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PROTOCOL FOR HUMAN-CENTERED TESTING OF BIOECONOMY PRODUCTS IN LIVING LABS BY CITIZENS

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A. LIVING LABS

Research shows that many new products and services fail after entering the market, often because they do not sufficiently reflect users' real needs. For this reason, companies increasingly involve users directly in research and development activities. When users participate as co-developers, the outcomes are usually more innovative and better aligned with market expectations.

Traditionally, user involvement focused mainly on collecting feedback on existing products or services. Through the Living Lab approach, users are actively involved in the development process and contribute as co-creators of value. This approach leads to user-driven innovation, where ideas, testing, and improvements are developed jointly. To co-create value successfully, companies, users, and other relevant stakeholders need to align their goals clearly, define roles and responsibilities. This shift from closed, ownership-based development towards more open and collaborative processes requires organisations to rethink how value is created and captured.

There is no single Living Lab methodology, but all combine and customise different user-centred, co-creation methodologies to best fit their purpose. The European Commission has characterised Living Labs as Public-Private-People Partnerships (PPPP) for user-driven open innovation.

1. Openness

Openness is a fundamental pillar of the Living Lab methodology. Principles of open innovation and user innovation emphasise collaboration among diverse stakeholders to co-create shared solutions. Instead of relying on closed, organisation-driven research and development processes, Living Labs foster open ecosystems in which businesses, citizens, public authorities, researchers, and other societal actors jointly contribute to innovation.

Openness within Living Labs is closely linked to inclusiveness and an explorative mindset. Participation is often encouraged regardless of formal qualifications, with curiosity, motivation, and willingness to experiment prioritised over predefined expertise. This inclusive approach allows for diverse perspectives, unexpected insights, and creative contributions that may not arise in more structured or expert-driven settings. It supports experimentation in real-life contexts and encourages stakeholders to explore emerging needs and opportunities together.

However, a highly open recruitment model can create knowledge gaps, therefore it is recommended to map participants' competencies by including skill- or expertise-related questions in registration forms. Such measures preserve openness while enabling organisers to strategically complement the participant pool and strengthen the overall co-creation process also for more targeted or technically specific product improvements.

2. User-centricity

The modern concept of co-creation, which underpins the Living Lab approach, emerged from the business sector in the 1990s as a new form of engagement with customers. Rather than viewing customers as passive consumers, companies began inviting them to provide feedback, generate new ideas, and actively participate in the development of products and solutions. All participants gained a greater sense of meaning and value from this process: customers felt more empowered and connected to products, while businesses were better able to refine and test products and access new markets.

Through this open and participatory structure, Living Labs help reduce the gap between technological possibilities and societal needs. User-driven innovation has increasingly become a key competitive factor for organisations. By involving users directly in product and service development, companies shift their focus from seeking predefined technical solutions to understanding underlying user needs. This approach keeps strategic options open, stimulates creativity, and increases the likelihood that innovations will meet real market requirements. User-centricity strengthens collaboration and inclusiveness while also enhances the effectiveness, relevance, and long-term viability of innovation outcomes. A user-centric approach views users as proactive agents, giving them direct involvement in defining their needs and priorities, collaboratively finding solutions, influencing decisions, and developing a bio-based product, service, or solution with improved outcomes.

However, effective co-creation requires adequate competencies within the Living Lab ecosystem. While many Living Labs possess strong facilitation and evaluation capacities – particularly when experts such as moderators, sensory analysts, or technical specialists are involved – certain expertise gaps can limit the depth of the process. Frequently identified missing competencies include marketing and branding expertise (to refine commercialisation strategies and sustainability communication), product designers and technical specialists (to optimise functionality and scalability), environmental and sustainability experts (to assess long-term material and process impacts), and consumer psychologists (to better understand behavioural drivers and strengthen market positioning). Addressing these gaps through targeted stakeholder recruitment or strategic partnerships enhances the robustness and impact of co-creation activities.

3. Resources

The Living Lab approach is seen in the scale from simple problem-solving technique, such as brainstorming, to the complexity of design thinking process. It requires time, a change in attitude, and sustained attention to be effective. Therefore, it is particularly suited to addressing complex problems. Such complexity may arise from a wide range of participants, disciplines, and resources. If a problem is simple, straightforward, time-constrained, and financially programmable, project management techniques may be preferable. For large, complex but well-understood problems, agile project management or programme management techniques are more appropriate. Numerous agile project and programme management frameworks are available, which divide projects into smaller phases (commonly known as sprints), allowing teams to adapt and continuously improve. This iterative process involves teams setting goals for each sprint, then building, testing, and reviewing their work with stakeholders before proceeding to the next sprint. After each sprint, teams reflect to identify potential improvements. Regular feedback enables teams to adapt to change, deliver results more quickly, and better meet customer needs.

Effective coordination and management of Living Labs require appropriate competencies, as well as strong facilitation and evaluation skills, especially when experts such as moderators, sensory analysts, or technical specialists are involved. Two main challenges may arise when implementing Living Labs in real-life settings: the capacity (time availability) and capability (skills and knowledge) of users involved in the process. Therefore, skilful planning and monitoring can address certain gaps that might otherwise limit the depth of

the process. Frequently identified missing competencies among stakeholders in Living Labs include marketing and branding expertise (to refine commercialisation strategies and sustainability communication), product designers and technical specialists (to optimise functionality and scalability), environmental and sustainability experts (to assess long-term material and process impacts), and consumer psychologists (to better understand behavioural drivers and strengthen market positioning). Addressing these gaps through targeted stakeholder recruitment or strategic partnerships enhances the robustness and impact of co-creation activities. By combining diverse expertise with active user participation, Living Labs ensure that innovation is technically sound, socially desirable, environmentally responsible, and economically viable.

4. Co-creation

Co-creation is a fundamental element of the Living Lab methodology, distinguishing it from traditional research and development approaches. At its core, co-creation involves the active and collaborative participation of diverse stakeholders – including users, companies, public authorities, researchers, and civil society actors – in jointly generating, refining, and validating innovations. Instead of innovation being driven solely by internal R&D departments, value is created through structured interaction, shared experimentation, and mutual learning in real-life contexts.

In Living Labs, co-creation is implemented through participatory formats such as assemblies, workshops, focus groups, pilot actions, and testing sessions. Workshops often serve as central components of the process, providing inclusive spaces for ideation, feedback exchange, and practical experimentation. These interactive sessions typically begin with introductory activities to familiarise participants with the product or concept under development. They often include hands-on testing, sensory evaluations, guided discussions, and expert-led analyses, enabling participants to provide immediate and actionable feedback.

For example, companies may organise structured product testing events where participants evaluate prototypes, complete assessment forms, and take part in moderated group discussions. Such formats support the refinement of product characteristics, positioning strategies, and commercialisation pathways. Direct interaction between producers and users improves feedback quality and accelerates learning cycles. In some cases, blind or anonymous testing methods are used to minimise bias and ensure objective evaluations, particularly when assessing sensory characteristics or user preferences.

Another important aspect of co-creation is the freedom for creative contribution. Allowing participants to experiment with their own ideas (e.g., by modifying prototypes, suggesting alternative uses, or contributing to concept development) fosters a sense of ownership and deeper engagement. This participatory dynamic enhances creativity, increases motivation, and often leads to more innovative and contextually relevant outcomes.

5. Value and lifecycle approach

From a theoretical perspective, Living Labs align with user innovation and value co-creation theories, which emphasise that innovation value emerges through interaction between producers and users, rather than being embedded solely in the product itself. Living Labs provide a structured environment in which this interaction can unfold under real-life conditions, thereby bridging the gap between technological development and user adoption.

A defining characteristic of Living Labs is the integration of real-time feedback loops. During hands-on testing sessions, participants provide immediate input while interacting with the product in authentic or simulated real-life settings. This enables companies to quickly identify areas for improvement and adjust

product features accordingly, whether related to functionality, sensory attributes, usability, or aesthetic design.

Iterative product development is a natural outcome of this approach. User suggestions generated during live testing sessions often inspire tangible adjustments, ranging from refining formulations and optimising technical performance to redesigning packaging or exploring alternative applications. The iterative nature of co-creation ensures that innovation evolves through successive cycles of testing, reflection, and adaptation, rather than following a linear development path.

In summary, a Living Lab is not a single event but a continuous, structured, and participatory process. It transforms users from passive evaluators into active contributors, embeds innovation in real-life contexts, and enables iterative refinement based on collective intelligence. Through inclusive collaboration, real-time experimentation, and multidisciplinary input, co-creation becomes the engine that drives relevance, acceptance, and sustainable value generation within the Living Lab ecosystem.

6. Business to Customer & Business to Business Living Labs

Business-to-consumer (B2C) companies sell their products and services directly to end users, focusing on individual customers and their experiences. In terms of innovation, B2C firms typically prioritise brand development, market presence, customer engagement, and user experience. As their success depends heavily on acceptance and satisfaction at the consumer level, understanding how individuals interact with products in real-life situations is crucial.

