Bio-fuel based district heating in Lithuania

Juozas Abaravičius

LUMES, Lund University, P.O.BOX 170, S-22100 Lund, Sweden

Northern Europe and Lithuania are in the climatic conditions that make artificial heating necessary during more than half of a year. Large amounts of different fuels are used for production and supply of heat energy. Fossil fuels are nowadays predominant in the heat sector of Lithuania. The country has no fossil fuel resources, therefore they are imported, mainly from Russia. However, the bio-fuel resources in Lithuania seem to be large enough to cover a significant part of the country's heat demand. The combustion of fossil fuels causes major environmental problems both locally (by emitting sulphur dioxide and nitrogen oxides) and globally (by emitting carbon dioxide and other greenhouse gases). Biomass is a carbon-neutral and low-sulphur energy source. Furthermore, utilisation of a local and renewable energy source is a way towards energy security and the major prerequisite for sustainable development. Bio-fuel can be successfully utilised in district heating (DH) systems. As a part of the urban infrastructure, DH is the most efficient and secure system for the production and supply of heat. The modernisation of DH systems and using bio-fuel is an obvious way towards sustainable heat energy production in Lithuania.

Key words: bio-fuel, district heating, emissions, transitional economy, climate change, sustainability, Lithuania

1. INTRODUCTION

Bio-fuels and the environment

In the European Union, a recent White Paper on Renewable Energy proposed that Europe could double its renewable energy contribution from 6% today to 12% by 2010. This would substantially help meeting the Kyoto Protocol targets [7].

In June 12, 1995 Lithuania signed the Treaty of Associate Membership to the European Union and is aiming to become a full and equal member of the European Union. One of the preconditions for the membership is the conformity of environment policy and relevant laws to the legal forms in use of European Union documentation [15].

The share of renewable energy in the total Lithuanian energy balance now reaches 8.5% [4].

In 1992 Lithuania signed the UN Framework Convention on climate Change (FCCC) and ratified it in 1995. In 1998 Lithuania signed the Kyoto Protocol, committing itself to a reduction in GHG emissions of 8% by 2008–2012 from the base of 1990. CO_2 emissions in Lithuania decreased from 41.6 Mtonnes in 1990 to 19.2 Mtonnes in 1998. This is essentially the result of an economical recession due to the transition from centralized planning to market economy [5]. Therefore it is obvious that with the current economic growth the CO_2 emissions will be increasing.

District Heating in Europe and Lithuania

District heating (DH) is supplied to 22 million people in the EU-15, or 6% of its population. A European Union, enlarged to 26 countries, would bring these figures up to 56 million, or 12% of the enlarged Union [6].

A very important benefit of DH is that it provides a possibility to use different sorts of fuels. The DH technology in the EU is becoming increasingly "green". In the period 1994–1999, a strong shift away from the use of coal and oil took place; the use of coal for DH decreased by 30% and gave way to natural gas as the predominant fuel. During the same period the use of renewable fuels grew strongly. Renewable sources account for almost half of the supply in Sweden [6].

After regaining its independence in 1990 Lithuania inherited a widely developed but inefficient DH sector, which was not designed for operation under free market conditions. The DH sector was an inseparable part of urban planning in the former planning economy. Approx. 70% of the urban population in Lithuania receives heat from DH systems. The DH share in the Lithuanian heat market reaches 65% (for comparison: Denmark – 58%, Finland – 50%, Sweden – 42%) [11]. The predominant fuels are oil and natural gas (usually there are technical possibilities to use both kinds of fuels) [11]. Renewable energy sources, particularly wood fuel, are being introduced in the Lithuanian DH sector. The sector itself however, faces certain technical and economical problems, primarily due to Lithuania's transition from planned to market economy. Changing economical conditions and increasing fuel prices have led to a significant decrease in heat consumption. During the years 1990–2000 it decreased more than 50% [14].

