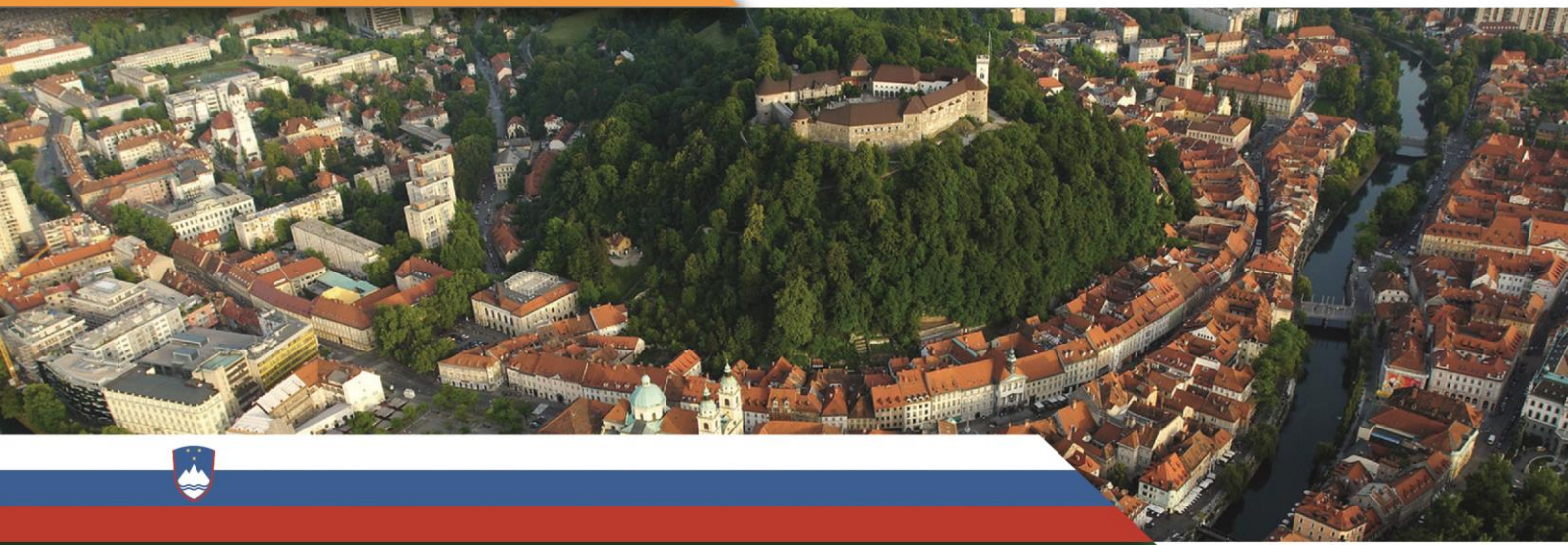


BIOECONOMY CONCEPT PAPER

EXECUTIVE SUMMARY



SLOVENIA

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EXECUTIVE SUMMARY OF THE STRATEGIC CONCEPT PAPER FOR BIOECONOMY: SLOVENIA

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Executive summary

1.1. Introduction, purpose of this document

This Concept Paper was prepared by a team of researchers of the Biotechnical Faculty University of Ljubljana. It is largely building on the findings of two strategic research projects, aiming at unlocking the bioeconomy potentials in Slovenia. The project *Bridging gaps in Bioeconomy - from Forestry and Agriculture Biomass to innovative Technological solutions, BRIDGE2BIO* (Juvančič et al., 2021) was conducted in the period 2018-2021. A multidisciplinary team of researchers from the leading national applied life science research institutions (i) provided evidence base about the biomass inventories and streams, (ii) analysed economic performance of bioeconomy value chains, analysed their gaps and potentials and (iii) evaluated the current policy framework related to bioeconomy development in Slovenia. The project *Advancing Sustainable Circular Bioeconomy in Central and Eastern European Countries (BIOEASTsUP)* has been conducted with same core research team between 2019 and 2022. The project (i) extended the evidence base on the structure and performance of bioeconomy sectors, (ii) provided an extensive expert survey on assets and transformation pathways underlying the development of the bioeconomy, (iii) allowed for macro-regional analysis and benchmarking with BIOEAST countries, and (iv) laid the foundations for strengthening macro-regional cooperation in research and innovation relating to bioeconomy.

