Evaluation of Energy Intensity in Lithuanian Wood Manufacturing Sector

J. Vasauskaite and D. Streimikiene

***Abstract*—This paper is based on the analysis of energy intensity in Lithuanian wood manufacturing sector aiming at highlighting the factors and effects which contribute to its reduction. In the recent decade, the energy intensity in Lithuanian industry has declined more than 35 percent, however, the decline has mainly been caused by the structural change effect with irrelevant contribution of each enterprise to the decreased overall energy intensity. The aim of the study is to analyse the energy intensity trends in Lithuanian industry as a whole as well as in one particular sector – wood manufacturing. The analysis of the change of energy intensity in wood manufacturing enterprises in Lithuania was performed using the theoretical energy intensity estimation framework and comparing the statistical data during the period of 2000 - 2012. The results of the research show that despite the decrease of energy intensity, Lithuania is still above EU average by this indicator. Therefore, the energy savings achieved by implementing advanced technologies, management strategies, new policies and measures would have a positive impact on energy intensity decrease in wood and furniture manufacturing sector.**

***Index Terms*—Energy intensity, technological innovation, wood and furniture industry, energy efficiency.**

I. Introduction

The development of Lithuanian manufacturing sector is strongly dependent on the consumption of energy. In general, the energy intensities of industrial sectors have decreased all around Europe. In particular, the industrialized countries with higher value of GDP per capita tend to have lower energy intensity which indicates that the efficiency of the energy use is achieved alongside with the technological advancement. The countries with higher GDP and smaller population tend to have lower energy intensity values and a lower energy intensity index [1]. Reference [2] shows, that increased industrial energy efficiency is one of the most important routes to sustainable development, particularly in developing countries. In the case of Lithuania, high energy intensity might have the impact on international competitiveness of the country and pose constrains for sustainable development. Growing demand for energy raises the doubts on whether a secure energy supply will be satisfied in the future and whether Lithuanian industry will be able to remain competitive in the international markets [3].

The concerns about the sustainability of the current patterns of energy use have gained such prominence in recent years that it seems justified to pay particular attention to the issues related to energy consumption from an economist's viewpoint. Moreover, environmental technologies, ecological innovation and their policy implications in industry have become a prominent and complex field of economic investigation. Transition to energy-efficient economics should also accelerate the development of innovative management and technology solutions and so increase industrial competitiveness while promoting economic growth. The intensity of energy consumption would appear to be a valuable measure for the solution of the problems mentioned above since it could contribute to economically efficient reduction of greenhouse gases and thus mitigate climatic changes. Economic studies often describe energy intensity ratio of the manufacturing process as the amount of the energy used to produce one unit of economic activity or total manufacturing value added. It is the opposition of energy efficiency – energy intensity decreasing over time is interpreted as improving energy efficiency [3]-[6].

The relevant issues mentioned above have gained a response in different scientific fields. The studies of industrial energy efficiency in different countries revealed that, in developed countries, industrial improvements in energy efficiency are achieved mainly through the changes in energy prices and investment whereas in the industry of developing countries, energy efficiency performance is achieved through the changes in productivity and implementation of new technologies. The importance of technologies as the tool of strategic industry performance has been stressed by many scientists [7]-[10]. Energy efficiency studies emphasize the importance of both implementation of efficiency measures and dealing with individuals and industrial organizations that are the entities implementing the technology. Other industrial studies also highlight the importance of technology, economies of scale, energy efficiency-oriented policies and management strategies in energy efficiency improvement within the particular industry. The issues of the environmental problems, objectives and perspectives emerging in Lithuanian manufacturing sector have been analysed by Lithuanian authors [3], [11]. In Lithuanian context, however, there is a shortage of the detailed research on energy intensity in the manufacturing sector of the country. A few notable studies performed by Lithuanian scientists include more general investigations at macroeconomic level: investigated relationship between energy consumption and the Lithuanian economic growth; examined economic structural changes related to energy consumption [12], [13]. Several studies examined energy intensity in wood manufacturing sector, highlighting the rational use of energy and innovative technologies alongside with appropriate management strategies [14], [15].

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The main objective of this research is to evaluate the perspectives of energy efficiency development in Lithuanian industry and, in particular, in wood manufacturing sector, and estimate the intensity of energy consumption during the period of 2000 - 2012.