A B2C Living Lab is therefore an open innovation environment in which users are actively participating in the innovation process. They provide feedback, suggest improvements, and help shape the final product. Companies co-create, test, and refine innovations together with end users in real-life contexts. They actively shape the innovation process by experimenting with prototypes in homes, communities, online platforms, or public environments. The primary goal is to reduce market uncertainty, enhance product-market fit, and optimise customer experience before scaling.

In **Business-to-business (B2B) Living Lab** companies co-develop, test, and validate solutions with a smaller group of stakeholders, professional users, partner companies, or institutional actors. Experimentation occurs within actual production systems, logistics chains, service infrastructures, or organisational workflows. In terms of innovation focus, B2B firms tend to prioritise internal processes, operational capabilities, efficiency improvements, and product-mix innovation rather than brand positioning or customer experience. These characteristics influence how innovation methodologies are designed and implemented through the Living Lab.

Innovation outcomes are shaped by contextual factors such as organisational culture, technical infrastructure, regulatory frameworks, and inter-organisational dependencies. Testing prototypes developed in the early design phase within real business processes is essential to identify performance issues, integration challenges, and operational risks before full-scale implementation. Small group of influential stakeholders can significantly shape the direction of innovation due to their purchasing power, strategic importance, and long-term contractual relationships.

In this context, the Living Lab serves as a risk-reduction and co-creation mechanism embedded in real economic activity. It enables companies to validate technological feasibility, organisational compatibility, and business viability under authentic operating conditions, ensuring that innovation is strategically aligned with the needs of professional users and partner organisations.

B. BIOECONOMY

The EU Commission defines the bioeconomy as the production of renewable biological resources from land and marine ecosystems (including crops, forests, fish, animals, and microorganisms) and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and materials, as well as bioenergy and services. It encompasses the sustainable utilisation of biological materials and aims to reduce dependence on fossil resources.

Countries develop their own national or regional bioeconomy definitions and strategies, which do not share a mutual understanding of the term, so the scope and emphasis vary according to each country's technological capacity, natural resource base, and economic and trade policies. Nevertheless, there is consensus on the cross-cutting nature of the bioeconomy across multiple sectors that use and produce biological resources: from agriculture, forestry, fisheries, aquaculture, agro-food industries, and the wood industry, to all others that produce bio-based materials, including construction, textiles, chemicals, pharmaceuticals, cosmetics, and energy.

The bioeconomy is widely regarded as a key approach to addressing major societal challenges such as climate change, food and nutrition security, energy independence, and environmental sustainability. The European Commission has articulated this vision through the European Bioeconomy Strategy, a multi-sectoral policy for all Member States that promotes sustainable resource management, reduced dependence on non-renewable resources, climate change mitigation and adaptation, and enhanced competitiveness and job creation.

As global demand for raw materials has increased dramatically over the past century, leading to resource scarcity and rising extraction costs. Sustainably managed biomass has emerged as a renewable alternative. Derived from agricultural and forestry residues, organic waste, algae, and biomass supports the production of bio-based energy, materials, and chemicals.

The bioeconomy stimulates economic growth by creating new markets and value chains. It modernises European industry by enabling the substitution of fossil-based raw materials in sectors such as construction, packaging, textiles, and chemicals. At the same time, it promotes more sustainable and resilient food systems by transforming organic waste into valuable bio-based products, supporting farmers and other primary producers, and contributing to the goal of halving food waste by 2030.

7. Bioeconomy sectors

The bioeconomy includes many sectors, highlighting its cross-sectoral nature. No sector is entirely bio-based, and virtually all industries use bio-based materials to some extent, either as inputs in production processes or as components of final products. To address this complexity, the bioeconomy is often organised according to the classic three-sector model of the economy, distinguishing between industries (as defined by standard classifications such as NACE) and broader economic sectors.

- Primary bio-based production includes the extraction, collection, and cultivation of biological resources from nature, mainly for use as raw materials. This includes activities such as agriculture, forestry, and fisheries.
- Secondary bio-based production involves the manufacturing of goods that use bio-based raw materials either in processing or as ingredients in final products. It includes traditional manufacturing industries such as food, beverages, textiles, wood, and paper; however, as only parts of these industries rely on bio-based inputs, they are often described as "mixed bio-based industries."

- Finally, tertiary bio-based production refers to activities that further refine manufactured bio-based goods and support their distribution and consumption, such as construction using wood-based materials, as well as trade, transport, and logistics services related to bio-based products.

Bioeconomy includes many sectors:

- Agriculture
- Forestry
- Fisheries
- Aquaculture
- Agro-food industry
- Wood industry
- Construction industry
- Textiles
- Chemical industry
- Pharmacy
- Cosmetics
- Synthetic biology
- Energy industry
- Other, such as waste management, etc.

8. Business activities related to bioeconomy

The new Common Agricultural Policy (CAP) explicitly includes the bioeconomy as one of its specific objectives and allows Member States to establish interventions to promote the development of the bioeconomy in rural areas. Particular attention is given to primary producers, as they play a key role in bioeconomy value chains. The main pillars of the bioeconomy include:

- Biomass production and processing, which covers agriculture, forestry, fishing, the manufacture of food and bio-based products, and construction;
- Services provided by or within biomass-producing and manufacturing enterprises (such as forest management planning, maintenance and after-sales services, research and development, patents, training, monitoring, and nature tourism).
- The involvement of farmers is especially important at the supplier end, as this is crucial to ensuring that farmers, primary agricultural producers, forest owners, their associations, and other small rural businesses, rather than being mere biomass suppliers, benefit from the profit-generating value added through innovative transformation processes in bioeconomy businesses. Countries with well-developed primary sectors have many opportunities to develop downstream value chains as well.
- Manufacturing activities where biomass is a key raw material: food production, beverage production, tobacco production, wood processing and refining, and paper production.
- Manufacturing activities in which biomass or bio-based components may constitute the raw material base include the production of textiles, clothing, leather, chemicals and chemical products, pharmaceutical raw materials and preparations, rubber and plastic products, furniture, and electricity.

Business activities related to bioeconomy:

- Extraction, collection and cultivation of bio-based materials from nature used primarily as raw materials (e.g. Plant and animal production; Hunting and related services; Forestry and logging; and Fishing and aquaculture)
- Manufacture of goods using bio-based raw materials in the production process or as components of end products (e.g. food, beverages, tobacco, textiles and leather, wood products and furniture, paper)
- Brokerage and logistics services (e.g. trading and transportation services for bio-based products)
- Replacement of fossil raw materials with bio-based raw materials for product manufacturing (e.g. chemical products made from bio-based solvents, bio-based polymers, bio-based packaging, biofuels and agrochemicals; rubber; clothing; footwear)
- Further refinement of the manufactured bio-based products (e.g. construction materials, bio-based chemicals, bio-based pharmaceuticals, bio-based plastics)
- Production of bioelectricity or liquid biofuels

8.1. Competitive market advantage

The bioeconomy is characterised by a strong emphasis on innovation through research and technological development. It has become one of the most representative research-intensive sectors in Europe, with SMEs, start-ups, and spin-offs in particular experiencing growth. Advances in biotechnology, synthetic biology, and related fields have made it increasingly feasible to convert biomass into a wide range of products, from biofuels to bioplastics. Numerous innovative ideas, bioproducts, and green processes have emerged and developed around bioeconomy.

However, many of these high-potential products and technologies do not reach the market. This is due to the gap between innovative research and profitable commercial exploitation. Regardless of how eager representatives of business-supporting organisations (such as clusters, farmers' associations, consultancy services, etc.) are to share bioeconomy-related technologies and opportunities within their networks, they must explain how their product or service will deliver value to customers. Companies in the start-up phase, during the evolutionary curve, need to overcome initial capital constraints to achieve profitability.

New business models are designed to present the value propositions of:

- new emerging technologies for bio-based products and materials,
- new forms of collaboration between stakeholders (such as business alliances based on the principles of industrial symbiosis or bioeconomy clusters), and
- new services that respond to changing consumer behaviours (e.g. the sharing economy).

Bioeconomy business models:

- New bio-based products that replace fossil fuel products
- New bio-based processes that replace chemical processes
- New technologies used for bio-based products and materials
- Integrated services that support the bio-based product and extend it into an integrated solution for the customer
- New services that respond to new consumer behaviour (e.g. sharing economy)
- Other, such as waste valorisation, upcycling techniques, and eco-friendly logistics solutions

The most recognisable competitive advantages focus on the following categorisation:

☐ BIO-BASED SUBSTITUTE PRODUCTS

This category includes all bio-based substitutes for fossil-based products. The value proposition is to offer customers environmentally friendly alternatives that perform the same functions as their fossil-based counterparts, with the potential to upgrade by-products from value-chain partners. Generating value from bio-based resources is often characterised by the sale of bulk products.

