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EFFICIENCY OF ENERGY CONSUMPTION AS A BASE FOR SUSTAINABLE ENERGY SECTOR

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Abstract. Lithuania, as many other EU countries, encounters key challenges in three energy sector fields: energy independence, energy sector competitiveness and sustainable energy sector development. Such situation is determined by historical and political conditions, as well as by limited internal energy resources. In such context an importance of energy consumption efficiency pursuing country energy sector sustainability is highlighted. By implementing the long-term goals and tasks a country may seek to increase the efficiency of energy production, distribution and consumption, as well as to increase energy production from renewable and waste energy sources. The main objective of the paper is to analyze the efficiency of energy consumption, the factors influencing energy sector competitiveness and sustainability, and to assess the development soundness of the use of renewable energy sources in Lithuania. The paper discusses the main EU legal documents and their provisions regulating energy sector, analyze energy production and consumption efficiency data in Lithuania and reveal the economic effect of the use of renewable energy sources in Lithuania.

Keywords: energy, renewable energy sources, energy production, energy consumption efficiency.

JEL Classification: O13, P28, Q42.

Introduction

The production of high value-added products and services, their competitiveness in the global market is basis of Lithuania's economy. The innovative business-friendly environment, education, science, research and experimental development system, an innovative energy component that interacts with the business to help foster a creative society, to develop high-level knowledge base on innovation, to develop a creative society and to create conditions for development of entrepreneurship and innovation allow producing these products and services. Lithuania, as many other EU countries, encounters key challenges in three energy sector fields: energy independence, energy sector competitiveness and sustainable energy sector development. Such situation is determined by historical and political conditions, as well as by limited internal energy resources.

In the energy sector emissions into the environment account for more than half of total emissions into the air of greenhouse gas. Lithuania is one of the few European countries, which almost does not have its fossil energy resources such as oil, coal, natural gas, and since 2009 has closed the Ignalina Nuclear Power Plant (INPP). These reasons determine the fact that Lithuania is heavily dependent on imports of fossil fuels from third countries. In such context an importance of energy consumption efficiency pursuing country energy sector sustainability is highlighted (Fellows 2006; Ignotas 2006a, 2006b).

Energy production resources decrease both in the world and Lithuania, therefore, it is increasingly focused on renewable energy sources and their more effective utilization (Bobinaite *et al.* 2011; O'Connor, Cleveland 2014; Serbi 2015). It is very important a more efficient use of renewable

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resources in the country, since they are less damaging to the environment than fossil fuels. It should be noted that local crude oil usage in Lithuania is small, so a wider RES utilization would be not only environmentally beneficial, but would also help reduce Lithuania's dependence on imported fossil fuels. By implementing the long-term goals and tasks a country may seek to increase the efficiency of energy production, distribution and consumption, as well as to increase energy production from renewable and waste energy sources. Current objective of Lithuanian National Sustainable Development Strategy is to increase energy saving and consumption efficiency (LR Aplinkos ministerija 2014).

The main objective of the paper is to analyze the efficiency of energy consumption, the factors influencing energy sector competitiveness and sustainability, and to assess the development soundness of the use of renewable energy sources in Lithuania.

Lithuanian energy, energy production and energy efficiency is the object of research.

These methods were applied in the work: critical scientific and legal literature analysis, statistical comparative analysis and graphical presentation.

1. The EU's economic competitiveness in the context of sustainable energy development

The EU economy is becoming more competitive and more innovative. It is conditioned by labour productivity, spending on research and development, resource efficiency and other factors (Rozmahel *et al.* 2014). The energy-related indicators (such as the greenhouse gas emissions, energy demand, consumption and importation, renewable energy sources development) showing progress of sustainable development also improves the competitiveness (Costantini, Mazzanti 2012; Gilli *et al.* 2013; Baek *et al.* 2014).

The energy intensity of the EU decreased from 2003 to 2009, depression followed in 2010, and even further decline increased in 2011. Positive change was observed along with full native energy use separation from economic growth (Sustainable development… 2013).

12 indicators were identified as key from more than 100 indicators presented in Sustainable Development in the European Union report. They are intended to give an overall picture of whether the EU has achieved progress towards sustainable development in terms of the goals and objectives of the EU Sustainable Development Strategy. Assessment of progress since 2000 based on the following key indicators shows a rather mixed picture (Sustainable development… 2013).