The evaluation methodology included quantitative and qualitative research methods: the analysis of primary and secondary sources of information. The information necessary for the evaluation was obtained from the strategic documents, statistical data sources, interviews with the experts and specialists of wood and furniture manufacturing enterprises, evaluations that were previously accomplished in the fields of environment protection and energy intensity, etc. The research was guided by the measurement of energy intensity based on the theoretic energy intensity estimation framework; it covers the data of energy consumption and output in Lithuanian wood manufacturing sector and it's sub-sectors during the researched period.

II. Research Background

In its general sense, energy intensity is considered to be the ratio of energy use. It can also be defined as the changes in energy use in comparison to the changes in GDP. There are different methods of energy intensity measuring. High energy intensity usually indicates low energy use efficiency while converting energy to GDP. The scientists also cover the problem of the construction of energy intensities from energy use and economic output by pointing out the differences of engaging either volume of output or market value of output [3]. Lower energy intensity, which usually indicates high energy use efficiency, can promote energy conservation and help to deliver the reduction of greenhouse gases with minimal costs. The decrease in energy intensity could be achieved by either using less energy to produce the same amount of commodities or by increasing the amount of commodities per energy unit. Energy prices, structural changes, technological advancement as well as governmental policies are considered to be the main determinants that have the impact on energy intensity in the manufacturing sector. Higher energy prices and new productivity per energy unit increasing technologies are the factors commonly mentioned in the scientific literature as the main determinants of the energy efficiency. It should also be noted that higher energy prices can improve the efficiency of energy consumption, i.e. lower energy intensity [17].

The two methods that are widely engaged to decompose the changes of the energy efficiency indicators include structural decomposition analysis (SDA) and index decomposition analysis (IDA). The SDA is based on input - output model, whereas IDA is based on the data aggregated at the sectorial level [4]. Energy intensity ratio is one of the major indicators of energy efficiency. It can be calculated for different industrial levels, i.e. sub-sectors, sectors, entire industry or the whole economics.

The analysis of the scientific literature [16] revealed that the changes in energy consumption may be evaluated considering such factors as entire industrial activity (activity effect), activity mix (structure effect) and sectorial energy intensity (intensity effect). Activity effect is determined by the output (or activity) generated in the particular economic sector, structure effect is determined by the changes in the structure of the particular activity, and finally, intensity effect is determined by the changes in energy intensity in the particular sector. Following the formulas, calculated energy intensity may be decomposed to measure energy intensity at sectorial level and to reveal the impact of structural changes on the overall energy intensity (see Table I.)

TABLE I: Energy Intensity Estimation Formulas

Ratio	Formula		Explanation
Energy intensity ratio of Sub-Sector	$EI_t = \frac{E_t}{Q_t}$	(1)	*there,* EI_t *- energy intensity for manufacturing sub-sectors* E_t *- total energy consumption by sub-sector per t year* Q_t *- output of manufacturing or value added per t year*
Energy intensity ratio of Sector	$EI_t = \sum_i EI_{i,t} S_{i,t}$	(2)	*there,* EI_t *- energy intensity for manufacturing sector* $EI_{i,t}$ *- energy intensity for i manufacturing sub- sector for year t* $S_{i,t}$ *- share of i sub-sector in total manufacturing value added*
Energy intensity effect for Industry	$\Delta EI = \sum_i \frac{E_i^t - E_i^0}{\ln E_i^t - \ln E_i^0} \ln\left(\frac{EI_i^t}{EI_i^0}\right)$	(3)	*there,* ΔEI *- energy intensity effect for industry* E_i^t *and* E_i^0 *- energy consumption in period t and 0* EI_i^t *and* EI_i^0 *- energy intensity of industry in period t and 0*

III. Intensity of Energy Consumption in Lithuanian Wood Manufacturing Sector

A. Situation Analysis of Lithuanian Wood Sector

Since the entrance of Lithuania in the EU in 2004, the industry of chemicals, chemical products and fibers has become the most significant industry in the country. However, it is important to note that the results shown by wood and furniture industry are not less significant for overall Lithuanian economics considering the fact that it is one of the engines of manufacturing which makes a substantial part in the industrial structure. Following the classification of Lithuanian Statistics, Lithuanian wood manufacturing sector is divided into:

- manufacture of wood and products of wood,
- manufacture of furniture (wooden furniture, upholstered seats with wooden frames, furniture parts of wood, etc.),

- manufacture of paper and paper products.