Typical challenges for this business model include low market acceptance due to a lack of confidence in the sustainable substitute, issues with product quality and availability because large quantities of biomass are required, and insufficient valorisation of biomass.

☐ BIO-BASED PRODUCTS WITH NEW FUNCTIONALITIES

This category includes new bio-based products with novel functionalities. These products are often highly specialised and therefore sold in lower quantities than many substitutes.

As these products are entirely new, firms often seek to protect their intellectual property through patents, which can be costly and time-consuming. This business model often requires integrating new knowledge into the firm or recombining knowledge from different sectors, leading to organisational challenges such as a lack of absorptive capacity, research facilities, skilled workforce, or limited access to knowledge networks and research facilities.

☐ PRODUCT-SERVICE SYSTEMS (PSS) BUSINESS MODEL

The third business model type represents services or a combination of tangible products and intangible services. The value proposition to the customer is either:

- an additional service sold with the purchased product (such as recycling),
- the use of a product without ownership (use-oriented PSS business models involve leasing or renting a product instead of selling it),
- or an agreed outcome or solution (result-oriented business models focus on providing an integrated solution for the customer rather than an isolated product or service).

In product-oriented business models, the customer pays for the product and the services provided, while in use-oriented business models, value is captured through ongoing payments over time (e.g. leasing). Unlike these two product-based business model types, service business models are less affected by input-related challenges. Instead, a lack of customer integration and interaction would significantly impact the value proposition and value creation. Additionally, internal company structures must be adapted to selling services, for example, by establishing a separate business unit, as changing logistics and internal structures to implement a service-based business model can be challenging.

C. HUMAN-CENTERED TESTING OF BIOECONOMY PRODUCTS AND SERVICES

Testing bio-based products or services through human-centred testing in Living Labs can be a crucial step in ensuring successful market uptake. Comparative analyses of business models in the bioeconomy show that the most successful bio-based products typically follow a market-pull orientation, meaning they are developed in response to clearly identified needs, demands, or problems expressed by users. In contrast to a purely technology-push approach, where innovation is driven primarily by scientific or technological advances without validated demand, market-pull strategies ensure that solutions are aligned with real-world expectations, usability requirements, and purchasing behaviour. Although technological innovation often arises from the interaction between push and pull forces, policies in the bioeconomy sector have historically focused more on supply-side measures such as R&D support. However, evidence, including analyses by the OECD, suggests that a successful transition to a bio-based economy requires stronger demand-side mechanisms to ensure real market adoption.

This is where Living Labs and human-centred testing play a transformative role. Involving potential customers (whether individuals or companies) in the development process helps bridge the gap between laboratory innovation and market reality. Early engagement enables developers to validate assumptions, refine functionality, test usability, understand willingness to pay, and adapt value propositions to specific market niches. Especially in the bioeconomy, where new materials or solutions often aim to replace fossil-based alternatives, customer involvement builds trust, reduces uncertainty, and strengthens acceptance. It also lowers the risk that promising technologies will fail to scale commercially due to a mismatch between innovation and user needs. By integrating feedback from real-life environments and real users, Living Labs create a co-creation ecosystem that increases the relevance, competitiveness, and long-term sustainability of bio-based products and services.

9. Purpose of testing

When setting up the methodology and techniques for Living Lab processes, it is important to acknowledge what business organisations aim to achieve through the process and how mature their product or service development is. For instance, a start-up might focus on ideation and prototyping, while an established company rather focus on market testing and commercialisation.

Possible purposes of bio-based product or service testing:

- Ideation
- Planning
- Concept design
- Prototyping
- Market test
- Commercialisation

Ideation is the initial step where ideas are generated. Brainstorming sessions are held to explore various potential solutions or innovations. Example: A focus group brainstorms ideas for a new plant-based energy bar, considering different ingredients such as oats, almonds, chia seeds, and plant-based protein sources.

The planning phase refines the idea and creates a roadmap for further action. Key resources, timelines, and goals are outlined to ensure successful development. Example: The focus group plans the sourcing of ingredients, defines production steps, and sets a timeline for producing the energy bars.

Concept design further develops the idea into a viable concept. This stage involves sketching the design, functionality, and structure of the product. Example: The focus group designs the layout for the energy bar, deciding on its nutritional content, packaging, and flavour profile.

Prototyping involves creating a working model or prototype to bring the concept to life. The prototype is used to test and refine the idea. Example: For a plant-based energy bar, prototyping involves making a small batch of bars, experimenting with ingredient combinations, texture, and appearance. This process allows the focus group to identify issues with the product's design or functionality and make improvements.

Market testing means the product is tested with a small target audience to gather feedback and identify any improvements or adjustments needed. Example: Samples of the energy bars are distributed to Living Lab participants or consumers at the event to gather their reactions and feedback on taste, texture, packaging, and overall satisfaction. The collected insights help refine the product further or confirm its market readiness.

Commercialisation means the product is launched to the broader market, with strategies for scaling, distribution, and marketing implemented. Example: Based on feedback, the focus group finalises the recipe and plans how to sell or distribute the plant-based energy bar, considering local markets, online sales, or partnerships with health stores.

10. Testing features

Organisations can tailor the Living Lab testing process to their specific innovation needs. This modular approach ensures that testing remains relevant, targeted, and capable of generating actionable insights within the Living Lab framework.

Specific features of bio-based product or service that can be tested:

- Market positioning
- Advertising strategy
- Usability and functionality
- Materials
- Design
- Technological innovation
- Environmental impact
- Circular economy
- Supply chain
- Other, such as consumer attitudes towards ethical production methods etc.

Market positioning: Organisations can test how their products are perceived by consumers, including brand awareness, interest in new products, and demand among target consumers. Through Living Lab testing, it is possible to learn about target audiences, market channels, and how to position products as sustainable or innovative offerings within industries (e.g., green cleaning, bio-based products, sustainable food).

Advertising strategy: Advertising campaigns are developed for various consumer segments with emphasis on sustainability, circular economy models, and product differentiation. Living Lab experiments are conducted to test the effectiveness of marketing channels, communication methods, and brand messaging.

Usability and functionality: Testing involves consumer feedback on product performance, functionality, and ease of use in actual applications, as used by consumers. Organizations test how effectively their

products perform and whether they meet consumer expectations, such as sensory and mechanical properties.

Materials: Experimentation with different raw materials for product production. Testing focuses on durability, sustainability, and user acceptance of the materials.

Design: Experimenting with novel product designs, ranging from packaging to product shape (e.g., balls instead of bars). The goal is to design products for maximum consumer appeal, ease of use, and sustainability.

Technological innovation: Experimenting with new production processes or ingredients, for example, bio-based catalysts. Innovations focus on improving product efficiency, minimising environmental impact, and introducing new sustainable materials in consumer products.

Environmental impact: Piloting the sustainability of products, such as CO_2 savings, waste reduction, water savings, and soil enrichment. Ensuring that products contribute to environmental benefits such as reduced plastic waste or increased upcycled content.

Circular economy: Assessing how products support circular economy models, for instance, by finding new options for cascading biomass use and minimising resources. Feedback on customers adoption of such models is gathered to enable fine-tuning of the sustainability component.

Supply chain testing: Especially in B2B Living Labs, pilot testing of supply chain aims to enhance collaboration between stakeholders. This includes analysis of distribution channels and logistics, to ensure products and processes are well aligned with all partners in the value chain.

Other: Testing for example consumer attitudes towards the overall product characteristics, such as product quality, ethical production methods, and ways to improve the user experience. Products are refined to align with consumer preferences and industry trends.

11. Focus groups

Living Labs can be established through focus groups comprising users, business representatives, and other relevant stakeholders where applicable. Focus groups should consist of 6 to 12 people. This number provides a wide range of perspectives while ensuring the group remains manageable and allows for meaningful discussion.

General criteria for the design of Living Lab focus groups:

- 6 to 12 participants (according to the type of activity, methodology, expected data feedback),
- balanced gender distribution,
- age groups from xx to xx (defined by the business and their respective product),
- users with varying levels of knowledge about bio-based solutions,
- the characteristics of the participants.

A general guideline for selecting participants is to consider their flexibility, willingness to change, and strong social skills, so that group dynamics and discussion can proceed successfully. Organisations should also consider whether they are targeting end customers (B2C) or seeking feedback from other businesses (B2B), as this distinction can influence the selection of user groups and the type of insights gathered. It is important to note that each Living Lab is unique - there is no right or wrong choice, and organisations should select the users they believe will provide the most relevant and valuable insights. Showcasing the variety of user groups considered in this project can help illustrate the many possibilities for involving diverse stakeholders.

