A follow up visit of Finnish experts to Slovenia

Woodheat solutions – IEE/07/726/SI2.499568

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Authors: Jyrki Raitila & Veli-Pekka Heiskanen. A follow up visit of Finnish experts to Slovenia. Wood heat Solutions Project Report 10/2009, Project IEE/07/726/SI2.499568. Jyväskylä, Finland, July 2010, pages.

Keywords Woodheat, entrepreneurship, district heating

Abstract

Finnish woodheat experts visited Slovenia in order to advice on three woodheat projects supported by the Woodheat Solutions project.

The municipality of Kozje (about 3,400 inhabitants) has initiated a project of building a biomass district heating system in the town center. The total annual heat consumption would be about 800 – 1,000 MWh. Thus the average heat consumption would be 115 kW.

Investment for a new 200 kW biomass boiler plant and 800 m new heating network was studied and compared with an option that no new boiler investment will be made. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 97 and 117 €/MWh, respectively. With an investment grant accounting for 50% of the total investment, the total costs for the biomass option would be only 79 €/MWh.

The municipality of Cerkno (about 5 000 inhabitants) is interested in building a biomass district heating system in the town center. The project is planned to be financed by the owner of the heating plant.

Investment for a new 200 kW biomass boiler plant and 800 m new heating network was studied and compared with an option that no new boiler investment will be made. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 79 and 98 €/MWh, respectively. With an investment grant accounting for 50% of the total investment costs, the total costs for the biomass option would be only 68 €/MWh.

In Šentrupert a possibility to install a small woodheat district system in the town center and building of an additional 350 kW biomass boiler with a planned biogas plant at a large prison were studied. Both investments seem very profitable. However, the biogas plant would include a CHP system which in case requires further studies for better optimization and sizing of boilers.

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General

Finnish woodheat experts from VTT visited Slovenia in order to provide their expert support to woodheat projects chosen by local project partners. These projects were/are being delivered by participants of WP2 and 5 or others made known to the project partners.

Experts gave advise to these projects on the manner new technologies can be introduced and how the economics of new wood fuel supply chains can be optimized. Also contracts to sell heat, plans to store wood fuels and development of local woodheat markets were to be reviewed. In general, by visiting potential woodheat sites and investors and woodfuel suppliers the projects were to be advanced and barriers resolved.

The project partners in each country had chosen very promising projects that have potential to develop quickly if suitable investors can be found and required permissions can be obtained. Each partner had widely informed the possibility for an expert visit through their existing network and by different activities (e.g. engagement seminars) done in previous work packages. Eventually the hosting partners together with Finnish experts chose the projects from among those that expressed interest for such a visit and that could benefit most from it.

In general, it seems there is more need to give advice to and comment on technical issues than to advice woodfuel supply chains because of a lack of experience of wood boilers and wood fuel heating systems. Woodfuel supply is often done by suppliers of round wood, and therefore their methods are usually professionally developed. On the other hand, in most cases there was a local supplier of wood fuels already. Thus different supply issues were settled unless specifically addressed in the studies. Therefore the focus of the expert visits was on technical matters like choosing a right kind of boiler, sizing it, and planning of the storage. Yet costs and necessary investments were discussed too.

Finnish experts, Mr. Veli-Pekka Heiskanen and Mr. Jyrki Raitila, visited several potential woodheat sites and agreed to advice to and/or comment on these cases as stated in the project plan. The contents of each study are based on information provided by local stakeholders and project partners. These studies reflect on what was asked for in particular. The Finnish experts also provided support for the greatest needs at this stage of each project. The detailed case studies are included in separate document files and in the appendices.

Program in Croatia and Slovenia

Slovenia and Croatia were visited during the same trip in order to save time and travel costs. The program was as follows.

Monday 31 May 2010

18:40 Arrive in Ljubljana

Drive to Hotel Antunovic in Zagreb, Croatia.

