BIOECONOMICS DEVELOPMENT IN THE REGIONS: LITHUANIAN CLUSTERING ANALYSIS

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Abstract: The development of renewable energy has a significant impact on the structure of the economy through the redistribution of capital resources and jobs. An essential part of renewable energy is biomass, based on natural resources. Biomass energy is an integral part of the bioeconomy. Bioeconomy involves the production of added value from natural resources, emphasize the use of organic waste. The authors aim to provide evidence of the importance of biomass clusters for the development of the bioeconomy by studying the economic and social changes in individual regions. Research has shown that the use of biomass has significantly improved the social and environmental situation of the regions, thus multiplying the positive economic effects. Conversely, regions that remain dependent on fossil fuels, which are imported in many cases, are halt economic development and facing significant economic and social problems.

Keywords: Sustainable development, regional development, bioeconomics, biomass cluster

1 Introduction

Biomass clusters combine different business entities involved in biomass extraction, transportation, and power generation. Clusters concentrate together scientific potential capable of improving the technologies used. The activities of the biomass cluster contribute to the development of the bioeconomy, where resources that have been considered as waste are used to create additional value. The use of indigenous resources enables the development of new technologies and the employment of people from different backgrounds, thus reducing unemployment and social exclusion. Using wood as a source for heating is as old as mankind but processing woody biomass to generate fuel and electricity is in its infancy. Regardless of the way woody biomass is used, biomass processing can directly support local economies and local job markets, which is especially advantageous to rural economies where other economic opportunities are often limited. The forest-related energy-source literature emphasizes that the potential impacts of woody biomass processing energy on local and national economies is substantial (Jackson, Neto, Erfanian, 2018). The usage of biomass creates synergistic effects, which can multiply the positive economic effects. However, to achieve these effects, co-operation based on the principles of co-operation is essential. This is most easily achieved through the cluster structure. In the research of Erkus-Ozturk (2009), it is stated that clusters unite firms from different levels in the industrial chain (suppliers, customers), with service units, making firms within the cluster interdependent due to the value chain links through common technologies, inputs, customers, infrastructure and distribution channels. Improving the strength of the structure of the biomass energy sector through a pooling of resources is one of the key components of competitive success. Distinguished three important processes underlie geographical clusters: face-to-face contact, social and cultural interaction and the development of knowledge and know-how (Dicken, 2003).

The research topic is unique as the authors link the concept of the cluster, the development of renewable energy and the principles of bioeconomy. According to the authors, these factors are integral, since it is the concentrated local resources that can enable the regions of the countries to solve the relevant economic, social and environmental problems. The study provides a case of Lithuanian regions where the economic and social structure of the country changed significantly during the analysed period. The use of biomass has reduced social exclusion, increased job creation, and tax collection.

In this research, the authors introduce possible directions for the impact of biomass cluster activities in developing a bioeconomy-based system, thereby enabling regions to become more economically self-sufficient and capable of ensuring the social well-being of their populations. Prosperity is achieved by creating new jobs and redistributing regional resources to meet other needs of the population. At the same time, new business units contribute to the development of the gross product bypassing the necessity to attract foreign direct investment.

Our study develops a rating system that allows comparisons between regions in different countries according to their level of economic and social development. A key component is the use of local resources to create new jobs and added value in the regions. At the same time, conditions are created for assessing the appropriateness of regional policy decisions within the framework of existing performance. Going beyond economic factors, the complex effects of adopting bioeconomy ideas across the country's regions are assessed.

The object of the study: Biomass clusters utilisation for regional bioeconomy development.

The aim of the study: To determine how the development of biofuel clusters can influence the development of bioeconomy in the regions.

The novelty of the study: The study showed that the sustainable development of the bioeconomy in the regions is ensured by biomass clusters, which create synergies through cooperation between business entities. Interacting business units in a biomass cluster create a combined total value that is greater than the sum of the values created by these units individually. Thus, the development of bioeconomy in the regions is accelerating due to clustering processes that ensure the sharing of resources and their benefits, relevant business information, etc. In the output, bioeconomy development ensures regional development.

2 Theoretical background

2.1 Interaction Between Biomass Clusters and Bioeconomy

The activities of the biomass cluster integrate different fields of activity - fuel preparation and consumption, transportation capacity, scientific progress, waste collection, etc. A successful cluster can have a significant impact on the home region through the creation of workplaces and economic value. With the development of renewable energy, it was intended to create a clear concept that describes the diffusion of green ideas. Thus, came the concept of bioeconomy, which includes activities of clean technologies and business entities to achieve positive environmental impact, but without losing the opportunity to achieve a profit. Biomass clusters are particularly well-suited to promoting the bioeconomy, as they support collaborative ideas and aim to create maximum added value with limited resources. At the same time, value is generated from renewable resources, waste, thus reducing environmental pollution.

