Lithuanian Bioeconomy
Development Feasibility Study

Summary

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Long-term forecasts have shown that in addition to political developments, the current trends of economic growth and development will have an essential impact on natural resources and ecosystem. With the rapidly increasing population and their need for food, increasing amounts of natural resources have been used, leading to increasing environmental impact and related climate change challenges. Thus a transition to the new economic growth method compatible with environmental protection and sustainable limited use of natural resources at the same time ensuring much higher standard of living and reducing poverty is necessary. The development of innovative biotechnology techniques and processes and their application in agricultural, health, chemical and energy sectors have lately been considered one of solutions for sustainable growth and development. A greater focus on research and innovation would allow creating new products derived from biomass and new services necessary for the development of bioeconomy, which helps reduce climate change, amounts of waste and create new jobs.

The development of biotechnology-based bioeconomy promotes the circular economy, which uses resources more efficiently and is increasingly based on renewable energy, products and materials made by sustainable use of land and water ecosystems. The development of bioeconomy helps reduce climate change, the amount of waste and create new jobs. With increasing interest in bioeconomy, high expectations related to the development of bioeconomy have been fostered in Europe and the world, reflected in high-level policy, science and industrial forums.

According to the OECD, by 2055 the bioeconomy will be the key principle of development of the European economy. This means that the main focus will be on production of renewable bio-resources, which will become the main source of industrial raw materials, while modern biotechnology will become the cornerstone driving force of economic development. Biotechnology and bio-products derived in application thereof are two of the six priority axes for promoting investment in innovation and new technology according to the European Commission’s industrial revival policy.

The purpose of this study is to evaluate the state and potential of bioeconomy in Lithuania, to take into account the best practices of the EU Member States and Norway and to present the conclusions and recommendations for the development of bioeconomy in Lithuania and measures promoting innovation in this sector, to identify the areas of bioeconomy where the cooperation between Lithuanian and Norwegian business has the greatest potential and to establish the measures for promoting bilateral cooperation.

The following research methods were used in the preparation of the study: content analysis, statistical data analysis, econometric time series analysis, general equilibrium modelling, questionnaires, interviews, case studies and others. The data for empirical research were collected from publicly available statistical databases such as Eurostat, Lithuanian Official Statistics Portal, Statistics Norway, joint statistics of the Organization for Economic Cooperation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO), International Trade Center (ITC) statistics and statistics of Lithuanian authorities. The study also included the Lithuanian Official Statistics Portal data provided upon special requests of the authors of the study as well as various studies, study reports and other data. Data limitations include: the statistics on national accounts, employment, business, science and technology according to the NACE2 economic activities are not suitable for the macroeconomic indicator analysis of development, R&D (research and experimental development) and innovation of partly bio-based manufacturing (textile, apparel, leather, chemicals, pharmaceutical products and preparations, rubber and plastic products, furniture), bioenergy and bio-waste processing sectors, because it includes both types of production, i.e. biomass and fossil resource-based production.

Main study results include:
1) recommendations were made for the definition and composition of bioeconomy;
2) the state of Lithuanian bioeconomy was analysed and projections for the development thereof till 2030 were prepared;
3) the favourability of environmental factors and their impact on the development of bioeconomy in Lithuania was assessed;
4) sectors of bioeconomy having the greatest potential in Lithuania and actions for their development were identified;
5) the potential of research and experimental development in bioeconomy was assessed;
6) good practice of EU member states was assessed, drafting recommendations for taking advantage of this practice in Lithuania;
7) recommendations were prepared to promote cooperation of the Lithuanian and Norwegian business in bioeconomy;
8) expediency of the Lithuanian bioeconomy strategy was substantiated;
9) trends for promoting Lithuanian bioeconomy innovation were foreseen;
10) recommendations (action plan) were drafted for promoting development of Lithuanian bioeconomy and innovation.

Definition and composition of bioeconomy

According to the definitions provided in documents of the European Union (EU), OECD and EU member states, bioeconomy is a part of economy associated with the following attributes:

- sustainable production of bioresources and their processing into value added products;
- land and water bio-resources (plants, animals and micro-organisms) and bio-based products;
- types of economic activities (in other words - economic sectors) related to the manufacture, processing or recycling and use of bio-resources such as plants, animals, micro-organisms and their products;
- the use of advanced technologies, such as biotechnology, nanotechnology, information and communication technologies, in addition to traditional technologies. Advanced technologies are seen as the main prerequisite for modern bioeconomy development, while knowledge-based bioeconomy may be an essential part of a viable and sustainable economic system.

Based to these attributes of bioeconomy, the description of bioeconomy presented in the Communication from the European Commission “Innovation for Sustainable Growth: A Bioeconomy for Europe” reflects the essence and content of bioeconomy. According to this Communication, the bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. This description of bioeconomy is suitable for defining the bioeconomy sector in Lithuania legislation.