Tuesday 1 June, 2010

(Host: Mr. Tomislav Starcic)

9:00 Pick up at hotel and meeting in Zagreb with the North West Croatia Energy Agency (Mr. Julije Domac and Mr. Velimir Segon, REGEA)

13:00 Visit Promming Ltd. and their woodheat project at Cakovec (Mr. Mihalj Novinscak, Mr. Tomislav Kralj, Promming Ltd.)

17:00 Visit Spa Sv. Martin (Mr. Tomislav Kralj, Promming Ltd., Mr. Sasa Gasparlin, Drvotrade Ltd.)

Stay over night at Sv. Martin

Wednesday 2 June, 2010

(Host: Mr. Tomislav Starcic, Croatia; Ms. Nike Krajnc, Slovenia)

9:00 Visit Lepoglava (project site: a large prison + municipal buildings) (Mr. Damjan Zupanic, Council of Lepoglava, Mr. Miljenko Zupanic, Croatian Forest Institute)

12:00 Border crossing at Dobovec, Slovenia, meet with Slovenian host

14:00 Meet with potential investors in Kozje (Mr. Andrej Kocman, Mayor, Mr. Damjan Čokec, Municipality of Kozje, Spatial and Environment sector, Mr. Janez Veržun, investor)

19:00 Arrive in Ljubljana

Stay over night at hotel Pri-Mraku

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Thursday 3 June, 2010

(Host: Mr. Tine Premrl)

9:00 Depart from Ljubljana to Cerkno

11:00 Meeting with potential investors in Cerkno (district heating system) (Mr. Jurij Kavčič, Mayor)

16:00 Arrive in Ljubljana at hotel Pri-Mraku

Friday 4 June, 2010

12:05 Depart to Finland

Another visit to Slovenia (in connection to a project meeting in Croatia)

Tuesday 9 November, 2010

(Host: Tine Premrl)

11:00 Arrive in Ljubljana

13:00 Meeting in Šentrupert with mayor Mr. Rupert Gole and Mr. Iztok Kovacic from the municipality of Šentrupert

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Summary of the visit to Slovenia

The expert visit to Slovenia revealed that there are some good examples of installed modern woodheat systems in Slovenia. Yet district heating is not very common in the country. Most wood heating is done is in domestic buildings with wood logs. However, our Slovenian partners had chosen good cases to be advised on because all of them were developed enough to have concrete plans to build on. Therefore it was possible to have fruitful discussions with potential investors and users of woodheat on one hand, and receive relevant background information from municipal and regional authorities on the other. Comments given and preliminary techno-economic assessments of the biomass utilization options done were based on these visits and materials provided by project partners and people involved in each woodheat case.

Figure 1: The advised woodheat sites in Slovenia. Map: Google.

Kozje

The municipality of Kozje (about 3,400 inhabitants) has initiated a project of building a biomass district heating system in the town center. The project is planned to be financed by the heating plant's owner and operator, who may get a grant for the investment accounting for 50% of the investment costs, however not more than 200,000 €. The project is currently in a planning stage.

The main customers of woodhea tare listed in the study. The total annual heat consumption would be about 800 – 1,000 MWh. Thus the average heat consumption would be 115 kW (calculated according to 1,000 MWh annual consumption) and the annual fuel input should be 1,300 MWh. The suggested owner and operator of the plant has calculated that the required amount of biomass would be available from the surroundings of Kozje for a price 15 – 16 €/loose-m^3. He would be responsible for supplying wood fuel too.

Investment for a new 200 kW biomass boiler plant and 800 m new heating network was studied and compared with an option that no new boiler investment will be made but the heating energy will be

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produced with the existing oil boilers. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 97 and 117 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 79 €/MWh. All in all, the investment for the biomass plant seems very profitable.

Cerkno

The municipality of Cerkno (about 5 000 inhabitants) is interested in building a biomass district heating system in the town center. The project is planned to be financed by the owner of the heating plant who may get a grant for the investment accounting for 50% of the investment costs, however not more than 200,000 €. The project is currently at a planning stage.

