

# Formation of Theoretical and Methodological Assumptions in the Assessment of Significance of the Bioeconomy in the Country Economy

## Tworzenie założeń teoretycznych i metodologicznych w ocenie znaczenia biogospodarki w ogólnej gospodarce kraju

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### Abstract

In order to ensure sustainable development of the modern economies, there is a need for transforming the linear economy model to circular or green economy model. Bioeconomy can contribute to this goal by ensuring the use of bioproducts and biotechnologies. The flow of material and energy in the bioeconomy is based on the use of biomass and renewable sources for food, feed, and materials production. Circulation principle reduces the amount of waste and increases the efficiency of resources use. It is important to discuss the notions of bioeconomy as described in the strategical and legal documents for bioeconomy development. This research mainly focuses on the theoretical and methodological assumptions of bioeconomy, the main measures for stimulating the development of bioeconomy. We also review the trends of the development of bioeconomy across different countries.

**Key words:** bio economy, sustainable development, renewable resources, bio based resources

### Streszczenie

Aby zapewnić zrównoważony rozwój współczesnych gospodarek, niezbędne jest przekształcenie linearnego modelu ekonomicznego w cyrkulacyjny lub zielony. Bioekonomia może się przyczynić do osiągnięcia tego celu wprowadzając na rynek bioprodukty i biotechnologie. Przepływ materii i energii w bioekonomii oparty jest na wykorzystywaniu biomasy i odnawialnych surowców w produkcji żywności, pasz i różnorodnych materiałów. Zasada cyrkulacji zmniejsza ilość odpadów i zwiększa efektywność wykorzystania surowców. W tym kontekście ważna jest dyskusja samego pojęcia bioekonomii, tak, jak jest ono rozumiane w dostępnych strategicznych i prawnych dokumentach. Niniejsze badania koncentrują się głównie na teoretycznych i metodologicznych założeniach bioekonomii, a więc głównych środkach stymulujących rozwój bioekonomii. Ponadto przeanalizowano trendy w rozwoju bioekonomii w wybranych krajach.

**Słowa kluczowe:** bioekonomia, zrównoważony rozwój, zasoby odnawialne, zasoby bio

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### 1. Introduction

The adoption of the Paris Agreement at COP21 in 2017 created the preconditions for updating and development of the new global and EU climate change policies. The ambitious target to limit global warming below 2°C and possibly even to 1.5°C above pre-industrial levels creates substantial reductions in

global greenhouse gas emissions (GHG) and gives a new motivation to the EU's long-term objective to reduce green gas house emissions by 80-95% by 2050 compared to 1990. (Behrens, 2016). The European Commission (EC) has recently (2015) published the Circular Economy Package, containing the initiatives for reduction of wastes and increasing of the durability of products, and provided the guideline

for bio economy development, changing the use of fossil resources by renewable and bio based resources. These targets together stimulate long term strategies in the action of all economic sectors and unite all stakeholders from political, public and private sectors towards reducing the consumption of natural and exhaustible resources and improve the natural environmental conditions. Political, economic and social supports are essential preconditions providing the base for the development of bio economy. Main theoretical and methodological factors for the development of bio economy have to be based on an attractive vision by the majority of stakeholders. There is a need to create consistent indicators for evaluation of achievements across the EU. The theoretical principles for setting policy objectives regarding the promotion of circular and bio economy, thus, need to be identified.

The major problem undermining the traditional economy is that the demand for the resources is virtually unlimited, yet the resource stocks can be depleted if renewable resources do not appear as factor inputs. Unsuitable and inefficient use of fossil and non-renewable resources has a negative impact to the ecosystem and natural environment. Sustainable and efficient use of fossil resources is a crucial factor for encouraging economic growth and improving the social and natural environment. According sustainable development paradigm *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* is necessary to concentrate efforts to protect and save the environment. The need for measurement of progress in sustainable development has been stressed in the literature (Rees, 1999; Rifkin, 2012). Such notions as third industrial revolution (Rifkin, 2012), prosperity without growth (Jackson, 2009) or the society of green capital (Meadows, 1992) also require additional insights into the process of sustainability and measurement thereof.

Bioeconomy development is a complex system where many stakeholders and economy sectors are interacting with environment. The use of fossil and local resources, increase the efficiency are one of the main factors influencing the local regional development. The use of bio-based and renewable resources is another important aspects where with the use of biotechnologies, science, research and innovation forms the framework of bioeconomy. One of the primary goals for bioeconomy development is to bring bio-based resources closer to consumers, use more renewable resources and promote biotechnologies. Consequently consumers can produce more bio-resources than they use. This overload or uptake of local and renewable resources is based on methodology of circular and bioeconomy, where every region has its own and specific local resources with specific environment and services for conversion of these resources to a value added products.