Various political documents, researches and statistical reviews analyse different composition of bioeconomy by types and sectors of economic activities. The attribution of certain economic activities or sectors of economy to bioeconomy may be based on different perspectives. The composition of the bioeconomy which is still forming is not finite, because new technology allows replacing products made of fossil resources with fully or partly bio-based products, or using biomass as the energy carrier in new sectors of economy in the future.

Classification of bioeconomy sectors used in the National Bioeconomy Profiles published by the European Commission was used in the study:

- **biomass production sectors** – agriculture, forestry and fisheries;
- **fully (100 percent) bio-based manufacturing sectors, processing biomass to higher added value products**, which include manufacture of food, beverages and tobacco; manufacture of wood, cork and their products, except for furniture; manufacture of paper and its products and manufacture of leather and related products;
- **partly (less than 100 percent) bio-based manufacturing sectors, where biomass is used as a part of materials.** This includes manufacture of textile and apparel, chemicals, pharmaceuticals, rubber and plastics, furniture and other bio-based manufacturing.
The study used the classification of bioeconomy sectors used in the National Bioeconomy Profiles published by the European Commission:

In NACE2, bioenergy is integrated in such economic activities as logging, manufacture of wood and chemicals, production of gas and waste treatment.

According to OECD definition, biotechnology is the application of science and technology for living organisms, parts thereof, products and models in order to replace living and non-living materials to receive knowledge, produce goods and provide services. The core biotechnology activities are biotechnology research and experimental development, and production. Areas of application of biotechnology in the EU economy are divided into three groups: 1) medicine and pharmacy; 2) agriculture, aquaculture and veterinary; 3) industrial processes. The biotechnology sector covers certain areas of primary and industrial production, research and health care services. The definition allows perceiving bioeconomy as production activities, thus solely production activities of biotechnology sector are attributable thereto.

**Lithuanian bioeconomy development and projections**

The study analyses the trends of the development of bioeconomy since 2005. The contribution of bioeconomy into the country’s GDP is almost 13 percent (by sectors see Figure 1). Bioeconomy turnover accounts for a sixth of the total turnover. Exports of biomass and products derived from biomass account for 44 percent of the total value of exports of Lithuania goods. Almost 18 percent of labour force is engaged in bioeconomy. In 2014, the food sector (agriculture, fisheries and food manufacturing) created more than a half of the gross value added of bioeconomy and forest biomass-based sector (forestry, manufacture of wood, paper and furniture) - slightly more than a third. The contribution of manufacture of bio-based textiles, apparel and leather products is 7.9 percent. Manufacture of bio-based chemicals and pharmaceuticals created a small share of value added of bioeconomy (4 percent). The contribution of manufacture of textile, apparel and leather products as well as of food sector in the gross value added of Lithuanian bioeconomy declined in the past decade, but the share of subsectors of forest biomass-based and bio-based chemicals and pharmaceuticals increased (Figure 2).

![Figure 1. Share of bioeconomy sectors in Lithuanian GDP (in percentage)](image)

Data source: authors elaboration on information in annex 2 table 3

Almost two thirds of persons working in bioeconomy were employed in the food sector in 2015. Slightly more than a fourth of them worked in the bio-based forestry sector, less than a tenth – in manufacture...
of bio-based textile, apparel and leather products, and a very small share (0.4 percent) – in subsectors of manufacture of bio-based chemicals and pharmaceuticals. The share of persons employed in the food sector and manufacture of bio-based textile, apparel and leather products decreased over the decade (by 2.7 and 1.5 percentage points, respectively). The proportion of persons employed in the remaining sectors increased: 4.1 percentage points – in the forestry bio-based sector and 0.1 percentage points – in manufacture of bio-based chemicals and pharmaceutical products and preparations.

**Figure 2. Structure of gross value added and employment in bioeconomy sectors**

Data source: Authors elaboration on information in annex 2 table 3 and 7

In bioeconomy, labour productivity (gross value added per person employed) is lower than the average productivity in the whole Lithuanian economy. This gap decreased significantly over the decade. Labour productivity in manufacture pharmaceutical products and preparations and the production of chemicals is very high in Lithuanian bioeconomy. Here labour productivity is from a few dozen to several times higher compared to the average labour productivity of the entire country. The lowest labour productivity levels have been observed in agriculture, which are half the country’s average. Low levels of labour productivity have also been observed in forestry and logging, manufacture of textiles, apparel and leather, and wood industry (Figure 2).

**Figure 2. Labour productivity and its growth in bioeconomy sectors**

Data source: Authors elaboration on information in annex 2 table 4
Such differences in labour productivity mainly come as a result of differences in intensity of technology use. As a matter of fact, manufacture of pharmaceutical products and preparations is attributable to high-technology industry and is a knowledge intensive business industry, while manufacture of chemicals is attributable to medium-high-technology industry. All other manufacturing industries of bioeconomy (manufacture of food, beverages and tobacco products, textiles, apparel, leather, wood and paper products, and furniture) are attributable to low-technology industry. In terms of technological intensity, primary production of biomass (agriculture, forestry and fisheries) also is a low technology area of bioeconomy. On the other hand, the gap in labour productivity between bioeconomy and the entire economy as well as among sectors of bioeconomy has also decreased due to innovative technological solutions in low technology industry, also in aquaculture, agriculture and logging.

