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WOOD ENERGY AND CLEANTECH

GUIDELINES

from the

WORKPACKAGE

TECHNOLOGY AND PRODUCTION

Estonian University of Life Sciences

Tartu, 2012

CENTRAL BALTIC INTERREG IV A PROGRAMME 2007–2013

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INVESTING IN YOUR FUTURE

WOOD ENERGY

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INTRODUCTION

This guideline was prepared in the framework of Workpackage 5 of the INTERREG IV A project Wood Energy and Cleantech, which was implemented from May 2010 to December 2012. The main focus of the project was on the development of Suitable Clean Wood Energy in the Central Baltic region.

Whereas most of the workpackages were addressed at detecting the problems and possible solutions in the field of policies; planning, business and competence, Workpackage 5 (Technology and Production) was aimed at providing mutual technical support and cross-border knowledge building to develop technology and its effective usage.

The activities in the "Technology and Production" workpackage therefore included thorough analysis of District Heating (DH) systems and study trips to the boilerhouse and combined heat and power generation facilities located in the participating regions.

For the analysis of District Heating systems, several reports were compiled:

a) System Analysis of District Heating in Tartu region;
b) Technology Studies of Wood Based Energy Production in the regions of Southern-Estonia, Östergotland, Vidzeme Planning Region;
c) Case Studies of the District Heating Systems of the town of Elva, municipality of Kisa, town of Alūksne and of the region of Beverina.

The results of these reports were used in the compilation of this guideline. The main purpose of this document is to offer support for future planning and investment decisions for the District Heating system's operator and local decision makers by pointing out the key problems and future activities that were found during the project's implementation time.

1 HEAT PRODUCTION – A HOT TOPIC IN THE CENTRAL BALTIC COUNTRIES

Compared to countries with warmer climate, the regions that participated in the project are focused on heat energy production through most of the year. The heating period usually begins from the end of September and ends in the beginning of May. During the years 1950…1990 the energy sources for producing heat energy were thoroughly changed to fuel oil, natural gas, coal, and electricity. Wood, as a traditional energy source, meanwhile maintained its position as a reliable and reasonably priced renewable energy source.

Ever since the price of fossil fuels started to rise (because of increased demand and stricter climate policies), woodfuels usage has started to increase. In the following table (table 1.1), an overview of the regions and their estimated woodfuels usage is given.

Table 1.1. Overview of the partner regions 2010[1]

	SE, Östergotland County	**EE, Tartu region (Tartu-, Võru-, Põlva- and Valga Counties)**	**LV, Vidzeme Region**
Area	9987 km²	9507 km²	15246 km²
Population	424333	252630	235576
Population density (pers/km²)	42,48	26,57	15,45
Number of municipalities	13	55 + 7 towns	25 + 1 town
Forest percentage	64%	48%	54%
Average temperature (October...April)	0,6 °C	-0,3 °C	-2 °C
Average minimal temperature (October...April)	-2,6 °C	-4 °C	N/A
Inventoried wood-burning heating units	13	88	120
incl boiler houses	10	87	120
incl CHP plants	3	1 (1 on natural gas)[2]	0 (3 on natural gas)
Installed capacity	2787 MW	1381 MW	332 MW
Annual Wood Consumption	2665 GWh	1650 GWh	237 GWh
Average installed capacity of wood-burning heating units (MW per boiler house)	214,4	15,6 MW	2,8 MW

[1] Allik et al. Comparison of wood fueled district heating in the regions of Östergotland (Sweden), Tartu (Estonia) and Vidzeme (Latvia). 2011. http://projektwebbar.lansstyrelsen.se/wood-energy-and-cleantech//SiteCollectionDocuments/Reports/Summary%20of%20technology%20studies.pdf

[2] In the end 2012, a new woodchip-firing boiler plant, Helme CHP, started working.

As can be seen from the descriptive data table above, the regions of Tartu and Östergotland County are about the same size, but the amount of wood-based boiler plants and the amount of energy they produce differs 1,6 times. Vidzeme Region, which covers the most area (but has the lowest population density), used, according to the study[1] woodfuels to produce 237 GWh of heat. It has to be noted, that the data collected from Vidzeme Region was estimated to be inaccurate, but descriptive enough to represent the situation in the region.

The average heating period (depending on the climate of a certain year) starts in the end of September and ends in the beginning of May, which means that heat energy has to be produced most of the year.

In the County of Östergotland, the heat is mostly distributed via District Heating (DH) systems with extensive networks and therefore the boilerhouses are big but there are not many of them. Using efficient DH systems in densely populated areas, enables the region to efficiently produce and distribute the heat energy with minimal costs.