**The scientific problem** of this paper what are the main the theoretical and methodological preconditions of the development of bio economy in the economy of the country and which measures can increase the development of bio economy in Lithuanian agriculture?

**The objective** of the paper is after the analysis of bio economy sector and its development data and trends to identify aspects that influence the development of agricultural sectors and penetrates the energy and RES development opportunities in the Lithuanian agriculture. According sustainable development concept and the methodology of a process network synthesis method the measures for the development of bio economy in agricultural sector were analysed. The following tasks are formulated: (1) status quo analysis of bio economy sector emphasizing the development of biotechnology, agriculture and energy sectors; (2) theoretical and methodological preconditions for the development of bio economy; (3) trends, opportunities and factors for the development of bio economy; (4) measures for the development of bio economy and biotechnologies optimizing the use of local and renewable energy resources in the agricultural sector.

## 2. Overview of bio economy and its development trends

### 2.1. Economy development towards the use of bio-based resources

The main problem the humanity facing is the global overpopulation, rapidly growing economy which depletes the non-renewable resources, the pollution and degradation of natural environment which influence the climate change. Consequently all the stakeholders of our economy are searching for solutions to cope with these problems. It was noticed that the processes in the nature are a perfect example of self-sustainable activities. Nature can provide self-regulation mechanism and waste-free solutions. So the best will be to copy the natural processes and try to implement it into practice, so the priorities of economic activities should be given to reductions of the amount of waste increasing the efficiency of use of resources. One of the primary goals to solve above mentioned problems is to bring resources closer to consumers, use more renewable resources and promote smart or biotechnologies. These phenomena creates prerequisite to establish so called prosumers which are not only consuming but also producing the certain amount of resources and energy. An uptake of local and renewable resources is based on methodology of circular economy, where every prosumer and every region has its own and specific local resources and can establish a specific environment for conversion of these resources to a value added products. The primary technical solution to tackle these problems is to develop the science, apply new tech-

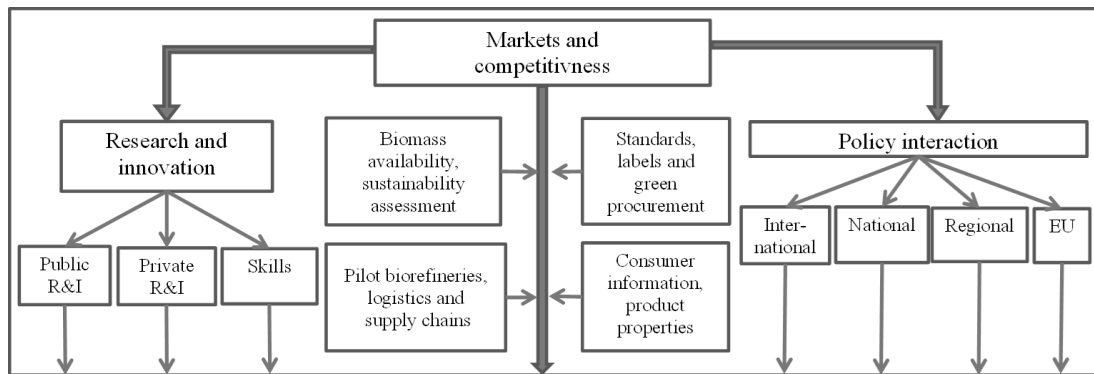


Figure 1. Bioeconomy observatory pillars

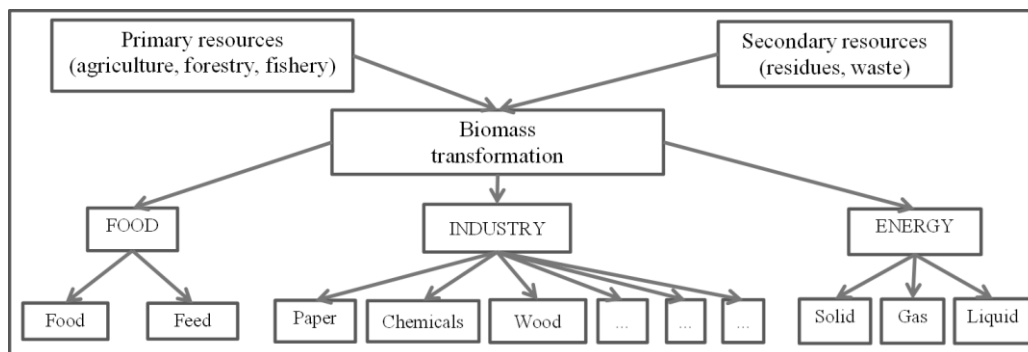


Figure 2. Bioeconomy chain

niques and technologies, especially in the field of biological and IT science. These tasks are set out in the theoretical and methodological definition of bioeconomy described in the strategical and legal documents of bioeconomy development.