2. OBJECTIVE

The objective of this study is to analyse the use of bio-fuel in district heating systems in Lithuania. By looking at the general renewable energy situation in the country and via analysis of recently implemented project in the Ignalina municipality certain conclusions and perspectives are being drawn. The kind of bio-fuel analysed is wood fuel. The major scope of the study is to analyse the political economical, social and environmental aspects of using wood fuel in DH systems in Lithuania and evaluate their correspondence to sustainable development.

3. METHODOLOGY

The Causal Loop Diagram (Fig. 1) is constructed in order to establish the key links between the analysed bio-fuelled DH system, economy, society and the environment. It is being used as the basic tool for the further analysis.

Biomass-based DH significantly reduces energy costs, reduces emission of hazardous pollutants to the atmosphere, thus gradually positively influencing both the local and the global environment. Biomass is produced locally and is therefore a stable and secure energy supply, what cannot be said about imported oil products. Biomass-based energy supply also provides new labour places in the stage of fuel preparation, transportation and production of utilization equipment. From the social perspective it is a very important benefit, especially in countries with a transitional economy.

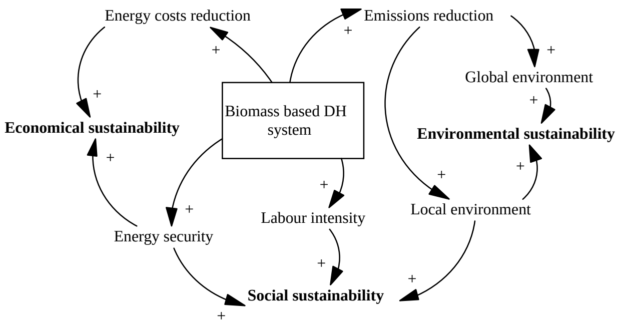

Fig. 1. Causal loop diagram

4. MATERIAL AND DATA

The analysis of national energy legislation, national energy statistics, and scientific articles as well as the interviews with the representatives from the Ministries of Economy and Environment, scientific institutions and associations were used to carry out the study of national issues.

The case of the Ignalina bio-fuel DH project is covered by the analysis of the company's annual reports, information from technical consultants of the project and by the field visits to the company and the municipality.

5. HEAT ENERGY PRODUCTION IN LITHUANIA

Heat energy in Lithuania is produced in Combined Heat and Power (CHP) plants, boiler plants and the industrial utilization equipment. Table 1 shows the heat energy production in Lithuania by sources.

Table 2 presents the fuel sources used for heat energy production. The indigenous fuels are peat,

Table 1. **Heat energy production in Lithuania 1996–2000 (TWh/yr)**

Year	Power plants (CHP)	Boiler plants	Industrial utilization equipment	Total
1996	8.1	13	1.5	22.6
1997	7.3	11.7	1.8	20.8
1998	7.3	10.7	2.1	20.1
1999	6.1	8.1	2	16.2
2000	5.2	6.3	2.2	13.7

Source: Energy Balance, 2001.

Table 2. **Fuel use in CHP and boiler plants in 2000 (TWh/yr)**

Hard coal	0.0814
Peat	0.0209
Firewood	0.0337
Other primary solid fuel	0.2942
Natural gas	13.038
Orimulsion	0.1826
Crude light oil	0.0023
Crude oil	0.0267
Heavy fuel oil-low sulphur	0.2093
Heavy fuel oil-high sulphur	3.946
Light fuel oil	0.0058
Diesel oil	0.0105
Liquified petroleum gases	0.014
Other petroleum products	0.0012
Total	17.87

Source: Energy Balance, 2001.

firewood and other primary solid fuels (sawdust, woodchips, etc.) Their contribution is only around 2% of total inputs in CHP and boiler plants. Other sources are imported. This proves the fact that the heat energy production in Lithuania is heavily dependent on the imported fossil fuels.

6. WOOD FUEL RESOURCES IN LITHUANIA

The figures on the potential wood fuel resources in the country differ according to different sources. The estimation is significantly complicated by the ongoing land reform in Lithuania. The hard discussions involving both Lithuanian and foreign experts are in the process. However, the most optimistic total approximate estimations reach 4.5–5 mill.m^3 annually [12] (Table 3).