Possible stakeholders in B2C or B2B Living Lab:

- Primary producers and land managers
- Industry and business stakeholders
- Consumers or general public
- Specialized audiences
- Educational or community groups
- Regulatory and legal experts

Primary producers and land managers offer insights into sustainable practices, cropand soil requirements, and resource management. Examples from BIOECO-UP Living Labs include farmers, small-scale and hobby farmers, agronomists, forestry owners, gardeners, and biogas producers.

Industry and business stakeholders provide feedback to optimise processes, packaging, and market feasibility. Examples from BIOECO-UP Living Labs include agricultural enterprises, food industry representatives (e.g., tomato processors), food technologists in manufacturing companies, large-scale retail trade, cosmetic raw material distributors, and panel manufacturers.

Consumers and the general public give direct feedback on product quality, sustainability, and purchasing motivations. Examples from BIOECO-UP Living Labs include regular shoppers, eco-conscious buyers, people with dietary restrictions, those concerned about skinand health products, the general public, and local communities.

Specialised audiences help test niche applications and assess product functionality in real-life scenarios. Examples from BIOECO-UP Living Labs include the HoReCa sector (chefs, restaurateurs), sports field managers, artistsand creatives, people with allergies, household managers, and those responsible for cleaningand maintenance.

Educational and community groups explore educational aspects, promote sustainable behaviours, and test community-level solutions. Examples from BIOECO-UP Living Labs include schools, teachers, universities, faculties, researchers, parents, students, and community groups involved in composting and recycling.

Regulatory and legal experts ensure products comply with market regulations and explore policy-driven adoption pathways. Examples from BIOECO-UP Living Labs include national, regional, and local governments, and legal experts in cosmeticsand food regulations.

12. Living Lab setting

Testing in Living Labs typically builds on four complementary pillars:

- Use cases focus on defining realistic scenarios in which the product or service will be applied. This includes specifying functional and non-functional requirements and validating whether the solution effectively addresses real-life needs. Clearly defined use cases help ensure that testing remains relevant and grounded in actual user contexts.
- Co-creation actively involves users and stakeholders in identifying needs, generating ideas, and shaping solutions. This participatory approach is particularly valuable in the bioeconomy, where acceptance, perceptions of sustainability, and behavioural factors strongly influence the adoption of a product or service in the market.

- Prototyping and testing involve early-stage experimentation, pilot demonstrations, and iterative improvements. These processes allow organisations to assess performance, usability, user acceptance, and potential market barriers before scaling.
- User research provides systematic insight into user behaviour, motivations, perceptions, and expectations. Qualitative and quantitative methods help identify patterns, validate assumptions, and understand the socio-economic implications of innovation.

Schuurman identified three main building blocks within a Living Lab:

> Exploration
> Experimentation
> Evaluation

Schuurman developed a methodological framework and suggested that Living Labs can be compared to an experimental approach. This includes a pre-measurement, an intervention, and a post-measurement, where the intervention is equivalent to the real-life experiment. Each phase is equally important for achieving the objectives of the activity and preparing the results. The exploration and evaluation process highlights the ability of the Living Lab methodology to assess changes in attitudes, habits, and practices related to the innovation being developed, and to reveal its "added value".

The exploration phase focuses on moving from an initial idea to a clearly defined concept or early prototype by developing a deep understanding of the current context. Its primary aim is to analyse the existing state, identify user habits, practices, and challenges, and uncover unmet needs and expectations. This phase relies on observation, participatory approaches, and in-depth interviews to gather insights into real-life situations and specific user contexts. By mapping current problems and opportunities, stakeholders can frame innovation challenges in a grounded and evidence-based manner.

In addition to understanding the present situation, the exploration phase encourages ideation and co-creation activities to generate potential tailored solutions. Brainstorming sessions and collaborative workshops help translate identified needs into concrete concepts for further development. An essential outcome of this phase is the establishment of a benchmark describing the existing conditions. This pre-measurement enables future comparison and provides a reference point for assessing the impact and added value of the innovation in subsequent phases.

The experimentation phase builds on the outcomes of exploration by testing the proposed concept or prototype in real-life or near real-life conditions. The central aim is to allow users to directly experience the solution and observe how they interact with it in practical settings. Depending on the maturity level, the prototype may range from an early mock-up to a more advanced product or service. Testing can take various forms, including short-term trials, user experience testing, or longer-term home or field experiments.

Through structured data collection and observation, this phase focuses on understanding user reactions, levels of acceptance, and potential barriers to adoption. It seeks to determine whether the solution effectively addresses the identified needs and whether it has the potential to influence new behaviours or usage patterns. The insights gained during experimentation inform the decision to refine and revisit the exploration phase or proceed to evaluation and market-oriented activities.

The evaluation phase compares the current state with the results generated during experimentation to assess the innovation's added value and market potential. It marks the transition from testing and learning to exploitation and practical application. If the innovation is ready for market entry, discussions focus on how it can be positioned effectively in relation to customer expectations and competitive alternatives.

This phase typically involves market research, development of marketing and communication strategies, and assessment of pricing and value propositions based on pre- and post-measurements. By quantifying

improvements and clarifying benefits, stakeholders can make informed decisions regarding product launch. Evaluation may also extend beyond market entry to include post-launch monitoring, redesign, or functional upgrades, ensuring that the innovation continues to evolve in response to user feedback and market dynamics.

12.1. Co-creation methods and tools

Living Labs are used as open or user innovation paradigms, where the user takes the initiative in one or more phases of the innovation process. Innovation processes are rarely linear: phases overlap, repeat, and evolve. Therefore, it is wise to choose methods and tools that fit the particular purpose of the organisation.

Widely used method and tools for carrying out engagement and co-creation activities:

- Design thinking
- Siscode toolbox

Design thinking is a solution-oriented, human-centred methodology for addressing complex problems. It emphasises empathy with users, collaborative brainstorming, and hands-on experimentation through rapid prototyping and testing. The process stimulates the development of innovative ideas and reframes challenges from a human perspective. This participatory technique is particularly suitable for rapid prototyping and learning by making. It also fosters collaboration by creating a shared language among SMEs, users, researchers, and other stakeholders.

Design thinking consists of five phases that can be adapted into an iterative cycle:

- Empathy: Understanding of human needs.
- Definition: Re-framing and defining the problem in a human-centred way.
- Ideating: Creating many ideas in ideation sessions.
- Prototyping: Adopting a hands-on approach in prototyping.
- Testing: Developing a prototype/solution for the problem.
- Documenting: Documenting the process and results.

Empathy is the first stage of the process, aiming to build a deep understanding of users' real needs, habits, and expectations regarding the product area being tested.

Initially, facilitators explore what users currently do, think, and feel regarding the product's purpose: their routines, unmet needs, and the products they already use to address these needs. The product is then presented, ideally through a live demonstration or trial, linking its value proposition directly to the needs users have expressed. By observing how users interact with the product, what motivates or discourages them, and where frustrations arise, facilitators gather valuable insights from a real-life perspective. In the third part of this phase, users receive structured guidance for testing the product according to usability, marketing, and environmental criteria. Testing may take place in daily-life field trials or group settings within the Living Lab, depending on the product's nature and maturity.

Definition reframes the identified challenges in a human-centred way. Insights gathered during the empathy phase are synthesised to clarify core problems, common pain points, and unmet needs. This step helps identify concrete starting points for further product development. The key outcome is a clear articulation of improvement opportunities and directions for innovation.

Ideation encourages the generation of a wide range of creative solutions to address the defined needs. Participants freely brainstorm and sketch ideas without constraints, prioritising quantity and creativity. Through discussion and exchange, ideas are combined, refined, and expanded, creating a diverse pool of potential improvements.

Prototyping takes a hands-on approach by transforming selected ideas into tangible representations. These prototypes enable teams to test feasibility and impact in practice. Feedback is collected, modifications are made, and iterative cycles of refinement follow. Sharing prototypes with additional user groups further strengthens the evaluation process and enhances solution robustness.

Testing involves returning improved prototypes or solutions to users for validation. Feedback focuses on whether the solution effectively addresses users' needs and whether it positively influences their experiences, perceptions, or task performance. This step confirms whether the innovation is ready for final development for the market or requires further refinement.

Documenting the iterative and co-creative nature of testing is essential, as systematic documentation ensures transparency, learning, and knowledge transfer. Notes, photos, videos, canvases, sketches, and other materials should capture key discussions, suggestions, and events.

The Siscode toolbox[1] is a structured framework that supports co-creation processes from problem framing to experimentation and prototyping. Developed under the SISCODE EU project, the toolbox assists co-creation laboratories, Living Labs, Fab Labs, science centres, and similar innovation platforms. Its core purpose is to make sense of existing data, tools, and toolkits, and to offer a practical pathway from problem understanding to real-world experimentation.

Iterative journey through Living Lab phases:

- Define the process
- Analyse the context
- Engage stakeholders
- Reframe the problem
- Envision and prioritise ideas
- Prototype and experiment

Each phase has distinct goals, outputs, and recommended activities, supported by specific canvases and tools. The purpose is to guide practitioners using practical canvases and tools such as stakeholder mapping, challenge reframing, and experimentation planning. In practice, teams select and adapt relevant templates to analyse context, define challenges, co-design solutions, and document learning cycles.