As for the region of Southern-Estonia and Vidzeme, the situation is rather different, since the population is dispersed and many previously made DH networks have to be reconstructed in order to maintain feasible prices. Converting to woodfuels and reconstructing the DH pipeline will not be an economically rational option because of the migration of inhabitants and increasing energy efficiency. In these cases, individual boilerhouses should be considered.

In the following chapters, an overview of the different problems in the DH systems and methods for analysing the systems is given.

2 GATHERING INITIAL DATA – THE FIRST STEP OF ANALYSIS

In the Wood Energy and Cleantech project Case Studies were compiled for investigating the problems and future perspectives of the participating regions (Figure 1).

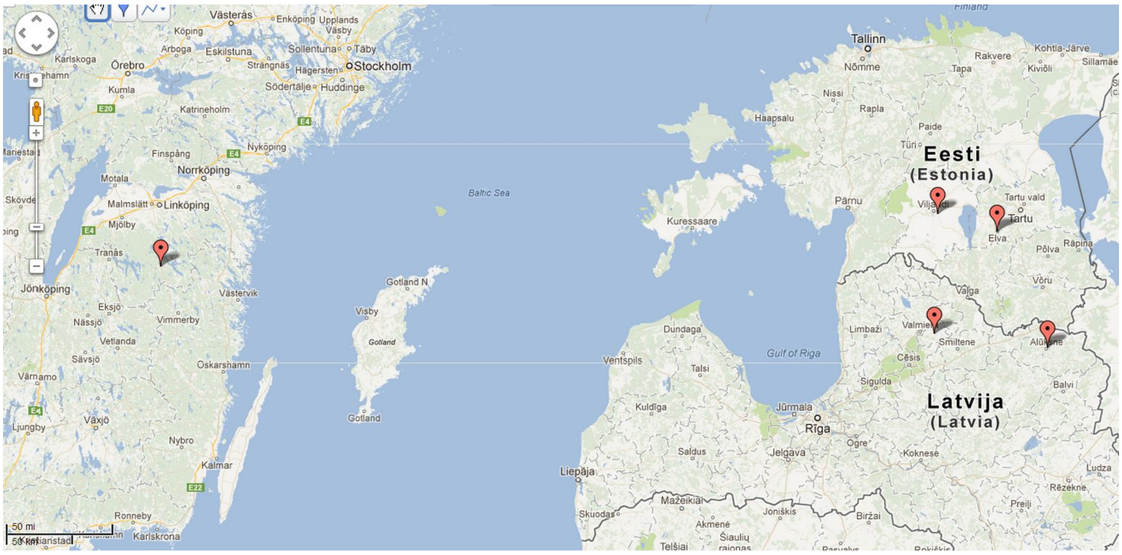

Figure 1. The location of the Case Study areas

As established in the previous paragraph, heating systems are used about 7…9 months during every year. Therefore it is crucial to have an effectively functioning (district) heating system. To determine, what the efficiency of the utilized system and equipment is, an analysis is needed.

The basis of an analysis is the representative description of the current situation. For the description, data must be gathered and analysed. For the most cases the **aggregated consumption and production data** (MWh/year; MWh/month or in best cases MWh/hour) will suffice to get an overview of the situation.

During the process of data gathering and analysis it is important to verify the quality of the data.

For example in the Case Study of Beverina[3] region it was discovered, that since the energy consumption was often poorly monitored, the specific energy consumption of similarly

[3] Roša, M., Blumberga, D. Summary of Beverina region. Ekodoma Ltd. 2012.

insulated buildings varied from 70 kWh/m^2 per year to 290 kWh/m^2 per year. In some buildings, the monitoring system was non-existent.

In cases where the consumption data or the monitoring system is found to be inadequate, the first action to implement should be establishing a reliable consumption database and monitoring system.

When proper data is acquired, it can be arranged to a heat load duration diagram (Figure 2).