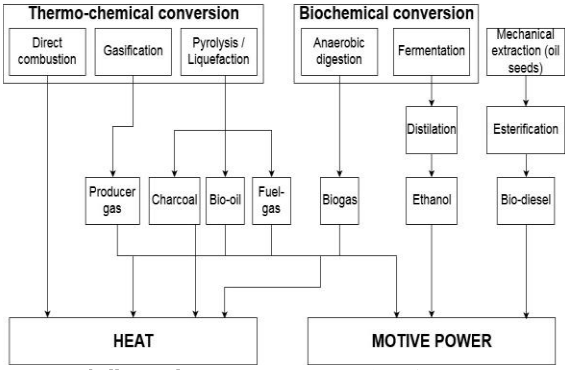
The main strength of the bioeconomy concept is the ability to use biomass in different directions according to the prevailing needs at that time. Biomass is the most continuous source of energy; biomass can be used either directly as solid fuel feeding power plants or indirectly after conversion into a secondary form of energy (e.g. syngas and biogas) by using air, oxygen and/or steam. In spite of the several advances achieved in biomass gasification systems, the direct use of biomass needs further developments (Amirante, Distaso, Tamburrano, 2017). There are unequal energy needs in different regions, and biomass consumption can fulfill the region energy needs. Several studies have analysed policies on international and national levels that support the use of woody biomass as energy generation source. These policies not only bring the environmental perspective, but also address the economic influence that woody biomass processing can have in the local and regional economy. Woody biomass has the potential to create direct and indirect local jobs in rural areas, and this characteristic can be key to attracting new business opportunities in rural forested economies. Because more jobs create more output, woody biomass – either as a subset of a larger and more general biomass sector or as a specifically independent category – is the focus of recent studies, most of which assessed woody biomass processing economic impacts using input-output analysis (Jackson, Neto, Erfanian, 2018). Proper municipal policy decisions and mobilization of initial resources can assist to achieve consistent regional development goals. At the same time, the area of clean air is expanded, and the state of the environment is improved. Authors supplement, that woody biomass processing has many benefits as a renewable energy source compared to fossil fuels. Numerous studies have assessed the potential contribution of a wood-based energy source as an inexhaustible, while sustainably harvested, alternative for energy generation on a regional, national, and worldwide level. Therefore, due to climate change and other potential issues related to greenhouse gas (GHG) emissions, exploration of more environmentally friendly and sustainable energy sources like woody biomass should be encouraged. As the use of biofuels is commercially viable, is necessary to perform not only environmental impact analysis but also economic benefit research.

The biomass cluster generates great economic significance. Because it is a local cluster, its benefits are noticeable first and foremost by the region of activity. Waste disposal, solving social problems, and increased local energy flows are just a few of the benefits of the cluster. Like other business clusters, the biofuel cluster may decrease incentives for new business formation due to increased competition and crowding-out effects (or congestion costs) that result in diminishing marginal returns to entrepreneurial opportunities. Others claim clusters might lower the cost of starting a business by providing specialized suppliers, a local customer base, and producers of complementary products and services (Slaper, Harmon, Rubin, 2018) This is another area of performance efficiency - the cluster, which manages the resources of its members, directs them in the direction that would ensure the lowest cost of the product and maximize the benefits of the cluster members. At the same time, it avoids overinvestment situations where cluster members invest in the same equipment and thus waste financial resources. Instead, the focus is on placing an attractive product on the market, lowering its cost and adjusting to market prices.

The interaction between biomass clusters and the bioeconomy is inseparable from the idea of sustainable development. The sustainable usage of resources while ensuring a positive impact on the environment is a cornerstone of the bioeconomy. Biofuel cluster activities help to achieve this goal by focusing on the use of local natural resources. Sustainable development processes involves three major approaches: (1) sustainability as the maintenance of the stock of capital (natural, man-made, human and socio-cultural); (2) the triangular approach, which considers the three interrelated dimensions of sustainability (economic, social and environmental); and (3) the materials balance approach (del Rıo, Burguillo, 2008). As the use of biomass is local in production, it multiplies the positive effects on the economies and promotes the development of the bioeconomy as a regional and national development direction. Modern bioenergy would be a central component of a future low carbon global energy system, playing a significant role in helping to decarbonize industries such as aviation, shipping, and long-haul road transport (IEA, 2017).

Bioeconomy analysis is inherent with the application of engineering solutions to energy production. The different ways of generating energy make it possible to achieve the desired effect in different regions of the countries. It depends on the desired use of fuel and the preferences of energy type. Woody biomass can be used for generating electricity, producing biofuels, and making biochemical such as adhesives, solvents, plastics, inks, and lubricants (Ozcan, Öztürk, Oguz, 2015).

Figure 1: Energy from biomass production possibilities



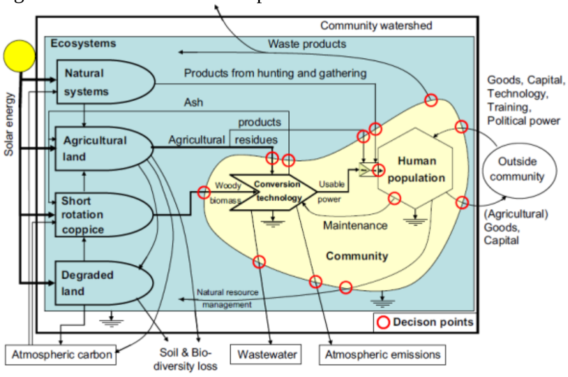
Source: Okello, Pindozzi, Faugno, Boccia (2013)

Fig. 1. present the basic processes that enable to produce certain types of energy from biomass. Each power generation technology requires different engineering solutions and investments, both for the power plant and for power distribution networks. In this case, the distinguished fuel groups are related to energy and heat extraction, natural gas extraction as well as biofuel for transport needs. Decision-making process, which engineering solutions are best suited for a particular region, assists further stimulate bioeconomy initiatives. It is performed with benefit-cost analysis, regional resource analysis, and evaluating of existing energy transmission networks. The cluster structure, which involves all stakeholders and guides them towards the common goal, contributes significantly to the efficiency of bioeconomy development.

