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ASSESSMENT OF HEAT PRODUCTION SAVINGS RESULTING FROM REPLACEMENT OF GAS WITH BIOFUELS

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ABSTRACT. ***A fast progress in the technology sector as well as clear intentions by the Lithuanian government to reduce pollution create advantageous circumstances for starting to utilise biofuel widely. A clear difference between biofuel and natural gas should help to reduce the price of heating noticeably. However, even though biofuel is 2–3 times cheaper than natural gas, the heat that was produced by utilising biofuel is only slightly cheaper than the one produced using natural gas.***

Special Paper

The object of this research is district heating sector. The research aims at investigating the savings that could be achieved after replacing natural gas with biofuel in heat production. The methods of research: the analysis of scientific and technical literature, articles, and statistical data. The results of research: the study showed that regulation is an integral part of the heating sector. The analysis of scientific and technical literature showed that the most widely analysed cost-cutting measure of heat production is the use of biofuels. The main part of the cost of heat produced by gas consists of fuel cost, i.e. natural gas. Scientists justify the shift to biofuel technology by the price of biofuels as they are more than two times cheaper than gas. On the other hand, biofuels are local raw materials, which do not have to be imported so the money can be kept in their economies. The measures on heat savings analysed by the researchers are related to the introduction of new technologies. Introduction of new technologies requires investment. As technology that enables heat production from biofuels is complex and very expensive, it is necessary to assess whether the investment in heat preparation with biofuels is cost-effective. It was found that the scientists use net present value method in investment assessment to calculate the discount rate and the cash flow generated by the investment.

KEYWORDS: heat production; replacement; gas; biofuels; district heating sector.

JEL classification: A12, Q4, Q5, Q28, L52.

Introduction

Nowadays, people live in comfort: they are provided with electricity, which lights the cities during night time, central heating, which keeps the cities warm during the winter, water supply and sewerage, Internet, conditioning, etc. Today it is difficult to imagine our daily life without these comforts. Many people would find it challenging to live in the city without central heating, electricity, water supply or sewerage. The infrastructure of the city consists of several kilometres of cables, which supply electricity to the houses. Water is supplied to our houses through pipes. Heating, which is produced by boiler-houses scattered around the city, is supplied the same way, through a web of pipes under the whole town. In order to supply heating to all citizens, it flows through the pipes for several kilometres. Thus, to guarantee a stable supply of heating, it is necessary to fix and sometimes even replace the pipes. All this influences the price of heating, which is rather high compared to the incomes of the citizens. For this reason, heating has become a luxury item and people willing to live in a city are forced to buy it.

Heating prices have been growing for a number of years and it is an important problem nowadays. Since the wages are not increasing while other expenses are growing, it is becoming more and more difficult to make a living in the city and this causes dissatisfaction of the community. Thus, the government is forced to compensate a part of the taxes. The rate of VAT is lower for those who live poorly. Decreased taxes for the needy result in lower government incomes. An insufficient budget limits the functions of the government. For this reason, it is

becoming more relevant to lower the expenses of the production of heating and supply it for smaller prices without changing the VAT rate.

Advancing technologies, aims to decrease air pollution and high prices of natural gas are the factors that create the conditions to build biomass boiling-houses in Lithuania. Such boiling-houses use fuel, which is much cheaper and friendlier to the environment. The only disadvantage is that the technologies used for burning and storing biomass are much more complex and expensive than the technologies used for supplying heating from natural gas. The obvious difference in the prices of natural gas and biomass should significantly decrease the prices of heating. Yet, here the main problem of the research becomes evident: why the heating created from biomass is sold at a marginally lower price than the heating obtained from natural gas although the price of biomass is 2–3 times lower.

Thus, the question is – what is the real difference between the prices of heating obtained from biomass and natural gas.

The object of research is district heating sector.

The research aims at investigating savings that could be achieved after replacing natural gas with biofuel in heat production.

Methods of research: the analysis of scientific and technical literature, statistical data and a comparative analysis.

1. The Means for Decreasing the Expenses for Heating

In Lithuania, research of district heating sector is mainly carried out for very specific, usually technical objectives. Research and analysis of the results are also carried out optimising the sector in order to reach the lowest cost of the system.

Scientists (Pažėraitė, 2015; Pažėraitė, Krasauskas, 2013; Simanavičienė, 2015) point out that the analysis and evaluation of the district heating sector development should start from a common European Union (EU) policy because they believe that common EU policy also sets the tone for the development of Lithuanian energy sector. On the other hand, the decisions in Lithuanian energy sector are still often made without evaluation of sustainable development as a prerequisite for a comprehensive welfare in the sector and general economic, social and environmental needs.

However, based on the analysis of scientific works (Barrett, Spataru, 2013; Brandoni, Polonara, 2012; McLellan *et al.*, 2015; O'Rielly, Jeswiet, 2015) on the issues of heat sector, it can be argued that the attention paid to district heating sector is very low and fragmented. Meanwhile, heat is supplied via the district heating system for more than 100 million people across Europe (excluding Russia). Total installed power of the district heating sector is more than 2 million MW and pipeline length is more than 400 000 km.

Pažėraitė (2015) indicates that development of district heating sector in different EU countries varies considerably. She states that in Central and Eastern Europe, where the district heating sector occupies a large part of the heat market, the production volume was relatively stable for a long time, but in the last five years has fallen significantly. District heating sector is decreasing in these countries: Croatia, Czech Republic, Hungary, Romania, Bulgaria, Slovakia, Slovenia.

