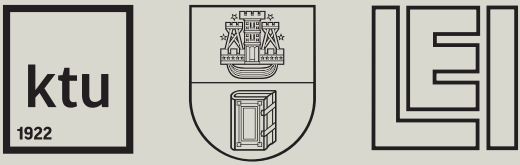

MANTAS ŠVAŽAS

THE IMPACT OF BIOMASS CLUSTERS ON THE ECONOMY IN THE ASPECT OF REGIONS

SUMMARY OF DOCTORAL DISSERTATION

SOCIAL SCIENCES, ECONOMICS (S 004)

Kaunas
2020

KAUNAS UNIVERSITY OF TECHNOLOGY
KLAIPĖDA UNIVERSITY
LITHUANIAN ENERGY INSTITUTE

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INTRODUCTION

Relevance of the study. The rising concern about global warming encourages investments in green energy solutions. Depending on the climate conditions and the abundance of natural resources available, countries in the world choose different ways of producing green energy. The developed Western European countries and the United States of America focus on electricity generation through the development of technologies using wind and solar resources. At the same time, the heat production sector faces a number of challenges: how to produce large amounts of energy without harming the environment, while at the same time replacing the polluting coal and natural gas fuels. Geothermal waters and biomass are mentioned in the scientific literature as cost-effective renewable energy sources (Caputo, Palumbo, Pelagagge, Scacchia, 2005); Kulcar, Goricanec, Krope, 2008); Wünsch, Gruber, Claupein, 2012); Ruzzenenti, Bravi, Tempesti, Salvatici, Manfrida, Basosi, 2014); Karimi, Mansouri, 2018). However, the distribution of geothermal water resources in the world is uneven and the use of biomass allows the combined generation of both heat and electricity. In addition, biomass is environmentally neutral, as incineration produces only the amount of carbon dioxide that the plant has absorbed during its life cycle. In other cases, the use of biomass for energy production has a positive impact on the economy: the processing of biomass in a biogas reactor allows the release and incineration of hazardous methane gas, which would otherwise be released directly into the planet's atmosphere. All these factors have created a situation where biomass is one of the most cost-effective solutions for green energy production. However, scientific literature still underestimates the economic, social and environmental impacts of the use of biomass. There is a lack of research to support synergies between the use of biomass and the society wealth accumulation, especially in developing countries.

The Republic of Lithuania is no exception. The country is committed to increasing the amount of energy produced from renewable resources on the basis of the European Union standards. Along with the global economic downturn, Lithuania has seen an increase in the use of local renewable fuels. The use of solid biomass has increased in particular. Lithuania's increase in the amount of energy produced from biomass raises questions about the adequacy of biomass and the sustainability of its use with the environment. The impact of the use of renewable energy resources on the economy has not yet been widely investigated. Another aspect is that existing studies do not assess the norms of sustainable development in the production of energy from these resources. The economic impact of the use of biomass on individual groups of entities has been evaluated most of all. Meanwhile, today the positive effects of the use of biomass can be further increased as clustering ideas evolve. Clustering can help to combine different resources in the energy sector with the overall objective of sustainable use of

biomass for heat and power generation. It is relevant for small countries with large local resources of fuel which are dependent on energy imports.

The cluster concept is based on cooperation between different entities in a certain region and striving for the common aim. In the classical cluster structure financial, human and intellectual resources are concentrated to achieve the cluster's activity objectives. The phenomenon under analysis in the dissertation is of relevance in two aspects. As regards the first aspect, there is a lack of research to demonstrate the action of a biomass cluster in a certain area. In the second case, it is stated that the biomass cluster is designed to satisfy the energy needs of a certain region or a group of regions. This is fundamentally different from the classic concept of clusters, where resources and work in a cluster are directed at national or export markets as a whole. The activities of the biomass cluster are reserved exclusively for the region of activity, the sustainable use of the resources it contains and the enrichment of the region. The uncertainty of the existing synergistic effects and the resulting difficulties in characterising the positive effect of the conversion of biomass make it necessary to identify positive trends in the effects of the biomass cluster and to define the market structure factors that support and influence the current activity of the biomass cluster.

Clustering is particularly encouraged at the European Union (EU) level (EC, 2019). The Commission encourages the clustering of small and medium-sized enterprises (SMEs) in order to improve performance. The Commission has established instruments to finance the development of clusters and has committed Member States to further contribute to clustering in different business sectors. Nevertheless, it is noted that clustering in the EU Member States from the Central and Eastern European (CEE) region is still sufficiently slack. This can be attributed to a lack of business entities education that would make it possible to highlight the benefits of clustering for doing business and creating added value. The complicated past of these countries, the inert legal framework, the prevailing atmosphere of mistrust also contribute to this. With the rise of climate change mitigation ideas, the role of clusters will become even more important, with the need for collective investment in solutions to reduce pollution and to sustainably use materials. The biomass cluster would contribute exclusively to the achievement of the climate change reduction targets, as the cluster would allow the production of green energy and the concentrated resources would lead to the creation of a higher added value.

Scientific Problem: How the impact of biomass clusters on regions with different biomass resources seeking the efficient use of resources can be assessed.

The degree of investigation of the scientific problem. The clustering of the biomass sector as an energy unit is relatively poorly investigated. Scientists turned to the idea of the use of biomass to meet energy needs only about a decade ago. The scientific problem is addressed through a number of different aspects, the studies are fragmentary and there are no developed research trends and topics of

particular relevance. The regional dimension is observed, i.e. in different continents ways of usage of different types of biomass and their impacts are investigated. A number of studies on the potential of usage of biomass in industrial clusters have been carried out (Herder, Stikkelman, 2004; Andersson, Broberg, Hackl, 2011; Broberg, Andersson, Hackl, 2011; Andersson, Broberg, Hackl, 2012; Tomei, Upham, 2011; Hackl, Harvey, 2013). In this case, biomass is considered to be a secondary factor meeting the energy needs of industrial clusters. In this way the scientists are investigating how industrial clusters start converting biomass, but industrial entities of biomass have not been seen as an important part of the cluster. They are treated as service providers and ensurers of energy supply. The recent articles have examined different types of biomass, such as woody biomass, methanol and different types of algae.

In most of the studies there is a lack of economic assessment. The combined technical-economic assessment prevails, when the technical perspective is distinguished, while the economic factors are treated as important, but do not determine the decision of technical modernization (De, Assadi, 2009; Pirraglia, Gonzalez, Saloni, Denig, 2013; Klein, Chagas, Junqueira, Rezende, de Fátima Cardoso, Cavalett, Bonomi, 2018). Studies have also been carried out where the use of biomass is combined with the use of other fuels (Gupta, Saini, Sharma, 2010; Theo, biomass, Ho, Hashim, Lee, Muis, 2017; Atkins, Walmsley, Walmsley, 2016). There is no specific emphasis on the energy consumption target here: in one case it may be clustered rural areas and in the other case different groups of business and private customers. Biomass plays a significant role in energy production, but it is combined with other forms of energy. In this case the technical and political characteristics are also emphasized, but there is a lack of in-depth economic assessment.

Bio-fuel, bio-energy and bio-economy clusters are relatively new concepts worldwide. With the increasing exploitation of sun, wind, geothermal energy, the use of biomass has been forgotten and considered a less modern option. However, clustering has made it possible to pool resources and define the role of biomass energy in the market. One of the main factors of the emergence of such clusters is the creation of a broad economic impact. In some cases, emphasis is placed on bioeconomy clusters of larger scale covering different clean energy production technologies (Stikkelman, Herder, van der Wal, Schor, 2003; Pätäri, Puumalainen, Jantunen, Sandström, 2011; Kalt, Kranzl, 2011; Kortelainen, Albrecht, 2013). The bioeconomy rarely includes positive synergistic effects resulting from the use of biomass, such as reductions in environmental costs, new workplaces, cheaper local energy raw materials, etc. (McKay, 2006; Kajikawa, Takeda, 2008; Huber, 2009; Scarlat, Dallemand, Monforti-Ferrario, Nita, 2015; Lund-Thomsen, Lindgreen, Vanhamme, 2016; Kircher, Breves, Taden, Herzberg, 2018). Scientific material on timber biomass-based clusters is markedly less frequent (Aho, Kumar, Lashkul, Eränen, Ziolek, Decyk,..., Murzin, 2010; Tégla, Hagen, Hollo, Takácsné, 2012;

Shegelman, 2014). Namely this type of biomass is considered to be a major biomass resource that can create a high added value for business, the state and society. An analysis of the development of the bioeconomy in the form of clusters shows an economic assessment effort to justify the positive effects of this direction. To support this, examples from individual countries and regions are used to illustrate the progress made in recent periods. Another option of clustering is to consider the supply chain as the basis of a cluster (Bernetti, Ciampi, Sacchelli, 2010; De Meyer, Cattrysse, Rasinmäki, Van Orshoven, 2014). It allows the concentration and management of different processes by involving a significant part of the different entities of the sector.

Significantly more scientific sources are found in the search for clusters of renewable resources. Most information is found on the combination of several technologies, without separating the use of biomass as the backbone. The investigation subjects are selected from a wide amplitude, the research can be conducted in the aspect of a continent (Porter, 2008), a country (Dudian, 2011; Essletzbichler, 2012; Hsu, Lin, 2012; Blumberga, 2015), a region (El Bakari, Myrzik, Kling, 2009; Zhu, Huang, Sharma, Su, Irwin, Mishra, ..., Shenoy, 2013), an island (Brown, Finn, Robinson, Salsbery, 2008), a metropolis (Marra, Antonelli, Pozzi, 2017), a building (Allen, Potiowsky, 2008). Most of the articles focus on technical analysis, considering economic factors only as additional ones. In this case, it is implicitly recognised that biomass is more suitable for CHT systems and is less flexible than other renewable types of fuels.