## 2.2. The assumptions for development of the bioeconomy

Bioeconomy can contribute to the development of the economy in a number of ways (McCormick K, 2013). The use of biotechnologies creates unique environment for resource utilization (Birekland, 2008). However the exploitation of renewable resources must not exceed the resilience limits of nature otherwise renewable resources can be treated as non-renewable resources (Čiegis, Gamtos išteklių ir aplinkos ekonomika, 2009). Dynamic development of science, technique and technology, especially in the field of biological and IT science, supports bioeconomy development (M. Adamowicz, 2017). The development of bioeconomy according principals of sustainable development is encouraging the use of a wide range of local and renewable resources (Pledger, 2013). The concept of circular economy and the development approach from cradle to cradle is investigated by A. Wijkman, J. Rockstrom, Walter R. Stahel, M. Braungart, W. McDonough. They stated that wastes generated in the economy can be reduced by increasing the efficiency of use of primary resources, promoting the new technologies, choosing eco-friendly products and materials whose components are less harmful to the environment.

Also they argued that the negative impact to environment can be reduced through more efficient use of non-renewable and renewable resources in the economy. These improvements can be achieved implementing the principles of circular economy and bioeconomy applying new development and technology models.

The complex challenges related to the bioeconomy in Europe is the competition between different biomass uses and potential impact on food prices (McCormick, 2013). There is a need to establish a basis for seeking synergies in policies and initiatives for development of bioeconomy. The European strategy for development of bio economy has various objectives such as: (1) to strengthen competitiveness of EU in the biological research, optimizing the innovation and research systems in the state, public and private institutions; (2) fostering the agricultural transformation for production of biomass and biobased food and feed; (3) developing the low carbon industries reducing the emission of CO<sub>2</sub>, greenhouse gases and wastes. During EU Bioeconomy observatory meeting which took part in December 2013 year, the principal of the actions under three pillars of bioeconomy (see figure 1) were suggested: (1) investments in research, innovation and skills; (2) reinforced policy interaction and stakeholder engagement; and (3) enhancement of markets and competitiveness in bioeconomy sectors.

The observatory pillars along and other strategic objectives of bioeconomy emphasise the need of innovation and research, transformation of industry in co-

operation of agriculture for development of bio-based technologies and production of food, feed, materials and energy, the competitiveness and growth of EU economy through policy interaction at EU, National and regional level. The definition of the bioeconomy concepts emphasise the possibilities for economic growth, higher employment, sustainable development of rural, coastal and industrial areas.

The basic purpose of bioeconomy is the use bio-based and renewable resource for production of biomass, food, feed, biofuels, bionergy and bio-based materials. Bioeconomy can be considered from the micro, mezzo and macroeconomic perspective where enterprises can be specialised in the innovative production of various products and services associated with living organisms for food and utility purposes and where regions can choose bioeconomy as the leading smart specialisation of development (M. Adamowicz, 2017).

The definition of bioeconomy is a new theoretical concept within economy theory however the principals of bio-based technologies and biomass production are well known processes. These bio-based technologies were usually wide used and still in use in agriculture, fisheries, forestry and processing of biological materials. However due to the use of fossil fuel resources and the development of mass production industry the bio-based technologies were not taken into account as a valuable and efficient technologies. Nowadays, in the threshold of global and climate changes, the bioeconomy became particularly important in the development of sustainable economy. Bioeconomy covers a specific chain of processing and value-creation, in which products from the biomass primary production sectors move through the processing sectors, trade and distribution chains, reaching final users in the form of food, biomaterials for further production and industrial bioproducts and consumption (M. Adamowicz, 2017). A scheme of this bioeconomy system in the European Union was outlined in the European Union documents of 2010 (Fig. 2).

Three essential chains of bioeconomy were identified: biomass transformation in the agricultural, industrial and energy sectors using primary bio-base resource such as biomass and secondary biodegradable resources such as bio-based residues and waste. This structure of bioeconomy is developed via the system of knowledge, science and innovation. According to the official work plan of Bioeconomy Information system and observatory project (JRC, 2014) the following tasks related to the sustainability assessment of bioeconomy chains were identified: (1) developing relevant key environmental indicators concerning biomass production, logistics and use; (2) comparative life-cycle based assessment of example bio-based products and their supply chains, from the primary production of biological resources to end-of-life processes. These tasks has to ensure the food security, sustainable management of natural

resources and increase dependence from non-renewable resources, mitigate environmental and climate change, create jobs and maintain EU competitiveness.