The main customers of woodhea tare listed in the study. A new sports center will be constructed by the school. Poor insulation of the school will also be improved. The total energy consumption of these buildings will be 550 MWh after that. The existing kindergarten will be partially replaced with a new one. The energy consumption of the kindergarten after the construction of the new section will be 230 MWh. The total annual heat consumption of all the connected users will be about 1,200 MWh. Thus the average heat consumption would be 135 kW. This includes also the summer months when only hot water is needed. Then the annual fuel input would be 1,600 MWh. It is assumed that the required amount of biomass would be available from the surroundings of Cerkno for a price of 18 – 25 €/loose-m^3.

Investment for a new 250 kW biomass boiler plant and 200 m new heating network was studied and compared with an option that no new boiler investment will be made but the heating energy will be produced with the existing oil boilers. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 79 and 98 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 68 €/MWh. All in all, the investment for the biomass plant seems very profitable.

Šentrupert

The municipality of Šentrupert is interested in building a biomass district heating system in the town center. This system would include two boilerhouses and a district heating network connecting two areas around the boilers. 5,000 m^2 of land has been zoned for a large community center that would include for example a public library and an old people's home. Because of this plan, an

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additional boilerhouse has to be built on top of the 320 kW boiler that is being built to provide heat for a school and residential buildings. The town center project is currently at a planning stage.

There is also the largest prison of Slovenia in the town of Sentrupert. The prison holds 14 ha of agricultural land and good farming facilities. farming produces a lot of agricultural residues that can be used for energy. Therefore the municipal council has plans to install a CHP biogas plant to provide heat for the prison and power to be sold to the local grid. However, it is estimated that an additional wood fired boiler is needed so that all energy could be generated from renewable sources and thus old oil based heating system could be replaced.

An investment for a new 150 kW biomass boiler plant with a 250 kW oil boiler back up and 800 m new heating network was studied and compared with an option that the heating energy will be produced with a new oil boiler only. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 97 and 125 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 75 €/MWh.

An investment for an additional 350 kW biomass boiler without any new heating network was studied and compared with an option that the heating energy will be produced with an existing oil boiler only. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 60 and 88 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 48 €/MWh. All in all, the investment for both biomass plants seem very profitable.

Because the original investment plan included the installation of a CHP system at the prison, it would be very interesting to do a sensitivity analysis with regard to power generation during the year. By optimizing the power production first, the sizing of the additional biomass heating plant would be easier and more realistic. However, such calculations require more information and are time consuming, and by nature are beyond the scope of this project.

Appendices (Woodheat projects)

CASE KOZJE IN SLOVENIA

Backgound

This study is part of an IEE (Intelligent Energy Europe) project called Woodheat Solutions (IEE/07/726/SI2.499568). Woodheat Solutions (WhS) aims to inspire investment in wood-based heat (and CHP) generation particularly from undermanaged forest. The project plans to transfer best practice from experienced EU Member States, namely Finland and Austria, through demonstration of case studies, training, engagement events and one to one support. The project will establish a network for long-term co-operation on biomass energy, offering tools and support that can be applied across the EU.

The municipality of Kozje (about 3,400 inhabitants) has initiated a project of building a biomass district heating system in the town center. The project is currently in a planning stage.

The project is planned to be financed by the heating plant's owner and operator, who may get a grant for the investment accounting for 50% of the investment costs, however not more than 200,000 €.

Main district heat users are listed in Table 1. The total annual heat consumption is about 800 – 1,000 MWh. Thus **the average heat consumption** would be 115 **kW** (calculated according to 1,000 MWh annual consumption).

Assuming that boiler and network losses are 18 and 8%, respectively**, the annual fuel input** should be 1,000/0.88/0.92 = **1,300 MWh**

Fuel availability and costs

The suggested owner and operator of the plant has calculated that the required amount of biomass would be available from the surroundings of Kozje for a price 15 – 16 €/loose-m^3. Assuming that the heat value is 0.9 MWh/loose-m^3, **the fuel costs** as received at the plant would be **17.8 €/MWh** (calculated according to 16 €/loose-m^3). The price of heating oil is **70 €/MWh.**

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Table 1. Main district heat users and their annual heat consumption.