Practical implementation steps:

Define your co-creation journey internally within the innovation team before engaging a wider stakeholder group. Use the phase and activity canvases to map out the intended co-creation path, including inputs, activities, and expected outputs.

Context analysis helps you gather and organise data on the challenge, local environment, existing policies, resources, and stakeholder network.

A stakeholder engagement and dissemination plan guides whom to involve at each step and how to communicate effectively to ensure broad participation and meaningful contribution.

Reframing refines the challenge into a shared problem definition that integrates diverse perspectives. Tools such as problem canvases and frame boards reveal hidden assumptions and broaden understanding.

[1] https://siscodeproject.eu/wp-content/uploads/2019/09/toolkit-27092019-1.pdf

Generate and prioritise ideas using ideation tools like idea cards and selection matrices. These help envision alternatives that best address user needs and contextual realities.

Prototype and experiment with the experimentation canvas and other synthesis tools that assist in planning, testing, and iterating prototypes in real-world environments. These help validate co-designed solutions with users or stakeholders.

For each phase, the toolbox provides:

- Phase canvases to help facilitators plan activities, define stakeholders and their roles, and clarify phase objectives, activities, and expected outcomes. This ensures clarity and alignment among stakeholders before activities begin.
- Activity canvases for detailed organisation of specific activities within each phase. These help map out co-creation activities, required resources, desired outcomes, tools to use, time requirements, and evaluation criteria.
- Synthesis tools to capture and visualise outputs (e.g., stakeholder maps, idea cards, problem definition canvases, experimentation canvases) to ensure outputs are actionable and meaningful.

This toolbox provides a coherent structure for iterative, participatory processes while remaining flexible enough to adapt to different stakeholders, innovation stages, and local ecosystems.

12.2. Activities and engagement techniques

There are various approaches to engaging participants in testing products or services and co-creating their further development. The main challenge is selecting and adapting the most appropriate methods to the specific phase of innovation and the objectives of testing. Practitioners are encouraged to combine and tailor these approaches to suit their context, target users, and development stage. The ultimate goal of this stage is validation: determining whether the product or service meets users' expectations and identifying barriers to its adoption.

Several activities can be adopted throughout the Living Lab process:

> hands-on product demonstrations
> usability testing in real-life settings (in public spaces, fairs or home environment)
> guided sensory or usability tests in workshop setting
> facilitated discussions with focus groups
> co-creation assemblies
> online campaigns
> home-testing
> open-innovation hackathons
> brainstorming sessions

Many Living Lab processes require a **hands-on demonstration** of a product or service that users will later test and evaluate. This enables facilitators to explain key features and value propositions of the product, helping to establish a common understanding among users and providing initial information for independent use later. Such demonstrations are particularly important when the object of observation is an idea or prototype, which may lack promotional material and packaging. Conversely, there are situations where no information should be given to users, as the aim is to observe their thoughts, associations, or first experiences with a product or concept.

Usability testing aims to assess how effectively and intuitively users interact with a product, service, or prototype in real-life settings. In practice, participants are asked to perform defined tasks while facilitators

observe behaviour, record difficulties, and collect feedback through structured questions or debrief discussions. In Living Lab settings, usability testing is especially important because it occurs in real-life or semi-real-life environments, allowing for natural behaviour, practical challenges, and real-world performance outside controlled environments. The direct observation component is a key strength, as it reveals issues users may not explicitly articulate.

For certain products, it may be preferable to organise **guided sensory or usability tests** where specific aspects of the testing environment are controlled, such as blind sensory testing. Users evaluate sensory characteristics such as scent, taste, texture, or handling of a product without knowing the brand or type. This anonymity enables honest comparison and helps identify strengths, practical challenges, and areas for improvement for each product tested.

Facilitated group conversations are designed to explore perceptions, experiences, and attitudes in depth. Focus groups encourage interaction among participants, often revealing shared concerns, diverse viewpoints, and collective insights. Such group discussions can be enhanced with brainstorming sessions, which generate scenario-based discussions, encourage collaborative solution mapping, and help uncover new product possibilities. Participants are encouraged to think openly and propose innovative solutions without immediate constraints. Another way to enhance group discussions is by involving specialists from relevant fields (e.g., technology, sustainability, marketing, regulation), who assess the product from a professional perspective and add important depth to the conversations.

Co-creation assemblies are facilitated, multi-stakeholder workshops designed to collectively explore challenges and co-design solutions. Their purpose is to bring together diverse actors – users, experts, businesses, scientists, or public representatives – to ensure that multiple perspectives inform innovation. Implementation typically involves thematic group discussions, moderated dialogue, and synthesis of key insights into shared action points. In Living Labs, co-creation assemblies are particularly valuable for building shared ownership, strengthening stakeholder alignment, and translating user insights into jointly supported development pathways to increase acceptance of the final solution.

An online campaign can provide a scalable and resource-efficient method for testing products beyond a physical workshop environment. It enables effective engagement of geographically dispersed participants, who are informed through company communication channels such as social media, mailing lists, newsletters, or established community networks. Testing packages or samples can be distributed with clear instructions for home testing. Structured online questionnaires are used to collect feedback from potential customer groups and professional stakeholders, generating valuable input for companies.

Home testing enables the involvement of a diverse group of participants who use the product across various lifestyles, preferences, and usage contexts over a defined period. The aim is to observe how products perform in real-life conditions. By allowing users to interact with products in their homes, workplaces, or other natural settings, developers gain insights into practical aspects of product use, such as ease of application, integration into daily routines, and perceived value. This method also helps identify user expectations, potential barriers to adoption, and opportunities for improvement. Participants typically receive the product with basic instructions or suggested usage methods and are asked to document their experiences during the testing period. Engagement may be supported through reminders via digital communication channels, such as SMS or email. Feedback is collected through structured questionnaires, user diaries, or follow-up discussions, enabling developers to gather both qualitative and quantitative insights and identify opportunities for product improvement.

Open-innovation hackathons are intensive, time-limited collaborative events designed to generate creative solutions to predefined challenges. Participants form multidisciplinary teams, develop ideas or prototypes, and present their results for feedback or evaluation. Successful implementation requires clear challenge framing, facilitation support, and a structured pitching or evaluation process. Hackathons are particularly useful for rapid ideation, engaging new stakeholder groups, and exploring unconventional solutions, while fostering networking and cross-sector collaboration.

Brainstorming sessions can be implemented through various techniques which serve as structured facilitation tools to actively engage participants and guide collaborative group processes. Role-playing exercises, further stimulate open discussion and creativity. These tools can foster creativity and strategic reflection on our activities.

Brainstorming techniques as structured facilitation tools:

- Idea dashboard
- Six thinking hats
- Open innovation tools

The Six thinking hats method is a structured group discussion technique that encourages participants to examine a problem from six distinct perspectives: factual, emotional, critical, optimistic, creative, and organisational. Implementation involves guiding participants to adopt one thinking mode at a time, ensuring balanced exploration of risks, opportunities, and innovative ideas. In Living Lab contexts, this method is particularly useful for managing diverse stakeholder groups, preventing the dominance of a single viewpoint, and creating a safe framework for expressing both critical concerns and creative proposals.

The Idea dashboard is a digital or visual management tool used to collect, organise, evaluate, and prioritise ideas generated during co-creation activities. Participants submit ideas to a shared platform where they can be categorised, rated, clustered, and tracked over time. The dashboard supports transparency and continuity of the group process by ensuring that contributions from different sessions or stakeholder groups are not lost. Its particular value lies in helping facilitators move from broad ideation to structured decision-making and actionable next steps.

Open innovation tools are digital platforms that enable organisations to crowdsource ideas and collaborate with external contributors. Their purpose is to expand the innovation ecosystem beyond internal teams by engaging users, experts, and partners in structured idea generation and evaluation. Implementation typically includes launching open calls, collecting submissions, facilitating online collaboration, and analysing contributions through integrated dashboards. These tools are especially valuable for scaling participation, reaching geographically dispersed stakeholders, and maintaining engagement beyond physical workshops.

12.3. Data collection

It is best to combine quantitative and qualitative methods for data collection to ensure a comprehensive understanding of user perceptions and testing outcomes with measurable indicators.

Different tools can be used to support data collection during activities:

- individual interviews as a structured qualitative data-collection method,
- testing questionnaires (paper or web-based),
- structured discussions report of debate with focus groups,
- surveys for anonymous feedback for broader outreach,
- user diaries for home-testing observation reports.