Meanwhile, there are countries where district heating sector is growing: the United Kingdom, Norway, Sweden, Austria, Italy. It should be noted that in all the countries with the developing district heating, the sector is more market-oriented than elsewhere.

District heating sector in Central and Eastern Europe as well as in Finland, Denmark and Sweden occupy around 40 per cent of household heating market. Meanwhile, the overall EU average is only about 10 per cent (Pažėraitė, Krasauskas, 2013).

It is also important to note that in most of the old EU members, the amount of district heat produced in co-generation plants is also high in comparison with other technology-intensive manufacturers. Moreover, these cogeneration plants are usually characterised by another typical aspect – distributed production. Orientation to the market and distributed production could contribute to sustainable development, however, these are only fragments that should be a part of an integrated solution. Acceptance and implementation of such decision both in Lithuania and the EU should have appropriate assumptions.

Scholars (McLellan *et al.,* 2015; O'Rielly, Jeswiet, 2015) believe that the lack of competition in the market is one of the main reasons why the price of district heating is constantly growing.

Competition is when businessmen limit each other's possibilities to dominate the market. Meanwhile, it prompts the production of commodities and services for the consumers. The Competition Council defines competition the same way. While evaluating the importance of competition in the market, the Seimas of the Republic of Lithuania released the Law on Heat Sector in 2010. It aims at legalising the substantiated competition in the sector of heat and to increase the effectiveness of heat production, transferring and consuming. This way the well-being of consumers would be improved and the monopoly of heat suppliers would be decreased. The law is not widely discussed, thus the sector of energy is not paid a considerate attention by Lithuania and the European Union (Pažėraitė, Krasauskas, 2013).

One way of increasing the competition in the market is liberalising the production of heat or in other words decentralising it. According to Rasimas (2014), decentralisation of the sector of energy is one of the key means to guarantee energetic safety and to bring the production of energy closer to the consumer. Moreover, it is a tool for prompting the usage of renewable energy (RE) as well as a great tool for stopping the climate change (Pažėraitė, Krasauskas, 2013). Both in theory and practice, liberalisation of the market is estimated as a process when the clients can choose their energy supplier.

Nowadays, the ways to induce competition in the trade sector are analysed more often rather than the induction of competition in centralised heating while increasing decentralisation of the heating sector. Due to this, only a few energy suppliers understand the benefits of decentralised energy. Small RE systems, which are in the areas where the need for energy is growing, can help the energy suppliers avoid large investments in the expansion of the systems of heat transferring and distribution in the area (Štreimikienė, Pareigis 2007; Martinaitis, 2013). However, because of the liberalised market, when the production, transferring and distribution of energy are all separate activities carried out by separate companies, the benefits of distributed production of energy are not evaluated properly and without the support from the government, there are no possibilities for expansion (Štreimikienė, Pareigis, 2007).

When interfering in the sector of heat, the government must guarantee the easiest way for the market participants to gain access to the market. The owners of heating networks must define clear standard terms for the heat producers, which would determine the minimal investments required to join the central heating network (Pažėraitė, Krakauskas, 2013). Thus, the authors single out the issues that prevent new members from joining the energy sector: Current networks for the distribution of the energy are created in such a way that the energy would be transferred from several large energy sources, thus, the new providers can cause

damage to the energy distribution system; A new energy provider has to invest himself if he wants to join the system of energy distribution; A new member of the market must comply with the nonstandard conditions of the system owner, which are not known in advance. It is evident that the authors distinguish a lot of advantages of decentralised heating. Only a few disadvantages are singled out: the inclusion of independent heat providers into the sector of heat production and transfer is difficult and the interest in decentralised heating is insignificant.

The price of the heat provided to people consists of several parts: production, transferring and selling of heat. The final price of heating is influenced by the variable and fixed expenditure of heat providers, which determine the size of separate parts. In the structure of heat expenses, the variable expenditure forms the biggest part from 70% to 80%, which includes: the fuel required for the production of heat, electricity and water. The remaining 20–30% are fixed expenses (related with the infrastructure, equipment, control, etc.).

The difference in fuel prices was caused by the growing price of gas. The price of natural gas in Lithuania increased 3.5 times in 2005–2011 while the price of biomass increased approximately 2 times. However, this does not mean that people should stop using natural gas for the production of heat. It would be wrong to shift to using heat produced only from biomass. If the heat was produced only from biomass, the demand for it would increase significantly and it might lead to a huge growth in price resulting in even more expensive heating. Researchers agree that using only biomass can result in high prices due to the monopoly of fuel and in the long term such change would not be purposeful (Pažėraitė, Krasauskas, 2013). Based on the scientists' opinion on which fuel to use while producing heating, it can be stated that the installation of technologies producing heat from biomass should be prompted. However, the fuel used should not be replaced by 100%. The competition between the fuels should remain so that biomass would not gain monopoly and would not disrupt the market.

A decrease in heat production expenses while replacing natural gas with biomass is only a part of the process of installing biomass technologies into heating systems. On the one hand, the increased usage of biomass will induce the demand for biomass and will result in growing prices. On the other hand, biomass is a local material, which means that it is produced in Lithuania. Natural gas is mostly imported. This reveals a hidden, even more important benefit of biomass. It is revealed when looking in the price structure of wood chip, which is used as biomass (*Table 1*).