### 3. The methodology of bioeconomy development using sustainable development paradigm

#### 3.1. The role of bioeconomy in the country's economy

Bioeconomy sector is based on development of economic policies in **agricultural, forestry, food production, biotechnology and energy sectors** where the relationships are regulated through sectoral policies. These cross-sectoral policies usually have common goals in protecting the environment, increase the share of use of renewable biological based resources and get rid of using non-renewable resources, increase the net added value in the chain of production, reducing wastes and move towards circular economy. (Include reference about bioeconomy). The use of biomass is treated as one of the priority because it produces wastes and by-products which have added value. Biotechnologies can be used in agro, chemical and other industries for production of bio-based products such as bioplastics, biochemical and medicines. Biotechnologies and the production of biomass create a value added products in health care sector.

To ensure the cross-sectoral interactions and the efficient transition to circular economy there is a need to evaluate the net value of products, materials and resources decreasing the amount of waste in the life cycle of consumption and production. This circular principal helps to develop the sustainable chain of use of bioresources in the different sectors of economy and to ensure that bio wastes generated in one sector becomes a bioresource for another sector. This is so called cascading principle of resources usage and this is one of the important principles in the circular economy because bio resources have to be first of all be used in the production of products with the highest added value. This principle provides possibility to ensure goal-oriented economic policy however the cascading principle is shifting production to the most valuable products which usually are pharmaceutical and cosmetics ingredients, bioplastics and polymers, lacking the opportunity to use bio resources such as biomass for production of low value products such as food and energy. Agricultural products and their wastes utilized for energy production have an impact on supply and demand of agricultural products. Emerged new market of bio-based products is increasing the prices of agricultural products, reducing the supply of food and increasing the competitiveness of products. (Biekša, 2015). Bio-based resources used for energy production is also can be used for other economic activities such as agriculture; therefore, the use of renewable resources

should be balanced with the other economic activities, and the use of renewable resources should not compete with agricultural resources.

### 3.2. Bioeconomy strategy and its development trends

The challenge of agricultural and other economic activities are to support the food productivity and supply of energy and other resources to global population which will increase from 7 to 9 billion people by the year 2050. The demand for global food production is estimating to increase by at least 70 percent. In order to cope with this problem there is a need to increase productivity of crop cultivation and efficiency of food production. This can be done either by developing new biotechnologies or by changing the behaviour of consumption. Food productions systems can be utilized by converting different feedstuffs into high-quality protein sources and contribute to food security without initiating the food feed competition with natural resources. Consumption behaviour can be changed by developing sharing and circular economy principals or adapting the new social networking systems. Production technologies can be changed improving resource and energy use efficiency and substituting the fossil resources by renewable. All these measures are positively influencing the environment as well. So there is a need to find solution and implement it to tackle with upcoming problems.

A new concept of economic development is associated with the new criteria, which give the meaning to human and nature interaction. Economist Jackson in the book *Prosperity without growth* argues that well-being and a better quality of life are possible in another economic dimension, where communities and their created social capital but not the capital, net added value or gross domestic product are the main driving force. Welfare of a new economy driven by the green capital will be developed using smart management and control methods in accordance with the ideas of sustainable development concept.

There is a need for the holistic approach to the system in order to reach sustainability in the society, where the system works as an ecological loop in the nature, where plants produce oxygen and other materials needed for animals, and animals produce carbon dioxide and residues needed for plant growth. Sustainable economy has to be balanced with the natural environmental cycles, and at the same time, it has to be connected with other regions without harming the environment. This is a step towards a green and bioeconomy that emphasises principles of sustainability. This modification of linear economic approach to a green, circular and bioeconomy have to be achieved without diminishing the life and social well-being and damaging the environment. The main challenge of this transformation is to substitute non-renewable and exhaustible resources with biodegradable and renewable resources which are available in the abundance in the living nature. The tran-

sition towards green, circular and a bio economy creates a high potential for economic growth, rural development and decreases the dependent from the fossil resources. However this is a challenging way because there is a need to overcome many obstacles in all levels of our economic and social life.

To realize it and provide benefits to our social and economic well-being it is necessary to implement new technologies, create conditions for key players in the economy and increase the competitiveness of companies in at EU and National level. There is a need to recognizes and establish main stakeholders in research, practical demonstration and organization of advanced bio-based products and biofuels, as well biotechnologies. Foremost there is a need to establish a good policy based and financial support mechanisms as well to find and define the priority sectors which can facilitate the development of bioeconomy. Feasibility studies, strategies and supportive legal documents is first step towards to sustainable development of bioeconomy. The second practical step is to apply biotechnologies for production of biomass and renewable resources and increase the net added value of by-products and services. The third practical step is to strengthen the security of resources supply and reduce the primary consumption of fossil resources, consequently to decrease the imports of resources. The forth practical step is to develop biotechnologies for production of bio-based products and materials with creation of a chain of added value products and services. The fifth step is to mitigate the climate change problems by reducing the greenhouse gas (GHG) and other emissions applying cost-efficient and effective solutions.