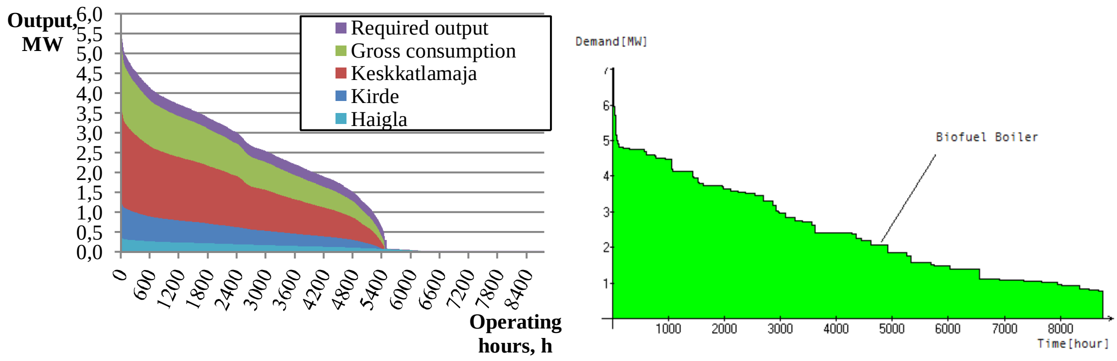

Figure 2. Calculated heat load duration diagram (on the left)[4] and heat load duration diagram based on hourly data (on the left)[5]

From the heat load duration diagram, the losses from the distribution network (production-consumption); minimal, maximal and base heat loads and the number of working hours can be read. A heat load duration diagram can be used for determining the optimal capacity of the boiler house as well as the amount of heat energy needed per year.

When hourly consumption and production data is not available, the heat load duration diagram can be calculated using yearly or monthly data[4].

In addition to the consumption and production data, an overview of the following aspects should be made as well[6]:

- the dispersion of the consumers and their distance from the boiler house;
- demographic tendencies;

[4] Uiga, J. A transition from fossil fuels to biofuels – a case study of Elva district heating system. EULS. 2012
[5] Amiri, S. The benefiits of energy co-operation between industriea and utility in the municipality of Kisa. University of Linköping. 2012.
[6] Blumberga, D., Roša, M. Analysis of alternatives of the district heating system in Alūksne. Ekodoma Ltd. 2012.

- change of energy efficiency of end users in time;
- social benefits system;
- the service level of heat supply and involved stakeholders.

For analysing the behaviour of the DH network an Excel chart (Figure 3) or specialised energy planning models (Figure 4) could be utilized. A more detailed description of how to implement these analysing tools is given in the respective Case Studies.

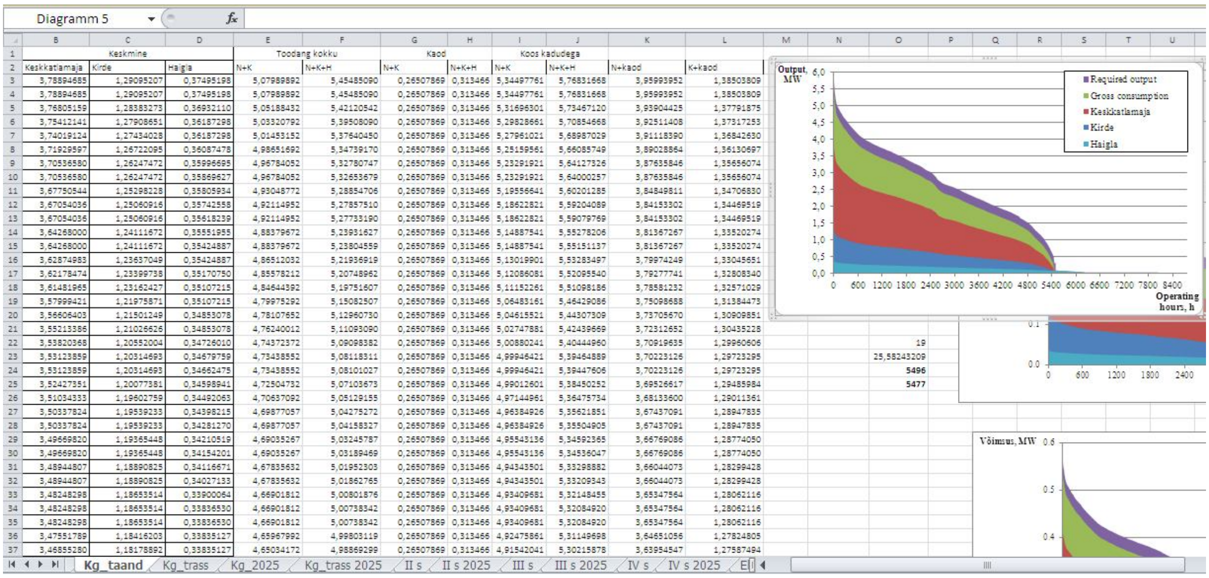

Figure 3. An Excel sheet for generating heat load duration diagram[4]