Generally it can be stated that the level of research on the scientific problem is moderate, with a broad, but not monetised technical analysis. There is a lack of economic basis for decisions on the development of use of biomass at national and regional levels.

Subject of scientific work: biomass clusters

The objective of the scientific work is to develop a conceptual model for assessing the economic impact of a biomass cluster and to carry out its verification in the regional aspect.

The tasks of the scientific work are as follows:

1. To analyse the main reasons for the clustering of the biomass sector and its development barriers;
2. To create the structure of biomass with economic value and the final products;
3. To investigate the impact of biomass clustering on different levels of the economy;
4. To develop a conceptual model for assessing the economic impact of a biomass cluster;
5. To investigate the position of Lithuanian regions in economic, social and environmental aspects;

6. To verify the methodology for evaluating the economic impact of regional energy use on the basis of the Biomass Convergence Index.

Analysis methods:

- Systematic, logical and comparative analysis of scientific literature;
- Synthesis of the results of the scientific literature analysis;
- Logical deduction and induction;
- Statistical analysis of the research data: cluster analysis, factor analysis;
- Mathematical and statistical processing methods using statistical data processing programmes: SPSS (v21.0) and Microsoft Excel (2016).

Novelty of the dissertation:

1. **A conceptual model for assessing the economic impact of a biomass cluster has been developed.** The model concentrates the main factors that influence the use of biomass in a certain locality. The model assesses the entities acting in the market, the products they produce, the affecting environment and also identifies under-examined factors that can have a significant impact on the success of market participants. The conceptual model for assessing the impact of a biomass cluster on the economy makes it possible to identify value-added items, to specifically distinguish their place of origin and the directions of cash flows. The model indicates that the biomass sector is in line with the principles of sustainable development at all levels and that businesses in an exclusively specific region are involved in the production and supply processes.
2. **The methodology for assessing the economic impact of a biomass cluster has been developed.** The methodology used for the economic impact assessment includes economic, social and environmental factors. The latter factors indicate the synergy that the biomass cluster creates through its activities. The methodology, which includes a wide range of data, enables to properly justify the results obtained with regard to the impact of the use of biomass. The different methodological instruments enable to analyse the available data in different sections, thus highlighting the comprehensive impact of the cluster on the development of the country and its regions.
3. **The interaction between the biomass cluster and the shadow economy has been investigated and certain components of the biomass cluster that may fall into the shadow economy risk area have been identified.** This indicates that the cluster may also contain manifestations of risks from the shadow economy. It has been investigated that the shadow economy may emerge in sectors characterised by a low level of control and complex traceability of processes. In the case of a biomass cluster, this can be the biomass preparation sector. It is acknowledged that irresponsibly controlled activities may lead to the risk of improper usage of natural resources and overproduction. The dissertation proposes solutions to neutralise the risk of

the shadow economy within a cluster, at the same time ensuring the transparency and sustainability of its activity.

4. **The economic and social impact of the cluster's activities on Lithuanian regions has been identified.** Scientific literature analysis has indicated that there is a lack of research manifesting both the economic and the social impact of the use of biomass on the region of activity. The social aspect is evaluated as a kind of synergy and the impact is often not monetised. The calculations presented in the dissertation highlight the significant impact of the cluster on the social pattern of the regions – a better redistribution of regional budgets, a decline in unemployment and an increase in employment rates. The dissertation has assessed the data from Lithuanian regions, but both the research methodology and the subsequent investigation actions can be used for the assessment of other countries without restrictions.
5. **A biomass convergence index has been compiled.** A biomass convergence index for the integrated assessment of the economic impact of biomass clusters, concentrating the indicators from an economic, social and environmental perspective has been compiled. The index enables to see the progress of the period under analysis in the municipalities, the competitiveness of the municipalities and their abilities to cluster and converge. The index is universal, suitable for measuring different countries through the regional dimension. It enables to compare biomass both within the country and with regions in other countries. The biomass convergence index consists of two sub-indices which define the income generated in the regions and the costs incurred in them.

The dissertation structure:

The first part of the dissertation presents the theoretical aspects of the biomass business, the conditions for clustering and the main obstacles hindering the development of clustering of biomass. The structure of biomass with economic value, as well as the structure of final products with economic value is created. The impact of biomass clustering on different economic levels is described, the role of the cluster in the market in the context of the activities of other clusters is defined. It is stated that the biomass cluster uses the same supply infrastructure and that the competitive advantage of the cluster is linked to cost management. At the end of the first part the biomass cluster value chain is formed.

The second part presents the analysis methodology that is used to perform the analytical steps. The methodology consists of clusters, factors, analyses of the main components, resulting in a convergence index for biomass at the final stage. The research follows the logic of a multi-criteria evaluation. The experience of foreign countries in carrying out similar investigations is presented in order to substantiate the logic of the dissertation research and to indicate the main differences among national investigations. This part states that the supply chain is the main link in the biomass cluster in which strict cost management is necessary.

Finally, factors of the structure of the biomass market indicating the impact of the biomass cluster on the different economic links, as well as the overall impact on the internal market have been presented. The market changes caused by the factors presented shall be substantiated by the analytical steps performed in the third part.

The third part is intended to verify the biomass convergence index and produce the results that would substantiate the distribution of regions according to the way of fuel used and the impact created by this decision. First the research presents the results of cluster analyses indicating the distribution of regions according to economic, social and environmental factors. The verification of the biomass convergence index is being carried out in order to clarify how the use of biomass has had an impact on the economy in an integrated manner. The index aims to clarify the distinction between the development of the regions using biomass and imported fuels. The research examines the period of 2008-2017, using the data from Lithuanian regions which have central heating systems.

Limitations of the study. The main factors which have limited the conducting of the dissertation research are related with certain data groups. All the income and expenses of the budgets of municipalities (regions) without separating the ones which were created from the activity of biomass use have been evaluated. The change of the indicator enables to establish the dynamics between the activity of biomass sector and general situation of the municipality (region). The revenue from the personal income tax received from the power generation sector is summarised, i.e., the size of the indicator reflects the production of power from both biomass and fossil fuel. The relevance of the indicator especially grows at the moment of conversion during the comparison of the municipalities (regions) employing biomass and fossil fuel and the dynamics of their income.

Content of the dissertation. The dissertation consists 200 pages, including Figures 41 and Tables 24, 567 Literary Sources.

Publication of the results of the dissertation: The results of the thesis have been published in 18 scientific articles. All the results obtained during the scientific work have been published in English, with majority of articles published in foreign scientific publications.

1. ASSUMPTIONS FOR THE FORMATION AND DEVELOPMENT OF BIOMASS CLUSTERS

1.1. The inevitability of the clustering of biomass in today's economy

1.1.1. Structure of the biomass energy sector

The ever-increasing development of renewable energy ideas around the world is the basis for the growing interest of scientists in exploring the economic benefits of the energy generated from renewable resources. Countries where natural biomass resources are abundant focus more on studies of the positive effects of biomass use. The existence of different types of biomass determines the diversity of research when the utility characteristics of the use of individual fuels are analysed. The emphasis is placed on the fact that biomass is a clean renewable resource and particular attention must be paid to the sustainable use of fuels, without damaging nature and with the aim of restricting to the use of biomass waste.

1.1.2. Products in the biomass energy market

During the development of biomass energy, the products are different, but they ought to be classified into two groups: primary and final products. The primary products are intended for the production of energy as the final product. These are various types of organic waste that can be incinerated or putrefied. They produce final products which are later sold in the form of energy. The cost of the final product depends on the original product type and varies from country to country depending on the renewable resources available in that country. The expansion of industrial activity leads to the emergence of new biomass sub-sorts that are subsequently used for energy generation.

1.1.3. Main barriers to the clustering of biomass and institutional obstacles

The main obstacles to the growth of the use of biomass and the clustering of the sector are mainly financial, administrative and political. External threats may threaten the existence of a biomass cluster. Faced with these obstacles the cluster wastes considerable financial and time resources, thus reducing involvement in key activities. In addition, the problem of data analysis is also relevant. According to Popp, Lakner, Harangi-Rakos, Fari (2014), the bioenergy sector is relatively complex because there are many forms of biomass resources; various solid, liquid, and gaseous bioenergy carriers; and numerous routes available for their conversion to useful energy services. Biomass markets often rely on informal structures, which make it difficult to formally track data and trends. Upreti (2004) presents some examples demonstrating that major barrier to promote biomass energy is public distrust and siting conflict. The main financial cause of retardation of clustering in biomass sector according to Baxter (2005) is the expensiveness of the technology. A general conclusion is that biomass cofiring

is commonly slightly more expensive than dedicated coal systems. If there are no motivations to reduce CO2 emissions, the rationale for cofiring is difficult to establish. At the same time, the role of the state in re-orienting the energy sector towards the use of renewable resources is crucial. This would allow avoiding artificial blocking of the development of activities, but would require a well-functioning public administration mechanism to achieve the objective. Political barriers can prevent a business initiative to act, thereby promoting inefficient and polluting energy production. At the same time, the threat of corruption in order to circumvent decisions that are unfavourable for business appears. The scientific level at which the state is present is crucial - it can determine the successful process of conversion of biomass.