District heat user	Heat consumption, MWh/year
Municipality building	51
School	261
Kindergarten	95
Building of Kozjausko natural park	400 – 600 for these six users together
New shopping center	
New industrial park	
Local health center	
Block of apartments	
New sports center	
Total	~ 800 – 1,000

<u>Preliminary techno-economic assessment</u>

Figure 1 shows how many hours a year the heat consumption is higher than any selected value of the consumption throughout the year. Figure 1 is valid for the heating and hot water production in the climate of southern Finland, where heating season is normally about 7 months. However, it can be employed with relatively good accuracy in the following calculations. As an example, Figure 1 shows, that the consumption is higher than 60% of its maximum during about 1,300 hours. Or correspondingly, the consumption is higher than 40% of the maximum about 3,800 hours. Figure 1 can be used to calculate the peak consumption if annual total and average energy consumption are known. The surface area under any selected period of time represents energy consumption during that particular period of time. The average annual energy consumption can be calculated by integrating the whole curve and dividing it with the number of hours in one year (8,760 h). This

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integration yields 38% of the peak consumption as annual average consumption. Since the average consumption was already calculated and is 115 kW, **the peak consumption** is 115/0.38 = **300 kW.** Since the efficiency of the district heating system is 92%, **the peak load of the boiler** is 300/0.92 = **325 kW,** and **the maximum fuel input** 325/0.82 **= 400 kW.**

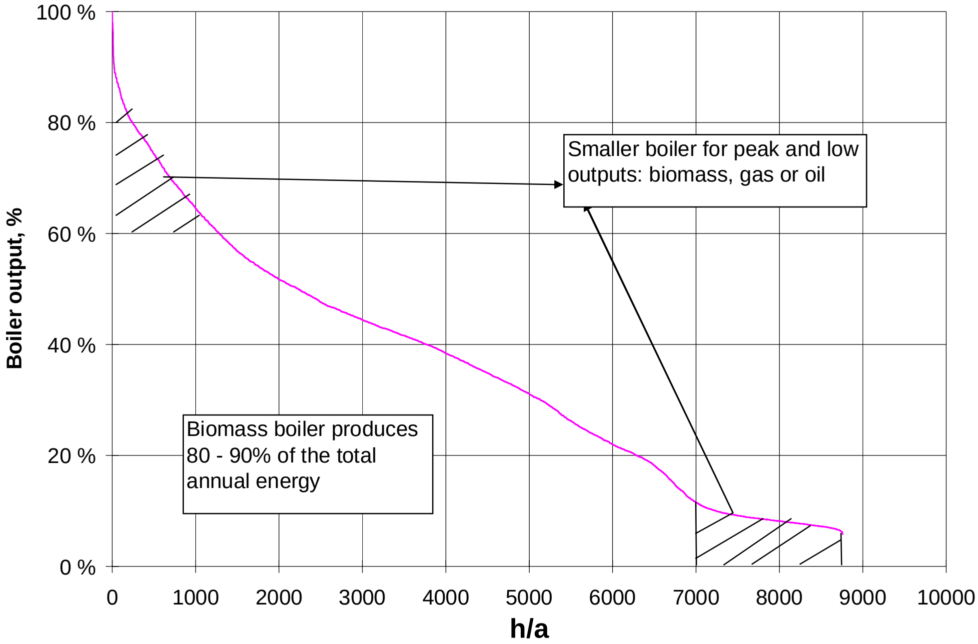

Figure 1. Heat consumption as a function of cumulative operating hours.

