberate-project.eu
Action performed: After two meetings during RP2, one meeting was held during RP3 to continue the exchange on the topics of highest interest, which had been previously identified to be: ➢ **Lignin depolymerization:** Based on objectives, concepts and results achieved by both projects so far, the idea emerged to couple the enzymatic lignin depolymerisation route from MetGen, as developed and scaled up in UNRAVEL, to the electrochemical depolymerization route that has been developed in LIBERATE. The exchange of UNRAVEL and LIBERATE samples for further testing is in preparation and will be completed shortly. ➢ **Techno-economic feasibility, TEA/LCA and energy savings**: LIBERATE will perform a techno-economic analysis (TEA) of the ethanol organosolv lignin and the electrochemical conversion in the SINTEF pilot plant. UNRAVEL will equally perform a TEA and full LCA of the entire FABIOLA™ lignin value chain. The data from LIBERATE's TEA of the ethanol organosolv lignin will be highly interesting for UNRAVEL (base case TEA in WP6) and vice versa. Discussions are in progress about the confidentiality of results. Data that are assessed by LIBERATE and UNRAVEL to be not confidential will be exchanged between sustainability experts of both projects. They further discussed an assessment of the future energy mix to be used in the TEA/LCA approach in LIBERATE with input given by UNRAVEL that has been of benefit for LIBERATE by extending their reference database. **Achievements:** Non-confidential process information for the UNRAVEL ethanol organosolv process and the associated TEA/LCA was shared with the LIBERATE consortium to facilitate the TEA work in that project. Several LIBERATE partners expressed their interest to test the performance of the MetGen depolymerized lignin as developed in UNRAVEL subsequently in the SINTEF/JGU Mainz pilot process for electrochemical depolymerization of lignin. No agreement on the conditions for the Material Transfer had been found between all partners involved by the end of UNRAVEL. However, MetGen will continue in their attempt to reach agreement in a smaller group of involved parties after the end of the UNRAVEL project. This may result in extended exploitation opportunities for UNRAVEL partner METGEN.	
Topic #2: High quality lignin, its properties and possible valorisation options (esp. using enzymatic depolymerization and characterization)	WoodZymes (funded by BBI JU) www.woodzymes.eu
Action performed: 1. **Meetings & knowledge transfer:** Two meetings were held during the final period between the coordinators and selected partners of both projects, especially to discuss the enzymatic treatment of lignin from different feedstocks, and the potential of future products for the novel, modified high quality lignin.	

2. **Sample exchange:** WoodZymes and UNRAVEL, based on results achieved, decided to test each other's lignin for the project's target applications, respectively. Several UNRAVEL lignin samples were exchanged with WOODZYMES partner FCBA to test the performance in phenol-formaldehyde resins. The results of the work were found to be successful as it was proven that 80% of the phenol could be replaced by lignin. TNO and FCBA are currently looking for further opportunities to develop this valorisation route and to test the properties in end applications from industrial partners.
3. **UNRAVEL participated in the WoodZymes final workshop (November 2021)**:

WoodZymes organised their Final Workshop on November 4th, 2021 from 9:00-15:30 as hybrid event in Bordeaux, hosted by FCBA. UNRAVEL in a dedicated session on lignocellulose valorization presented concepts and results in an oral presentation (20 mins).

In addition to the inter-project exchange described above, TNO introduced the FABIOLA™ mild organosolv fractionation process that will be upscaled by UNRAVEL to the **EU COST Action 'LignoCOST'** as part of Working Group 2: Production and catalytic conversion technologies. It has been listed in the overview of fractionation methods to produce lignin.

Further knowledge transfer is planned after the end of UNRAVEL as part of the LignoCOST working group activities (e.g. TNO, SOPREMA and IFEU presented at the LignoCOST meeting in Wageningen, June 2022).

3.1.3. Engagement with industrial stakeholders and end-user representatives

Direct knowledge exchange and engagement with industrial stakeholders and future end users via meetings has mainly been implemented via an Industrial Stakeholder Panel, which includes selected representatives from the various lignin application and the biomass supply sectors.