It is observed that the greenhouse gas emission in the EU is decreasing, but the climate temperature increases, because the greenhouse gas (mainly carbon dioxide) concentration is increasing in the world. The World Meteorological Organization (WMO 2014) states that carbon dioxide (causing the greatest impact on climate change) concentration reached 389 molecules per million air molecules in 2010. From 2009 until 2010, carbon dioxide emission increased by 2.3 molecules per million air particles. This exceeds last decade average of carbon dioxide concentration increase; the average is 2.0 molecules per million air particles per year. This means that the particle concentration increases at a faster rate.

EU greenhouse gas emission has been steadily declining since 1990. The strongest decline was the beginning of the nineties and from 2007 to 2011. Objective of Europe of 2020 strategy (to reduce greenhouse gas emission by 20% compared with 1990 levels) is possible by the year 2020.

The greatest reduction was achieved in manufacturing and construction and energy industries. Waste and agricultural sectors also reduced emissions, but their contribution to the whole is less. The only transport sector keeps rising emission level. Emissions from international aviation and maritime transport grew particularly quickly. Emissions from above-ground transportation also remained above the 1990 level, but since 2007, the downward trend emerged.

Greenhouse gas emission reduction in EU is counterbalanced by rapidly growing global emission. Concentration of greenhouse gas in the atmosphere is rising. Although there is a time lag between emission and temperature rise, global average surface temperature records show a clear upward trend. Climate warming has grown steadily over the last four decades.

The declining demand for energy trend does not also appear. After sustained growth from 1990 to 2006, the primary energy consumption in the EU has fallen to 1990 level in 2011. However, the falling trend was not continuous. The future will show whether the decrease can be maintained when the EU's economic growth will increase. In Lithuania pre-crisis period, the total energy consumption in the country grew and in 2008, final energy consumption amounted to 5068.1 thousand ton of oil equivalent. In 2009, the economic crisis about 10% resulted in energy consumption reduction. In 2011 and 2012, final energy consumption increased in comparison with 2009, but did not reach the amount of energy consumed in 2008: 4715.3 thousand toe was used in 2011, 4837.1 thousand toe – in 2012 (Statistics Lithuania 2014).

The EU imported more than half of its energy consumption in 2011. Since the early nineties energy needs satisfied through imports from non-EU countries increased almost every year. Since 2006, it remained little more than 50%.

The rapid development of renewable energy sources is observed, particularly in the electricity sector (Meade, Islam 2015; Paska, Surma 2014; Pazheri *et al.* 2014; Sun, Nie 2015). Energy from biomass, wind, solar and geothermal bores is

helping to supply the growing energy demand in the EU. All Member States have increased their energy from renewable resources between 2005 and 2011. While the largest part consists of energy from biomass, solar and wind energy extraction has been expanding most rapidly.

The biggest use of energy from renewable resources is in the electricity sector, where renewables provide a fifth of the energy produced in 2011. In Lithuania in 2010, renewable resources in general primary energy expenses accounted for 15.2%, 15.8% of the electricity have been produced from those resources. It has been implemented in a short-term task that in 2010 the heat generated from renewable sources would account for 12% of the total heat balance, and production of electricity from renewable sources would represent more that 7% of total domestic electricity consumption.

In contrast, part of energy from the renewable resources used in the transport sphere decreased in 2011 in comparison with the previous year. However, this is due to statistical adjustments, where biofuels are deleted because they where not certified as sustainable product. However, the 2010 figures show that the EU has not reached its interim goal to increase energy from renewable sources in the transport sphere. In Lithuania since 2004, consumption of biodiesel grew most rapidly. In 2004, 0.7 thousand toe of this energy source was used, in 2012–51.8 thousand toe. International commitments relating to greenhouse gas emission reduction and increase of the use of biofuels in transport promote biofuel production and use in Lithuania. Biofuels amounted to 3.5% in 2011, and in 2012, it accounted for 5% of the total balance of fuels.

It has been scheduled in The National Strategy for Sustainable Development that the heat produced from renewable and waste energy resources in 2010 would be 12% of the total heat balance, and production of electricity from renewable energy sources would represent more than 7% of total domestic electricity consumption. This task has been implemented, because in 2010, the renewable resources in general expenses of primary energy accounted for 15.1%, 15.8% of the electricity have been produced of these resources. In 2012, the part of renewables in total energy expenses accounted for 15.7%, part of electricity produced from renewable sources exceeded 23% in 2011–2012 (LR Aplinkos ministerija 2014).

