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GREEN-LOOP

Sustainable manufacture systems towards novel bio-based materials

WP2 – Sustainability and Circularity by design

D2.7 – Standardization landscape for biomaterials

Version 2.1

Document information

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Topic	HORIZON-CL4-2021-TWIN-TRANSITION-01-05 Manufacturing technologies for bio-based materials (Made in Europe Partnership) (RIA)
Consortium	17 organizations: 15 from EU Member States + 2 from UK

GREEN LOOP Consortium Partners

	Partner	Acronym	Country
1	IDENER RESEARCH & DEVELOPMENT	IDE	ES
2	NATIONAL INSTITUTE OF CHEMISTRY	NIC	SI
3	SLOVENIAN NATIONAL BUILDING AND CIVIL E. I.	ZAG	SI
4	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V	FHF	DE
5	LABRENTA SRL	LBRT	IT
6	MIXCYCLING SRL	MYX	IT
7	NERO SU BIANCO	NSB	IT
8	GERACE MARIA CRISTINA - TERRE DI ZOE'	TDZ	IT
9	IRIS TECHNOLOGY SOLUTIONS, SOCIEDAD LIMITADA	IRIS	ES
10	GLOWNY INSTYTUT GORNICTWA	GIG	PL
11	AACHEN UNIVERISTY: PROCESS CONTROL ENGINEERING / AACHEN UNIVERISTY: INSTITUTE OF SOCIOLOGY	AAU	DE
12	AUSTRIAN STANDARDS INTERNATIONAL	ASI	AT
13	INSTITUTO DE SOLDADURA E QUALIDADE	ISQ	PT
14	AXIA INNOVATION UG	AXIA	DE
15	ASOCIACIÓN DE INVESTIGACIÓN METALÚRGICA DEL NOROESTE	AIMEN	ES
16	NATIONAL COMPOSITE CENTER	NCC	UK
17	UNIVERSITY OF BRISTOL	UBRIS	UK

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Executive Summary

GREEN-LOOP aims at enhancing and supporting the bioeconomy at European level through robust product design adapted to new sustainable and circular schemes, reducing the cost of manufacture and accelerating the market introduction of novel bio-based products.

Throughout the project, 3 innovative bio-based materials and components will be designed and optimized for the industrial sectors of construction, packaging, food and beverage, and appliances and tooling. The value chain of each of the following three products will be optimized from raw material sources to End-Of-Life of products, ensuring the circular economy:

1) multifunctional rubber panels with fire resistance and vibrational applications,
2) bioplastic bottle closures for oil and fruit juice,
3) wood composites bearings for plastic injection machines.

The project duration extends from 2022-09-01 to 2025-09-01.

The work described in this deliverable (D2.7) is part of the work carried out in Task 2.4, belonging to *Work Package 2 – Sustainability and Circularity by design*. D2.7 builds on the preceding deliverables D2.4 (submitted in M5) and D2.5 (submitted in M12). Apart from these previous versions, one final version of the standardization landscape for biomaterials will be provided within Task 2.4 at the end of the project (D2.6 to be submitted in M36).

This deliverable (D2.7) gives an overview of the achievements of the task since the submission of the preceding deliverable D2.5 and focuses primarily on describing the results of the standardization workshop, which was conducted in February 2024. D2.7 also outlines the next steps regarding the standardization activities of the project and provides an outlook for the upcoming and final deliverable.

During the standardization workshop, various standardization ideas were put forward by the participating consortium members, four of which were given higher priority by the experts of the GREEN-LOOP project. Briefly summarized, the prioritized ideas include: a standardization framework for the sustainable design of new materials, challenging the applicability of ASTM D 6814-02, measuring the chemical composition of fire effluents using cone calorimetry, and a sustainability standard for plastic production, usage and disposal. Each of the ideas is described in more detail along the present document. In the next steps, the approach to contributing to standardization will be tailored to each specific idea, in close consultation with the involved consortium members and aligned with usual standardization procedures. By ensuring that GREEN-LOOP's results resonate in standardization where applicable, the market uptake of the project results is supported.

For more detailed information regarding standardization processes, relevant standardization bodies and different kinds of standardization deliverables, please refer to deliverable of 2.4, which was submitted in M5. For more detailed information regarding the results of the standardization questionnaire, which was conducted to gain first insights regarding potential standardization gaps existing in relation to the GREEN-LOOP project, please refer to D2.5, which was submitted in M12. The results of D2.5 served as one of the main pillars of input for the standardization workshop of the GREEN-LOOP project.

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Abbreviations

The following table shows a short overview of the abbreviations used in this deliverable.

Table 1 - Abbreviations

Abbreviation	**Description**
ASTM	American Society for Testing and Materials
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
D	Deliverable
EN	Standard adopted by CEN or CENELEC
IEC	International Electrotechnical Commission / standards developed by IEC
ISO	International Standardization Organisation / standards developed by ISO
MX	Month X of the GREEN-LOOP project
NSB	National Standardization Body
NWIP	New Work Item Proposal; proposal for a new work item which is submitted to the TC for approval
SC	Subcommittee; SCs may be established by a TC having responsibility for a large programme of work; frequently in large ISO/TCs or IEC/TCs but being phased out in CEN/TCs and CENELEC/TCs; SCs operate more independently than WGs
TX.x	Task X.x
TC	Technical committee; a TC consists of a group of stakeholders from various fields of expertise drafting standards according to the most recent state of the art
TR	Technical report developed by CEN, CENELEC, ISO or IEC
TS	Technical specification developed by CEN, CENELEC, ISO or IEC
WG	Working group; A Working Group (WG) is established by a Technical Committee or a Subcommittee to undertake a specific short-term task within a target date
WP	Work package

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1. Introduction

1.1 Objectives of the Work Package and Task

This deliverable (D2.7 – *Standardization landscape for biomaterials*) is developed within task 2.4 *Standardization activities of GREEN-LOOP*, which is part of GREEN-LOOP work package 2 – *Sustainability and Circularity by design* and is the succeeding document of D2.4 [M05] and D2.5 [M12].

In general, WP2 aims at the following:

1) creating and utilizing a methodology to obtain optimized designs, ensuring the circularity of bio-based materials,
2) reducing the environmental impact by implementing A.I. models, thermo-economy studies and environmental analysis, and implementing a platform to evaluate and optimize the bio value chains.

In this context, task 2.4 focuses on investigating the standardization potential of the end products, allowing the project to interact with the related technical committees. In order to achieve this, the following will be developed throughout the project timeline:

- the standardization landscape, based on the needs of material development (WP3 to WP5) regarding relevant existing standards and the related standardization committees;
- a standardization plan detailing the relevant standardization activities and actions taken by the project (partners).