The revival of wood and furniture industry after the economic crisis has contributed to the improvement of the overall economic structure of the country. At present, wood and furniture industry is the type of manufacture which more than others contributes to GDP growth in the country (see Fig. 1).

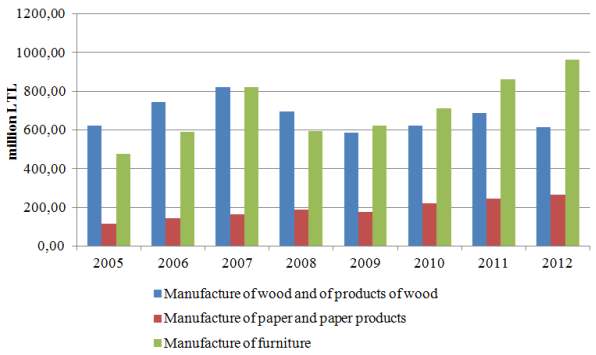

Fig. 1. Gross value added by the wood manufacturing sector (current prices), LTL million (source: Statistics Lithuania).

The biggest part of the overall wood industry consists of furniture manufacture growing since 2008. The growth of this industry has been determined by the increasing furniture export and creation of new furniture production companies. Also, wood sector employs the biggest number of people in the field of processing industry in Lithuania.

Among the numerous markets that drive the forestry-based sector, the furniture market stands out with a strong image worldwide due to its high level of technical and aesthetic quality [15]. In 2011, the share of wood and furniture manufacture made 11% of the overall sold manufacture production in Lithuania. Lithuanian furniture manufacture is positively influenced by the well-developed logistic infrastructure in the country. The qualitative road infrastructure integrated in trans-European nets allows the manufacturers to integrate in the EU and other countries' industry while dealing with international orders. It also ensures the availability of raw materials in Eastern Europe and other countries. Moreover, Lithuanian wood and furniture manufacturers compete with both local and foreign companies since the majority of Lithuanian furniture is exported. The export of Lithuanian furniture has gradually been growing since 2009. The recovery of the foreign demand is linked with the rise of global economics, which has been observed since 2010. Such tendencies of export show Lithuanian competitive advantage and confirm the marketability of Lithuanian furniture in foreign countries. During all the researched period, the biggest part of the furniture was exported to the EU countries, namely Sweden and Germany, and since 2011, the export to these countries has increased even further. Before the beginning of the economic crisis, the biggest part of Lithuanian furniture was exported to Germany (nearly 375 million LTL in 2007); in 2009, the volumes of the export to Sweden and Germany were very similar, with export to Germany slightly (by 0.49 million LTL) exceeding the export to Sweden. Since 2010, the volumes of the export to Sweden have consistently grown and reached the leading positions. Such distribution of the countries by the volumes of the export has been determined by the activities of the largest Lithuanian furniture purchaser – Swedish concern IKEA. Thus, it is extremely important to evaluate the situation of Lithuanian furniture manufacturing companies in both global and regional context. However, it should be noted that Lithuania has the advantage in international markets for its relatively cheap labour force as well as cheap local wood. As a result, little investment is made in other value chain components such as production capacity, quality and so forth. The products made by Lithuanian wood and furniture manufacture are often distributed to the final customer via the marketing channels managed by Western companies and trademarks such as IKEA, JYSK and others. This way, the biggest part of Lithuanian wood and furniture manufacturers do not participate in the chains where the highest value added is created. Lithuanian furniture manufacturers focus on the needs of mass market and middle-class customers which means participation in fierce competition in international arenas and relatively low profit margins.

In spite of being easily-managed, energy costs in energy non-intensive companies operating in wood and furniture industry are often considered as fixed overheads. However, due to the constant growth of energy prices, furniture production companies face the need to use energy efficiently and practice innovative ways of energy management with a view to increasing their profits, which leads to restructuring towards lower energy intensity and a higher value-added. The shift to energy-efficient production should also accelerate the development of innovative technological solutions and increase industrial competitiveness while promoting economic growth. From the perspective of furniture manufacturing enterprises, the role of energy efficiency is significant as it leads to direct economic benefits, increased competitiveness and higher productivity.