1.2. Reasons for the clustering of the biomass sector

1.2.1. Micro- and macro-level effects of biomass clustering

The biomass cluster generates manifold impact on both the state and society. The positive impact of the cluster manifests itself in the creation of new workplaces, increase of energy independence and the employment of ecological ideas for today's societal needs. The opportunities for creating benefits from the clustering of biomass to a large extent depend on the reasons of development of clusters. They can be conditioned by a variety of reasons most of which depend on the particularity of the country. The reasons of development are most visible when the country is looking for secure energy supply on a local resource basis.

1.2.2. The Factors of a Conceptual Model of Evaluation of the Impact of a Biomass Cluster on Economy

In general the structure of a cluster can be defined as an interaction of reacting factors when the representatives of separate processes after uniting into a cluster are striving for positive financial impact. The whole structure of a cluster presented in Figure No 2 indicates the direct cooperation and the overlapping of activities of every factor. Every factor is inseparable from the cluster activity, but their contribution to daily and the long period cluster activity is different. For ensuring the daily activity the interaction of the supply chain and the providing structures is necessary. For the success of the long period these elements must take into consideration the opinion of advisers. The role of municipal and state institutions is irregular and not necessarily positive. It is especially obvious in developing countries which do not have the culture of understanding of business demands. In the most positive case the municipality is included in the cluster activity as the manager of the municipal networks and in this way it becomes one of the subjects directly feeling the positive economic impact.

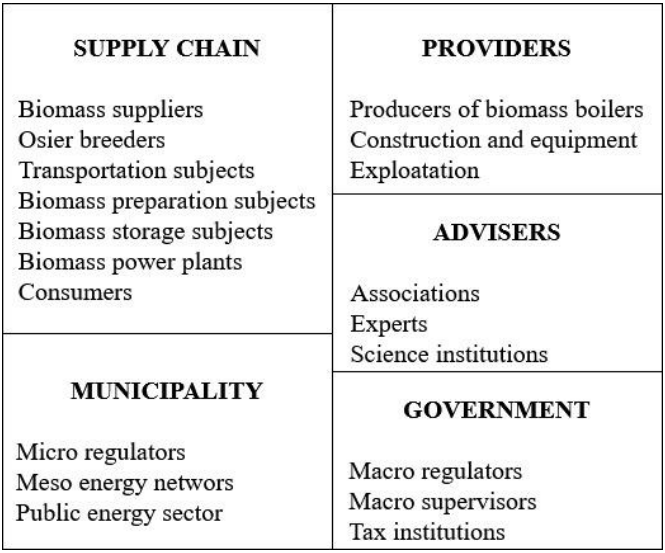

Figure No 1. The structure of a biomass cluster – the factors from the institutional viewpoint

The sector of biomass energy can be presented via the interaction of resources and products markets. Biomass preparation entities, biomass managers, logistics and transportation structures are attributed to resources market. The main goal of the participants of resources market is to provide biomass to power plants using it and create value from the greens which are universally considered to be waste. The resources market is characterised by a big number of market participants, as the aim is to decentralize the directions of biomass supply. All the entities having biomass resources in their disposition can participate in it. In the resources market solid biomass, solid and liquid agricultural waste and sub-products obtained during the management of conservation of the environment are employed. They are adequately processed and delivered to the incinerating equipment. A marked quantity of low skilled human resources is employed in the market activity, in this way the regions employment problem is solved. All the activity is carried out in the regional rural localities in which the quantity of the renewable biomass resources is abundant. The main direction of prepared biomass supply is city localities, industrial enterprises for which heat energy, electricity or natural gas is necessary. The phases of market action are related to weather conditions and the quantity of constant energy demand. During the heat supply season the biomass demand increases and during the warm season of the year biomass is used for the satisfaction of the demands of industrial enterprises and domestic electricity and gas consumers.

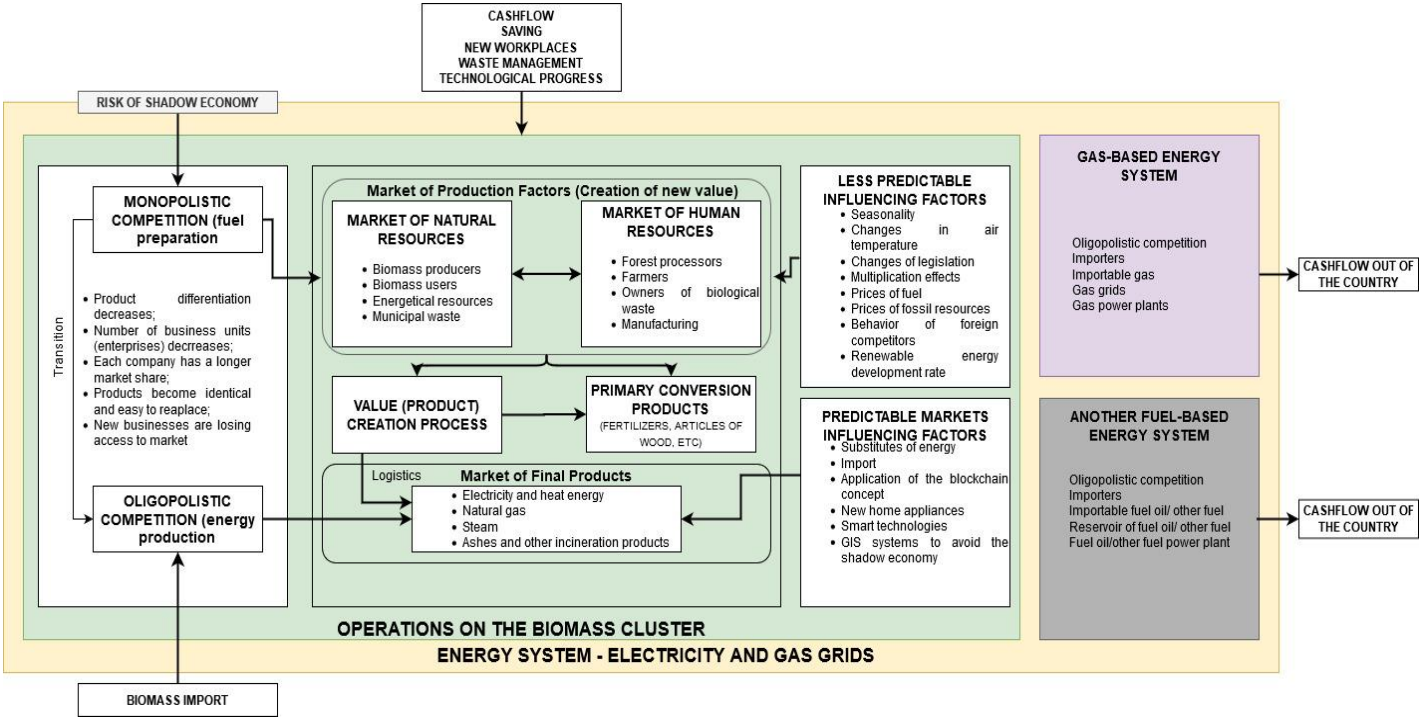

Figure No 2. Factors in the structure of the biomass energy market

2. THE METHODOLOGY OF EVALUATION OF THE IMPACT OF BIOMASS CLUSTER ON THE MACROECONOMIC LEVEL

2.1. The Good Experience of the Renewable Energy Clustering Processes Abroad

The development of the biomass clusters is influenced by the formed trends of fuel consumption. It is reflected during the analysis of the experience of different countries. During the analysis of the features and impact of clustering in the biomass sector it is necessary to see into the examples of separate states.. The aim of the analysis of the experience of states has been to systematise the principles of the action of a cluster and to cleanse the directions of the impact.

2.2. The Methodological Solutions of Evaluation of Biomass Clusters Impact on Economics

The formation of the research methodology is inseparable from consecutive steps by which the conducting of the dissertation research is regulated. In this case empirical research consists of several parts uniting different statistical methods. During the final research phase a general index is compiled which will enable to verify the created evaluation model and create the conditions for its application for the investigations of energy independence of different states. Till that phase the principal evaluation indicators are chosen, their significance and positions in the index are established (Figure No 1).

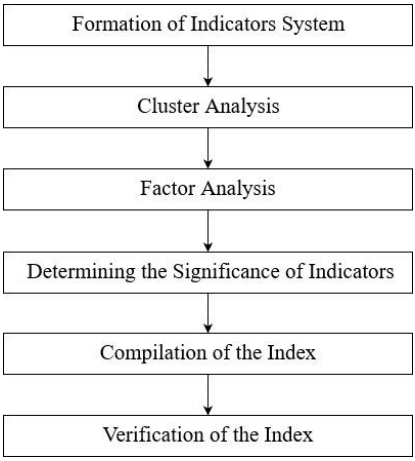

Figure No 3. The logical sequence of the stages of the research methodology

During the final stage of application of the methodology the value of the index is calculated. The index in this case is named *biomass convergence index*.