1.2 Scope of Deliverable

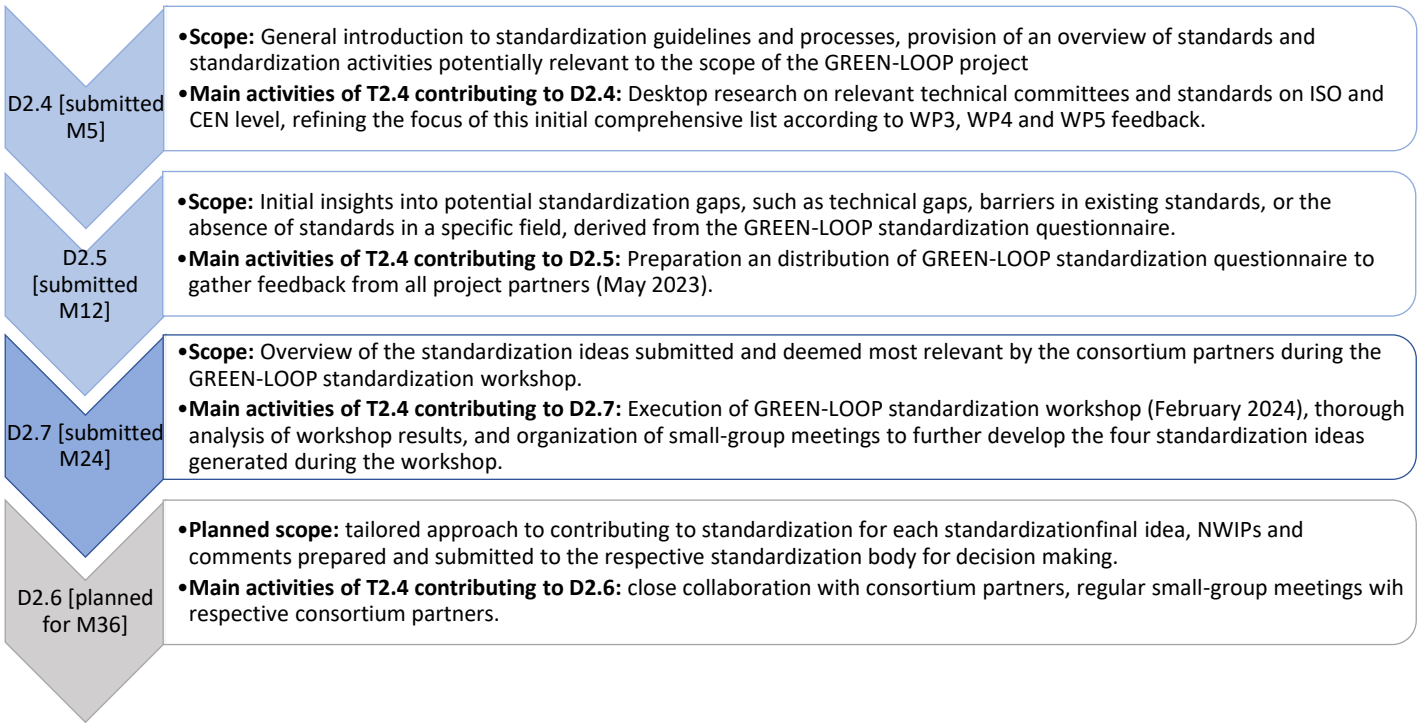

Figure 1 - Progress and deliverables achieved by T2.4 to date, along with the planned final deliverable D2.6 [M36]

Figure 1 provides an overview of the progress made and deliverables prepared within T2.4 to date, along with the planned final deliverable. The first deliverable of task 2.4 (D2.4, M5) focused primarily on providing

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general standardization guidelines and a description of the most common standardization processes and procedures, as well as on providing an overview of standardization activities potentially relevant to the scope of the GREEN-LOOP project. Building on this, the second deliverable of task 2.4 (D2.5, M12) highlighted the results gathered via a standardization questionnaire, which was circulated to the project consortium. The questionnaire was circulated in May 2023 and aimed at the identification of standardization gaps (i.e. gaps or barriers regarding the implementation of existing standards or the lack of standards for a specific topic area).

Since the submission of the first two deliverables, further steps have been taken within task 2.4 to support the project in context of standardization and to achieve the goals of task 2.4. In particular, a standardization workshop was conducted within the GREEN-LOOP consortium, focusing on the identification, evaluation and ranking of standardization gaps. During this workshop, the results of the primarily conducted standardization questionnaire as well as potential new standardization ideas were examined.

The present deliverable (D2.7) provides an overview of the standardization ideas which were submitted and considered most relevant by the GREEN-LOOP consortium partners. These standardization ideas form one of the main pillars for developing a standardization plan for the GREEN-LOOP project. Additionally, detailed information is provided regarding the methodology used for identifying the most relevant standardization ideas, as well as on the next actions to be taken.

2. Methodology for the elaboration of D2.7

2.1 General

Building on the first two deliverables of T2.4, a standardization workshop was conducted with the GREEN-LOOP consortium in February 2024. The workshop focused on identifying standardization needs that are critical to the project's success and areas where processes and results elaborated in the project can help close existing standardization gaps. Table 2 provides the most relevant properties of the standardization workshop conducted. The results of the standardization workshop and the status of the four different standardization ideas elaborated during the workshop are presented in more detail in the following. The results serve as the baseline for the next steps toward standardization within the GREEN-LOOP project.

Table 2 - GREEN-LOOP standardization workshop data

Title	GREEN-LOOP standardization workshop
Date	20th February 2024
Duration	3h
Goal and Scope	Identifying standardization needs critical to the project's success as well as areas where GREEN-LOOP processes and results, etc. can support closing existing standardization gaps to support the market uptake of the project's results.
Participants (Order by Organization Acronym)	Lisa Filzmaier (ASI) Karl Grün (ASI) Rocio Pena (AIMEN) Cristina Onorato (AXIA) Thayana Rigo (AXIA) Liviu Toma (FHF) Mariusz Kruczek (GIG)

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	Małgorzata Markowska (GIG) Patricia Royo (IDE) Óscar Rodríguez (IRIS) Manuel Gomes (ISQ) Roberta Behar (MYX/LBRT) Tom Andrews (NCC) Riccardo Varotto (NSB) Ramy Hana (RWTH) Friderick Knez (ZAG)
Results obtained	The following four standardization ideas were generated during the workshop: • Idea 1: New Work Item Proposal (NWIP) for a standardization framework for sustainability by design of new materials • Idea 2: Challenging the applicability of ASTM D 6814-02(2018), *Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density* to the practical application of project results • Idea 3: NWIP for measuring the chemical composition of fire effluents using cone calorimetry • Idea 4: NWIP for a sustainability standard for plastic production, usage and disposal (specially for their biodegradability and compostability)

2.2 Methodological approach for the online standardization workshop

A standardization workshop was executed in February 2024. In advance to the workshop, the GREEN-LOOP consortium was kindly asked to get familiar with D2.5 in which the results of the standardization questionnaire were provided. Additionally, a short instruction was provided to the consortium to facilitate the identification of potential standardization gaps which the (technical) partners might have come across throughout the GREEN-LOOP project. Screenshots of the Miro-board used to conduct the workshop are provided in the Annex of this deliverable.