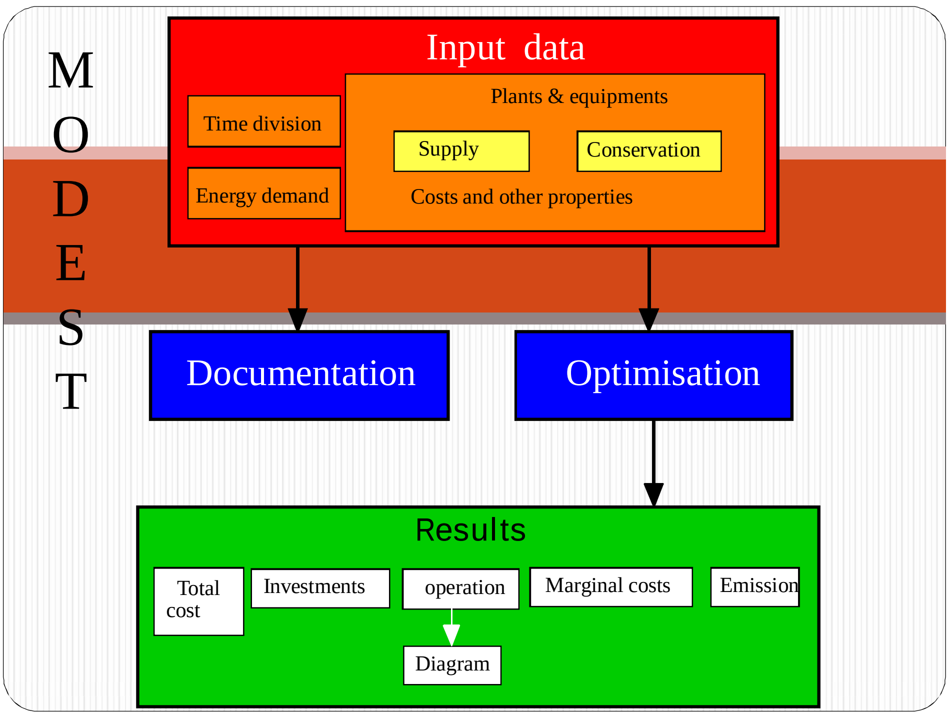

Figure 4. The optimisation routine in MODEST[5]

3 IDENTIFYING PROBLEMS AND POSSIBLE SOLUTIONS

After the initial data is gathered, the process of identifying the main problems in the heating system can begin.

Most common issues range from high heat losses (>15…20 %) from the distributing system to the decreasing numbers in population. For example, in the Case Study region of Elva, the number of inhabitants (Figure 5) decreased during the period of economic downfall (Figure 6).

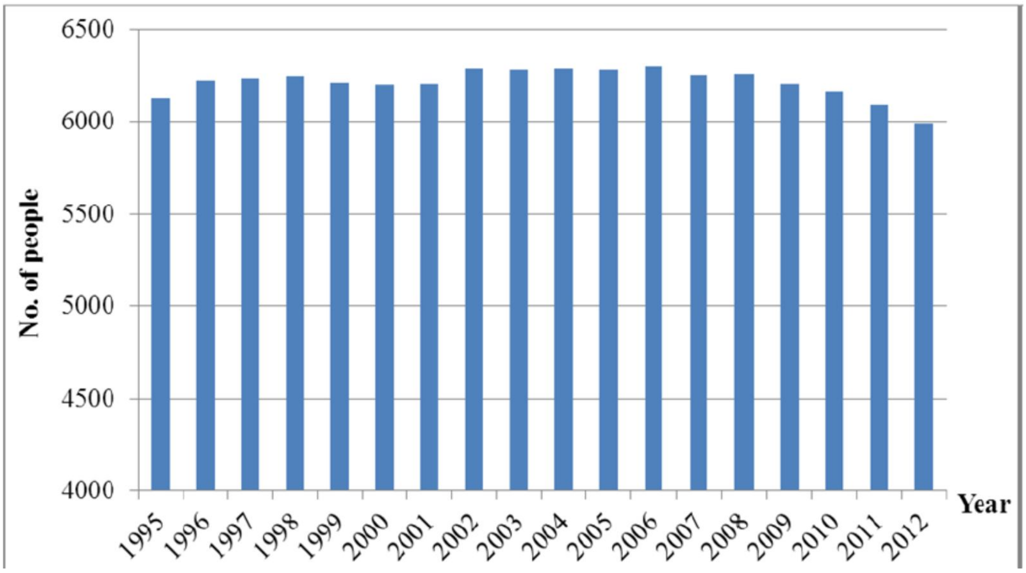

Figure 5. Number of peole living in the town of Elva during 1995…2012[4]