It is necessary to emphasize the importance of economic vitality research. Additional aspects that strongly influence the economic viability are: (1) the estimated installed power; (2) the estimated lifetime, frequently laying between 15 and 35 years; (3) the heat and electricity efficiency, highly depending on the type of fuel and the conversion technology used; (4) the average load factor of the power plant, as it is directly related to the electricity generated and consequently to the revenues obtained (Carneiro, Ferreira, 2012). With this engineering information, the objective of an efficient energy production process can be achieved while strengthening the overall structure of the bioeconomy. Combustion, used to convert biomass energy into heat, mechanical power or electricity. Net conversion efficiencies range from 20% to 40%, even if higher values may be obtained when the biomass is co-combusted in coal-fired power plants. Meanwhile, critical logistic aspects strongly affect the economic and energy performances of bio-energy conversion systems, introducing limitation on their suitability (Caputo, Palumbo, Pelagagge, Scacchia (2005). The way in which energy is produced and the purpose for which it is used depend on the production strategy chosen and the prevailing circumstances. In some bioenergy pathways, farms are nothing more than the supplier of raw materials, for example for bioethanol fuels. In other cases, further processing and energy conversion takes place on farms by means of onsite biogasification plants and generators (Plieninger, Thiel, Bens, Hüttl, 2008).

The development of the bioeconomy concept encompasses various economic, engineering, environmental factors that enhance the country's competitiveness and the level of technical resources. The process of converting biomass into energy requires various engineering solutions that shape the need for innovation. This allows for a positive economic impact through the creation and development of engineering technologies. The Fig. 2. The development of the bioeconomy concept encompasses various economic, engineering, environmental factors that enhance the country's competitiveness and the level of technical resources. The process of converting biomass into energy requires various engineering solutions that shape the need for innovation. This allows for a positive economic impact through the creation and development of engineering technologies. The Fig. present all bioeconomy processes, how biomass becomes an energy source and what economic, managerial and engineering solutions are needed to achieve the goal. The efficiency of biomass utilization depends on the current situation of transmission and distribution networks, their throughput, as well as the cluster's ability to handle residual materials (ash, natural fertilizers, etc.). The necessary engineering solutions significantly increase the efficiency of the cluster activities and opportunities to remain in the competitive market.

Figure 2: Biomass conversion process



Source: Buchholz, Volk, Luzadis (2007)

The structure of the bioeconomy is conducive to clustering, since all participants in the structure can make productive contacts with each other. The structure is conducive to information exchange and pooling of resources. Clusters possess a stockpile of knowledge built over time based on experience of their members. Cluster members can take advantage of this knowledge stock through what calls "knowledge spillovers" (Steinfield, LaRose, Chew, Tong, 2012). In this case, the biomass energy sector matches the efficiency criteria for information exchange due to the necessity to maintain a short operating distance. bioenergy projects involving energy crops can make a significant contribution to rural income or employment increment. For example, energy crops lead to changes in agricultural labour patterns and give positive contributions to rural economic diversification (Thornley, 2006)

Elements of a study by Cannemi, García-Melón, Aragonés-Beltrán, Gómez-Navarro (2014) can assist to analyze the structure of the biofuel energy sector. The authors apply different approaches to analyzing the biomass market. The principles are based on the different characteristics of power plants, choice of investment solution, and flexibility of supply. According to the authors, the structure of the biomass energy sector may be influenced by the following factors:

- Valorization of agro-industrial waste or dedicated cultivation;
- Electricity and/or heating (cooling) production;
- Private or public investment;
- Short supply biomass chain (o70 km) or other (including importation);
- Smart/mini-grid distribution or centralized general grid connection.

The main sustainability indicators that are noticeable in the operation of the biofuel cluster are also highlighted (Evans, Strezov, Evans, 2009):

1. Price of energy generation unit must be considered since unfavourable economics are not sustainable;
2. Efficiency of energy transformation must be known for meaningful comparison;
3. Land use requirements are important as renewable energy technologies are often claimed to compete with agriculturally arable land or to change biodiversity;
4. Social impacts are important to correctly identify and quantify the human risks and consequences will allow better acceptance and understanding of some technologies that are often subject to public objection.

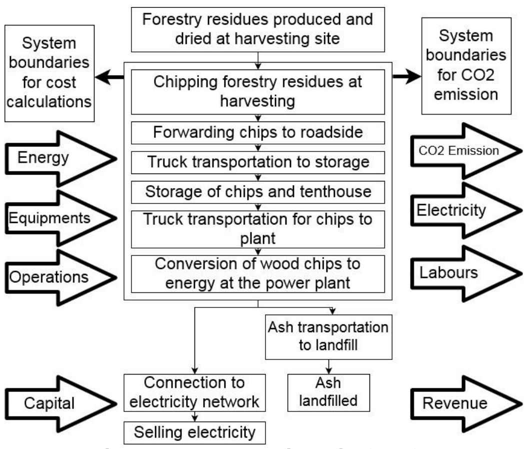
Biomass can be used quite widely. It can be used not only to obtain different types of energy but also for the production of green fuels and other raw materials. Biomass is part of the broader concept, which is often identified with biological fuel for transport. One type of resources are formed quickly enough (energy crops), but the other type of resources requires a very long time (water sludge). Certain raw materials that are formed over many years - sludge, fossil materials, peat - are separated from biomass. All these groups can be used to produce electricity, various types of energy (heat, steam, etc.), as well as fuel and the necessary chemistry. The main differences in production are related to the technologies used to generate energy and use renewable resources (Holmgren, Andersson, Berntsson, Rydberg, 2014)

When describing the full potential of biomass use, it is necessary to look at the benefits to the state and smaller subjects who have chosen to use renewable resources. Benefits of using biomass (Lapinskas, 2013):

- Ecological safety - abolishing polluting fossil fuels by using indigenous renewable resources instead;
- Economic benefits - funds, spent on buying fossil fuels, stays inside the country and is poured into the domestic economy. Also, GDP and people's purchasing power are growing;
- Social benefits - the creation of new jobs in all stages of biomass utilization;
- Energy security - independence from volatile energy supply markets, unilateral fuel pricing disappears;
- Export / Import Balance - With imports of energy and fuels decreasing, the ratio of imports to exports improves;
- Regional development - regions with low regional development would gain access to biofuel production and thus become more competitive at the national level.