During the second phase of UNRAVEL a Stakeholder Panel has been established which comprises, as one of two sub-units, the **Industrial Stakeholder Panel**. It includes partners from the industry and end users as well as manufacturers relevant along the UNRAVEL value chain.

Members of the "Industrial Stakeholder Panel – Market End Users" are:

- **EIFFAGE** (www.eiffage.com): Market leader in pavings. Possible valorisation of lignin in bitumen without competition with key exploitation partner SOPREMA or other UNRAVEL partners.
- **Polybridge** (www.polybridge.com): Consultancy for innovation strategies and valorisation in wood chemistry and polymer products.
- **SOPREMA (**www.soprema.fr**)**: One of the world leaders in insulation and roofing materials, using lignin as compound for PU/PIR and bitumen. SOPREMA is industry partner in UNRAVEL and also participates as expert in the Industrial Stakeholder Panel.
- **SAPPI (**www.sappi.com**)**: Sappi is a large company in the pulp and paper industry. They are interested in alternative products from the feedstocks they normally use and the valorisation of cellulose, hemi-cellulose and lignin towards different end-users.

3.1.4. Engagement with biomass suppliers and logistics stakeholders

One group of key stakeholders that during the first two years of UNRAVEL have been identified as crucial for future industry-scale lignocellulosic value chains are biomass suppliers and experts in biomass logistics. Therefore, as second subunit of the UNRAVEL Industrial Stakeholder Panel, the **Biomass Supplier & Logistics Panel** was set up. It includes partners from the biomass supply side as well as public authorities at national and European levels.

Members of the "Industrial Stakeholder Panel – Biomass Suppliers & Logistics" are:

- **Staatsbosbeheer - Dutch Forestry Management Agency** (www.staatsbosbeheer.nl): Staatsbosbeheer is a Dutch public institute that protects, maintains and develops the Dutch nature (270.000 ha forest, nature areas and typical landscapes). They are interested in the valorisation of forestry residues and other residues coming from their activities. They have a good overview of the feedstock market and can indicate the needs from their perspective.
- **Italian Biomass Association/ITABIA** (www.itabia.it): An Italian network promoting the local transformation towards a sustainable bioeconomy, using renewable resources, such as agricultural biomass and residues for bio-based products and bioenergy.

First online meetings were organised in January/February 2021 with both sub-units of the Panel individually, during which the UNRAVEL concept has been introduced. Two follow-up meetings were organized to further discuss the results and potential outlook for UNRAVEL. A short overview of the topics and outcomes of the meetings with the industrial stakeholder panel (end users and logistics/suppliers) is given in Table 5.

Table 5: UNRAVEL Industrial stakeholder panel – Topics and actions performed.

Topic stakeholder meeting	Outcome
Presentation of the UNRAVEL LCA results	Information to the stakeholder panel members and basis for further discussions to optimize the LCA profile of the project.
From an LCA point of view, the C5 valorisation does not gain much because the product (xylonate) is replacing an already bio-based source for the production (gluconate is normally used and that is of bio-based origin).	The UNRAVEL recommendation for C5 utilisation is to look for alternative products that replace fossil-based products. An alternative outlook might be to use both the C5 and C6 for fermentation to ethanol because that always works and the market is large so it will be relatively easy to sell.
Discussion of the potential markets for UNRAVEL products.	It is complicated to valorize three different bio-based components into various markets, e.g. due to different market sizes. It was proposed by Polybridge that one could maybe use all cellulose for one specific product in a high volume market. However, the lignin might be used in several lower volume markets with specific needs.
Supply chain issues with biomass feedstocks	ITABIA addressed the supply chain issues for feedstocks such as agricultural residues. The residues are usually produced in relatively small farms and there is no organized collection of residues for further uptake in biorefinery processes. In addition, there can be barriers with regulations when the residues are considered as a waste material. Important aspects to be solved when upscaling technologies that use these feedstocks.
Use of lignin to replace bitumen in asphalt	Kraft lignin is already used in demonstration roads to replace bitumen (e.g. CHAPLIN project in NL). Eiffage wonders about the potential for UNRAVEL. It looks like the organosolv lignin is too hydrophilic to be compatible with asphalt. This was seen from the bitumen application work at Soprema.
UNRAVEL final conference at EUBCE	Positive feedback on the idea and members of the stakeholder panel were interested to contribute and prepare the panel discussion.
Alternative use of lignin in applications	Suggestions from industry are to look into polymer additives for e.g the automotive industry. In addition, lignin use as anti-oxidant or (after modification) as flame retardant.