The significance of bioenergy increased in Lithuania having decommissioned the Ignalina Nuclear Power Plant. The contribution of bioenergy to the production of primary energy in Lithuania lately accounted for about 73 percent, of which firewood and wood waste for fuel accounted for 64 percent, biodiesel made up about 5 percent, biogas – almost 2 percent and the remaining types of biofuel – less than one percent each.

Gross value added of bioeconomy in Lithuania increased from EUR 2.7 to 4.7 billion (in 2005–2014), while its share in GDP changed only slightly, decreasing from 13.1 to 12.8 percent. The contribution of biomass production sector to GDP (from 4.3 to 3.4 percent) decreased, while the contribution of manufacturing sectors increased: contribution of fully bio-based manufacturing grew from 5.3 to 5.8 percent and that of party bio-based manufacturing – from 3.4 to 3.6 percent. Since 2010, Lithuania has been among leaders in terms of growth of bioeconomy in the EU in all subsectors of biomass production and fully bio-based manufacturing: the first in terms of growth of paper industry, the third – according to growth rates of fisheries, the fourth – in terms of the growth of agriculture, food, beverage and tobacco, and wood (except for manufacture of furniture) industry and the fifth – according to the growth of forestry and logging subsectors.

Three methods were used to prepare Lithuanian bioeconomy development projections: econometric time series analysis, general equilibrium modelling and analysis bioeconomy business expectations. The following trends of development of the Lithuanian bioeconomy are likely in the long-term: the gross value added, which was EUR 4.7 billion in 2014, may increase to EUR 7.8–9.1 billion in 2030, which would be a growth of 68–95 percent. Projections of persons employed in bioeconomy have some contradictions (see Figure 3).

![Figure 4. Projections of gross value added and employment in bioeconomy until 2030](image-url)

Data source: Authors elaboration

The projection based on bioeconomy business expectations shows a certain increase in the number of employees to 305 000 (in 2030), while projections prepared in application of different methods forecast the
reduction to 153–209 thousand compared to 234.4 thousand in 2015. These projections are first of all associated with the general demographic projections in Lithuania, i.e. significant decrease of working-age population during the same period and increasing labour productivity in bioeconomy (see Figure 3).

**Favourable environmental factors and their impact on the development of bioeconomy in Lithuania**

In Lithuania, the development of bioeconomy is mainly regulated and promoted via certain sectoral policies of agriculture, forestry, fisheries, energy, environment (including waste management), development of research, innovation and biotechnology, etc. On the other hand, the analysis of documents revealed the existing interconnections between sectoral policies, for example, forestry and energy, agriculture and food industry, agriculture and energy or forestry and wood industry. Legal environment in Lithuania is favourable for developing bioeconomy. Nevertheless, cross-sectoral relations will inevitably grow in the future for the need to reduce waste and move towards circular economy. Institutional framework and coordinating policy will be important to ensure these relations.

The assessment of the impact of factors of the external environment (political, economic, social, technological, natural and legal) on business operating in bioeconomy was conducted by way of a survey of business entities, using the PESTEL method used to monitor macro-environmental factors. The factors were assessed in two periods, i.e. according to their manifestation in 2012–2016; and their potential manifestation in the nearest future – in 2017–2021.

The survey results revealed that external bioeconomy business environment is assessed as changing slowly and moderately; no significant favourable opportunities, just like no significant threats, were observed therein, but more threats than opportunities have been observed therein (Figure 4).

**Figure 4. Significance of factors of the political environment (in points)**

<table>
<thead>
<tr>
<th>Threats</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotechnology science in Lithuania</td>
<td>0.1</td>
</tr>
<tr>
<td>Diffusion and accessibility of technological innovation</td>
<td>0.2</td>
</tr>
<tr>
<td>Public support for innovation</td>
<td>0.4</td>
</tr>
<tr>
<td>Public support for business (EU, national and municipal)</td>
<td>0.5</td>
</tr>
<tr>
<td>Immigration from Lithuania</td>
<td>3.5</td>
</tr>
<tr>
<td>Population aging</td>
<td>3.2</td>
</tr>
<tr>
<td>Tax burden</td>
<td>3.2</td>
</tr>
<tr>
<td>Labour market disparities</td>
<td>2.9</td>
</tr>
<tr>
<td>Labour price increase</td>
<td>2.7</td>
</tr>
<tr>
<td>Increase price of other factors of production</td>
<td>2.7</td>
</tr>
<tr>
<td>Shadow economy in Lithuania</td>
<td>2.3</td>
</tr>
<tr>
<td>Climate change</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*Note: 1 point – very slight opportunity or threat, 5 points – very high opportunity or threat, 0 points – insignificant*

This could mean that entrepreneurs operating in bioeconomy and managers and specialists whom they hire lack entrepreneurial characteristics, leading to defensive rather than offensive business strategies used in this field more frequently, which may mean slow growth rates of the sector. The main emphasis was placed on more significant threats appearing in economic, social and legal environment. Respondents referred to factors related to the country’s demographic problems as the greatest threats to business, including emigration of the population from Lithuania and the aging of the population. Greater opportunities were observed in technological environment only (especially in biotechnology science and dissemination of innovation) and measures
of support for business and sustainable use of resources. In pursuit of a more rapid bioeconomy development, government institutions must focus on the promotion of the expression of entrepreneurship and improvement of favourability of economic and legal environment partnering with research, organizations representing business entities and non-governmental organizations.