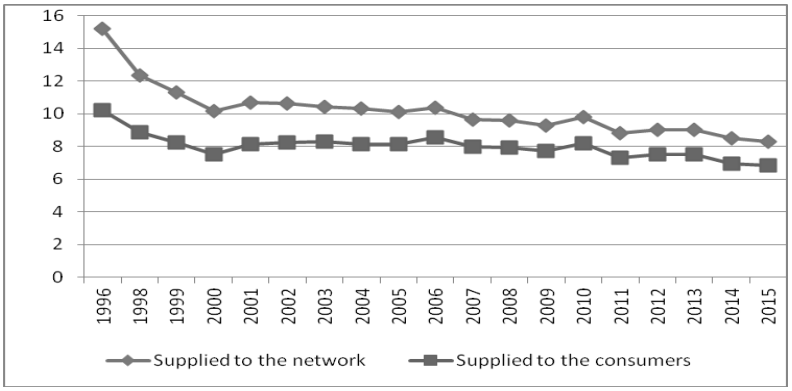
Table 1. The elaboration on the components of price of biomass

Cost type	Percentage	Part of input in national economy
Wage with taxes	15	100
Fuel and excise	13	50
Equipment and real estate	8	20
Machinery repair	7	70
Interest	2	0
Other expenses	2	50
Additional revenue from: Firewood, wood processing and logging waste; Profit of sales, contractors, transporters and storekeepers	52	100
TOTAL:	***100 %***	

Source: created by authors.

Thus, when employing biomass in heat production, the most part of expenses will return to the national economy as: taxes; wages for Lithuanian citizens; extra income for forest owners, farmers, the wood processing market; profit for the companies in Lithuania.

Taking into consideration the author's presumptions about the share of expenses staying in the national economy and converting these numbers into money value, it becomes evident that almost 81% of the money spent on buying biomass would remain in the national economy of Lithuania. Author suggests forming a macroeconomic price of biomass, which would reflect the sum of money that goes out of Lithuania's economy. Thus, while evaluating the price of biomass, it is profitable to use biomass for producing heat in Lithuania even in those cases when the price of biomass is higher than the price of any other fuel. Nonetheless, it is important to take the macroeconomic price into account since it must be lower than the macroeconomic price of any other fuel. The author stresses out that the price of imported fuel is almost equal to its macroeconomic price.



Source: LDHA Annual Report (2015).

Figure 1. **Balance of Heat Energy Production in Lithuania, 1996–2015**

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Studies show (LŠTA, 2015) that the main users of district heating are residents as they account for 72.6 per cent of all users (*Figure 1*). The rest of the market is occupied by budgetary institutions and business organisations. Considering that more than one person is living in each apartment, it is obvious that this is the main method of heating and hot water heating in Lithuania. In recent years, while natural gas has been rapidly replacing biofuel, prices of district heating decrease, however, there still remains one of the biggest problems in heat sector, i.e. inefficient use of heat energy. The average annual heat consumption of Lithuanian buildings reaches 209 kWh/m^2, while the neighbouring Nordic countries consume about 128 kWh/m^2 per year for heating buildings. Most technical indicators of DH and heat prices in the Baltic and Nordic countries are similar, but slow renovation of flat houses determine the size of most heating bills. The decline of heat price could be even higher, however, compulsory purchasing of expensive natural gas from the LNG terminal was started in 2015. With alternating pricing and regime of natural gas supply, and imprecise and old requirements for use of reserve fuel, it is difficult for district heating companies to form a rational long-term strategy and plan the investments. The newly discussed principles of the National Energy Strategy, which are likely to make further development of district heating systems irrational and prevent the development of cogeneration and would reduce the reliability of heat supply, add even more confusion.

According to the Lithuanian District Heating Association (LDHA) (2016), DH supply is even more important in terms of the state. Then it reveals even more of its advantages, which

can be converted into serious levers, having a significant impact on the state economy. Here are the advantages:

1. In thermal power plants, while producing electricity and heat together, the fuel is used much more efficiently and there are relatively fewer emissions;
2. Low-grade fuel and various waste can be used more effectively;
3. Geothermal energy and waste heat from industrial processes can be used;
4. It requires less operating personnel; there is no need of special area for boiler rooms in buildings, so it can be advantageously used for other purposes;
5. Emissions from centrally produced heat sources are much easier to control than from individual heat sources. They can be efficiently removed from flue gases;
6. District heating systems are sufficiently flexible and therefore their modes can be easily changed, taking into account the environmental factors.

2. State Regulation of the District Heating Sector

Economic sector of district heating is one of the most important energy sectors in Lithuania. It is closely related to other energy sectors: electricity, natural gas, petroleum products, and renewable energy sources. In such countries as Lithuania, where heating is maintained for 6–7 months a year, heating costs and pricing become particularly important. For this reason, the sector is strictly regulated by the state, applying laws and licenses for heat suppliers and regulating supply conditions and pricing.

According to the Lithuanian Free Market Institute (2005), price regulation in energetics is applied due to the following reasons:

- the need to protect consumers from the natural monopolies and unrealistically high prices, to prevent monopolies from getting excess profit;
- to ensure the availability of energy;
- to maintain low energy prices so that it would not slow down the economic growth;
- to ensure equal energy prices in a relatively large area.