B. Evaluation of Energy Intensity in Lithuanian Industry

Lithuania's primary energy balance consists of natural gas, oil and oil products, local and renewable energy sources and coal. A share of natural gas in 2012 composed 35.9% of primary energy sources; in 2001, it composed 26.0%. All natural gas consumed in the country is extracted in Russia and transported to Lithuania by the means of pipelines. In 2012, the imported and consumed amount of natural gas made 3.3 billion m^3. Petroleum products, including emulsified fuel, made 34.2 % of primary energy in 2012 while in 2011 they made 33.7 %. Domestic oil resources are not abundant, thus, the indicators of oil and petroleum products sector are dependent on imports [18].

Following the closure of the last unit of Ignalina nuclear power plant (NPP) in 2009, the bulk of the fuel and energy consumed in Lithuania is imported. Lithuania is not able to satisfy its electricity demand competitively. The grids are not connected with the European electrical energy systems, so Lithuania can only import electricity from other countries. In the field of increasing energy efficiency, the efforts are being made to renovate existing buildings, modernize their energy systems, increase the efficiency of energy production and consumption in the cogeneration and district heating sectors, in industrial processes, in the equipment used by undertakings,

institutions and households for energy management and in transport, and to use renewable and waste energy resources in order to make the country less dependent on the import of primary energy resources. The final energy consumption was increasing by 4.0% per annum during the period of 2000 - 2008, and in 2008 it was 4.9 Mtoe. During this period, the final energy consumption was increasing in all sectors of the national economy. In 2009, total final energy consumption was by 6.4% smaller than in the previous year, and the most severe impact of the economic recession shook the construction sector where energy consumption decreased by 35%. Energy consumption in the transport sector decreased by 18.5%. As a result of Lithuanian economy recovery, the final energy consumption increased by 3.7% in 2010. However, in 2011, the final energy consumption reduced by 0.86% and amounted to 4.72 Mtoe. This decrease was mainly caused by reduced energy consumption in transport, residential and commercial/institutional sectors. The final energy consumption in industry increased by 5.1% in 2011 due to growing activities of Lithuanian manufacturing sector. In 2012, the final energy consumption increased by 2.6% and amounted to 4.84 Mtoe [18].

The most important indicator of energy efficiency of the country is energy intensity of economy. This indicator represents the ratio between the gross inland consumption of energy and the GDP for a given calendar year. The gross inland consumption of energy is calculated as the sum of the gross inland consumption of five energy types: coal, electricity, oil, natural gas and renewable energy sources. The GDP figures are taken at chain linked volumes. Since gross inland consumption is measured in toe (tonnes of oil equivalent) and GDP in EUR, this ratio is measured in toe per mill. EUR [19].

In spite of the decrease of Lithuanian energy intensity by more than 35 percent in the last decade, the energy required to produce a unit still more than twice exceeds the average of the European Union countries. As it can be seen from Table II, the total energy intensity in Lithuania for the period of 2004 - 2011 decreased about 1.2 times, from 70 to 58 toe/million LTL. The energy intensity in household and transport sectors decreased about 1.2 times, from 22 to 19 toe/million LTL. The energy intensity in industry during the same period decreased by 1.2 times, from 60 to 50 toe/million LTL, finally, in the services sector it decreased about 1.4 times, from 21 to 15 toe/million LTL.

TABLE II: FINAL ENERGY INTENSITY IN LITHUANIA BY USERS GROUPS FOR THE PERIOD OF 2000-2011 (TOE/MILLION LTL)

