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BIO-FUEL BASED DISTRICT HEATING IN LITHUANIA – TOWARDS SUSTAINABILITY

M.Sc. Thesis

By

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ABSTRACT

Northern Europe and Lithuania has climatic conditions, which make artificial heating necessary during more than half of the year. The production and supply of heat energy employs large amounts of different fuels. Fossil fuels are nowadays predominant in the heat sector in Lithuania. The country has no fossil fuels 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, the utilisation of local and renewable energy source is the guarantee for 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 proves to be 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 sustainability in the production of heat energy in Lithuania.

Keywords: Bio-fuel, District Heating, emissions, transitional economy, climate change, sustainability, Lithuania

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1. Introduction

1.1. Bio-fuels and the environment

There is a continuous worldwide discussion about the need to reduce the production of the so-called greenhouse gases. When their atmospheric concentration increases, these gases, mainly carbon dioxide, cause the average global temperature to rise with potentially disastrous results. Fossil fuel burning is the main cause of the increased levels of atmospheric carbon dioxide.

Renewably grown biomass is a CO_2-neutral fuel with low sulphur content and can be converted to electricity, heat, liquid and gaseous fuels. There are numerous environmental and socio-economical advantages from growing and producing biomass energy (D.O. Hall, 2000).

Wood (most widely used sort of biomass) differs from the fossil fuels such as oil and gas because it is a renewable fuel. As a tree grows, it absorbs carbon dioxide from the air and stores it in the wood as carbon. This carbon makes up about half of the weight of the wood. When the wood is burned, carbon dioxide is released again to the atmosphere. The same amount of carbon dioxide would be released if the tree died and was left to rot on the forest floor. Forests can be a perpetual source of fuel provided they are cared for and managed properly (Woodheat, 2001).

In the European Union a recent White Paper on Renewable Energy proposed that Europe could double its renewable contribution from 6% today to 12% by 2010 that would substantially help meet Kyoto Protocol targets (D.O. Hall, 2000).

In June 12, 1995 Lithuania signed Treaty of Associate Membership to the European Union and after the transfer period expired it would become 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 (FNCCC, 1998).

The majority of environment standards and norms applied in Lithuania fully satisfy the requirements of European Union (FNCCC, 1998). The share of renewable energy in total Lithuanian Energy balance now reaches 8.5%, what is even higher than average in EU (Energy Agency, 2001). Furthermore, the share is continuously increasing.

In 1992 Lithuania signed the UN Framework Convention on Climate Change (FCCC) and ratified it in 1995. In 1996 the government approved the FCCC National Programme in. Its major goals are to reduce the import of energy resources, reduce the climate change impact, and cut the CO_2 emissions as well as address other environmental issues. Also in 1998 Lithuania signed Kyoto protocol, committing itself to a reduction in GHG emissions of 8% by 2008-2012 from the base of 1990 (Energy Charter Secretariat, 2000).

1.2. 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 (Euroheat & Power, 2001). District heating can play an important role for a number of key policies of the European Union. By providing the pipeline system to receive and transport waste heat from electricity production, DH systems facilitate the extended use of CHP (Combined Heat and Power) in the domestic sector. CHP, in turn, allows for a much more effective use of input fuel compared to separate production of heat and electricity, thereby not only saving scarce primary resources, but also reducing CO_2 emissions and local emissions (Euroheat & Power, 2001).

A very important benefit of DH is that it provides a possibility to use the different sorts of fuels. The DH technology in the EU is becoming increasingly "green". In the period 1994 - 1999, a strong shift away from 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 use of renewable fuels grew strongly. Renewable sources account for almost half of the supply in Sweden (Euroheat & Power, 2001).

Approx. 70% of urban population in Lithuania buys heat from DH systems. The predominant fuels are oil and natural gas (LSTA, 2001). Renewable energy sources, particularly wood fuel, are being started to use in Lithuanian DH sector. The sector itself, however, faces certain technical and economical problems, primarily due to Lithuania's transition from planned to market economy.

1.3. 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 study is to analyse the political, economical, social and environmental aspects of using wood fuel in district heating systems in Lithuania and evaluate their correspondence to sustainable development.

1.4. Methodology

Bio-fuel based energy supply is a complex process, therefore requiring a systematic approach. The whole process is analysed as a system with its feedbacks and relationships. Each step is a system element having certain impact on the whole system. System analysis methodology enables to evaluate the current situation from different viewpoints as well as to predict possible effects and behaviour of the system.

A choice of energy system is a choice of a society. According to the german sociologist Niklas Luhmann (1927-1998) the society consists of four autonomous functional systems, the political system, the economical system, the law system and the scientific system. These functional systems are self-controlled and reproduce and change their structure with respect to their environment. The four functional systems are environment to each other and will of course influence each other but the decision is made by the system itself. Individuals and nature are complex environments to the four functional systems. According to Luhmann, the systems are communicating with their specific communication means. The political system uses power as a mean for communication, the economical system uses money, the law system uses "right" defined by a judgment and the scientific system uses truth defined by a continuous academic arguing (Adamson, 2001).

In the case of the energy system the political system issues laws, regulations, forms a strategy and policy. Economical system is the energy infrastructure, capital, investments, etc. It aims to reduce energy production costs and receive profit. Scientific research is necessary to define the possibilities, provide technological innovations, etc. Individuals and nature are environments, which are affected by the system but also can "fight back" against the energy system. Nature is an energy resource, but also a complexity, which balance can be harmed by cuts and emissions. Individuals are also complexities, which behaviour sometimes is hard to anticipate. When individuals are working within a system (political, economical, law and science) they have to follow the rules given by the system or quit. Luhmann define them as persons to separate them from individuals. Graphical representation of the system is showed in the picture below.

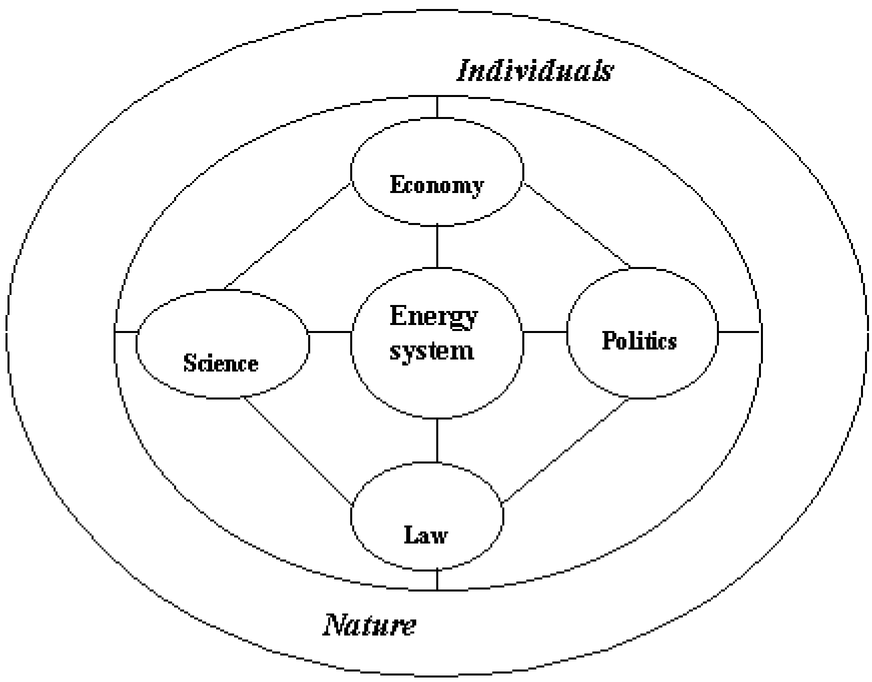

Fig.1.1. *Energy system*

Any energy system can be treated as a sustainable one only after it can successfully address three basic sustainability issues – economical, social and environmental. The causal loop diagram below emphasizes the basic parameters of shifting to the biomass based District Heating (DH) system leading towards sustainable development.

Biomass use significantly reduces energy costs, reduces emission of hazardous pollutants to the atmosphere, what gradually positively influences both the local and the global environment. As biomass is produced locally, it guarantees stable and secure energy supply, what cannot be said about imported oil products. “Energy security means the availability of energy at all times in various forms, in sufficient quantities and at affordable prices. These conditions must prevail over long term if energy is to contribute to the sustainable development” says World Energy Council (World Energy Council, 2000). Biomass based energy supply also provides new labour places in the stage of fuel preparation, transportation and production of utilisation equipment. From the economical point of view the higher labour intensity is not a favourable parameter, as it gradually increases product costs, however, from the social perspective it is a very important benefit, especially in countries with transitional economy.

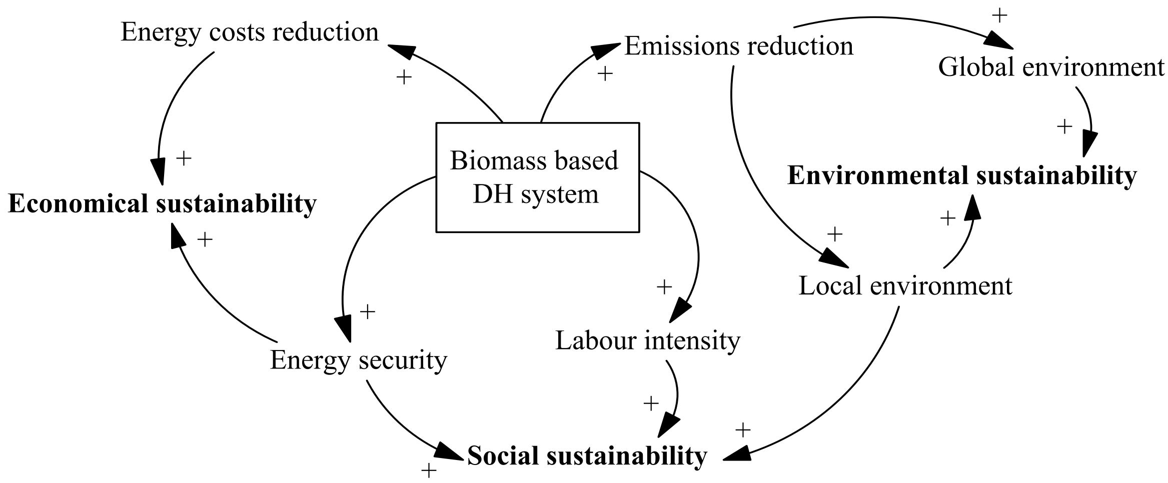

Fig. 1.2. *Causal Loop Diagram.*

1.5. 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 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.

1.6. Paper outline

The paper consists of 10 chapters. Chapters 2, 3 and 4 provide general analysis of energy production and consumption, DH situation and renewable energy policy in Lithuania.