The size of the boiler is reasonable to choose to be clearly less than the peak load of the year. Firstly, the boilers normally do not work properly if the load is less than 20% of its maximum output, and consequently another boiler should be in use for such loads. Secondly, the investment cost will be significantly lower. Figure 1 shows also an example when boiler's maximum output has been selected to be 60% of the boiler's peak load. In this case, if the required maximum peak load of the boiler plant would be 325 kW as mentioned, **the biomass boiler's maximum output** should be selected to correspond to 0.6 * 325 kW **=** 195 kW**,** say **200 kW**. The line-filled areas in Figure 1 represent the annual amount of energy that has to be produced using back-up boiler or other means. That amount is normally only 10 – 20 % of the total, as indicated in Figure 1. An oil boiler for instance can be used for that purpose. In this case, oil boiler's capacity should be at least 325 – 200 = 125 kW. Public buildings of Kozje have their individual existing oil boilers, which are still in reasonable condition and their total capacity is obviously much higher than the required 125 kW. Therefore, there is no immediate need for investment to new oil boilers.

The before-mentioned concept is widely in use in Finland, and Figure 1 is valid for the heating and hot water production in the climate of southern Finland, where the heating season is normally about 7 months and additional 5 months for hot water production only. It can be employed with relatively good accuracy in the following calculations.

Annual fuel input was calculated to be 1,235 MWh. Assuming that heating oil accounts for 15% of the fuel input, **The annual fuel costs** are therefore 0.85 * 1,300 * 17.8 + 0.15 * 1,300 * 70 = **33,300 €**.

According to the discussions with the project owners in Kozje (2 June 2010), the need for **the new district heating network** is 800 m. Estimated costs for that are **160,000 €**.

Investment costs for **the new 200 kW boiler** including fuel storage, foundation, building, unloading and conveyors are according to discussions with boiler manufacturers about **110,000 €**. **Total investment costs** would be therefore **270,0000 €**.

Following parameters has been used in annual costs calculations:

- Share of biomass and oil in annual energy use are 85 and 15%, respectively
- Interest rate is 5%
- Investments will be paid in 10 years
- Annual labour costs have been calculated according to 1.0 man year for the biomass boiler and 0.2 man year for the oil boiler(s)
- Labour costs 1,200 €/person/month
- Maintenance costs correspond to 2% of the boiler plant and network investment, and 4 months labour per year
- Fuel prices: biomass 17.8 €/MWh, fuel oil 70.0 €/MWh,
- Losses: bioboiler 18%, oil boiler 10% and heating network 8%
- Total cost as energy supplied to the customers without taxes and profit

The annual costs are shown in Table 1. Third column shows a comparison, if the existing oil boilers would be used and only heating network would be invested and used with the existing boilers.

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Table 1. Annual energy costs.

Costs, €/year	**Biomass boiler plant:** **biomass 85%, fuel oil 15%**	**Oil boiler plant:** **Fuel oil 100%**
Investment	**35,000**	**20,700**
Labour	**16,800**	**2,900**
Fuel	**33,300**	**86,500**
Maintenance and service	**10,200**	**6,100**
Electricity	**1,300**	**500**
Total	**97,000**	**116,700**
Cost, €/MWh	**97**	**117**

Table 1 indicates that biomass boiler plant could supply heat at a significantly lower cost than oil-based system. It does not include the investment grant. If the investment grant could cover 50% of the whole investment 270,000 € (= 135,000 €), the annual total costs for the biomass boiler plant option would be only **79,000 € (79 €/MWh)**.

Conclusions

Investment for a new 200 kW biomass boiler plant and 800 m new heating network was studied and compared with an option that no new boiler investment will be made but the heating energy will be produced with the existing oil boilers. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 97 and 117 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 79 €/MWh. All in all, the investment for the biomass plant seems very profitable.

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20.11. 2010 Jyväskylä

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CASE CERKNO IN SLOVENIA

Backgound

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The municipality of Cerkno (about 5 000 inhabitants) is interested in building a biomass district heating system in the town center. The project is currently at a planning stage.

The project is planned to be financed by the owner of the heating plant who may get a grant for the investment accounting for 50% of the investment costs, however not more than 200,000 €.

Main district heat users are listed in Table 1. New sports center will be constructed by the school. Poor insulation of the school will also be improved. The total energy consumption of these buildings will be 550 MWh after that. The existing kindergarten will be partially replaced with a new one. The energy consumption of the kindergarten after the construction of the new section will be 230 MWh. The total annual heat consumption of all the connected users will be about 1,200 MWh. Thus **the average heat consumption** would be **135 kW**. This also includes the summer months when only hot water is needed.