The world’s population will rapidly increase, and will reach 9.7 billion in 2050. The continuously increasing demand for food products in the world will promote the development of agriculture, aquaculture and food manufacturing sectors in Lithuania. The impact of climate change on the bioeconomy business will continue increasing for changes occurred in the past and the current greenhouse gas (GHG) emissions. The assessment of individual types of economic activities revealed that the highest GHG emissions were in agriculture, accounting for 50.4 percent (in 2014), followed by the chemicals industry with 30.1 percent (with producers of chemical fertilizers being the main pollutants) and waste sector with 14.5 percent. Thus, the trends of the development of bioeconomy will be highly dependent on all these factors.

**Potential for the development of sectors of bioeconomy and its factors**

The food sector is the largest share of Lithuanian bioeconomy, just like in the majority of other EU states. Food industry and agriculture are the largest subsectors of Lithuanian bioeconomy, which can be characterized by average growth rate over the past mid-term period. Fishing and aquaculture is a very small part of the food sector, also developing at an average rate. The strategic principle of bioeconomy of the priority of food security ensures the priority of the food sector in bioeconomy. The priority of agriculture and fisheries is also determined by the principle of combination of food security with sustainable use of renewable energy sources for industrial (including energy) purposes and assurance of environmental protection.

The development of the Lithuanian food sector has been encouraged by rapidly increasing food demand in the world as a result of a rapid growth of population and their purchasing power. A relatively slow growth of agriculture and food production in the future has been forecasted. The potential of biomass production in agriculture has been increased by the possibility of including suitable abandoned agricultural land in production and sustainably intensifying agricultural production in order to increase the productivity of agriculture. Also, solving the increasing problem of soil degradation especially in territories of productive land, is very important. The forecasted rapid increase of demand for fish and other aquatic products in the world has increased the potential of the development of aquaculture in Lithuania; aquaculture will help meet this demand, because according to forecasts of FAO and OECD, fish catch will decrease, while the production of aquaculture products will increase. Moreover, controlling the quality of fish resources in open water has become increasingly difficult. The development of aquaculture in Lithuania is associated with the increase of quantities of valuable species of fish in ponds and the aquaculture cultivation in closed systems, which has been rapidly developing in the world and is much simpler compared to pond aquaculture.

The forest bio-based sector (forestry and logging, production of wood, paper and furniture) is the second largest sector of Lithuanian bioeconomy. In the utilization of forests, wood resources are used first of all. The priority of the forestry sector is determined by the strategic principle of combining food security with sustainable use of renewable energy sources for industrial (including energy) purposes and the assurance of environmental protection. The total volume of wood has constantly increased in Lithuania. Farmed forests make up 71.4 percent. The use of forest biomass is limited by environmental goals prohibiting or limiting economic activities. The forest area has a potential to expand by afforestation of abandoned agricultural land and other land unsuitable for agriculture. Forests perform many ecosystem functions: they help protect the soil, form a part of the water cycle and regulate climate; they are important in the implementation of EU climate goals by accumulating coal, and protect biodiversity. Other products (such as food, cork or resin) are derived
from forests. Forests are also a source of various services, which increases the significance of forestry in the Lithuanian bioeconomy.

The majority of wood resources in Lithuania are used traditionally, i.e. in manufacture of wood, its products and furniture, also as biofuel in energy. Bio-based manufacture of furniture is the third medium-sized subsector of bioeconomy characterized by a rapid growth of turnover, labour productivity and gradually increasing share of exports. Even though manufacture of wood and its products is characterized by an average growth of turnover and rapid increase of exports, its labour productivity is low. The contribution of wood waste for firewood and fuel to the production of primary energy of Lithuania accounted for almost two thirds in recent years, however, low value added chips intended for the domestic market with a low growth potential have been produced for the most part. In order to increase the contribution of forest bio-based sector to Lithuanian bioeconomy and enhance its competitiveness, promoting sustainable use of forest in the production of higher value added industrial products is necessary.