The activity of biomass cluster is an integral part of a successful supply chain operations. The supply chain ensures a smooth supply of biomass and its conversion into energy. The biomass is sourced from different geographic locations, and different engineering solutions – trucks, rail, ship, etc. – are used to ensure smooth supply of biomass. The bioenergy process in the supply chain in Fig. 3. consists of three parts - the initial stage, the main supply procedure, and the impact analysis. The latter part links the effects of supply chain processes and bioeconomic processes in general. This suggests that the positive effects of the bioeconomy require sustainable development, engineering, and social solutions.

Figure 3. Bioenergy supply chain



Source: Ayoub, Martins, Wang, Seki, Naka (2007)

Critical solutions are related to biomass conversion in power plants, transportation, connections to energy networks. This ensures operational efficiency and consistent energy supply. The activities of the biomass cluster are essential in order to realize sustainable development goals. Being in a cluster allows mobilizing different types of local resources to create added value. Over time, cluster activities become a significant part of the bioeconomy through the involvement of scientific institutions and public services. In this way, high technologies are created to meet the needs of society and strengthen the importance of the cluster. The development of the bioeconomy is beneficial not only for individual regions but also for the country, as it creates conditions for problems solving in long-term unemployment among the low-skilled employees, low national budget income, high social costs spheres.

2.2 Cluster Bioeconomic Importance for Sustainable Regions' Development

The development of bioeconomy involves two strands - local and large-scale. In the case of local development, each household switches to renewable resources, thus contributing independently to climate change mitigation. Large-scale development is ensured by the municipality's decision to invest in green energy production and its efficient transmission. The development of the bioeconomy is governed by documents and international agreements issued by international organizations.

An important factor contributing to the development of the bioeconomy is household investment. Every household's efforts to reduce fossil fuel consumption are important for future success. One of the most effective solutions is investing in low-generation technologies that enable fulfill all household energy needs. Micro-generation technologies allow households to produce their own electricity. Examples are photovoltaic solar panels, micro-cogeneration units and small wind turbines. A micro-cogeneration unit is a particular type of micro-generator, in the sense that it is a heating system with high efficiency, producing electricity as a by-product of the heat it generates based on fossil fuel or biomass (Geelen, Reinders, Keyson, 2013). Often households are more energy-efficient than public entities. This allows for increasing the degree of green energy efficiency.

The EU's position that bioenergy will remain the main source of renewable energy for the 2020-2030 period. Bioenergy will increase the potential for achieving positive climate and energy targets. Bioenergy is a highly flexible form of low carbon and renewable energy because it can be used in power and heat generation and transport. Bioenergy offers significant benefits in terms of energy security, growth, and jobs, especially in rural areas, technological innovation, environmental protection, and climate protection. On the other hand, despite the many positive results, there are concerns about the sustainability risks associated with its production and use (European Commission, 2016). In order to reduce the negative impact of conventional biomass production on food balance and greenhouse gas emissions, it is proposed to limit the production of first-generation biofuels from rapeseed and cereal grains and encourage biomass usage from agriculture and wood wastes, algae.

Various policy documents, scientific studies, statistical surveys analyzed the different composition of the bioeconomy by industry or sector. For example, in the sustainable bioeconomy strategy adopted by the European Commission, the bioeconomy sector includes agriculture, forestry, fisheries, food, wood and paper production, as well as part of the chemical, energy and technology industries (European Commission, 2012). The National Bioeconomy Inventories (by EU countries) published by the European Commission provide a breakdown of the bioeconomy sectors into three categories of economic activities (European Commission, 2014):

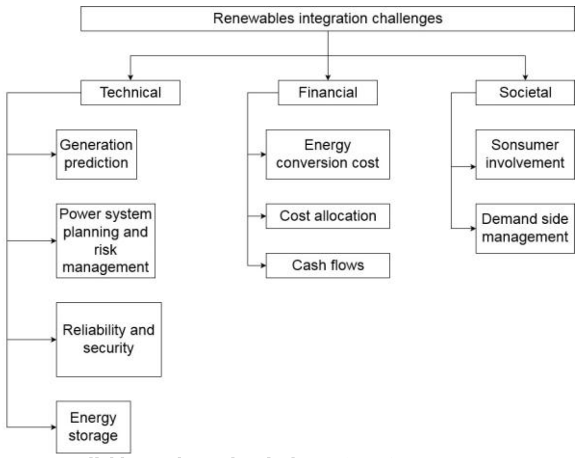
- Biomass production sectors - agriculture, forestry and fisheries;
- Fully (i.e. 100%) bio-based manufacturing sectors where biomass is processed into higher value-added products. It is the manufacture of food, beverages and tobacco products; manufacture of wood and of cork and articles thereof, except furniture; manufacture of paper and paper products, leather and related products;
- Partially (i.e. less than 100%) bio-based manufacturing sectors where biomass is used as part of the raw material. These include textile, chemical, basic pharmaceuticals, rubber and plastic, furniture and other production.

The use and development of renewable resources are directly linked to sustainable energy conception and therefore the impact of economic, environmental and social development needs to be assessed for each sector. The use of each resource must be cost-effective, contribute to the reduction of greenhouse gas emissions, improve the human and natural environment, and at the same time help to solve social problems by creating new jobs, contributing to regional development and reducing social exclusion.

