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CIRCULAR BIOECONOMY ROADMAP ESTONIA

2023

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1. Introduction

Bioeconomy is the production of renewable biomass and converting it mainly into food, feed or other bioproducts and bioenergy. Bioeconomy covers agriculture, forestry, fisheries, aquaculture, food, fibre and paper, and partly the chemical, biotechnology, and energy industries [1].

The ambitious objectives of the European Green Deal [2] require fundamental changes in business, lifestyle and societal norms in general. The bioeconomy is a prerequisite for, and also a result of, the green transition [3]. Since, in terms of sustainability, economic development and increasing added value, the bioeconomy is an interdisciplinary concept based on the principle of the circular economy [4], we suggest the concept of the **circular bioeconomy**, to mark the importance of combining these approaches and the possibilities of bio-resources to replace (imported) fossil materials with more sustainable bio-based alternatives.

The "Estonia 2035" strategy **[5] aims at ambition to become a successful promoter, implementer and tester of R&D in selected fields in the world, in order to be an attractive destination country for foreign investments and an exporter of technology-intensive goods and services. At the same time, the goal has been set to make Estonia a recognised development centre for the bioeconomy in Europe. The bioeconomy is also a horizontal and cross-cutting theme in the "Agriculture and Fisheries Development Plan 2030" [6] as well as in the programmes implementing it, as well as a number of development and action plans (and their drafts) concerning the development of the bioeconomy, in particular the Development Plan for Research and Development, Innovation and Entrepreneurship (RDIE) 2021–2035 and its roadmaps [7], the White Paper on Circular Economy, the Forestry Development Plan [8], Energy Development Plan 2035 [9] etc.**

Estonia is a successful biomass-producing country, but its ability to process biomass and create added value per employee has remained below the European Union (EU) average. Increasing added value and innovation potential is a key theme for the development of a sustainable circular bioeconomy, as well as an opportunity to contribute to the green transition by reconciling the objectives of climate change mitigation, preservation of biodiversity, social and economic development.

The circular bioeconomy roadmap defines the broad fields of activities for the development of the circular bioeconomy in Estonia and the activities necessary for its development in the short term (2023–2027) and in the long term (until 2035). This will form the basis for the **development of regional circular bioeconomy roadmaps** based on local bio-resources, the needs and opportunities of communities and municipalities. The regional roadmaps translate activities into innovative local initiatives and forms of cooperation, leveraging the growth and sustainability of the added value of the regional bioeconomy.

The circular bioeconomy roadmap was prepared under the coordination of the Estonian Ministry of Regional Affairs and Agriculture in cooperation with the Ministry of Climate and other ministries, scientists, entrepreneurs and interest groups, and with the help of the Estonian University of Life Sciences.

2. Current situation, global trends and potential[1]

Global trends

The European Union is committed to becoming climate neutral by 2050. Preserving global biodiversity is equally important as climate goals. The decline of ecosystems is primarily due to changes in land use and the overexploitation of resources. Alongside arable land and woodland, oceans, seas, coastal and inland waters are seen as a source of biomass production.

The world's population will grow to around 10 billion by 2050, driven primarily by Africa and Asia, while the populations of Europe and the Americas are ageing rapidly. In connection with global population growth and continued urbanisation, food needs are estimated to increase by 50-200% [10]. However, the area of agricultural land cannot increase on such a large scale.

Global energy consumption is projected to grow by around 50% by 2050 [11]. Europe's energy system is based on fossil fuels – renewable energy meets slightly more than 20% of the EU's energy consumption. Climate goals and the war in Ukraine, started by Russia at the beginning of 2022, will force the search for alternative sources to energy and materials based on fossil raw materials of Russian origin and to reduce greenhouse gas (GHG) emissions in all sectors. Biomass, on the other hand, is a rather inefficient source for covering the world's growing energy needs, e.g., the entire biomass of the world in 2010 would only cover an estimated 20% of the world's energy needs in 2050 [12], although it can be an important regional/local energy source.

In the context of climate and environmental objectives, the role of new technologies (digital solutions, biotechnology) in increasing innovation, productivity and sustainability will also increase in the bioeconomy sectors. At the same time, bio-based technology has the potential to become one of the main engines driving world economic growth, similar to the developments in information technology in recent decades. The direct annual global economic impact of the 'bio-revolution' could be estimated at between USD 2-4 trillion between 2030 and 2040 [13].

Use of Estonian bio-resources

For the production of wood and agricultural biomass, 3.32 million hectares (73.2%) of Estonia's area is included. The area of utilised agricultural land and woodland has gradually increased over the past 20 years at the expense of the disused area (26.6% agricultural land and 2% forest land). A total of 69.3% of agricultural land is arable land, the rest is permanent grassland (30%) and other permanent crops (0.7%). The total area of permanent grassland and short-term grassland is 421,700 hectares (42.6% of all agricultural land).

