Use of biofuels in the district heating system of Riga

The increasing demand for energy, the shortage of the reserves of fuel, as well as the environment pollution and the global climate changes are the reasons for the growing interest in renewable energy resources in Latvia where the share of renewable energy resources account for one third in the total balance of primary energy resources. Wood and hydro energy are the two major types of renewable energy resources. Latvia has set the goal to increase the share of renewable energy resources up to 40% by 2020. The biggest possibilities for the use of local renewable energy resources refer to heat production – this applies to energy resources, like granulated wood or wood chips (hereinafter referred to as biofuel) with the highest efficiency. This article demonstrates the use of biofuel and the possibilities of increasing its share, as well as measures for increasing the efficiency of the biofuel fired heat sources in the district heating system of Riga.

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District heating system in Riga was established in 1958

District heating system consists of the supply network of heat energy and heat production sources for a city or a part of a city. The district heating system is a modern heat energy supply system, which provides a possibility to produce heat in cogeneration cycle and to use biofuel, as well as other advanced technologies the application of which is not efficient or feasible in local heat sources. At present JSC "RĪGAS SILTUMS" is the operator of the district heating system in Riga and is in charge of providing heat energy supply to households, state authorities and businesses in Riga. JSC "RĪGAS SILTUMS" plays an important role in the heat supply of Latvia accounting for 53% of the total volume of the district heat supply provided by the district heating systems.

The company purchases approximately 70% of the heat required for the needs of Riga city from CHP plants of an independent producer and produces the remaining approximately 30% by itself (**Table 1**).

Table 1. Heat production capacities of the district heating system.

	Heat capacity, MW
Owned by operator, including:	**942**
DHP "Imanta"	405
DHP "Ziepniekkalns"	104
DHP "Zasulauks"	257
DHP "Daugavgrīva"	32
DHP "Vecmīlgrāvis"	63
38 automated small local boiler houses	81
Heat sources owned by others, including:	**1657**
TEC-1	493
TEC-2	1148
Juglas jauda	16
Total installed heat capacity	**2599**

The implementation of the rehabilitation project of Riga district heating system started in 1996 and was aimed at achieving considerable improvement of the efficiency of Riga district heating system, ensuring its competitiveness and reducing the impact of the district heating system upon the environment. Within the framework of the rehabilitation it was planned to eliminate the centralised heat substations, to reconstruct individual heat

substations and pipeline networks, to close non-efficient medium and small capacity heat sources and to connect the relevant consumers to the district heating, as well as to reconstruct the major heat sources of JSC „RĪGAS SILTUMS". In the course of implementing the rehabilitation project the arrangement of the heat metering system, improvement of the service level and establishment of the possibilities of control of the heat consumption by heat consumers were defined as the priority areas.

Individual heat metering installed from 1996

3000 heat meters were installed in Riga until September 1996 based upon the initiative of the house owners. In the course of implementing the guidelines of the rehabilitation project of the district heating system, the installation of heat meters started in 1996 both at consumer side and in heat sources. The costs of procurement and installation of heat meters were included in the heat tariff. In October 1997 the installation of 6000 heat meters was completed and it permitted to transfer to the system of settlements with heat consumers based upon the actual consumption of heat. The metering of actual heat consumption encouraged the arrangement of the internal heat supply systems of buildings, thanks to the optimisation of the flow of network water and hot water consumption. Residents, in their turn, can accurately account for the consumed water based upon the readings of the meters installed in apartments and adjust their consumption to their economical abilities. Settlements for heat based upon meter readings increased the consumers' interest to save the heat energy, supplied to the building, and to demand provision of higher quality heat. The measures of saving and improving the heat quality yielded their results because the heat sales to households decreased.