Table 3. **Approximate total annual wood fuel resources in Lithuania**

Firewood, mill. m^3	1.3
Forest logging residues, mill. m^3	0.8
Pre-commercial thinning, mill. m^3	1.2
Processing industry residues, mill. m^3	1.6
Total, mill. m^3	4.9
Possible heat energy generation*, TWh	9.8
Source: LSWFDP, 2000.	

*It is assumed that 1 m^3 of wood fuel gives approx. 2 MWh of heat energy.

7. WOOD FUEL USE IN LITHUANIA

General overview

Wood fuel is the most widely used renewable energy source in Lithuania. During the last decade wood fuel utilization in Lithuania has been increasing rapidly. At the moment, the households in rural areas use the major part of wood fuel in the form of firewood. The share of firewood in the total wood fuel balance is around 90%. The gross consumption of wood chips and sawdust is around 0.9 TWh [3], whilst the potential mentioned in Table 3 is around 3.2 TWh. It means that only 28% of the potential is utilized. At present, the total capacity of woodchip-fuelled boilers has reached 150–165 MW [13].

Currently the wood fuel to DH plants comes from woodwork industries. It is cheap, as preparation costs are not counted. Thus, when the fuel is collected directly from the forest, its costs increase significantly. The costs for fuel from forest are depending on the efficiency of the processing of forest residuals to fuel. Today there is no developed infrastructure for the production of this kind of wood fuel, but it has started with smaller companies working in this area, and the Swedish National Energy Administration (STEM) is supporting the study "Potential for Bio Fuel Use in Lithuania" [12]. The aim of the study is to elucidate the costs of fuel by modern methods and also to define the potential. Depending on the market and the development of the infrastructure, the share of fuel coming directly from the forest might increase in the future.

EAES programme

A significant increase of wood fuel utilisation was also a result of the Swedish Programme for an Environmentally Adapted Energy System (EAES) in the Baltic region and Eastern Europe. The programme is managed by STEM. The aim of the programme is to improve the energy systems in the Baltic region and Eastern Europe through energy efficiency measures and the use of renewable energy sources. There are 10 projects implemented within the framework of this programme, including the Ignalina project [13].

8. THE IGNALINA BIO-FUEL (DH) PROJECT

General technical description of the project

Heat production in Ignalina DH Company was earlier based on 40% light oil and 60% heavy oil (mazout). A wood fired boiler of 6 MW has been installed in the new boiler house. It will cover the base load demand for the heat and hot water. Mazout is still being used in the boiler house for peak load and as a reserve capacity. Expected technical lifetime is 25 years which means that the plant is expected to be in operation till 2023 [1].

The plant was commissioned in March 1999.

The effects of Ignalina project

The effects are presented by analysing the parameters of three recent years of boiler plant operation: 1998, when bio-fuel was not used, 1999 when a bio-fuel boiler was commissioned, and 2000 when bio-fuel covered base load demand for heat and hot water production. Table 4 describes the fuels used during 1998–2000.

Table 4. **Fuel used (tons of conditional fuel)**

	Mazout	Light oil	Bio-fuel	Total
1998	3108	2172	0	5280
1999	2584	920	1592	5096
2000	819	1	3916	4736

Source: Ignalina District Heating.

The bio-fuel used was sawdust and wood chips coming from woodwork industries in the municipality area. Sawdust comes directly from sawmills (approx. 10% of the total wood fuel used), whilst third companies that own chipping equipment provide wood chips (approx. 90%). Wood chips are chipped from the wood scrap that accumulates in the municipality sawmills.

Economical effects

The calculations show that the expenses of heat energy production in the company decreased from 4291 thous. LTL to 3155 thous. LTL or by 26.5% during years 1998–2000 (1 LTL = 0.25 USD). The percentage of fuel costs in total heat production expenses dropped from 47.6% (1998) to 21.4% (2000).

Total heat energy production costs per unit of output decreased by 20.49 LTL/MWh or by 17.7% (Fig. 2).