Additional feedstocks for the FABIOLA process	ITABIA suggests that it is interesting to valorize rice straw with the UNRAVEL concept. There is a vast amount of rice straw produced with limited use currently.
Further steps towards upscaling and market implementation	Polybridge offered to perform a SWOT analysis of the UNRAVEL concept and will share with the consortium (see results below).

Polybridge provided the consortium with the outcome of the SWOT analysis of three applications:

-Lignin to polymer additives

-C5 sugar valorisation to xylitol

-C5 and C6 sugar valorisation to bio-ethanol

The results of the SWOT analysis (Figures 1-3) contain valuable details for the current and potential other applications for the UNRAVEL sugars (C5 and C6) and the lignin from the FABIOLA process.

SPECIALITIES: FABIOLA® Lignin valorisation to POLYMER ADDITIVES

STRENGTHS	WEAKNESSES
• Bio-based additive • Sulfur-free additive • Cost competitive versus synthetic AOs at ca. 4000 EUR/ton • Specialties do not require an upstream mobilization of large volumes of biomass → lower risk of conflict bewteen the various biomass valorisation routes	• Color which can lead to initial discoloration of polymers • Hydrophilicity ? (to be checked) • Purity > 99% ? • AO efficiency versus synthetic phenolic AOs ? (to be checked)
OPPORTUNITIES	**THREATS**
• Increasing interest of the polymer industry in reducing the carbon footprint of formulations • Potential use in applications not sensitive to discoloration: black pigmented elastomers, recycled plastics	• Other lignins derived from other Organosolv processes

Figure 1: SWOT analysis results for lignin to polymer additives.

SPECIALITIES: FABIOLA® C5 valorisation to XYLITOL

STRENGTHS	WEAKNESSES
• Non GMO bio-based C5 sugar • C5 derived from biomass leading to no conflict with food chain • Specialties do not require an upstream mobilization of large volumes of biomasss → lower risk of conflict between the various biomass valorisation routes	• Cost-competitiveness versus C5 derived from LENZING viscose process ? • Lack of hydrogenation process on site to convert C5 to xylitol ? • No partnership so far with the global XYLITOL market leader DANISCO
OPPORTUNITIES	**THREATS**
• The global market growth CAGR of XYLITOL is + 7% over the period 2021-2024 • High demand of the personal care and food industries	• Cost positioning versus other C5 sources derived from other biomasses sugar cane, beets, corn..... • Lengthy approval process by xylitol producers like DANISCO ?

Figure 2: SWOT analysis results for C5 sugar valorisation to xylitol.

COMMODITIES: FABIOLA® C5 & C6 valorisation to BIO-ETHANOL

STRENGTHS	WEAKNESSES
• C5 & C6 sugars derived from biomass leading to no conflict with food chain	• Cost-competitiveness of the FABIOLA process versus C5 & C6 sugars derived from other vegetal biomasses sugar cane, beets, corn, cellulose pulp process (TEMBEC, BORREGAARD..) • Large production capacity needed to meet the demand: high investment costs involved
OPPORTUNITIES	**THREATS**
• The global market growth of BIO-ETHANOL is CAGR + 4.5% • Rising demand for a cleaner and renewable source of energy	• Substantial mobiliization of biomass needed to meet the very high demand for sugars, leading to potential conflicts between the various biomass valorisation routes • Very competitive, cost-driven environment, meaning other products generated by the FABIOLA process (lignin in particular) will have to be very well valorized to ensure C5&C6 cost-competitivess • High fluctuations of the average ethanol market price which could j jeopardize the profitability of the sugar business

Figure 3: SWOT analysis results for C5 and C6 sugar valorisation to bio-ethanol.