Chapters 5 and 6 focus on wood fuel, its resources and the use for energy production in Lithuania.

Chapters 7 and 8 are devoted for the analysis of the case of Ignalina bio-fuel DH project.

Chapters 9, 10 and 11 aim to put the case of Ignalina into National perspective as well as discuss general conclusions and perspectives.

2. Energy Balance and Heat Production in Lithuania

2.1. Energy production and consumption in Lithuania

Lithuania still beholds the transition from the centralised planning to the market economy. The process results in significant changes in the energy consumption. It has decreased significantly during last decade and the changes are still taking place. Primary energy annual consumption during years 1996-2000 decreased from 107.9 to 82.9 TWh. The process is typical for the economy in transition. Though the energy consumption has decreased the energy intensity remains very high. Energy system is extensive and well developed, but inefficient and oversized. Energy in Lithuania is mainly based on fossil and nuclear fuels. The Ignalina Nuclear Power Plant produces around 80% of total electricity in the country (Energy Balance, 2001).

Table 2.1. *Gross inland energy consumption in Lithuania 1996-2000 (TWh/yr)*

Year	**1996**	**1997**	**1998**	**1999**	**2000**
Hard coal and ignite	2.36	1.81	1.54	1.23	0.91
Peat	0.21	0.21	0.18	0.23	0.13
Firewood	5.07	5.14	5.77	6.13	6.31
Other primary solid fuel	0.83	0.89	0.87	0.75	0.90
Other secondary solid fuel	0.060	0.094	0.11	0.12	0.11
Crude oil, other inputs to refineries	50.44	65.56	80.10	53.77	58.07
Natural gas	25.22	23.29	20.40	21.24	24.02
Orimulsion and crude light oils	-	0.38	0.47	0.31	0.19
Nuclear	42.25	36.44	41.08	29.89	25.52
Hydro	0.33	0.29	0.42	0.41	0.34

Source: Energy Balance, 2001

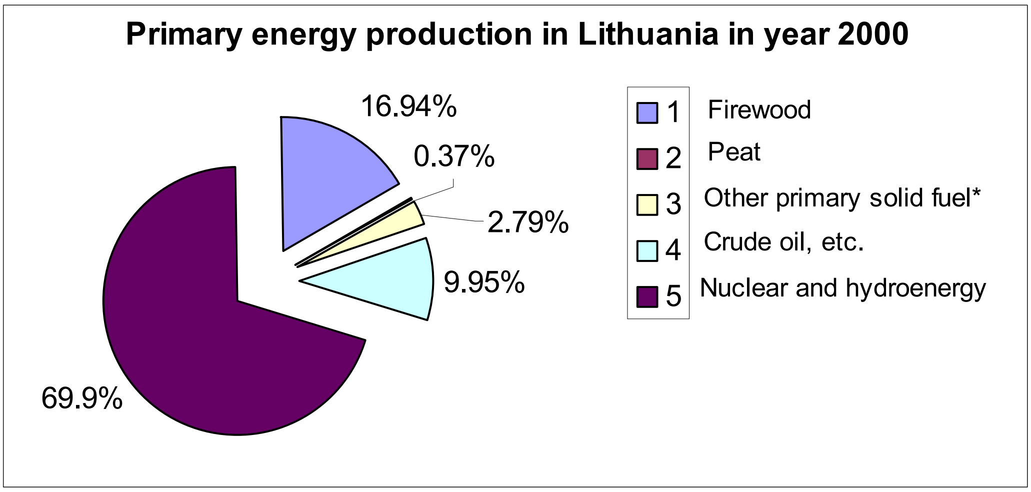

Fig.2.1. *Primary Energy Production in Lithuania in year 2000*, Source: Energy Balance, 2001

*other primary solid fuels-vegetal materials and wastes (including wood waste, wood chips, sawdust, crops used for energy production)

2.2. 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. The table below shows the heat energy production in Lithuania by sources.

Table 2.2. *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 2.3. *Fuel use in CHP and Boiler plants in year 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

The indigenous fuels from the mentioned above are peat, firewood and other primary solid fuels. 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.

3. District Heating Situation and Policy in Lithuania

"District Heating" means heat generated in a central boiler plant and distributed through pipes to customers. District Heating systems provide the means to exploit waste heat from a number of different sources. Combined Heat and Power (CHP) implies that waste heat from electricity production is supplied to District Heating systems. CHP is also known as "co-generation" (Euroheat & Power, 2001). Other benefits promoting the development of DH are following (Stasiunas, 2001):

- better comfort conditions for the inhabitants as undertakes all heat supply related duties (fuel supply, equipment maintenance, operation controll, etc.)
- higher safety standards for the inhabitants as there is no direct combustion in dwelling premises that might cause risk of indoor air pollution
- better controll of emissions from heat production sources and lower emissions per unit of output
- provides better possibilities for the high-tech development
- enables use of different sorts of fuels
- creates better conditions for the harmonised development of urban infrastructure

3.1. District Heating (DH) sector in Lithuania

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. For example, the heat consumption in dwellings in 1990-1997 reached 450 kWh/m^2, that is twice more than in Denmark (FNCCC, 1998). Extremely large investments were put into heat supply infrastructure. At present the value of existing heat supply infrastructure exceeds 1 billion LTL (250 million USD). The most expensive part is the underground piping networks. Total installed capacity of heat production units reaches 10500MW (electrical power 6156MW) and DH piping length is 2360km (Stasiunas, 2001).

The graphs below represent the distribution of installed capacities and respective heat energy production in Lithuanian DH sector.

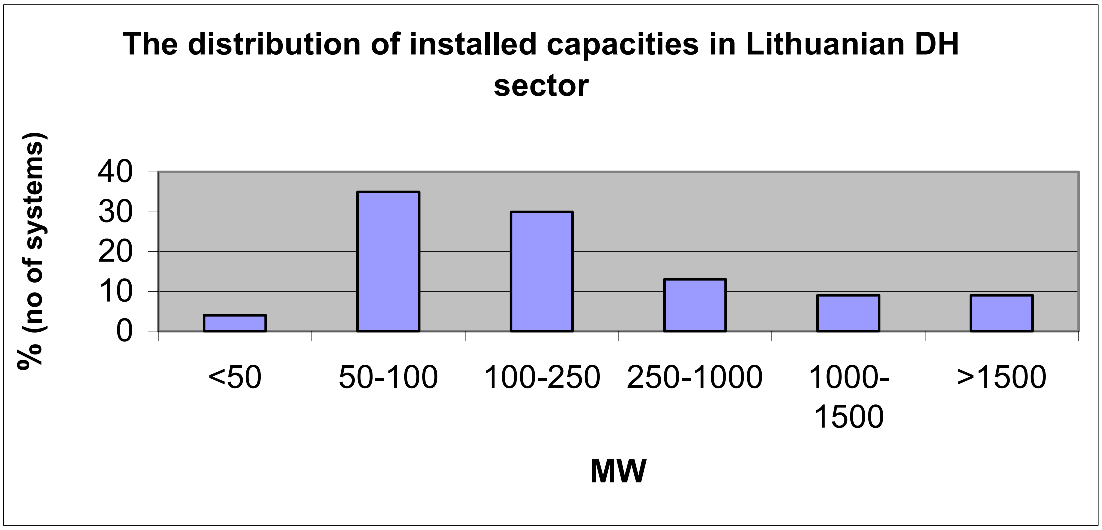

Fig. 3.1. *The distribution of installed capacities in Lithuanian DH sector,* Source: LSTA, 2001

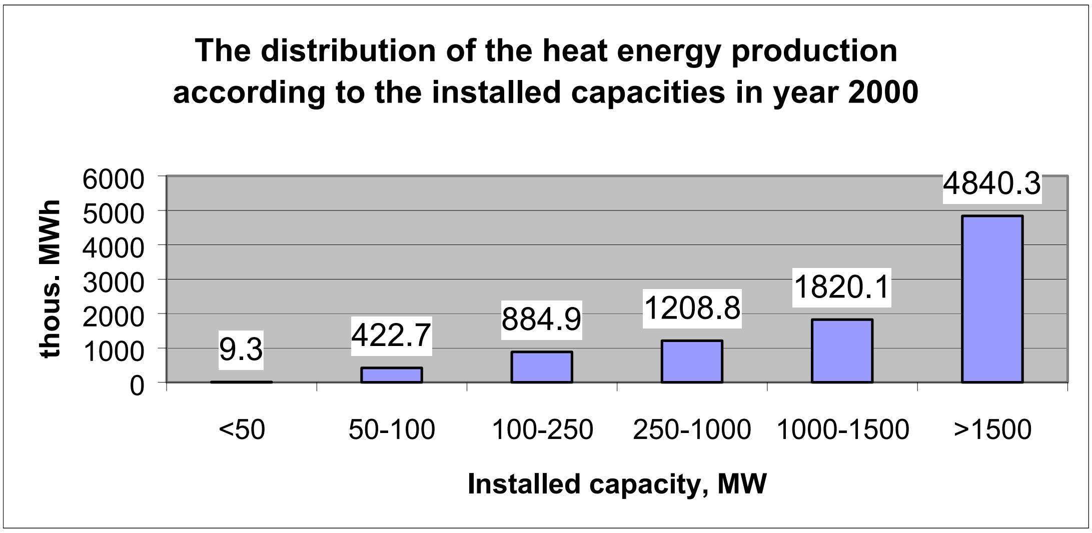

Fig. 3.2. *The distribution of the heat energy production according to the installed capacities,* Source: LSTA, 2001

Note: The data above includes only the members of Lithuanian District Heating Association (LSTA). LSTA has 21 members. It should be mentioned, that many DH companies with installed capacities of less than 50MW are still not the members of LSTA and the data from these companies is not available, therefore the actual energy production of the companies with installed capacity of less than 50MW might be significantly higher.

The turnover of heat produced (including electricity produced in CHP) reached approx. 1 billion LTL (250 million USD) in year 2000. Heat supply enterprises employ 7600 people and provide heat for 1.5 million inhabitants (the total population of Lithuania is around 3.7million). The major share of heat produced is sold to the inhabitants of multifamily houses (Stasiunas, 2001).

Approx. 70% of urban population buys heat from DH systems. In Vilnius and Kaunas (two largest cities), around 90%. The DH share in Lithuanian heat market reaches 65% (for comparison: Denmark-58%, Finland-50%, Sweden-42%). DH companies produced around 9 TWh of heat in year 2000 (total in Lithuania – 13.7 TWh) (LSTA, 2001).

Changing economical conditions and increasing fuel prices have led to significant decrease in heat consumption. During years 1990-2000 it decreased more than 50% (Stasiunas, 2001).