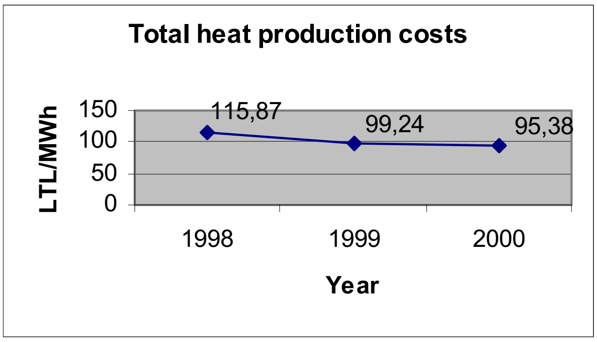

Fig. 2. Total heat production costs

During the years 1998–2000 the heat tariff for consumers was 108.8 LTL/MWh [8]. The tariff was set by the Ignalina DH Company and approved by the National Control Commission for Prices and Energy. As Fig. 2 shows, the price fully covered heat production costs in years 1999 and 2000.

Light fuel oil and heavy fuel oil are imported from outside, and bio-fuel is produced locally. Expenses for fuel import during years 1998–2000 decreased by (93.4%) (Fig. 3).

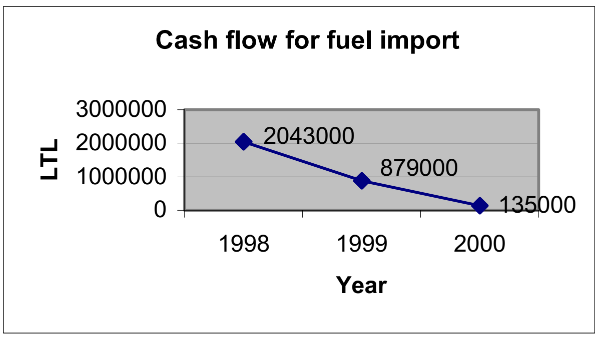

Fig. 3. Sach flow for fuel import

1,908,000 LTL remained in the municipality due to avoided fuel import.

Environmental effects

The reduction of fossil fuel concumption resulted in significant changes of emissions of certain hazardous pollutants. The emissionss howed in Fig. 4 are monitored and recorded according to the national legislation document LAND 12–98.

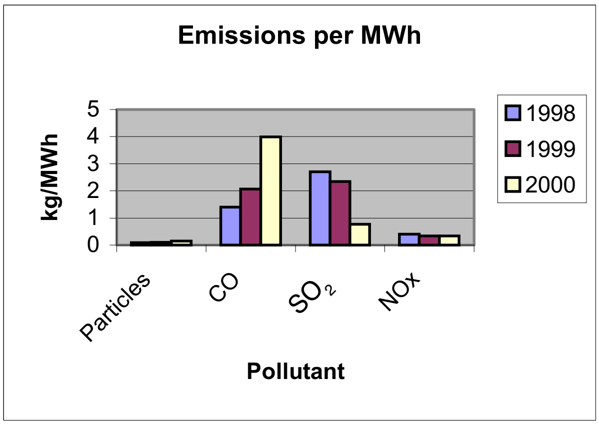

Fig. 4. Measure emissions per unit of output. Source: Ignalina District Heating

The most significant reduction of SO_2 has been achieved. The results are quite unfavourable regarding CO emissions. According to provided data, CO emissions increased from 51.74 to 132.05 t/year during years 1998–2000, while the designed annual emissions in 1999–2000 were around 63 t/year [2]. This can be explained as a result of certain technical imperfections, as well as measurement technology peculiarities.

CO_2 emissions are calculated according to IPCC (Intergovernmental Panel on Climate Change) recommendations [16] and presented in Fig. 5. Bio-fuel is considered as a CO_2-neutral fuel.