UNRAVEL organised its final event as an open workshop at the occasion of the largest European biomass conference EUBCE on the 10th May 2022. The workshop was organised by EURIDA and TNO as a 1 hr 45 min event that covered two sessions. Session 1 included short overview presentations on the UNRAVEL concept and key findings from the scientific and technological, the industrial and the sustainability perspectives. Session 2 was organised as a Panel Discussion with panelists including UNRAVEL experts (André van Zomeren/TNO, Heiko Keller/IFEU), members of the external UNRAVEL Industry & Biomass Stakeholder Panel (Carla de Carolis/ITABIA, Pascal Xanthopoulos/Polybridge), biorefinery and bioenergy experts (Jaap Kiel/TNO, Francisco Girío/LNEG) and policy experts from the European Commission (Thomas Schleker/EC DG Research & Innovation). The Panel Discussion was moderated by Rita Clancy, Communication Manager of UNRAVEL. The event and list of speakers as well as the detailed agenda are shown in Figure 4 and

Figure 5.

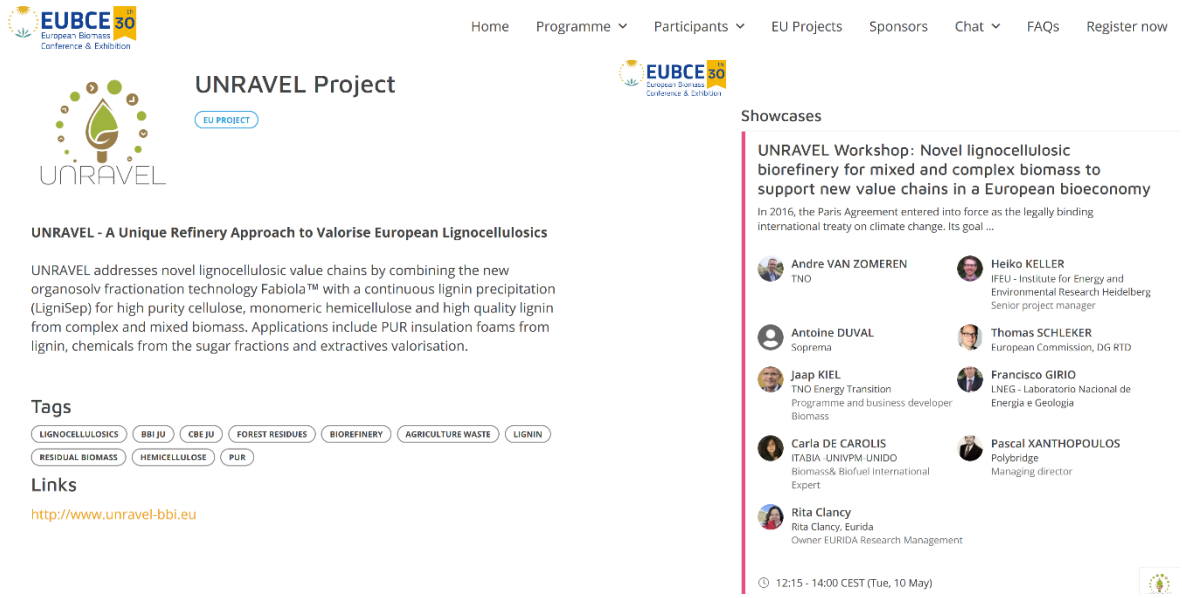

Figure 4: UNRAVEL Workshop at EUBCE 2022 and speakers list.

Workshop Title:

UNRAVEL Workshop:

Novel lignocellulosic biorefinery for mixed and complex biomass to support new value chains in a European bioeconomy

Short description of the event:

In 2016, the Paris Agreement entered into force as the legally binding international treaty on climate change. Its goal is to limit global warming to well below 2° Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reduce global greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century. One of the pillars of the European Union to reach treaty targets foresees more sustainable products and production processes that minimise the use of fossil resources. A major challenge for the transition towards a low-carbon bio-based economy is the development of new value chains for innovative added-value products based on sustainable and industrially viable biomass.