Overall, the workshop followed the following structure:

1) Collecting ideas (based on gap analysis or introduction of new ideas as part of the workshop)
    a. for a completely new standardization project which is not covered by standardization yet
    b. for revising an existing standard
    c. for participating in relevant standardization committees
2) Clustering the ideas according to the topics they concerned (e.g. LCA, energy impacts, artificial intelligence) and potential type of standard (e.g. product or material standard, process standard, testing standard,…)
3) Merging ideas where appropriate
4) Evaluation and ranking of ideas
5) In-depth processing of ideas ranked highest

As the main result, the following four ideas were developed during the workshop:

- Idea 1: New Work Item Proposal (NWIP) for a standardization framework for sustainability by design of new materials

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- Idea 2: Challenging the applicability of ASTM D 6814-02, Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density to the practical application of project results
- Idea 3: NWIP for measuring the chemical composition of fire effluents using cone calorimetry
- Idea 4: NWIP for a sustainability standard for plastic production, usage and disposal (specially for their biodegradability and compostability)

2.3 Standardization small-groups

During the standardization workshop, the experts were asked to indicate in which small groups they would like to participate to support the in-depth processing of the ideas. Currently, small-group meetings are being organized and conducted for individual standardization ideas to discuss them and options for standardization in greater detail. An invitation to join the small groups was circulated to all consortium members.

3) Identified standardization ideas of GREEN-LOOP

3.1 General

In the following, the four identified and prioritized GREEN-LOOP standardization ideas are described in more detail. It needs to be emphasized that the list, content and next steps are subject to change and will be adapted throughout the course of the project. It must also be borne in mind that the individual standardization ideas are currently at different stages of development, causing the depth of the descriptions to vary.

At present, three New Work Item Proposals suggesting the creation of a new standard (idea 1, idea 3, idea 4) and once comments for the next revision of a standard (idea 2) are foreseen. In this regard, it is important to point out that the responsibility to decide whether or not a new work item proposal or comments for the revision of a standard are accepted lies within the respective European or International standardization committees or, more precisely, their national mirror committees.

For example, in the case of the new work item proposals to be developed, the respective European or International technical committee will consult all national members via a survey, and the voting result will determine whether or not this standardization project will be pursued further. If the vote is positive, the next step could be to set up a working group in the respective technical committee and start drafting the standard. If the vote is negative, the work regarding the proposed new standardization area will not be continued.

To ensure that the technical committees take up proposed new standardization work, the involved project partners can, for example, contact their national standardization body and ensure that their own country's vote will be positive.

3.2 Standardization idea 1: Standardization Framework for sustainability by design of new materials

3.2.1 Description

The idea is about standardisation of the framework following a Safe and Sustainable-by-design (SSbD) approach of new materials based on related European and International Standards, including (EN) ISO 14040, *Environmental management – Life cycle assessment – Principles and framework* and ISO/TS 14027, *Environmental labels and declarations – Development of product category rules*.

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Such standardization would help to answer the question of how to find reliable information, tackle data problems at all stages and apply a common methodology in different sectors.

3.2.2 Standardization landscape

The identified European and International standards such as

- ISO 14040ff (ISO/TC 207/SC 5 – Life cycle assessment), which describe the principles and framework for life cycle assessment (LCA) as well as specify requirements and provides guidelines for LCA, including the definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.
- ISO/TS 14027 (ISO/TC 207/SC 3 – Environmental labelling), which provides principles, requirements and guidelines for developing, reviewing, registering and updating PCR within a Type III environmental declaration or footprint communication programme based on life cycle assessment (LCA) according to ISO 14040 and ISO 14044 as well as ISO 14025, ISO 14046 and ISO/TS 14067.

are the basis of the idea, but are too generic in their nature for the aim of this specific standardization idea.

EN 18027, *Bio-based products - Life cycle assessment - Additional requirements and guidelines* for comparing the life cycles of bio-based products with their fossil-based equivalents, will be considered in addition.

3.2.3 Next steps

The next step is the drafting of a NWIP for the elaboration of either a European or International standardisation deliverable in close cooperation with the experts of the GREEN-LOOP consortium. The NWIP will include aspects such as quality of data, circular value chains, how to handle general assumptions for lower TRLs, newly developed materials, processes and systems (such as nanomaterials) and their disposal. Should a new European Standard be chosen, the most appropriate standardization committee is CEN/TC 411, Bio-based products, considering its scope to develop standards for bio-based products covering horizontal aspects. This includes consistent terminology, sampling, certification tools, bio-based content, application of and correlation towards life cycle analysis, sustainability criteria for biomass used and for final products, and aspects where further harmonization is needed on horizontal level.

The consortium partners FHF, AIMEN, IDENER and GIG will collaborate with ASI to further develop this standardization idea.

3.3 Standardization idea 2: Challenging the applicability of ASTM D 6814, Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density to the practical application of project results

3.3.1 Description

This idea is about challenging the applicability of ASTM D 6814, *Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density* to the practical application of project results. During the standardization workshop, different potential adaptions of the standard were discussed, which would enhance the reproducibility of testing results and simplify the accurate application of the standard.

3.3.2 Standardization landscape

Researching the standardisation landscape of idea 2 is not relevant, as the identified document (ASTM D 6814) is the basis of the idea.

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- ASTM D 6814, *Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density*

  Scope: *This test method covers the procedure for determining percent devulcanization from crosslink density measurements of devulcanized rubber and control crumb rubber in the laboratory. Percent devulcanization is a quantitative determination.*

3.3.3 Next steps

To optimise ASTM D 6814 regarding its applicability for GREEN-LOOP project results, corresponding comments are being prepared in cooperation with the GREEN-LOOP consortium partners. The collected comments will be forwarded to the relevant standardization organisation (ASTM) for consideration in the next revision of the standard. If the comments are taken into account in a future revision, ASTM D 6814 can be applied directly; if the comments are not taken into account, further steps (e.g. creation of a separate standard based on the ASTM) should be considered.

The consortium partners UBRIS and IRIS will collaborate with ASI to further develop this standardization idea.

3.4 Standardization idea 3: Measuring the chemical composition of fire effluents using cone calorimetry

3.4.1 Description

Standardization idea 3 focuses on developing a standard for measuring the chemical composition of fire effluents using cone calorimetry. The standard is currently planned to be applicable for multiple material types (10 x 10 cm) and to provide a common approach for toxicity testing which enables comparisons between different test houses and laboratories for repeatability.