Assuming that boiler and network losses are 12 and 8%, respectively**, the annual fuel input** would be 1,200/0.82/0.92 = **1,600 MWh**

Fuel availability and costs

It is assumed that the required amount of biomass would be available from the surroundings of Cerkno for a price of 18 – 25 €/loose-m^3. Assuming that the heat value is 0.9 MWh/loose-m^3, **the fuel costs** as received at the plant would be **23.9 €/MWh** (calculated according to 21.5 €/loose-m^3). The price of heating oil is **70 €/MWh.**

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Table 1. Main district heat users and their annual heat consumption.

District heat user	Heat consumption, MWh/year
School + new sports center	550
Kindergarten	230
Music school	65
Museum	95
Guest house	70
8 apartments	200
Total	~ 1 200

Preliminary techno-economic assessment

Figure 1 shows how many hours a year the heat consumption is higher than any selected value of the consumption throughout the year. Figure 1 is valid for the heating and hot water production in the climate of southern Finland, where heating season is normally about 7 months. However, it can be employed with relatively good accuracy in the following calculations. As an example, Figure 1 shows, that the consumption is higher than 60% of its maximum during about 1,300 hours. Or correspondingly, the consumption is higher than 40% of the maximum about 3,800 hours. Figure 1 can be used to calculate the peak consumption if annual total and average energy consumption are known. The surface area under any selected period of time represents energy consumption during that particular period of time. The average annual energy consumption can be calculated by integrating the whole curve and dividing it with the number of hours in one year (8,760 h). This integration yields 38% of the peak consumption as annual average consumption. Since the average consumption was already calculated and is 135 kW, **the peak consumption** is 135/0.38 = **355 kW.** Since the efficiency of the district heating system is 92%, **the peak load of the boiler** is 355/0.92 = **385 kW,** and **the maximum fuel input** 385/0.82 **= 460 kW.**

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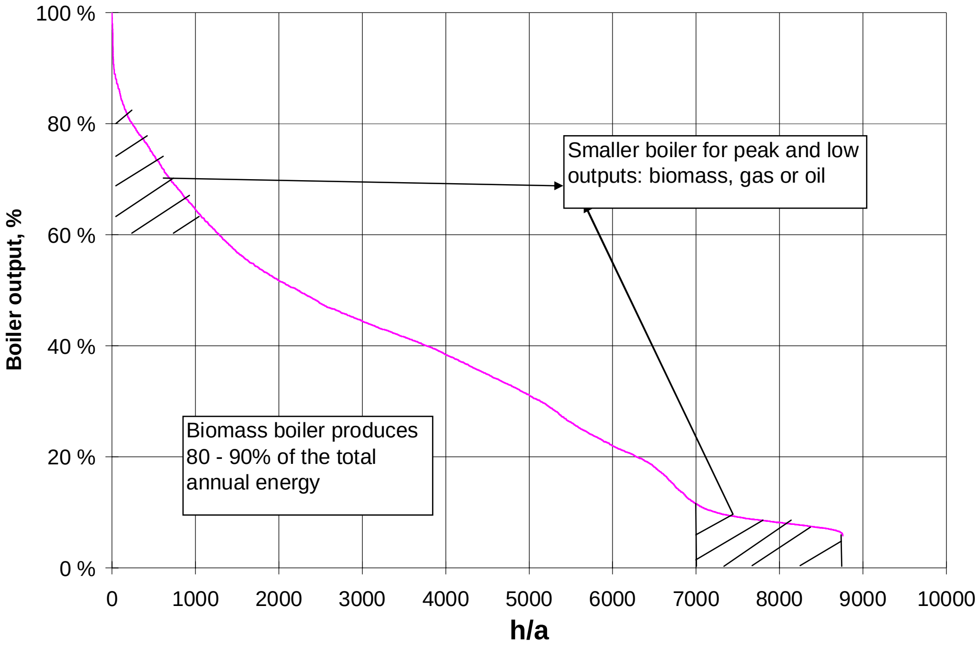

Figure 1. Heat consumption as a function of cumulative operating hours.