The two projects, together with some previous research (most notably CELEBio, see Virant et al., 2020) and policy initiatives (most notably the Comprehensive Strategic Project of Decarbonisation, see Karba, 2022) provide a **solid foundation to creating the bioeconomy strategy** by defining sector-specific transformation pathways towards unlocking the potentials for a more sustainable, integrated and better performing bioeconomy in Slovenia. The Concept Paper aims to **intensify the exchange between the policymakers and stakeholders** about the model of the future bioeconomy development in Slovenia. This exchange should **align our views about relevant pathways of bioeconomy sectors** in Slovenia: from primary production (agriculture, forestry, aquatic production systems) and conventional bioeconomy manufacturing sectors (food products and beverages, wood processing, pulp and paper), to the expanding 'hybrid' bioeconomy sectors, such as pharmaceutical preparations, textiles, manufacture of chemical products, construction, as well as energy supply, and service sectors engaged in ecosystem services valorization. We hope that this exchange will prove beneficial for enterprises and other economic entities operating in various bioeconomy sectors in Slovenia, to **recognise their synergies and accelerate cooperation** in integrated value chains. This would lead not just to the improved economic performance of participating companies, but also to a better exploitation of the potential for value added of the bioeconomy sectors, as well as **improved sustainability of the economic system** by closing (material, energy) loops of biomass utilisation.

The aim of this exchange is also **to review and critically assess the supporting environment** for the development of the bioeconomy in Slovenia. Dedicated strategic framework and coordinated policy support can direct and accelerate the processes of the restructuring of bioeconomy in the direction of improved economic performance, resilience and sustainability of the economic system. The Concept Paper is developing some proposals in this regard. Rather than suggesting a developed set of solutions, they are meant to intensify the exchange about the appropriate placement of the bioeconomy of the current institutional setup and system of development planning in Slovenia. These proposals are meant also as a starting step towards

a systematic coordination among policy makers in planning future actions to support the development of the bioeconomy and the favourable state of ecosystems.

1.2. Context and objectives¹

A sustainable bioeconomy addresses current environmental and societal challenges

The social context in which the importance of the bioeconomy is growing coincides with the experience of the global economic and climate crisis in the first two decades of the new millennium, which revealed, among other things, the vulnerability of a growth-oriented economy based on non-renewable resources and the unsustainable use of renewables. The prevailing production and consumption patterns lead to long-term and irreversible environmental changes, which are reflected in the degradation of the environment and ecosystems and the loss of biodiversity. Profound changes are also taking place in the global trading system and organising business processes, in which a number of short-term disruptions, regional restructuring of distribution chains and a long-term reduction in international trade have happened in the last decade. If we add to this growing geopolitical tensions and unexpected events (COVID-19 pandemic, Russian aggression), we can conclude that we are entering a period of growing uncertainty in all key aspects - the state of the natural environment, access to sources of raw materials and energy, business environment and, last but not least, in the wider social context.

Understanding sustainable bioeconomy as an economic paradigm that addresses various aspects of production and conversion of biomass, as well as sustainable ecosystem management and a different, circular organisation of business processes, can be seen as one of the answers to the listed societal challenges. Sustainable bioeconomy enables synergies between the economic (added value, innovation, knowledge, competitiveness, industrial development, advanced technologies), social (jobs, balanced development, rural development, responsible consumption, health) and ecological (climate change management, conservation of natural resources, waste reduction) components of development. At the same time, it also suits the changing geostrategic context, with the increasing importance of short and integrated supply chains.