The European Union (EU) strategy *EU 2012 European Bioeconomy* defines bioeconomy as *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 as well as bio-energy*. The Bioeconomy Strategy recognised that *in order to cope with an increasing global population, rapid depletion of many resources, increasing environmental pressures and climate change, Europe needs to radically change its approach to the production, consumption, processing, storage, recycling and disposal of biological resources*. The major aim of this strategy is *to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of biotic renewable resources for industrial purposes, while ensuring environmental protection*. To achieve this aim, the Bioeconomy strategy identifies five objectives: (1) ensuring food security, (2) managing natural resources sustainably, (3) reducing dependence on non-renewable resources, (4) mitigating and adapting to climate change, and (5) creating jobs and maintaining EU competitiveness. These five objectives addressed via the strategy's Action Plan are focused on 3 areas of action with a total of 12 actions, subdivided into 54

Table 1. Analysis of documents and legal acts of bioeconomy

No.	Title of documents	Year and country of issue		Definition	Defined sectors		
		1	2		3	Agriculture	Industry
1	Innovating for Sustainable Growth: A Bioeconomy for Europe	2012	EU	Production of renewable resources and conversion of RES to value added projects	Agriculture, forestry, fisheries	Biotechnologies, chemical	
2	Bioeconomy ERA-NET Actions, European Research Area Networks of the 6th and 7th FP	2007	EU	Production of renewable biological resources and conversion it food, feed, bio-based products, bioenergy	Agriculture, forestry, fisheries	Biotechnologies, chemical	Bioenergy
3	A Bioeconomy for Europe	2011	EU	Production based on biological processes	Natural ecosystems	Waste free technologies	Energy efficiency
4	A strategy for a bio-based economy. Green New Deal	2012	EU	Production based on biomass	Resource efficiency		
5	The Application of Biotechnology to Industrial Sustainability	2001	OECD	The use of renewables	Bio products	Eco-efficient processes	Bioprocesses
6	Industrial Biotechnology and Climate Change. Opportunities and	2011	OECD	Bio-based economy, no fossil fuel use	No fossil fuel		
7	International Futures Project The Bioeconomy to 2030: Designing a Policy Agenda	2009	OECD	Transforming science, knowledge	Competitive products	Eco-efficient processes	Sustainable energy
8	Baltic Sea Region	2014	IS	Optimal utilization of biological resources	Maritime and terrestrial resources		
9	Towards a Belgian and Regional Strategy for the Economy	2013	BE	Conversion of renewable feedstock	Biomass and organic waste	Biotechnology based on plant sources	Energy derived from plant-based sources
10	Denmark as growth hub for a sustainable bioeconomy	2014	DK	Use of renewable resources	Bio products	Bio-based products	Bioenergy
11	National Bioeconomy profile	2014	FIN	Use of renewable resources	Food	Products and	Energy
12	National Bioeconomy Policy Strategy: Renewable resources and biotechnological processes	2014	DE	Knowledge-based production	Biological processes	Sustainable systems	
13	National Bioeconomy profile: Italy	2014	IT	Relocation and reorganization of production	Reorganization of the natural resources		
14	National Bioeconomy profile: The Netherlands	2014	NL	Production of bio-based materials		Vegetable raw materials	Bioenergy
15	Swedish Research and Innovation Strategy for Bio-based Economy	2012	SE	Sustainable production of biomass		Reduce the use of fossil based	Biomass
16	Bioeconomy facts and figures 2015. Driving economic growth and productivity	2015	UK	Bioscience based processes	Food	Fuel, Bio-chemicals	
17	National Bioeconomy Blueprint	2012	USA	Economy powered by research and innovation			

sub-actions. The Action Plan of 2012 EU Bioeconomy Strategy is mobilised R&I funding, in particular under Horizon 2020, as well fostered R&I investments in EU Member States, and it has also delivered on standards for bio-based products and supported private investment with major deliverables such as the launch of the Bio-Based Industries Joint Undertaking.

Analysis of the definitions and the priorities within sectors of bioeconomy has highlighted three main activities: (1) sustainable production of bio resources; (2) conversion these resources to value added products and (3) the use of biological and bio-based resources for production of food, fuel, chemicals and energy. The type of industry and production

includes the conversion of plants, biological and animal wastes. The use of advanced, new technologies and innovations are the main preconditions for development of bioeconomy. The knowledge-based innovation and research is essential for the development of bioeconomy based on bioscience and the use of biomass. Analysis of the definitions within strategic documents and legal acts have shown that the development of bioeconomy is based on three main pillars: (1) the increase of efficiency of use of resources; (2) replacement of fossil resource by biological, bio-based and renewable sources; (3) conversion of present production to biotechnologies and bio-based processes. (Include reference about bioeconomy development in EU countries). These

changes are possible with cooperation of science, innovation and research sectors.