The size of the boiler is reasonable to choose to be clearly less than the peak load of the year. Firstly, the boilers normally do not work properly if the load is less than 20% of its maximum output, and consequently another boiler should be in use for such loads. Secondly, the investment cost will be significantly lower. Figure 1 shows also an example when boiler's maximum output has been selected to be 60% of the boiler's peak load. In this case, if the required maximum peak load of the boiler plant would be 385 kW as mentioned, **the biomass boiler's maximum output** should be selected to correspond at least to 0.6 * 385 kW **= 230 kW**, say 250 kW just to be on the safe side. The line-filled areas in Figure 1 represent the annual amount of energy that has to be produced using back-up boiler or other means. That amount is normally only 10 – 20 % of the total, as indicated in Figure 1. An oil boiler for instance can be used for that purpose. In this case, oil boiler's capacity should be at least 385 – 230 = 155 kW. Public buildings of Cerkno (school and museum) have their individual existing oil boilers. Their capacities are 500 and 300 kW. These boilers are relatively old and may need to be replaced with new ones. The following calculations have been carried out assuming that the existing boilers will not be replaced.

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Annual fuel input was calculated to be 1,480 MWh. Assuming that heating oil accounts for 15% of the fuel input, **The annual fuel costs** are therefore 0.85 * 1,600* 23.9 + 0.15 * 1,600 * 70 = **49,300 €**.

According to the discussions with the project owners in Cerkno (3 June, 2010), the need for a **new district heating network** is 200 m. Estimated costs for that is 4**0,000 € (**200 €/m**)**.

Investment costs for **the new 250 kW boiler** including fuel storage, foundation, building, unloading and conveyors are according to discussions with boiler manufacturers about **140,000 €**. **Total investment costs** would be therefore **180,0000 €**.

Following parameters have been used in annual calculations:

- Share of biomass and oil in annual energy use are 85 and 15%, respectively
- Interest rate is 5%
- Investments will be paid in 10 years
- Annual labour costs have been calculated according to 1.0 man year for the biomass boiler and 0.2 man year for the oil boiler(s)
- Labour costs 1,200 €/person/month
- Maintenance costs correspond to 2% of the boiler plant and network investment, and 4 months labour per year
- Fuel prices: biomass 23.9 €/MWh, fuel oil 70.0 €/MWh,
- Losses: bioboiler 18%, oil boiler 10% and heating network 8%
- Total cost as energy supplied to the customers without taxes and profit

The annual costs are shown in Table 1. Third column shows a comparison, if the existing oil boilers would be used and only heating network would be invested and used with the existing boilers.

Table 1 indicates that biomass boiler plant could supply heat at a significantly lower cost than oil-based system. It does not include the investment grant. If the investment grant would cover 50% of the whole investment 180,000 € (= 90,000 €), the annual total costs for the biomass boiler plant option would be only **84,000 € (68 €/MWh)**.

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Table 1. Annual energy costs if the existing oil boilers will be used.

Costs, €/year	Biomass boiler plant: biomass 85%, fuel oil 15%	Oil boiler plant: Fuel oil 100%
Investment	**23 300**	**5 200**
Labour	**14 400**	**2 900**
Fuel	**49 300**	**103 700**
Maintenance and service	**7 100**	**5 600**
Electricity	**1 400**	**600**
Total	**95 000**	**118 000**
Cost, €/MWh	**79**	**98**

If the fuel price at the plant would instead of 21.5 €/loose-m^3 be 18 or 25 €/loose-m^3, the energy production costs would be 73 and 83 €/MWh, respectively.

Conclusions

Investment for a new 250 kW biomass boiler plant and 200 m new heating network was studied and compared with an option that no new boiler investment will be made but the heating energy will be produced with the existing oil boilers. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 79 and 98 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 68 €/MWh. All in all, the investment for the biomass plant seems very profitable.