The index consists of two sub-indices the values of which are calculated according to formulas:

$$RAS_{BCI} = w_1 \times regional\ income\ factor + \\ + w_2 \times the\ situation\ of\ forests\ in\ the\ region \quad (1)$$

$$RCES_{BCI} = w_3 \times main\ expenses\ factor + \\ + w_4 \times heat\ price\ factor \quad (2)$$

$$\boldsymbol{BCI = RAS_{BCI} - RCES_{BCI}} \quad (3)$$

In the formula:
RAS_{BCI} - Regional activity sub-index
$RCES_{BCI}$ – Regional cumulative expenditure sub-index
$w_1 \ldots w_4$ - factors' weights
BCI = Biomass convergence index

3. THE EMPIRICAL SOLUTIONS OF THE EVALUATION OF THE IMPACT OF BIOMASS CLUSTER ON ECONOMY

3.1. The Research of the Country Regions on the Basis of Conceptual Model of Evaluation of the Impact of Biomass Cluster on Economy

In the first case the results of the early period – 2008 have been analysed (Figure No 4). In this case the regions are distributed into the second and the third clusters. There is no precedent of the first cluster which would characterize so far relatively passive municipalities. The major part of the municipalities belongs to the second cluster. As has been investigated before, the municipalities of the second cluster are characterized by the use of fossil resources and relatively lower analysed indicators. The major part of the municipalities located in the Eastern Lithuania which have abundant biomass resources in their disposition belong to the third cluster. Varena, Mazeikiai, Ignalina municipalities ought to be attributed to the municipalities which use biomass relatively abundantly. Other municipalities such as Prienai, Rokiskis, Kelme, Svencionys municipalities are characterised by big forest covers and strong sector of biomass preparation, however the amounts of biomass consumed by them during the analysed period were not marked. Other municipalities are attributed to the second cluster. Nearly all the municipalities are in Middle Lithuania excluding several individual municipalities in the Western and Eastern Lithuania. The only observed exception is Panevezys City Municipality in which biomass was used relatively abundantly,

although due to the size of the municipality no biomass preparation sector of a wide scale was created. Excluding Lazdijai, Sakiai, Zarasai municipalities for the production of heat energy the absolute majority of the municipalities of the second cluster were using natural gas. The mentioned municipalities although they had abundant resources of biomass and were using them for energy generation had not managed to exploit the natural resources enjoyed by them on a wider scale.

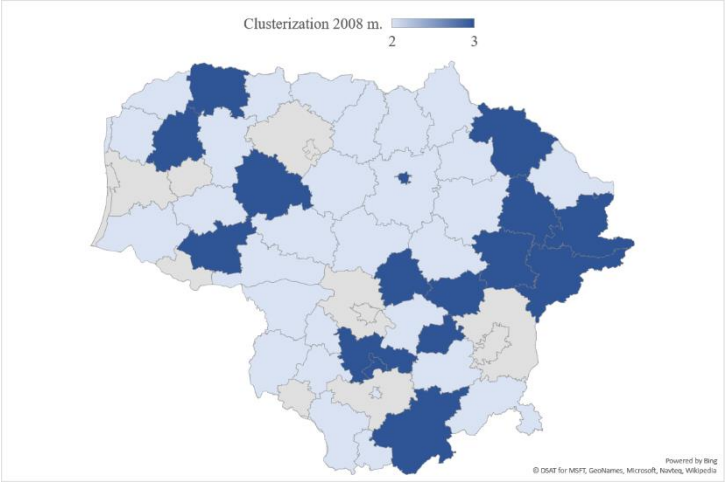

Figure No 4. The results of clustering applying clusters analysis of 2008.

The results of 2017 have been presented likewise (Figure No 5). In this case the effect of biomass conversion is clearly visible – the number of municipalities which have been attributed to the third cluster has grown significantly. Nearly in the whole Middle Lithuania excluding the Kedainiai District Municipality conversion effect has occurred – the municipalities have progressed to the use of biomass, improving the other analysed indicators in this way as well.

In comparison with the period before a decade only three municipalities the results of which are attributed to the second cluster have remained. In these municipalities biomass makes the main share in the general consumption of fuel, but these municipalities have no big own fuel resources and this has hindered the creation of strong biomass preparation sector. Inter alia these municipalities have inveterate problems of unemployment, the level of salaries is also low and the heat price due to the lack of efficiency of fuel use is high. During the analysed period a situation which significantly increased the number of municipalities belonging to the first cluster has arisen. It indicates that these municipalities have not managed to avail of the enjoyed advantages (in the form of resources) via the creation of positive impact on the region and the society. Although these municipalities are using biomass in the major part of cases, have abundant

resources of this fuel, the sector of fuel preparation had not been created in them, they have not managed to reduce the number of the payees of welfare benefits and create well paid workplaces. This has reduced the competitiveness of the municipalities, although a decade before they were among the leaders. This enables to state that the disability of these municipalities to encourage the business entities to develop the processing of natural resources into biomass has reduced the attractiveness of these municipalities among both the society and the business entities.

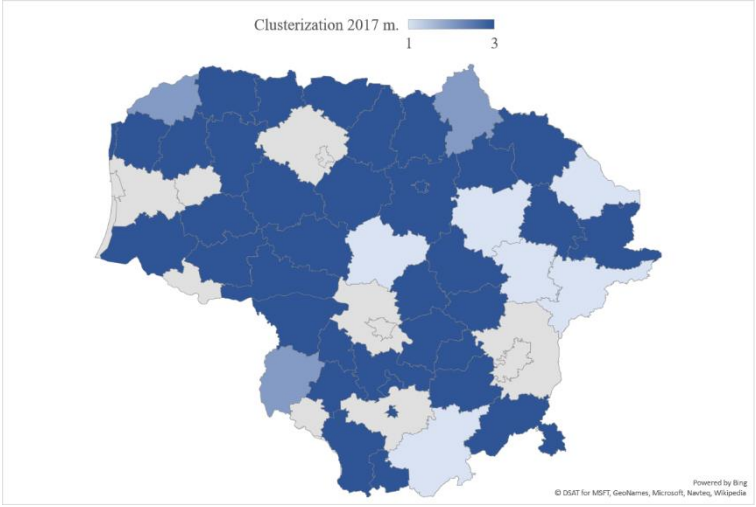

Figure No 5. The results of clustering applying clusters analysis of 2017.

3.2. The Analysis of Factors and the Results of the Analysis of the Main Components

As the author has the results of the analysis of factors and main components he proceeds to the compilation of a universal Index. The index is compiled of two parts by concentrating the data obtained during the calculation of the Regional activity sub-index and Regional cumulative expenditure sub-index. The sub-indexes are obtained according to the loads of the square coefficient of the positively classified indicators and expenses indicators and the distinguished factors. In this way the formula of the first sub-index is obtained:

$$RAS_{BCI} = 0{,}83 \times regional\ income\ factor\ + \\ + 0{,}17 \times\ the\ situation\ of\ forests\ in\ the\ region \quad (4)$$

The formula of the second sub-index is obtained likewise. As in the first case the evaluation is done via the regional dimension as well. Generalising the

obtained results the formula of the Regional cumulative expenditure sub-index is formed:

$$RCES_{BCI} = 0{,}97 \times main\ expenses\ factor + \\ + 0{,}03 \times heat\ price\ factor \quad (5)$$

As the author has the data of every region on the performed activity creating added value and the incurred expenses, a universal assessment index is obtained. It will help to verify the results obtained in the theoretical part, in this way indicating the impact of use of biomass on the regional economies. The index is named biomass convergence index aiming to demonstrate the complexity of the impact of biomass use and the created opportunity for interregional cooperation. The biomass convergence index is calculated according to formula:

$$\boldsymbol{BCI = RAS_{BCI} - RCES_{BCI}} \quad (6)$$

3.3. The Statistical Grouping of the Regions Using the Biomass Convergence Index

The verification of the compiled index is performed employing the data groups presented in the methodology of the research. Just as in the case of clusters analysis 47 municipalities are evaluated without evaluating the municipalities which do not possess well-developed central heating systems, also the four great cities and the circular municipalities surrounding them. According to the established weights of different indicators analytical actions which will enable to establish the value of biomass convergence index of every municipality in 2008-2017 are performed. The values of the index have been obtained using the normalized indicators, in this way aiming to equalize the different dimensions and quantities of the analysed constituents. The maximal value of the index is 1 (one), the bottom value reaches – 1 (minus one).

First of all the results of the initial period are separated (Figure No 6). At that time only several municipalities were using biomass in their energy system as the main source of energy production. Still the situation of that time has been insufficiently reflected in the index due to the biomass import possibly carried out by the municipalities and the sector of biomass preparation unfunctioning in them. It was especially reflected in high unemployment rate, big expenses for welfare benefits, small average salary. At the same time due to the lack of the related businesses the income of the municipalities budgets were at a low level. The changes of the heat prices were uneven, as the biomass market had not been formed and was not competitive and this did not ensure the most favourable conditions to purchase fuel at a competitive price. At the same time the projects of forest management which during the latter years used to contribute to the saturation of the biomass demand and the maintenance of competitive price level significantly were not being implemented fundamentally. All this determines the relatively low, in certain cases even negative indicators of the first year of the

analysed period. The latter aspect is conditioned by high level of the use of imported gas and the inveterate social problems. From the historical perspective one can state that the beginning of formation of the biomass sector in 2008 which essentially was not active – was based on several precedents which appeared in certain districts, in different places of Lithuania. It ought to be considered as unclusterised actions, separate initiatives of enthusiasts, when it had not been clear in which direction this sector will move. In the picture sufficiently significant non-uniformities between municipalities can be seen, in this way certifying about the adolescentia of the sector and the dependence of the energy systems of the regions on the imported energy resources.