DH sector is now the responsibility of the municipalities. Before 1997 they were state owned. This is a difficult transition because many municipalities did not have the managerial skills or financial resources to modernise the companies. Some of DH companies now are being rented for the foreign Energy Service Companies or Joint Ventures. However, the process does not solve the DH problems and is an object of hard discussions in the country.

Lithuanian District Heating Association (LSTA) has 21 members. The companies basically use either natural gas or heavy fuel oil (mazout). Usually there are the technical possibilities to use both kinds of fuels. Besides, there have been projects that have switched plants to indigenous renewable fuels (LSTA, 2001).

3.2. DH policy

The National Energy Strategy, adopted by Seimas (the parliament) of Lithuania in 1999, sets following strategic guidelines for the future technical development of DH:

- Introducing Combined Heat and Power plants on natural gas
- Incineration of combustible waste - where economically feasible
- Heat metering in the heat sector - motivating consumers
- Upgrading of District Heating systems
- Enable control of heat consumption at consumer level

Main guidelines for management and price policy:

- Indicators of efficient management:
  - Reduction of losses, increase of the quality of services
  - NOT increase of the heat generation
- Establishment of Energy Service Companies
- Stimulating consumers' involvement and influence in the heat sector
- Tariffs and pricing systems must stimulate modernisation
- Define pricing principles for energy from CHP plants

The Energy Law of the Republic of Lithuania guides DH activities. Heat Law of the Republic of Lithuania is still in the stage of preparation.

3.3. Energy pricing

The National Control Commission for Prices and Energy was created by Decree of the President on February 10, 1997. The commission, which is independent and reporting to the President, was given the responsibility to set regulated energy prices for the electricity, natural gas and district heating. According to article 15 of the Energy Law, tariffs are designed to cover the costs and investments. Energy companies set their own prices following methodologies set by the Commission. The prices are then submitted to the Commission for approval. Following the Commission's analysis, an open meeting is held to allow all interested parties to voice their concerns. If there is no agreement, the commission unilaterally sets the price (Energy Charter Secretariat, 2000).

3.4. Major problems in Lithuanian DH sector

Lithuanian DH sector, as well as the overall Lithuanian Energy sector, now is in the transitional process from planned to market economy. The process underlines a number of most important problems that the DH sector is facing today. They can be divided into technical and political-economical.

Major technical problems (Stasiunas, 2001):

- Installed overcapacities and poor efficiency both in the heat production and transmission systems
- Poor quality and design of heat distribution systems in buildings and poor heat parameters of buildings itself
- Improper and insufficient heat metering system

Major political –economical problems:

- Unclear and inconsistent long-term National Energy Strategy implementation perspectives
- Lack of planning when separating natural monopolies and competition markets (DH, gas) [Natural gas suppliers are providing serious competition because of a high price difference. To use natural gas for the heating now is cheaper. However, this difference is essentially a result of unreasonable price of the gas for big consumers (DH comp.) and individual households. The price is extremely unfavourable for DH companies. Currently there are no legal instruments to prohibit consumers from switching to gas. This is causing problems, because losing customers randomly reduces the heat load and affects overall DH efficiency]
- Integrated social and DH company economy (compensations for heating needs of low-income population are paid via DH companies. As municipalities usually fail to pay the money in time the DH companies gets big losses)
- Not cost covering operation
- Lack of money for human resource development
- Severe debts – difficult to attract financing for technical modernisation and etc.
- Marketing shortcomings within DH companies (The major problems are in the relations with customers. The companies are often not flexible with providing

the service [for exp. setting exact dates of the beginning of the heating season, whilst some customers might need it earlier and etc.]. There is a lack of communication between DH company and the customers. The customers are usually poorly informed about the real cost structure of the service they receive.)

4. Renewable Energy Policy in Lithuania

4.1. General overview

Indigenous energy resources (wood, peat and hydro, etc.) represented about 8.5 % of total primary energy consumption in 2000. The rest part was the imported fossil and nuclear fuel. During period 1990-2000 shares of indigenous resources increased more than 4 times (Jarmokas, 2001).

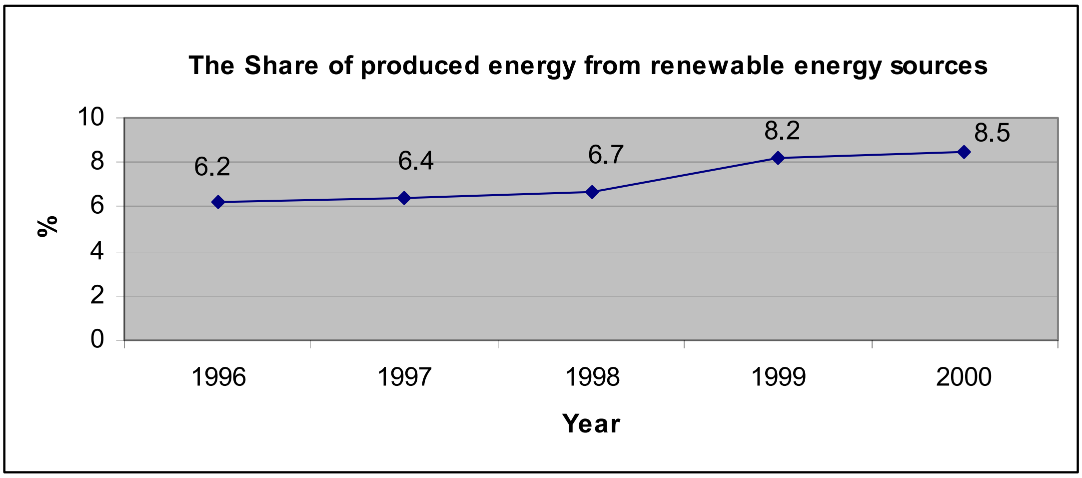

Fig. 4.1. *The share of produced energy from renewable energy resources compared to the primary energy input (1996-2000).* Source: Energy Agency, 2001

Pilot projects implemented during recent years justify the possibility to accelerate the utilisation of indigenous energy resources particularly for the heat supply; e.g. installed capacity for incineration of wood waste at present reaches approximately 150-160 MW. The Lithuanian energy efficiency and renewable energy policy is based on the following basic legal acts (Katinas, Skema, 2001):

- The national energy strategy
- Energy Law of the Republic of Lithuania
- The National Energy Efficiency Programme (NEEP)
- United Nations (UN) Framework Convention on Climate Change (FCCC) and other documents compliant with the EU environmental policy

The National Energy Efficiency Programme (NEEP), approved by the government of Lithuania in 1992, is the basic document guiding the renewable energy policy. It is being reviewed every year. The NEEP has following goals regarding the renewable energy:

- Development and improvement of the legislation acts and norms for usage of indigenous fuel
- Economic, legal and organizational measures promoting the use of wood, municipal and agricultural waste and other kinds of indigenous fuel
- A wider utilisation of other energy resources (hydro, waste energy, biogas, municipal waste, wind, solar and geothermal energy), on the basis of the experience gathered and generalised in pilot projects supported by the state as well as funded by foreign investors
- Seeking that the energy generated by renewable sources will form a share corresponding to the directives of the European Union by the year 2020
- Organising and carrying out the indigenous energy usage information dissemination, promotion and advertising activities

In September 19, 2001 the Government of the Republic of Lithuania revised and updated NEEP and core directions for implementation in 2001 through 2005. The major goals, however, remain the same.

Policy related to renewables was included into the National Energy Strategy that was approved by Seimas (the parliament) of the Republic of Lithuania in 1994. The strategy was updated on 5 October 1999.

As mentioned above, in 1992 Lithuania signed the UN Framework Convention on Climate Change (FCCC) and ratified it in 1995. In 1996 the government approved the FCCC National Programme in. Its major goals are to reduce the import of energy resources, reduce the climate change impact, and cut the CO2 emissions as well as address other environmental issues. Lithuania prepared its first national communication to the UNFCCC in 1998 and the second one is currently in preparation. Also in 1998 Lithuania signed Kyoto protocol, committing itself to a reduction in GHG emissions of 8% by 2008-2012 from the base of 1990 (Energy Charter Secretariat, 2000).

Table.4.1. *The evolution of carbon dioxide emissions in Lithuania (Mtonnes):*

1990	1996	1997	1998
41.6	18.9	18.5	19.2

Source: Energy Charter Secretariat, 2000

Unfortunately, this dramatic decrease in CO_2 emissions (showed in the table above) is not a result of the increase in energy efficiency. This is essentially the result of economical recession due to the transition from the centralized planning to market economy. Therefore it is obvious that with recent economic growth the CO_2 emissions will be increasing.

Lithuania has been active using AIJ (Activities Implemented Jointly under the UNFCCC), notably with Sweden, with whom it has had 10 projects worth more than 5.5 million USD and for which the Swedish National Energy Administration (STEM) has provided technical assistance. While Lithuania has participated in AIJ projects, to date it does not have a national strategy for Joint Implementation (JI) and does not have a JI office to coordinate activities. The JI questions are handled within the Ministry of Economy and the Ministry of Environment. Lithuania is planning an emission trading system with other Baltic states (Energy Charter Secretariat, 2000).

4.2. Implementation of renewable energy projects in Lithuania

During recent decade the major efforts in Lithuania were aimed at drafting the bio-fuel (wood chips, straw, biogas) and small hydro projects and their subsequent implementation (Katinas, Skema, 2001).

Table 4.2. *State of usage of Renewable Energy Sources (RES) in Lithuania in 1999*

Sort of RES sources	Rated power of installed equipment, MW	Substitution of heavy fuel oil, (tons)	Cost saving for purchase of heavy fuel oil, (million USD)	Reduction of emissions from combustion of heavy fuel oil if substituted by RES, (tons)			
				CO_2	SO_2	NOx	Solid particles
Wood chips	140	123000	11	396000	6000	1000	110
Straw	10	8800	0.8	28300	430	30	8
Biogas	2.1	1800	0.16	5800	90	6	2
Small hydro	8	7000	0.6	22500	300	24	6
Total	160.1	140600	12.56	452600	6820	1060	126

Source: (Katinas, Skema, 2001)

Other renewable energy sources in Lithuania are geothermal energy, wind, solar energy, landfill gas, for which new demonstrational projects have been started at present.