In Estonia, the main production based on agricultural bio-resources is food and animal feed. There is no significant valorisation of agricultural bioresources or the industrial use thereof in the production of chemical, pharmaceutical, textile and other products. There is a fairly large amount of raw materials (cereals, raw milk) among exports.

The following are more significant quantities of bioresources produced in Estonia:

- The main product of agricultural production is cereals (wheat and barley), a total of 900,000–1,600,000 tonnes per year (depending on the crop yield). Another important product is plant biomass (3,200,000–4,300,000 tonnes), which is mainly used as cattle feed and makes it possible to produce a significant amount of milk and meat in Estonia.

[1] Chapter 2 is based throughout on the final report of the ADDVAL-BIOEC study: ADDVAL-BIOEC (2021) Increasing added value and the more efficient use of raw materials in the Estonian bioeconomy. Final report of the ADDVAL-BIOEC study, Tallinn & Tartu. www.taltech.ee/biomajandus.

- The main output in animal husbandry is raw milk, the vast majority of which is processed, although an average of 200,000 tonnes per year is also exported.
- For all meat product groups and eggs, Estonia's export-import balance is negative.
- In the last decade, there has been a significant increase in the cultivation of legumes and fodder corn, where the amount of production is 70,000–120,000 tonnes and 320,000–470,000 tonnes per year, respectively. The growing area of oil crops reached its optimal level a decade ago, with production ranging between 110,000–200,000 tonnes of rape and colza per year.
- The area under berries, fruits, vegetables and potatoes has decreased significantly over the past 20 years, with the quantities of these crops failing to cover the need for domestic consumption.
- It is calculated that a total of 1,252,500 tonnes of straw is generated in Estonia per year, as well as 40,600 tonnes of sorting residue. Although an untapped resource can be seen in straw production, it is important to return the vast majority of straw to the soil to maintain the humus balance of the soil.

In the last ten years, the area of woodland has remained in the range of 2.2–2.3 million ha. Total forest reserves were 472 million m^3 according to the statistical forest inventory calculations, with an increment of 7.6 m^3/ha/a [14]. In addition, forest land management (in particular the timber industry) is influenced by the maturity of forests that varies over time, which places limits on the sustainable use of woodland biomass in the different value chains of the circular bioeconomy. Based on the prevailing tree species, forest reserves are mainly divided between pine (35%), spruce (20%), and birch (26%). In the coming decades, due to the cyclical maturity of forests, a significant decrease in logging volumes is expected [15].

Like agriculture, mechanical valorisation of biomass and the export of raw materials dominate. While less than 10% of timber is sent for chemical processing in Estonia, compared to about 40% in Finland [16]. About half (7.5 million m^3) of the wood material handled in Estonia is used for heating [15]. Although the Estonian timber industry is relatively traditional and focuses mainly on the mechanical processing and use of wood for energy production, residues and by-products are also significantly valorised in the sector. The production of wooden buildings and furniture contributes to the long-term storage of carbon.

In the Baltic Sea, fish and, to a lesser extent, bottom vegetation are the most important bio-resources. Sprat and herring account for the largest percentage of fish resources caught from the sea, with the amount of fish caught from the Baltic Sea ranging from 55,000–70,000 tonnes per year. The share of inland waters is relatively modest in the total volume of catches (around 4%), although it is quite considerable on a global scale. Estonian fish farms have produced up to 900 tonnes of fish per year, although there is potential for around tenfold growth in terms of marine farms in the coming years. The main export item is frozen fish (mainly sprat and herring). Products with low added value account for the largest share of export articles in the fish sector.

Estonia's net GHG emissions in 2021, including land use and forestry (LULUCF), amounted to 15.6 million tonnes of CO_2 equiv. [17]. Without the LULUCF sector, Estonia's net emissions amounted to nearly 12.7 million tonnes of CO_2 equivalent. In Estonia, the main source of CO_2 emissions is the use of fossil fuels in energy, but in recent years the LULUCF sector has also changed from a sink to an issuer.

Economic added value and competitiveness of the Estonian circular bioeconomy

The EU bioeconomy added around € 665 billion in 2020, of which agriculture and food accounted for 64.3%, and forest and timber, 18.2% [18].

Within the framework of the ADDVAL-BIOEC project, an internationally developed methodology for compiling overviews of the economic and innovation behaviour of companies in the field of the bioeconomy was introduced in Estonia for the first time. This methodology includes data from both biomass production and industries that are fully bio-based and partly bio-based.[2] Based on the data from 2017-2019, the sectors and activities related to the bioeconomy in Estonia have provided approximately **13% in added value to the economy and 17% to exports, while providing employment for 12% of** those employed.