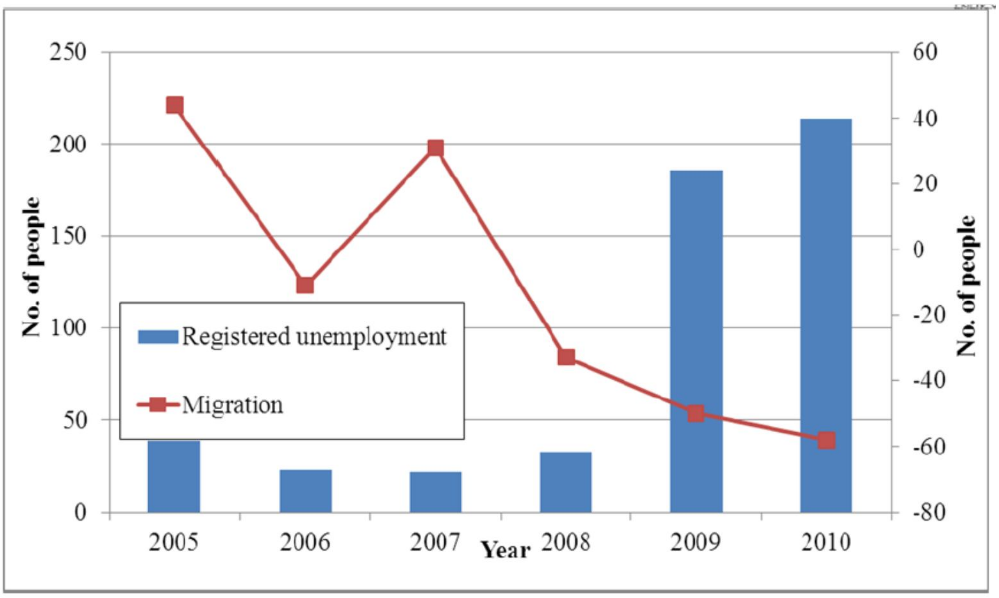

Figure 6. Balance of the registered umemployed and migrants in Elva in 2005…2010[4]

It can be assumed that one of the reasons for emigration was the rising level of unemployment. Since the price of heating plays a major role in the total household expenses, the price level of DH should be kept as lowas possible.

The price of the heat energy has become a noteworthy issue ever since the price of the "comfortable fossil fuels" has started to grow. As the prices of fossil fuels in Estonia and Latvia were relatively low until the beginning of the 21st century, Sweden has had a head start in converting from fossil fuels to biofuels.

Since the price of woodfuels does not follow the market fluctuations as severely as the price of fossil fuels, converting a local boiler house to burn woodfuels is one of the main possibilities to solve price-related issues.

Of course, converting to woodfuels requires and availability of woody biomass in the maximal distance of 100…150 km, which should not be a problem in the regions covered by the Case Studies.

Renovations in the DH network don't always lead to improvements. Especially since the long-term climate and energy policy of the EU demands for a reduction in energy consumption in the housing sector. For that several support mechanisms and funding schemes have been implemented.

For example, in the Case Study of Elva, a 40% heat energy reduction was assumed to occur by the year 2025 in both residential and public sector buildings due to different energy saving measures and renovations. An additional 10% reduction was presumed to happen in the industrial and trade sector buildings. A reduction in the energy consumption causes the heat losses to have a larger proportion of the total energy production. This might lead to a rise in the price of heat energy, rendering the gain received by the renovations down to zero.

An example of setting a "benchmark" in specific heat consumption, from which to be guided by when planning modifications in the DH system, is given in Figure 7.