The use of biofuels is an important factor to reduce greenhouse gas emissions in the air. While the growing production of biofuels is determined by the European Union requirements to install and develop renewable energy sources and requirements related to greenhouse gas emission reductions, it is necessary to take into account the fact that it is rational to produce biofuels only if there is sufficient productivity and fossil fuels are burned less than biofuels are produced.

2. Energy efficiency initiatives in Europe

Energy efficiency is one of the European Union's strategic directions, significant financial resources and specific attention is given to those directions, as well as ambitious aspirations are set (Energy Efficiency Plan 2011). Strategic objectives, requirements, and the results in the field of energy efficiency are named in a number of EU strategic documents. The following is a brief analysis of the most important of these instruments related to energy efficiency.

Europe 2020

Europe 2020 (2014) is the EU's growth strategy of this decade. This strategy is targeted to make the EU economy more sustainable and inclusive. The EU has set itself goals in five areas (employment, innovation, education, social inclusion, climate and energy), and each Member State has set national objectives for these areas. The strategy is based on specific EU and national level action. Climate change and energy targets further called 20–20–20 targets:

- Greenhouse gas emissions should be reduced by 20% (or even 30%, if the conditions are right), if compared to 1990 indicators;
- 20% of energy should be produced from renewable sources;
- Energy efficiency should be increased by 20%.

Energy Efficiency Directive No. 2012/27/EU (Europos parlamento ... 2012)

Energy Efficiency Directive is an executive document, which provides member states the conditions required to guarantee and achievement of one of the Europe 2020 objectives (energy efficiency increased by 20%).

One of the areas covered by this Directive is renovation: *"Member States shall ensure that from January 1st 2014 3% of the total area of premises owned and used by central government entities heated and (or) cooled buildings should be annually renovated in order to meet at least the minimum energy performance requirements. 3% rate is calculated by the Member States entities owned and used buildings by the central government; these buildings each year on 1st January do not meet the national minimum energy performance requirements and their total useful floor area exceeds 500 sq. m. Since July 9th 2015 the limit is reduced to 250 sq. m."*

The relative directives requirements are also in flats modernization; these requirements (such as individual meters) affect even the specific technical measures installation in blocks: *"Individual consumption meters, which, if it is technically feasible and cost effective to measure for each space heating, cooling and hot water consumption are also installed in block of flats and multi-purpose use buildings with central heating / cooling source or which are served by the district heating network or central many buildings serving source not later than December 31st 2016."*

Energy efficiency directive also regulates the establishment of the obligations, corporate energy audits, encourages public bodies to prove energy efficiency plans at local or regional level, promotes the achievement of the higher energy audit quality and increasing public awareness of energy audits benefits, stimulates ensuring the most accurate information in accounts for the energy consumption and so on.

Energy efficiency will increase in the future. It is provided in National Energy Independence Strategy for increasing the efficiency by 1.5% annually until 2020. Also, the strategy states that for efficiency measures in 2050 power requirements should be 30–40% lower than if there would be no efficiency. According to the National Energy Independence Strategy and the aforesaid, it is assumed that the power consumption for the period 2014–2020 will increase to 1.55%, the optimistic variant – 1.8%, pessimistic – by 1.3% annually.

Energy Efficiency Directive encourages Member States to promote energy service companies (ESCO market) disseminating relevant information, promotes the development of quality labels and so on. This analysis also covers the significant provision of Energy Efficiency Directive (article 18, paragraph 1, part *d*): Member States [...] *"support the public sector in its adoption of proposals for energy services, particularly for the renovation of buildings; this is done by: i) preparing model contracts for energy efficiency [...]; providing information on agreements on energy efficiency best practices, including, where appropriate, cost-benefit analysis, based on a life-cycle approach."*

All member states have to prepare the energy efficiency action plan that will guide the implementation of the Energy Efficiency Directive raised 20–20–20 requirements.

Energy Performance of Buildings Directive No. 2010/31/EU(Europos parlamento ... 2010)

Energy Performane of Buildings Directive is the supplementing instrument of the Energy Efficiency Directive, which regulates the energy performance of buildings within the Union taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

The European Council and Parliament General Provisions Regulation No. 1303/2013(Europos parlamento... 2013)

The European Council and Parliament General Provisions Regulation lays down European Union investment funds and the Common Strategic Framework thematic objectives. Priorities of every European Union investment fund are set according to these thematic objectives; priorities are specified in the fund-specific rules.