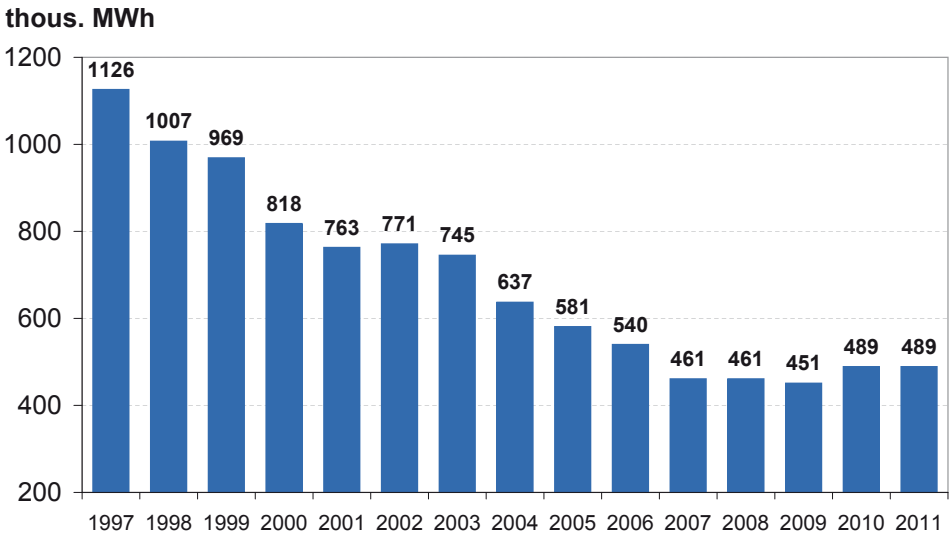

Figure 1. Heat losses in DH networks.

Individual heat substations

Before 1997 approximately 46% of the heat consumers connected to Riga district heating system received heat via central heat substations (places where the heat carrier is produced for ensuring space heating and domestic hot water supplies to a group of buildings). When hot water was supplied and space heating was provided via the central heat substations it was not possible to guarantee the high quality of service to the customers. In autumn and spring periods the premises were overheated (the adjustment possibilities were limited). In the result heat was not used efficiently. For the purpose of providing the required amount and quality of heat to heat consumers, improving the security of the heat supply and achieving more efficient use of heat JSC "RĪGAS SILTUMS" was consistently implementing the measures aimed at reducing the heat demand, including the implementation of the program of elimination of central heat substations and setting up individual automated heat substations. Within this program 3008 modern individual heat substations were constructed in the buildings. All the 185 central heat substations and the hot water networks associated with them with the total length of 134.77 km were eliminated by the end of 2001. At present more than 8000 individual heat substations have been modernised.

Reduction of heat transmission losses

For the purpose of ensuring the operation of the district heating system and its competitiveness on the heat market the good technical condition of the elements of the heat supply systems has to be maintained. The main and distribution heat networks are major elements of the district heating system. By maintaining the good technical condition of the main and distribution heat networks JSC "RĪGAS SILTUMS" provides high quality heat supply to customers and is reducing transmission heat losses and leakages of the heat carrier. Generally, thanks to the implementation of the measures aimed at reducing the transmission heat losses it was possible to reduce the transmission heat losses in Riga district heating system approximately 2.3 times (**Figure 1**).

Quality of biofuels

In order to reduce dependence on one type of fuel, to improve the security of heat supply and to reduce carbon dioxide emissions, the sustainable justified diversification of fuel was defined as the priority aimed at rapid and considerable increase of the share of biofuel. The requirements were set to

- composition (bark, stones, sand, metal items, ice, etc.
- fraction size: 20…50 mm – 89…90%, 100 mm – not exceeding 1%, 5 mm - not exceeding 10%
- heating value – 2800 kWh/kg;
- moisture – 30…55%.

Figure2. The biofuel fired boiler house at the plant Vecmilgravis.

Three types of production of the biofuel were recognised:

1. Planned production of energy wood chips by cutting the forest trees and chipping the round timber at specially equipped places;
2. At the felling areas where the waste of the forest cutting works is being utilised (branches, stems, bushes, etc.) – the timber is chipped at the site and transported to boiler houses;
3. In the course of cleaning the protective areas, constructing roads and carrying out the maintenance of overhead power lines – the chipping of the wood is done at the site and then it is transported to boiler houses;

Use of biofuels in the Riga DH system

Taking into account the particular circumstances when the operator of the district heating JSC "RĪGAS SILTUMS" can operate only the heat production plants owned by itself, the first biofuel fired unit in the district heating system of Riga was installed in 1996 at the heat plant "Daugavgrīva". The biofuel prefurnace with the heat capacity 7.5 MW and with the efficiency rate up to 75% was added to the existing steam boiler.