Table 4.3. *Feasible energy generation from local and renewable energy sources*

Sort of Renewable Energy Source	Feasible energy generation, (TWh/year)	Production in 1999, (TWh)	Share of total energy in 1999, (%)
Wood*	9.8	6.87	7.31
Peat	1.4	0.24	0.26
Straw	1.5	0.05	0.05
Municipal waste	0.8	-	-
Biogas	0.4	0.02	0.02
Geothermal energy	0.8	-	-
Hydro energy	1.5	0.42	0.45
Solar energy	1.5	-	-
Wind energy	0.2	-	-
Total	17.9	7.6	8.09

Source: (Katinas, Skema, 2001)

* more explicit wood fuel analysis see on page 21

4.3. Action plan

The National Energy Strategy sets the following short, medium and long-term priorities for the implementation of the renewable energy policy (Lithuanian Ministry of Economy, 1999):

Short/medium term

- Programmes and studies for enhancing local and renewable energy utilisation
- Monitoring of implemented renewable energy projects
- Implementation of demonstrational projects for new renewable energy technologies (solar, wind and biomass)
- Awareness campaigns and courses for both general public and specialists

Long term

- Implementation of more than 400 renewable energy projects

4.4. Renewable energy projects' financing and support

Renewable energy projects at present are financed form following sources:

- State budget
- Municipalities budget
- EU programmes
- Interested Lithuanian companies
- Foreign companies

Considerable support is also received from governments of Sweden, Denmark, Germany, World Environmental Fund, European Bank of Reconstruction and Development, and various other international funds and banks (Katinas, Skema, 2001).

Due to current Lithuanian economical conditions around 90% of implemented projects would not have been possible without foreign aid (Jarmokas, 2001). The interest rates, set by commercial banks seem to be too high for the implementation of renewable energy projects, therefore the interested companies are not willing to take a risk by taking loans from them (Jarmokas, 2001).

According to the Law of Energy of the Republic of the Lithuania, the state (municipality) is obliged to promote the use of local and renewable energy sources while setting the tax policy, providing credits and subsidies (Law on Energy, 1998). According to the newly adopted Law on Electricity of the Republic of Lithuania, where the electricity price is uniform, the market operator must give priority to the producers using local, renewable or waste energy resources (Law on Electricity, 2000).

Regarding the state support for bio-fuel the VAT (Value Added Tax) privilege of 50% should be mentioned. However, the privilege will be in force only up to the year 2004, as it does not come in line with EU recommendations (Jarmokas, 2001).

As a privilege can be also treated quite high allowable CO emission norm in national regulation LAND 12-98 (the document is issued by the Ministry of Environment and defines allowable emissions from stationary combustion sources) as the combustion of bio-fuel typically results in higher CO emissions as compared with fossil fuels (Brazauskas, 2001).

5. Wood Fuel

5.1. General description

Wood fuel can be of different kinds. It has following constituents (Dickens, 1983):

- Ash (calcium, magnesium, phosphorous) – approx. 0.5%
- Combustible materials: carbon (50-52%), hydrogen (6-6.5%), sulphur (around 0.2%), nitrogen (around 0.2%)
- oxygen (40-44%)
- Water (20-60%)

The quality of the wood fuel is of the decisive importance to the opportunities for the storage, furnace feeding and combustion. Significant quality factors include structure, moisture content, density, fraction size and caloric value (Dickens, 1983).

Table 5.1. *Wood fuel types*

Unprocessed wood fuel	Processed wood fuel	Pulp industry residues
Firewood Wood splinters Wood chips Sawdust Logging, thinning residues (branches, bark, etc.)	Briquettes Pellets Pulverised wood fuel	Paper residues Packaging residues

Source: (Pedisius 2000)

Normally, the wood fuel is delivered to the consumers (Boiler plants) as chips. The chip quality can differ widely depending on the tree species involved and the type of fuel-wood, used, i.e. branches, tops with or without needles, entire small trees, or crudely limbed tree sections.

The would fuel flow from different sources is represented in the diagram below:

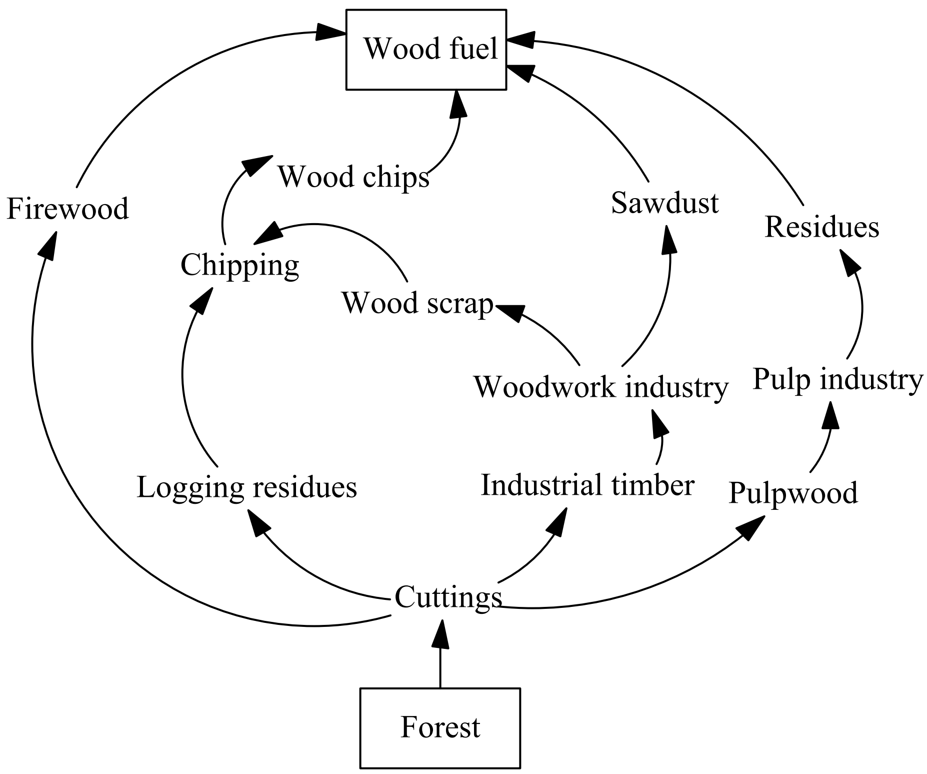

Fig.5.1. *Wood fuel flow diagram*

5.2. Wood fuel and the global environment

The implications of wood fuel use for the global environment can be evaluated by estimating the associated greenhouse gas emissions. The major greenhouse gases are carbon dioxide (CO_2), water vapour (H_2O), ozone (O_3), methane (CH_4), nitrous oxide

(N_2O), and chlorofluorocarbons (CFCs) (Miller, 1999). CO_2 is widely recognised as the main greenhouse gas therefore it requires special attention.

Carbon cycle. The energy-rich carbon in wood fuels came from the transformed carbon dioxide, which the trees already sequestered during their growth. When these biomass fuels are burned, the CO_2 that is emitted becomes part of the natural carbon cycle that includes trees, air and other normal CO_2 emissions. This cycle is closed-loop: new tree growth readily absorbs the emitted carbon. Hence, there is no net contribution to the atmospheric CO_2 level. The picture below illustrates the process.

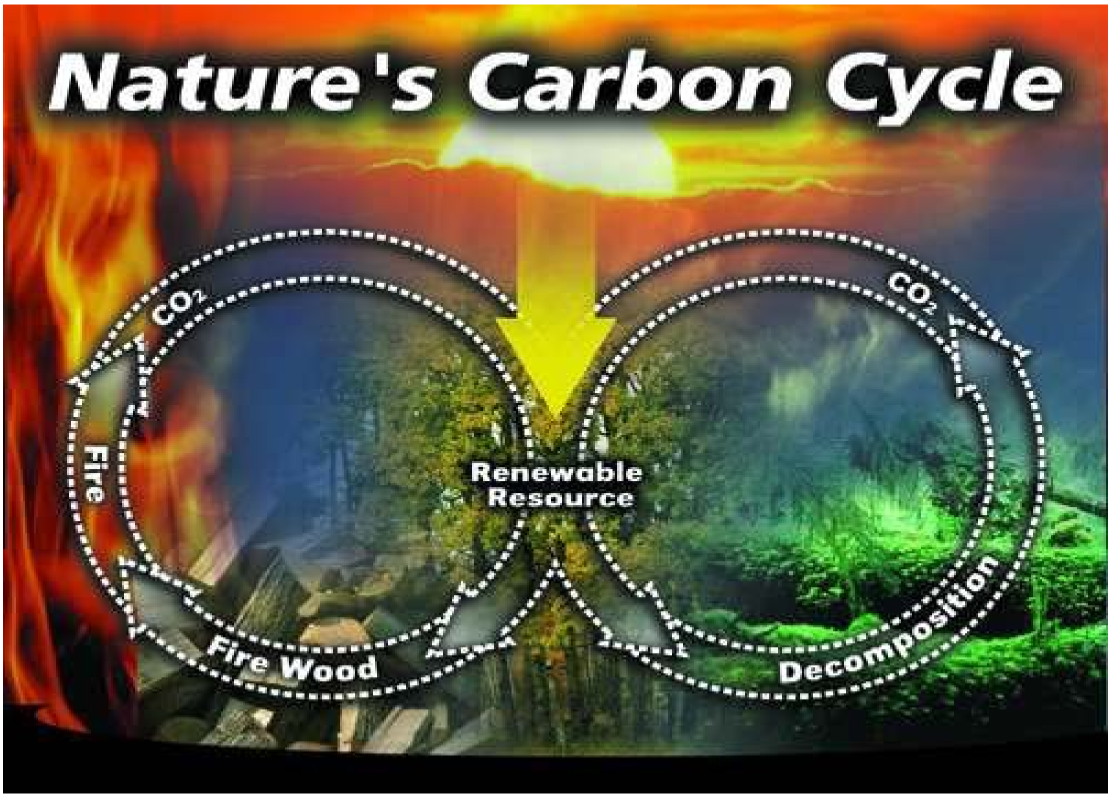

Fig.5.2. *Nature's Carbon Cycle*, Source: Woodheat, 2001

However, in order to keep the neutral carbon cycle, a consistent planting/rejuvenation system must be implemented.

CO_2 emissions caused by wood fuels can be compared with CO_2 emissions from alternative fossil fuels.

Table 5.2. *CO_2 emissions from fossil fuels*

Fuel	**CO_2 emission, kg CO_2/MWh fuel**
Natural gas	202
Light fuel oil	272
Heavy fuel oil (Mazout)	275
Coal	327

Source: Gustavsson et al, 1995

It should be also mentioned that wood fuelled plants also divert wood waste from landfills, which reduces the productions and atmospheric release of methane, another potent greenhouse gas. A molecule of methane (CH_4) is nearly 30 times as effective as a molecule of CO_2 in trapping earth's radiated heat (Boyle, 2000).

As noted in chapters 1 and 4, in 1998 Lithuania signed Kyoto protocol, committing itself to a reduction in GHG emissions of 8% by 2008-2012 from the base of 1990.