Lignocellulosic biomass is an abundant and renewable resource from plants mainly composed of polysaccharides, such as cellulose and hemicelluloses, and an aromatic polymer – lignin – and represents an important category of feedstocks suitable for biorefinery processing. It has a high potential as an alternative to fossil resources to produce second-generation biofuels, bio-based chemicals and materials. Especially biomass residues that originate from forestry or agriculture could be sustainable feedstocks for higher value products that could help to avoid competition over hardwood with a generally high demand.

Recent studies indicate that the feedstock availability in the EU can be sufficient to provide a significant part of the carbon needed for material use such as polymers. However, competition exists over certain lignocellulosic feedstocks from various sectors, with bioenergy currently being one of the most abundant applications.

Future scenarios will therefore have to consider biomass availabilities and assure higher feedstock flexibilities of biorefinery processes to ensure their economic feasibility at industrial scales. Furthermore, environmental and biodiversity aspects will play important roles in the future success of lignocellulosic value chains.

This side-event of the 30th EUBCE comprises presentations and a panel discussion and is organised by the BBI JU UNRAVEL project. It will give the audience insight in:

- Breakthroughs on the way to high value applications from complex and mixed lignocellulosic biomass, combining a new biomass upgrading concept with organosolv fractionation and a continuous lignin precipitation technology

- Environmental and socio-economic aspects of lignocellulosic value chains, future prospects, challenges and remaining barriers
- The challenges and opportunities that in the future may arise from utilising the same type of second generation feedstocks for different sectors, among those energy and bio-based materials, growing feedstock demands, the risk of competition and the role of climate change and biodiversity strategies and programs

Agenda

12:15 – 13:00 CET - Session 1: Oral Presentations

12:15 – 12:30 Session 1.1 (Technology focus): Effective lignocellulosic biorefinery for new value chains in a European bioeconomy – The UNRAVEL approach
Speaker: André van Zomeren, TNO/The Netherlands

12:30 – 12:45 Session 1.2 (Sustainability focus): Environmental and socio-economic aspects of lignocellulosic value chains – Prospects, remaining challenges & recommendations
Speaker: Heiko Keller, IFEU/Germany

12:45 – 13:00 Session 1.3 (Industry focus): Lignin, (hemi)cellulose and extractives – Promising applications for a bio-based future
Speakers: Antoine Duval, SOPREMA/France

13:00 – 14:00 CET - Session 2: Panel Discussion

Second generation biomass for energy AND material use – Future conflict or opportunity?
Panellists:

- *Thomas Schleker (EC DG Research & Innovation)*
- *Jaap Kiel (TNO/The Netherlands)*
- *Francisco Gírio (LNEG/Portugal)*
- *Carla de Carolis (ITABIA/Italy)*
- *Pascal Xanthopoulos (Polybridge/France)*
- *Heiko Keller (IFEU/Germany)*

Moderation: *Rita Clancy (Eurida/Austria) & André van Zomeren (TNO/The Netherlands)*

Figure 5: Description and agenda of the UNRAVEL Workshop at EUBCE 2022.

3.1.5. Engagement with the wider public and citizen stakeholders

To assure a wide interest in UNRAVEL beyond the scientific and industrial technology communities project results and concepts have been embedded in a wider context, which included future applications of societal impact that will be enabled based on our project's progress. Key messages have been formulated with the support of all consortium partners. We put a particular focus on non-technical easy-to-understand language to convey the bigger picture to the general public and interested citizens from various backgrounds. To this end, key messages and findings from the UNRAVEL project have been translated into easy-to-understand language and transferred to Fact Sheets. These Fact Sheets have been described in detail in Task 7.5 as part of the overall knowledge exchange activities.