The main principles of heat sector are established by the Law on Energy of the Republic of Lithuania (2016), which regulates the overall energetic activities, basics of energy development and management, efficient consumption of energy and energy sources. The law sets out the key objectives of state energy activity and heat sector regulations:

- safety of energy supply;
- efficiency of energy sources and energy consumption;
- reduction of adverse effects of energy activities on the environment;
- promotion of fair competition;
- promotion of local and renewable energy resources consumption.

The same Law regulates that the state management of energetics in Lithuania is performed by: Government or its authorised institution; Ministry of Agriculture; Ministry of Environment; Municipalities.

Lithuanian heat sector is being administered by more than 100 laws and 1,000 secondary legislation.

In addition to the law regulating heat supply enterprises, companies are required to have a heat supply license. The National Commission for Energy Control and Prices (hereinafter – the Commission) issues licenses for companies supplying not less than 10 GWh per year taking into account the recommendations of municipal authorities. The Commission also suspends,

repeals the suspension and controls licensed activities. Licenses for companies supplying less heat are issued, changed, suspended and revoked by the municipal authority.

Heat sector in Lithuania is regulated in administrative (direct) way, by directly changing or stabilising prices. Administrative (direct) regulation of prices is implemented by specialised state bodies on the basis of existing laws, government resolutions and certain economic and social conditions.

The Law on Heat Sector of the Republic of Lithuania (2016) regulates state management of heating sector, activity of thermal economic entities, their relationship with heat consumers, interrelations and responsibility. The law provides for a number of goals:

1) to ensure reliable and high-quality heat supply to consumers at the lowest cost;
2) to legalise reasonable competition in heat economy;
3) to protect heat consumers' legitimate rights and interests;
4) to increase the efficiency of heat production, transmission and consumption;
5) to increase the use of local fuels, biofuels and renewable energy sources when generating heat;
6) to reduce the negative impact of heat energetics on the environment.

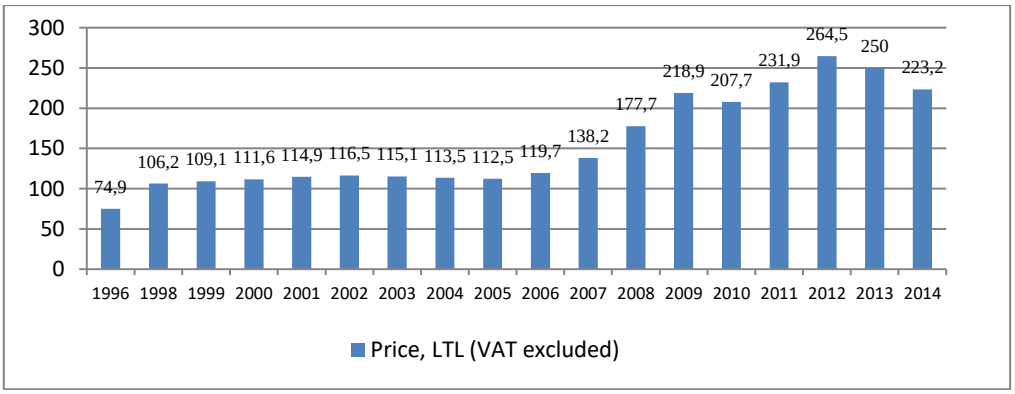
The law states that heat supply is a delivery of centrally produced heat and sale of heat to consumers. The law also regulates the planning of heat economic activity.

According to the Law on Heat Sector of the Republic of Lithuania (2016), the regulation of district heating companies is carried out by the National Commission for Energy Control and Prices (NCECP) and the municipalities, depending on the amount of heat supplier's disposed heat. In general, it is guided by heat pricing methodology prepared by the NCECP.

Since 2003, in Lithuania the principle of long-term (basic) heat pricing and annual recalculation has been applied according to the Law on Heat of the Republic of Lithuania, where heating costs are determined for a period of 3–5 years, the fixed costs are adjusted only for inflation changes and variable costs (for fuel) – according to the index of market price. The heat price consists of fixed and variable price components.

When applying the method of long-term (basic) heat pricing and annual conversion, the economic motivation is achieved when the heat supplier has an economic interest to operate more efficiently (in order to reduce costs and generate additional revenue), and more efficient functioning of the district heating system is more useful to the consumer after each adjustment period. In this way, the goal of pricing to align upstream and downstream economic interest is achieved.

The economic incentive effect of long-term base pricing can be based on variation of the average components of heat price in Lithuania in the period of 2004–2014. The above introduced pricing system was introduced during this period (*Figure 2*).



Source: Stasiūnas, 2015.

Figure 2. **Dynamics of District Heat Prices (excluding VAT) (1996–2014)**

In this period, the price of heat was almost constantly growing, but the growth of prices for the most part was due to increases in fuel prices rather than long-term heat pricing. The fixed part of the cost changed slightly (+1.12 cents/kWh), while the variable portion – fuel consumption – demonstrated a significant increase (+7.82 cents/kWh). Even in 2004, the heat price components accounted for a relatively equal share in the price of heat, and in 2010 the variable costs had a significant increase and these indicators have changed (69% vs. 31%).

The assessment of the previously reviewed information indicates that the main ways to reduce the price of heat is the promotion of competition in the market and new technologies that allow using biofuels in the heat production. It was investigated that competition would force heat producers to find ways to make heat production more efficient, i.e. to change the technology. However, for competition to work, the state has to contribute to its promotion, creating a legal framework that would separate the production of heat from the heat supply and transmission. The main way to make production of heat more efficient is to reduce the losses in the system or the cost of production.