5.3. Wood fuel resources in Lithuania

Forest reserves in Lithuania have been increasing rapidly during the second half of the 20th century. The total growing stock has more than doubled during that period (in 1948- 125 mill.m^3, whilst now it reaches 370 mill.m^3). The forest coverage expanded from 19.7% in 1948 to 30.7% in 2000 (Lithuanian Statistical Yearbook of Forestry, 2000).

Lithuanian forest reserves are still increasing. Considering the recent trends it can be assumed that the forest coverage will increase by 2-3% in coming decade (Kuliesis, 1999).

Table 5.3. *General facts on Lithuanian forestry*

Total forest coverage, %	Total area, ha	The mean volume per ha, m^3	Total volume, mill.m^3	Annual current increment per ha, m^3	Total annual increment, mill.m^3	Average annual cut, mill.m^3
30.7	1978000	193	370.6	6.2	12.3	4.9

Source: Lithuanian Statistical Yearbook of Forestry, 2000

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. The National Bio-fuel Establishment and Development Program speaks of about 1mill.m^3 of firewood and some 2 mill.m^3 of forest logging and processing industry residues annually. Calculations using models show the volume of firewood to be 1.2-1.3 mill.m^3 per year with the tendency to increase. Calculated logging residues alone reach 2.4 mill.m^3, but only 0.8 are recommended for extraction due to economical and environmental considerations. Small size timber (diameter 5.6-13,5 cm) from pre-commercial thinning according to these calculations amounts to 1.1-1.2 mill.m^3 per year (LSWFDP, 2000). Thus, it should be noted that these figures do not include (because of lack of statistics) the volumes of self-collected firewood by small town and rural population.

Table. 5.4. *Approximate total annual wood fuel resources in Lithuania*

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

Source: LSWFDP, 2000

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

The potential can be compared with the present heat energy production in Lithuania. Total heat energy production in Lithuania in year 2000 was around 14 TWh (Energy Balance, 2001). By utilising only the processing industry residues, as it is the most favourable sort of fuel for boiler plants and CHP, around 3.2 TWh (23% of total production) of heat energy can be produced.

The contribution of forest energy to the national energy balance is also difficult to evaluate using only figures disclosing the resources of the whole country. A national strategy should be based up on data collected by forest and energy specialists on the county and regional level. The ongoing Lithuanian – Swedish Wood Fuel Development Project, supported by the Swedish National Energy Administration (STEM) is a good example of such an initiative. The project analyses the possibilities for the procurement of wood fuel in seven forest enterprise areas in North Eastern Lithuania.

If bio-fuels are to compete with the present fuels, they must be able to meet the demand for appropriate forms of the energy at competitive prices. Two important criteria are the “availability” and the “transportability” of supply (Boyle, 2000). The premium fuels – oil and natural gas – are valued because their energy can be stored with the little loss and are easily transferred from place to place. Bio-fuels tend to decompose rather quickly and because of their relatively low energy densities, they are likely to be rather expensive to transport over appreciable distances (Boyle, 2000).

The availability of wood fuels depends on different factors. It is not enough to indicate only the biological potential. The real quantities of wood fuel, available for heating, depend on wood market and are influenced by different factors. Lithuanian-Swedish Wood Fuel Development Project underlines the following ones:

- Present forest resources and the potential future sustainable cut
- Ecological restrictions on the removal of woody biomass
- The production cost of the energy from wood and its relation to alternative fuels
- Forest site types and the road network
- Data on non-forest lands and abandoned agricultural lands
- Export of forest products
- Forecasted industrial consumption of the wood
- Location and capacity of wood fuelled boilers
- Population density and distribution
- Standard of living and the cost of labour power
- Taxation system and environmental fees

The above-mentioned factors still demand deep analysis in Lithuania.

6. Wood Fuel Use in Energy Production in Lithuania

6.1. General overview

Wood fuel is the most widely used renewable energy source in Lithuania. Basic reasons for that are: quite high wood fuel resources, low price, comparing with fossil fuels, and relatively cheap fuel to energy conversion technologies. Besides, new wood fuel incineration technologies enable significant reduction of different hazardous emissions. The last, but not the least benefit is the establishment of new jobs for collection, preparation and transportation of wood fuel, as well as for the production of bio-fuel utilisation equipment.

During last decade wood fuel utilisation in Lithuania have 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 remaining part is basically sawdust and wood chips. The gross consumption of firewood is approx 2.7 million m^3 (6.1 TWh) annually (Energy Balance, 2001). This number comes in slight contradiction with the potential described in the previous chapter. It means that the certain amount of wood, which could have been used for other purposes, was used as firewood. The gross consumption of wood chips and sawdust is around 0.9 TWh (Energy Balance, 2001), whilst the above-mentioned potential is around 3.2 TWh. It means that only 28% of the potential is utilised.

Practically there was not a single wood-chip-fuelled boiler 6 years ago in Lithuania, but the support of PHARE programme and governments of Sweden, Denmark and other countries changed the situation (Katinas, Skema, 2001). At present the total capacity of wood-chip-fuelled boilers has reached 150 – 165 MW (Pedisius 2000).

Small wood fuel based CHP was commissioned this year in Klaipeda in the woodwork Joint Stock Company “Pajurio mediena”. The installed electrical power capacity is 1.5MW. Heat energy capacity is 13.3MW. Two steam boilers with 10MW wood fuel pre-furnaces had been installed. This is the first project of such kind in Lithuania. Part of heat energy is being used for the production needs, whilst another part is supplied to Kalipeda District Heating network. However, the company has problems with the excess electricity realization, as there is no demand along with some institutional barriers (Citvaras, 2001).

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 from the forest and is specially prepared, it’s 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 STEM is supporting a study “Potential for Bio fuel Use in Lithuania”. The aim of the study is to find out the costs for fuel using modern methods and also to find out the potential. Depending on the market and the development of the infrastructure share of fuel coming directly from the forest might increase in the future.

6.2. Interest groups

There are certain interest groups involved in the implementation of renewable energy and energy efficiency projects in Lithuania and in Central and Eastern Europe (CEE) countries in general. Four such groups can be identified (Salay, 1999): donor country institutions, local project partners, host country institutions and commercial investors. All these groups support the realisation of the projects, but may have different rationales and incentives for their participation.

Table 6.1. *Interest groups*

Interest Group	Rationales
Donor country institutions	Cost effective reduction of CO_2 emissions
Local project partners	Lower heat production costs Access to new technology Improved DH service Reduced air pollution
Host country institutions	Reduction of air pollution and CO_2 emissions Technology transfer Reduced energy imports
Commercial investors	Economic return on investment (profit)

Source: Salay, 1999

A governmental institution responsible for the cooperation with CEE countries usually represents the donor country. The local project partner is the organisation, which owns or operates the facility where the investment is made. It can be a commercial or non-commercial organisation. In Lithuania as well as in other CEE countries the municipality typically owns the DH companies. The national energy or environmental institution represents the host country institution. The commercial investor can be an investment bank or another financial organisation which invests in the energy project by providing a loan to the project partners or acquiring ownership in the business. The rationale for its engagement in a project is to earn a profit on the investment. Thus, it should be noted that it is still difficult to find commercial financiers for renewable energy projects in Lithuania (Salay, 1999). In fact both political and commercial interests are represented by the same organisations – the donor country institution and host country institution. The loan is used as a tool for achieving emission reductions rather than as a mean for earning money. Political, not commercial interests determine their engagement.

6.3. EAES programme

Effective increase of wood fuel utilisation was as well a result of the Swedish Programme for an Environmentally Adapted Energy System (EAES) in the Baltic region and Eastern Europe. The programme was initiated by the Swedish Government in 1993 and managed by the Swedish National Board for Industrial and Technical Development, NUTEK up to 1997. From 1998 the responsibility of the EAES programme rests with the new energy agency, the Swedish National Energy Administration (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 under guidance of this programme (Pedisius, 2000).

Rapid increase of wood fuel utilisation created favourable conditions for prioritising of existing and creation of new local companies producing wood fuel utilisation equipment.

7. The Ignalina Bio-fuel District Heating (DH) Project

7.1. North Eastern Lithuania and Ignalina region

The Ignalina Region is a miniature version of Lithuania, with one third of the area covered with beautiful forests and with over 200 lakes. The largest portion of the Aukstaitija National Park, founded in 1974 to protect the Eastern Lithuanian natural, cultural and historical heritage, is located here. There are also 12 regional parks and 4 unique historical villages.

The Town of Ignalina, the administrative center, is located in Utena County in the North Eastern part of Lithuania, 110 km. from Vilnius and 63 km. from Utena. The town was first mentioned in 1810 when several smaller villages were combined. Ignalina became an important commercial center in the 1860's when the St. Petersburg - Warsaw railway was built.

At present the population of the city is around 7100. Total population of the municipality is around 27000. Urban population (towns and boroughs) is 44% and rural population is 56% (Ignalina Municipality). The town is situated in a nature reservation area and subject to stricter environmental regulations.

There are working 315 Individual Enterprises, 86 Joint Stock Companies and 23 Stock Companies in the municipality. Dominating are trade enterprises – 190, automobile services – 30, and woodwork enterprises – 18 (Ignalina Municipality). Another, rapidly developing branch of the region’s economy is tourism. Thus the general economic performance of the area, including forestry and forest industry, is bellowing the total average in Lithuania.

A higher forest area compared to the other parts of the country distinguishes the eastern part of Lithuania. The forest covers 32.5% of the Ignalina municipality territory. Forest area per capita is 1.4 ha, growing stock per capita – 278 m^3 (compare average in Lithuania 0.54 ha and 100 m^3, respectively). Total area of the municipality is 123365 ha (Ignalina Municipality).

7.2. General technical description of the project

The bio-fuel boiler house and district heating rehabilitation project attempts to create an environmentally, economically and socially sound heat supply system in Ignalina town. The project makes it possible to concentrate the heat production to a one new, boiler house and to close down two old oil-fired boiler houses. The project also comprises the improvement of the heat and hot water supply and the distribution in the town. The annual energy production before conversion was 36 000 MWh. Heat production 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 (heavy fuel oil) is still being used in the boiler house for peak load and as a reserve capacity. The project includes firing equipment, basic fuel storage on the ground (asphalt), fuel conveyor, flue gas cleaner (cyclone), civil works, buildings, control equipment, commissioning, training etc. A new pre-insulated pipeline has been installed to connect the networks as well as 30 new substations in buildings and block central. Expected technical lifetime is 25 years which means that the plant is expected to be in operation till 2023 (AIJ report, 2000). The plant was commissioned in March 1999.