Many technologies can be used to generate energy from biomass, ranging from solid biomass combustion in heating systems to biogas plants and large biomass gasification plants. The importance of biomass energy is steadily increasing as concerns about climate-related emissions to the atmosphere increase. The use of biomass for heat production is already economically viable, but measures to promote the use of biomass for electricity generation are still needed. Such promotion shall be based on environmental, security of supply and social benefits.

The development of the bioeconomy concept faces challenges that make innovation applying more difficult. The challenges relate to both the search for engineering solutions and economic factors. Properly evaluated costs and selected technical solutions can ensure the success of the cluster and its competitiveness in the market, which shape the success of the whole bioeconomy sector. Fig. 4 classify the main challenges facing the realization of bioeconomy ideas. The challenges are technical, financial and societal. This is to emphasize the need to reconcile technological innovation, financial viability and public expectations of energy at competitive prices. Technical factors include the engineering parameters, necessary to ensure a smooth transition of the region towards the use of renewable resources. This is done based on cash flow and costs. Demand-side management is one of the societal factors which is the agreement with consumers on the distribution of energy consumption rates. Continuous collaboration with users allows achieving the most effective cluster activity, thereby gaining a competitive edge over competitors of biomass cluster.

Figure 4. Potential challenges in integration of renewable energy resources



Source: Ellabban, Abu-Rub, Blaabjerg (2014)

The wide concentration is needed for a smooth transition to biomass for energy purposes. This objective can be achieved by concentrating resources within the cluster structure. The positive effects of the cluster relate not only to increased competition in energy production but also to the synergistic effects of a growing social level, a stronger regional economic structure and better use of local resources. The influence of the biomass cluster on the development of the bioeconomy allows different regions to interact with each other through the exchange of biomass resources and the workforce, thus creating a sustainable and socially acceptable environment. In further analyzing the positive impact on society, it should be noted that the impact of biomass clusters is not limited to reduced pollution levels and improved bio-waste management. The usage of biomass in the energy sector creates conditions for the development of a sustainable society. A sustainable society is conceived as a community of people capable of using scarce resources in a sustainable manner. One factor necessary for developing a sustainable society is decreasing, or at least not increasing, the total amount of energy used (Suzuki, Tsuji, Shirai, Hassan, Osaki, 2017). Tangible benefits of cluster activities are inter-firm synergies, cross marketing activities, search for innovative solutions (Perles-Ribes, Rodríguez-Sánchez, Ramón-Rodríguez, (2017). Biomass clusters can contribute to this by offering consumers a switch to more energy-efficient solutions. By maintaining constant communication with energy users, the cluster can guide them along the path of energy changes. This will allow for the preservation of funds within the country and multiplicate it for the fulfil the needs of society. A strong regional cluster (and related clusters) may enable agglomeration economies, including larger pools of skilled employees, knowledge spillovers, specialized suppliers, and sophisticated buyers (Haviernikova, Okręglicka, Lemańska-Majdzik, 2016). Proximity of related economic activity can also reduce transaction costs and induce the growth of specialized local institutions, such as educational programs and trade groups that reinforce the complementarities across related industries. Thus, a strong regional cluster should enhance the employment growth of the industries in the cluster through increasing efficiency, productivity, and/or returns to investment.

The development of the bioeconomy is inextricably linked to the cooperation of business subjects to achieve a common goal. The use of biomass helps to increase entrepreneurship in the regions by reducing the use of fossil resources. In less-developed countries, this fuel is often imported, thus biomass consumption promotes local energy production. In order to evaluate the impact of biomass cluster activities in the regions, a research methodology is used that allows assessing the complex effects created by the cluster. At the same time, the importance of bioeconomic processes is demonstrated. The Lithuanian case, which provides an understanding of the economic, social and environmental benefits of biomass conversion, is selected for evaluation.

2.3 Methodology and research findings

The main methodological tool is the application of cluster analysis. It allows subdividing regions according to certain characteristics that are selected for the purposes of the study. The research data covers economic, social and environmental perspectives. Cluster analysis investigates the economic capability of regions and the changes brought about by the change in the way energy is produced. This will allow an objective analysis of the changes caused by the use of biomass.

The initial phase of the study involves determining the characteristics of the study. Reference is to the case of Lithuania, analyzing different regions of the country. Lithuania has made significant progress over the decade in promoting the usage of biomass, which was reflected in its evaluation of economic and social indicators. The country has significantly reduced its imports of fossil fuels through the use of indigenous biomass, thus enabling the conditions for regional competitiveness growing. The information in Table 1 shows that the dynamics of the five indicators will be studied over the last nine years. The indicators cover the main characteristics of energy use, the social situation and the size of regional budgets.

Table 1: Research information

Indicator	Meaning
Sample	49 municipalities
Data	Municipalities income and expenditures, thousand EUR
	Costs for social allowance, th. EUR
	Heat price, euro ct./kWh
	Expenditure for gas, th. EUR
	Costs for biomass, th. EUR
Analyzing period	2008-2017
Currency	Euro

Source: Statistics Lithuania

The study uses data on municipalities' in Lithuania, excluding the largest cities and municipalities, that do not have district heating systems. The selected municipalities are similar in population, economic capacity, and have similar problems. Renewable biomass and fossil fuels are the most used in municipal heat production. This has a significant impact on budget revenue and expenditure. The number of recipients of the social allowance reflects unemployment problems and the ability of municipalities to solve them. However, the potential of biogas production from agricultural and food industry waste and biodegradable municipal waste is underutilized in Lithuania, although the production of biogas from agricultural waste and sewage sludge has been increasing lately. The potential of biogas production for this production is increased by the low utilization potential of agricultural and food industry waste, biodegradable municipal and food waste in Lithuania.