On September 30, 2008 Riga was the first European capital, which has signed the Covenant of Mayors. The Covenant of Mayors is the main document of forming the European energy policy uniting 3000 cities in the European Union and other countries.

The Covenant of Mayors is an ambitious initiative by the European Commission expressing the unilateral undertaking to reduce the CO_2 emissions caused by the EU by 20% until 2020, and achieving this by means of improving energy efficiency by 20% and increasing the share of renewable energy sources in the total energy consumption by 20%.

Taking into account the above, as well as the rapid increase of natural gas prices and the support available from the EU structural funds, JSC „RĪGAS SILTUMS" has actively engaged in the use of biofuel in its production sites. The use of biofuel contributes to the fuel diversification aimed at more intense use of local renewable energy resources and reduces the impact of the natural gas upon the heat price.

Along with the development of the biofuel incineration technologies and in the course of continuing the increase of the share of biofuel in Riga district heating system in 2010 a biofuel fired boiler house with the capacity of 14 MW and the efficiency rate up to 85% was constructed in the heat plant „Vecmīlgrāvis" (**Figure 2**) and it is operated at the base load.

In summer period only the operation of the biofuel fired boilers is envisaged in the heat plants „Daugavgrīva" and „Vecmīlgrāvis". For the purpose of ensuring the compensation for the daily changing heat loads - heat accumulators were installed in the heat plants and they are covering the heat loads during the peak hours and charge the load of the boilers during night hours.

The development measures implemented at the heat plant „Vecmīlgrāvis" permitted to improve the operational efficiency of this heat source and has increased the share of use of the biofuel in the total production scope from 2.4% to 6.4%.

Further development of the biofuel usage

By increasing the share of use of the biofuel, the impact of the increase of natural gas prices upon the heat production costs will be reduced. Currently two modernisation projects have been initiated providing for the installation of highly efficient heat production units using biofuel:

- a cogeneration unit producing up to 22 MW heat and 4 MW electricity with the total efficiency rate up to 97% will be installed at the heat plant "Ziepniekkalns";
- the installation of the water heating boiler with the capacity of 20 MW and the fluidised bed furnace allowing to burn a wide range of biofuel is planned in the modernisation project of the heat plant "Zasulauks".

In both above mentioned projects the flue gas utilisation technologies (flue gas condensers) will be installed ensuring the efficiency rate of the boiler operation close to 100%. The maximum automation level and construction of the automated storage of biofuel is planned to be placed at the boiler houses. The implementation of the projects will permit to save the natural gas consumption of approximately 11.2 mill. n.m³/year, at the same time increasing the consumption of biofuel by approximately 112 thous. loose m³/year.

Following the implementation of the projects of biofuel at the heat plants "Ziepniekkalns" and "Zasulauks" the share of biofuel in the total production volume will reach 5.82% (**Figure 3**).

By year 2014, thanks to the implementation of the modernisation projects providing for the use of biofuel in the heat plants "Ziepniekkalns" and "Zasulauks", the total consumption of biofuel in Riga district heating system will increase from approximately 0.03 mill. loose m³ per year to approximately 0.4 mill. loose m³ per year or more than 13 times.