The potential of the development of the bioenergy sector has been increased by the EU provision that bioenergy will remain the main renewable energy source in the pursuit of climate and energy goals of 2020–2030. In order to reduce adverse effect of the production of traditional biofuels on the balance of food products and greenhouse gas emissions, the production of first generation biofuels from rape and cereal grain should be replaced by the production of advanced second and third generation biofuels made of agricultural and wood waste, and algae. Due to their attractive price, sufficient amount of local resources and low GHG emissions, bioenergy resources should remain the principal fuel in Lithuanian district heating systems. This has a potential for increase, even though it is limited. The potential of the production of biogas from agricultural and food industry waste and biodegradable municipal waste has been poorly exploited in Lithuania, even though lately the production of biogas from agricultural waste and sewage sludge has increased. Based on the experience of advanced European countries, the use of biogas derived from biodegradable municipal (especially food) waste in the city transport through public procurement procedures of biogas held by government of the city helps resolve urban pollution problems and reduce GHG emissions.

Currently, the contribution of manufacture of bio-based chemicals and pharmaceutical products and preparations using advanced biotechnology processes and techniques to the Lithuanian bioeconomy is poor due to its small scale. It creates a mere 4 percent of the gross value added of bioeconomy, while its contribution to the country’s GDP is a mere half percent. However, the projections of the development of bioeconomy business based on business expectations till 2030 show the greatest potential of growth of this subsector. The most rapid increase of productivity of this subsector is associated with much greater expectations for attracting investments in R&D and qualified employees. Trends of rapid growth observed since 2010 determined by way of statistical analysis also show the greatest growth potential in the pharmaceutical industry.

The rapidly growing biotechnology sector is one of the main driver of the potential of manufacture of pharmaceutical products, preparations and chemicals. According to the European Commission’s policy on industrial revival, biotechnology as one of the main most advanced areas of technology, and bio-products derived in application thereof are two of six priority axes for promoting investment in innovation and new technology. Biotechnology is one of the most promising new pollution prevention, resource preservation and cost reduction methods. Its application could also become the cornerstone driver in other sectors of bioeconomy, i.e. it would increase productivity, reduce adverse environmental effects and allow for a more sustainable use of renewable energy sources, especially in light of the fact that Lithuania has sufficient resources necessary for the development of the biotechnology sector (such as a sufficient number of highly qualified and production of large amounts of biomass).

The transition of plastics production companies operating in Lithuania to the production of bioplastics could be another driver of increasing potential of bio-based chemicals industry. Access to local biomass resources must be ensured in Lithuania for the production of bioplastics to stay competitive with countries that have more favourable conditions for business development. The increasing popularity of plastic packaging and plastic components in main industries, such as food industry, cars, furniture or transport, will have a positive effect on the production of plastics, while demand should increase in both local and export markets.
Potential of research and experimental development in bioeconomy

More than a third of R&D expenditure was allocated for fundamental research in Lithuania during the examined period of time, and only slightly less than 2/3 – for applied research and development. Nevertheless, low focus of projects of research and education institutions on prototypes and products suitable for the market has been observed. Results of the survey of universities and research institutes revealed that in the performance of R&D projects in the bioeconomy area, the involvement of these institutions in subsequent R&D stages is very low. The majority of research project results is associated with the knowledge application concept (about 87 percent), must fewer research results (about 50 percent) – with new (fundamental) knowledge, and only a very small share (18 percent) – with layout design, tests and check, creation of a prototype trial version and demonstration, as well as the production and assessment of the trial batch. Lithuanian research and education institutions have little experience and motivation in creating patented, licensed or other-wise commercialised products suitable for the market, there is a shortage of start-ups and spinoffs.

The Lithuanian research system is fragmented, thus the culture of cooperation not only between researchers and entrepreneurs, but also between scientists from different institutions is low. Interinstitutional and international coordination of innovation activities remains inefficient in Lithuania; the created infrastructure necessary to ensure research and business partnership also functions ineffectively. Activities of open access centres do not attract business as planned: science and technology parks are mainly engaged in the rent of premises, and businesses take little advantage of equipment of valley laboratories operating under the open access principle. In order to increase the efficiency of activities of centres, parks and valleys, periodic control and assessment of their activity results is necessary.

Business admits that innovations are a very risky area, and failures are frequent here, thus not all business representatives are willing to take the risk. Another problem is the lack of control and the sharing of managerial skills: there is a shortage of specialists, who could help find the missing professionals of different areas, who could work with the company from the initial stage of the creation of innovation till its practical adaptation, ensure a smooth project implementation and familiarize with opportunities to receive additional financial support. Businesses in the country often confine themselves to providing financial assistance at the product development stage only, without rendering assistance for the introduction of a new product into the market, where the risk of a failure is significant. On one hand, it was determined that as many as 75 percent of new products in the market fail. On the other hand, the introduction of a product into the market is an expensive procedure. The process of commercialization of industrial biotechnology products is long for regulatory constraints, poor consumer awareness of the products, the advantages and functions whereof are not sufficiently clear.