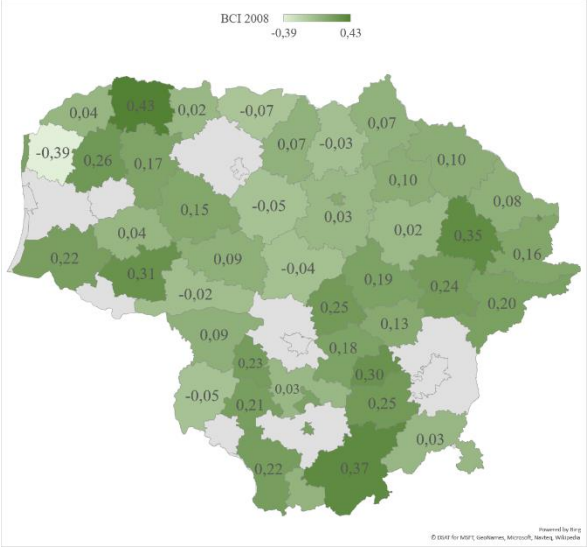

Figure No 6. The results of verification of biomass convergence index in the case of Lithuanian regions in 2008.

During the last year of the investigated period significant changes in evaluating the results of the index occurred. The rising economy level and the stable growth of biomass use has determined the fact that no municipalities in which the value of the index was negative have remained (Figure No 7). All the regional municipalities have significantly increased the quantities of biomass use changing the outdated gas or oil-incineration boilers to new capacities using biomass. The employed Lithuanian technologies have created synergy and increased the indicators of the municipalities' profit-making capacity.

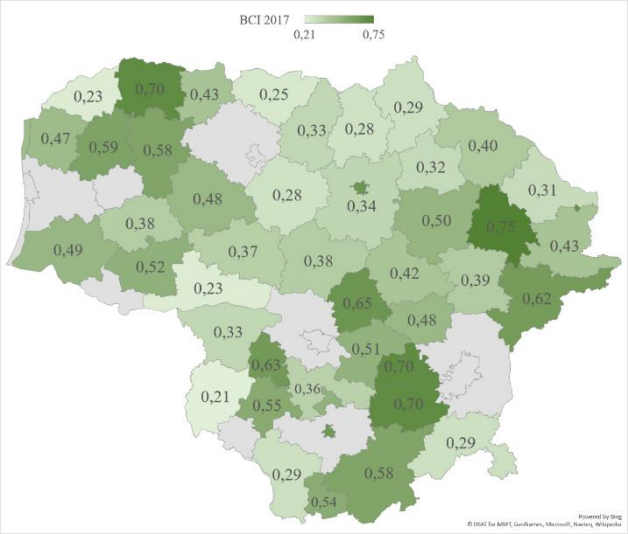

Figure No 7. The results of verification of biomass convergence index in the case of Lithuanian regions in 2017.

The performed analysis has indicated that the cluster model presented in the theoretical part is acting in the market by changing the economic structure of the regions. The scale of the use of biomass has directly influenced the dynamics of the income of municipalities, the social pattern and the efficiency of the use of means increasing due to it. The analysis based on the use of clusters analysis and the verification of the biomass convergence index has enabled to see the impact of biomass use during the latter decade in various angles. The results enable to state that the employment of biomass changes the economy structure, as on the basis of local resources energy products, new workplaces are created, the environmental state is improved and the competitiveness of the municipalities is increased. At the same time it is proved that municipalities can cluster and inter-cooperate in the aspects of fuel supply and efficient use of natural resources. In the un-clustered municipalities the social disjuncture increases and the economic structure remains fundamentally unchanging.

CONCLUSIONS AND RECOMMENDATIONS

1. The analysis of the scientific literature has enabled to separate out the following motives of biomass clusterisation:

- *The aim to extract economic value from waste*. Biomass clusters aim to extract value from devalued resources which had not been used till that time. The essential motive of cluster activity is the employment of waste in the process of value creation.
- *The conformity with the principles of sustainable development.* The process of value creation is inseparable from the principles of sustainable development. During the performance of the activity, solutions which would be keyed to economic, social and environmental principles are constantly sought.

Indefiniteness in the following spheres can prevent from the implementation of had clusterisation motives:

- *Political restrictions*. Political indefiniteness or even formed adversarial attitude towards cluster activity can prevent or completely discredit it. Fundamentally it can be related to the patronage of employment of fossil fuel.
- *Gaps in legal system.* Incompletely regulated legal use of biomass can have negative effects on the striving to use waste, employ innovative generation ways and build new power plants using biomass.
- *Failure to follow the principles of sustainable development* related to the irresponsible exploitation of biomass sources, employment of food raw materials and use of land fit for them.

Specific measures related to the application of technologies, explicitness of legal regulation assist in eliminating or reducing the influence of obstacles. It should be recommended to take into consideration the quantity of the possessed biomass resources and to take decisions concerning the conversion of the power system on the basis of it. Under few local resources it is worthwhile to take into account the neighbouring regions supposing the provision of biomass from them.

2. After the systematisation of the economically valuable biomass resources into a uniform system it has been established that the economic value created in the region is divided into two parts. The first part encompasses the processing of primary biomass products into biomass fuel. The economically valuable biomass depending on its sort is used under different circumstances:

- In the primary stage of biomass power sector it is necessary to use the forming wood waste the source of which are the forests managed in accordance with the projects of forest management, also the waste got after separating the high-yield and low-value wood. The use of wood waste would enable to create economic value in several trends – first of

all, value would be extracted from the raw materials which are not fit for processing. Secondly, the wood waste is formed naturally, so its extraction does not require a long period.

- Aiming to conform with the principles of sustainable development, during the strategic period it is necessary to plant plantations of energy crops, diversifying the supply of biomass and maintaining the environmental balance in this way. The growing of energy crops must take place in the land plots exclusively unfit for agriculture where the extraction of value by growing the plants fit for food is impossible. The use of infertile land for power industry will enable to extract economic value, diversify farmer income and maintain a stable level of biomass prices.
- It is necessary to develop the infrastructure of employment of biomass aiming to manage the waste of biological origin efficiently and sustainably, at the same time extracting from it economic value – fundamentally that is the energy of all types, the ecological fertilizers as well. The employment of biogas is possible in rural localities, eventually it can become one more measure for creating jobs and new business entities.
- The remaining sorts of biomass must be employed in such a way that they could create positive impact on waste managers and society. It is necessary to invest in new sorts of production aiming to employ the forming waste as effectively as possible, however, the investments must be carried out following the economic logic.

The second part of the value created within the region encompasses the energy produced from biomass in the power plants. Aiming to create positive economic impact, the following principles should be taken into consideration:

- If it is technologically and financially possible, it is necessary to undertake combined heat and power generation in cogeneration power plants.
- Under an opportunity it is necessary to catalyze projects of biogas generation aiming to reduce the employment of natural gas in households.

3. The impact of clusterisation of biomass sector encompasses microeconomic and macroeconomic factors. The impact of biomass clusterisation on microeconomic level manifests itself in the following aspects:

- *Decentralisation of power generation in the region*. The employment of biomass creates the conditions to diversify the power market in the region, thus increasing the competitiveness of the locality.
- *The increased level of innovativeness.* The activity of the biomass cluster is constantly innovated, thus forcing other power industry structures to maintain high level of efficiency.

- *The springing up of new business entities serving the cluster.* The constant necessity to provide biomass and maintain a smooth supply chain creates the conditions to establish new SMEs entities.

The impact created by the clusterisation of biomass sector on the macroeconomic level is concentrated on the following trends:

- *The growth of energetic safety*. By diversifying the energy system of the region a biomass cluster increases the energetic safety level, as the cluster activity enables to avoid the external sabotage actions appearing due to the unexpected interruptions of energy resources supply and the inadequately growing prices of the resources.
- *The improvement of environmental situation and the positive economic consequences resulting from it.* By employing organic waste which in certain cases may have negative impact on environment, economic value is extracted and cleaner dwelling environment is created.
- *The improving life quality and social situation in the regions.* The clusterisation of biomass enables to create new jobs in the whole supply chain of biomass thus reducing the scale of social problems and creating an independent, ambitious and satisfied society.

4. The developed conceptual model of the evaluation of the impact of biomass cluster on economy is based on the separated out factors of biomass market structure. The main axis of the factors is the transition from the monopolistic competition state in the sector of biomass preparation to oligopolistic competition in the execution of power generation. During the transition different products of fuel, energy and by-products are created. They are marketed in both local and international market. The factors of market structure encompass the market changes which happen during the production of different products and also the market participants which participate in the processes of product development. The factors which are forecastable and the factors which are difficult to forecast have been defined. In both cases it can significantly impact on the remaining structure factors, ipso facto influencing the competitiveness of the whole activity of biomass cluster. The conceptual model proves the complexity of the biomass market and its multidirectional impact on the evolution of economy. It has been imparted via the link between economic, social and environmental perspectives. In this way the created synergy which progresses via the levels of sustainable development is demonstrated. Employing the developed research methodology the impact of market structure factors on economy is investigated. The axis of the methodology is the compiled biomass convergence index and the verification of the index making use of the data of the regions of Lithuania. The main limitation of the research is the fact that the whole revenue collected by the municipalities (regions) and their expenses have been evaluated without deducting the share of income related with biomass. The income from personal income tax received from

the power generation sector has been summarised by evaluating the power plants using biomass and imported gas.