According to the Lithuanian District Heating Association (2015), decisions of the authorities determined that 2015 was the last year when the "quota" of electricity was purchased from co-generation power plants using fossil fuels at higher than market prices. Therefore, it was the last year when a large part of the heat was produced by cogeneration (2,760 GWh), comprising 33 per cent of all the heat produced in DH sector. It is paradoxical that the authorities on the one hand oblige cogeneration plants to mandatory buy natural gas from liquefied natural gas (LNG) terminal in price fixed by state, which is several times higher than the price of natural gas suggested in the free market, and on the other hand destroy the quotas of power purchasing, arguing that electricity production is not competitive. At the end of the year, TE 3 in Vilnius was disabled, and other major cogeneration plants work only periodically. In cogeneration plants, which use biofuels and waste, the installed capacity of electricity generation (67.8 MW) is too small for them to have some significant impact on the adequacy of power system. It is assumed that institutions forming Lithuanian energetics must find ways to pitch the complete large cogeneration power plants in balancing of the electricity system or reservation markets. After all, their total electrical capacity reaches 655 MW and electrical cogeneration with heat is much more efficient than the generation discharging the heat into the lake (Elektrėnai). By combining the advantages of cogeneration with market instruments it is likely to achieve cost-effective activity. In 2015, cogeneration power plants of the Lithuanian DH sector produced 850 GWh of electricity.

Birgitta Resvik, a spokeswoman of Finnish energy company "Fortum", which is one of the largest investors in energy in the post-Soviet countries, compared heat economy regulation in different European countries. According to her assessment, Lithuania has a strict regulatory regime, detailed comparative analysis is used for cost justification and the allowable gain is limited. A similar heat pricing, in her view, is applied in Denmark and Estonia. The comparison of heat prices showed that the average price for district heating is the highest in Denmark and Norway (104 EUR/MWh) and the lowest in Poland (49 €/MWh). In Lithuania, the level of heat prices is slightly higher – 60.3 €/MWh – but Lithuanian and Polish consumers spend the largest share of their income for heating and an average heating bill accounts for 9% of gross domestic product per capita. Meanwhile, in Denmark this indicator is 4 per cent, while in Norway it is only 2 per cent. This illustrates the fact that it is low cost of living in Lithuania rather than the high price of heat that is one of the major problems hindering the availability of heating. In the opinion of "Fortum" representative, the regulation of DH sector should be based on economic motivation to improve the performance and ensure the returns of invested capital, even though it is regulated. In the long run, the DH sector must be prepared to compete with alternative methods of heating and use the maximum of technological advantages: to supply not only heat but also cooling, to produce more electricity in DH systems, to introduce the renewable energy resources, to utilise waste and emissions from energy, to accumulate and store heat and cooling energy.

In countries where district heating sector is not regulated, heat prices are determined by the heat supplying company. In case this sector is regulated, the heat price is determined by an independent regulator or public authority.

In Denmark, supervision and regulation of heat sector is carried out by the Danish Energy Regulatory Agency (DERA). Heat price is determined by the heat supplying company, but the final price is confirmed by DERA.

In Finland, heat prices are not regulated, thus in general no methodology is applied. For this reason, the price of heat is determined by the heat supplying company, its profits are unlimited. However, supervision and control is necessary, therefore it is supported by the competition agency. Urban Persson, a representative of Swedish Chalmers University of Technology (2015), presented an interesting study in which he examined the characteristics of 83 Western European cities and studied what methods would be appropriate to be applied (as compared with the existing alternative methods of heating) in order to develop district heating systems there. It was found that under current investment and fuel prices in most of the Belgian, Dutch, French and German cities it would be economically expedient to supply approximately 60% of the total heat demand centrally. Unfortunately, currently, the DH technology penetration in these urban areas is much lower and it is very difficult to create an infrastructure in built-up urban areas.

Poland, Lithuania and Russia have transition economies, which means that in these countries only part of the heat prices is regulated. In case of Lithuania, it is a constant component. In Lithuania, regulation and supervision is under the competence of NCECP and municipality. Heat price is being recalculated once a month, most usually if comparing to other countries. Normative profit is calculated according to the weighted average cost of capital (WACC). Base heat prices in Lithuania are valid from 3 to 5 years.

Meanwhile, in Poland methodology and supervision of heat prices are determined by the Energy Regulatory Authority. The period of base price adjustment is shorter, but the heat price conversion is carried out less frequently, i.e. once a year. In Russia, the methodology is

determined by the Federal Service of Tariffs. Heat prices are set and supervised by the Regional Ministry.

An interesting research that was relevant to Lithuania was carried out by the International Energy Agency, where the DH sector regulation of non-EU countries was examined and introduced by the expert Kalkum (2015). The situation in the former Soviet Union and Yugoslavia countries shows consequences of separate regulatory episodes. Efficiency of the DH pricing, when they are regulated by state and municipal authorities, was compared. In the first case, the controller has qualified staff, use uniform methods and databases for cost estimation, while in municipalities this process is unpredictable, heat prices are set unreasonably, their differences are huge and the incompetence of municipalities and games of the local politicians often condemn DH companies to agony. Summing up the results, recommendations were made for DH economic regulation in countries of "transition" economies:

1. Heat prices have to be determined by the central (state) controller;
2. The regulation should cover at least rationing of the cost, pricing, licensing, rules of exploitation and management;
3. The heat used in the buildings must be measured and paid – in most countries it is still not fully implemented;
4. Binomial price should be applied for settlements for the heat;
5. Heat supply costs should be determined on the basis of clear and predictable rules;
6. The heat price should include the normative profit, if it is unavailable due to objective reasons – compensated for the following year;
7. Property of DH systems must be separated from the regulation;
8. Cogeneration power plants must be supported (if, for whatever reason, they cannot compete in the market);
9. Allocation of costs between heat and electricity should be clear and predictable.