Lithuania has a scientific potential for the development of bioeconomy activities. The number of doctoral bioeconomy students accounted for an average of 16–18 percent of the total number of doctoral students in the past four study years, and increased more rapidly than the number of doctoral students of other areas unrelated to bioeconomy. The analysis of the Lithuanian research and development potential in the bioeconomy area revealed that the research area attributable directly to bioeconomy employed 15 percent of conditional R&D researchers in 2015. The highest number of R&D employees in business was in the production of chemicals during the examined period of time. An increase in the number of R&D employees has been observed in this business. Business inclusion in R&D could be increased via projects funded under Horizon 2020, Interreg Baltic Sea region programme and the Lithuanian Research Council. Business can make very limited investment in R&D, because enterprises are relatively small. In such a case, acquiring the already created product is more efficient than investing in its creation. Commercialization of research results may also be accelerated via the implementation of European Innovation Partnership projects.
Good practices of EU states and recommendations for taking advantage thereof in Lithuania

Good practice of EU Member States in the development of bioeconomy was analysed and summarized in four levels: 1) at the national strategic level of EU Member States; 2) at the state governance level of EU Member States; 3) at bioeconomic cluster level of EU Member States and 4) at the level of good practice examples of research and the created products of EU Member States. Good practice of Ireland, Belgium, Denmark, Estonia, Spain, Italy, Latvia, the Netherlands, France, Finland, Sweden and Germany was analysed and summarized. The opportunities for adapting good practice in Lithuania have been provided for considering the situation in the Lithuanian bioeconomy sector and the maturity stage.

The analysis of good practice of bioeconomy strategies of EU states revealed different opportunities for adapting it in Lithuania. First of all, advising the Nordic Council of Ministers and institutions responsible for the bioeconomy sector of most advanced EU states in the drafting of the Lithuanian bioeconomy strategy and the action plan is recommended. Secondly, the Ministry of Economy could be responsible for the drafting of the Lithuanian bioeconomy strategy and the action plan in cooperation with other ministries (usually strategies are prepared by the Ministry of Economy, the Ministry of Food Sector or the Ministry of Agriculture). Thirdly, main components of bioeconomy strategies of EU states could be used in the preparation of the Lithuanian bioeconomy strategy. Fourthly, the Lithuanian bioeconomy strategy should provide for measures to promote the creation of biotechnology aimed at the most efficient use of biomass as a scarce resource, or its takeover from more biotechnologically mature member states. The greatest focus should be placed on biotechnology aimed at the manufacture of products of a higher value rather than at the use of biomass for the production of bioenergy (see Figure 5). Fifth, the Lithuanian bioeconomy strategy should be focused on wasteless production and bio-waste processing technologies that meet the needs of all sectors of bioeconomy; competition for the use of arable land in the production of food and non-food items would be eliminated growing biomass for industrial processing in abandoned agricultural land and using alternative raw materials to produce fuel; bioeconomy demand shall not interfere with the pursuit of goals, such as food security, preservation of biodiversity, poverty reduction, etc.

Figure 5. Biorefining pyramid

Source: Danish Transport Authority. Sustainable Fuels for Aviation. An Analysis of Danish Achievements and Opportunities. 2013.

The analysis of good practice of management of the bioeconomy sector of EU states revealed that EU states have been solving issues related to the drafting, implementation and monitoring of bioeconomy strategy and strategies of the related sectors somewhat differently. The formation of working groups and councils under the integrated and strategic approach remains the main principle. Working groups are delegated the drafting function, while councils are delegated the function of monitoring the strategy and the action plan as well as the advisory function. The majority of support measures for the development of bioeconomy are typical in
other economic activities, including of Lithuania. Nevertheless, such incentives as encouraging consumers to buy (and pay more for) for sustainable bio-based products as substitutes for traditional products, the creation and funding of public procurement programme and large data arrays are noteworthy.

The analysis of good practice of clusters in EU countries revealed that their creation at the national level is expedient only when there is a very strong research potential and many business enterprises prepared to commercialize products. Support for their establishment should be linked to the implementation of strategic bioeconomy goals. The creation of clusters should first of all be initiated “from the bottom”, and only in the absence of the initiative they should be created “from the top”. In presence of a weak scientific potential, searching for membership opportunities in clusters created in EU countries would be better.

The analysis of good practice in EU countries showed that the following are the trends of bioeconomy: use of waste as biomass; integration of bioeconomy subsectors; use of biomass in the production of high value added products; replacement of one type of biomass by another; search for alternative forms of biomass; development of circular economy. These trends inevitably determine the trajectories of development of the Lithuanian bioeconomy sector.

**Opportunities of cooperation of the Lithuanian and Norwegian business in bioeconomy**

Opportunities of cooperation of the Lithuanian and Norwegian business in bioeconomy have been assessed having conducted the analysis of good Norwegian practice and interviewed business companies and associations in Lithuania. Three areas of adaptation of good practice in Lithuania were identified having conducted the analysis of the good Norwegian practice, namely, the development of research and bioeconomy business, and cooperation between bioeconomy business and local government.

The following is recommended in the field of research: 1) development of innovative biotechnologies and biomaterials in search for cost-effective and sustainable solutions for the conversion of biomass; 2) improvement of the use of resources and innovative solutions in the creation and improvement of sustainable bioprocess technologies in various biomass value chains and fields; 3) improvement of quality of animal feed and digestibility, creation of new feed from sources of biomass, which do not directly compete with those used in food production in order to increase the value added in the production of aquaculture products, meat and dairy products.