The European Council Parliament Regulation general provisions set out in the 4th thematic objective activities are supported by European Regional Development Fund and are detailed in the European Regional Development Fund Regulation:

"(4) the transition to a low carbon dioxide emitting economy in all sectors:

a) promoting the production and distribution of energy produced from renewable energy sources;
b) promoting energy efficiency and renewable energy use in enterprises;
c) supporting energy efficiency, advanced energy management and renewable energy use in public infrastructure (including public buildings) and homes industry;
d) developing and deploying advanced distribution systems operating in low and medium voltage;
e) promoting low-carbon strategies in all types of areas, particularly in urban areas, as well as promoting sustainable and diversified urban mobility and mitigation relevant adaptation measures;
f) promoting research and innovation in low-carbon technologies and implementation of these technologies;
g) promoting high efficiency combined heat and power production based on the useful heat demand."

The 2014–2020 European Union Structural Funds Programme of Action

The 2014–2020 European Union Structural Funds Programme of Action Priority 4 "Energy Efficiency and Renewable Energy Production and the Promotion of the Use" details the activities supported in various energy efficiency areas. These *ex ante* analyzed activities are accentuated in 4.3 investment priority *"Sponsorship of Energy Use Efficiency, Smart Energy Management and the Use of RES in Public Infrastructures, Including Public Buildings and Residential Housing Sector"* and in 4.3.1 specific task *"Reducing Energy Consumption in Public Facilities and in Blocks of Flats."* (2014–2020 metų Europos... 2014).

It is mentioned in the detailed application of aforesaid specific task that it is possible to save most energy in the industry and households – in total 61 percent, as well as considerable energy saving potential occurs also in modernizing the street lighting: the successful implementation of such projects would allow to save up to 50 percent energy and operating costs would be cut by 60 percent.

2014–2020 National Programme on Advancement

2014–2020 National Programme on Advancement is prepared to implement the state strategy for progress "Lithuania's progress strategy "Lithuania 2030" and create an innovative, modern and strong state characterized by the smart society, smart economics and smart management tune. Energy efficiency is one of planned areas of the National Programme on Advancement; energy efficiency

is defined in National Programme on Advancement 3.3 objective. 3.3.2 task "to ensure the sustainable use of energy resources" provides specific activities in the field of energy efficiency. These main task areas are planned:

- 3.3.2.1. to promote renewable energy production and use;
- 3.3.2.2. to promote energy efficiency in residential and public buildings sectors;
- 3.3.2.3. to develop and implement modern energy and other natural resources-efficient technologies and process control systems;
- 3.3.2.4. to increase the energy resources efficiency in energy production and use;
- 3.3.2.5. to develop use of electric and other alternative-fuel vehicles and to promote the intermodality. (LRV 2014).

Table 1. Lithuanian energy production data, ktoe (Statistics Lithuania 2014)

	2009	2010	2011	2012
Crude petroleum	117.5	117.3	116.9	104.6
Peat	14.7	8.7	11.7	16.9
Nuclear power	2828.2	–	–	–
Hydropower	36.5	46.4	41.3	36.3
Firewood and wood waste	1003.2	1002.9	984.0	992.7
Biogas and liquid biofuels	113.0	114.1	95.2	121.6
Energy from chemical processes	214.6	209.4	244.3	235.9
Other resources	18.7	23.8	44.1	50.5
Energy production, in total	4346.3	1522.7	1537.5	1558.5

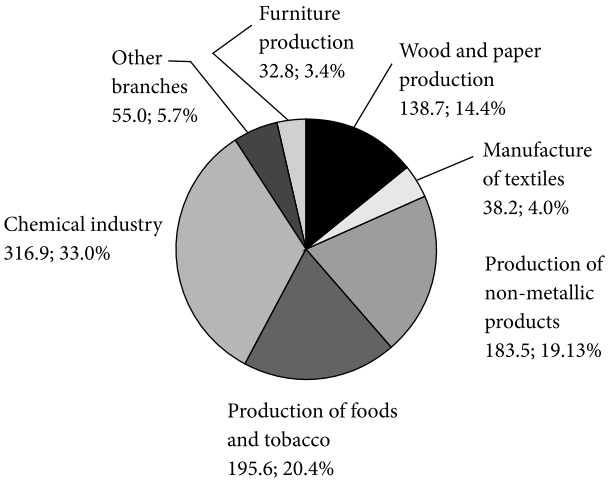

Fig. 1. Structure of final energy consumption (thousand toe) in industry sectors, 2012 (Statistics Lithuania 2014)