Especially the content on applications and biomass valorisation are of high interest and relevance for wide stakeholder groups, including citizens and civil society. Social media campaigns were launched to promote the UNRAVEL materials and activities that are of highest interest for society at large and UNRAVEL will continue to promote relevant results after the project end. Table 4 summarises the key messages and online campaigns targeted at a wider public until project M48.

Table 4 *UNRAVEL key messages and online campaigns for a wider public*

Key Message	Campaign/Timeline
#1 'Pre-extraction for increased lignocellulosic biorefinery flexibility' UNRAVEL developed a versatile strategy to improve biorefinery feedstock flexibility , sugar yields and lignin purity. Results and data were published in ACS Sustainable Chemistry (see list of Open Access publications). Target groups, outside the scientific community, were the biorefinery industry, end users, biomass suppliers, policy and NGOs.	**07/2022** 5 posts on: Twitter LinkedIn Linked to: Open Access publication Short video of the ELEANOR pre-extraction process (patented by TNO)
#2 'Final UNRAVEL Workshop @EUBCE' The final UNRAVEL event at EUBCE 2022 was promoted with the aim to increase awareness of the overall lignocellulosic biorefinery concept based on a combination of pre-extraction and an organosolv fractionation process, promising applications and key sustainability aspects. Target groups were the biorefinery industry, end users, biomass suppliers, policy and NGOs.	**04-05/2022** 11 posts on: Twitter LinkedIn Linked to: EUBCE event page Overview graph UNRAVEL
#3 'UNRAVEL Environmental assessment report publicly available' The environmental assessment report as public deliverable became available for a wide audience in March 2022. It was posted on the UNRAVEL website for download and promoted via social media channels in a dedicated campaign. Target groups were the biorefinery industry, biomass suppliers, policy and NGOs as well as civil society and environmental organisations.	**03/2022:** 4 posts on: Twitter LinkedIn Facebook

UNRAVEL Fact Sheets as material for multi-stakeholder groups

The results, data and knowledge gained within UNRAVEL, as well as key implications for future European lignocellulosic value chains, were summarized in two project fact sheets, understandable for a non-scientific audience. The sheets were promoted with selected target groups within the scientific, technology, bioeconomy, energy, biofuel, and other relevant communities at the European level. The Fact Sheets are described in detail in deliverable D7.4, submitted on the 30th November 2021.

The fact sheets were furthermore made available for download (http://www.unravel-bbi.eu/data-resources) on the project website to assure wide access by multi-stakeholder groups, including non-expert groups.

4. CONCLUSIONS

The stakeholder engagement activities carried out within the UNRAVEL project are designed to maximize the project's impact and to facilitate the uptake of results and newly generated knowledge by all stakeholder groups. During project period, Soprema filed one patent on the production of polyols from lignin using ethylene carbonate.

Based on the stakeholder engagement activities performed and based in the evaluation of preliminary results and knowledge outputs as well as existing knowledge gaps and potential risks and future market barriers that are of relevance, we have come to the conclusion that the topic of securing a solid biomass supply chain and sound feedstock logistics is one of the most important areas for intense stakeholder engagement.

The stakeholder engagement activities have also revealed valuable input and opinions from industry on the product applications. It was concluded that the lignin valorisation in PUR foams was definitely a good application with sufficient technical and economic viability. However, the sugar (C5 and C6) valorisation routes are not yet optimal and some additional applications were brought in by the stakeholder panel members. An initial SWOT analysis was performed by Polybridge to explore potential additional valorisation routes.

The importance of both above-listed topics to support a strong bio-based economy and the necessity to engage with relevant stakeholders has lately been confirmed by the BBI JU in their Annual Work Plan (AWP) 2021. In line with the Strategic Innovation and Research Agenda (SIRA), the AWP 2021 confirms the commitment to strengthen the participation of biomass feedstock suppliers in the value chain. BBI JU further will encourage partnerships with end-market actors to create a market pull for bio-based products. In UNRAVEL, based on our stakeholder engagement strategy and hands-on action, we strongly contribute to these strategic goals as set out by BBI JU.

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