Developed societies recognize the strategic importance of the bioeconomy in designing their long-term strategies

Considering the fact that the organization of technological and business processes in accordance with the principles of the bioeconomy contains elements of technological and social innovation, it is probably not surprising that the beginnings of integrating the bioeconomy into the strategic activities in Europe coincide with research, development and innovation (RDI) policy in early 2000s. Over the last two decades, various activities took place also at the multilateral level, integrating of the bioeconomy into strategic development priorities. In this context, we highlight in particular the achieved consensus of countries on the untapped potential of the bioeconomy in achieving the UN's Sustainable Development Goals (SDGs), the role of the bioeconomy in achieving the goals of the Paris Climate Agreement (2015) and the OECD guidelines for the strategic placing of the bioeconomy in its member countries' development policies (2009).

¹ Apart from this Concept Paper, this section largely draws largely from the findings of the nationally funded strategic research (Juvančič et al., 2021).

The EU published its Bioeconomy Strategy with an Action Plan in 2012, which coincided with the publication of similar documents other leading world economies (eg. USA, China, Brasil). Year 2018 saw the publication of a renewed EU bioeconomy development strategy, which includes internationally accepted commitments (sustainable development goals, Paris Climate Agreement) and EU-level goals (European Green Deal, energy union, renewed industrial policy), as well as emphasises (eco)system aspects more strongly than before.

With the adoption of joint strategic guidelines in 2012 and its amendment in 2018, the bioeconomy is the strategic development priority of the European Union, which combines the goals of the reduction the society's dependence of fossil fuels, and the development of sectors that produce and add value to the biomass, based on knowledge and taking into account the environment and nature conservation goals. In line with this endeavour, eleven EU Member States have so far adopted dedicated national bioeconomy strategies, whereas seven national strategies are under development (EC, 2022).

Slovenia (along with other Central and Eastern European countries) is among the countries with an underutilised potential of the bioeconomy

As it is described in a greater detail in the main text of this Concept Paper (sections 2 and 3), the utilisation of the potential of the bioeconomy for Slovenia is not favourable. Slovenia has a significant but sub-optimally exploited raw material potential (in particular wood biomass and residues in primary agricultural production). Due to demand-push, a growing number of manufacturing firms operating in trans-national value chains turn their operations towards circular business models and biobased technologies, which are however poorly integrated in terms of closing local (material and energy) loops in biomass use. Relatively high inputs into RDI activities yield in good academic performance of the leading national research institutions, whereas the results are not sufficiently integrated into the business process.

Review of statistical data and institutional overview in this Concept Paper (section 4) outlines the key challenges of bioeconomy development in Slovenia. Factor productivity and economic performance of primary bioeconomy sectors (agriculture in particular), is below par with the rest of the national economy, as well as in macro-regional comparison with other BIOEAST countries. Synergies between (advanced and internationally integrated, but transient) industry and RDI sector in the domain of bioeconomy remain largely untapped. Also the institutional status of bioeconomy remains poorly defined. No ministry or other government body can be described as an institutional holder of the bioeconomy portfolio. The level of coordination between instruments and measures supporting various aspects and sectors of bioeconomy remains low.

Integration of bioeconomy into strategic development planning of Slovenia

Slovenia is one of the seven EU Member States without a dedicated national bioeconomy strategy. Extensive review of national strategic documents carried out in this Concept Paper reports that bioeconomy is not explicitly identified among the national strategic priorities in Slovenia. It needs to be accentuated though, that inter-ministerial coordination on various issues related with bioeconomy development is operating. Elements of (circular) bioeconomy have been integrated into various strategic documents and policy instruments. As for the letter, the coordination between various ministry portfolios / funds is largely lacking (eg. criteria for selection of operations, coverage of related investments from different funds).