Cluster analysis is used to conduct the study. The K-mean method was chosen as the most appropriate method of analysis, which allows to efficiently group regions according to different characteristics in search of causation. The simplest and most commonly used algorithm, employing a squared error criterion is the *K*-means algorithm. This algorithm partitions the data into *K* clusters (*C*1*; C*2*; : : : ;CK*), represented by their centers or means. The center of each cluster is calculated as the mean of all the instances belonging to that cluster. The algorithm starts with an initial set of cluster centers, chosen at random or according to some heuristic procedure (Delgado, Porter, Stern, 2014). In each iteration, each instance is assigned to its nearest cluster center according to the Euclidean distance between the two. Then the cluster centers are re-calculated.

The center of each cluster is calculated as the mean of all the instances belonging to that cluster:

$$\mu_k = \frac{1}{N_k}\sum_{q=1}^{N_k} x_q \quad (1)$$

where N_k is the number of instances belonging to cluster k and μ_k is the mean of the cluster k (Rokach, Maimon, 2005).

The cluster analysis resulted in three clusters which are characterized differently. Table 2 gives the main characteristics that allow to draw initial conclusions about the distribution of clusters

Table 2: Information of cluster analysis (Part 1)

Cluster Number of Case		Costs for biomass, th. EUR	Expenditure for gas, th. EUR	Costs for social allowance, th. EUR
1	Mean	796792,1	1191199,7	1104,2
	Std. Deviation	740480,7	2263087,4	833,5
	Minimum	0,0	0,0	32,5
	Maximum	3485510,0	13628891,3	5962,7
2	Mean	540728,9547	2062653,959	1869,513
	Std. Deviation	614318,8	3643976,8	1244,4
	Minimum	0,0	0,0	49,9
	Maximum	3909484,5	29611508,3	7177,0
3	Mean	472564,5	309982,3	1455,4
	Std. Deviation	261144,1	491455,7	892,1
	Minimum	68998,8	0,0	388,0
	Maximum	1077863,8	1808350,9	3734,4

Source: created by authors

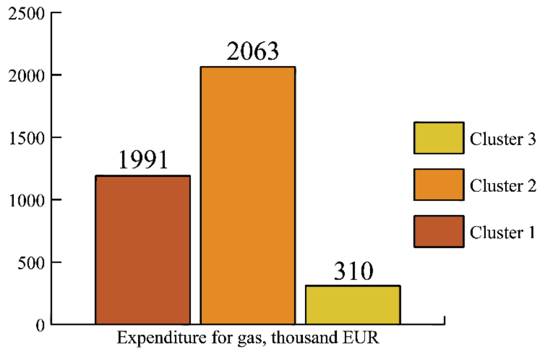
Table 3: Information of cluster analysis (Part 2)

Cluster Number of Case		Municipalities expenditures, th. EUR	Municipalities incomes, th. EUR	Heat price euro ct/kWh
1	Mean	27230,2	26702,5	6,12
	Std. Deviation	14562,7	14750,7	0,8
	Minimum	6199,9	5871,3	4,12
	Maximum	97994,2	101508,1	8,23
2	Mean	26901,16	26207,116	7,86
	Std. Deviation	12448,8	12065,1	1,08
	Minimum	7697,4	7937,4	5,78
	Maximum	78229,8	77050,1	10,27
3	Mean	21526,1	20622,5	6,53
	Std. Deviation	3792,7	3812,5	1,15
	Minimum	14349,5	13609,8	5,14
	Maximum	29428,5	28793	10,31

Source: created by authors

In the case of the first cluster, significant differences between the clusters are related to the use of the chosen fuel. This later shape the changes in the following indicators. A more detailed analysis of the changes is presented in the figures.

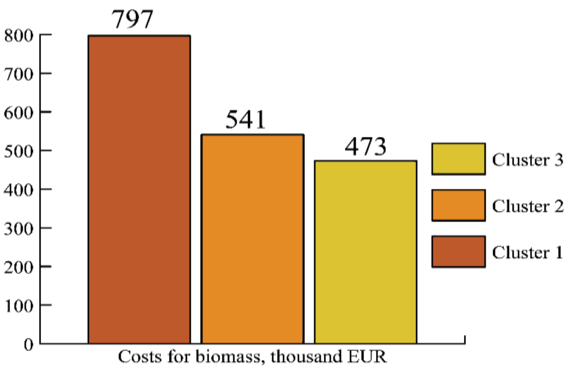
Figure 5: Cluster analysis by expenditure for gas information



Source: created by authors

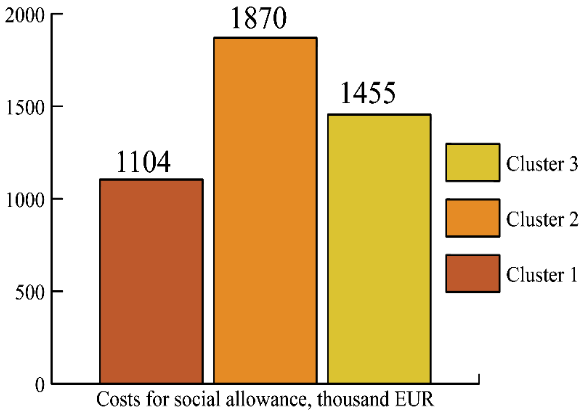
Both Fig. 5, and Fig. 6 the first cluster combines municipalities, that using biomass, while in the second cluster the gas-consuming regions are concentrated. The third cluster is dominated by indecision about the most appropriate fuel type - neither biomass nor fossil fuels dominate these regions. The information in the second cluster reveals significant costs for gas, thus revealing the inability of regions to access local resources. The information presented in Fig. 6 shows similar dynamics of the change of indices.