The ability of the Estonian bioeconomy to create added value per employee has been approximately one-third below the EU average. For example, in 2019, the value added per employee in the food sector in the EU averaged € 45,500, compared to € 27,900 in Estonia [18].

While approximately two-thirds of the value added in Europe is created within the manufacturing industry, and the pharmaceutical and chemical industries, among others, occupy an important place in the portfolio of bioeconomy products of wealthier countries, **Estonia's bioeconomy has thus far also been heavily focused on forest and timber, as well as agriculture and food products in terms of economic value added and exports** – these value chains have provided 90% of value added and 85% of exports:

- the sales revenue of forestry and wood and paper companies accounts for about 50% of the sales revenue of bioeconomy enterprises, and exports account for about 60% of bioeconomy exports;
- agriculture and food and beverage production account for about 40% of the sales revenue of bioeconomy companies and about 25% of bioeconomy exports.

The product groups with the largest net export volume in the Estonian bioeconomy are factory houses (9406), wooden joinery and carpentry products (4418), firewood (including pellets, 4401), continuous profile wood (4409), wheat and meslin (1001), furniture and furniture parts (9403).[3] Among the food products with a higher volume of net exports, cheese and curd (0406), as well as milk and cream (0401) can be highlighted.

Challenges and potential for developing the circular bioeconomy in Estonia in different value chains

The main challenges and potential for the development of the circular bioeconomy in Estonia are as follows:

- In order to increase the added value of the circular bioeconomy in Estonia, it is necessary to valorise the resources produced in agriculture significantly more (in particular, cereals and raw milk and yet

[2] For industries that are partly biobased – e.g., textiles and clothing, chemicals and chemical products, basic pharmaceuticals and pharmaceutical preparations, rubber and plastic products, furniture manufacturing and power generation – the shares of bio-based companies in the total volume of industries outlined in international comparative methodologies were utilised in order to use industry data.

[3] In addition to wooden furniture and factory houses, CN group 94 also includes furniture made of metal and other materials.

to be valorised biowaste, residues and by-products), both by increasing today's processing capabilities and by introducing innovative technological solutions (e.g., biotechnological applications). In addition, it is necessary to monitor the development of the livestock sector, which may be affected by changes in consumption preferences and also by the need to limit greenhouse gas emissions. With a potential decline in the livestock sector, plant biomass will not be used accordingly, and agricultural land use may change. In the circular bioeconomy, plant biomass can be used for the production of various materials and bioenergy and valorised as animal feed (protein production during biorefining, etc.). At the same time, the supply of bio-resources must take into account the ensuring of biodiversity and functioning of ecosystems, as well as climate change adaptation and mitigation needs.

- The value chain of Estonian **timber is currently based on the mechanical valorisation of timber and is central to the production of** lumber, wood pellets, and heating material. Approximately 50% of handled wood material is directed to heating. The share of exports of pulpwood as a raw material is also large, as cellulose and paper are produced in a limited volume in Estonia and there are no other/more novel forms of valorisation, such as chemical valorisation. However, activities and products that valorise the output of the sawn timber industry, such as factory houses, wooden joinery and carpentry products, furniture and furniture parts, can also be highlighted in exports.
- The development of the Estonian fisheries and aquaculture sector is subject to regulatory limits in order to preserve natural resources and aquatic ecosystems, and the state of fish stocks needs to be improved. Therefore, it is important **to better valorise already existing fish resources**. In addition, attention needs to be paid to the development of cultivation technologies for seaweed (Clawed fork weed, bladderwrack) and clams (blue mussels) and to finding additional opportunities for economic use (e.g., biotechnology), which are currently underused as a resource and help to remove biogenic substances from the sea and reduce the eutrophication of the Baltic Sea. There is also great potential for offshore aquaculture in Estonia, which would make it possible to produce animal protein for food.
- Renewable energy in Estonia is and will continue to be linked to the use of woody biomass; however, in order to achieve the best possible level of efficiency in forestry and energy, attention must be paid to the initial industrial valorisation of biomass. **Without the cascading use of biomass, energy is not a creator of high added value**, which is why it is advisable to find new solutions for the commercial valorisation of biomass, where by-products and residues that are not necessary for commercial use are valorised in energy.
  Residues of biological origin, waste (including sewage sludge[4]treated as biowaste) and by-products, in particular manure from agriculture, would be more widely used in biogas and -methane production, which provides a solution both for local energy (and heat) production and helps to reduce emissions of greenhouse gases and air pollutants associated with agriculture. The resulting digestate is an economically valuable material that has a positive effect on maintaining and increasing the nutrient content of the soil. Enriching the digestate with bio-based as well as fossil (e.g., oil shale ash) substances allows for a further increase of the positive impact on the soil. Algae and/or residues from their production would be a good alternative to synthetic fertilisers used in agriculture, bringing nutrients (N, P) from the sea back to the field and thus creating a nutrient cycle. In the case of synergistic use of marine space, it is also possible to combine algae and shellfish farming with offshore wind farms, i.e., renewable energy.
- An important challenge for the further development of the valorisation of Estonia's domestic bio-resources is **the lack of comprehensive planning for the circular bioeconomy and industries with a wider scope, as well as the lack of cooperation** that supports the growth of the added value of the circular bioeconomy, as the small volumes of bio-resources and the costs of transport arising from dispersion impose their own restrictions on the application of various technologies, as well