Wood fuel directly from the forest was not supplied during the study period; therefore there were

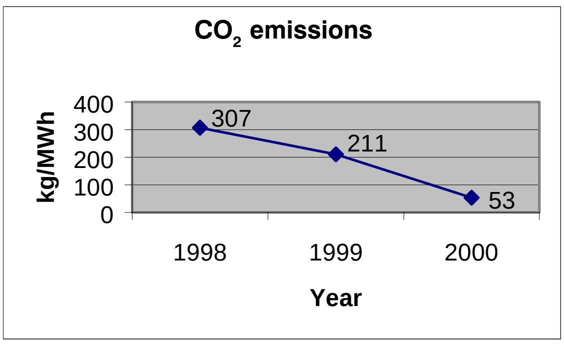

Fig. 5. Calculated CO_2 emissions per unit of output

no direct effects on the environment such as a decrease of soil fertility due to extraction of biomass. As a benefit should be mentioned the use of the sawdust in the boiler, because otherwise it would have been exposed to the landfills and during the process of decomposition release methane.

A major part of ash accumulated from the combustion of bio-fuel was utilised by neighbouring gardeners as a fertiliser. Some portions were also brought to different forest sites. However, there is no consistent system for ash returning to the forest [9].

Considering the forest area *per capita* in the municipality (1.4 ha, average in Lithuania 0.54 ha) and the mean gross annual increment of growing stock (5.8 m^3/ha), the mean gross annual increment *per capita* will be 8.1 m^3, or in energy units – 16.2 MWh. As the average residential heat energy consumption in Lithuania is 3.2 MWh/capita (year 2000), the heat energy needs of the municipality might be covered by 20% of mean gross annual increment of growing stock.

Social effects

Most significant reductions were exhibited by SO_2 and NO_x. The concentrations of these pollutants in the atmosphere have negative impacts on human health. Obviously, it is too early to estimate the effect of the project on the health of the inhabitants, but later on such an analysis could be done.

There is a general assumption made both by the Lithuanian Ministry of Economy and the foreign experts that installed 1 MW bio-fuel capacity-employs 2 extra people [10]. Considering 6 MW installed in the Ignalina boiler house, it should have created 12 extra labour places in the area. Thus, practically it is very complicated to evaluate the exact number of created new jobs. Some shifts were typically observed. As the most labour consuming the fuel production (chipping) chain should be mentioned.

9. CONCLUSIONS AND DISCUSSION

The Ignalina case in a national perspective

Regional distribution is quite strong in Lithuania, as there are no extremely big concentrations of population in one area. This is an important prerequisite for the implementation of bio-fuel projects. Therefore, by analyzing the Ignalina case certain general conclusions valid for many municipalities in the provinces of Lithuania might be drawn.

The possibilities for using bio-fuel from the resource point of view are really good. The technical potential is also good, as the DH systems are usually installed in every municipality. Typically, the poorest state of DH systems and gradually higher heat energy costs prevail in smaller municipalities. The population incomes in these areas are lower than in larger ones, therefore the heat energy issues are of crucial importance. On the other hand, the possibilities of using bio-fuel are most favourable, as due to the lower heat value of bio-fuel the transportation and supply problems would not be as important as in big cities. Furthermore, the generally poorer social situation in these areas will be improved.

DH and bio-fuels – a sustainable combination

The DH system is an integral part of the urban infrastructure, providing the possibilities for the most efficient and secure production and supply of heat. Bio-fuel as the local and renewable energy source is the best choice both from the environmental and socio-economical point of view. Therefore the renovation of DH systems and bio-fuel projects should come in line. In other words, the renovation of DH systems can offer an opportunity for the bio-fuel to be used. The Lithuanian National Energy Strategy supports the development of DH and the renewables. However, when it comes to the implementation of the strategic guidelines, lack of consistent long-term political and economical decisions becomes evident.

Without a developed infrastructure of indigenous fuel production and utilization the production costs are high. The reduction of taxes (especially VAT), providing grants, subsides, state guarantees for the loans for bio-fuel projects are the crucial promotion measures. The implementation of Polluter Pays Principle, and the introduction of Carbon Tax in the long run would obviously create a good economical environment for renewable energy.

Finishing of the land reform and clarifying the resources of bio-fuel, especially on a local (regional) level, is another important policy issue to be addressed. First of all, attempts should be directed to use woodwork industry residues, as only around 28% of the total potential is now utilised.