5. During the cluster analysis while investigating the statistical indicators of the regions it has been stated that:

- The regions are being fragmented according to the type of the used fuel and the impact created by this solution on other levels of economy. The municipalities using fossil fuel get less income into their budgets, collect less personal income tax and their population buys thermal power for a higher price. The situation is opposite in the municipalities using biomass – in them significantly more personal income tax is collected from the sector, the heat price is significantly less, thus indicating the opportunities of the populations of these municipalities to save means or redirect them to other directions.
- During the change of the analysed period the structure of clusterisation changes as well – the regions which had progressed to the use of biomass were significantly improving their results on the economic and social plane. It has been investigated that the regions using biomass increase the level of the received income, ipso facto, the conditions for bigger expenses are created in them.
- The indicators of the registered unemployed and the expenses for welfare benefits in the municipalities using fossil fuel in comparison with the results of other municipalities are markedly bigger and also inversely proportional to the dynamics of employment of biomass.
- The municipalities in which the level of forest cover is high and which are implementing projects of forest management on a vast scale are not able to multiply the created positive impact and to spread it wider to economic and social spheres.

6. The created biomass convergence index demonstrates the income received in the region and the expenses incurred in it which are related to the economic and social state of the region. The present proportions of the biological wealth and the scales of management of this wealth have been presented as well. The application of the index has demonstrated that:

- During the primary period of the research the following several municipalities were distinguished for positive values - Mažeikiai district (0.43), Varėna district (0.37) and Utena district (0.35). The latter municipalities were the main axes of the municipalities of South-western Lithuania using biomass. The least value (-0.39) was recorded in Kretinga district. The main causes of change of the indicators were as follows: the type of the used fuel, the collected personal income tax and the dynamics of the recipients of the welfare benefits.
- During the period of economic depression the data of all the municipalities significantly declined. Only the municipalities of Kazlų

Rūda, Birštonas, Elektrėnai and Varėna districts retained positive index values during the period of 2009-2012. It was related to both the prevailing use of biomass and the strong sector of biomass preparation. The least value of the index (-0.52) was recorded in Vilkaviškis District Municipality in 2011-2012, it was determined by one of the highest prices of heat in Lithuania resulting from the use of imported fuel and multiple social problems.

- In 2013-2017 the following three municipality clusters formed: South-eastern Lithuania (biomass convergence index average in 2017 – 0.45), Western Lithuania (biomass convergence index average in 2017 – 0.41) which represent the employment of biomass and Middle Lithuania (biomass convergence index average in 2017 – 0.32), the user of concentrating fossil fuel. The highest value of the index during the analysed period was recorded in 2017 in Utena District Municipality (0.75), whereas in Vilkaviškis District Municipality the least index values continued since very 2011.
- The performance of sensitivity analysis has demonstrated that under the change of conditions municipalities converge differently. In the case of income change municipality clusters of two levels appear, they are expeditiously or especially expeditiously creating the sector of biomass preparation, increasing the collection of taxes and the generation of biomass within the region. The control of the expense sensitivity has enabled to maintain more equal results by maintaining the pattern of the same three clusters of big municipalities.

The verification of the index has proved that the employment of biomass influences different levels of economy and the regions which are characterised only by strong biomass preparation sector are less competitive than the regions which besides it satisfy all their needs for thermal power employing biomass. The employment of biomass changes the economic and social pattern of the region and it is reflected in the speed of the index growth. The regions which had high indicators of employment of biomass, but did not improve the social situation in the region have fallen behind the regions which were creating new jobs more expeditiously and were accumulating the taxes related with labour relations. The dynamics of the growth of the index indicates that during the growth of a region – leader, other municipalities around it were growing as well, thus reaching the convergence effect. More active actions in employing organic waste to generate power are necessary in the Middle Lithuania. A more active development of biomass preparation sector, thus increasing the number of jobs and employing the organic waste of various types, would enable to increase the index value significantly.

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REZIUMĖ

Tyrimo aktualumas. Kylantis susirūpinimas dėl visuotinio klimato atšilimo skatina investicijas į žaliosios energetikos sprendimus. Priklausomai nuo klimatinių sąlygų ir turimų natūralių išteklių gausos, pasaulio valstybės renkasi skirtingus žaliosios energijos gamybos būdus. Išsivysčiusiose Vakarų Europos valstybėse ir Jungtinėse Amerikos Valstijose orientuojamasi į elektros gamybą plėtojant vėjo ir saulės išteklių panaudojimo technologijas. Tuo tarpu šilumos gamybos sektoriuje susiduriama su tam tikrais iššūkiais – kaip pagaminti didelius energijos kiekius nekenkiant aplinkai, ir tuo pačiu pakeičiant taršų anglies ir gamtinių dujų kurą. Mokslinėje literatūroje kaip rentabilūs atsinaujinantys energijos ištekliai minimi geoterminiai vandenys ir biomasė (Caputo, Palumbo, Pelagagge, Scacchia, 2005); Kulcar, Goricanec, Krope, 2008); Wünsch, Gruber, Claupein, 2012); Ruzzenenti, Bravi, Tempesti, Salvatici, Manfrida, Basosi, 2014; Karimi, Mansouri, 2018). Tačiau geoterminio vandens ištekliai pasaulyje pasiskirstę netolygiai, o biomasės paruošimas į biokurą leidžia kartu gaminti tiek šilumos, tiek elektros energiją. Be to, biokuras yra neutralus aplinkai, kadangi deginant išskiriamas tik toks anglies dioksido kiekis, kurį augalas sugėrė per tam savo gyvavimo ciklą. Kitais atvejais biokuro panaudojimas energijos gamybai turi teigiamą poveikį ekonomikai – biokuro apdorojimas biodujų reaktoriuje leidžia išskirti ir sudeginti pavojingas metano dujas, kurios kitu atveju patektų tiesiogiai į planetos atmosferą. Visi šie veiksniai sukūrė padėtį, kad biokuras yra vienas iš ekonomiškai rentabiliausių žaliųjų energijos gamybos sprendimų. Vis dėlto, mokslinėje literatūroje dar nepakankamai įvertinama, koks yra biokuro panaudojimo poveikis ekonomikai, socialinei sanklodai, aplinkosaugai. Stokojama tyrimų, kurie leistų pagrįsti sinergiją tarp biokuro panaudojimo ir visuomenės turtėjimo, ypač besivystančiose valstybėse.

Ne išimtis ir Lietuvos Respublika. Šalis, remdamasi nustatytais Europos Sąjungos normatyvais, yra įsipareigojusi didinti energijos, pagamintos iš atsinaujinančių išteklių kiekį. Kartu su pasauliniu ekonomikos nuosmukiu Lietuvoje padidėjo vietinio atsinaujinančio kuro panaudojimo apimtys. Ypač išaugo kietosios biomasės panaudojimas. Lietuvai didinant pagamintos energijos iš biokuro kiekį, iškyla klausimai dėl biokuro pakankamumo ir jo naudojimo darnumo su aplinka. Atsinaujinančių išteklių panaudojimo energetikoje poveikis ekonomikai dar nėra plačiai ištirtas. Pastebimas ir kitas aspektas – esamuose tyrimuose neįvertinamos darnaus vystymosi normos gaminant energiją iš šių išteklių. Plačiausiai vertinamas ekonominis biokuro panaudojimo poveikis atskiroms subjektų grupėms. Tuo tarpu šiandien, vystantis klasterizacijos idėjoms, teigiamas biokuro panaudojimo poveikis gali dar padidėti. Klasterizacija gali padėti apjungti skirtingus energetikos sektoriaus išteklius siekiant bendro tikslo – tvaraus biomasės panaudojimo gaminant šilumos ir elektros energiją. Tai aktualu

mažosioms šalims, turinčioms didelius vietinio kuro išteklius ir priklausomoms nuo energijos išteklių importo.

Klasterių koncepcija grįsta skirtingų, tam tikrame regione esančių subjektų, bendradarbiavimu ir vieno tikslo siekimu. Klasikinėje klasterio struktūroje sutelkiami finansiniai, žmogiškieji ir intelektualiniai ištekliai siekti klasterio veiklos tikslų. Disertacijoje nagrinėjamas reiškinys aktualus dviem aspektais. Pirmuoju aspektu, stokojama tyrimų, kurie pateiktų biokuro klasterio veikimą tam tikroje vietovėje. Antruoju atveju konstatuojama, kad biokuro klasteris yra skirtas tam tikro regiono ar regionų grupės energetinių poreikių tenkinimui. Tai iš esmės skiriasi nuo klasikinės klasterių koncepcijos, kai klasteryje esantys ištekliai ir darbas orientuojami į visos šalies arba eksporto rinkas. Biokuro klasterio veikla yra skirta išskirtinai veiklos regionui, tvariam jame esančių išteklių panaudojimui ir regiono turtinimui. Dėl egzistuojančių sinerginių efektų neapibrėžtumo ir dėl to kylančių sunkumų apibūdinti teigiamą biokuro konversijos poveikį atsiranda būtinybė išskirti teigiamas biokuro klasterio kuriamo poveikio kryptis ir apibrėžti rinkos struktūros veiksnius, kurie remia ir veikia einamąją biokuro klasterio veiklą.