[4] The draft state waste management plan (2022–2028) provides for the preparation of a road map for the promotion of sewage sludge treatment in Estonia.

as economic activity. In addition, it is necessary to find ways to use potential energy surpluses (e.g., growing vegetables under glass in cooperation with power plants set up to produce energy).

- Increasing the research and development (R&D) **and innovation capacity of areas that are important for increasing the added value of Estonia's bioeconomy, such as the furniture industry, the chemical industry, the wood and paper industry, and addressing their needs in the education system, in order to prepare suitably trained specialists**, is of paramount importance. The very modest capacity of the business sector to spend on R&D limits the opportunities to directly engage in the introduction of new technologies and product development, but even less so in the development and innovation of technologies. At different levels of education, insufficient attention is paid to the transfer of knowledge regarding the circular bioeconomy and related R&D and innovation capacity. As a result, there is a lack of specialists who would be able to link existing bio-resources to different processing methods, bioproducts and opportunities related to value chains. Consumer awareness of the environmental impact of their choices and of bio-based alternatives with a low environmental impact is also low. In scientific fields related to the bioeconomy, research teams are fragmented. Cooperation between research groups and businesses needs to be improved.
- The chemical and bioengineering of bio-resources and the creation of new bio-based industries and value chains means **changes in existing value chains and business models**.
- **For their part, structural changes in land and sea use are** influenced by the implementation of EU initiatives by Member States and related policy decisions (e.g., LULUCF (AFOLU), Objective 55) and changes in the consumption preferences of people.
- When developing new circular bioeconomy value chains, it must be ensured that the production of the bio-resource necessary for their functioning remains **within ecological tolerance limits** in terms of carbon emissions and sequestration, biodiversity, and the condition of soils and water bodies.
- The circular bioeconomy is a so-called twin transition, where at the same time the fossil resource is being **replaced by a bio-based one, and the linear economic model is being replaced by a circular one**, which requires a significant amount of support, guidance, stimulation of demand, creation of assumptions and new models of governance. However, it is important to avoid the creation of market distortions. **Existing development plans, strategies and other development documents and forms of cooperation address the topic in a fragmented manner, as well as on the basis of some aspects of the circular bioeconomy, but not holistically**.

3. Broad fields of activities for the development of the circular bioeconomy and activities necessary for development

The circular bioeconomy is the backbone of the future economy and an enabler of the green transition, which increases the added value created in the field and helps to make Estonia a leader in the regional circular bioeconomy.

The objectives of developing the circular bioeconomy are:

- reduce dependence on non-renewable and imported resources with a large environmental footprint, ensure self-sufficiency in food and raw materials and food security,
- increase resource efficiency, material circulation and the use of by-products and residues as raw materials,
- strengthen research and development and innovation competences, the development, deployment and acceptance of new technologies in society,
- leveraging the emergence of innovative initiatives and forms of cooperation (e.g., clusters, cooperative business models, industrial symbiosis[5], international cooperation, etc.) that support the export capacity of companies and foreign investment in the circular bioeconomy, which support the growth of the added value of the circular bioeconomy.

The general starting points on which the development of the circular bioeconomy are based:

- **Sustainability**: `do no significant harm`[6]; a balance between the economy, the social sphere and nature – which also ensures the needs of future generations – is a central principle and starting point for the circular bioeconomy. All products and services must be guided by this principle; the use of biomass (including water and soil) in the procurement of raw materials must not have a significant negative impact on biodiversity and the regenerative capacity of ecosystems.
- **Cascade use**: the use and processing of a resource on the basis of a higher value-added priority – food and feed, bio-based materials and chemicals before using the bio-resource for energy and fuel production.
- **Circularity**: smart, needs-based and as low use as possible of all resources, with the highest possible societal, social, and economic value. Materials are in circulation both safely and for as long as possible, with the products being long-lasting.
- **Resource Security:** food first. Food security is the priority, and safe and health-supporting food must be accessible to all. Self-sufficiency in resources and the use of local resources are also central in energy and other areas.