When it comes to the development of bioeconomy, the transition from petroleum-based to bio-based additives of cellulose from wood - most abundant organic polymer on Earth - in the production of adhesives, coatings, agricultural chemicals, cosmetics, etc.; bio-refinery of wood and agricultural by-products and waste into higher value added chemical bio raw materials; processing fishery and aquaculture by-products into food and feed; bio-waste treatment and processing into new products, and production of biogas from waste is recommended.

Development of the local biomass bioenergy chain on the basis of local partnership, when all stakeholders, affected parties or actors in the chain are involved in interaction; creation of competitive conditions for start-ups to establish in aquaculture or other sectors of bioeconomy, giving them an easy access to bio-resources, research infrastructure, accumulated R&D competencies, product development skills, etc.; collection of municipal and household food waste, its processing into biogas in sludge treatment facilities in local sewerage plants; the use of the produced biogas in city transport with local government subsidising the difference in biogas prices; sustainable construction solutions in order to increase the use of wood and other bio-materials in the construction of public buildings in cooperation with local government are opportunities in the area of cooperation between bioeconomy business and local governance.

Surveys of business enterprises and business associations were conducted with the aim to identify areas of cooperation of Lithuanian and Norwegian business and the need therefor. The survey revealed that
main areas of the said cooperation include implementing biomass waste processing technologies, green innovations and biodegradable solid waste treatment. The processing of forestry and fisheries by-products and biorefinery of waste and other bio-waste (including food) are one of the most innovative areas of business development in Norway. This was revealed both by the analysis of good Norwegian practice and expectations of cooperation with the Norwegian business identified by way of survey of business and associations.

It turned out during the survey of business entities that the majority of enterprises and farms have never taken any effort to find out about Norwegian business enterprises and cooperation therewith, because they did not have any information thereon. Still, only a fifth of all the surveyed respondents did not show any interest in cooperation with the Norwegian business. The respondents themselves additionally entered no areas of cooperation of interest to them in neither of the questionnaires, which illustrates a lack of information available about the Norwegian business and markets. Contact fairs would be an important assistance for entrepreneurs in companies that do not have time or resources for the search allowing to decide on future cooperation.

Looking at the short-term prospects of cooperation between the Lithuanian and Norwegian business, the main elements of promotion of cooperation should be based on the following areas of cooperation: development of R&D and innovation (creation of new innovations in particular); transfer of biotechnology (especially of Norwegian know-how); development of business competencies (professional advisory, training, business development assistance services for enterprises); improving investment climate; dissemination of good practice; strengthening cross-sectoral relations. Bioeconomy needs not only new and innovative technology, but also new and innovative ways of cooperation both inside the countries and among countries and regions. Long-term projects are most successful, because long-term cooperation creates efficient results. Lithuanian and Norwegian business cooperation may be encouraged by incentives managed via the following three financial mechanisms: Norwegian Financial Mechanism, European Economic Area (EEA) Financial Mechanism, EU Research and Innovation Programme “Horizon 2020”, EU funds, Lithuanian state budget funds, etc.

**Substantiation of expediency of the Lithuanian bioeconomy strategy**

The expediency of the Lithuanian bioeconomy strategy is based on experience of regulation of Lithuanian bioeconomy using different sectoral policies and the increasing need for consistent cross-sectoral complementarity and interoperability-based policy; experience of EU and advanced European countries in solving issues of the strategic development of bioeconomy; the need for strategic development of bioeconomy of the Baltic Sea Region, and the opinion of business, government and educational institutions on the fact that the bioeconomy strategy is very important for Lithuania.

The development of bioeconomy in Lithuania is mainly regulated and encouraged through sectoral policies: the policy of agriculture, forestry, fisheries, energy, environment (including waste management), R&D, innovation and biotechnology development, etc. There are interconnections between individual cross-sectoral policies, for example, forestry and energy, agriculture and food industry, agriculture and energy or forestry and wood industry. These cross-sectoral relations will inevitably grow in the future for the need to reduce waste and move towards circular economy.

Bioeconomy cross-sectoral relations in Lithuanian legislation are linked solely through the use of biomass and its waste in energy. Meanwhile, the analysis of the content of EU and OECD strategic documents revealed that bioeconomy shall be developed to combine food security, sustainable use of renewable resources for industrial purposes and assurance of environmental protection. To ensure this synergy, transition to circular economy, the circle of which would retain the value of products, materials and resources for the longest possible period of time and result in generation of minimum possible amounts of waste, is of particular importance. Those same limited bio-resources are used in various subsectors of bioeconomy, while bio-waste generated in one subsector becomes a source of biomass for another subsector. Biomass cascading principle has become increasingly important. In accordance with this principle, biomass must first of all be used in the production of products of the highest value added. Thus, future bioeconomy must be focused on the use of biomass in the
production of pharmaceutical and cosmetics ingredients, bioplastics and polymers rather than on its use in the production of energy. Cascading principle of the use of bioeconomy will lead to the formation of winners and losers, often in the same sector, thus creating the highest possible value added will be possible only having a targeted coordinating policy. The analysis of bioeconomy strategies and policies in the Baltic Sea Region countries also revealed that Lithuania needs a bioeconomy strategy, which would speed up the sustainable growth and development of the Baltic Sea Region.