Along with the planned increase of the share of energy produced on the basis of the biofuel in the total volume of heat production for Riga district heating system, also measures for improving the efficiency of biofuel fired heat sources are consistently implemented. In the near future, in addition to fossil biofuel fired water heating boilers at the heat plant „Vecmīlgrāvis", it is planned to installed condensers of flue gases. The condensers of flue gases will be installed in the flue gas channel behind the boiler and flue gas treatment devices, and by means of

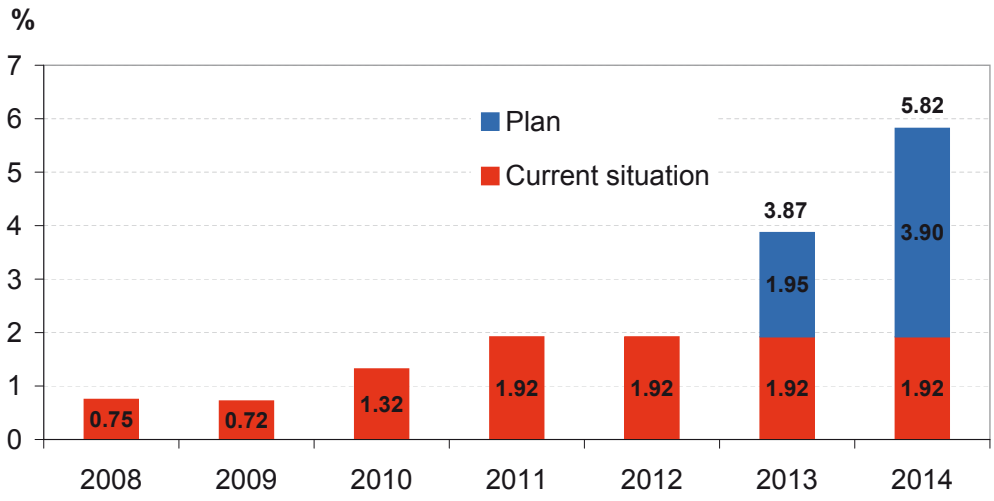

Figure 3. Increase of the share of biofuel in heat sources (%).

spraying water in the flue gas flow it is possible to recover a considerable portion of the heat of the flue gas produced in the process of combustion of the biofuel. The installation of the flue gas condenser will result in the increase of the efficiency of use of the biofuel by 15% (**Figure 4**), as the temperature of emitted flue gases is decreased.

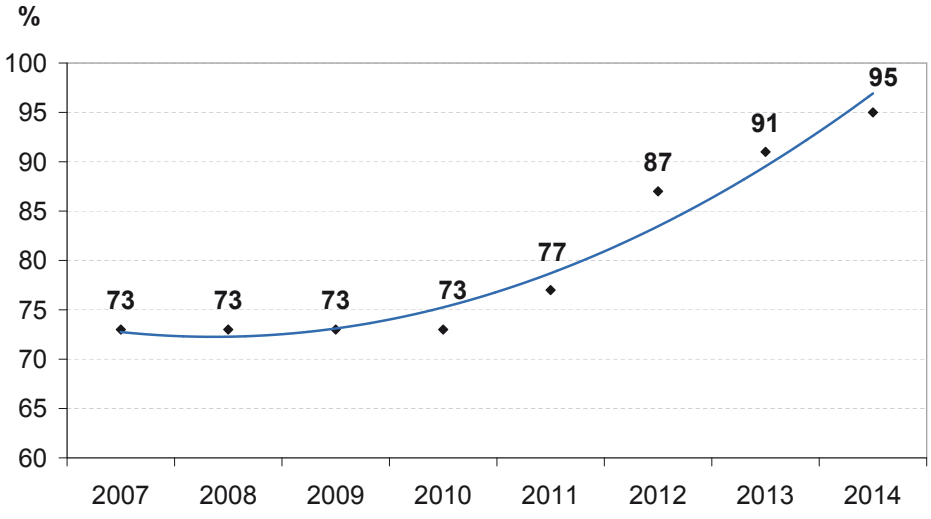

Figure 4. The dynamics of the improvement of the average efficiency of use of biofuel.