1.3. Current state of the system components, opportunities and challenges

Availability and possible uses of residual biomass of agricultural origin

The project work that forms the quantitative basis of this Concept Paper, provided estimates of the amount, composition, utilization and dynamics of the available biomass from agri-food chain. In the biomass characterization phase, we converted the data into categories relevant for planning circular use and value adding.

Among the priority residual streams of agricultural biomass, we highlight **livestock excrements** with a total amount of more than 620 thousand tons of dry matter. The overall performance of its current use (organic fertilizer) can be significantly improved by **exploiting its energy content** (biogas production) and improved soil fertilization techniques, which improves the nutritional value of livestock manure and drastically reduces environmental burdens.

When selecting raw materials and preparing a technological design for the circular use of residues and by-products of plant production, we proceed from two principles. First, that the proposed solutions should not threaten the balance of organic matter in the soil. Secondly, they need to take into account the structural features of farming in Slovenia (small-scale and fragmented property structure). The most extensive raw material source in plant production is represented by harvest residues and secondary crops of arable production, the total amount is in the range of 700,000 tons of dry matter. The remains of vegetable, oil and root crops represent the next quantitatively and qualitatively perspective raw material source, the total amount is in the range of 100,000 tons of dry matter. Other potentially relevant raw material source, are also residues in horticulture, amounting to 30,000 tons of dry matter.

When searching for alternatives for circular use of above listed perspective groups of agricultural biomass, we must take into account either their **limitations in ensuring efficient logistics and scalability**, and **ecologic limitations**. However, these biomass streams provide the potentials for technologically and economically sound circular uses, such as: (i) cascading use of lignocellulosic residues with an emphasis on the extraction of bioactive components and the production of packaging materials; (ii) transformation of biomass with a high fiber content into composite materials or (iii) biorefining of more complex raw material sources (e.g. residues from the processing of fruits, vegetables and oilseeds into components with a high added value).

Considering the chemical composition and technological properties of **side streams in food processing**, there are untapped potentials in the extraction of bioactive compounds and application of various biotechnological processes. The range of compounds obtained is extensive and offers a strong potential for adding value. Our research identified unexploited reserves particularly in the sectors, which provide **homogenous streams of biomass and allow for scalability**. Such sectors are dairy, animal by-products, brewing industry and wine production.

Availability and possible uses of forest-wood biomass

With an **exceptional forest cover** (58 % of the country area are forests with a relatively strong production capacity), wood is by far the most promising source of raw materials in the Slovenian bioeconomy. This potential is somewhat limited by a **fragmented ownership**

structure (average size of a forest property is 2.9 ha), which is the main drawback for organizing cost-efficient supply of wood biomass at the industrial scale. Furthermore, the structure and production potential of Slovenian forests is irreversibly changing due to climate change. Future projections forecast an **increase of hardwood potential**, particularly from the increasing share and faster growth of the beech forests.

The average yearly production of forest wood assortments in Slovenia amounts to about 4.5 million m³, about two thirds of these are conifers. The largest domestic consumer of round wood is the sawn wood industry (over 1 million m³), followed by the wood composites, mechanical pulp and chemical industries with a total processing volume of around 0.5 million m³. Large consumers of round wood are households, which annually consume over 1 million m³ of wood for firewood. Slovenia is a prominent exporter of unprocessed round wood, which is particularly evident in the coniferous log category with about 1.3 million m³.

Looking from the viewpoint of the overall economic performance of the forest-wood related bioeconomy in Slovenia, the current situation is not favourable. Improvements are sought in particular in terms of a **higher share of harvested round wood processed domestically**, and in the strengthening of **more technologically advanced alternatives** to the current uses of round wood. Reserves exist also in the enhanced exploitation of the economic potential of the forest, as currently, only 60-70 % of the annual increment of wood is harvested. The largest potentials are estimated for the **wood categories of lower quality**. From the point of view of the long-term perspective, this category will gain in importance with changes in forest stands (increasing proportion of beech). **Unexploited possibilities** are therefore especially in the categories of wood, which are a suitable input raw material for **biorefining** processes and the subsequent production of new bio-based materials.