Individual interviews with structured conversations provide valuable qualitative insights into perceptions, expectations, and real-life experiences. These interactions can be guided by questionnaires or structured debate frameworks to ensure comparability of responses while allowing space for diverse viewpoints and spontaneous reflections. Interviews may be conducted during public events, fairs, or open-space activities,

which are particularly useful for reaching individuals with varied backgrounds and profiles. This approach enables the collection of authentic reactions from potential users who may not otherwise participate in more formal testing settings.

Questionnaires, whether paper-based or web-based, serve as structured instruments for collecting comparable data across a larger group of participants. They can be used as guidance tools during usability tests, helping participants focus on predefined criteria such as functionality, environmental aspects, or marketing perception. Questionnaires are also effective as follow-up tools, allowing users to provide anonymous responses after workshops or brainstorming sessions. Their structured format supports quantitative analysis while still offering space for open-ended comments.

Reports from structured engagement debates with focus groups document the key arguments, concerns, agreements, and disagreements expressed during moderated discussions. These reports synthesise qualitative insights generated through participant interaction and help capture collective perspectives. Systematic documentation of such debates ensures that nuanced opinions and emerging themes are preserved and translated into actionable recommendations. It is therefore advisable to assign this note-taking task to a specific person during the activity.

Online survey tools can effectively broaden communication and outreach to wider target groups. They can be used to explore general habits and opinions on a specific theme or to complement individual home tests of bio-based products. Anonymous online feedback mechanisms encourage honest responses and may increase participation among users who prefer digital interaction. When users test products in their home or daily environments, they are encouraged to document their experiences, observations, and reflections in a structured manner. Combining digital surveys with real-life testing strengthens both the qualitative and quantitative dimensions of evaluation.

User diaries are another valuable tool for home-testing observation reports. Participants record their experiences over a defined period, noting practical challenges, emotional responses, changes in habits, and contextual factors influencing product use. Diaries may be written, photo documented or audio-recorded and digitally submitted. Daily or periodic reminders via mobile phone or email help maintain consistency and establish a systematic reporting routine, ensuring that feedback is not lost and that insights can be meaningfully integrated into subsequent development phases. This longitudinal perspective helps identify usage patterns, moments of frustration or satisfaction, and the gradual domestication of the product in everyday life.

12.4. Main testing topics: usability, marketing, environment

Three dimensions for testing bio-based products:

- Usability: functionality, effectiveness, intuitive use, sensory experience, durability, …
- Marketing: user perception, core value, competitive advantage, trust, market positioning, …
- Environmental dimension: ecological impact, renewable resources, water and waste pollution, …

The usability dimension focuses on how effectively a bio-based product or service functions in practice and how easily people can use it in their daily activities. It assesses whether the solution fulfils its intended purpose, how intuitive it is for different user groups, and whether it integrates with existing routines, equipment, or systems. Usability is closely linked to reliability, safety, and accessibility; therefore, the bio-based solution should combine functional performance with intuitive operation and a positive overall user experience.

Another important aspect of usability is durability and long-term functionality. Products and services should be designed to remain operational under normal usage conditions and ideally include support mechanisms such as repair services, technical assistance, refurbishment options, or product take-back systems. These elements not only extend product lifespan but also contribute to resource efficiency and waste reduction. Safety considerations are equally critical, particularly regarding potential risks to users and the environment, including toxicity or harmful substances.

The marketing dimension focuses on how a bio-based product or service is presented, communicated, and positioned in the market. It examines how clearly the product's value is explained to potential users and how well the benefits are understood. This includes highlighting features such as renewable materials, lower environmental impact, safety, or other advantages compared to conventional alternatives.

Clear communication and straightforward explanations are important to help customers understand what differentiates a bio-based product and why it may be a better choice. Through Living Lab, we can test their perceptions of quality, performance, design, sustainability claims, and price compared with similar products on the market. Marketing analysis therefore considers whether customers recognise the added value of the bio-based solution and whether they view it as a competitive and trustworthy alternative.

The environmental dimension focuses on the ecological impact of a bio-based product or service throughout its entire life cycle. This includes how raw materials are sourced, how the product is manufactured and used, and what happens to it at the end of its life. Through Living Lab, we can evaluate attitudes and behaviours of users regarding these themes. Feedback from Living Lab participants can reveal their purchasing habits and how strongly environmental aspects may influence their future decisions to buy bio-based alternative to conventional products. Understanding these perceptions helps identify opportunities to improve product design, communication, and circular business models that better align with environmental expectations.

D. TEMPLATES FOR LIVING LAB IMPLEMENTATION PROCESS

13. Phase 1: Exploration

The exploration phase is the initial step for organisations planning to test and co-create bio-based products or services through a Living Lab. In this phase, the organisation reflects on its activities, the characteristics of the product or service to be tested, and the main questions it wishes to explore during the Living Lab process. The aim is to clearly define the objectives of the Living Lab, establish the starting point of the innovation, understand the context in which it operates, and identify the most relevant aspects to be examined during testing and co-creation activities.

As a first step, the organisation considers how its activities relate to specific bioeconomy value chains, such as agriculture, forestry, food production, bio-based materials, energy, or biotechnology. Organisations also consider the main competitive advantages of their product or service, such as innovative technologies, new bio-based materials, improved production processes, or integrated services accompanying the product. Based on this, the organisation determines which phase of the innovation process it wants to focus on during the Living Lab activities, such as ideation, concept design, prototyping, market testing, or preparation for commercialisation. This helps ensure that the testing activities correspond to the current maturity level of the innovation.

Another important step in this phase is identifying the main research questions the organisation wants to explore. These questions may relate to usability, marketing potential, environmental performance, or other aspects of the product or service. Based on these questions, the organisation defines which product features or development areas should be presented and tested with Living Lab participants, such as materials, design, technological innovation, functionality, market positioning, sustainability aspects, regulatory compliance, or supply chain considerations.

The organisation should also consider which user groups and stakeholders could provide the most valuable feedback during the Living Lab activities. Potential participants may include end users, professionals, industry representatives, researchers, public institutions, civil society organisations, or other companies. Involving a diverse group of participants can help generate a broader range of insights, supporting product improvement, innovation development, and better alignment with user needs and market expectations.

In addition, the organisation should clarify what type of results or insights it expects to obtain from the Living Lab process. These may include feedback on product usability, suggestions for improvements, insights into user expectations, evaluation of market potential, or a better understanding of habits and usage of the product. If relevant, organisations may also consider the benefits of testing their product in different geographical or cultural contexts, which can help identify differences between target markets.

Finally, before initiating Living Lab testing, the organisation should review the safety, regulatory compliance, and documentation related to the product or service. This includes confirming that the product meets applicable legal requirements, that relevant certifications or quality standards are in place, and that appropriate instructions, labels, and warnings are available for users. Organisations should also assess potential risks associated with product use and ensure that measures are in place to guarantee safe testing conditions. This preparation helps ensure that Living Lab activities can be conducted responsibly and that participants can interact with the innovation safely and transparently.

Annex I provides the template for organisations to reflect on and plan the first phase of their Living Lab.

14. Phase 2: Experimentation

The experimentation phase is the practical implementation stage of the Living Lab process. In this phase, organisations design and conduct specific activities that enable bio-based products or services to be presented, tested, and further developed with users and other stakeholders. The aim is to progress from the initial exploration of ideas and needs to real-life testing and collaborative refinement of solutions. The focus is on facilitating direct interaction between the innovation and its potential users in realistic settings.

A key aspect of the experimentation phase is the active involvement of various stakeholder groups, such as companies, researchers, public institutions, community organisations, and end users. Their collaboration supports a co-creation process in which ideas, experiences, and feedback are shared openly. A range of participatory tools and innovation methods (such as design thinking workshops, usability testing, co-creation meetings, and open innovation sessions) can be used to encourage discussion, experimentation, and the generation of new ideas.

At the same time, organisations should establish clear governance structures, define roles and responsibilities, and plan how information will be collected, documented, and analysed. Structured feedback mechanisms, evaluation tools, and reflection activities help ensure that the insights gathered during the experimentation phase are meaningful and can support further development of the innovation.

The experimentation phase thus creates an environment in which products and services can be improved through collaboration and practical experience. Annex II provides the template for efficient preparation of the Living Lab implementation.

15. Phase 3: Evaluation

The evaluation phase enables organisations to assess whether the objectives of the Living Lab were achieved and to identify lessons for further development of the tested bio-based product or service. Evaluation determines the effectiveness of the chosen methods, tools, and activities, as well as the overall value of stakeholder engagement in the process. It also considers whether the questions guiding the testing process were sufficiently clear, relevant, and specific to enable participants to provide meaningful feedback and ideas.

The evaluation phase also focuses on identifying concrete outcomes that emerged during the Living Lab activities. Particular attention is given to results and improvement suggestions related to the three main testing dimensions: usability, marketing, and environmental performance. In addition to these areas, partners may identify other insights, unexpected findings, or innovative ideas that arose through the interaction between participants and the tested product or service.

By systematically analysing these aspects, the evaluation phase provides valuable conclusions about the effectiveness of the Living Lab approach. The insights gained can guide future improvements to the tested product or service, support further development and market preparation, and help refine the design and implementation of future Living Lab activities. Annex III provides the template for meaningful reflection and evaluation of results and information gained through the Living Lab.

To support the process, the Annex IV outlines several categories of questions within usability, marketing, and environmental impact of bio-based products and services. For each category, questions are formulated separately for business representatives and users. These questions are intended to facilitate dialogue among Living Lab participants during joint testing events. The proposed questions should be adapted to the specific characteristics and properties of the bio-based products being tested.

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Annexes I, II, III and IV to the Protocol for human-centered testing of bioeconomy products in Living Labs by citizens

Deliverable 2.3.2

and Output 2.2

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Annex I: EXPLORATION

Business organization

1. Name of the company:

2. Form of organization:
   - SME
   - Microenterprise
   - Start-up
   - Spin-off

3. Are you associated with one of the bioeconomy sectors (select one/several)?

   - Agriculture
   - Forestry
   - Fisheries
   - Aquaculture
   - Agro-food industry
   - Wood industry
   - Construction industry
   - Textiles
   - Chemical industry
   - Pharmacy
   - Cosmetics
   - Synthetic biology
   - Energy industry
   - Other (please specify):

4. Are your business activities related to (select one/multiple):

   - Extraction, collection and cultivation of bio-based materials from nature used primarily as raw materials (e.g. Plant and animal production; Hunting and related services; Forestry and logging; and Fishing and aquaculture).

   - Manufacture of goods using bio-based raw materials in the production process or as components of end products (e.g. food, beverages, tobacco, textiles and leather, wood products and furniture, paper).

   - Brokerage and logistics services (e.g. trading and transportation services for bio-based products).

   - Replacement of fossil raw materials with bio-based raw materials for product manufacturing (e.g. chemical products made from bio-based solvents, bio-based polymers, bio-based packaging, biofuels and agrochemicals; rubber; clothing; footwear).

   - Further refinement of the manufactured bio-based products (e.g. construction materials, bio-based chemicals, bio-based pharmaceuticals, bio-based plastics).

   - Production of bioelectricity or liquid biofuels.

   - Other (please specify):

5. What is your competitive advantage in the market (choose one/several)?

   - New bio-based products that replace fossil fuel products.
   - New bio-based processes that replace chemical processes.
   - New technologies used for bio-based products and materials.
   - Integrated services that support the bio-based product and extend it into an integrated solution for the customer.
   - New services that respond to new consumer behaviour in the bioeconomy (e.g. sharing economy).
   - Other (please specify):

Testing bio-based products in the Living Lab

6. Describe your bio-based product or service (hereinafter "product") that can be tested and co-developed in the Living Lab (max. 1000 characters):

7. Which step(s) of the innovation process would you like to focus on in the Living Lab (select one/several)?

   - Ideation
   - Planning
   - Concept design
   - Prototyping
   - Market test
   - Commercialization
   - Other (please specify):

8. What are your most important research questions or topics that you would like to test and explore with Living Labs in the following areas?

   - Usability:
   - Marketing:
   - Environment:
   - Other (please specify):

9. Which areas would you like to present, test and co-create with the Living Lab participants?

   - Innovative technology
   - Materials
   - Design
   - Usability and functionality
   - Market positioning
   - Advertising strategy
   - Environmental compatibility
   - Circular economy and sustainability
   - Compliance with legal regulations
   - Supply chain and logistics
   - Engagement and collaboration with stakeholders
   - Other (please specify):

Product liability, safety and compliance

10. Is your product compliant, i.e. does it meet all applicable legal requirements and regulations at national and EU level?

11. Have you carried out special tests for safety and quality standards? What kind of approvals, certificates or technical standards have you obtained?

12. Do you have specifications, including labels, manuals and warnings for product use?

13. Do you have proper technical documentation and adequate communication with the authorities?

14. Do you know the potential product risks for users and what solutions do you have to mitigate these risks?

15. We consider the safety of consumer products or services to be a fundamental right. Do you take responsibility for reasonably safe use? This means that the consumer who uses the product, service or solution as expected and normally should be safe. If this is not the case, do you take full responsibility for the consequences?

Annex II - EXPERIMENTATION

1. What are the main objectives of your Living Lab (choose from options i) and ii))?

   i) To co-create the product indicated by the companies in the development phase?
   Choose one or more options and define them more precisely in your case.

- Ideation:
- Planning:
- Concept design:
- Prototyping:
- Market testing:
- Commercialization:
- Other (please specify):

(ii) Are you testing specific features or addressing the challenges identified by the companies?
Select one or more options and define them in more detail in your case.

- Innovation Technology:
- Materials:
- Design:
- Usability and functionality:
- Market positioning:
- Advertising strategy:
- Environmental impact:
- Circular economy and sustainability in practice:
- Regulatory compliance:
- Supply chain and logistics:
- Stakeholder engagement and collaboration:
- Other (please specify):

2. What is the focus of product testing and co-development?
   For each dimension, define which challenges or hypotheses you would like to explore or test in relation to your case.

- Usability:

- Marketing:

- Environment:

- Other (please specify):

3. What type of stakeholders or users will be involved in the Living Lab?
   Identify each participant in the sectors that are relevant to your case.

- Companies:
- Research organizations:
- Government agencies:
- Community organizations:
- Users:

4. How will you define the governance structures and roles within the Living Lab, including leadership, decision-making processes and time management?

5. What methods and brainstorming techniques will you use to encourage collaboration and co-creation between stakeholders (described in the Methodology document, section 2.3.1)?

- Design Thinking
- Siscode toolbox
- Idea dashboard
- Six thinking hats
- Open innovation tools

6. How do you plan to implement activities to promote brainstorming, design thinking and experimentation processes as well as idea testing and ideation?
- hands-on product demonstrations
- usability testing in real-life settings (in public spaces, fairs or home environment)
- guided sensory or usability tests in workshop setting
- facilitated discussions with focus groups
- co-creation assemblies
- online campaigns
- home-testing
- open-innovation hackathons
- brainstorming sessions

7. What questions will you use to ensure that the solutions meet the needs and preferences of users (some options can be found in Annex IV)?
For each of the themes, define the most important questions that you want to test or validate.

- Usability:

- Marketing:

- Environment:

- Other (please specify):

8. Which qualitative or quantitative method do you plan to use for gathering the data, insights, ideas and feedback from users, stakeholders and business representatives in LL:

- individual interviews as a structured qualitative data-collection method
- testing questionnaires (paper or web-based)
- structured discussions report of debate with focus groups
- surveys for anonymous feedback for broader outreach
- user diaries for home-testing observation reports

Annex III - EVALUATION

1. Were bio-based products or services technologically and economically mature enough to enable successful testing and co-creation throughthe Living Lab activities?

2. Did you have any problems in defining the objectives of the Living Lab and the characteristics of the bio-based products tested in the Living Lab?

3. Did you succeed in achieving the objectives of the Living Lab? Please explain the what, how and why.

4. Were the questions and activities for the testing and co-creation process valid and relevant to achieving the objectives of the LL? Please give some examples.

5. What results and ideas for product improvement emerged in the usability dimension?

6. What results and ideas for product improvement emerged in the marketing dimension?

7. What results and ideas for product improvement have emerged in the environmental dimension?

8. Are there any other results or ideas that emerged during the testing and co-creation process in LL?

9. Was the focus group sufficiently diverse and balanced? Did you identify a lack of skills or expertise among the LL participants that would have been beneficial to the testing and co-design process?

10. Please describe what were the benefits and setbacks in terms of co-creation of LL participants (users, relevant stakeholders and business representatives). Add lines according to your needs.

LESSONS LEARNED	
Benefits	Setbacks
1.	1.
2.	2.
3.	3.

11. Include documentation about the planning of the LL, the implementation activities and the evaluation (e.g. list of participants, photos, notes, sketches, list of questions used for the tests, etc…).

Annex III - TESTING QUESTIONS

USABILITY PERSPECTIVE

Bio-based products or services should use renewable resources efficiently and aim to reduce waste as much as possible. For wider use, these solutions should be adaptable to different contexts and capable of scaling up to meet larger demands. Technological innovation, such as advances in biotechnology and data analysis, can help improve their performance and efficiency. At the same time, following relevant regulations is important to ensure that products are safe, easy to use, and accepted on the market.

Another important aspect is economic viability. Bio-based solutions should offer cost-effective alternatives to conventional products in order to be widely adopted. Engagement with different stakeholders, including government bodies, businesses, and local communities, is beneficial to support development and implementation. In addition, raising awareness and educating stakeholders about the benefits of bioeconomy can increase acceptance. Ultimately, bio-based solutions should contribute to long-term sustainability goals and support a more sustainable use of resources.