Klasterizacija yra ypač skatinama Europos Sąjungos (ES) lygiu (EK, 2019). Komisija skatina mažas ir vidutines įmones (MVĮ) telktis į klasterius taip efektyvinant veiklą. Komisija yra nustačiusi instrumentus, skirtus finansuoti klasterių plėtotę, taip pat įpareigojusi valstybes nares papildomai prisidėti prie klasterizacijos skirtinguose verslo sektoriuose. Nepaisant to, pastebima, kad klasterizacija ES narėse iš Centrinės ir Rytų Europos (CRE) regiono dar yra pakankamai vangi. Tai gali būti sietina su nepakankamu verslo subjektų švietimu, kuris leistu išryškinti klasterizacijos naudą verslo vykdymui ir pridėtinės vertės kūrimui. Prie to prisideda ir sudėtinga šių valstybių praeitis, nepaslanki teisinė bazė, vyraujanti nepasitikėjimo atmosfera. Aktyvėjant klimato kaitos stabdymo idėjoms, klasterių vaidmuo taps dar svarbesnis, atsiradus būtinybei kolektyviai investuoti į taršos mažinimo ir tvaraus medžiagų naudojimo sprendimus. Biokuro klasteris išskirtinai prisidėtų prie klimato kaitos mažinimo tikslų pasiekimų, kadangi klasterio veikla leistų gaminti žaliąją energiją, o sutelkti ištekliai leistų sukurti didesnę pridėtinę vertę.

Mokslinė problema. Kaip įvertinti biokuro klasterių poveikį regionų ekonominei sanklodai vertinant per vietinių išteklių panaudojimo prizmę.

Mokslinės problemos ištirtumo lygis. Biokuro, kaip energetikos vieneto, sektoriaus klasterizacija yra santykinai menkai ištyrinėta. Į biokuro panaudojimą energetiniams poreikiams tenkinti mokslininkai atsigręžė maždaug prieš dešimtmetį. Atliktuose moksliniuose tyrimuose analizuojama problema nagrinėjama fragmentuotai, tiriant tik tam tikrą konkrečią poveikio kryptį. Pastebimas regioninis aspektas – skirtinguose žemynuose tiriami skirtingų biomasės rūšių panaudojimo būdai ir formuojamas poveikis. Yra atlikta nemažai tyrimų, kuriuose pateikiamos biokuro panaudojimo galimybės industriniuose

klasteriuose (Herder, Stikkelman, 2004; Andersson, Broberg, Hackl, 2011; Broberg, Andersson, Hackl, 2011; Andersson, Broberg, Hackl, 2012; Tomei, Upham, 2011; Hackl, Harvey, 2013). Šiuo atveju biokuras yra laikomas antraeiliu veiksniu, patenkinančių industrinių klasterių energetinius poreikius. Tokiu būdu tiriama, kaip industriniai klasteriai pradeda biokuro konversiją, tačiau nepastebėta, kad biokuro pramonės subjektai būtų laikomi svarbia klasterio dalimi. Jie traktuojami kaip paslaugos teikėjai ir energijos pasiūlos užtikrintojai. Pastaruosiuose straipsniuose buvo nagrinėtos skirtingos biokuro rūšys – medienos biomasė, metanolis, skirtingų rūšių dumbliai.

Didžiojoje dalyje tyrimų ekonominis poveikis pateikiamas kaip viena iš techninės modernizacijos pasekmių. Vyrauja kombinuotas techninis – ekonominis vertinamas, kai išskiriama techninė perspektyva, tuo tarpu ekonominiai veiksniai traktuojami kaip svarbūs, tačiau nelemiantys techninės modernizacijos sprendimo priėmimo (De, Assadi, 2009; Pirraglia, Gonzalez, Saloni, Denig, 2013; Klein, Chagas, Junqueira, Rezende, de Fátima Cardoso, Cavalett, Bonomi, 2018). Taip pat buvo vykdyti tyrimai, kai biokuro panaudojimas yra kombinuojamas su kito kuro panaudojimu (Gupta, Saini, Sharma, 2010; Theo, Lim, Ho, Hashim, Lee, Muis, 2017; Atkins, Walmsley, Walmsley, 2016). Šiuo atveju nėra konkrečiai akcentuojamas energijos vartojimo tikslas – vienu atveju tai gali būti klasterizuotos kaimų vietovės, kitu atveju – skirtingos verslo ir privačių klientų grupės. Biomasė užima reikšmingą vietą energijos gamyboje, tačiau ji yra kombinuojama su kitomis energijos rūšimis. Šiuo atveju taip pat akcentuojamos techninės ir politinės charakteristikos, tačiau stokojama ekonominio vertinimo, kuris leistų kiekybiškai apibendrinti biokuro panaudojimo poveikį veiklos regionui, jo ekonominei ir socialinei būklei.

Kita atliktų tyrimų grupė susijusi su žaliosios ekonomikos veiksniais. Visame pasaulyje biokuro, bioenergetikos, bioekonomikos klasteriai yra santykinai naujos sąvokos. Vis plačiau įveiklinant saulę vėją, geoterminę energiją, biokuro panaudojimas buvo primirštas ir laikomas ne tokia modernia opcija. Vis dėlto, klasterizacija sudarė sąlygas telkti išteklius ir apibrėžti biokuro energetikos vietą rinkoje. Vienas pagrindinių tokių klasterių atsiradimo veiksnių – kuriamas platus ekonominis poveikis. Vienais atvejais akcentuojamai platesnio masto bioekonomikos klasteriai, apimantys skirtingas švarios energijos gamybos technologijas (Stikkelman, Herder, van der Wal, Schor, 2003; Pätäri, Puumalainen, Jantunen, Sandström, 2011; Kalt, Kranzl, 2011; Kortelainen, Albrecht, 2013). Bioekonomika retais atvejais apima sinerginius efektus, kurie kyla naudojant biokurą – išlaidų aplinkosaugai mažėjimas, naujos darbo vietos, pigesnės vietinės energetinės žaliavos ir kt. (McKay, 2006; Kajikawa, Takeda, 2008; Huber, 2009; Scarlat, Dallemand, Monforti-Ferrario, Nita, 2015; Lund-Thomsen, Lindgreen, Vanhamme, 2016; Kircher, Breves, Taden, Herzberg, 2018). Ženkliai rečiau randama mokslinės medžiagos apie klasterius, paremtus medienos biomase (Aho, Kumar, Lashkul, Eränen, Ziolek, Decyk, ..., Murzin,

2010; Tégla, Hagen, Hollo, Takácsné, 2012; Shegelman, 2014). Būtent ši biomasės rūšis laikytina pagrindiniu biokuro ištekliumi, galinčiu sukurti didelę pridėtinę vertę verslui, valstybei ir visuomenei. Tiriant bioekonomikos krypties formavimąsi klasterių pavidalu, skirtingai nuo techninio-ekonominio vertinimo, matoma ekonominio vertinimo pastanga, siekiant pagrįsti teigiamą šios krypties kuriamą poveikį. Siekiant tai pagrįsti pasitelkiami atskirų šalių ir regionų pavyzdžiai, rodantys pastarųjų laikotarpių progresą. Dar viena klasterizacijos opcija – klasterio pagrindu laikyti tiekimo grandinę (Bernetti, Ciampi, Sacchelli, 2010; De Meyer, Cattrysse, Rasinmäki, Van Orshoven, 2014). Ji leidžia koncentruoti ir valdyti skirtingus procesus įtraukiant reikšmingą dalį skirtingų šakos subjektų.

Reikšmingai daugiau mokslinės produkcijos randama ieškant atsinaujinančių išteklių klasterių. Daugiausiai informacijos randama apie keleto technologijų derinimą, neišskiriant biokuro panaudojimo kaip kertinės pozicijos. Tyrimų objektai pasirenkami iš plačios amplitudės – tyrimas gali būti vykdomas per žemyno (Porter, 2008), šalies (Dudian, 2011; Essletzbichler, 2012; Hsu, Lin, 2012; Beloborodko, Romagnoli, Rosa, Disanto, Salimbeni, Karlsen, ...Blumberga, 2015), regiono (El Bakari, Myrzik, Kling, 2009; Zhu, Huang, Sharma, Su, Irwin, Mishra, ..., Shenoy, 2013), salos (Brown, Finn, Robinson, Salsbery, 2008), metropolio (Marra, Antonelli, Pozzi, 2017), pastato (Allen, Potiowsky, 2008) dimensiją. Didžiojoje dalyje straipsnių orientuojamasi į techninę analizę, ekonominius veiksnius nagrinėjant tik kaip papildomus. Šiuo atveju netiesiogiai pripažįstama, kad biokuras yra labiau tinkamas CŠT sistemose ir nėra toks lankstus kaip kitos atsinaujinančio kuro rūšys.

Visumoje galima teigti, kad mokslinės problemos ištirtumo lygis yra vidutinis – atlikta plati techninė analizė, tačiau ekonominio vertinimo diapazonas nėra platus. Stokojama ekonominio pagrindimo, kuris leistų įvertinti vietinių išteklių panaudojimo poveikį šalies ir regiono mastu, taip pat teigiamų regionų veiklos pavyzdžių vertinimo.

Mokslinio darbo objektas – biokuro klasteriai

Mokslinio darbo tikslas – sukurti konceptualų biokuro klasterio poveikio ekonomikai vertinimo modelį ir atlikti jo verifikavimą regiono aspektu.

Mokslinio darbo uždaviniai:

1. Išanalizuoti pagrindinius biokuro sektoriaus klasterizacijos motyvus bei vystymosi barjerus;
2. Suformuoti ekonominę vertę turinčio biokuro ir galutinių produktų struktūrą;
3. Ištirti biokuro sektoriaus klasterizacijos poveikį skirtingiems ekonomikos lygiams;
4. Sukurti konceptualų biokuro klasterio poveikio ekonomikai vertinimo modelį;

5. Ištirti Lietuvos regionų pasiskirstymą ekonominiu, socialiniu, aplinkosaugos aspektais;
6. Verifikuoti regionų energetinių išteklių panaudojimo poveikio ekonomikai vertinimo metodologiją pagal biokuro konvergencijos indeksą.