3.4.2 Standardization landscape

The following compilation attempts to provide a short overview of existing standards, which will be important with regard to the further development of standardization idea 3 according to the experts' feedback:

- ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement) — Amendment 1* (ISO/TC 92/SC 1, Fire initiation and growth)

  Scope: *This part of ISO 5660 specifies a method for assessing the heat release rate and dynamic smoke production rate of specimens exposed in the horizontal orientation to controlled levels of irradiance with an external igniter. The heat release rate is determined by measurement of the oxygen consumption derived from the oxygen concentration and the flow rate in the combustion product stream. The time to ignition (sustained flaming) is also measured in this test.*

  The dynamic smoke production rate is calculated from measurement of the attenuation of a laser light beam by the combustion product stream. Smoke obscuration is recorded for the entire test, regardless of whether the specimen is flaming or not.

- ISO/TS 5660-5, Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 5: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement) under reduced oxygen atmospheres (ISO/TC 92/SC 1, Fire initiation and growth)

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Scope (shortened): *This document specifies the apparatus and procedure for measuring reaction to fire behaviour under reduced oxygen atmospheres. Continuous measurements are made to calculate heat release rates, smoke and specific gas production rates, and mass loss rates. Ignition time measurements are also made and ignition behaviour is obtained. Pyrolysis parameters of specimens exposed to controlled levels of irradiance and controlled levels of oxygen supply can be determined as well.*

- ISO 19701, Methods for sampling and analysis of fire effluents (ISO/TC 92/SC 3, Fire threat to people and environment)

  Scope: *This International Standard presents a range of sampling and chemical analytical methods suitable for the analysis of individual chemical species in fire atmospheres. The procedures relate to the analysis of samples extracted from an apparatus or effluent flow from a fire test rig or physical fire test model and are not concerned with the specific nature of the fire test.*

  This International Standard doesn't cover aerosols (detailed in Reference [3]) and FTIR technique (detailed in Reference [4]). The gases of environmental interest, such as PAH, dioxins, furans, endocrinal disturbers, will be developed in a future document by ISO TC92/SC3.

- ISO 19702, Guidance for sampling and analysis of toxic gases and vapours in fire effluents using Fourier Transform Infrared (FTIR) spectroscopy (ISO/TC 92/SC 3, Fire threat to people and environment)

  Scope (shortened): *This International Standard specifies requirements and makes recommendations for sampling systems for use in small and large-scale fire tests, for the selection of parameters and use of the FTIR instrument itself and for collection and use of calibration spectra.*

3.4.3 Next steps

The next step is the drafting of a New Work Item Proposal (NWIP) for the elaboration of an International standardisation deliverable in close cooperation with the experts of the GREEN-LOOP consortium. Currently, it is planned to develop a NWIP for a new standard in the ISO 5660 series (e.g. part 6). If this proceeds, the NWIP will fall under the responsibility of ISO/TC 92 – Fire safety.

The consortium partners ZAG and NCC will collaborate with ASI to further develop this standardization idea.

3.5 Standardization idea 4: Sustainability standard for plastic production, usage and disposal (specially for their biodegradability and compostability)

3.5.1 Description

The idea is to develop a new sustainability standard for bio-plastic production, usage and disposal (specifically for their biodegradability and compostability).

According to the European commission, CEN has published several standards on biobased products, but there is no clarity around the part of a plastic product that is entirely or partly derived from biomass. Currently, there are no EU sustainability criteria that apply to biobased plastics[1].

[1] See https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostable-plastics_en

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The proposed standard is, therefore, intended to serve as a basic document for the life circle of bio-plastic.

3.5.2 Standardization landscape

As mentioned in 3.5.1, no basic standard on the life circle of bio-plastic exists at present. Nevertheless, there are some related standards which might be relevant when applying the standard or creating it, e.g.

- EN 13432:2000 + AC:2005, *Packaging – Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of packaging* (CEN/TC 261, Packaging)

  Scope (shortened): *This European Standard specifies requirements and procedures to determine the compostability and anaerobic treatability of packaging and packaging materials by addressing four characteristics:*
  1) biodegradability,
  2) disintegration during biological treatment,
  3) effect on the biological treatment process and
  4) effect on the quality of the resulting compost.
- EN 14995:2006, *Plastics - Evaluation of compostability – Test scheme and specifications* (CEN/TC 249, Plastics)

  Scope: *This European Standard specifies requirements and procedures to determine the compostability or anaerobic treatability of plastic materials by addressing four characteristics:*
  I) biodegradability,
  II) disintegration during biological treatment,
  III) effect on the biological treatment process and
  IV) effect on the quality of the resulting compost.
- EN 16575:2014, *Bio-based products – Vocabulary* (CEN/TC 411, Bio-based products)

  Scope: *This European Standard defines general terms to be used in the field of bio-based products, including horizontal aspects relevant for bio-based product standards.*
- CEN/TR 16957:2016, *Bio-based products – Guidelines for Life Cycle Inventory (LCI) for the End-of-life phase* (CEN/TC 411, Bio-based products)

  Scope (shortened): *This Technical Report provides guidance on how to compile an inventory for the end-of-life phase in LCA of bio-based products.*

3.5.3 Next steps

The next step is the drafting of a New Work Item Proposal (NWIP) for the elaboration of a European standardization deliverable. The NWIP is planned to be submitted to CEN/TC 411, Bio-based products. The consortium partners FHF, AXIA, AIMEN, LBRT/MYX and ISQ will collaborate with ASI to further develop this standardization idea.

A draft of the content of the planned standard has been developed and is displayed below, emphasizing that it is a work in progress and not yet fully comprehensive:

I. Definition of bio-plastics incl.
   - ontology,
   - taxonomy (e.g. BIOVOICES platform, see https://eubionet.eu/biovoices-project/)
   - examples of existing standards
     - EN 16575:2014, *Bio-based products - Vocabulary*

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II. Process of production (in principle)
    - for producers and
    - testing of the biodegradability
    - digitization of data/data chain processes for materials (https://catena-x.net/de/)
    - input from
        - Work package 3 → Bio-rubber material production
        - Work package 4 → Bio-plastic material production
        - Work package 5 → Wood composites material production

III. Usage of products
    - end users
    - processors

IV. Storage of products
    - environmental conditions
    - examples of existing standards
        - EN 13432:2000 + AC:2005, *Packaging – Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of packaging*

V. Disposal of products
    - methods for consumers (incl. labels,…)
    - methods for disposal companies
    - examples of existing standards
        - CEN/TR 16957:2016, *Bio-based products - Guidelines for Life Cycle Inventory (LCI) for the End-of-life phase*
        - EN 14995:2006, *Plastics - Evaluation of compostability - Test scheme and specifications*

VI. Annexes
    - test conditions
    - use cases / best practices

4) Conclusions

The methodology employed in the elaboration of D2.7 reflects a comprehensive and collaborative approach to addressing standardization within the GREEN-LOOP project. Building upon the findings from earlier deliverables (D2.4 and D2.5) and leveraging insights from the GREEN-LOOP standardization workshop, a set of standardization ideas was developed.

