Policy briefs and strategy papers with recommendations for policy making

Unravel -Project
H2020-BBI-PPP-2017-9

Rita Clancy, Eurida
André van Zomeren, TNO
Heiko Keller, IFEU

Deliverable D7.5
Work package 7
Version: Final/15-07-2022

Project number: 792004

Deliverable No. 7.5

Dissemination Level		
PU	Public	X
PP	Restricted to other program participants (incl. the Commission Services)	
RE	Restricted to a group specified by consortium (incl. the Commission Services)	
CO	Confidential, only for members of the consortium (incl. the Commission Services)	

Nature		
R	Report	X
O	Other	

Deliverable Details			
Due date:	30-04-2021		
Submission date:	15-07-2022		
Involved participants:	Rita Clancy	EURIDA	
	André van Zomeren	TNO	
	Heiko Keller	IFEU	
WP no. and title:	WP7, Communication, dissemination and exploitation		
WP leader:	EURIDA		
Task no. and title:	Task 7.6 Provide a knowledge base for policy makers		
Version/Date	Final/15-07-2022		
Keywords:	Policy Brief, policy input, sustainability		

Summary

Aim of this document is to report on the policy input activities to provide policy makers with evidence-based information and key findings from the UNRAVEL project as possible input to future European policies and strategies.
The UNRAVEL project over four years (2018-2022) achieved numerous breakthroughs in technologies and processes to realise:

- An efficient and sustainable lignocellulosic biorefinery concept based on a combination of a pre-extraction and mild organosolv fractionation process
- The effective use of complex lignocellulosic biomass like wheat straw, roadside grass, forestry residues and mixes thereof for higher biorefinery feedstock flexibility
- A cascading approach for a wider range of biorefinery products to increase the range of product applications and resulting industrial value chains.
- A positive sustainability performance of future lignocellulosic biorefinery and their products as compared to the state-of-the-art and their fossil-based counterparts.

Besides those scientific goals, a specific objective in UNRAVEL during its entire project term has been to evaluate the knowledge and data generated by the project for their policy relevance. The resulting policy brief is presented in this deliverable report D7.5. The Brief has been designed based on relevant partner inputs in cooperation of EURIDA, TNO and IFEU.

After the project end, EURIDA will follow-up on submitted material and liaise with policy makers (together with researchers from all UNRAVEL partners) to support the integration of knowledge in policies and public strategies. EURIDA has been responsible for leading policy-related activities and for compiling this report.

This report further complements Deliverable 7.4 (submitted on the 7th December 2021) which described the activities within UNRAVEL on more general knowledge transfer and exchange with EU knowledge and stakeholder platforms. Report D7.4 also described in more detail how UNRAVEL evaluated and made available the generated knowledge and data to EU stakeholder platforms and the knowledge community (in all relevant project areas: overall biorefinery concept, pre-treatment, fractionation, application, sustainability and impact assessment), and shares it by means of a project knowledge repository.

Knowledge relevant for the Policy Brief was evaluated as part of the overall knowledge exchange activity (T7.5) and transferred separately with the goal of specifically addressing the target group of policy makers.

Core of this report is the Policy Brief itself, which is enclosed in this report as Annex.

Contents

UNRAVEL approach to policy input

With this policy brief, stakeholders and policy makers are informed about the current status of lignocellulosic biorefinery and possible sustainable scenarios, opportunities and challenges of the future. In addition, the potential contribution of lignocellulosic biorefinery to EU strategies on tackling climate change, such as the EU Green Deal and the declaration on 'A Green and Digital Transformation of the EU' is addressed. These policies are based on decarbonizing the materials sector and other applications that can be of relevance for lignocellulosic biorefinery and are at the core of UNRAVEL.

Within the project, research progress and breakthroughs have been achieved at medium Technology Readiness Levels (TRLs 4-5). More research and development will be needed to realise fully mature commercial lignocellulosic biorefineries and to mature the UNRAVEL cascading approach as well as involved technologies and processes towards levels that are of commercial interest for the target sectors. Identified sectors are 'Construction', 'Wood Chemistry' and other fields that could strongly benefit from UNRAVEL breakthroughs, for example biomass suppliers from agriculture and forestry, possible end users of extractives.