The potential of logging residues for collection and processing in industrially relevant quantities is limited, as their removal is not cost-efficient. Some bioeconomic potential in this category can be attributed to bark, which by volume represents around 20% of the cut and is an important category of raw materials for bio-based products due to a high content of bioactive compounds (e.g. tannins, polyphenols) and is also a good structural material for composting biogenic waste.

Structure and performance of bioeconomy-related industries

The experience of the leading EU countries and regions reveals that sectors with strong, consolidated firms in conventional bioeconomy sectors find it easier to provide leverage for the development of industrial-scale biorefineries and the resulting potentials for value-adding. Slovenia has a **vibrant structure of enterprises** engaged in conventional bioeconomy-related industries (food processing, wood processing, paper mills), but most of these operate at the **SME scale**. Conventional bioeconomy manufacturing sectors are relatively strongly represented on international markets. Enterprises operating in wood processing achieve 55 % of revenues on international markets, whereas the share of food processing sector records 34 % export orientation, which is below the par of the manufacturing sector in Slovenia.

The scale and the level of integration of industrial operations in these sectors significantly dropped throughout the political transition and economic restructuring in the 1990s. Some industrially-relevant operations that could serve as the core for future industrial-scale biorefineries, ceased with their operations in the last two decades. The **level of business integration** in conventional bioeconomy-related industries is rather low (vertically, as well as horizontally), which **prevents the scale effects** needed for a functioning of the 'enhanced' bioeconomy concept, integrating firms in the same, or complimentary sectors, with a

biorefinery at its core. In the development of more diversified and innovative bio-based value chains, **two scenarios** seem feasible: (i) integration into bioeconomic clusters, with a network of **small-scale modular biorefinery operations** in its core, or (ii) integration into **wider, cross-border value chains**, supplying biomass to, and supplying intermediate outputs from industrial biorefineries, located within operating distance from Slovenia.

Apart from the 'conventional' bioeconomy sectors, integration of firms operating in technology-intensive sectors that are strongly integrated into international value chains (eg. chemical industry, automotive) may also play a catalytic role in the transition towards bioeconomy. Demand for biobased technologies and components in these industries is increasing at an accelerated pace. A number of factors, such as disruptions on global raw material markets, technological prowess in biobased technologies and changed price-cost relationships, are simultaneously contributing towards the accelerated turn towards innovative biobased technologies in sectors that were traditionally operating with non-renewables. Increased demand for biobased technologies and components in technology-intensive sectors may serve as important engine of growth also in 'conventional' biobased sectors. Apart from being the providers of biomass (often with poorly-valorised side-streams), integration with technology-intensive sectors may act as a stimulus to improve their performance in several aspects (closing the material and energy loops, improved economic performance).

Catalytic role of RDI sector and commercial enabling institutions in bioeconomy development

In Slovenia, a vibrant RDI sector is operating, engaging in state-of-the art applied research and technology development in various bioeconomy-related fields of science. This sector, consisting of both, public research institutions and private companies, can play a stronger catalytic role in unlocking the bioeconomy potentials as it is currently the case. In some sectors, which can be regarded as the cornerstones of the national economy (eg. pharmaceutical industry), RDI is strongly integrated with the industry. In other sectors, these linkages are less strong, or even not adequately established. The industry is reluctant to act as the sole investor in new technologies for different reasons (eg. focus on cost efficiency, demand-side risks, lacking financial leverage), while the technology developers also seek for returns that surpass the capacities that are not attainable at the usual scale of enterprises operating in (conventional, or new) bioeconomy-related manufacturing sectors. To some extent, this gap has been successfully tackled within industry-research partnerships, developed within the national Smart Specialisation Strategy.