Currently, the creation of three NWIPs is planned, suggesting the creation of three new standards (idea 1, idea 3, idea 4). Additionally, for idea 2, comments for the next revision of an existing standard are anticipated. The following four ideas will be further developed in the upcoming months:

- **Idea 1:** New Work Item Proposal (NWIP) for a standardization framework for sustainability by design of new materials
- **Idea 2:** Challenging the applicability of ASTM D 6814-02(2018), *Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density* to the practical application of project results
- **Idea 3:** NWIP for measuring the chemical composition of fire effluents using cone calorimetry

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- **Idea 4:** NWIP for a sustainability standard for plastic production, usage and disposal (specially for their biodegradability and compostability)
- For a detailed overview regarding the current status of the ideas, as well as next steps and partners involved, please refer to section 3 of this document.

Each idea addresses specific standardization gaps or needs (i.e. technical gaps or barriers in existing standards or the lack of standards for a specific field) identified during the workshop and is currently being further refined through small-group discussions. By ensuring that standards will be updated or created in alignment with the results of the GREEN-LOOP project, the market uptake and relevance of the project's innovations are aimed to be supported.

It is important to highlight that the success of GREEN-LOOP's standardization efforts fundamentally relies on the expertise of the consortium experts' knowledge and contributions. Their insights are essential to advancing the project's standardization initiatives. To mitigate the risk of lacking experts' contributions, regular updates either during small-group meetings or via e-mail, depending on the respective case, are foreseen.

5) Outlook and next steps

The standardization workshop's results, which were addressed in the previous sections of this deliverable, will serve as a main pillar for the next steps regarding standardization within the GREEN-LOOP project. Specifically, Objective #2 focuses on manufacturing bio-based materials at relevant scales. The present task development supports its achievement by pursuing Specific Objective 2.4, "SO2.4. New characterization and standardization activities."

In the next steps, the approach to contributing to standardization will be tailored to each specific idea, in close consultation with the involved consortium members. Depending on the particular case, the next steps may include drafting NWIPs or providing comments for the revision of existing standards.

As an example, for Idea 1 the next workshop is scheduled for late September 2024 in order to enhance the proposal with content from relevant GREEN-LOOP Deliverables such as D2.2 and D2.4, and how to engage with the Leadership of the CEN/TC 411 in order to make them familiar with the forthcoming NWIP. Similar steps will be taken for the other standardization ideas.

Once they are finalized, the NWIPs and comments will be forwarded to the relevant standardization committees. In accordance with the usual standardization procedures, the committees will then decide whether to proceed with the proposed new standards and the comments forwarded. The results will be included in the final Deliverable D2.6 of Task 2.4.

Lastly, it needs to be emphasized that the decision to accept new work item proposals or comments for standard revisions lies with the respective standardization committees and their national mirror committees.

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Annex

The following section provides an overview of the individual steps and results of the standardization workshop. The workshop was conducted interactively via MS Teams and the online-collaboration platform Miro. For easier readability, the contents and results have partially been converted into plain text in the present document.

At the beginning of the workshop, a brief overview of the workshop objectives, as well as earlier standardization related project results was provided. After the participants entered their names and expectations to the Miro board, the workshop could delve deeper into the technical subject matter and related gaps in standardization.

Introduction

Purpose of this workshop:

In the last months, we have gathered a first insight regarding potential standardization gaps via the GREEN-LOOP standardization questionnaire. The findings are one source (but not the only one) for today's workshop.

Our aims are to

- *identify standardization needs which are critical to the success of the project*
- *find out where GREEN-LOOP processes and results, etc. can support closing existing standardization gaps to support the market uptake of the project's research results*

Who is here today? – Take a sticky note from the left toolbar, click below to place it and let us know your name and organization!

- *Mariusz Kruczek (GIG)*
- *Cristina Onorato (AXIA)*
- *Thayana Rigo (AXIA)*
- *Karl Grün (ASI)*
- *Rami Hana (RWTH)*
- *Roberta Behar (MYX/LBRT)*
- *Óscar Rodríguez (IRIS)*
- *Tom Andrews (NCC)*
- *Patricia Royo (DIE)*
- *Lisa Filzmaier (ASI)*
- *Liviu Toma (FHF)*
- *Riccardo Varotto (NSB)*
- *Gosia Markowska (GIG)*
- Friederick Knez (ZAG)
- Manuel Antonio Gomes (ISQ)

Rules of the game – How we want to collaborate today

- *Share your thoughts!*
- *Taking 5-10 min breaks after each hour*

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Expectation Management – What is important for you today?

- *Understand standardization procedure for innovative products*
- *Amazing progress and results to be disseminated for GREEN-LOOP!*
- *I would like to talk about the ASTM D 6814 protocol and how this links to compounding work in WP3*
- *Better underestanding of standarization framework for new materials*
- *Clear identification of standardisation gaps and existing one that affect the project and the products towards its commercialisation*
- *Understand which are current standardisations that applies to the project and which one could be developed*

Results so far – Quick review of collected earlier via the GREEN-LOOP Standardization Questionnaire

From your perspective: Are any of your before mentioned standards difficult to apply or are there any barriers for its implementation?

- *None of the mentioned standards represents a barrier either to the application or to the development of materials. It should mention the additions of the following tests/standards (some included in D4.1):*
  - *EN 1186 - Materials and articles in contact with foodstuffs (same as MOCA)*
  - *UNI EN 13130 - Materials and articles in contact with foodstuffs - Plastics substances subject to limitation - Guide to test methods for the specific migration of substances from plastics to foods and food simulants and the determination of substances in plastics and the selection of conditions of exposure to food simulants - SPECIFIC MIGRATION TEST*
  - *EN 1186 standard - GLOBAL MIGRATION TEST*
  - *ASTM D5229 - Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials*
- *Materials and articles in contact with foodstuffs - Plastics substances subject to limitation - Part 1: Guide to test methods for the specific migration of substances from plastics to foods and food simulants and the determination of substances in plastics and the selection of conditions of exposure to food simulants*
- *Some test standards need additional decisions on testing parameters. They are possibly lacking appropriate conditioning. Some measurement techniques require extensive calibration and external data.*
- *Comment refers to ASTM D 6814, Standard Test Method for Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density:*
  The determination includes several steps which are also long ones, i.e: soxhlet extraction with acetone for 16 h, toluene immersion for 72 h. The total protocol could take 1 working-week. Besides, the data used for the calculation of the Devulcanization percentage involves only gravimetric (weight) measurements.