The Heat Law of the Republic of Lithuania is still under preparation. The adoption of this law is necessary to provide the consistent legal grounds for the rehabilitation and the development of the DH systems.

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Juozas Abaravičius

BIOKURO NAUDOJIMAS LIETUVOS ŠILUMOS ŪKYJE

S a n t r a u k a

Dėl esamų klimato sąlygų šildymo sezonas Lietuvoje tęsiasi ilgiau nei pusę metų. Šilumai pagaminti naudojami dideli įvairių rūšių kuro kiekiai. Šiuo metu vyrauja iškastinis kuras. Lietuva šio kuro išteklių praktiškai neturi, todėl jie importuojami iš užsienio, daugiausia iš Rusijos. Tačiau Lietuvoje yra pakankamai dideli biokuro (medienos atliekų, šiaudų ir kt.) ištekliai, kuriuos panaudojus būtų galima patenkinti ženklią šalies šilumos poreikių dalį.

Iškastinio kuro deginimas sukelia daug aplinkos problemų tiek vietiniu (išskiriant sieros dioksidą, azoto oksidus ir kt.), tiek globaliu (išskiriant anglies dioksidą bei kitas „šiltnamio efekto" dujas) mastu.

Biomasė – tai ekologiškai švarus vietinis kuras. Jo sudėtyje praktiškai nėra sieros, o degimo metu išsiskyręs anglies dioksidas yra natūralaus anglies dioksido ciklo dalis, t. y. jis absorbuojamas augmenijos ir fotosintezės procese paverčiamas deguonimi. Be to, naudojant vietinį atsinaujinantį energijos šaltinį yra užtikrinamas patikimas ir nepertraukiamas energijos tiekimas bei einama subalansuotos plėtros link.

Straipsnyje nagrinėjami biokuro naudojimo šilumai gaminti centrinio šilumos tiekimo (CŠT) sistemose klausimai. CŠT yra neatsiejama miesto infrastruktūros dalis, galinti laiduoti efektyviausią, saugiausią šilumos gamybą bei tiekimą. CŠT plėtra bei biokuro panaudojimas yra žingsnis subalansuotos plėtros link tiek aplinkos, tiek socialiniu ir ekonominiu požiūriais.

Raktažodžiai: biokuras, centrinis šilumos tiekimas, tarša, klimato kaita, pereinamojo laikotarpio ekonomika, subalansuota plėtra, Lietuva

Юозас Абаравичюс

ИСПОЛЬЗОВАНИЕ БИОТОПЛИВА В ПРОИЗВОДСТВЕ ТЕПЛОЭНЕРГИИ В ЛИТВЕ

Р е з ю м е

Климатические условия Литвы обусловливают необходимость более полугода использовать отопление. Для производства и теплоснабжения используются значительные количества различных видов топлива. На данный момент в секторе теплоснабжения в Литве преобладает использование ископаемых видов топлива. Поскольку Литва не обладает их русурсами, страна вынуждена импортировать топливо, в основном из России. Однако ресурсы биотоплива (отходы древесины, солома и т. д.) в Литве достаточны для обеспечения значительной части потребности государства в теплоэнергии.

Сжигание ископаемых видов топлива приводит к загрязнению окружающей среды как на локальном (выделения двуокиси серы и оксидов азота), так и на глобальном (эмиссии двуокиси углерода и других газов, вызывающих парниковый эффект) уровнях.

Биомасса – экологически чистый источник энергии. К тому же использование местного и возобновляемого источника энергии является шагом на пути к устойчивому развитию и энергетической независимости Литвы.

В статье анализируются вопросы использования биотоплива в системах централизованного теплоснабжения. Будучи частью городской инфраструктуры, системы централизованного теплоснабжения являются наиболее эффективными. Модернизация систем централизованного теплоснабжения и использование биотоплива, без сомнения, позволят достичь устойчивого развития производства теплоэнергии в Литве.

Ключевые слова: биотопливо, централизованное теплоснабжение, эмиссии, экономика переходного периода, изменение климата, устойчивое развитие, Литва