Slovenia has a vigorous network of enabling institutions supporting innovative and development-oriented entrepreneurial projects. Technology parks and business incubators provide professional business support services, such as favorable lease of business premises and start-up mentoring support. Business accelerators offer professional consultation and seed financing for innovative start-ups. Both programs are complemented with public funding. Market for venture capital is less developed, limited mainly to specialised products of banks and insurance companies. All the above described services are general, not relating specifically to bioeconomy.

2. Overall conclusion and strategic actions

1. Setting up the strategy; need for context-based solutions

The **idealized model of circular bioeconomy** is based on continuous and cost-effective access to industrially relevant quantities of biomass of homogeneous composition, its gradual decomposition in large integrated biorefineries into simpler (chemical, material) building blocks, which are then integrated a wide range of biobased products. The process is following the cascading use principles – starting with high value-added products and finishing with the energy use. Economic entities interact in the development of new technologies and processes (bioeconomic clusters) and in the exchange of material and energy flows (industrial symbiosis). The transition towards circular bioeconomy and its growth depends also on the wider supporting environment. It consists of a business supporting system supporting the early-stage companies, capable venture capital market to meet the firms' growth potentials, and the state with stable business environment, responsive legal framework, and consistent policy support.

In reality, the utilization of the development potential of the bioeconomy is **context-based**. The development of circular business models in the context of the Slovenian bioeconomy differs from the idealized model described above in practically all elements. It starts already with a small scale and fragmented production structure in primary sectors. Starting from this, it is clear that in the design of circular business models suitable for the conditions of the Slovenian bioeconomy, we will have to resort to innovative and context-adapted solutions. On the other hand, the primary sectors of the bioeconomy (agriculture, forestry) and the resulting value chains show characteristics typical of countries participating in the BIOEAST initiative: a **low level of productivity in primary production** with a relatively high share of employees in these industries, the **unused potential of residues and by-products** in production, processing and consumption, the **absence of biorefinery capacities** and the **low level of awareness of opportunities** for circular technological solutions and business models. The latter is present both on the side of industry, and on the side of public development policies. In this context, it is expedient to **cooperate with the countries of the BIOEAST macro-region**, which are facing similar challenges, in developing appropriate solutions.

2. Sector-specific pathways and challenges for unlocking bioeconomy potentials

The current performance of bioeconomy in Slovenia can be significantly improved. This is illustrated by a relatively low contribution of bioeconomy sectors to the overall value added (20 % or 11 percentage points below the EU 27 average) and low labour productivity (11,500 EUR per employee, or less than one third of the EU 27 average). **Unlocking bioeconomy potentials** in Slovenia should take place in **two directions**. The **first** one involves agriculture, forestry and related 'conventional' manufacturing value chains (wood & paper processing, whose reserves lie in **boosting the sector's productivity and value added**, partly also in the closing the material and energy loops within their operations. The **second trajectory is more demand-driven**. Its forerunners are firms, which are integrated into international value chains and include some of the key national manufacturing (eg. chemical, automotive, electrical) and other sectors (eg. construction), where the demands and needs for the transition to bio-based materials and technological solutions is increasing. Increased demand for biobased final

products from these sectors creates **opportunities for growth along its upstream** (technology developers) **and downstream** (primary and conventional manufacturing) **sectors**.

In order to unlock the potentials for a more integrated and sustainable bioeconomy in Slovenia, three challenges and opportunities can be pointed out.

First, Slovenia faces a **significant, but suboptimally utilized raw material potential** of agricultural and forest-wood biomass. The structure of practically all activities dealing with the processing of agricultural and forest-wood biomass is fragmented and produces large amounts of side streams and residues, whose current mobilisation is currently limited mostly on energy use. The added value of side-streams and residues in primary production and conventional processing sectors is therefore relatively low and poorly diversified.