Deliverable 7.5 mainly consists of the policy brief, which has been created within Task 7.6 'Provide a knowledge base for policy makers'. The brief summarizes selected research results from WP1-6 and transfers them into conclusions and recommendations for policy makers. The aim is to help safeguarding novel sustainable lignocellulosic biorefinery with the potential of bringing manifold societal and environmental impacts and keeping Europe at the top of frontier research.

The Brief will be available for download at www.unravel-bbi.eu.

ACKNOWLEDGEMENT

This deliverable is part of the UNRAVEL project. This project has received funding from the Bio-Based Industries Joint Undertaking under the European Union Horizon 2020 research and innovation programme under grant agreement No 792004.

ANNEX

UNRAVEL Project

POLICYBRIEF

UNRAVEL – A concept for a cascading, mild organosolv lignocellulosic biorefinery

Findings and recommendations from the UNRAVEL BBI JU research and innovation project (www.unravel-bbi.eu)

Key Messages from the UNRAVEL Project

1. The Fabiola™ organosolv platform shows a positive outlook regarding economic and environmental sustainability, is feasible at pilot scale and it is ready to be combined with both upstream and downstream modules.

2. Feedstock flexibility is important for future commercial biorefinery and the UNRAVEL concept has shown that processing mixed feedstocks and complex lignocellulosic biomass could be processed at pilot scale.

3. To increase the economic viability of biorefinery the product portfolio should be extended, covering high value lignin and cellulose applications strategically combined with biofuels production.

4. A viable route shown by UNRAVEL can be a mixture of biofuels applications and bio-based materials.

5. The use of energy from renewable electricity instead of natural gas is possible and one important option to further reduce the carbon footprint of biorefinery processes.

What is a lignocellulosic biorefinery?

The concept of biorefinery is the sustainable processing of biomass to obtain new bio-based products and/or bioenergy, often to reduce the need for fossil-based resources. A biorefinery should be able to process feedstocks that have no direct competition with food or feed, either in the use of the feedstocks and/or the occupied land to grow them. Therefore, residues are interesting feedstocks as they are by-products from other primary uses of the biomass and are regarded as second generation feedstocks. Full valorisation of these residues is an important pre-requisite for a biorefinery process to become economically viable and environmentally friendly since the production competes with well-established and optimised fossil-based industries. Within UNRAVEL, several existing technologies for fractionation, conversion, modification and product applications have been integrated to obtain a new bio-based value chain. The new value chain is able to use a mix of hardwood wood chips, forest residues and bark, as well as straw and nutshell feedstocks via acetone organosolv (Fabiola™) processing to deliver extractives, lignin-based polyols for PUR/PIR foams, polymer additives and chemical building blocks from the sugar fractions such as acetone or xylonic acid.

Why lignocellulosic biorefinery?

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, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reduce their greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century. Other policies and strategies that focus on climate change mitigation, economic prosperity and social resilience as major sustainability goals include the EU Green Deal[1], the EU Taxonomy[2] and the Recovery and Resilience Facility[3], the key instrument at the heart of NextGenerationEU[4].

One of the pillars of the European Union to reach climate treaty targets foresees more sustainable products and production processes that minimise the use of fossil resources. Sustainable biorefinery can play a significant role in reaching the climate change mitigation and overall sustainability goals by transformation of fossil-based processes and products towards a more sustainable and bio-based economy and society. This is addressed by several policies and directives, among those the European Bioeconomy Strategy[5], the Renewable Energy Directive (RED III)[6], the EU Biorefinery Outlook to 2030[7] and Foresight Scenarios for the EU Bioeconomy in 2050[8].