Having summarised the information, it can be stated that regulation of heat sector in Lithuania is similar to the regulations in foreign countries. The closest practice is applied in Poland. The greatest differences were between the methods used in Lithuania and Finland. As shown by the studies, state regulation, influencing economic viability of Lithuanian DH sector, was one of the key factors that had influence on political decisions of separate municipalities and technical strategy of heat companies, and thus the final prices of heat in individual municipalities.

Expediency of the district heat supply regulation.

In Lithuania, long-term (basic) heat pricing and annual recalculation principle are applied, where the heat price consists of fixed and variable price components. Heat supply costs are set for a period of 3–5 years, fixed costs are adjusted only for inflation changes and variable costs in accordance with the market price index. The application of this methodology lets achieve the economic motivation and the heat supplier has economic interest to operate more efficiently, while benefit to the consumer after each adjustment period is better and more efficient functioning of the centralised heat supply system.

For optimal price and the best result for heat consumers it is necessary to regulate the heating sector because only state measures can stop the arbitrariness of monopolistic market companies and prevent high heating prices.

Lukoševičius, Balaišytė (2012) indicates that for development of district heating pipelines the state regulation and streamlined spatial planning in municipalities is necessary so

that it would harmonise the national interests with plans of the local energy infrastructure in order to provide consumers with thermal energy and use the local resources maximally.

In addition to the strategic quests, Lithuanian DH sector has continued trying to solve chronic problems, which certainly do not help to improve the supply of heat and make the economy more attractive to consumers. Among these problems, it should be mentioned that installation of modern metering and control devices for heat and hot water is not legally regulated and harmonised in multi-residential buildings, ensuring the user's right to get the desired amount of heat energy and correct bill for it.

Lithuanian District Heating Association (2015) states that various political or business interests, often superficial and short-sighted approach to heating sector which is the most important for people of Lithuania, hinder the development of sustainable and attractive heating system. District heating should be integrated into complex infrastructure of modern urban energetics and should perform various functions required by the society, as it is stated in the European Commission's recently published project of strategy for heating and cooling. When assessing trends of the neighbouring advanced countries in the district heating sector, Lithuanian heat suppliers should launch a further stage of development: to introduce flexible integrated energy systems, helping to accumulate surplus and cheap heat flows, to switch to a lower temperature regime, to modernise the heat points, allowing to supply not only heat, but also cooling, to exchange energy with customers, to introduce smart networks and devices, to expand cogeneration and trigeneration.

3. The Effect that Heat Production Promotion has on Heating Prices

One of the most important aims of energetics policy is to encourage the providers and the consumers to use RE. In Law on Energy of the Republic of Lithuania and in the National Energy Independence Strategy, one of the priorities of the energy sector is to prompt local and renewable energy.

According to the development and usage of the central heating system, its infrastructure can be a valuable asset which helps to solve the strategic energy and other tasks of the government: reliable production of energy, decreasing pollution; the diversification of fuel; using communal waste to produce heat and electricity; the integration and provision of the spare heat from the industry into CHP (EN – Central Heat Production) systems. However, it must be admitted that this is more realistic in theory. Nonetheless, there are new opportunities due to the directives that the European Union has already enacted or is planning to enact.

In 2008, the European Commission presented a set of laws to the members of the European Union, which regulates the areas of climate change and energy. It also singles out a directive which prompts the usage of renewable energy. According to this directive, until the year 2020, Lithuania must reach a limit when 23% of energy is produced from renewable sources. Štreimikienė, Pareigis (2007) suggest dividing the means of RE promotion into three main categories: financial (subsidy and tax relief for investments); fiscal (various taxes); versatile and market imitating means for reducing climate change. It is believed that in 2020 the heat produced from renewable energy sources will make up more than 39% of the central heating system. In such case, in the central heating provision network in Lithuania, 1050 MW devices using biomass should be installed and it would bring approximately 0.3 billion EUR of investments.

The European Union provides support from the Investment Funds which are meant to finance the production of energy using renewable sources. This corresponded with the Lithuanian Single Programming Document for 2004–2006 1.2. *Ensuring of Energy Supply Stability, Accessibility and Increased Efficiency,* specifically with the activity groups: *Boilers Upgrade and Fuel Conversion* and *Local and Renewable Energy Sources*. Furthermore, in 1996 public organisation *Lithuanian Environmental Investment Fund* (LEIF) was founded. It was founded by the Ministry of Environment of the Republic of Lithuania. The fund receives its resources from the taxes collected on the basis of the Law on Pollution Tax. From 2000 the rate was 20%, however, since 1 January 2013 the rate is 30%. The key aim of the fund is to give out preferential loans to finance environmental projects and to give out subsidies to finance projects committed to using renewable energy sources. All projects funded by LEIF must decrease the effect of economic activity to the environment. The sum of the subsidy provided for one receiver of the grant cannot exceed 100 thousand eur per three years, furthermore, it cannot exceed 70% of the general sum of the investments (Štreimikienė, Pareigis, 2007). The value of the investment, which heat producers transfer via amortisation to the fixed part of the heating price, decreases due to the support for boiler-houses using biomass received from the EU Investment Funds and LEIF. This way a part of the invested capital is recovered and the heating price can be reduced.