Another challenge lies in a **low level of horizontal and vertical integration along the bioeconomy value chains**. This should not be misinterpreted by the general absence of technologically advanced and competitive firms in sectors operating along these chains. On the contrary, their number and significance is increasing. What is lacking however is the low level of their integration, or at least cooperation. As a result, most of the firms in bioeconomy sectors are operating at the SME scale. Consequently, a large percentage of primary products in agriculture and forestry is valorised outside the national economy, and the conditions for biorefining of biomass side-streams at industrial scale is hardly attainable. Both are limiting the potentials for sustainable valorisation of biomass and economic performance (value added, employment) of the bioeconomy sectors within the national economy.

Comparative review of the research outputs, based on standardised quantitative criteria, reveals **a vibrant RDI activity** in the field of bio-based materials and supporting technologies in the country. Research institutions and teams are well integrated into international RDI effort. Investments in research and development and publications in this area are constantly increasing. This can be regarded as an opportunity. On the other hand, in the same field of analysis, **Slovenia performs poorly in terms of innovation adoption**. On the positive side, there is a **vigorous startup community** and many of their business ideas are inspired by biobased innovations. Although these firms are operating at the niche scale and in the early stages of the business cycle, they can be seen as the harbingers of the entrepreneurial transition to the bioeconomy.

3. Actions to unlock the bioeconomy potentials

For a serious qualitative leap towards (resilient, circular, sustainable) bioeconomy, all actors operating in the bioeconomy sectors or directing the development of bioeconomy in Slovenia, need to significantly strengthen their effort. This involves reaching a social consensus on the strategic importance and institutional consolidation of the bioeconomy.

First, measures would be needed to strengthen the motivation of companies for inter-sectoral and cross-sectoral cooperation in extended bio-based value chains, adding value to locally sourced biomass in closed (material, energy) loops.

- **Establishment of the National Bioeconomy Hub** could be seen as a step in this direction. The hub would serve as a platform for mutual exchange of information, the dissemination and exchange of expertise, and the creation of business opportunities through cooperation. Institutionally, it would be expedient to assign the role of a hub to an already operating platform with similar tasks. With the implementation of the Smart Specialization Strategy, the coordinating role is attributed to Strategic development innovation partnerships (SRIPs). SRIP Networks for the transition to a circular economy,

with the Focus Area Biomass and alternative raw materials seems as the most appropriate candidate for this task;

- **Identifying of national industrial leaders** in bioeconomy and motivating them to commit for a long-run cooperation with local operators. They should be motivated to upgrade their activities and supporting investment decisions with financial and equity input in the form of public-private partnerships;
- **Establishing a virtual platform** for exchange (and trade?) with individual biomass waste streams;
- **Strengthening knowledge intensity** (applied research, integration of RDI and industrial partners) is one of the prerequisites for the improvement of bioeconomy performance in terms of innovation adoption. Additional funding would further stimulate these processes;
- **Actions would be needed to boost demand** for biobased technological solutions and materials. These start with institutional buyers through the system of Green public procurements.

Part of this effort is also systematic and targeted work in terms of the regulation of data bases, evidence-based strategic planning, inter-industry and inter-institutional integration of stakeholders, development of a supportive environment and enhanced integration into processes operating at the EU-level. When designing and implementing public policies, plans, programs and measures to unlock the development potential of the bioeconomy in Slovenia, the following points should be considered:

- The development of **systematic and coordinated measures** to support the development of more ambitious forms of cooperation between economic entities (industrial symbiosis) and development-innovation inter-industry cooperation within the framework of bioeconomy clusters;
- Encouraging the development and use of **cost-effective, innovative low-carbon technological and non-technological solutions**;
- Encouraging the **construction of biorefinery capacities**, which represent a bridge between conventional and new bioeconomy products and technologies and represent a key link in the formation of branched value chains;
- **Improvement of support services** (subordinate legislation, data, rules, logistics);
- **Development of new business models**, which include, among other things, the cascading use of resources of biological origin and digital transformation;
- **Changing consumer habits** towards the purchase of bio-based products and services.

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