Final energy intensity	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Industry	74.2	67.1	71.5	65.0	60.5	57.7	56.9	55.2	48.3	49.2	50.5	49.7
Agriculture	34.3	40.7	38.2	35.9	36.8	33.7	41.3	38.8	36.8	32.4	36.9	34.5
Household	27.5	28.1	26.4	24.0	22.3	20.9	20.2	17.6	17.7	20.9	20.9	18.9
Transport	21.,2	23.7	22.9	21.2	21.7	19.9	19.9	21.5	21.0	20.1	20.4	19.0
Services	18.3	21.4	20.9	20.8	20.5	16.3	16.7	15.9	14.8	16.2	16.6	15.3
Construction	16.4	14.6	14.9	12.8	12.3	9.8	8.2	6.8	6.9	8.2	9.7	7.7
Total	**75.8**	**79.4**	77.2	**72.0**	**69.8**	**63.7**	**62.9**	**60.3**	57.7	**61.3**	**62.5**	**58.2**

The comparison of energy intensity of Lithuanian economy and other EU member states has been presented in Fig. 3:

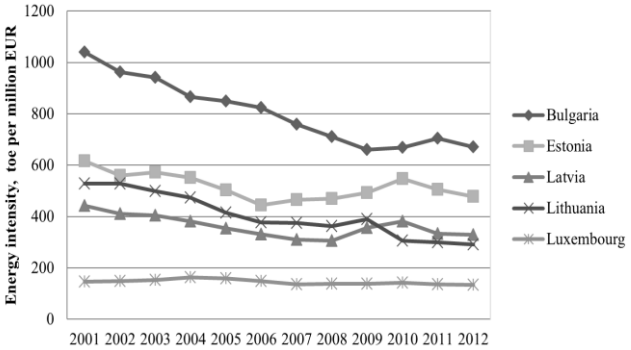

Fig. 2. The development of energy intensity in Lithuanian economy and other EU member states (source: Eurostat, 2012).

As it can be seen from the data presented in Fig. 2, energy intensity in Lithuania decreased about 1.5 times, or from 479 to 292 toe/million EUR, from 2004 to 2012. In comparison, energy intensity of Bulgarian economy decreased 1.3 times, from 870 to 670 toe/million EUR. The average of energy intensity in EU-27 countries decreased only 1.1 times, from 167 to 152 toe/million EUR during the same period. The best performing EU country in terms of energy intensity is Luxemburg where energy intensity made 134 toe/million EUR and remained almost stable during the whole period. The worst performing EU member state in terms of energy intensity is Bulgaria, having nearly twice higher energy intensity than Lithuania.

C. Evaluation of Energy Intensity in Wood Manufacturing Sector

Lithuanian industry sector is among the most energy intensive sectors and its contribution to overall energy intensity of Lithuania is very significant. Therefore the energy savings achieved in this sector would have positive impact on overall energy intensity decrease. In general, Lithuanian manufacturing activities are classified into three categories, such as high energy intensive, medium energy intensive and low energy intensive. In the last decade, the intensity of energy consumption varied from 5.3 to 2.4 J/LTL in the high energy intensive industries group, from 1.3 to 0.6 in the medium energy intensive group, and from 1.2 to 0.3 in the low energy intensive group [3].

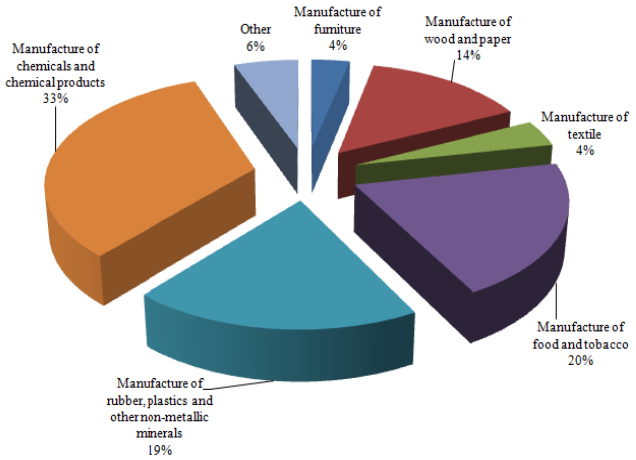

Fig. 3. Total final energy consumption (TCF) in 2012, % (source: Lithuanian Energy Institute report, 2013).