Reviewing further possibilities of the use of wood chips we have studied the implementation of the gasification of wood chips in heat production and power generation. Taking into account that low-capacity units are used now in practice we are planning to consider the possibilities of installation this type of equipment in the small scale heat sources where the winter loads range from 16 to 17 MW and in summer the load decreases to 2 MW. Considering the high capital investment in the wood chips gasification equipment it should be operated for the maximum number of hours during year. If the process of gasification of wood chips is compared to the classic process of incineration of wood chips the gasification process is characterised by a better proportion in producing heat and electricity. Taking into account that electricity is a much more profitable product that can be sold on the market, the technology with the maximum electricity generation during a year is more profitable. It is planned to install the wood chips gasification unit with the heat capacity of 1.9 MW_{th} and electrical capacity of 1.0 MW_{el}.

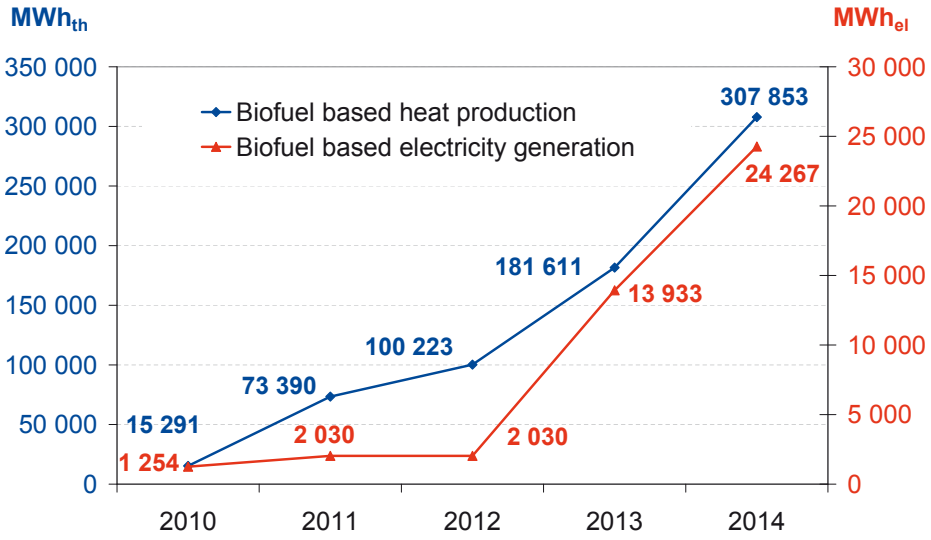

Figure 5. Biofuel based heat production and electricity generation.

Generation of electricity at biofuel fired heat sources

In order to improve the efficiency of a heat source, to provide auxiliary power supply and to sell the surplus electricity, which would contribute to the improvement of the overall efficiency of the district heating system, in 2004 the modernisation project of the heat plant „Daugavgrīva" was implemented with the installation of the steam turbine with the electrical capacity of 0.5 MW_{el} and construction of the heat storage tank with the volume of 100 m^3. In 2007 the capacity of the turbine was increased up to 0.6 MW_{el}. Due to the implementation of the modernisation project at the heat plant „Ziepniekkalns" – construction of the biofuel fired cogeneration unit with the electrical capacity of 4 MW, the electricity generation based on biofuel will increase more than 19 times in 2014 compared to 2010 and will amount to 24 thous. MWh per year (see **Figure 5**).

Conclusions

In the current situation in the fuel market when the prices of fossil fuels increase rapidly the use of biofuel for production of heat and generation of electricity is economically justified. However, I would also like to point out that each situation has to be analysed on case by case basis. The example described by me provides an insight of the use of biofuel in the district heating system. When a new biofuel based technologies with high efficiency parameters are applied for the heat production, these units can be used in the existing and newly constructed production sources.

When biofuel based energy production sources are built or reconstructed, the load of the units has to be carefully assessed. It is because the investments in biofuel based units are much higher than the investments in the units using natural gas. Therefore, in the course of planning it is necessary to ensure that the selected biofuel based units use the heat produced in the process to the maximum extent and are loaded during the whole year.

The district heating system provides a possibility for the efficient use of biofuel in heat sources because the heat sources are linked within a common system. When several sources operate within a joint system it is possible to ensure that the biofuel based units are efficiently loaded. If the biofuel based production sources are utilised efficiently within the district heating system this provides an opportunity to produce heat the costs of which are competitive in the heat market.

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