Diversification of land, sea and biomass use, support for the cultivation and valorisation of biomass[7] that contributes to biodiversity and soil health, reduces the carbon footprint, increases carbon sinking and adaptation to climate change, and supports the use of solutions using ecosystem services,[8] and

[5] The aim of industrial symbiosis is to achieve a closed production cycle in which waste, waste heat and other surpluses from one company or production unit are used up by another company. An example of industrial symbiosis in Estonia is, for example, PAKRI Science and Industrial Park.

[6] https://www.rtk.ee/toetuste-taotlemine-ja-korraldamine/kiirelt-katte/keskkonnanouded#Ei%20kahjusta%20oluliselt.

[7] In addition to terrestrial resources, coastal waste, marine plants, reeds, etc.

[8] Agroecology and restorative agriculture, agroforestry, wetland farming, sustainable aquaculture and fishing, and 'blue' carbon sequestration, among others. In addition, ensuring the preservation of the genetic and biochemical resources that are collected and exist in breeding sites, established collection gardens, tissue culture collections and seed banks.

sustainable forest management[9] are all essential prerequisites for the development of the circular bioeconomy.

The following broad fields of activities for the development of the circular bioeconomy were selected, in particular on the basis of the results of the RITA1 bioeconomy project, the activities of road maps and action plans more directly related to the topic of the circular bioeconomy – in particular the RDIE focus area roadmaps, the Circular Bioeconomy White Paper – and in discussions with representatives of businesses, R&D and state agencies. **The focus is on policies and activities based on the above-mentioned objectives for the development of the circular bioeconomy and the approach to the circular bioeconomy as a holistic economic model, as well as on activities that are not (sufficiently) addressed in other development strategies and plans**.

Fields of activities

The fields of activities in the development of the circular bioeconomy in Estonia are:

1. Greater added value from the circular bioeconomy.
2. Sustainable supply of resources and preservation of biodiversity.
3. Research and development, innovation and technology.
4. Competitive business environment.
5. Education, skills and awareness.

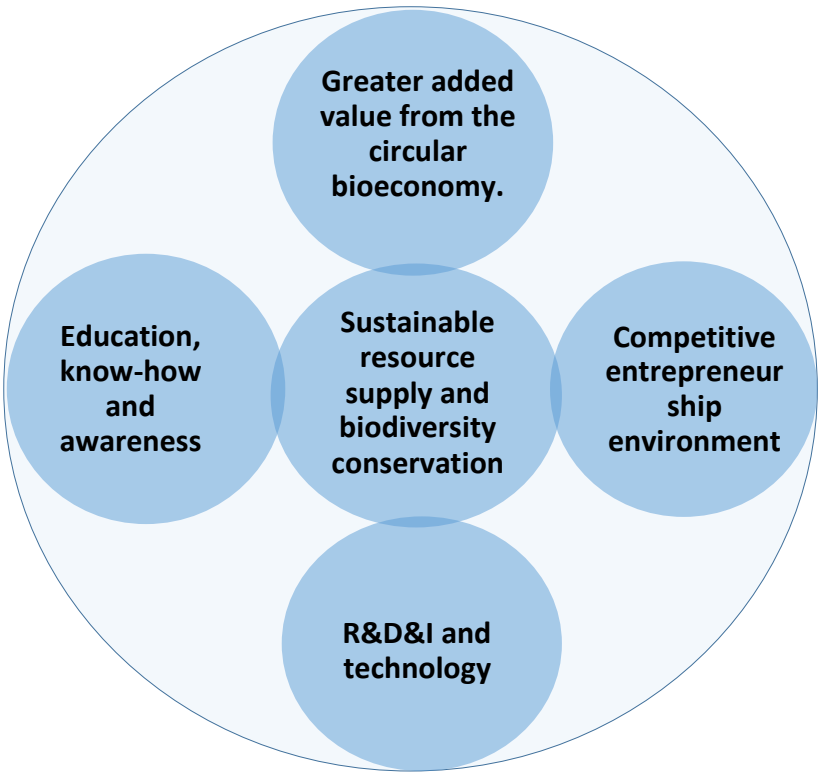

Figure 5. The broad fields of activities in the development of the circular bioeconomy in Estonia.

[9] The diversity and vitality of forest biota ensures the capacity for renewal and productivity on which forest management is based. The carbon sinking capacity of forests and their adaptation to climate change are part of sustainable management. Reforestation would be based not only on sustainability but also on the needs of the circular bioeconomy of the future, so that wood that can be used for different purposes (chemical industry, construction, durability products, etc.) is guaranteed.