In the EU, industrial energy intensity fell down by about 15% during the period of 2005 - 2012. However, a recovering economy requires more energy, especially for Lithuania, where the overall economic structure as well as the sectors bearing a high vulnerability to energy sources, i.e. the manufacturing sectors, are predominant. Furniture industry is engaged in manufacturing and assembly of furniture parts alongside with appropriate finishing operations. Wood and wood-based materials are the main types of raw material used in furniture industry. Recently, business companies, manufacturers and building administrators show their increased interest in energy efficiency solutions and saving. In the furniture industry, the companies have made substantial investment in infrastructure and equipment: more than 50 per cent of wood and furniture companies use modern technologies in their activities.

Efficient waste management technologies are wide-spread in wood sub-sector while the use of modern technological equipment, computer-aided production planning and management systems as well as process automation technologies prevail in furniture production sub-sector. Increasing global competition requires more efficient strategies of investment in the measures linked with creation, development and implementation of new technologies. Evaluation of technological intensity by the industry and by the product is based on R&D intensity analysis. R&D intensity reveals the significance of the scientific research on technological development, but other important characteristics of high technologies stay aside.

According to energy intensity ratio estimation, two sub-sectors of wood manufacturing sector appear to be high energy intensive industries, i.e. the sub-sector of wood and wood products as well as the subsector of paper and paper products. Furniture manufacturing belongs to low energy intensive industries group.

Despite the decreasing energy intensity in Lithuanian wood manufacturing sector (see Table III), Lithuania is still above the EU average by this indicator. It is, hence, important to identify the most energy intensive industrial sectors. As Table III demonstrates, the most energy intensive sub-sector in terms of the output expressed in the monetary terms was that of wood and wood products manufacturing. The second most energy intensive sub-sector was the paper and paper products manufacturing sub-sector. But evaluating the wood manufacturing sector as a total, it should be noted that the energy intensity in this sector fluctuated during the period of 2008 – 2010, and since then has been decreasing, reaching its lowest value in 2012.

TABLE III: ENERGY INTENSITY (J/LTL 1000) OF WOOD MANUFACTURING SECTOR

Wood manufacturing sub-sectors	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Manufacturing of wood and wood products (C16)	1,28	2,02	2,43	2,30	2,39	2,15	1,98	1,99	2,08	1,79	1,88	1,46	1,42
Manufacturing of paper and paper products (C17)	3,10	3,15	1,89	1,63	1,13	1,26	1,03	1,03	0,97	1,63	2,01	1,35	1,27
Manufacturing of furniture (C31)	0,67	0,95	0,86	0,97	0,79	0,70	0,56	0,44	0,32	0,29	0,29	0,33	0,33

Source: calculation based on Lithuanian Statistics data.

IV. CONCLUSION

The evaluation of energy intensity has earned a significant scientific attention during the recent decades. The relevance of this topic lies not only in the necessity of cost saving in manufacturing sector, but also in the need to deal with the growing prices of energetic resources caused by their scarcity.

The results of the research have revealed the trends of energy intensity variation in Lithuanian manufacturing sector as a whole as well as in wood manufacturing sector.

With reference to the research results, in spite of the decrease in Lithuanian energy intensity by more than 35 percent in the last decade, the energy required to produce a unit still more than twice exceeds the average of the European Union countries. It reveals high vulnerability of the manufacturing sector of the country to energy sources.

Lithuanian wood and furniture manufacturers, being recognised world-wide for producing the commodities of the high technical and aesthetic quality, are able to create opportunities to further seize other markets, in particular, the high-end segments and emerging markets. Although wood and furniture industry is the type of manufacture which more than others contributes to GDP growth in the country, it still involves the need to increase energy efficiency. The increase in prices of raw materials and energy recourses has had a negative impact on the scope of turnover and energy efficiency in this industry, particularly in the sub-sectors of wood and wood products, paper and paper products. It has also been revealed that the latter manufacturing sub-sector can be attributed to high energy intensity industries group. Due to the constant growth of energy prices, furniture production companies also face the need to use energy efficiently and practice innovative ways of energy management with a view to increasing their profits, which leads to restructuring towards lower energy intensity and a higher value-added.

Considering the circumstances explicated above, Lithuanian wood and furniture manufacturing enterprises have to search for more efficient ways of energy consumption. More efficient use of local wood recourses, clusterisation and

the development of new business models could contribute to lower energy intensity in this sector. The measures of sustainable industry development such as the improvement of production processes or projecting of the products in accordance with the principles of cleaner production could also be engaged. The reliance on raw materials obtained from sustainable sources could have a positive impact selling the production to the environmentally concerned end-users worldwide. Finally, implementation of advanced manufacturing technologies would enable the creation of high technology and knowledge-intensive jobs, which, in turn, would help to rejuvenate the sector while keeping it highly competitive in global markets.