Fig. 7.1. *Ignalina Biofuel Boiler Plant*

7.3. Institutional overview

The "donor" country is Sweden, represented by the Swedish National Energy Administration (STEM). The project is a part of EAES programme. The Swedish government's reason for supporting the project is to achieve cost-effective abatement of CO_2 emissions.

The local project partner is Ignalina District Heating Company, owned by the Ignalina municipality. The company and the municipality have several rationales for engaging in the project. The most important is to decrease the heat production costs. Other rationales are to gain access to new technology, improve the reliability and quality of the heat supply and decrease the emissions.

The host country institutions are the Ministry of Economy, Energy department and the Ministry of Environment. They support the project in order to reach certain environmental and energy-policy related objectives, such as to reduce the dependency on imported fuels. The most important environmental goal is to reduce the emissions of SO_2 , CO_2 and other harmful air pollutants. The technology and know-how transfer as well as the creation of local jobs are also important reasons for the governmental support of the project.

7.4. Financial overview

The project was financed by loan from Swedish National Energy Administration, STEM. The amount of loan is 1.6mln. USD (1USD=4LTL). Grace period is 2 years and the maturity period is 10 years. STEM also provides grants for technical assistance and administrative support reaching around 180 000 USD. 500 000 USD are invested by Lithuanian side - Vilnius District Heating Company (formerly Ignalina's and other smaller regions' DH companies were managed by Vilnius DH Company) and Ignalina municipality.

Table.7.1. *Project costs (USD)*

Sweden		**Lithuania**	
Loan	1600000	Investment/instalment*	500000
Technical assistance grant	137500		
Administration grant	33250		
Reporting costs	2500		
Total	**1773250**	**Total**	**500000**

Source: (AIJ report, 2000)

*Investment/instalment = the borrower's possible own financing of the investment, followed by the borrower's repayment of the loan

8. 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 bio-fuel boiler was commissioned and 2000, when bio-fuel covered base load demand for heat and hot water production.

8.1. General technological facts

Energy production

The total energy production in the company Ignalina District Heating decreased during the years 1998-2000, although the number of consumers remained approx. the same. This is a result of rehabilitation of district heating network, installing new substations in buildings and partially due to milder winters in these years (the average heating season temperatures during years 1998-2000 were –0.2C, +0.8C and +2.7C respectively) (Ignalina District Heating). Energy produced in 1998 was 37 032 MWh, whilst in 2000 it was 33 077 MWh.

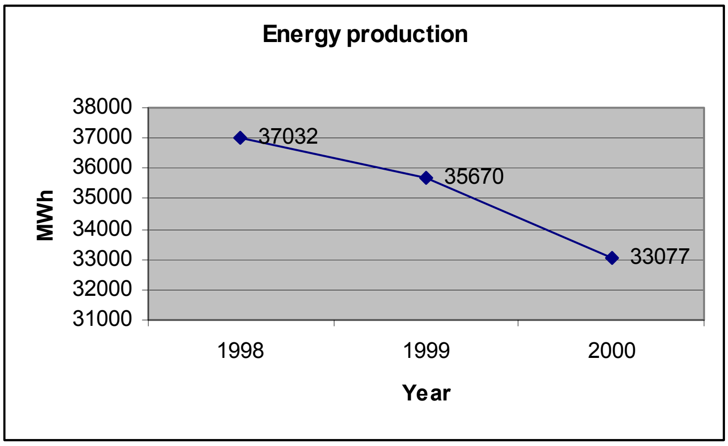

Fig. 8.1. *Energy production*

Technical difficulties

There were quite many long duration stops in boiler operation during the first year (1999) due to the defects in design of the pre-furnace. Therefore the planned energy production from bio-fuel was not reached in 1999. Major technical problems were fuel feeding (the fuel spreads on the grate of pre-furnace unevenly), air supply (not proper primary and secondary air adjustment), insufficient quality of metal used.

Large parts of the repair works were covered by the suppliers' guarantee.

Fuel

The distribution of fuel used is presented in the table and graphs below:

Table.8.1. *Fuel used (tons of conditional fuel)*

	Mazout	**Light oil**	**Biofuel**	**Total**
1998	3108	2172	0	5280
1999	2584	920	1592	5096
2000	819	1	3916	4736

Source: Ignalina District Heating

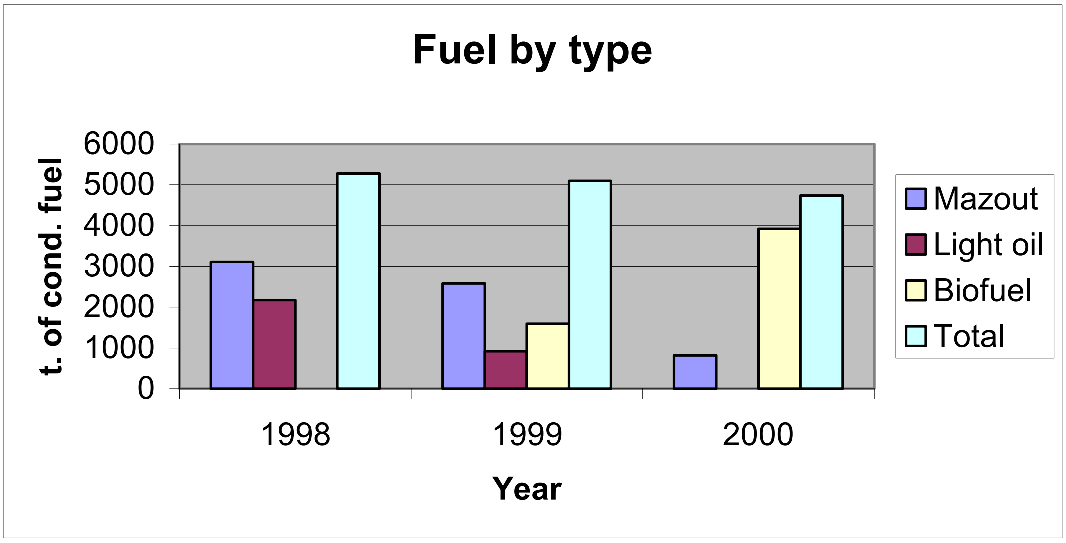

Fig. 8.2. *Fuel by type*

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

8.2. Economical effects

The major indicators for the analysis of economical effects are following:

- Heat production costs
- Energy "imports"

Heat production costs

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. The percent of fuel costs in total heat production expenses dropped from 47.6% (1998) to 21.4% (2000).

Below are presented tables and graphs representing the dynamics of fuel costs:

Table 8.2. *Ignalina District Heating expenses on fuel and total expenses*

Year	Expences on fuel, thous. LTL	Total expenses, thous.LTL	% of fuel costs in total expenses
1998	2043	4291	47.6
1999	1129	3540	31.9
2000	675	3155	21.4

Source: Ignalina District Heating

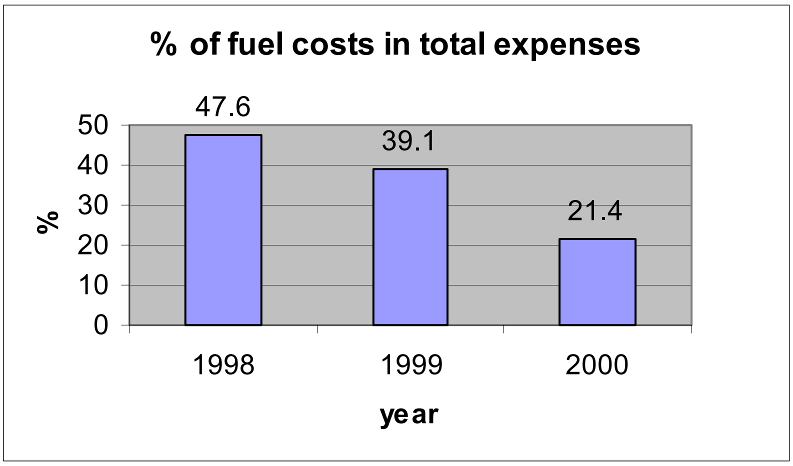

Fig. 8.3. *Fuel costs in total expenses*

Table 8.3. *Expenses for fuel according fuel source, (thous. LTL)*

Type of fuel	**1998**		**1999**		**2000**	
	Forecasted	**Real**	**Forecasted**	**Real**	**Forecasted**	**Real**
Light fuel oil	1009	1297	0	401	0	1
Heavy fuel oil	663	746	61	478	61	134
Wood	206	0	590	250	590	540
Total	1877	2043	652	1129	652	675

Source: Ignalina District Heating

Fuel/energy

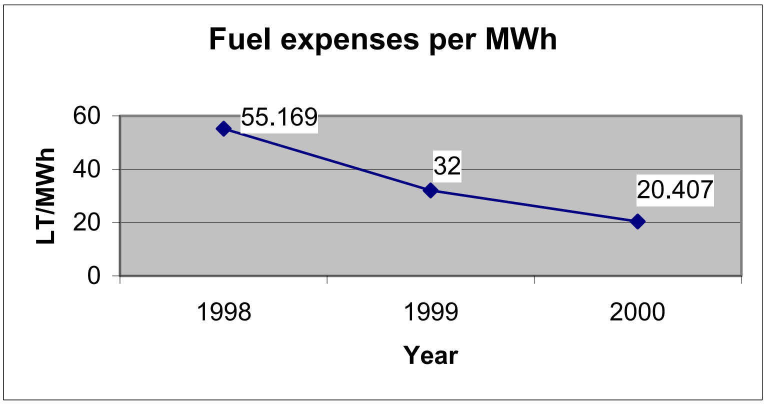

Fig. 8.4. *Fuel expenses per unit of output*

Fuel expenses per MWh of energy produced decreased by 34.8 LT (63%) during years 1998-2000.

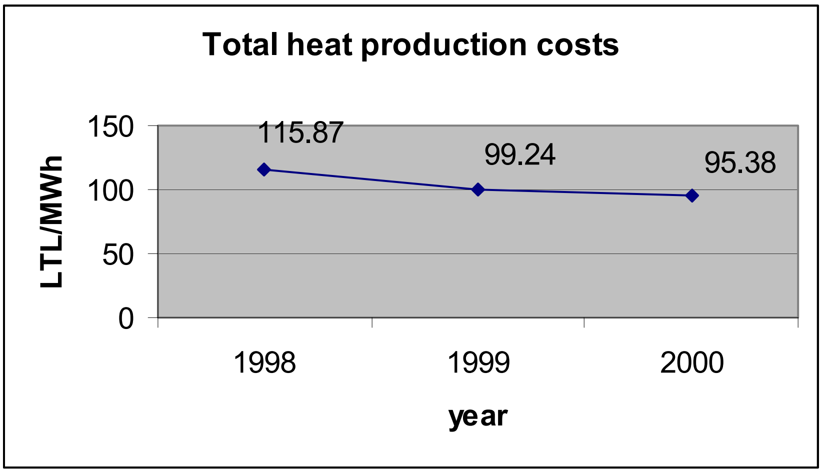

Fig.8.5. *Total heat production costs*

Total heat energy production costs per unit of output were decreased by 20.49 LTL/MWh or by 17.7%.