3. The structure of the energy sector and energy consumption

Maximum power consumption levels in independent Lithuania were achieved in 2008. According to the Lithuanian Energy Institute (LEI) information in that year in Lithuania consumers of the final energy in its various forms have used in total 57 TWh. The maximum annual amount of final energy was consumed by thermal power generation – about 26 TWh, or 46 percent of the total amount of energy consumed in Lithuania. To meet these needs about 10 TWh heat was produced in centralist heating (CH) systems, and the remainder (about 16 TWh) was produced by burning multi-fuel on the spot of heat consumption (decentralized use of fuel). In this decade of economic growth total electricity consumption rather steady grew approximately 0.4 TWh per year, so about 2020, Lithuania should consume about 13 TWh of electricity (Lietuvos energetikos institutas 2014).

Some of the Lithuanian energy production data is presented in Table 1.

Lithuanian general electricity demand increased on average by 3.3% per year in 2001–2008. The economic crisis, which began at the end of 2008, led to a drop in electricity demand more than 7%. Since 2009 until 2013, average annual electricity demand growth rate was lower than 1.0%. In 2013, general electricity demand amounted to 10.57 TWh and the highest asking power has increased to 1.810 MW and its usage time has reached 5.842 to 6.185 hours level.

At present, most electricity is consumed in the industrial and service sectors and in the household. In 2013, industry accounted for 39% of the total final electricity consumption structure, the service sector – 31%, while household about 27%. Over the past five years, the industrial sector costs in the overall structure increased from 29 to 39%, while household consumption fell from 30 to 27%.

The final energy needs quite consistently follow increase in production *in industrial sector.* But here more efficient production technology that reduces energy consumption is being introduced. For example, much more efficient industrial electric motors, tools and so on are rapidly implemented in developed countries of Europe and the US. Greater production of lasers and biopharmaceutical products is monitored in Lithuania, but this production uses less power, and therefore should not significantly affect electricity consumption growth. The emergence of new energy-intensive industries (trucks, locomotives production or shale gas and oil wells) would lead to higher electricity demand growth. However, a large and sudden breakthrough in energy-intensive industries cannot be expected, so sudden electricity demand growth is not also expected.

As can be seen from Figure 1, in 2012, four very important for the national economy industries (chemicals and chemical products (33.0%), production of non-metallic

mineral products (19.1%), production of foods, beverages and tobacco (20.4%), wood, paper and paper products production (14.4%)) consumed the majority (86.9%) of the final energy. Industries according to electricity consumption distribute slightly more balanced, but these four industries consumed 77.2% of the total electricity consumed in the industry.

In 2013, industrial sector in total consumed 247.5 thousand toe electricity and 204.8 thousand toe of thermal energy.

The services sector is the second according to electricity consumption and is expanding in advanced economies, but the electricity consumption is relatively stable due to the installation of more efficient lighting systems and other used devices. Therefore, it is assumed that also in Lithuania the power consumption in the services sector will not substantially grow even in the log perspective, especially with decreasing population.

The final energy consumption in the services, households, transport and agricultural sectors is presented in Table 2.

Table 2. Final energy consumption, thousand toe (Statistics Lithuania 2014)

Year	Service sector	Households sector	Transport	Agriculture
2008	603.9	1 551.6	1 847.9	114.1
2009	592	1 568.7	1 506.0	102.1
2010	601	1 594.2	1 551.2	109.1
2011	583.2	1 533.6	1 544.1	109.2
2012	611.8	1 535.1	1 574.5	108.6
2013	594.1	1 467.8	1 578.8	103.1

In the household sector electric power consumption could continue to fall due to emigration and a low birth rate and the transition to less electricity-intensive chandeliers, household electric equipment and other measures. Electricity consumption could increase if electric cars would become well-off people need and the opportunity to buy. However, according to the current electric cars technological progress and their functional limitations and a high price, even in the United States a substantial increase in electric cars park is not provided at least for 10 years. It is assumed that in Lithuania more significant growth of electric cars park can begin no earlier than after 15 years.