In your view, which main areas of knowledge relevant to the GREEN-LOOP project are not covered by standardization yet?

- *Communication, Dissemination and Exploitation of results*
- *Biomass performance*
- *Probably the standards required for the commercialization of the final products. For WP4, it's mandatory that the bottle closures respect the alimentary standards (MOCA/EN 1186), whereas other*

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standards are optional. Each cap must have a Technical Data Sheet (the safety one is optional) and have explicit conditions of sale (in accordance with the client).

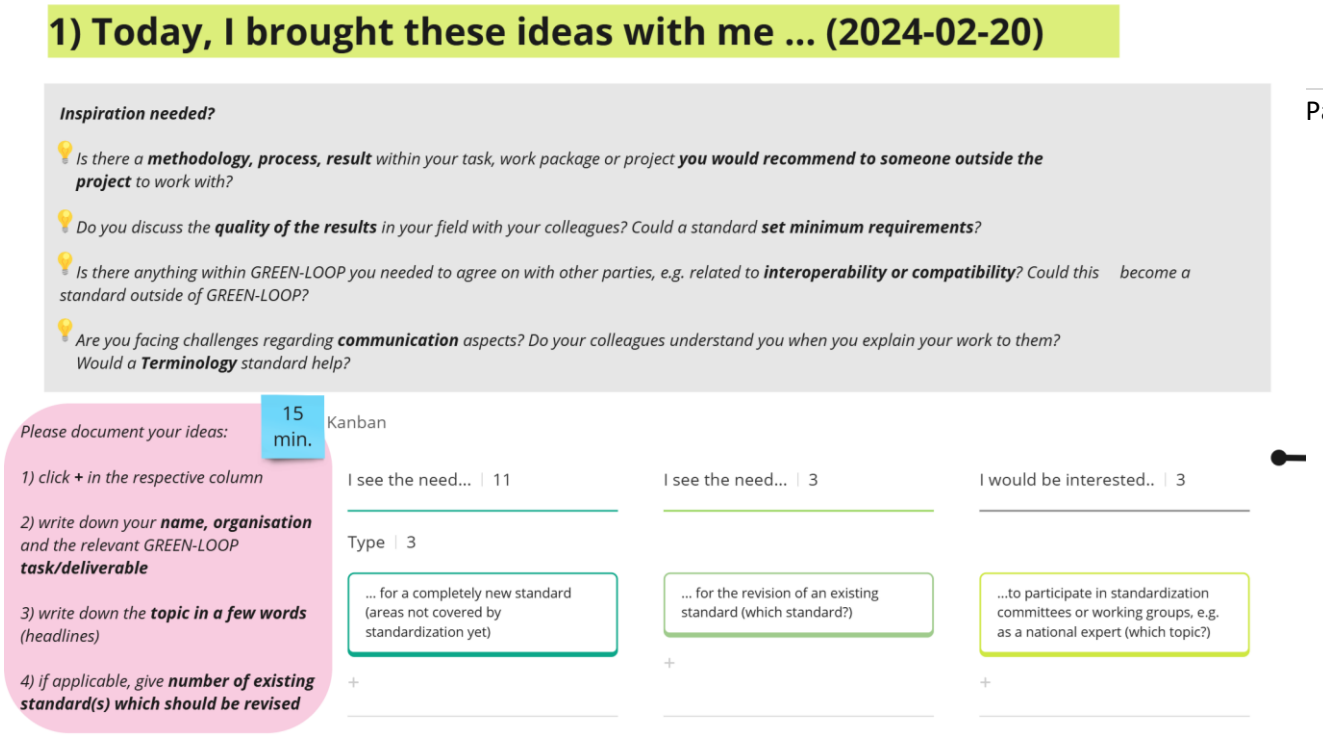
- *Specific characteristics / performance such as toxicity of released compounds, fire toxicity.*
- *LCC, social-LCA*
- *Manufacturing process*
- *Bio contents and properties of new biomaterials*

In your view, is there a substantial need for a new standard related to the focus of the GREEN-LOOP project?

- *There is minor need, most WP3 performance are well covered*
- *At least related to the Percentage of Devulcanization of the Rubber as I mentioned. Also the purity of the Lignin extracts, although there is a protocol developed by NIC, it would be useful another one, simpler and faster.*

1st collaboration action "Today, I brought these ideas with me …"

In this section of the workshop, the participants were asked to enter their ideas for either a new standardization project, suggestions for improving an existing standard, or the interest in participating in a standardization committee to the following Kanban board. The results are presented on the following page.



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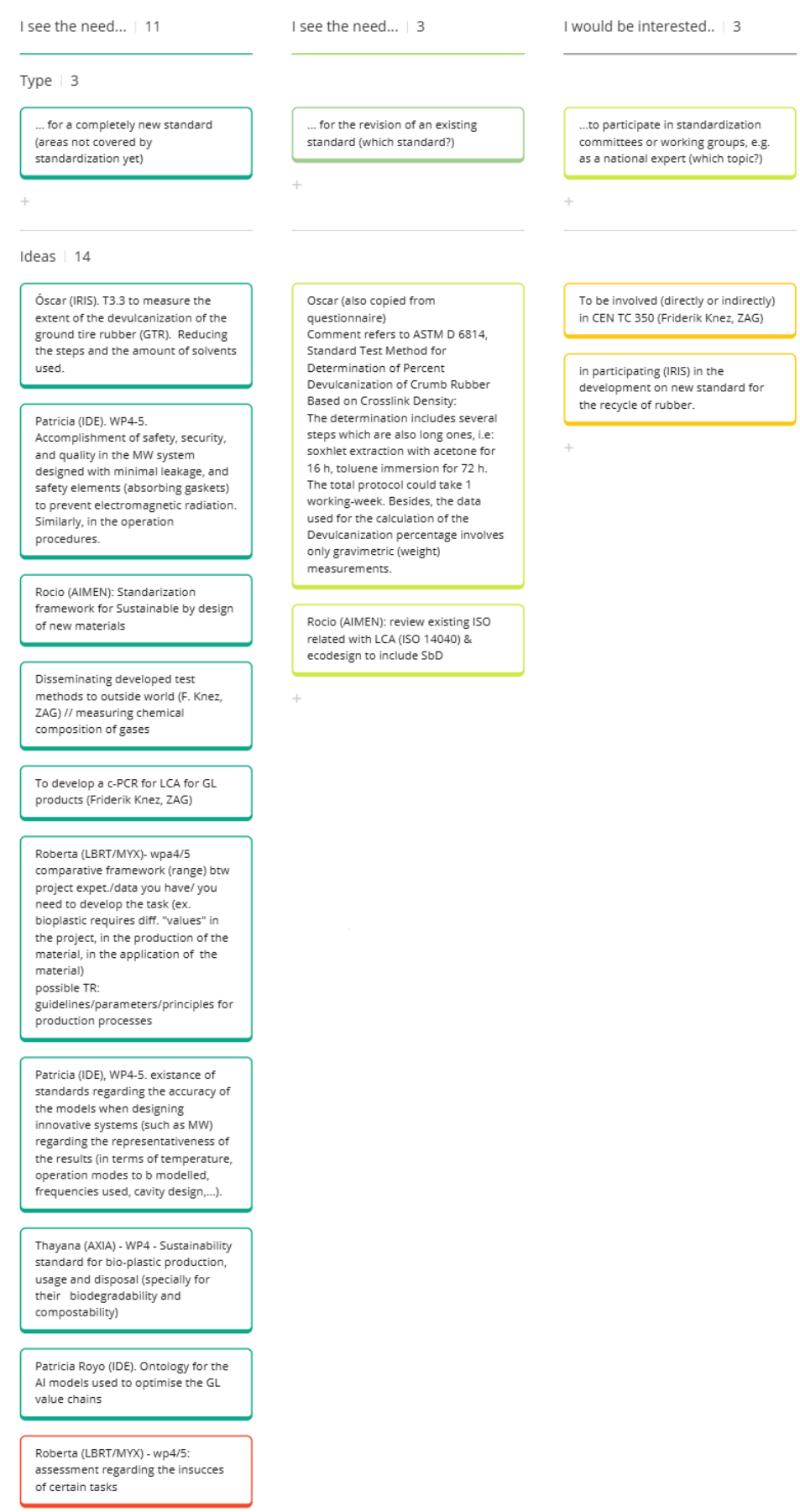