During years 1998- 2000 the heat tarif for consumers was 0.1088 LTL/kWh (Ignalina District Heating). The tarif was set by the Ignalina District Heating Company and approved by the National Control Commission for Prices and Energy. As the graph above shows, the price fully covered heat production costs in years 1999 and 2000.

"*Import*"

Light fuel oil and heavy fuel oil are imported from outside municipality, thus bio-fuel is produced locally. Expenses for fuel import during years 1998 – 2000 were decreased by 1908000 LTL (93.4%).

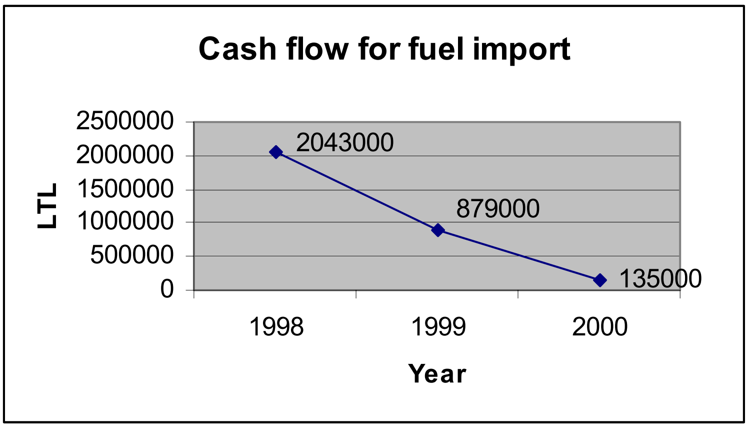

Fig. 8.6. *Cash flow for fuel "import"*

During years 1998-2000, 1908000 LTL remained in the municipality due to avoided fuel import. For the comparison - the budget of the municipality in year 2000 (Ignalina municipality, 2000):

- Budget incomes – 28542000LTL
- Budget expenses – 28282400LTL

Environmental taxes

The obvious reduction in expenses for environmental taxes can be observed. The expenses were decreased by 50% during years 1998-2000.

Table. 8.4. *Expenses on taxes for environmental pollution (thous.LTL)*

1998		**1999**		**2000**	
Forecasted	Real	Forecasted	Real	Forecasted	Real
22.3	32	16.1	28	16.1	16

Source: Ignalina District Heating

8.3. Environmental effects

The major indicators for the analysis of environmental effects are following:

- Changes in emissions and air pollution
- Sustainable bio-fuel resource allocation

The reduction of fossil fuel consumption resulted in significant changes of emissions of certain hazardous pollutants. The following emissions are monitored and recorded according to the national legislation document LAND 12-98.

Table 8.5. *Emission of pollutants to the atmosphere (ton/year)*

Pollutant	**1998**	**1999**	**2000**
Particles	3.14	3.71 (+6.85)	5.06 (+1.35)
Carbon monoxide (CO)	51.74	73.79 (+22.05)	132.05 (+58.26)
Sulphur dioxide (SO_2)	100.35	83.75 (-16.6)	25.48 (-58.27)
Nitrogen oxides (Nox)	14.69	12.04 (-2.65)	11.22 (-0.82)

Source: Ignalina District Heating

Measured emissions per unit of produced energy:

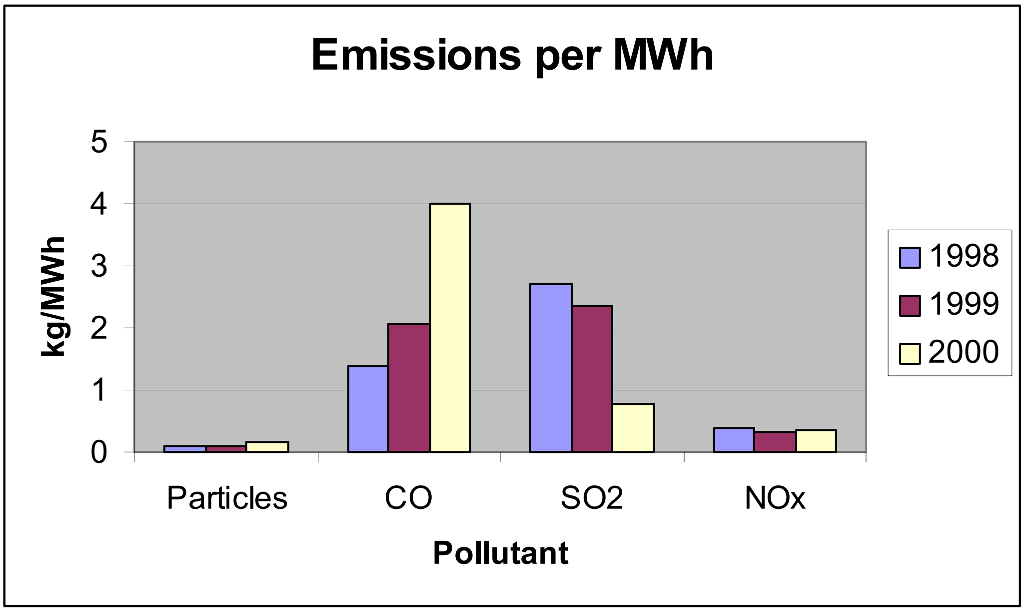

Fig. 8.7. *Measured emissions per unit of output,* Source: Ignalina District Heating

Most significant reduction of SO_2 is achieved. Quite unfavourable results can be observed regarding CO emissions. According provided data the CO emissions increased from 51.74 to 132.05 t/year during years 1998-2000, while the designed annual emissions in years 1999-2000 were around 63 t/year (Business plan, 1997). This can be explained as a result of certain technical imperfections, as well as measurement technology peculiarities. However, the CO emissions are negligible comparing with CO_2 emissions (see calculations below).

LAND 12-98 legislation does not include the monitoring and record of CO_2 emissions, therefore they are calculated according IPCC (Intergovernmental Panel on Climate Change) recommendations (Watson, et al., 1996). Bio-fuel is considered as CO_2 neutral fuel.

Table 8.6. *CO_2 emissions from heat production in Ignalina boiler plant*

Year	**Energy production, MWh**	**CO_2 emissions***				
		Biofuel, ton	**Mazout, ton**	**Total, ton**	**Emission per unit of output, kg/MWh**	**Savings, ton**
1998	37032	0	11355	11355	307	-
1999	35670	0	7536	7536	211	3819
2000	33077	0	1763	1763	53	5773

Source: Ignalina District Heating

*The calculations above do not include the CO_2 emissions from fossil fuels employed in wood fuel production and transportation (so called leakage). At the moment such calculations are very complicated to perform due to following reasons:

- Wood fuel used (sawdust and wood chips) comes from woodwork industries
- Production of wood chips employs electricity, which in Lithuania now basically comes from nuclear power, what means that CO_2 is not emitted

- Transportation distances and vehicles used for transportation of wood fuel vary a lot and often are not fixed

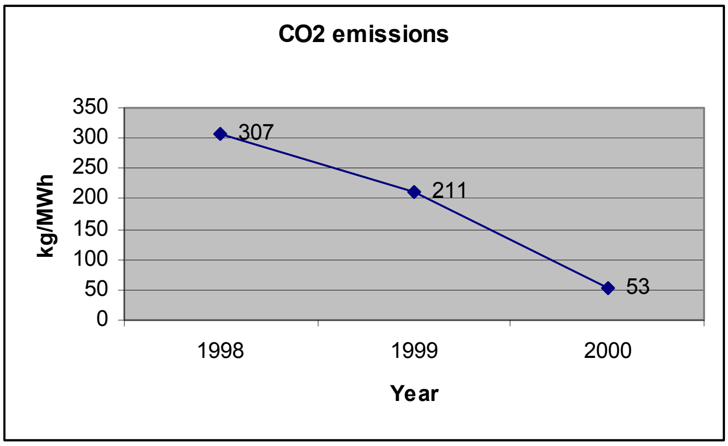

Fig. 8.9. *Calculated CO_2 emissions per unit of output*

Wood fuel used in Ignalina boiler plant during years 1998-2000 came from woodwork industries in the form of wood chips and sawdust. Wood fuel directly from the forest was not supplied; therefore there were no direct effects on the environment as for exp. decrease of soil fertility due to the 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.

Regarding the sustainability in wood fuel resource allocation the following procedure can be applied:
Considering the forest area per capita in the municipality 1.4 ha, and the mean gross annual increment of growing stock 5.8 m^3/ha, the mean gross annual increment per capita will be 8.1m^3, or expressed in energy units – 16.2 MWh.

Considering the average residential heat energy consumption in Lithuania 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.

8.4. Social effects

The major indicators for the analysis of social effects are following:

- Living quality improvement due to reduced pollution
- Created employment
- Money saving and improved welfare of the population

Most significant reductions were SO_2 and NO_x. The concentrations of these pollutants in the atmosphere have negative human health impacts. SO_2 is a harsh irritant, it causes human respiratory problems, exacerbates asthma, bronchitis and emphysema. Acidified water is suspected of having certain adverse health effects, especially concerning infants. Health effects of NO_x include lungs irritation and may be a cause of bronchitis and pneumonia, it may increase susceptibility to viral infections. Obviously, it is too early to estimate project impact to these diseases, but later on such an analysis should be done.

There is a general assumption made both by the Lithuanian Ministry of Economy and the foreign experts that installed 1MW bio-fuel capacity employs 2 extra people (Jarmokas, 2000). Considering 6 MW installed in Ignalina boiler house, it should have created 12 extra labour places in the area. Thus practically it is very complicated to evaluate the created jobs. According companies reports, after starting using bio-fuel new labour places were not created at ”Ignalina District Heating”. The number of employees remained approx. the same. Some shifts were, however, observed.

In fuel production (chipping) chain new labour places were created. 1 worker approximately produces 714.3 m^3 of wood chips per heating season (number derived from the data obtained from the interviews with fuel suppliers). Ignalina boiler house consumed around 14000 m^3 of wood chips during year 2000.

New labour places in transportation sectors were not created. The same work force for that purpose was used. However, the shifts took place.

Though the transportation around boiler house increased, no special complains from nearby living people were received yet.

Cost covering operation of the company enables the municipality to avoid paying subsidies for the heat energy, what significantly influences municipality budget. Gradually there are more budget resources for the implementation of different projects for the improvement of people’s quality of life in the municipality.