#### 4. Analysis of bioeconomy sectors and their main development trends

##### 4.1. Strategic documents and their major promotion sectors

Many countries followed by European Commission action on Bioeconomy *Innovating for Sustainable Growth: a Bioeconomy for Europe* (nuoroda) have prepared their own National Bioeconomy strategies or have released a number of documents and reports for development of bioeconomy linking the scientific disciplines and innovations with biotechnologies. Other important common reports on development of bioeconomy are as follow: *Bioeconomy to 2030* prepared by the OECD, the report on industrial biotechnology prepared World Wildlife Fund, the report on the future of industrial bio-refineries prepared by the World Economic Forum, the French *Agrimonde* study, the British study on the future of food and farming, the 3rd foresight report of the Standing Committee on Agricultural Research, the BECOTEPS final report and KBBE-Net analyses (*Innovating for sustainable growth: A Bioeconomy for Europe*. European Commission, 2012)

EU countries such as Germany, the Netherlands, Finland, France, Belgium and Sweden have also initiated the number of bioeconomy initiatives. Analysis of the definitions of bioeconomy and the defined sectors within documents of EU institutions and other organizations are provided in a figure below. The analysis of strategic documents for development of bioeconomy in EU and other countries showed that the development of bioeconomy is based on the following 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.

Several EU states have already approved the draft version of bioeconomy strategies: Belgium and Germany in 2013 year, Finland in 2014, Spain and Italy in 2016. Germany has also approved the National Research Strategy BioEconomy 2030 in 2011. Sweden approved *Research and Innovation Strategy for a Bio-based Economy* in 2012. Denmark still has no approved bioeconomy strategy however their National bioeconomy advisory council introduced bioeconomy relevant policy document *Growth Plan for Water, Bio and Environmental solutions*.

Germany among EU was a first country which has adopted *National Research Strategy BioEconomy 2030* in 2011. The priorities were towards the promotion of research and innovation in the food sector (food security), sustainable agriculture, healthy nutrition, industrial processes and bioenergy. After-

ward the Nordic Council of Ministries and Finland in 2014 has adopted the strategies such as *Future opportunities for bioeconomy in the West Nordic Countries* and *The Finnish Bioeconomy Strategy*. Nordic Council of Ministries has identifies the priorities within bioeconomy sectors in Denmark, Finland, Iceland, Norway, Sweden, Greenland, Faroe Islands and Aland. They was given a lot of attention to the development of fishing industry since it represents a large part of the region's GDP. Finland has prioritized the development of renewable resources as the biomass in the forests, including as well soil, fields, water bodies and the sea, and fresh water because forestry is the fundamental economic sector. The Spain has adopted *The Spanish Bioeconomy Strategy* in 2015 and it strategy is based on the sustainable and efficient production and use of biological resources with targeted sectors such as food and agriculture, as well as forestry, conditioned by water availability. The Spanish bioeconomy strategy also includes the development of industrial bioproducts and bioenergy obtained from other sources of biomass. Norway has adopted *Norwegian Bioeconomy Strategy* in 2016 with integrated approach to Bioeconomy and Climate, Green shift, Circular economy, Resource effectivity, Low carbon society. France is the last country in EU so far which has adopted the strategy called *A Bioeconomy Strategy for France* where they have emphasised bioenergy, green chemicals, clusters and circular economy. An overview of the countries which already have adopted bioeconomy policies and the countries which have introduced bioeconomy relevant policies are shown in a table 2.

Other EU countries so far have prepared feasibility studies or other type of documents identifying priorities and trends for the development of bioeconomy. Ireland, Estonia and Latvia are currently at the final stage of preparation of the strategy. Lithuania has also prepared *Lithuanian Bioeconomy Development Feasibility Study* in 2017. Its main action plan is set for the development of bioeconomy in the food, agriculture and biotechnology sectors based on the integration of stakeholders to ensure sustainable growth of bioeconomy via the biomass value chain. The analyses of legal documents within bio economy showed that the priority was giving to the development of food sector while bioenergy, biofuels and biomass production was placed in the second position. Consequently the all the efforts in the development of bioeconomy policies and practical applications was made towards the development of 2<sup>nd</sup> and 3<sup>rd</sup> generation of sustainable production of biofuels. Abandoned agricultural land and the inappropriate land for agricultural purpose have be utilized for growing of biomass for biofuels production. The analysis of research of EU countries and good practice of bioproducts created by their companies revealed the following trends: 1) the use of waste as biomass; 2) integration of sectors of bioeconomy; 3) the use of biomass in the production of high value