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en
[3] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en
[4] https://europa.eu/next-generation-eu/index_en
[5] https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-149755478
[6] https://ec.europa.eu/energy/topics/renewable-energy/directive-targets-and-rules_de
[7] https://op.europa.eu/en/publication-detail/-/publication/7223cd2e-bf5b-11eb-a925-01aa75ed71a1
[8] https://publications.jrc.ec.europa.eu/repository/handle/JRC123532

The Challenges

Overall Sustainability. A single focus on climate change mitigation in the context of sustainability is neither sufficient nor recommendable. Therefore, all of the above policy frameworks are linked to the 'Do No Significant Harm' principle to ensure that the environment is not significantly harmed in other important aspects, such as biodiversity, and that important transformation processes are not impeded.

Biorefineries in general can support various sustainability goals, in particular by contributing to climate change mitigation and by strengthening rural economies. However, biorefineries also have the potential to cause damage regarding other environmental impacts, which needs to be avoided as far as possible.

Sustainable biomass. A major challenge for the transition towards a low-carbon biobased 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 (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, biobased chemicals and materials. Especially biomass residues that originate from agriculture could be feedstocks for higher value products that could help to avoid competition over hardwood with a generally high demand. Biomass residue availability in the EU can contribute substantially to providing carbon for products that cannot be otherwise decarbonised such as chemicals and materials[9].

However, for future sustainable lignocellulosic biorefinery it must be ensured that only sustainably available biomass residues are used as feedstock. This firstly means that location-specific ecological extraction limits of biomass residues such as straw and forest residues need to be respected to avoid harming soils and biodiversity.

Secondly, biomass should not be withdrawn from other productive uses which, as indirect effects, could prevent emission savings in those applications and entail social disadvantages by restricting the livelihoods of current users. For wood, the competition is generally high and increases with wood quality. In this regard, the UNRAVEL biorefinery concept provides advantages because optional pre-extraction can make low-quality and otherwise unused feedstocks useable.

Key findings from UNRAVEL

Biomass choices and flexibility. The sustainably available amounts of lignocellulose biomass feedstock are sufficient to feed several large-scale biorefineries with a capacity of 300 000 tonnes (dry matter content) per year, as assessed by UNRAVEL in our integrated sustainability assessment, which is publicly available as report on the project website[10]. At the same time, sustainable availability is very location-dependent and may vary annually. Therefore, it is important to ensure during the site selection process that sufficient biomass

[9] Andersen, S. P., B. Allen and G. C. Domingo (2021), 'Biomass in the EU Green Deal: Towards consensus on the use of biomass for EU bioenergy' Policy report, Institute for European Environmental Policy (IEEP)

[10] http://unravel-bbi.eu/wp-content/uploads/2022/05/D6.7_Integrated-assessment.pdf

is available for all local users, including the biorefinery. As costs are lower in Eastern Europe, location search should start there.

A feedstock-flexible concept such as the one developed in this project can be crucial to ensure sufficient sustainably available biomass amounts and thus to avoid potential negative impacts on environmental and social sustainability. As a next step of process development of the UNRAVEL biorefinery concept, concrete measures were identified to optimise the process for low-density feedstocks such as straw and roadside grass, which are underutilised or not used at all. This includes an optimisation of the reactor design and processing conditions and is potentially feasible by modification of existing demonstration facilities.

The core fractionation process. The core process is responsible for the highest investments and sustainability impacts and should therefore be optimised further regarding demand for energy and material inputs and installations. Nevertheless, energy demand will remain substantial and needs to be covered by additional wind and solar power as far as possible. Regarding equipment and investments, in particular the design and costing of pulp and lignin filtrations and vapour compressor in the organosolv fractionation are important elements in addition to the optimisation of the process for low-density feedstocks as discussed above.

Pre-extraction and downstream processing of biomass fractions. The potentials of pre-extraction to enable feedstock flexibility as well as the use of further sustainably available biomass residues should be explored further. Potentially, pre-extraction of biomass might also allow previously unreachable product applications and can enhance sugar yields during fractionation. Valorisation of extractives is technically feasible but not yet economically feasible with the betulin target compound studies in UNRAVEL.
The sustainability assessment also indicated the need to find more sustainable use options for hemicellulose/C5 sugars (xylonic acid was produced) and cellulose/C6 sugars (acetone was produced). Together with optimisations of the core process, this could create synergistic benefits regarding most sustainability aspects of potentially substantial but as yet unknown magnitude. Furthermore, markets should be targeted in which customers are willing to pay a certain green premium for bio-based products because this may be needed to ensure economic viability.