The increase in added value requires, inter alia, an improvement in farming and technologies for introduction of new breeding techniques, the introduction of new crops (e.g., protein crops, algae, berries rich in bioactive substances etc.), as well as increasing and ensuring self-sufficiency, including, in the case of feed, in particular, the replacement of imported protein feeds with domestic ones.
A prerequisite for increasing added value is healthy soils, marine areas in good environmental condition, sustainable production of high-quality and safe raw materials and their high value-added processing and maximum use in the local food and feed industry. The dispersion of biomass and the associated small quantities of raw materials require cooperation and often smaller-scale solutions.

The move towards a climate-neutral economy and the creation of new value chains and business models, and thus higher added value, will be based on research, development and innovation (RDI). At the same time, it is important that the most efficient valorisation of biomass is based not on the view of a single company, but on cooperation across sectors, companies and value chains, the principles of industrial symbiosis and cascading use[10]. The broader development of industrial symbiosis requires systematic coordination and management by the state. Whereas entrepreneurs from the primary sector (agriculture, forestry, fisheries, and aquaculture) must also be included in the new value chains.

The nature of the circular bioeconomy requires a multidisciplinary approach at all levels of the education system. University curricula generally do cover key topics in the circular bioeconomy (e.g., life sciences and technology, economics, marketing, ecology), but not as part of a comprehensive curriculum. The same applies, in general, to education programmes and training. Vocational training must provide workers with the necessary knowledge and practical skills for the labour market, and the circular bioeconomy should be an attractive career choice for young people. The availability of (applied) studies and data commissioned by the state must be centrally organised in the Estonian Research Information System (ETIS) and the possibilities of ETIS must also be more actively communicated outside the academic community.

More broadly, it is necessary to direct and change the attitudes and stances of society as a whole (*Not In My Backyard*, *Not On My Plate* etc.).

1. Greater added value from the circular bioeconomy

ACTIVITIES:

1. Development and promotion of the uptake of alternative raw materials (including from the blue economy) and novel foods.
2. Development and introduction of alternative feed components (including those based on plant and processed animal proteins produced in Estonia) that inhibit greenhouse gas emissions.
3. Development of technological solutions for synthetic biotechnology, cell farming, hydroponics and vertical farming, as well as related ICT solutions.
4. Use of unused or underused by-products and residues (including from fisheries and aquaculture) in the chemical, cosmetic and pharmaceutical industries and in the production of fertilisers/soil improvers.
5. Identification and use of economically valuable genetic or biochemical resources from nature for the development of new products (*bioprospecting*).

[10] The residues and by-products of one company – which the company itself would use, for example, to produce energy – may be suitable as higher value inputs in the value chain of another company (e.g., food producer residue as feed for another company or biotechnological valorisation for another company; wood residues for biochemical and biotechnological valorisation input, use of heat or hot water in another process).

6. Review of the arrangements for the handling and valorisation of animal by-products according to categories.
7. Finding uses for ash obtained from the incineration of animal by-products.

8. Chemical valorisation of wood (including the use of by-products and residues from processing) and development of new wood-based products, e.g., use of cellulose, lignocellulosic material, hemicellulose and lignin for the production of textiles, biocomposites, packaging, etc.
9. Development of insulation, surface treatment and building materials based on wood-based and other renewable materials.
10. Promoting the use of wood and other renewable materials in the construction of new long-term products, structures and buildings.

11. Development of infrastructure for the collection, logistics, pre-treatment and storage of biowaste, as well as area-based solutions (including small solutions), technologies and value chains[11].
12. Further development of biogas plants into refineries operating on the principle of cascading use, which, in addition to energy, also produce bio-based materials and chemicals.
13. Development and application of technologies for the capture and use of atmospheric carbon.

2. Sustainable supply of resources and biodiversity conservation

ACTIVITIES:

1. Improving and making available data on biomass and by-product generation and demand (also at the regional and local government level), as well as developing the relevant digital platforms.
2. Breeding of varieties suitable for the Estonian climate and expansion of the use of native plant species and varieties, including as protein-rich feeds.
3. Promotion of algae and shellfish cultivation and processing technologies to remove nutrients from the Baltic Sea and valorisation of inland water bioresources[12].
4. Optimising synergies between land-based, marine and aquaculture-based production systems[13], to increase sustainability and production efficiency.