Tyrimo metodai:

- Mokslinės literatūros sisteminė, loginė ir lyginamoji analizė;
- Mokslinės literatūros analizės rezultatų sintezė;
- Loginė dedukcija ir indukcija;
- Tyrimo duomenų statistinė analizė: klasterių analizė, faktorių analizė;
- Matematinis ir statistinio apdorojimo metodai, naudojant statistines duomenų apdorojimo programas: SPSS (v21.0) ir Microsoft Excel (2016).

Disertacijos naujumas:

1. **Sukurtas konceptualus biokuro klasterio poveikio ekonomikai vertinimo modelis.** Modelyje sutelkiami pagrindiniai veiksniai, kuriems biokuro panaudojimas daro įtaką tam tikroje vietovėje. Modelis įvertina biokuro klasterio veiklos regionus, jų naudojamo vietinio kuro apimtis, veikiančią aplinką, taip pat įvardija mažai ištyrinėtus veiksnius, kurie gali turėti reikšmingą poveikį rinkos dalyvių sėkmei. Konceptualus biokuro klasterio poveikio ekonomikai vertinimo modelis leidžia identifikuoti pridėtinę vertę kuriančius regionus, pridėtinės vertės kūrimo apimtis, išreikštas augančia vietinio biokuro ruoša ir mažėjančiu energetinių išteklių importu ir pinigų srautų, sukurtų pakeitus importą vietine gamyba, kryptis. Modelis rodo, kad biokuro sektorius atitinka darnaus vystymosi principus visuose lygiuose, o gamybos ir tiekimo procesuose dalyvauja tik tam tikro regiono įmonės.
2. **Suformuota biokuro klasterio poveikio ekonomikai vertinimo metodologija.** Poveikio ekonomikai vertinimui naudojama metodologija, kuri apima ekonominius, socialinius, aplinkosaugos veiksnius. Pastarieji veiksniai rodo sinergiją, kurią biokuro klasteris kuria vykdydamas veiklą. Metodologija, apimanti plataus spektro duomenis leidžia tinkamai pagrįsti gautus biokuro panaudojimo poveikio rezultatus. Skirtingi metodologiniai instrumentai leidžia analizuoti turimus duomenis įvairiais pjūviais, taip pabrėžiant visapusį klasterio kuriamą poveikį šalies ir jos regionų vystymuisi.
3. **Ištirta biokuro klasterio ir šešėlinės ekonomikos sąveika ir nustatytos tam tikros biokuro klasterio dedamosios, kurios gali patekti į šešėlinės ekonomikos rizikos zoną.** Taip parodoma, kad klasteryje taip pat gali būti šešėlinės ekonomikos rizikos apraiškų. Ištirta, kad šešėlinė ekonomika gali susiformuoti tuose sektoriuose, kurie pasižymi žemu kontrolės lygiu ir sudėtingu procesų atsekamumu.

Biokuro klasterio atveju tai gali būti biokuro ruošos sektorius. Pripažįstama, kad neatsakingai kontroliuojama veikla gali sukelti netinkamo natūralių išteklių panaudojimo riziką ir perprodukciją. Disertacijoje siūlomi sprendimai, kurie leistų neutralizuoti šešėlinės ekonomikos riziką klasteryje, tuo pačiu užtikrinant klasterio veiklos skaidrumą ir darnumą.

4. **Nustatytas ekonominis ir socialinis klasterio veiklos poveikis Lietuvos regionams.** Mokslinės literatūros analizės metu paaiškėjo, kad stokojama tyrimų, kurie rodytų ne tik ekonominį, bet ir socialinį biokuro panaudojimo poveikį veiklos regionui. Socialinis aspektas vertinamas kaip tam tikra sinergija, tačiau dažnu atveju poveikis nėra išskiriamas tikslus ekonominių ir socialinių veiksnių poveikis. Disertacijoje pateikti skaičiavimai pabrėžia reikšmingą klasterio poveikį regionų socialinei sanklodai – geresniam regionų biudžetų perskirstymui, bedarbystės mažėjimui ir užimtumo lygio augimui. Disertacijoje vertinti Lietuvos regionų duomenys, tačiau tiek tyrimo metodologija, tiek po to sekantys tyrimo veiksmai gali būti naudojami kitų šalių vertinimui be apribojimų.
5. **Sukurtas biokuro konvergencijos indeksas.** Biokuro klasterių poveikio ekonomikai kompleksiniam vertinimui sukurtas biokuro konvergencijos indeksas, sutelkiantis ekonominės, socialinės ir aplinkosaugos perspektyvos rodiklius. Indeksas sudaro sąlygas pamatyti analizuojamo laikotarpio progresą savivaldybėse, savivaldybių konkurencingumą ir jų galimybes klasterizuotis bei konverguoti. Indeksas yra universalus, tinkamas skirtingų šalių vertinimui per regioninę dimensiją. Taip sudaromos sąlygos lyginti regionus tiek šalies viduje, tiek su kitų valstybių regionais. Biokuro konvergencijos indeksą sudaro du subindeksai, kurie apibrėžia regionuose generuojamas pajamas ir išlaidas.

Disertacijos struktūra:

Pirmoje disertacijos dalyje pateikiami teoriniai biokuro verslo aspektai, klasterizacijos sąlygos, pagrindinės kliūtys, kurios trukdo biokuro klasterizacijos plėtotei. Suformuojama ekonominę vertę turinčio biokuro struktūra, taip pat galutinių, ekonominę vertę turinčių produktų struktūra. Apibūdinamas biokuro klasterizacijos poveikis skirtingiems ekonominiams lygmenims, apibrėžiama klasterio vieta rinkoje, kitų klasterių veiklos kontekste. Konstatuojama, kad biokuro klasteris naudojasi ta pačia tiekimo infrastruktūra ir klasterio konkurencinis pranašumas yra susijęs su sąnaudų valdymu. Pirmosios dalies pabaigoje suformuojama biokuro klasterio vertės grandinė.

Antrojoje dalyje pateikiama tyrimo metodologija, kuria remiamasi atliekant analitinius veiksmus. Metodologija susideda iš klasterių, faktorių, pagrindinių komponentų analizių, galutiniame etape suformuojant biokuro konvergencijos indeksą. Tyrimas vykdomas pagal daugiakriterinio vertinimo

logiką. Pateikiama užsienio šalių patirtis vykdant panašius tyrimus, taip siekiant pagrįsti disertacijos tyrimo logiką ir nurodyti pagrindinius skirtumus tarp valstybėse vykdomų tyrimų. Šioje dalyje konstatuojama, kad tiekimo grandinė yra pagrindinė biokuro klasterio grandis, kurioje būtinas griežtas sąnaudų valdymas. Pabaigoje pateikiami biokuro rinkos struktūros veiksniai, rodantys biokuro klasterio sukeliamą poveikį skirtingoms ekonomikos grandims, taip pat kuriamą bendrąjį poveikį vidaus rinkai. Rinkos pokyčius, kuriuos sukelia pateiktieji veiksniai, turi pagrįsti trečiojoje dalyje atliekami analitiniai veiksmai.

Trečioji dalis skirta verifikuoti biokuro konvergencijos indeksą ir išgauti rezultatus, kurie pagrįstų regionų pasiskirstymą pagal naudojamo kuro būdą ir šio sprendimo kuriamą poveikį. Tyrime pirmiausiai pateikiami klasterių analizės rezultatai, parodantys regionų pasiskirstymą pagal ekonominius, socialinius ir aplinkosaugos faktorius. Siekiant išsiaiškinti, kaip biokuro panaudojimas veikė ekonomiką kompleksiniu požiūriu, atliekamas biokuro konvergencijos indekso verifikavimas. Indeksu siekiama aiškiau pateikti skirtį taip biokurą ir importuojamą kurą naudojančių regionų raidos. Tyrime nagrinėjamas 2008-2017 m. laikotarpis, tyrimui naudojami Lietuvos regioninių savivaldybių, kurios turi centralizuotas šilumos tiekimo sistemas, duomenys.

Tyrimo apribojimai. Pagrindiniai disertacijos tyrimo atlikimą ribojęveiksniai susiję su tam tikromis duomenų grupėmis. Vertinamos visos savivaldybių biudžetų pajamos ir išlaidos, neišskiriant jų į tas, kurios sukurtos iš biokuro naudojimo veiklos. Rodiklio pokytis leidžia nustatyti dinamiką tarp biokuro sektoriaus veiklos ir bendros savivaldybės situacijos. Gyventojų pajamų mokesčio pajamos, gautos iš energijos gamybos sektoriaus, yra subendrinamos, t.y. rodiklio dydis atspindi energijos gamybą tiek iš biokuro, tiek iš iškastinio kuro. Rodiklio aktualumas ypač išauga konversijos momentu, lyginant biokurą ir iškastinį kurą naudojančias savivaldybes ir jų pajamų dinamiką.

Disertacijos turinys. Disertaciją sudaro 200 puslapių, įskaitant 41 paveikslą ir 24 lenteles, 567 literatūros šaltinius anglų ir lietuvių kalbomis.

Disertacijos rezultatų publikavimas: Disertacijos rezultatai publikuoti 18-oje mokslinių straipsnių. Visi disertacijos metu gauti rezultatai publikuoti anglų kalba, didžioji dauguma (14) straipsnių publikuoti užsienio mokslo leidiniuose.

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