Creation of suitable boundary conditions. Sustainability is not only dependent on an optimised process but also on the boundary conditions of its implementation. For operators of future biorefineries this in particular concerns environmentally and socio-economically sustainable procurement and employment. Besides sustainable biomass feedstock procurement, which is discussed above, this primarily relates to chemicals, energy and services. Social risks in the supply chain that have been identified in this sustainability assessment and mostly arise from indirect suppliers outside of the EU are no reason to refrain from implementation but rather entail obligations. They need to be managed and monitored during implementation and operation of a future biorefinery.
Responsible procurement and employment can not only avoid risks but also create benefits. The realisation of potential benefits requires a location in less privileged rural areas, equal employment opportunities and a local procurement approach that should be important criteria for public support.
Politics needs to create conditions for equitable competition and negotiations between unequal partners. In this context, specific and partially new challenges are arising from

competition about limited biomass residues. Such conflicts are already present or may arise e.g. between small and/or non-commercial biomass users, nature conservation and biorefinery operators as well as between the bioenergy sector that already receives substantial public support and the bio-based materials / chemicals sector that is currently lagging behind.

UNRAVEL's contribution to future sustainable lignocellulosic biorefinery:

A novel concept for high value applications from mixed and complex lignocellulosic biomass

The novelty of the UNRAVEL biorefinery concept is the combination of a new biomass upgrading concept, an organosolv technology (Fabiola™) and a lignin precipitation technology (LigniSep) to obtain high purity cellulose, monomeric hemicellulose and a less-condensed lignin fraction that are suitable for downstream product applications.

The sugar fractions are fermented as this is a proven technology to obtain chemicals (acetone and xylonic acid were chosen as examples).
Lignin is applied both in PUR insulation foams and as a polymer replacement in bitumen roofing membranes.
The biomass extractives form a basis for further use and product development to optimise the full valorisation of residue streams.

The use of pre-extraction does also lead to a lower catalyst dosage during fractionation and improves the quality and quantity of sugars and lignin. The novel acetone-based fractionation technology improves the energy consumption by about 30% compared to state of the art fractionation technologies as well as the sugar yields and lignin quality.

POLICY RECOMMENDATIONS

- Phase out **one-sided incentives** for biofuels.
- Establish **sustainability criteria** for biomass residues that are consistent across all biomass-using sectors and take local restrictions into account.
- Support the further development and scale-up of biorefineries with high **flexibility** in terms of biomass and product portfolios.
- Biomass supply chains have to involve **small farmers** to assure reliable supply of agricultural residues, such as straw, and a share of the economic revenues at local levels.
- Harmonise **definitions and regulations** for waste, residues and by-products across Europe to facilitate biomass supply and logistics.
- In the mid- to long-term, holistic biomass **allocation plans** should be developed at regional, national and European level to avoid unproductive competition about biomass.
- Actively manage the **transition** from a fossil- to bio-based economy, especially in regions with fossil-based industry, to mitigate social implications.

Project Identity

Coordinator André van Zomeren, andre.vanzomeren@tno.nl
TNO/The Netherlands, www.tno.nl

Communication Rita Clancy (Dissemination Officer), r.clancy@eurida-research.com
EURIDA Research Management, Austria www.eurida-research.com

Project Officer Oliver Zobell, BBI JU/CBE JU

Consortium

Duration June 2018 – May 2022

Budget EU Contribution: 3 603 545,00 €

Website This UNRAVEL Policy Brief and other publications are available at:
http://unravel-bbi.eu/data-resources/

www.unravel-bbi.eu

If you have any further questions and for further discussions, please contact us at:

andre.vanzomeren@tno.nl

Main contact: André van Zomeren, UNRAVEL Coordinator

This Policy Brief is part of the UNRAVEL project. The project has received funding from the Bio Based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 792004. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium.