



Spanish Focus groups from food industry information

Report from the Institute of Agrochemistry and Food Technology (IATA, CSIC)

Dates: November, Monday 17th and Monday 24th at 12:00

Attendants: 12 attendants (8 from industry, 4 from academia)

Industrial Symbiosis: Concept and Current Understanding

Currently, the participants of focus group belief that the knowledge of industrial symbiosis is largely at the research and pilot-project level. Most participants were familiar with it through European or academic projects, rather than through consolidated, long-term industrial applications, although few shares real examples already exist in sectors such as food, chemicals, energy, and waste management.

Examples of Waste Valorisation given by participants

In their opinion, a wide range of residues have been explored or applied in industrial symbiosis schemes, including:

- Agri-food and biomass residues: olives, grapes, nuts, avocado pits, brewery spent grain, algae, marine biomass, plant residues, coffee husks.
- Industrial and urban residues: plastic waste, cardboard, solvents, industrial fumes, laboratory waste.

These materials have been valorised into cosmetics, food ingredients, biogas, animal feed, compost, biomass, bioplastics, and other bio-based products. Higher success is observed when high value-added products are targeted, rather than low-value applications that are already economically saturated (e.g. direct sale as animal feed).

In their opinion, the scientific and R&D community plays a key role in enabling industrial symbiosis by developing technologies that transform waste into higher-value products. However, the main challenge lies in transferring research outcomes to industry, particularly when technologies have low or insufficient TRL (Technology Readiness Level).

Main Barriers to Implementation

Despite its potential, real implementation faces multiple challenges grouped in technical, economic, practices (culture), and regulatory

Technical and operational barriers

- Irregularity and seasonality of waste streams
- Lack of homogeneity and standardization of raw materials
- Hazardousness or microbiological instability of certain residues
- Insufficient technological maturity for industrial scaling

Economic and logistical barriers

- High investment and scaling costs
- Uncertain profitability
- Transport and logistics costs
- Small waste volumes, especially for SMEs, often not economically viable to manage individually

Lack of practice examples as barriers

- Low culture of collaboration among companies
- Reluctance to share data due to industrial secrecy
- Poor communication between industry and academia
- Strong dependency among multiple actors within symbiotic chains

Need of Regulatory barriers

- Complex legislation and waste management requirements
- Mandatory involvement of authorized waste managers in many cases
- Each exchange must be assessed individually according to material type and regulation

Importance of Geography and Platforms

Geographic proximity is critical for sustainability and economic feasibility. Industrial symbiosis works best within industrial clusters or between neighbouring companies, where transport distances are minimized.

Some existing platforms (e.g. [Simbylay](#)) are highlighted as valuable tools to:

- Match waste producers with potential users
- Enable direct contact between companies
- Provide geographic localization
- Increase awareness of cross-sector opportunities

Industrial Perspective and Decision Drivers

From an industrial point of view, adoption occurs only when solutions:

- Are simple to implement
- Require minimal investment

- Reduce costs or secure raw materials
- Solve a clear and existing operational problem

Key drivers that can promote industrial symbiosis include:

- Legislative and regulatory pressure
- Economic incentives and subsidies
- Scarcity or rising costs of conventional raw materials

Conditions for Success and Recommended First Steps

Industrial symbiosis is considered a real, viable, and growing opportunity, though not all waste can be valorised. Success depends on meeting technical, economic, regulatory, and logistical conditions.

To promote implementation beyond European projects, recommended first steps include:

- Clear presentation of real, long-term success stories
- Solid technical and economic data demonstrating feasibility
- Concrete examples showing tangible benefits for similar companies
- Focus on high-value applications rather than marginal uses

Overall Conclusion

Industrial symbiosis has strong potential to improve sustainability, reduce costs, and create new value chains. While barriers remain significant, especially for small companies, when conditions are right, by-products can become valuable raw materials, delivering both economic and environmental benefits and supporting the transition toward a circular economy.

- **In order to improve symbiosis knowledge, the participants agreed on:**
 - Show cases of industrial symbiosis success
 - Availability of a platform (where to consult) of the different residues generated and the need
 - To know what is mandatory by law to recycle and how to do it

FOCUS GROUP ON INDUSTRIAL SYMBIOSIS
IN SLOVENIA: AN AGRI-FOOD PERSPECTIVE

Report prepared by CCIS-Chamber of Agricultural and Food Enterprises

December 2025, Ljubljana



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1. Introduction

This report presents the outcomes of a focus group conducted in Slovenia within the framework of the Symbios Project, which explores opportunities for industrial symbiosis in the agri-food sector. Industrial symbiosis, which promotes the efficient use of resources and collaboration between different sectors, has the potential to enhance sustainability, innovation, and competitiveness in the agri-food industry.

The purpose of this report is to summarize the discussions, insights, and perspectives shared by participants during the focus group. The session aimed to capture participants' understanding of industrial symbiosis, identify current practices, explore barriers and challenges, and highlight opportunities for support and collaboration.

The focus group provided a platform for participants from diverse backgrounds, including industry, research, regulatory bodies, and technology, to share their experiences and contribute to a comprehensive understanding of the potential and challenges of industrial symbiosis in Slovenia.

2. Methodology

2.1. Focus group design

The primary objective of the focus group was to explore the significance of industrial symbiosis in the agri-food sector within the context of Slovenia. The session aimed to capture participants' understanding of the concept, identify practices of industrial symbiosis they are familiar with or already implement in their work, and examine their collaboration with different sectors both within and outside agri-food. The discussion further explored perceived feasibility, barriers, and areas where support or guidance would be most valuable.

The design ensured the inclusion of diverse perspectives from industry, research, regulatory bodies, and technological expertise. This allowed the creation of an open space in which participants could freely share their views regardless of their professional background, fostering rich and varied insights.

The session began with an introductory question to establish participants' current understanding of industrial symbiosis. This was followed by ten thematic questions aimed at deepening the discussion. The focus group was conducted online on December 12th and lasted 1 hour and 15 minutes.

The focus group was led by Barbara Rupnik, Head of Department at CCIS- Chamber of Agricultural and Food Enterprises, with extensive experience coordinating thematic areas within SRIP HRANA, internationalization, European and national projects, as well as managing promotional programs and events. Her prior interactions with participants through other activities helped create a relaxed environment. Her knowledge of agri-food companies provided valuable insight into their practices and operational contexts.

She was supported by Monika Jerovšek, who works on the implementation of activities and communication for the Symbios project. She introduced the focus group objectives and the Symbios project, prepared real-time notes to facilitate subsequent analysis, and occasionally contributed to discussions with follow-up questions when necessary.

The focus group was conducted online via Microsoft Teams. The session was recorded and transcribed, while both facilitators simultaneously noted key points in real time. A simple presentation was prepared to guide the discussion and ensure the session remained structured and focused.

2.2. Participant Recruitment and Profiles

The focus group consisted of six participants, carefully selected to provide diverse and relevant expertise in the field of industrial symbiosis. Participants were chosen based on their professional experience, sectoral perspective (industry, research, regulatory), and direct engagement with sustainable food production, resource efficiency, or innovation in the food sector. Invitations were extended to individuals who could offer both practical insights and strategic knowledge to enrich the discussion and inform project outcomes.

Participant 1: Representative of the SRIP HRANA program, a Strategic Research and Innovation Partnership in the priority area S4 – Sustainable Food Production. SRIP HRANA brings together agricultural farms, companies, associations, research institutions, investors, and other stakeholders to intensify research and development activities in the food sector. As an advisor within the program, the participant maintains direct contact with food companies and contributes to project implementation, providing valuable insights into industry needs and innovation practices.

Participant 2: Expert Associate for Sustainability and Animal Welfare at Ljubljanske Mlekarne, a major food company. She covers areas including animal welfare, sustainable livestock production, food ethics, and food safety. Over the past four years, she has been professionally engaged in the livestock sector, first as a field consultant on alternative treatment approaches for dairy cows and calves, and more recently leading a key internal project to develop higher animal welfare standards within a large food company. Her practical experience in sustainability and industrial operations brings a critical industry perspective to the discussion.

Participant 3: Representative of EMONA RCP, a food development center focused on addressing issues in animal and human nutrition, transferring new technological solutions into practice, and quality control of feed, food, and ingredients. The participant works as an independent researcher and serves as the chair of the SRIP HRANA supervisory board. His dual perspective from research and strategic innovation partnerships adds depth to understanding industrial symbiosis opportunities in the food sector.

Participant 4: PhD in Biotechnology and one of Slovenia's leading researchers on fungi, their medicinal properties, and cultivation. He teaches at the Biotechnical Faculty of the University of Ljubljana and is a member of the Global Mycology and Fungal Products Organization. He also leads MycoMedica, a high-tech company developing new cultivation techniques for medicinal and edible fungi and producing nutritional supplements. His expertise contributes innovative biological and biotechnological insights relevant to industrial symbiosis.

Participant 5: Director of the Environment, Climate, and Energy Department at the Chamber of Commerce and Industry of Slovenia. An experienced professional in industrial symbiosis projects, she is recognized as a trusted expert by policymakers and stakeholders. Her strategic and regulatory knowledge provides guidance on systemic and policy-related aspects of industrial symbiosis.

Participant 6: Representative of Mlekarna Celeia, specializing in sustainability reporting and sustainable business practices in accordance with the EU CSRD directive and European ESRS standards, covering environmental, social, and governance aspects. Her role ensures that discussions incorporate the challenges and opportunities of sustainability reporting and compliance in industrial operations.

2.3. Data Collection Methods

Data collection during the focus group was designed to encourage open and candid discussion among participants. At the beginning of the session, participants were informed that:

- There are no right or wrong answers; their opinions and experiences are valuable.
- All information shared remains confidential within the group.
- Open, respectful, and constructive dialogue is encouraged.
- The session is being recorded solely for research purposes.
- Contributions will be treated anonymously, without linking comments to participants' names.

The focus group was conducted online via Microsoft Teams and was recorded in its entirety. No additional tools or digital aids were used, as the aim was to allow participants to express their views primarily orally and to maximize discussion time. Real-time notes were taken by the facilitators, and the session was later transcribed to ensure a complete and accurate record for subsequent analysis.

This approach ensured that participants' insights were captured comprehensively while maintaining a natural and interactive discussion format suitable for a small group of six participants.

2.4. Tools and Materials Used

The following tools and materials were used to facilitate the focus group:

- **Presentation slides:** A simple slide deck to guide the discussion and introduce the key topics.
- **Recording and notes:** The session was conducted via Microsoft Teams and recorded for documentation purposes. Real-time notes were taken by the facilitators to complement the recording and support subsequent analysis.

No additional tools or materials were used, as the focus was on enabling participants to share their experiences and insights orally, ensuring a natural and interactive discussion.

3. Findings

Understanding of Industrial Symbiosis

The focus group started with an open question on how participants understand the concept of industrial symbiosis. One participant described it primarily as cooperation between different companies, particularly through the exchange of by-products, and associated it with a zero-waste approach. Another participant expanded this view by emphasizing that industrial symbiosis is not limited to material exchanges but can also include collaboration in developing new projects, products, ideas, or services across companies and sectors.

It was also highlighted that the concept of industrial symbiosis is not new, but its implementation has slowed in recent years, partly due to stricter European legislation and the application of the precautionary principle. Participants noted that industrial symbiosis can involve the exchange of water, energy, and other resources, with the key condition being that it takes place within an industrial context.

Following this initial discussion, participants were presented with a baseline definition of industrial symbiosis based on the European Committee for Standardization (CEN, 2018) to establish a common understanding for the remainder of the session.

Good Practices



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Participants were asked whether they were familiar with or involved in examples of good practices related to industrial symbiosis. One participant described existing practices within their company, where they collaborate with other companies by exchanging materials used for the extraction of fungi, which is the core focus of their business. These collaborations are mainly established within research, development, and innovation (RDI) projects, where responsibilities are divided (e.g. analytical work by one partner and extraction processes by another), leading to jointly developed products.

Another participant explained that their company produces very few by-products during feed production and that they intentionally source raw materials in a way that allows almost complete utilization, thereby minimizing waste. Nevertheless, they have received inquiries from other companies, such as insect farming businesses, interested in potential by-products. Their cooperation mainly takes place in the field of research and development, often in collaboration with research institutions, and occasionally with companies seeking support in developing new products.

A representative from a dairy company stated that while they are familiar with industrial symbiosis practices, they are currently not involved in such collaborations. However, they highlighted significant demand for whey as a by-product of milk processing, as well as water streams generated through ultrafiltration processes. They also mentioned biological sludge from wastewater treatment plants that is free of heavy metals, pesticides, and other hazardous elements. Although this material is currently classified as waste, the company has been exploring options for its reuse within a circular framework.

Participants emphasized that legislation represents a major barrier to implementing symbiotic practices. One participant noted that within the Slovenian Circular Economy Centre, where industrial symbiosis is a key focus area, a shared database is being developed to connect providers of by-products with potential users. While industrial symbiosis is already relatively well developed in the electrical industry in Slovenia, there is a strong ambition to expand such practices to other sectors, including food. However, in the food sector, ensuring food safety remains a significant challenge.

Another participant pointed out that although they lack a comprehensive overview of industrial symbiosis activities within their own company, collaboration with institutes, schools, and educational programs is common, primarily through projects. They also highlighted that in livestock farming, cooperation between companies and cooperatives is widespread, particularly in the use of soybean meal and brewers' spent grains.

Across the discussion, participants critically reflected on legislation, expressing concern that regulatory frameworks are often developed by individuals without sufficient sector-specific expertise, leading to unnecessary restrictions on exchanges that could otherwise provide environmental benefits.

Potential for Industrial Symbiosis

Participants identified significant potential for industrial symbiosis across the entire food value chain. Based on practical experience, one participant illustrated how various challenges faced by companies can be addressed through the use of different by-products, citing examples such as whey or brewer's yeast as valuable inputs for biogas production.

Beyond material exchanges, participants also highlighted the potential for knowledge and skills exchange. An example was given from feed production, where extensive use of machinery creates challenges related to maintenance and upgrades. Collaboration with faculties of mechanical engineering or equipment manufacturers was seen as a promising solution. Slaughterhouse waste was also mentioned, noting that such materials are currently exported to Italian companies, indicating untapped domestic potential.

Further examples included collaboration with the Faculty of Chemistry and Chemical Engineering and textile departments, where feathers were used as a raw material for keratin extraction and subsequently for textile fibre production. These fibres have biological functionality and antimicrobial properties, with potential applications in sanitary and pharmaceutical materials.

Participants noted, however, that many development projects do not progress to practical implementation despite strong research outcomes.

Feasibility and Main Barriers

Overall, participants agreed that the implementation of industrial symbiosis practices is feasible and aligned with expectations related to the green transition. Nevertheless, legislation remains the primary barrier. Market competition and reluctance to cooperate, particularly among competing companies, were also identified as challenges. Despite this, participants emphasized that cooperation, even with competitors, can be beneficial in the long term.

Some participants expressed an optimistic view of industrial symbiosis, noting that current trends strongly support such collaborations. They stressed that it is not always necessary to define the final solution or product at the outset; rather, platforms that connect companies and guide them toward joint development of solutions are essential. These exchanges may occur both within and across sectors.

A recurring concern was that companies often lack awareness of potential partners, available resources, or existing by-products. Participants suggested that a dedicated platform could help address this information gap. It was further emphasized that progress would require more proactive engagement from policymakers at both national and European levels, as well as a shift in business mentality toward greater openness and collaboration.

Identified Needs

Participants identified the need for a dedicated platform that would function as a “business card” for companies, presenting what they offer, what they need, and what resources are available. They also suggested the inclusion of an online chat function to facilitate initial contact and exchange of ideas between companies. Advanced filtering and search options based on company profiles or specific outputs were considered essential to efficiently identify potential partners.

In addition, participants highlighted the importance of education and capacity building, particularly related to project applications and administrative procedures required for collaboration.

4. Conclusions

The focus group confirmed that industrial symbiosis is generally well understood among stakeholders in the agri-food sector and is perceived as a relevant and promising approach for advancing sustainability and resource efficiency in Slovenia. Participants demonstrated awareness that industrial symbiosis extends beyond the exchange of by-products and can also include collaboration in knowledge transfer, joint development of products, services, and innovative solutions across sectors.

Although several examples of good practices already exist, mostly within research and development projects, the discussion revealed that industrial symbiosis is not yet systematically implemented in the agri-food sector. Existing practices are often fragmented, project-based, and

dependent on individual initiatives rather than embedded in long-term business strategies. The food sector faces additional constraints related to safety requirements and regulatory compliance.

Legislation emerged as the most significant barrier to wider adoption. Participants consistently highlighted regulatory complexity, cautious interpretation of EU legislation, and a lack of sector-specific understanding among policymakers as factors limiting the exchange and reuse of materials that could otherwise contribute to circularity. In addition, market competition, limited trust, and insufficient awareness of available resources and potential partners further hinder cooperation between companies.

Despite these challenges, participants expressed an overall optimistic outlook. The green transition, growing policy emphasis on circular economy principles, and increasing sustainability expectations are seen as strong drivers for industrial symbiosis in the future. There was broad agreement that effective implementation will require dedicated platforms to connect companies, increase transparency of available outputs and needs, and facilitate initial collaboration. Equally important is targeted support in the form of education, guidance on project development, and clearer regulatory frameworks.

In conclusion, the focus group findings underline that industrial symbiosis in the agri-food sector holds substantial untapped potential. Unlocking this potential will require coordinated efforts across industry, research, and policy levels, supported by enabling infrastructures, proactive governance, and a shift toward more collaborative business mindsets.

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January 2026, Ljubljana



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2. Methodology

2.1. Focus group design

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Participant 1: Representative of the wine company Puklavec Family Wines. She has 20 years of experience within the company. Her focus is on quality standards, waste management and water waste management.

Participant 2: The participant is the head of the organizational unit for strategic intellectual property commercialization at the University of Ljubljana. As head of the unit, she is responsible for connecting researchers and companies, promoting and strategically commercializing intellectual property, and preparing researchers for innovation presentations. She connects the research and business communities and networks them to foster new development projects. For over ten years, she has worked within the largest Slovenian business association on promoting and presenting innovations and fostering development cooperation. She is well-acquainted with Slovenian companies as well as the national and international support ecosystem for entrepreneurship and innovation.

Participant 3: The participant is an Associate Professor at the Biotechnical Faculty of the University of Ljubljana, Department of Animal Science, where he serves as Head of the Chair for Agricultural Economics, Policy, and Law. He is also the coordinator of the Circular Economy

Center, established in 2025. This open platform connects researchers from various disciplines, ranging from agronomy and forestry to food science, biotechnology, economics, and engineering.

Participant 4: The participant is an Assistant Professor in the field of food at the Faculty of Health Sciences, University of Primorska. His research focuses on new foods and products, functional properties of foods, and food safety and quality along the supply chain. He also has extensive experience in the food industry, having worked for a large bakery company as head of the development and technical department. As Technical Director, he led numerous development, research, and investment projects and contributed to the implementation of new technologies, production programs, and quality systems. He remains partially employed in the company, while the majority of his professional work is now conducted at the faculty.

Participant 5: The participant holds a master's degree in Sustainable Development with a focus on circular economy initiatives since 2018. He is a Project Manager at Anteja, a company specializing in the design and implementation of innovation strategies and circular business models. Anteja provides digital services to help companies add value to waste and by-products and identify potential partners for circular value chains. In the company, he plays a key role in developing circular bioeconomy strategies in Slovenia and Europe and significantly contributes to the transition toward more sustainable economic models. He specializes in consulting for the food and beverage sector; leading projects aimed at accelerating the adoption of circular business models through comprehensive feasibility studies and the development of innovative project concepts.

Participant 6: The participant is the CEO of Medex, where he oversees production as well as research and development. He leads a registered research team that develops innovative products with clinically proven effects in modern laboratories.

2.3. Data Collection Methods

Data collection during the focus group was designed to encourage open and candid discussion among participants. At the beginning of the session, participants were informed that:

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No additional tools or materials were used, as the focus was on enabling participants to share their experiences and insights orally, ensuring a natural and interactive discussion.

3. Findings

Understanding of Industrial Symbiosis

The focus group started with an open question on how participants understand the concept of industrial symbiosis.

The first participant immediately asked for a definition, noting that while everyone might have their own idea of what “symbiosis” and “industry” mean, the context is also important. One participant explained the concept by drawing an analogy from the animal world, stating that symbiosis means that both members generate some shared added value—essentially, 1+1 is greater than 2. He concluded that symbiosis should bring mutual benefit. Another participant added that it also means that a by-product from one production process can become a raw material for the next.

Following this introductory discussion, we presented the participants with the definition prepared by the European Committee for Standardization (EU Committee, 2018).

Good Practices

Participants were asked whether they were familiar with or involved in examples of good practices related to industrial symbiosis.

The first example highlighted by a participant was joint transport for exports, where neighboring companies collaborated on export routes, for instance, to the United States. A single company would not have been able to fill an entire shipping container on its own, so two companies shared it. This practice was described as “transport symbiosis.” The participant also noted that while industrial symbiosis is usually discussed in the context of waste, opportunities exist more broadly. He emphasized that in the food sector, it is important not to refer to materials as “waste,” because once something is labeled as waste, it can only go to landfill. In the context of industrial symbiosis, it is better to use the term “secondary raw material,” which can be further utilized.

The representative from Medex added that their company’s operations, from a raw materials perspective, revolve around industrial symbiosis. Their focus is on the circular economy and the use of by-products to create higher-value products. Many of the raw materials they use illustrate this approach, for example, egg shell membranes. In the dietary supplements sector, residues from the food industry, such as fish or beef by-products, are often repurposed for new products. They currently do not engage in local collaborations within Slovenia, but highlighted examples such as fir tree extracts or pumpkin seeds, which have high potential as by-products. While Medex, as a final product manufacturer, has no interest in sourcing these materials, they represent significant opportunities for companies lower in the value chain.

The representative from the University of Ljubljana emphasized that the university collaborates with companies and seeks partners from around the world, not only Slovenia. Many researchers investigate how secondary raw materials could be converted into new products or materials. She provided examples such as research at the Faculty of Mechanical Engineering on wastewater valorization and opportunities in olive oil production, where by-products could be repurposed. Another good example she provided came from the company Lušt, which, in collaboration with research organizations (ICP LJ), developed packaging from discarded tomato stems to sell their tomatoes. As a university, their role is primarily in research and innovation development rather than market operations.

Another participant illustrated industrial symbiosis with a German example: a frozen potato product manufacturer supplied excess heat and processing residues to a company engaged in

insect bioconversion. The insects were fed these residues and required the heat for breeding purposes.

The Associate Professor at the University of Ljubljana added that they have already researched various business models companies use to “close loops.” In Slovenia, these are mainly small-scale company practices (e.g., using leftover toast ends for *brodka* - high-quality alcoholic beverage; use of acidic whey for vitamin B12 production) and research projects. Developmental projects exist, as do excellent technology developers (e.g., ACEIS BIO). A major challenge in Slovenia is achieving industrially relevant quantities of homogeneous biomass. Another key limitation is tracking and recording by-product flows. Waste reporting is good because it is mandatory, but data on by-product streams are weak due to lack of systematic monitoring.

A representative from a wine company noted that most waste biomass or by-products occur during the harvest. They explored ways to utilize it, but the required investments were large and they could not find a suitable partner. Consequently, they store the by-products and use them in the spring for fertilization, while some are sent to a nearby biogas plant for biogas production.

Potential for Industrial Symbiosis

The discussion on potential partners and opportunities within industrial symbiosis practices continued with the importance of economies of scale. One participant noted that for economic feasibility, large quantities of by-products are needed. He observed that Slovenia has only a few such sources, highlighting forestry residues, brewery spent grains, whey from the dairy industry, and manure, it becomes increasingly difficult to find sufficient quantities beyond these.

He identified the best potential link for the food sector as the chemical sector, but primarily with larger companies, which recognize opportunities for exchanging input materials and have demand for bio-based raw materials. Brewery spent grains were highlighted as the most promising by-product, as they are concentrated in one location, produced in large volumes, and offer significant opportunities for utilization.

The participant also mentioned model-based solutions, noting that higher TRL (Technology Readiness Level) innovations are important for these approaches. This point was echoed by a

representative from the University of Ljubljana, who added that where secondary by-products are sufficient in quantity and quality, consistency over time is crucial.

The university also sees opportunities in the metal industry.

The Associate Professor at the Biotechnical Faculty of the University of Ljubljana stated that in the Slovenian context of industrial symbiosis, the greatest potential lies in sectors where even small quantities can achieve high added value, for example through extracts or bioactive components. He also suggested that opportunities should be sought in energy and heat exchanges and noted potential in the animal feed sector.

The Assistant Professor from the Faculty of Health Sciences, who is also employed at Mlinotesta, shared a case in which the company attempted to collaborate with a smaller dairy to use whey in bread production. Although the project was not successful, he emphasized that whey is highly versatile and not considered waste in other parts of the world.

Regarding whether by-products should be used for energy or feed, he explained that while composting is possible, it does not create added value. True added value comes from producing extracts or components with enhanced properties, for example using whey as a medium or growth substrate. He believes that many other by-products could similarly be utilized, but achieving this requires higher TRL stages and advanced technologies capable of generating added value in the future.

Feasibility and Main Barriers

Participants had already highlighted in earlier parts of the discussion that insufficient volumes of by-products represent a major constraint for industrial symbiosis.

The representative of Medex pointed to regulatory barriers in the production of higher value-added products, particularly when by-products are used to create new foods, which then require safety assessments and regulatory approval. These procedures require significant new investments and represent a major legislative constraint.

A similar regulatory challenge was raised by the representative of the wine company, who described a past collaboration in which grape seeds were used to produce oil. Although the volumes were small, the partner faced regulatory difficulties, which led to the termination of the cooperation.

Throughout the discussion, a clear need emerged for basic and applied research at low Technology Readiness Levels (TRL 1–3), conducted by public research institutions and made accessible to companies. Many researchers work on topics connected to industry symbiosis, but information and knowledge flows are weak. Some faculties are not strongly market-oriented, meaning that relevant results do not reach companies. There is a strong possibility that researchers are working on exactly what companies need, but no connection is made between them.

The representative of the University of Ljubljana agreed that knowledge transfer is too slow. Their researchers are developing various technologies, but face low responsiveness from companies, partly because solutions often remain at TRL 3, which is too uncertain for business adoption. Companies typically prefer to become involved only when solutions reach TRL 6. However, research institutions often have funding only up to TRL 3, after which a financing gap appears. In addition, it is difficult to identify the specific company that is facing the exact challenge addressed by a given solution, as companies have multiple priorities and competing objectives.

The discussion concluded with a shared view that the environmental, economic, and social benefits of industrial symbiosis are not in doubt. Nevertheless, significant barriers remain, including insufficient volumes, fragmented resource streams, lack of awareness of opportunities, regulatory obstacles, limited market pull, and low company engagement.

From the company perspective, an additional barrier is the risk of investing time and resources in projects that may not deliver tangible results. One participant also noted a lack of innovative thinking in Slovenia: discussions often focus on cost reduction, while the profit potential of industrial symbiosis is underestimated, even though it can also deliver environmental benefits. From this perspective, greater investment in feasibility studies was proposed, as these are

currently lacking in Slovenia. In particular, targeted public funding schemes are needed to support such studies financially.

Identified Needs

Participants identified a strong need for financial resources and dedicated funding calls to support industrial symbiosis practices. In particular, investment in feasibility studies was seen as essential, together with mechanisms for identifying concrete opportunities and supporting collaboration with researchers. Participants also emphasized the importance of structured support for connecting companies with relevant partners.

Another key need is the establishment of platforms that can bridge existing gaps in knowledge and information flows between research and industry. Such platforms should facilitate the exchange of data on by-products, technologies, and potential partnerships.

Equally important is the interest and commitment of companies themselves. Industrial symbiosis requires companies to allocate time and appropriate staff to these initiatives, which represents a significant internal investment. Without this organizational capacity and strategic interest, even well-designed support mechanisms will not lead to concrete collaboration.

4. Conclusions

The focus group confirmed that industrial symbiosis is well understood by key stakeholders as a model that creates mutual value through the exchange of materials, energy, and knowledge across organizational and sectoral boundaries. Participants clearly distinguished between “waste” and “secondary raw materials,” emphasizing that value creation depends on recognizing by-products as usable resources rather than disposal streams. Across all profiles represented there was a shared recognition that industrial symbiosis can deliver environmental, economic, and societal benefits.

At the same time, the discussion showed that the practical implementation of industrial symbiosis in Slovenia remains limited and fragmented. Existing good practices are mostly isolated, niche, or project-based, while large-scale, stable value chains are rare. Economies of scale remain a critical constraint: only a few by-product streams in Slovenia (such as forestry residues, brewery spent grains, whey, manure, and some agro-industrial by-products) reach volumes that are economically viable for more advanced valorization. Where higher value-added pathways exist, such as extracts, bioactive components, or functional ingredients, they require advanced technologies and higher Technology Readiness Levels, which are currently difficult to reach within the existing innovation support system.

A central bottleneck lies in the gap between research and market deployment. Public research institutions mainly operate at low TRLs (1–3), while companies are typically willing to engage only when solutions reach TRL 6 and risks are significantly lower. In parallel, regulatory barriers, especially in the food sectors, further increase costs, risks, and uncertainty when developing products based on secondary raw materials.

Despite these constraints, the focus group revealed strong potential for industrial symbiosis in Slovenia, particularly in niches where high added value can be generated from relatively small volumes (e.g. bio-based extracts, functional components, specialized feed ingredients, or energy and heat exchanges). However, realizing this potential will require a shift from opportunistic, ad hoc collaborations toward more systematic, supported, and data-driven approaches.

Overall, the findings indicate that industrial symbiosis in Slovenia is not limited by a lack of ideas or technological options, but by insufficient scale, weak coordination, regulatory complexity, and gaps in financing and knowledge transfer. Targeted public support for feasibility studies, higher-TRL development, and structured matchmaking between companies and researchers combined with stronger strategic engagement from industry will be essential to transform isolated examples into a functioning and scalable industrial symbiosis ecosystem.