Figure 6: Cluster analysis by costs for biomass information



Source: created by authors

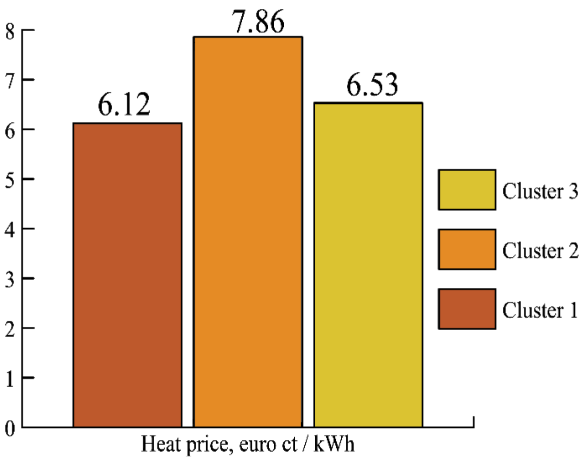
Figure 7: Cluster analysis by costs for social allowance information



Source: created by authors

According to Fig 7, there is a significant difference in the level of social allowance expenditures, reflecting the efficiency of the first cluster income structure and job creation in the forestry sector. Meanwhile, the second cluster is problematic - the funds allocated for social assistance outweigh the costs of other clusters. The competitiveness of the biomass cluster and the efficiency of the bioeconomy concept is reflected in the heating price, which is the lowest compared to the other two clusters. This enables people to save funds while channelling it to other needs. This enhances regional competitiveness and demonstrates the positive impact of bioeconomy processes on both society and municipalities. As in previous cases, the third cluster has no clear direction.

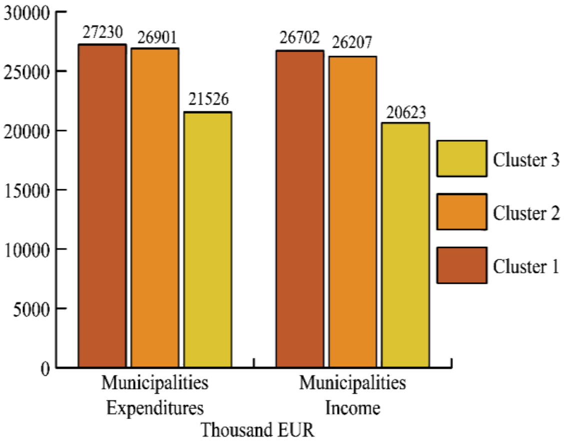
Figure 8: Cluster analysis by heat price information



Source: created by authors

Regions in the first cluster generate more budget revenue, while spending similarly as regions in the second cluster. In addition, the cost structure of the first cluster is more sustainable than that of the other clusters, as it creates value within municipalities and solves social problems such as long-term unemployment and costs for social allowance. Municipalities that use biomass attract more funds into their budgets, thus enabling the creation of public benefits.

Figure 9: Cluster analysis municipalities expenditures and income information



Source: created by authors

In conclusion, the use of local resources promotes economic circulation in the regions, enabling their sustainable development. It paves the way for wider bioeconomy initiatives related to more efficient use of biomass, utilization of various organic wastes, and development of technologies inside the country. Regions with high levels of unemployment and high expenditure on social allowance need to rethink their policies, perhaps choosing to follow the example of neighboring regions and develop renewable energy systems. Lithuania's example shows that it can be an effective route for small countries that are significantly dependent on fossil fuel imports.

3 Conclusion

The biomass cluster is a structure based on today's realities, which allows the regional potential to be mobilized for prevailing economic and social challenges. The main idea of the cluster is to utilize local organic wastes and create added value. Biowaste is formed in woodlands, livestock farms and abandoned lands. Cluster activities enable wastes to become a marketable product with economic value. The use of biomass can also be developed internationally, thus developing bioeconomy ideas. The concept of bioeconomy is based on the cooperation of different business entities in order not only to improve environmental conditions but also to obtain tangible financial benefits. As the bioeconomy grows, cluster activity is critically important.

The analysis of Lithuanian case showed that during the period under review, the competitiveness of certain regions increased significantly due to the increased use of biomass. As the use of biomass increases, related indicators are changing - reduces the heat price and the cost of social allowance, meanwhile increases the revenue of municipal budgets, which can be used to increase the welfare of the population. The biomass cluster is the backbone of the bioeconomy, solving long-standing social problems and reducing regional inequalities.

Literature:

1. Amirante, R., Distaso, E., and Tamburrano, P. *Novel, cost-effective configurations of combined power plants for small-scale cogeneration from biomass: Design of the immersed particle heat exchanger, Energy Conversion and Management*, 2017, vol. 148, pp. 876-894.
2. Ayoub, N., Martins, R., Wang, K., Seki, H., and Naka, Y., *Two levels decision system for efficient planning and implementation of bioenergy production*, Energy conversion and management, 2007, vol. 48, no. 3, pp. 709-723
3. Buchholz, T. S., Volk, T. A., and Luzadis, V. A., *A participatory systems approach to modeling social, economic, and ecological components of bioenergy*, Energy Policy, 2007, vol. 35, no. 12, pp. 6084-6094.
4. Cannemi, M., García-Melón, M., Aragonés-Beltrán, P., and Gómez-Navarro, T., *Modeling decision making as a support tool for policy making on renewable energy development*, Energy Policy, 2014, vol. 67, pp. 127–137
5. Caputo, A.C., Palumbo, M., Pelagagge, P.M., and Scacchia, F., *Economics of biomass energy utilization in combustion and gasification plants: effects of logistic variables*, Biomass & Bioenergy, 2005, vol. 28, pp. 35–51.
6. Carneiro, P., and Ferreira, P., *The economic, environmental and strategic value of biomass*, Renewable Energy, 2012, vol. 44, pp. 17-22.
7. Delgado, M., Porter, M.E., and Stern, S., *Clusters, convergence, and economic performance* Research Policy, 2014, vol. 43, pp. 1785–1799.
8. Dicken, P., Global *Shift: Reshaping the Global Economic Map in the 21st Century*. London: Sage, 2003.
9. del Rıo, P., and Burguillo, M., *Assessing the impact of renewable energy deployment on local sustainability: Towards a theoretical framework,* Renewable and sustainable energy reviews, 2008, vol. 12, pp. 1325–1344.
10. Ellabban, O., Abu-Rub, H., and Blaabjerg, F., *Renewable energy resources: Current status, future prospects and their enabling technology*, Renewable and sustainable energy reviews, 2014, vol. 39, pp. 748-764.
11. Erkus-Ozturk, H., *The role of cluster types and firm size in designing the level of network relations: The experience of the Antalya tourism region*, Tourism Management, 2009, vol. 30, pp. 589–597.
12. Evans, A., Strezov, V., and Evans, T.J., *Assessment of sustainability indicators for renewable energy technologies*, Renewable and sustainable energy reviews, 2009, vol. 13, pp. 1082–1088.
13. European Commission. *Innovating for Sustainable Growth: A Bioeconomy for Europe. Communication from the commission to the European Parliament, the council, the European economic and social committee and the committee of the regions*, 2012.
14. European Commission. *National bioeconomy profile. Policy Structure of the Bioeconomy Institutional system (United Kingdom, Latvia, Ireland, Netherlands, tc.),* 2014
15. European Commission (2016). *Newsletter Bioeconomy Stakeholders Panel*, Brussels, June 2016.
16. Geelen, D., Reinders, A., and Keyson, D., *Empowering the end-user in smart grids: Recommendations for the design of products and services,* Energy Policy, 2013, vol. 61, pp. 151-161.
17. Haviernikova, K., Okręglicka, M., and Lemańska-Majdzik, A. *Cluster cooperation and risk level in small and medium-sized enterprises*, Polish Journal of Management Studies, 2016, vol. *14*, no. 2, pp. 82–92.
18. Holmgren, K.M., Andersson, E., Berntsson, T. and Rydberg, T., *Gasification-based methanol production from biomass in industrial clusters: Characterisation of energy balances and greenhouse gas emissions*, Energy, 2014, vol. 69, pp. 622–637.
19. International Energy Agency (IEA). *Technology roadmap: delivering sustainable bioenergy*. Paris: OECD: International Energy Agency, 2017.
20. Jackson, R. W., Neto, A. B. F., and Erfanian, E., *Woody biomass processing: Potential economic impacts on rural regions*, Energy policy, 2018, vol. 115, pp. 66-77.
21. Lapinskas, R. *Biomasės energetika Lietuvoje: esama situacija, galimybės ir iššūkiai*, 2013.
22. Okello, C., Pindozzi, S., Faugno, S., and Boccia, L., *Development of bioenergy technologies in Uganda: A review of progress*, Renewable and sustainable energy reviews, 2013, vol. 18, pp. 55-63.
23. Ozcan, M., Öztürk, S., and Oguz, Y., P*otential evaluation of biomass-based energy sources for Turkey*, Engineering Science and Technology, an International Journal, 2015, vol. 18, no. 2, pp. 178-184.
24. Perles-Ribes, J. F., Rodríguez-Sánchez, I., and Ramón-Rodríguez, A. B., *Is a cluster a necessary condition for success? The case of Benidorm*, Current Issues in Tourism, 2017, vol. 20, no. 15, pp. 1575-1603.
25. Plieninger, T., Thiel, A., Bens, O., and Hüttl, R. F., *Bioenergy clusters in Austria and Germany: From public goals to private action*, Public and Private in Natural Resource Governance: A False Dichotomy, 2008, pp. 149-166.

26. Rokach, L., Maimon, O., *Clustering methods In Data mining and knowledge discovery handbook*, Springer, Boston, MA, 2005, pp. 321-352
27. Slaper, T. F., Harmon, K. M., and Rubin, B. M., *Industry clusters and regional economic performance: A study across US metropolitan statistical areas*, Economic Development Quarterly, 2018, vol. 32, no. 1, pp. 44-59.
28. Statistics Lithuania. *Official Statictics Portal,* https://www.stat.gov.lt/home, 2019
29. Steinfield, C., LaRose, R., Chew, H.E., and Tong, S.T., *Small and Medium-Sized Enterprises in Rural Business Clusters: The Relation Between ICT Adoption and Benefits Derived from Cluster Membership*, The Information Society, 2012, vol. 28, no. 2, pp. 110-120.
30. Suzuki, K., Tsuji, N., Shirai, Y., Hassan, M. A., and Osaki, M., *Evaluation of biomass energy potential towards achieving sustainability in biomass energy utilization in Sabah, Malaysia*, Biomass & Bioenergy, 2017, vol. 97, pp. 149-154.
31. Thornley, P., *Increasing biomass based power generation in the UK*, Energy Policy, 2006, vol. 34, no. 15, pp. 2087-2099.

Primary Paper Section: A

Secondary Paper Section: AH