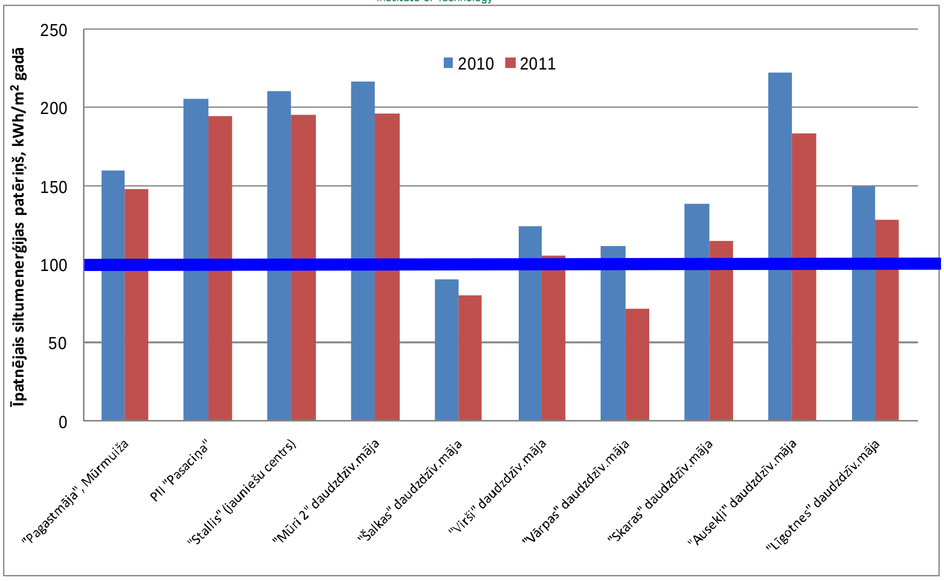

Figure 7. Specific heat energy consumption benchmark in the future[3]

For solving the problems with high heat losses from the distributing network, the raising energy efficiency has to be taken into consideration!

It has to be noted that centralised heating systems aren't always sustainable. Producing heat in one boilerhouse might seem easier and more cost-efficient, but in many cases the distance of the consumers will cause higher losses from the distribution network. For example for the small town of Elva (which has 3 different DH networks) it was calculated, that connecting the DH networks will not be feasible even when a CHP unit will be built.

For the town of Alūksne, the centralisation project that has already been approved, was found to be too risky, because of the extensive costs of replacing 4 boilerhouses with just one. In that project, a CHP unit was not considered though.

4 FUTURE PERSPECTIVES

As was mentioned in the previous chapter, the reduction in the total heat demand will become one of the main issues to deal with in the DH networks. One of the possibilities to solve this issue is finding new consumers and/or constructing a CHP plant for generating revenue from producing heat as well as electrical energy.

Since connecting private houses is considered to be too costly, at least in Estonia and in Latvia, co-operation with industries might be the solution.

In the Case Study of Kisa region the benefits of energy co-operation between a local energy supplier and industries in a Swedish municipal energy system, were analysed. The results of the study revealed that the Kisa municipality could, using energy co-operation between utility and nearby industries and a new CHP plant, can convert up to 10.6 GWh/year of fossil fuel derived heat energy to biomass-based energy. The expansion of biomass utilization to 100 GWh/year provides the possibility to increase the electricity generation with approximately 29 GWh annually in the municipality of Kisa[5] (Figure 8).

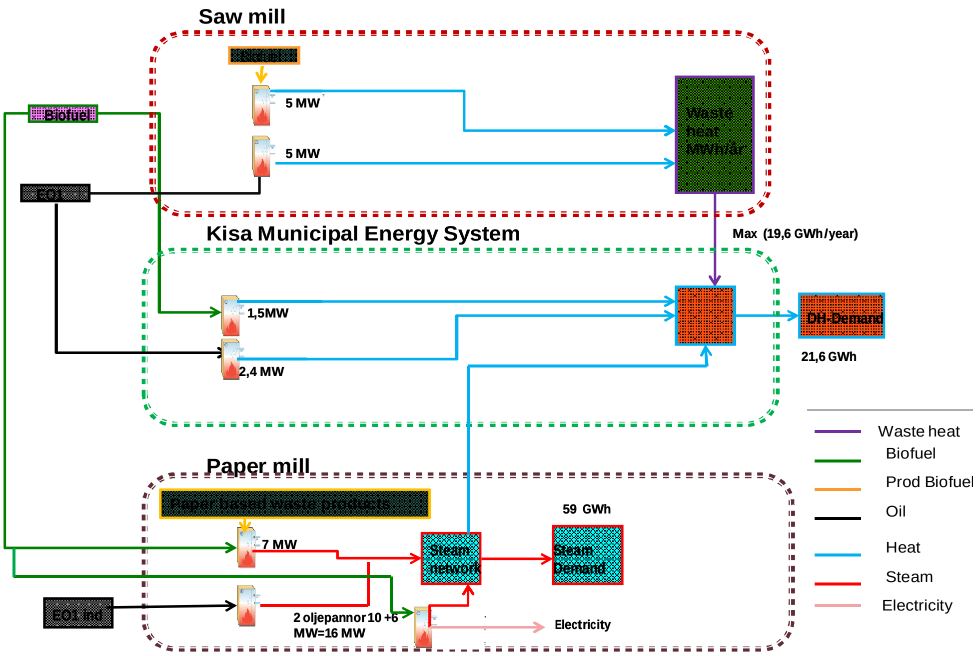

Figure 8. Simplified and aggregated scheme of the structure for the MODEST model of analysed district heating system with possible energy co-operation with nearby industries[5]

In the town of Elva, the number of companies showing interest in connecting with the DH network has been rising ever since the prices of fossil fuels have started to rise annually. It has to be noted that the investment costs have to be thoroughly considered. For the town of Elva, connecting the new consumer means building a relatively long pipeline (Figure 9).