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2nd collaboration action "Clustering your ideas – what should be standardized?"

In this section of the workshop, the participants were asked to present their standardization ideas to the group and copy their ideas to the most applicable field of a matrix. The matrix indicated several relevant technical fields of GREEN-LOOP as well as different types of standards. Where applicable, related standardization ideas were merged. The results are provided below together with the results of the 3rd collaboration action focusing on the evaluation and ranking of the standardization ideas.

3rd collaboration action "Evaluation and ranking"

In this section of the workshop, the participants were asked to vote for the standardization ideas which were most important to them. Each participant could provide up to three votes by placing one avatar each next to the idea in the matrix. The results of the 2nd and the 3rd collaboration action are presented on the following page. Standardization ideas which were ranked highest are marked red. To improve readability, columns and rows of the matrix which were not used during the workshop have been deleted.

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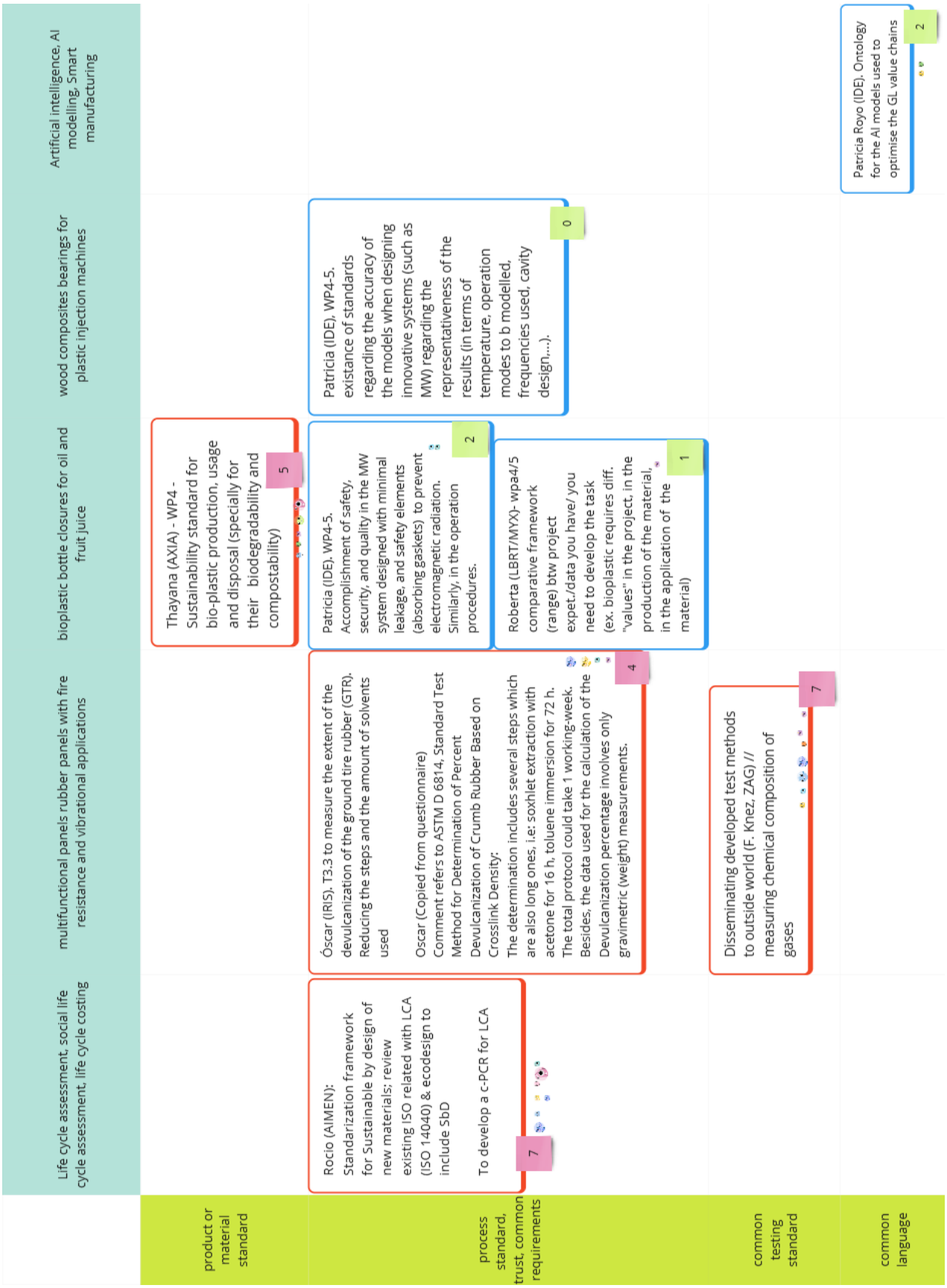

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4th collaboration action "Develop your idea(s) further"

In this section of the workshop, the 4 highest-ranked standardization ideas were explored in detail. Workshop participants were able to join individual break-out sessions for this purpose. The same brainstorming questions were asked to each group. For better readability, the results of this section of the Miro board are presented in Table 3.