Urban buses and local goods distribution truck parks now are sufficiently developed in *the transport sector.* Furthermore, transport depots are supplemented by cheaper higher-green non-electric buses and trucks. City electric vehicle growth and electrification of railway lines can encourage the growth of electricity demand. However, it is assumed that more significant electricity demand growth in the transport sector will begin no earlier than after 15 years.

It is not likely to start more significant electricity demand growth in *agriculture*, because this sector does not undergo major changes. Arable areas of land are scarce, and the methodology and technique in terms of electricity consumption change a little.

4. Renewable energy sources

Biofuel consumption structure analysis shows that the maximum content (56% in 2012) is consumed in households. According to association "Litbioma", approximately 80–90 percent detached houses in Lithuania burns biofuel, but very inefficiently (Litbioma 2014). The average efficiency (the so-called coefficient of performance) amounts to only 40 percent in currently operating furnaces and old boilers. Changing them into new and more efficient would let the rate to rise to 85–90 percent, this would be even 1 million solid cubic meters of timber extra savings. Parallel effect is less pollution and lower fuel price, because saving raw material influences the district heating market and national industrial development (Dujomis – pasirūpinome... 2014).

During the last decade, biofuel consumption in district heat supply companies' power plants and boilers has grown rapidly. In 2012, 311.5 ktoe of biofuel were burned in power plants and boiler houses, i.e. almost 8 times more than in 2000. About 31% of the total amount of biofuel was consumed in district heating companies' boilers (221 ktoe) and power plants (90.5 ktoe) in 2012.

Close to 1 000 ktoe of biofuel have already been burned in Lithuania in 2011–2012. Total consumption of biofuel was about 1.5 times higher in 2012 than in 2000 (Statistics Lithuania 2014). And this share is growing extremely rapidly. The annual natural increase of biofuel raw in nature of the country consists of over 2.2 million toe plus unused dewatered sludge, which accumulates over the year about 70 thousand tones, or unused land (about 170 to 280 thousand ha), where short rotation energy plantations (willows, hybrid aspen, a variety of perennial grasses) could grow. In considering the various factors (individual housing renovation program, increasing biofuel boiler-house efficiency, emigration and migration (from rural areas to cities) processes), it is provided that the demand for local fuel will be about 1.5 million toe in 2020–2025. It is much less than it is predicted to prepare raw materials of biofuels in 2020–2025.

It is indicated in Lithuanian transmission system operator "Guarantee of Origin" database that in 2013, 977.67 GWh of electrical energy has been produced from renewable energy sources (excluding Kaunas Hydroelectric Power Plant), out of 977.67 GWh of electrical energy biofuel power plants amounted to 241.01 GWh (224.7 GWh of solid biofuel and 16.3 GWh of biogas). 92 MW biofuel-fired power plants (53 MW biomass, 18 MW biogas and 21 MW

waste-burning power plants) were installed on January 1st 2014 in Lithuania. It represented 2.1% in the total installed electric power structure.

The overall potential of biofuel, including solid biofuel, straw, biogas, municipal waste and peat, is based on a generalized assessment study "Existing Renewable Energy Sources (Biofuel, Hydropower, Solar Energy, Geothermal Energy) in the Municipalities of Country and Municipal Waste for Energy Production" (Galinis *et al.* 2009) carried out by Lithuanian Energy Institute scientists in 2009 and it is evaluated 2 147 ktoe in 2020. The total potential of biofuel established in Lithuanian Energy Consultants Association assessment study "Evaluation of Biofuel Potential in Lithuania, Price Forecast for Biofuel, the Social Benefits of the Biofuel Use and Proposals for Development of the Use of Biofuel Required State Backing" is 2 222 ktoe in 2020–2025. As can be seen, obtained results of biofuel potential assessment are very similar.

EU Directive 2009/28/EC on the promotion of renewable energy requires that the share of RES in gross final energy consumption would be not less than 23% in 2020 (Directive 2009/28/EC). It is estimated that in order to achieve the objective, it is necessary to increase share of RES electric power (RES-E) to 21% (in 2020). Lithuanian Renewable Energy Action Plan (2010) states that 626 GWh of electricity should be produced from solid biomass in 2016, and 263 GWh from biogas. This means that the total installed capacity of solid biomass power plants should be 135 MW and biogas plants – 40 MW in 2016. At a later period, the share of electricity produced from solid biomass and biogas is expected to increase and should consist of 8.68% in 2020, while the overall objective set in the electricity sector is 21%.