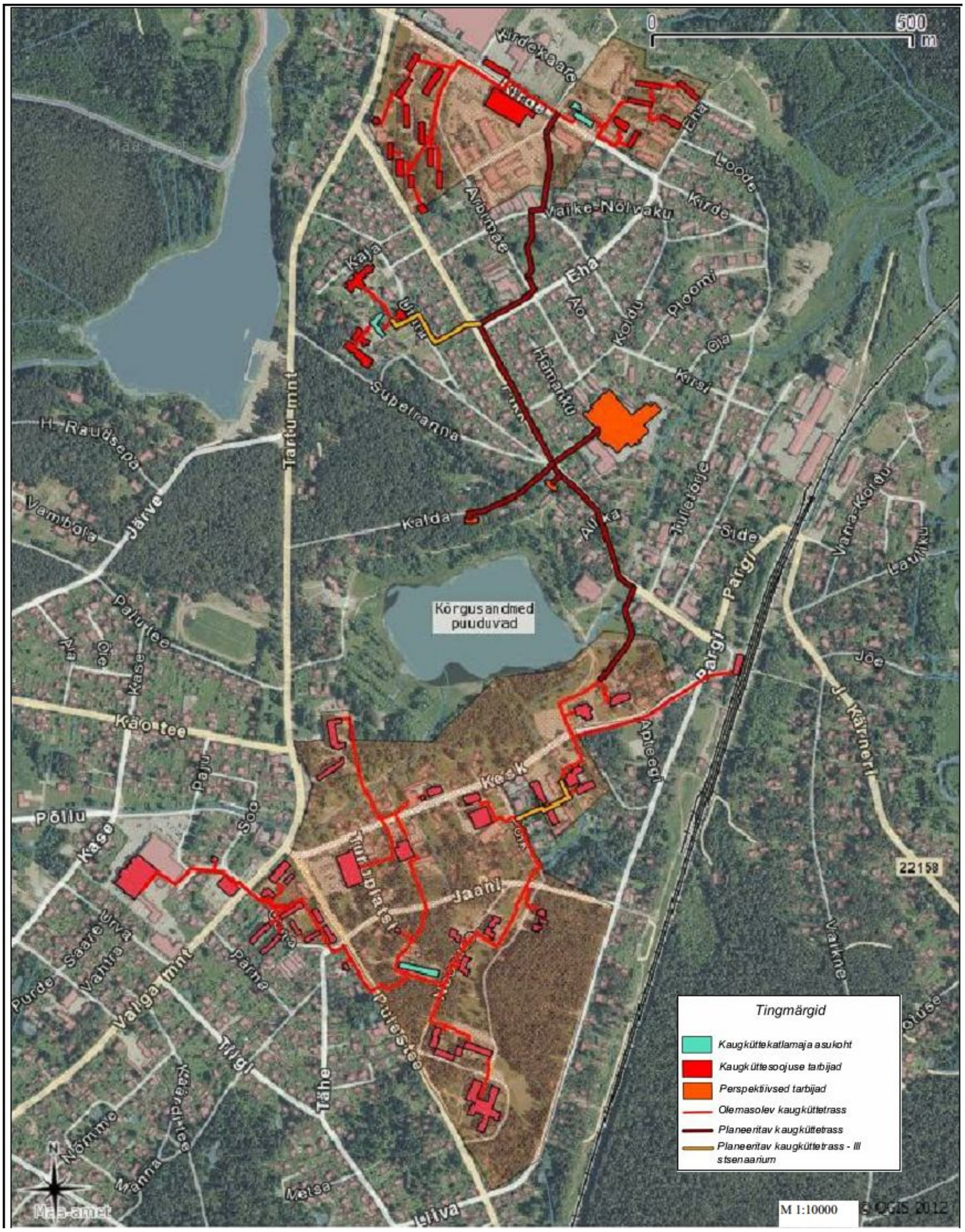

Figure 9. The DH network in the town of Elva. The perspective pipeline and consumers are shown by yellow, dark red and orange respectively[4]

5 ENVIRONMENTAL IMPACT

With the so called 20-20-20 targets, the European Union set goals for reducing greenhouse gas emissions by 20%. For setting goals beyond the year 2020, EU has prepared an energy strategy for 2050, which assumes a 80…95% reduction in CO_2 emissions.