Table 2. Overview of EU Member States and third countries with bioeconomy policies

No	Country	Title of strategy	Year of adoption	The major trends within bioeconomy		
				Agriculture	Industry	Energy
1	France	A Bioeconomy Strategy for France	2017		Green chemicals	Bio Energy
2	Spain	The Spanish Bioeconomy Strategy	2015	Bio-based resources		
3	Italy	Bioeconomy in Italy	2016			
4	Finland	The Finnish Bioeconomy Strategy	2014	Biomass Forestry		
5	Germany	National Research Strategy BioEconomy 2030	2011	Food security	Industrial processes	Bio Energy
6	USA	National Bioeconomy Blueprint	2012		Bio medicine	
7	Japan	National Plan for the Promotion of Biomass Utilization	2010		Industrial use of biomass	
8	Malaysia	Bioeconomy Transformation Programme (BTP)	2013		Bio technologies	
9	South Africa	The Bioeconomy Strategy - Partnership for Action on Green Economy	2014		Training Education	
10	Norway	Norwegian Bioeconomy Strategy	2016		Low carbon society	
11	Nordic Council of	Future opportunities for bioeconomy in the West Nordic Countries	2014	Fisheries		

added products; 4) replacement of one type of biomass by another; 5) search for alternative forms of biomass; 6) development of circular economy (Vitunskiene, 2017).

#### 4.2. The size of bioeconomy and its values

The bioeconomy is important for the country's sustainable and rational use of resources, employment and creation of the national product. According European Commission documents (2012) the overall annual value of bioeconomy sector is worth 2.2 trillion Euros in turnover and accounting for 9% of the EU's workforce, and therefore it plays a central role in addressing a number of key interlinked challenges. Approximately 55 % of employment is linked with agriculture, 20 % with food industry and almost 14 % with forestry (European Commission (2012). Commission Staff Working Document Accompanying the document, Communication on Innovating for Sustainable Growth: A Bioeconomy for Europe, reference). The effects of employment in agriculture in the form of turnover are only partly counted as effects of the sector because these effects is transferred to other sectors and shows in the production value of food and other products from outside the very agriculture sector (M. Adamowicz, 2017). The bioeconomy sector such of food, beverages and tobacco industry in 2014 year generated more than a half of bioeconomy turnover in EU, where agriculture accounted for 17 % (0.38 trillion

EUR), biomass production – accounted for 20 % and its contribution into the overall employment of bioeconomy was 55 % (Vitunskienė, 2017).

An average turnover of EU-28 countries was 4400 Euros per person. The leaders of generated the added value in the bioeconomy sector amongst EU-28 countries were Germany (150 bill. of EUR), Italy (110 bill. of EUR) and France (75 bill. of EUR) however Ireland, Finland and Denmark were at the top compare turnovers per person (about 8800 EUR). Belgium, the Netherlands, Sweden and Austria were at the second place with 6200 – 6900 Euros of turnover. Lithuanian bioeconomy sector turnover so far is around 3800 Euro per person which is below an average level compare with other EU-28 countries (Piotrowski, 2018; Lietuvos bioekonomika, 2017). The bioeconomy in EU countries employs 18.5 million people in total. The primary biomass production, mainly agriculture plus forestry and fishery, generates a lot of employment (55%) but low turnover (20%). The bioeconomy sector of Eastern European countries such as Poland, Romania and Bulgaria are stronger in less value added sectors of the bio-based economy consequently it generate a lot of employment (Piotrowski, 2018). In comparison, Western and Northern European countries generate much higher turnover compared to the employment generated (Piotrowski, 2011).

In the period from 2004 to 2014 the number of persons employed in the EU bioeconomy decreased by



Table 3. The countries which have introduced bioeconomy relevant policies

No	Country	Title of documents	Year	The major trends within bioeconomy sectors			
				Agriculture	Industry, Clusters	Energy (bioenergy)	Health, Biotech
1	Austria	Research, Technology and Innovation Strategy for Biobased Industries in	2014		Agro-Timber industry		Health care
		Policy Paper on Bioeconomy	2013				
2	Great Britain	Agri-Tech strategy	2014	Forestry			
		UK Bioenergy Strategy	2012				
		UK Cross-Government Food Research and Innovation Strategy	2010	Agro	Agro-industry		
		Natural Environment White Paper	2011	Marine			
		S&I strategy for Forestry in Great	2010				
		Marine Science Strategy	2012				
3	Ireland	Harnessing our Ocean Wealth	2012	Forestry	Agro-Timber industry		Health care
		Delivering our Green Potential	2012	Marine			
		Towards 2030	2008				
4	Lithuania	National Industrial Biotechnology Development Programme (2007-2010)	2007		Chemistry, Bioplastics		Health care
5	Netherlands	Groene Groei: voor een sterke, duurzame	2013				
		Groene Groei – van Biomassa naar	2012				
		Frameworkmemorandum on the Biobased Economy	2012		Bio-based chemicals		
		Green deal Program	2011				
6	Belgium	Bioeconomy in Flanders + Action Plan	2014	Forestry, Fisheries	Agro-industry		
7	Denmark	Growth Plan for Water, Bio and Environmental solutions	2013		Industry, cosmetics, chemicals		
		Growth Plan for Food	2013				
8	Portugal	Estrategia Nacional para o Mar (2013-2020)	2013	Aquaculture	Cosmetics		