BUSINESS REPRESENTATIVES:

Production functionality:

- Do you have particular difficulties with the collection of biomass feedstocks in terms of quantity, seasonality, frequency or continuity, quality level?
- Can you use different natural resources as input for your biomass or are you dependent on a specific one?
- Do you have local, regional, national or cross-border value chains?
- Have you developed or do you use innovative technologies for your production?

User experience:

- Do you offer other services along with your product (e.g. consulting)?

Ease of use:

- Do you use innovative technologies in your product or solution? Do you think your product is intuitive to use?

Durability:

- Do you offer a repair service for your products?
- Do you offer technical support for your products or solutions?
- Do you have an additional manufacturing stream for refurbishing products? Do you disassemble the old products and use their components to manufacture the new products?

Compatibility:

- Is the bio-based product or solution compatible with existing systems, equipment or infrastructure?

Safety:

- Are there any safety concerns for the user and the environment (in terms of toxicity, harmful chemicals) associated with the use of the bio-based product or solution?

Feedback mechanisms:

- Do you offer customer service and through which channel?
- Do you offer product recalls when products become obsolete and customers want to throw them away?

USERS:

Functionality:

- Does the bio-based product or solution perform its intended function effectively and reliably?

User experience:

- What is the user's overall experience of interacting with the bio-based product or service?

Ease of use:

- Is the bio-based product or service intuitive to use (for different user groups)?

Durability:

- Do you believe the product is durable and will achieve a long lifespan under normal conditions of use?

Compatibility:

- Is the bio-based product or solution compatible with existing systems, devices or infrastructure?

Safety:

- Do you have any safety concerns related to the use of the bio-based product or solution? Do you think it may be hazardous to the environment (in terms of toxicity, harmful chemicals)?

Feedback mechanisms:

- Do you know of a mechanism to solicit feedback from users in order to continuously improve the product?

MARKETING PERSPECTIVE

Brands can build stronger relationships with consumers through storytelling about the origin and purpose of the product, and by encouraging long-term loyalty through sustainability-oriented initiatives and continued engagement after purchase. It is important to ensure transparency and traceability in the supply chain, clearly communicating where materials come from and how they are sourced. At the same time, bio-based products must meet quality and performance expectations, demonstrating that they are reliable and effective alternatives.

To stand out in the market, companies should clearly communicate the unique value of bio-based products, such as biodegradability or lower toxicity. Marketing messages should be adapted to the priorities of different target groups. Trust can be strengthened through credible certifications and labels, while partnerships with sustainability-focused organizations or influencers can expand visibility and credibility.

Marketing efforts can also include education and awareness activities to help consumers better understand the benefits and potential of bio-based solutions.

BUSINESS REPRESENTATIVES:

Value proposition:

- What is your value proposition (the sum of the benefits a company offers its customers)?

Customer insight:

- Who are your customers?
- Are you selling B2C or B2B?

Message effectiveness:

- What value drivers (practical reasons for the customer's motivation to buy) are you communicating to the market?
- Do you carry out any of the following activities? - awareness campaigns; - eco-labelling; - educational activities or materials?

Competitive Analysis:

- Where on the market is your organization in comparison with competitors?
- Is product or solution price competitive compared to conventional alternatives? If not, please explain what makes it more expensive (production scale, availability of raw materials, technological advancements)?

Channel Effectiveness:

- What kind of communication channels have you established with your customers before and after the purchase?
- Do you practise direct selling, online selling or via retailers?

Added Value:

- What is your value-added product (e.g. food, feed or other bio-based products or materials, bio-based and bio-derived chemicals, advanced biofuels, bioenergy), service or solution?

Trust and Credibility:

- Are you part of any bioeconomy cluster in your region?
- Do you publicly publish customers' reviews or have you received any public recommendations on the market?

USERS:

Consumer perception:

- How do you perceive the sustainability claims of the bio-based product or solution?

Brand awareness:

- Have you heard of this brand or company before? Were you aware of their sustainability and circular economy efforts?

Message effectiveness:

- What advantages can you see in the bio-based product or solution over conventional fossil fuel?

Competitive analysis:

- Do you prefer the bio-based product or solution over the conventional fossil fuel product or solution due to its sustainability and environmental impact? If not, what are your reservations?
- Have you seen other similar products on the market? How would you compare them to this product?

Effectiveness of channels:

- What marketing channels (e.g., social media, traditional advertising, influencer marketing) do you prefer to use to learn about bio-based products or solutions like this?

Perceived value:

- Do you think this product or solution offers better value for you and the environment compared to conventional alternatives?
- What do you particularly like about this product (e.g. the design, the smart solution, the sustainability approach)?
- How do you rate the quality of the product?
- Do you think that the price of the product corresponds to the additional production processes and measures that have to be carried out to obtain the biomass material?
- Do you think that the price of the product is appropriate for the innovative functions?

Trust and credibility:

- Do you trust the sustainability claims and certifications that advertise bio-based products or offerings?

ENVIRONMENTAL PERSPECTIVE

Bio-based products and services aim to reduce environmental impact throughout their entire life cycle, from sourcing raw materials to production, use, and disposal. They rely on renewable biological resources, which helps decrease dependence on fossil-based materials. Many bio-based products also have a lower carbon footprint, as plants capture carbon dioxide during photosynthesis, and their production and use often generate fewer greenhouse gas emissions than conventional alternatives. In some cases, these products are biodegradable or compostable, which helps reduce waste and supports circular economy principles.

In addition, bio-based solutions focus on efficient use of resources, often turning waste or by-products into valuable materials or energy. They typically involve lower toxicity, which reduces pollution and protects ecosystems. Sustainable sourcing practices can also support biodiversity conservation, while certain bio-based approaches improve soil health, water retention, and reduce land degradation. Water use can be optimized through better irrigation, pollution reduction, and reuse systems. Finally, using life cycle analysis helps evaluate environmental impacts across all stages of a product's life and identify opportunities to further improve sustainability.

BUSINESS REPRESENTATIVES:

Please check the boxes if you contribute to:

- ☐ sustainable management of land, forest or water
- ☐ reuse of residues in your manufacturing process
- ☐ use of renewable materials
- ☐ cascading or circular economy in your production processes
- ☐ efficient water and energy consumption
- ☐ waste hierarchy and minimization of waste generation

Please check the boxes if you contribute to the following:

- ☐ food and nutrition security
- ☐ sustainable management of natural resources
- ☐ reducing dependence on non-renewable and non-sustainable resources
- ☐ adapting to and mitigating climate change
- ☐ strengthening European competitiveness and improving employment opportunities

Life cycle assessment:

- Have you prepared a life cycle assessment for this pilot project? If not, do you plan to do one in the near future or why not?

Resource efficiency:

- To what extent does the bio-based product or solution utilize renewable resources? If it is not 100%, please explain which sources are not bio-based?
- How well does it minimize resource use?

Carbon footprint:

- Do you know the carbon footprint of the bio-based product or solution?
- How does it compare to conventional alternatives?

Biomass and biodegradability:

- What biological resources are used for your product or solution (e.g. plants, forests, fish, animals and microorganisms)?
- Is the product biodegradable? If yes, to what percentage? If not, why not?

Impact on the ecosystem:

- How does the sourcing of bio-based raw materials potentially impact biodiversity, land use, forests or aqua systems and ecosystems?
- Does your company and product or solution have a significant impact on climate change, food security, energy independence or environmental sustainability?

Waste reduction:

- How does the bio-based product or solution contribute to reducing waste generation and promoting circular economy principles?
- Do you separate and recycle materials in the production line?
- Do you practice industrial symbiosis (sell some of it to other companies)?
- Do you use any decomposition processes?
- Do you generate your own energy?

Regulatory compliance:

- Has your product or solution been developed in response to a specific environmental regulation or standard?
- Do you have certificates for the products or solutions you offer on the market?

USERS:

Purchasing practise:

- Do you practise reuse or recycling models or do you prefer to buy new products?
- Do you buy products on the second-hand market?
- Would you rather buy a product that has been refurbished by a company or a new one?
- Do you repair your items or do you prefer to buy new ones?
- Do you recycle the material when you throw it away?

Bio-based products, services or solutions:

- PRODUCT-ORIENTED BUSINESS MODEL

- Do you like to buy products in combination with services or do you prefer to pay for the basic product separately and for the service when and if you need it? And why?
- What is the benefit of the additional service if you receive it together with the product?

- USAGE-ORIENTED BUSINESS MODEL

- Do you prefer to rent or use the product or service instead of buying and owning it? And why?
- Is the communication and technical support for this service or solution efficient?

- RESULTS-ORIENTED BUSINESS MODEL

- What needs does a solution meet for you compared to a product?
- Why do you prefer to buy a solution as a whole rather than buying products and doing it yourself or finding a professional service to do it?
- What do you miss about this product, service or solution?

Product value from an environmental perspective:

- What is the environmental impact of this product (CO_2 emissions, resource depletion, pollution) compared to a product made from fossil fuels?