Since woodfuels are considered to be carbon neutral (a growing tree is assumed to absorb as much carbon as it releases when brunt), using wood as an energy source will gradually (as the CO_2 emission quotas will be gradually lowered and taxed) become more important.

Therefore, when planning for modernization of the DH system, it is crucial to take environmental aspects into consideration. For the Case Study of Elva, the environmental impact of switching from fossil fuels to biofuels was thoroughly analysed[7]. The conclusions are summarised in the following table (Table 1).

Table 1. Pollutant emissions from the boiler plants in Elva.

	Business as Usual		CHP plant
Pollutant	**Total emissions (t/y) SHALE OIL**	**Total emissions (t/y) WOODCHIPS**	**Total emissions (t/y) CHP**
NO_x	9,499	6,391	**11,69**
Particles (PM SUM)	6,333	**15,038**	5,028
CO	6,333	**62,3**	39,986
SO_2	**25,968**	1,091	0,9
VOC COM	0,069	2,956	**3,142**
CO_2	**4851**	83,639	22,135
Heavy metals	**25**	7,5 kg/a	9,2 kg/a

In the table above, total emissions from the two major boiler houses in Elva are described. The current situation (Woodchips) is compared with the theoretical shale oil usage and CHP plant scenarios. As can be seen, the amount of CO_2 emissions is much lower in cases of woodfuels usage. In case of CHP plant construction, the CO_2 emissions could be further reduced by the reduction in shale oil usage during peak loads[4].

Taxation of CO_2 emissions is just one of the measures to reduce emissions. In Sweden (2011) electricity consumers were required to buy certificates corresponding to 17.9 % of their electricity use. The price of certificates depended on the interaction of supply and demand on a competitive market. Several factors affect the price levels, such as the expected demand for

[7] OÜ Hendrikson & Ko. Case Study of Elva Heat Sector. Environmental and Economic Aspects. 2012.

electricity. If the market is expecting, for example, a shortage of electricity, then the price of certificates will rise and vice versa[5].

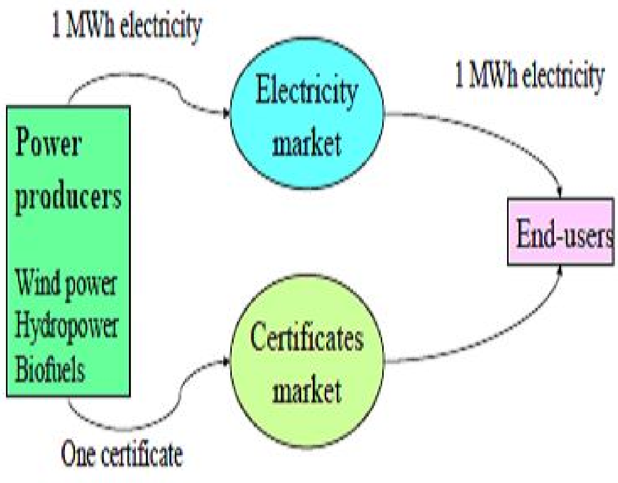

Figure 10. Simplified view of the Green Electricity certificate system in Sweden[5]

The following reference values should be noted:

a) In Sweden - 1 GWh electricity = 974 tonne CO_2 emissions;
b) In Estonia – 1 GWh electricity = 980 tonne CO_2 emissions;

From these values, primary potential environmental gains from electricity production can be calculated.

CONCLUSIONS

As the price of fossil fuel-derived heat energy has been constantly rising due to the prices of fossil fuels and the environmental taxes, some consideration should be made to the total efficiency and fuel usage of any heating system.

Before planning new investments for a DH system the following aspects should be considered:

- the spatial dispersion of the consumers and their distance from the boiler house;
- demographic tendencies;
- change of energy efficiency of end users in time;
- social benefits system;
- the service level of heat supply and involved stakeholders;
- environmental benefits.

For that an analysis of the DH network (distribution pipeline, consumers, boiler house) has to be made. An essential part of the analysis is on the available data, which could be gathered aggregately for each hour (MWh/h), month (MWh/month) or for the whole year (MWh/year). For better results, at least 3…5 years worth of data should be available.

The analysis could be made by utilizing relevant formulas in an Excel sheet or by using specially made programs (MODEST, PowerPlan, RETScreen, EnergyPlan). It has to be noted that some of these programs aren’t freely available and might need expert knowledge to operate them.

The results of the analysis may not always be comfortable – a centralised heating system isn’t always feasible and therefore local heating might be needed, but in the long run, wellthought through actions will be beneficial for the whole region.