3. Research and development, innovation and technology

ACTIVITIES:

1. Fostering collaborative models and networks based on collaboration within, across and between value chains for the development and the introduction of technologies and the development of higher value-added products and services.
2. Supporting the participation of R&D institutions in international networks and consortia, using EU research and innovation funding opportunities (Horizon Europe, Interreg, etc.).
3. Supporting the emergence of piloting and technology scaling infrastructure (including offshore) and bio-processing facilities, and investments in the development of already existing facilities in cooperation between the state, public and private sectors.

[11] E.g., composting and development of compost products, biogas production and biogas purification into biomethane, use of CO_2 extracted in production and industry, use of digestate from biogas plants as fertiliser/soil improver, including further processing and production of digestate.

[12] Exploitation and valorisation of inland aquatic bio-resources such as sediments, riparian aquatic plants, aquatic plants, algae, fine fish and non-native species (e.g., zebra amphipod, zebra mussel), including technologies to remove nutrients from inland waters and direct them into circulation.

[13] Synergies between terrestrial, marine and aquaculture systems would, for example, make it possible to optimise agricultural by-products (e.g., fish feed) used in aquaculture or vice versa; aquaponics, i.e., fish farming water and fish excrement, and the resulting CO_2 are directed to crop production, etc.

4. Adaptation, testing and application of circular bioeconomy research results, best practices and technologies to Estonian circumstances.
5. Applying IT solutions, including artificial intelligence, to use circular bioeconomy data and develop products and services, create digital collaboration platforms, optimise processes and increase efficiency.

4. Competitive business environment

ACTIVITIES:

1. Creating the necessary funding models to support start-ups and R&D institutions, including to reach a higher TRL[14] level.
2. Providing conditions and support for the use of highly qualified labour, including foreign labour, in enterprises and R&D institutions.
3. Intensifying the mobilisation of private investment in tackling the challenges of the circular bioeconomy and sector development, supporting private (equity) investments and loans, or providing sureties to reduce risks.
4. Supporting business participation in EU circular bioeconomy-related networks, partnerships and projects, as well as in international circular bioeconomy and new technology hackathons, fairs and other events.
5. Implementing green (public) procurement in the areas of the circular bioeconomy and prioritising products from local raw materials/resources (e.g., food, feed, wood) or recycled materials.
6. Continue to support the export and marketing of circular bioeconomy technologies, products and services.
7. Adapting the regulatory framework to the needs of the circular bioeconomy, in particular speeding up procedures, introducing EU-wide changes (e.g., state aid rules, rules for different EU funds) to facilitate, inter alia, the introduction of new and innovative bio-based products to the market.
8. Empowering county development centres and local governments (e.g., increasing the tax revenue base by the state) and supporting regional competence and incubation centres for the development of the regional and community-based circular bioeconomy.
9. Updating the definitions (waste, including biowaste, by-products) and related requirements with regard to the circular bioeconomy in legislation.

5. Education, skills and awareness

ACTIVITIES:

1. Systematic organisation of the approach and dissemination of the principles and communication of the circular bioeconomy as a new economic model.
2. Introduction of (continuing) training at all levels of education, knowledge transfer and further training in order to prepare a sufficient number of specialists with the necessary skills and numbers.
3. Creation of a formal education curriculum, provision of micro-degrees related to the circular bioeconomy in Estonian universities.
4. Training local government officials and agencies on the topic of the circular bioeconomy and their active involvement in the development of the field.
5. Demonstration of opportunities for joint activities and cooperation (e.g. different cooperative models) suitable for the community and regional level.
6. Empowering ambassadors and spokespersons for the circular bioeconomy at the regional level and for different age-groups.

[14] https://www.etag.ee/wp-content/uploads/2019/01/Tehnoloogilise-valmiduse-tasemed.pdf.

7. Creation and use of ‘hands-on’ circular bioeconomy teaching materials in kindergartens and general education schools.

4. Sources

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Annex 1. Circular Bioeconomy Roadmap activities 2023–2027

The activities were evaluated in the focus group, taking into account the urgency of starting activities. In the opinion of the focus group, the activities that are most prominent are marked **with an asterisk (*).**