5 out of 12 examined EU states have drafted bioeconomy strategies: Flanders and Germany (2013), Finland (2014), Spain and Italy (2016). In addition to the bioeconomy strategy, Germany has also drafted the National Strategy for Bioeconomic Research 2030” (2011). Sweden has a drafted Strategy for Bio-based Economy Research and Innovation (2012). Denmark set up the national bioeconomy advisory council in 2013, however, it has no bioeconomy strategy so far. Ireland, Estonia and France plan to draft a bioeconomy strategy, while the Ministry of Agriculture of the Republic of Latvia is currently finishing up with the preparation of the Latvian strategy in cooperation with the Latvian University of Agriculture.

Business entities, business associations, governmental and research institutions assessed the expediency of the Lithuanian bioeconomy strategy. Research institutions and business associations were the ones needing such strategy the most (with 4.8 out of 5 points). Other stakeholders rated the expediency of the bioeconomy strategy giving 3.7 – 4.1 points therefor.

**Directions for promoting Lithuanian bioeconomy innovation**

The following directions for promoting Lithuanian bioeconomy innovation are recommended:
- promoting investment in high value added activities;
- promoting the introduction of new products into the market; encouraging cross-sectoral cooperation in the creation of innovation and developing high-impact innovation;
- promoting the creation, development of value networks and their internationalization;
- promoting the cooperation between business and science, knowledge and technology sharing; encouraging the development of clusters and integration into international value creation networks.

Strong bio-economy clusters have been created in EU member states. The analysis of good practice of clusters revealed that their creation at the national level is expedient only when there is a strong research potential and many business companies prepared to commercialize products. Support for their establishment should be associated with the implementation of strategic goals of bioeconomy. Joining in clusters is one of the opportunities to take up a greater share of export markets, because competing for an individual company is quite difficult. Promoting the culture of cooperation and innovation by increasing popularity of the benefit rendered by the development of clusters, also encouraging national clusters to become a part of international value creation chains, especially in the Baltic Sea Region, is very important.

Financial and non-financial instruments for promoting innovation are first of all targeted at the growth of biomass-based economy through a more rapid commercialization of new products: different tax reliefs, constraints, financial support for the establishment of start-ups and spin-offs, provision of consultation and acceleration services to small and medium-sized enterprises, organization of innovative (pre-commercial) and green public procurement procedures and search for export markets. Creating favourable legal, organizational and financial conditions necessary for the establishment and operation of biomass value chain-based knowledge centres and clusters, production and demonstration of new bio-product test batches, development of international partnership and increasing the number of R&D jobs in the bioeconomy sector is important for promoting innovation. Information and education of Lithuanian business sectors and the public on bioeconomy-related issues is indirect but important instrument for promoting innovation.
**Recommendations (plan of measures) on the development of bioeconomy and innovation in Lithuania**

Recommendations – action plan for promoting the development of Lithuanian bioeconomy and innovation is based on the following 4 principles: 1) to give the priority to food security; 2) to combine food security with sustainable use of renewable resources for industrial purposes and assurance of environmental protection; 3) to apply the cascading principle in the biomass value chain, first of all using biomass in the production of the highest value added products; 4) to maximise recycling and reuse and minimise waste (to develop circular economy).

There are foreseen goals, objectives and measures for promoting the development of Lithuanian bioeconomy and innovation in the action plan (the detailed action plan is presented in the Study):

1. To pursue sustainable and strategically oriented development of bioeconomy:
   1.1. To ensure interinstitutional interaction of all stakeholders in resolving issues related to strategic development of bioeconomy (3 measures).
   1.2. To ensure strategically oriented development of bioeconomy (3 measures).
   1.3. To inform and educate the Lithuanian business sector and the society on bioeconomy issues (6 measures).

2. To increase the efficiency and sustainability of biomass production, processing and use of bio-waste:
   2.1. To increase scopes of biomass production in demand using spare resources suitable for such production (2 measures).
   2.2. To increase bioenergy production and use (4 measures).
   2.3. To increase the efficiency of biomass logistics (2 measures).
   2.4. To develop R&D for the creation of new innovation (4 measures).
   2.5. To intensify the development and implementation of innovative technology (especially biotechnology techniques and processes) and the creation and implementation of prototypes of bio-products (6 measures).
   2.6. To use more biomass in the production of products of higher value added and to manage bio-waste more effectively (4 measures).

3. To increase the demand for bio-products and improve their consumption:
   3.1. To improve conditions of sale of bio-products (5 measures);
   3.2. To reduce food waste (3 measures).

The measures provided for in the plan are primary measures and will have to be specified and supplemented, linked to other EU and national programmes according to the approved bioeconomy strategy and the action plan implementing it.