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REFERENCES

[1] D. Kepplinger, M. Templ, and S. Upadhyaya, "Analysis of energy intensity in manufacturing industry using mixed-effects models," *Energy*, vol. 59, pp. 754-763, 2013.
[2] Industrial energy efficiency for sustainable wealth creation, *Industrial Development Report*, UNIDO, 2011, p. 261.
[3] G. Dudzeviciute, "Energy intensity in the Lithuanian manufacturing sector," *Journal of Security and Sustainability Issues*, vol. 3, no. 2, pp. 77–85, 2013.
[4] A. Balezentis, T. Balezentis, and D. Streimikiene, "The energy intensity in Lithuania during 1995–2009: A LMDI approach," *Energy Policy*, vol. 39, pp. 7322–7334, 2011.
[5] A. Markandya, S. Pedroso-Galinato, and D. Streimikiene, "Energy intensity in transition economies: Is there convergence towards the EU average?" *Energy Economics*, vol. 28, no. 1, pp.121–145, 2006.
[6] J. Cornillie and S. Fankhauser, "The energy intensity of transition countries," *Energy Economics*, vol. 26, pp. 283–295, 2004.
[7] H. Kemal, "Energy usage and cost in textile industry: A case study for Turkey," *Energy*, vol. 30, no. 24, pp. 24-46, 2004.
[8] P. I. Martinez, "Energy use and energy efficiency development in the German and Colombian textile industries," *Energy for Sustainable Development*, vol. 14, no. 2, pp. 94-103, 2010.
[9] J. E. Payne, "Survey of the international evidence on the causal relationship between energy consumption and growth," *Journal of Economic Studies*, vol. 37, no. 1, pp. 53–95, 2010.
[10] S. M. Lu, C. Lu, K. T. Tseng, F. Chen, and C. L. Chen, "Energy saving potential of the industrial sector of Taiwan," *Renewable and Sustainable Energy Reviews*, vol. 21, pp. 674-683, 2013.
[11] D. Streimikiene, A. Volochovic, and Z. Simanaviciene, "Comparative assessment of policies targeting energy use efficiency in Lithuania," *Renewable and Sustainable Energy Reviews*, vol. 16, no. 6, pp. 3613-3620, 2012.
[12] V. Bobinaite, A. Juozapaviciene, and I. Konstantinaviciute, "Assessment of causality relationship between renewable energy consumption and economic growth in Lithuania," *Engineering Economics*, vol. 22, no. 5, pp. 510-518, 2011.
[13] G. Dudzeviciute, "The research of the economic structural changes: Energy consumption aspect," *Journal of Security and Sustainability Issues*, vol. 2, no. 4, pp. 13–23, 2013.
[14] M. Puidokas and G. Jucevicius, "The inter-organizational industrial learning of Lithuanian furniture manufacturers in the value chains of the Baltic sea region," *Social Sciences*, vol. 3, no. 65, pp. 29-39, 2009.
[15] J. Vasauskaite and D. Streimikiene, "Energy efficiency development in Lithuanian furniture industry," *Journal of Advanced Management Science*, vol. 4, no. 1, 2015.
[16] B. W. Ang, A. R. Mu, and P. Zhou, "Accounting frameworks for tracking energy efficiency trends," *Energy Economics*, vol. 32, pp. 1209–1219, 2010.
[17] N. Che and P. Pham, "Economic analysis of end-use energy intensity in Australia," Bureau of Resources and Energy Economics (BREE), Canberra, May 2012.
[18] Lithuania's 6th National Communication and 1st Biennial report under the United Nations Framework Convention on Climate Change, Ministry of Environment of Republic of Lithuania, 2013.
[19] Energy prices and costs report, European Commission Working Document, Brussels, 2014.
[20] Lithuanian Statistics Department database. [Online]. Available: http://osp.stat.gov.lt/statistiniu-rodikliu-analize?id=1110&status=A

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