Scientists (Štreimikienė, Pareigis, 2007) state that pollution taxes for stationary pollution sources in Lithuania are calculated for a ton of pollution and collected according to the basic or enlarged rate.

Comparing Lithuania to the neighbouring Baltic States, the pollution tax rates in Lithuania are the highest, yet they are not applied to biomass which is produced in Lithuania. According to the Law on Pollution Tax, which was initiated in 1999 by the Seimas of the Republic of Lithuania, natural and legal persons, who use biomass in stationary pollution sources and who present documents proving its usage, are dispensed from paying the tax. Such relief of the tax reduces the expenses of producing heat from biomass even more.

4. Changing Ways of Producing Heat as a Means to Lower Heat Prices

According to the aforementioned information, the main means of lowering the prices of heating is to prompt competition in the market and to install new technologies which would use biomass when producing heat. Competition would force heat providers to search for ways to make the production process more effective, which would mean changing the technologies. However, in order for the competition to work, the government must help prompt it and create a legal system, which would separate heat production from transferring and supplying. The key means to make heat production more effective is to decrease the damages in the system or the expenses.

Biomass boiler-houses.

An effective way of lowering the expenses is to use cheaper fuel as the fuel component in the heating price is the largest. The benefits of biomass boiler-houses cannot be evaluated only for saving fuel. Because of the difficult technology, it is much more challenging to build a biomass boiler-house than a gas boiler-house. A simplified process of producing heat in biomass boiler-houses would be like this: solid and dry fuel are used in the biomass boiler-houses, thus, its serving system is much more complicated and further away from the boiler. What makes the biomass boiler-house expensive is the complicated biomass transfer system,

which is designed to guarantee a sustained process of transferring the fuel to the firebox, where it is burnt. The fuel must be transported to the warehouse where with the help of hydraulics, the fuel is pushed onto the transporters that carry the fuel to the transitional bunker through which the fuel is put to the firebox. Another difference between biomass and gas boiler-houses is that ash is produced from solid fuel. It needs to be neutralised, removed from the system and exported. All of these processes make the biomass boiler-houses very expensive.

Due to the aforementioned reasons, the exploitation expenditure for biomass boiling-houses are becoming more expensive. More people are needed for the proper operating of work in a biomass boiling-house than in a gas boiling-house. The complicated technologies of fuel provision and ash removal increase the possibility of damages as well as the expenses for repair.

Condensational economisers.

A device used in the production of heat is condensational economiser, which helps to save some money on fuel. When burning the fuel and warming the water in the boiler, a great amount of heat transfers to the air in the form of steam and this heat can be used again to warm up the water returning to the system.

Cogeneration and trigeneration.

Another way to decrease heating prices is to change the system of heat production, which would mean joining the processes of producing heat and electricity. Scientists suggest using cogeneration as a more effective means of using fuel in the production of energy (Lund, Moller, Mathiesen, Dyrelund). Researches have showed that cogeneration technologies can differ depending on the needs of energy, parameters of the heat or the fuel used. Scientists single out such systems of cogeneration (Ministry of Economy of the Republic of Lithuania, 2007): a) steam turbine of combined cycle with a system of heat removal; b) counter-pressure steam turbine; c) condensational turbine which extracts steam; d) gas turbine with a heat removal system; e) internal combustion engine; f) organic Rankine cycle.

With cogeneration, both heat and electricity are produced at the same time. Separately producing heat or electricity in such a system would further increase damages. In a lot of cases, the cogeneration system in Lithuania could work only during the heating season, thus, there would not be a lot of potential in producing and selling electricity. This is due to the reason that heating is not needed in Lithuania during the summer season when the heat is only required to supply warm water.

Another solution which could be applied in Lithuania would be trigenerational boiling-houses, which produce electricity, heat and cold. This means that the boiling-house could produce heat and electricity during the winter season and electricity during the summer season and when the need for heat reduces, they could supply cold to the industry or to the people through central heating. Rentizelas, Karellas, Kakaras, Tatsiopoulos discuss the benefits of this model and its perspectives (2009).

The scientists have modelled a system which consists of two separate blocks of technologies: cogeneration block and biomass boiler, which is meant to make up for the increased need for heat during peak time. Trigeneration power plant supplies the local Greek community with heat, the community uses it mainly to warm the rooms and for hot water and it uses the cooling to cool off the rooms. In the analysed region, likewise in Lithuania, the demand for heat and cooling depends on climate change, thus, the demand is constantly changing. The boiler-house itself is meant for producing heat and coolness and it has produced just enough to fill the consumers' demands. Meanwhile electricity, which is made when producing heat, is all sold to electrical networks. In the presented example, the legal system of

Greece foresees that the electricity made from biomass is bought first, so the model foresees that all heating and cooling will be sold together will all electricity.