9. The Ignalina Case in a National Perspective

By analysing the Ignalina case certain general conclusions, valid for many municipalities in the province of Lithuania, might be drawn. The possibilities for using bio-fuel from the resource point of view are really good. As analysed above, the forest cover is sufficiently high to cover the population’s heat energy demand in a sustainable manner. Besides, the forest coverage in Lithuania is increasing. Road network is well developed, what means favourable conditions for the supply of bio-fuel. Technical potential is also good, as quite well developed DH system in the town already exists. Thus it requires certain technical renovation, it is not necessary to construct a new one. The DH system creates most favourable conditions for using bio-fuel, as the same system and the same boiler house can be used, only the bio-fuel pre-furnace and fuel storage facilities are needed to install. Regarding these features (population distribution, infrastructure, forest resources, etc.) Ignalina municipality can be treated as a typical municipality in the province of Lithuania.

Generally it should be said that regional distribution is quite strong in Lithuania. There are no extremely big concentrations of population in one area, which is true for a neighbouring country Latvia with its biggest population concentration in capital Riga. This is important prerequisite for implementation of bio-fuel projects. The population of Lithuania is 3.7 million. There are two municipalities, Vilnius and Kaunas, where the population varies from 400000 to 600000. The population of Klaipeda, Siauliai and Panevezys varies between 100000 and 400000. In seven more municipalities the population varies between 60000 and 100000. 21 municipalities, have the population between 30000 and 40000. In the remaining municipalities the population usually varies between 20000 and 30000. Totally there are 60 municipalities in Lithuania (LSA, 2001).

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 bigger ones, therefore the heat energy issues are of crucial importance. On the other hand, the possibilities of using bio-fuel are the most favourable as due to lower heat value of bio-fuel, the transportation and supply problems would not be as important as in big cities. Furthermore, the local production of bio-fuel will employ local population and gradually improve generally poorer social situation in these areas. Therefore the renovation of DH systems and bio-fuel projects should come in line. In other words, the renovation of DH systems can be used as an opportunity for the bio-fuel.

10. Discussion

10.1. General political, economical, environmental and social issues

Political issues. Energy policy questions are most sensitive in the country's economical policy. Usually the energy issues can be considered as important reasons for political instabilities. Different political parties in their election periods (usually 4 years) have different interests. It very negatively affects energy projects, as their implementation requires long term stable policies (for exp. the lifetime of Ignalina project is 25 years). The absence of long-term policy stability makes the projects unattractive for commercial investors.

District heating future in the country is still not clearly defined. Though the National Energy Strategy promotes the development of DH, its long-term implementation is unclear and inconsistent. The delay to accept the Heat Law of the Republic of Lithuania is one of the major reasons for that inconsistency.

Obviously, from an energy security and environmental point of view, the DH systems have many advantages. DH can be fuel flexible because it can switch from oil to natural gas or to renewables. Ignalina case here can be a good example.

CHP plant in Klaipeda had a good demonstrational effect of a good technical potential for bio-fuel based cogeneration. Thus with recent overcapacities in electricity production, the company has problems with electrical power realization. Generally CHP is having difficult time increasing its market share because of institutional barriers that make it difficult for excess electricity to be sold to the grid and because of the current overcapacity of the generating system. However, closing unit 1 of Ignalina Nuclear Power Plant will reduce much of the overcapacity and economic growth will probably reduce the rest of the overcapacity in a fairly short period. To prepare for that eventually, the financial and institutional barriers to CHP need to be addressed as soon as possible (Energy Charter Secretariat 2000).

Another important constraint is the not finished Land reform in the country. It complicates the estimation of feasible bio-fuel resources. Contribution of the forest energy to the national energy balance is also difficult to evaluate using only figures disclosing the resources of the whole country. A national energy strategy should be based up on data collected by forest and energy specialists on the county and regional level.

The implementation of the Polluter Pays Principle (PPP) and the internalisation of external costs in the future will create better economical environment for bio-fuel projects. Therefore, considering the age of energy projects, the decisions should be taken now.

Economical issues. A very important problem in DH sector is that it has the legacy of a large, often inefficient infrastructure. The marketing shortcomings within DH companies still prevail. This specially reflects in relations with consumers and the administration of companies. The administration costs are too high. The DH systems are in serious need for investment. Many municipalities do not have the managerial skills or financial resources to modernise the companies. There is a growing interest by consumers to switch to natural gas as it costs cheaper than heat. With some consumers switching, this is causing capacity, efficiency and revenue problems for DH companies and gradually increase the price for the remaining consumers.

The increase of indigenous fuel utilisation is limited by the growth of prices for the domestic fuel, which in some cases reaches the price of imported heavy fuel oil (especially considering the fluctuating oil price nowadays). Without a developed infrastructure of indigenous fuel production and utilisation the production costs are high. Market relations are still in stage of development in the local fuel production area.

The tax regime, grants, subsidies, etc. can make the difference between success and failure for a bio-fuel project, as a new initiative. However, the grants, subsidies, and certain tax privileges (50% VAT tax reduction for bio-fuel) are only the short term promotion solutions, as essentially are not in line with market economy principles. The introduction of Carbon Tax and the implementation of PPP would probably be the most favourable and fair solution for the economical success of bio-fuel projects.

Environmental issues. The reduction of SO_2 and CO_2 emissions is the most important and evident benefit of the bio-fuel projects. Thus, the poor environmental monitoring system does not allow a clear estimate of the environmental performance of the implemented projects. Permanent air monitoring is not performed in the municipal level. Emissions measurement methods often are not reliable enough to provide exact information.

CO_2 emissions are calculated by comparing emissions from fossil fuels. Thus there is no overall data on CO_2 in municipal level.

Though the recent utilization of wood fuel does not have direct impact on forest ecosystems, as wood fuel comes as a waste from woodwork industries, in future, when the use of fuel directly from forest will increase, the corresponding guidelines will need to be set out.

The bio-fuel projects lack the explicit quantitative data regarding the environmental and social performance. The overall Environmental Impact Assessment EIA of the projects should be performed. Other advanced tool for the coverage of projects' environmental performance could be the Life Cycle Assessment (LCA), covering all the energy chain from the resource extraction to the final consumption.

Social issues. The results show that bio-fuel projects result in various social benefits, the most important of which is energy security. Local renewable energy source provides stable energy supply with lower costs. Decreased hazardous emissions improves living environment and decreases health risks. Thus, it is obvious, that health issues can be estimated only after longer period of boiler plant operation. It should be noted that societal awareness regarding bio-fuel is increasing, mainly due to mass media information. Thus the society still very often sees bio-fuel as a complete controversy to DH system. District heating system is realised as only fossil fuel based system, as it was designed, constructed and operating for many years. There is no proper systematic attitude towards energy system as such. The society should be better informed about the whole energy chain – from the resource to the end use. It should be underlined that the renewable energy based district heating system in urban areas is the most appropriate and sustainable energy supply, as it is proved nowadays in many countries.

10.1. Renewable energy importance in national level

Political. The stimulation of energy producers and consumers for efficient use of local and renewable energy sources are the major goals of energy policy, as governed by the Energy Law of the Republic of Lithuania and the National Energy Strategy. Considering the implementation results of the on-going renewable energy projects, it is assumed that the share of renewable energy sources will constitute 12-13% in national energy balance. It is in line with the targets of European Union for the use of renewable energy sources in each Member State (Katinas, Skema, 2001). Lithuania also supports 1994 Madrid declaration, which recommends European community states to increase the share of local and renewable energy up to 15% in the total energy balance (Pedisius, 2000).

Socio-Economical. Since 1% of the imported fuel in the national energy balance costs 8 million USD, the assumed gain of avoided import cost could be up to 100 million USD (Katinas, Skema, 2001). In addition, the emission release to the atmosphere will be diminished significantly and the social issues will be favourably affected, as new jobs will be created for the production and operation needs of renewable energy technologies.

The most appropriate use of indigenous energy resources (except hydro and wind energy) is for district heating purposes.

10.2. DH importance in national level

In its biannual survey, Euroheat & Power documents that district heating technology continues its expansion in the EU, and is becoming increasingly "green". District heat and cooling is now supplied to over 22 mln. people in the EU, from Greece to Finland, producing an annual turnover of approximately € 19 bln. for sales of heat, cooling and electricity supply services. The penetration of district heating grows very strongly in the EU. Denmark has now the highest penetration of district heating in the EU with 58%, followed by Finland with 50% and Sweden with 42%. Market shares in key accession countries such as Poland, Slovakia, Estonia and Lithuania are in the same order of magnitude or even higher (Euroheat & Power, 2001).

Lithuanian National Energy Strategy underlines the importance of integration into European Union; therefore the successful operation of DH systems here plays a very important role. High DH market share in Lithuania can be used as an advantage in the integration process.

11. Concluding Perspectives

Concluding it can be said, that the bio-fuel and DH system is a good combination for the sustainable production and supply of the heat - the service that plays extremely important role in Lithuanian socio-economical, political, environmental issues. DH system, as a part of the urban infrastructure, proves to be the most efficient and secure system for the production and supply of heat. Bio-fuel, as the local and renewable energy source, is the best choice both from the environmental and social point of view.

Lithuanian National Energy Strategy draws very favourable guidelines for DH, and the renewables. However, when it comes to the implementation of the strategic guidelines, lack of consistent political and economical policies becomes evident. The successful implementation of bio-fuel DH projects requires certain political and economical decisions both in national and in local levels. As the most important can be mentioned following:

Nationally

- Setting of long term bio-fuel policy in national and municipal level and making it attractive for commercial investors
- Reduction of taxes, providing grants, subsidies, state guarantees for the loans for bio-fuel projects in the short run - as the promotion measures
- The implementation of PPP principle, and the introduction of Carbon tax in the long run
- Environmental Impact Assessment (EIA) and Life Cycle Assessment (LCA) of bio-fuel projects, integrating environmental and social issues within the project area
- Finishing of the Land reform
- Adoption of Heat Law
- Technical development of bio-fuel utilisation equipment, especially in design stage. Training of the operators of bio-fuel equipment.

- Analysis of future possibilities of bio-fuel based CHP (introduction of new technologies, for exp. biomass gasification).
- Improved or newly established educational programmes regarding climate change and renewable energy issues in different levels.
- Better communication between energy institutions and commercial structures

Locally

- Energy planning within the municipalities. Municipalities should draw up heat plans. This will protect areas and allow for the better planning. Heat planning should be an element of the municipal planning.
- Rehabilitation of the DH system and improved marketing of the companies
- Clarifying estimation of the resource of bio-fuel in local (regional) level; First of all attempting to use woodwork industry residues, as only around 28% of total potential now is utilised
- Air quality monitoring in regional level

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