Table 4. Bioeconomy sectors and its gross added value in EU countries (Information source used by authors is the European Commission science and knowledge service Hub, <https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html>)

Economic Activities (by NACE)	LT	LV	EE	BE	DK	FI	FR	DE	IT	NL	PL	SE
	Turnover (mill. EUR)											
Food, beverage and tobacco	4.057	2.130	2.285	45.887	26.947	19.277	1.153.006	205.734	131.770	71.657	1.153.006	17.921
Agriculture	2.664	1.711	1.811	9.970	9.711	10.936	380.164	49.322	49.142	23.458	380.164	13.853
Wood products and furniture	1.774	1.277	833	8.143	9.494	6.711	186.616	40.407	46.850	7.285	186.616	11.035
Forestry	1.609	939	668	5.374	2.523	4.616	177.044	36.736	22.341	5.758	177.044	6.097
Paper	418	120	222	4.439	1.334	3.659	173.724	36.196	21.801	4.044	173.724	5.444
Bio-based textiles	341	116	113	1.765	642	1.913	103.497	9.249	19.372	614	103.497	4.726
Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)	235	100	51	1.308	622	829	50.101	8.854	1.787	446	50.101	908
Liquid biofuels	116	75	40	746	600	728	12.194	2.197	1.491	254	12.194	823
Fishing and Aquaculture	58	20	16	411	290	553	11.650	156	1.461	-	11.650	263
Bio-based electricity	38	-	3	82	96	94	10.831		882	-	10.831	173

2.2 million (or 10.5 percent), while bioeconomy turnover increased by EUR 140 billion (or 7 percent). It should be noted that the greatest reduction in the number of employees was in agriculture (by 1.2 million) due to its constant restructurization, also, in manufacture of wood and furniture made of wood (by 390 thousand), bio-based textile and clothes (300 thousand) and food, beverages and tobacco (by 200 thousand). It should be noted that the growth of the EU bioeconomy turnover was mainly

determined by the development of food production (the turnover increased by EUR 98 billion), and slightly less – by changes in agriculture, where the turnover increased by EUR 26 billion, also in the production of chemical substances, medicines, plastics and rubber based solely or partially on raw materials of biological origin (Lietuvos bioekonomika, 2017).

Every EU country has own strategy and priorities in bioeconomy with different specialisation and contri-

tribution to national economy. Every sector of bioeconomy can be characterized by the added gross value and by the turnover which values are presented in table 4.

## 5. Conclusions

The bioeconomy policy is oriented towards mitigation of primary and secondary wastes in the production processes and at the end user and creation of value added product using bio-based resources and biotechnologies. Both EU and Lithuanian legislation documents give attention to the reduction of bio-waste, especially in the food sector in order to decrease the food waste, organizing and managing the collection system of food wastes and implement measures allowing reducing the generation of food waste. Reduction of food waste, extension the chain of the use of food and provide by-products in feed production is prioritized policies in the bioeconomy legal documents. It also emphasized the education and information management systems which plays an important role in awareness of public about reducing the food wastes.

Meanwhile EU and OECD strategic documents emphasize the bioeconomy strategy on three areas: investment in research and innovation (R&I), improvement of innovation and skills; strengthening policy interaction and participation of stakeholders; increase the competitiveness of bioeconomy sector. The attention is given to the development of biotechnologies, because they are centre of bioeconomy sectors. Biotechnologies provide the knowledge-based development for competitive industrial and service sectors creating the higher value added. The highest added value products are created in the pharmaceutical sector because it is innovation and knowledge intensive industry based on of the use of high level of technologies. Manufacture of chemicals and bio-based plastics is a medium-high-technology industry while production of biomass is considered as low technology industry. Currently, the contribution to production of biomass and bioenergy is a priority of bioeconomy sector in Lithuania since the manufacture of bio-based chemicals and pharmaceutical products using advanced biotechnology processes is poor due to its small scale. However, biotechnologies and its applications have a high potential because of generated high added value, consequently it expected as the most promising development sector because of attracting investments in R&I and qualified employees.

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