1. Greater added value from the circular bioeconomy		
	1.1	Development and promotion of the uptake of alternative raw materials (including from the blue economy) and novel foods.
	1.2	Development and introduction of alternative feed components (including those based on plant and processed animal proteins produced in Estonia) that inhibit greenhouse gas emissions and zootechnical feed components.*
	1.3	Development of technological solutions for synthetic biotechnology, cell agriculture, hydroponics and vertical farming, as well as related ICT solutions.
	1.4	Use of unused or underused by-products and residues (including from fisheries and aquaculture) in the chemical, cosmetic and pharmaceutical industries and in the production of fertilisers/soil improvers.*
	1.5	Identification and use of economically valuable genetic or biochemical resources from nature for the development of new products (*bioprospecting*).
	1.6	Review of the arrangements for the handling and valorisation of animal by-products according to categories.*
	1.7	Finding uses for ash obtained from the incineration of animal by-products.*
	1.8	Chemical valorisation of wood (including the use of by-products and residues from processing) and development of new wood-based products, e.g., use of cellulose, lignocellulosic material, hemicellulose and lignin for the production of textiles, biocomposites, packaging, etc.*
	1.9	Development of insulation, surface treatment and building materials based on wood-based and other renewable materials.
	1.10	Promoting the use of wood and other renewable materials in the construction of new long-term products, structures and buildings.
	1.11	Development of infrastructure for the collection, logistics, pre-treatment and storage of biowaste, as well as area-based solutions (including small solutions), technologies and value chains.*
	1.12	Further development of biogas plants into refineries operating on the principle of cascading use, which, in addition to energy, also produce bio-based materials and chemicals.
	1.13	Development and implementation of technologies for the capture and use of atmospheric carbon.
2. Sustainable supply of resources and biodiversity conservation		
	2.1	Improving and making available data on biomass and by-product generation and demand (also at the regional and local government level) and developing the relevant digital platforms.*
	2.2	Breeding of varieties suitable for the Estonian climate and expansion of the use of native plant species and varieties, including as protein-rich feeds.*

	2.3	Promotion of algae and shellfish cultivation and processing technologies to remove nutrients from the Baltic Sea and valorisation of inland water bioresources.
	2.4	Optimising synergies between land-based, marine and aquaculture-based production systems to increase sustainability and production efficiency.
3. Research and development, innovation and technology.		
	3.1	Fostering collaborative models and networks based on collaboration within, across and between value chains for the development and introduction of technologies and the development of higher value-added products and services.*
	3.2	Supporting the participation of R&D institutions in international networks and consortia, using EU research and innovation funding opportunities (Horizon Europe, Interreg, etc.).*
	3.3	Supporting investments in piloting, piloting and technology scaling infrastructure (including offshore) and bio-processing facilities, and investments in the development of already existing facilities, in cooperation between the state, public and private sectors.*
	3.4	Adaptation, testing and application of circular bioeconomy research results, best practices and technologies to Estoniancircumstances.*
	3.5	Applying IT solutions, including artificial intelligence, to use circular bioeconomy data and develop products and services, create digital collaboration platforms, optimise processes and increase efficiency.
4. Competitive business environment		
	4.1	Creating the necessary funding models to support start-ups and R&D institutions, including to reach a higher TVT level.
	4.2	Providing conditions and support for the use of highly qualified labour, including foreign labour, in enterprises and R&D institutions.*
	4.3	Intensifying the mobilisation of private investment in tackling the challenges of the circular bioeconomy and sector development, supporting private (equity) investments and loans, or providing sureties to reduce risks.
	4.4	Supporting business participation in EU circular bioeconomy-related networks, partnerships and projects, as well as in international circular bioeconomy and new technology hackathons, fairs and other events.*
	4.5	Implementing green (public) procurement in the areas of the circular bioeconomy and prioritising products from local raw materials/resources (e.g., food, feed, wood) or recycled materials.*
	4.6	Continue to support the export and marketing of circular bioeconomy technologies, products and services.*
	4.7	Adapting the regulatory framework to the needs of the circular bioeconomy, in particular speeding up procedures, introducing EU-wide changes (e.g., state aid rules, rules for different EU funds) to facilitate, inter alia, the introduction of new and innovative bio-based products to the market.*
	4.8	Empowering county development centres and local governments (e.g., increasing the tax revenue base by the state) and supporting regional competence and incubation centres for the development of the regional and community-based circular bioeconomy.
	4.9	Updating the definitions (waste, including biowaste, by-products) and related requirements related to the circular bioeconomy in legislation.*

5. Education, skills and awareness		
	5.1	Systematic organisation of the approach and dissemination of the principles and communication of the circular bioeconomy as a new economic model.*
	5.2	Introduction of (continuing) training at all levels of education, knowledge transfer and further training in order to prepare a sufficient number of specialists with the necessary skills and numbers.
	5.3	Creation of a formal education curriculum, provision of micro-degrees related to the circular bioeconomy in Estonian universities.*
	5.4	Training local government officials and agencies on the topic of the circular bioeconomy and their active involvement in the development of the field.*
	5.5	Demonstration of opportunities for joint activities and cooperation (e.g., different cooperative models) suitable for the community and regional level.*
	5.6	Empowering ambassadors and spokespersons for the circular economy at the regional level and for different age-groups.*
	5.7	Creation and use of ‘hands-on’ circular bioeconomy teaching materials in kindergartens and general education schools.