At present, the energy produced from renewable energy sources is more expensive if compared to conventional fossil energy or the relative initial investment in renewable energy technologies are higher than investments in traditional fossil fuels technologies. Therefore, in order to promote the use of renewable energy sources in energy production, state aid and (or) transfer of these higher costs to consumers will be required in the initial development phase (Ignotas 2010, 2012).

To achieve the purpose for 2010–2020 required investments and maximum support indicators are presented in Table 3.

Increasing renewable energy consumption by up to 1 474 ktoe in 2020:

- 10% of transport fuel would be replaced with renewable energy resources;
- 21% of electricity would be generated from renewable energy sources;
- demand for natural gas would be reduced 2 times in the district heating sector and about 80 percent of the heat would be produced from renewable resources.

About 430 ktoe (about 540 million cbm) natural gas would be replaced by biofuel. That would be about 430 million Lt/year. According to renewable energy attractiveness index set in 2010 by independent experts, currently, investing in renewable energy is best in the US and China (World Energy Outlook 2010).

These renewable and low used energy resources are generated every year in Lithuania: biofuel (wood waste, firewood and wood processing waste, straw, fast-growing willows, other vegetative mass, sludge of sewage – 2.25 million tons of oil equivalent) – 25 TWh energy; biodegradable fraction industrial and municipal waste (1.3 million tons) – 3 TWh energy; wind energy (generating potential) – 5.5 TWh energy; solar energy (technical potential) – 2.1 TWh energy; running water in hydropower plants could produce 1 TWh energy; biogas (technical potential) – 2 TWh energy; used geothermal heat would allow to produce up to 1 TWh heat; biofuel production capacity can produce 20% of Lithuania's fuel consumption; all these local sources of energy together account for about 40 TWh Lithuania's annual energy potential, which significantly exceeds the global heat and electricity demand.

The amount of energy from different renewable energy sources is presented in Table 4, and part of renewable energy

Table 3. Energy sector investment and support indicators (Ignotas 2010)

Energy sectors	Investments, billion Lt	Support, billion Lt	Potential funding sources	Contribution to "23%", %
Electricity sector	4.8	2.4*	Electricity end-user resources	21
Heat energy sector	2.0	1.0*	State and municipal budgets	36
Transport sector	–	1.4	State budget and users funds	10

Note: * – a maximum of 50% of the aid intensity is applied in calculations.

Table 4. Final consumption of renewable energy sources, thousand toe (LR Aplinkos ministerija 2014)

Year	Biofuel	Wood charcoal	Biogas	Bio-ethanol	Biodiesel
2008	694.6	1.5	1.4	8	45.7
2009	689.7	0.9	2.1	14	37.8
2010	687.2	1.2	4.5	10.4	34.8
2011	678	1	3.1	9.5	35.4
2012	690.8	0.7	3.1	8.7	51.8

Table 5. Part of renewable energy sources in general final energy consumption, % (Eurostat 2014)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Goal
EU 28	8.3	8.7	9.3	10.0	10.5	11.9	12.5	12.9	14.1	20
Lithuania	17.2	17.0	17.0	16.7	18.0	20.0	19.8	20.2	21.7	23

sources in general final energy consumption is presented in Table 5.

Increasing competition between biofuel market participants reduces biofuel prices. Experts estimate that the average fuel price can be 30% lower and may range about 657 Lt per ton of oil equivalent (Lt/toe). In August 2013, the average price of timber origin biofuel amounted to 519 Lt/toe, in 2012 – 668 Lt/toe, in 2011 – 747 Lt/toe.

In 2014, the Government adopted Resolution No. 277, tightening rules of trade in biofuel, intended for heat production. The document requires that as from January 1st 2015 heat production companies, publishing biofuel procurement tenders, would ensure such prerequisite requirements that allow the participation of not less than seven contenders.

The government has tightened the rules for biofuel purchase for high concentration of market participants (more than 71% fall on the three largest suppliers).

One additional Energy resources market law requirement for customers of biofuel at least 30% of used biofuel for the heat production to purchase in Exchange (the minimum requirement for this year amounted to 10%) will enter into force starting next year.