Table 3 - Results of 4th collaboration action "Develop your ideas further"

Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Group members:	Rocio (AIMEN), Patricia (IDE), Gosia (GIG)	Óscar & Hesam (IRIS & UBRISTOL), Tom Andrews (NCC)	Friderik Knez (NCC), Tom Andrews (NCC)	Rocio (AIMEN), Roberta (LBRT/MYX), Liviu (FHF), Thayana & Cristina (AXIA)
Which activity (work package, deliverable, solution) forms the basis for this proposal?	T2.3. WP2. T2.5 a module in the GL platform. D2.4. T6.5 Task 6.5 End Of Life of products and next use. D2.2. Milestone 4. LCA inventory for manufacturing system. Milestone 11 End Of Life of GREEN-LOOP products.	T.1.3 Application of the ultrasound in the rubber manufacturing.	WP3. Task 3.6.	WP4 & WP5.

Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Which challenges should be tackled by developing a new standard or revised standard?	How to find standardization information. Understand it properly to be able to apply it. Data problems at all stages (lack or difference of data. How apply methodology in different sectors.	Easy to apply. Accurate. Reproducible.	Change in sampling methodology (ultrasonic sampling, better than soxhlet). Use of GCMS as an analysis method (beyond just FTIR). Wider acceptance of the method among scientific community - Beyond just scientific papers. Comparison between different test houses for repeatability.	Go through all the norms that exist currently and try to adapt to Green-Loop's Value chains. Lack of some regulation within the circular bio-plastic, causing unclarity to based the standard. Confusion within so many standards.
What are the future benefits of the standard?	Compare results. Exploitation: efficiency improvement. Avoiding mistakes, learning from the standards --> less time-consuming process. Dissemination of results Validation of results.	It could be possible for researchers and industrial partners to evaluate the % devulcanization of the material. Motivate more partners to investigate towards this topic Properly evaluate the devulcanization methodologies proposed in the literature/industry.	Contribution to testing which enables less toxic products . Applicable to many material types Bring together human and ecotoxicology (particularly for fire). Common approach to toxicity testing.	Provide clarity and guidance to future companies to process under this standardised process. So manufacturers adapt to new circular process (business model). Good conditions where the product should kept and stored. A clear guide for the final consumer with labels (symbols) to dispose the bio-polymer.

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Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Legal environment Directives and relevant European legislation	Ecodesign directive. SSbD methodology by JRC. Waste directive. Green Deal. Circular economy. Action plan. Directive on Green Claims (proposal).	I am not aware of that. However, less solvents involved in the protocol could be beneficial for the enviroment.	No existing legislation on toxicity. CEN/TC 349 and CEN/TC 350 only covers regular use and not abnormal use (e.g. fire). Building regulations currently cover 'time to burn' and 'optical density' but do not cover the composition of the compounds released. Toxicity will need to be built into the existing building regulations/ standards.	CEN has published several standards on biobased products. A clear guide for the final consumer with labels (symbols) to dispose the bio-polymer. EU communicated an adoption on a policy framework for biobased, biodegradable and compostable plastics. Figure on “Einteilung der biologischen Abbaubarkeit“.
Scope: What is the standard about? (requirements, framework, etc.)	ISO: 14040: Very general methodology. PCR: more specific for products or sectors. Market oriented.	Measurement of crosslink density, potentially using techniques like swelling tests or other analytical methods. Soxhlet equipment Solvents: acetone, toluene. Gravimetric scale and specific accesory (measure density of particles).	Measurement standard for chemical composition of fire effluents using cone calorimetry. Cone calorimetry procedure already covered by existing standards. Sampling technique. Analysis technique. All materials (10x10cm).	Define the Region and Markets. Updated comparative table within different sectors (define the sectors). Figure on “Einteilung der biologischen Abbaubarkeit“.

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Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Scope: Who is the target group of this standard?	people (both experts/technicians & decision makers) dealing with environmental decision support for products & processes. Scientific and academic community. Industry owners and operators Policymakers.	Researchers. Industry.	Test houses / laboratories. Material users (using the results of the standard). Legislators (using the results of the standard).	B2C and B2B, waste management companies and final users.

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Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Proposer of the standard: Who from the project could be the initiator and who the main contributors? Who else should be involved (project internal & external) and who has already agreed to take part in the standard development?	MAIN POINT: REVIEW current ISO standards. Include new features that are related with technology development: biomateirals, nanomaterials,... INTERNAL: AIMEN, GIG, AXIA, IDENER. External: JRC- EC.	Not sure. Anyone with the tools (laboratory, knowledge) to try new protocols. The issue was raised during the project because due to discrepances in the results obtained. Could take part: UBRIS NCC IRIS.	Frederik Knez Plus wider group from ZAG Rise (Research Institutes of Sweden). Effectis - France - https://efectis.com/en/ University of Central Lancashire	Marco Scatto - from Mixcycling ASI supporting the standardisation process. TDZ and industrial partners of this sector. Labs conducting tests of this specific materials.

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Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Why is this also important for other stakeholders?	GL results for biomaterials LCA comparison. GL Flagshit to validate methodologies at low TRL.	I consider having an standard, easy to apply and to reproduce, will give us the chance to scale up the methodologies we are testing in Greenloop.	Material users (using the results of the standard). Material users - how their materials will behave when exposed to fire. Material users - ability to differentiate between different materials. Legislators (using the results of the standard). Legislators - Public health, environmental health.	It sets the baseline for future standardize processes. For future companies entering the industry /new business.
How strongly is a common basis needed?	Compare results. Validation of results. Most strongly needed: Avoiding mistakes, learning from the standards --> less time-consuming process.	It is strongly needed.	Required - different methods currently being used in different labs. Needed for standardised material comparison.	-
What is explicitly not part of the standard?	NOT SURE NOT to be included.	Some steps require more description, related to gravimetric measurements, filtering steps.	Limited to chemical composition not toxicology. Limit values/ safe thresholds - This would come from regulations	-

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Standardization idea:	**1 - Standardization framework for Sustainable by design of new materials; review existing ISO related with LCA (ISO 14040) & ecodesign to include SbD // ISO 14040**	**2 - ASTM D 6814**	**3 - Measuring chemical composition of gases**	**4 - Sustainability standard for bio-plastic production, usage and disposal (specially for their biodegradability and compostability)**
Market environment: What is already on the market and how does the envisaged standard differ from it?	ISO 14064. PCR: more specific for products or sectors. ISO: 14040: Very general methodology. more market oriented. AIM: review, not new standard. ISO 14044 - more focused on requirements & guidelines. ISO 14067 --> focus on quantifying carbon footprint / impact on climate change.	So far only this standard has been found and researchers use it.	-	-
Possible elements of the standard: How would the standard look like (e.g. table of contents)? Which elements need to be included?	Data sources. General assumptions for low TRLs. Circular value chains. Newly developed materials, processes, systems (ie, nanomaterials) and its disposal Future schemes in Use and End Of Life phases.	It should be a protocol. List of steps. Reagents used It should be more descriptive	-	-

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