This trigenerational power plant model could be adapted in Lithuania since the circumstances are very similar, climate change influences the need for heating and conditioners are becoming more popular during the summer time. This would guarantee the operating of the boiler-house all year long, which would improve its effectiveness. Treating the produced electricity as a side effect of the production and saying that the part of electricity which is sold decreases the price of heating, all of this would decrease the price of central heating.

Solar energy.

The technological means to decrease heating price is producing heat with solar energy rather than fuel. Solar energy can be used for heating warm water. Solar collectors are the most effective as showed by all the other countries which are in a similar latitude and have used solar collectors as a means to supply hot water. This way almost the whole demand for hot water can be fulfilled during the non-heating season. Such systems are not made for central heating but directly for hot water consumers instead, and they are installed at home as a cheaper alternative to central hot water. Thus, such means of producing heat is presented as an alternative and a way to produce heat cheaper, nonetheless, it will not be analysed in detail.

According to the scientists, solar collectors could help produce more than 50% of hot water consumed yearly. It seems unbelievable since the sun shines only during day time and it is not as strong in the morning and in the evening, furthermore, not every day is sunny. For this reason, there is an accumulator integrated in the system, which stores the heat produced by the sun and when there is not enough sunshine to produce energy, the storage is used for heating up the water.

Conclusions

The research revealed that regulation is an important part of the production sector. Heat is an item of primary importance and the businesses can use the dependence on heat to their benefit. When taking part in the sector of heat production and supply, the government controls the businesses and this way protects the people.

The sector of district heat supply is one of the most important energy sectors in Lithuania, which is closely linked to other energy sectors: electricity, natural gas, petroleum products, and renewable energy sources. In Lithuania, heat supply is ensured by the Lithuanian District Heating Association, which consists of 42 heat supply companies. LDHA's heating companies produce more than 99% of district heat in Lithuania.

Having examined the market of district heat supply, it can be said that monopoly dominates here. It is the type of market structure with only one seller of product and no close substitutes. Users do not have any possibility to influence the price of the service delivery. High input and output barriers in the sector, strict state control operating in the market. Heat sector in Lithuania is regulated in administrative (direct) way by directly changing or stabilising the prices. Administrative (direct) price regulation is implemented by specialised state bodies on the basis of existing laws, government resolutions and certain economic and social conditions.

The analysis of scientific and technical literature revealed that the most researched means of decreasing heat production expenses is the usage of biomass in heat production. When the heat is produced from gas, the main reason for expenses is fuel – natural gas. For this reason, scientists are analysing the benefit of substituting gas for biomass. The shift to biomass is based

on the price of biomass since it is more than two times cheaper than gas. On the other hand, biomass is a local material and does not need to be imported and this allows to keep the money in the national economy.

The research revealed that the most effective way to reduce the heating price is by introducing an independent heat producer, which uses biomass, to the heat sector and this way increasing the competition. Due to a low price of biomass and its benefit to macroeconomics, the technologies of biomass seem very perspective nowadays when the price of natural gas is very unstable. Furthermore, the usage of a condensational economiser is a much more effective means when using damp biological fuel rather than organic, which increases the advantages of this technology. Finally, the government prompts the installation of this technology when giving out subsidies and preferential loans for new investments and dismissing heat producers using biomass from pollution taxes. Nevertheless, the difficult technology of biomass demands large investments, thus, it needs to be evaluated if installing biomass systems into the market is beneficial to the economy.

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Special Paper

ŠILUMOS GAMYBOS EKONOMIJA DUJAS KEIČIANT BIOKURU

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SANTRAUKA

Palankias pozicijas biokuro naudojimui sudaro technologinio sektoriaus pažanga, taršos mažinimo reikalavimai, Lietuvos Vyriausybės pozicija. Didelis skirtumas tarp biokuro ir gamtinių dujų padeda mažinti šildymo kainą, kuri labai svarbi vartotojui. Biokuras yra 2–3 kartus pigesnis negu gamtinės dujos, tačiau šildantis biokuru pastebima, kad šilumos gamybos kaina sumažėja labai nedaug.

Straipsnio objektas – tiekiamos šilumos gamybos sektorius. Tyrimo tikslas – išanalizuoti ekonomijos susidarymą dujas keičiant biokuru. Tyrimo metu buvo analizuojama mokslinė ir techninė literatūra, įvairūs moksliniai straipsniai ir statistiniai duomenys. Tyrimas parodė, kad verslas naudojasi gyventojų poreikiu šilumai, o valstybė, siekdama apsaugoti vartotojų interesus, riboja verslo patekimą į šilumos gamybos ir tiekimo sektorių.

Mokslinės ir techninės literatūros analizė atskleidė, kad plačiausiai analizuojama šilumos gamybos sąnaudų mažinimo priemonė yra biokuro naudojimas šilumai gaminti. Didžioji dalis pagamintų dujų kainos susideda iš kuro kainos. Todėl mokslininkai nagrinėja naudą, kuri gaunama dujas keičiant biokuru. Kita vertus, biokuras yra vietinė žaliava, kurios nereikia importuoti. Tai leidžia sutaupyti pinigus ir juos skirti naujų technologijų plėtrai. Atlikus tyrimus, buvo nustatyta, kad investicijų vertinimui mokslininkai naudoja grynosios dabartinės vertės metodą. Juo naudojantis apskaičiuota diskonto norma ir pinigų srautai.

REIKŠMINIAI ŽODŽIAI: šilumos gamyba, keitimas, dujos, biokuras, centralizuotai tiekiamos šilumos gamyba.