Biofuel for transport were started to use in 2004, when European Union (Directive 2003/30/EB set the objective that biofuel in balance of consumed transport fuel would amount 5.75% in 2010 (Europos parlamento … 2012). In accordance with Directive 2009/28/EB (Direktyva 2009/28/EB… 2009), renewable energy use in transport must be increased to at least 10% of the fuel used for transport (in 2008 – 3.8 percent):

- 95 make motor gasoline must be made using the additive bioethyltertiarybutylether, which must be not less than 7% volume but not more than 15% volume in a mixture of petrol. 47 percent bioethanol by volume are used to produce one unit volume in bio–ETBE;
- 95 make motor gasoline produced without bio-ETBE must contain 5% by volume of bioethanol;
- diesel fuel (except for class 2 arctic diesel) must contain 5% by volume of fat acid methyl ester (FAME) produced from vegetable oils or animal fats.

Part of the price was compensated for biofuel producers to purchase cereals and rape seeds needed for biofuel. This aid scheme covers the period up to 2012. In 2007–2009, the compensation for cereal grains intended for the production of bioethanol amounted to 114 Lt/t, for rape seeds – 160 Lt/t. The excise rate reduced in proportion to the biological origin annexes part in the product was also applied for energy products containing biological substances. This exemption was revoked since 2010.

At present, the use of biofuel is promoted introducing compulsory blending of biofuel to mineral fuels, compensating part of the acquisition cost of raw materials for biofuel producers and applying excise relief for biofuel when its part of the fuel exceeds the mandatory blending part. If by 2020 raw material acquisition compensation and excise relief for that part of biofuel, which exceeds the compulsory 5 percent part of the volume in fuel, would be left, over the period 2010–2020, the state predicted support would compose 1.4 billion. The abolition of excise duty concession increases transport fuel prices by 1–2 percent for consumers and has a negative impact on business competitiveness.

In 2014, Seimas adopted the Renewable Energy Law amendment and stated that "places of the sale of fuel should trade petrol consistent with Lithuanian or European standards; between 5 and 10% of biofuel should be in petrol, not less than 7% of biofuel should be in diesel fuel". In addition, the law requires that gas stations "can trade biofuel and fuel blends containing the percentage of biofuel blended in mineral oil products, exceeds referred percentages, and who meet Lithuanian, European or company's requirements of standards" (Gudavičius 2014).

Conclusions

Energy efficiency is one of the European Union's strategic directions which are given particular attention, considerable financial resources and raised ambitious goals. The most important documents, which provide energy efficiency-related provisions, are the "Europe 2020 Strategy", the Energy Efficiency Directive No. 2012/27/EU, the Energy Performance of Buildings Directive No. 2010/31/EU, the European Council and Parliament General Provisions Regulation No. 1303/2013.

Analyzing the final energy consumption data, it was observed that most of the energy is consumed in the transport; the final energy consumption in households is a little behind. The lowest energy consumption occurs in agriculture. In 2012, these (important for the country's economy) industries consumed most of the final energy: manufacture of chemicals and chemical products (33.0%), manufacture of non-metallic mineral products (19.1%), food products, beverages and tobacco (20.4%).

Electricity consumption in the industry is consistently growing for the period 2009–2013, and thermal energy consumption in industry began to decrease slightly from 2012.

Examining the renewable energy resources end-use, it was observed that the biofuel and biodiesel consumption in recent years has tendency to increase, and charcoal, biogas and bioethanol consumption declined slightly in 2010–2012. Electricity and thermal energy production from renewable energy sources gradually increased in the period 2008–2012. Renewable energy sources part in gross final consumption of energy is almost consistently increasing, but still has not achieved its goal. A similar trend is observed also in other EU countries.

Despite the fact that consumption of renewable energy sources is more expensive than traditional fossil energy sources in electricity and petroleum sector and significantly less expensive in heat production, renewable energy sources development is also an important benefit. The country's energy dependence is reduced by reducing the need for imported energy resources, human resource needs for biofuel preparation and supply is increased, the creation of industrial enterprises in the country and research development is encouraged and environmental pollution is reduced. In this way, renewable energy resources are becoming a significant element of energy sustainability.

Improving energy efficiency in all sectors is obvious, but still insufficient for the EU to implement its ambitious energy efficiency targets. Efficiency improvement measures require significant additional investments, which together with investment projects of the energy independence in addition will increase the final cost of all kinds of energy to consumers; it will reduce the availability of energy to them and a key stumbling block will be formed in achieving the country's energy sustainability.

In order to ensure further sustainability and coherence of three components of the energy sector: 1) energy independence, 2) energy sector efficiency and competitiveness, and 3) the sustainable development of energy sector, multifactorial analysis and scientific study are needed.

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