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31.8. 2010 Jyväskylä

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CASE ŠENTRUPERT IN SLOVENIA

Backgound

This study is part of an IEE (Intelligent Energy Europe) project called Woodheat Solutions (IEE/07/726/SI2.499568). Woodheat Solutions (WhS) aims to inspire investment in wood-based heat (and CHP) generation particularly from undermanaged forest. The project plans to transfer best practice from experienced EU Member States, namely Finland and Austria, through demonstration of case studies, training, engagement events and one-to-one support. The project will establish a network for long-term co-operation on biomass energy, offering tools and support that can be applied across the EU.

The municipality of Šentrupert is interested in building a biomass district heating system in the town center. This system would include two boilerhouses and a district heating network connecting two areas around the boilers. 5,000 m^2 of land has been zoned for a large community center that would include for example a public library and an old people's home. Because of this plan, an additional boilerhouse has to be built on top of the 320 kW boiler that is being built to provide heat for a school and residential buildings. The town center project is currently at a planning stage.

There is also the largest prison of Slovenia in the town of Sentrupert. The prison holds 14 ha of agricultural land and good farming facilities. It used to produce most of food stuff for all prisons in Slovenia. Active farming can still produce substantial amounts of grain, vegetables and meat. On top of this, farming produces a lot of agricultural residues that can be used for energy. Therefore the municipal council has plans to

Figure 2: Šentrupert prison. Photo: Jyrki Raitila.

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install a CHP biogas plant to provide heat for the prison and power to be sold to the local grid. However, it is estimated that an additional wood fired boiler is needed so that all energy could be generated from renewable sources and thus old oil based heating system could be replaced.

The projects are planned to be financed by the owner of the heating plant who may get a grant for the investment in a biomass heating system accounting for 50% of the investment costs, however not more than 200,000 €.

Fuel availability and costs

According to a regional inventory, there is about 100,000m^3 increment in the growing stock of the forests in the region. About 30,000 m^3 of wood could be used for energy within 15 km from the town center. Local entrepreneurs could deliver fuel wood at a price of 15 €/loose-m^3. Assuming that the heat value is 0.9 MWh/loose-m^3, **the fuel costs** as received at the plant would be **16.7 €/MWh**. As a comparison, the price of heating oil is **70 €/MWh.** It can be concluded that there is plenty of wood fuel available at a very reasonable cost.

Preliminary techno-economic assessment of a woodheat system in the town center

Main district heat users of the town center are listed in Table 1. The total energy consumption of these new buildings is estimated to be 600-700 MWh. This estimation is based on information about similar buildings studied with other cases of the Woodheat Solutions project. Assuming that boiler and network losses are 18 and 8%, respectively**, the annual fuel input** would be 700/0.82/0.92 = **930 MWh**

Table 1. Main district heat users and their annual heat consumption.

District heat user	Heat consumption, MWh/year
Community center including library, old people's home and community house	600-700 MWh

Figure 1 shows how many hours a year the heat consumption is higher than any selected value of the consumption throughout the year. Figure 1 is valid for the heating and hot water production in the climate of southern Finland, where heating season is normally about 7 months. However, it can

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be employed with a relatively good accuracy in the following calculations. As an example, Figure 1 shows, that the consumption is higher than 60% of its maximum during about 1,300 hours. Or correspondingly, the consumption is higher than 40% of the maximum about 3,700 hours. Figure 1 can be used to calculate the peak consumption if annual total and average energy consumption are known. The surface area under any selected period of time represents energy consumption during that particular period of time. The average annual energy consumption can be calculated by integrating the whole curve and dividing it with the number of hours in one year (8,760 h). This integration yields 37 % of the peak consumption as annual average consumption. The average consumption can be calculated by dividing the total energy consumption with the total number of hours in one year; 700,000 kWh/8,760h = 80 kW. Having calculated this, **the peak consumption** is 80/0.37 = **220 kW.** Since the efficiency of the district heating system is 92%, **the peak load of the boiler** is 220/0.92 = **240 kW,** and **the maximum fuel input** 240/0.82 **= 293 kW.**

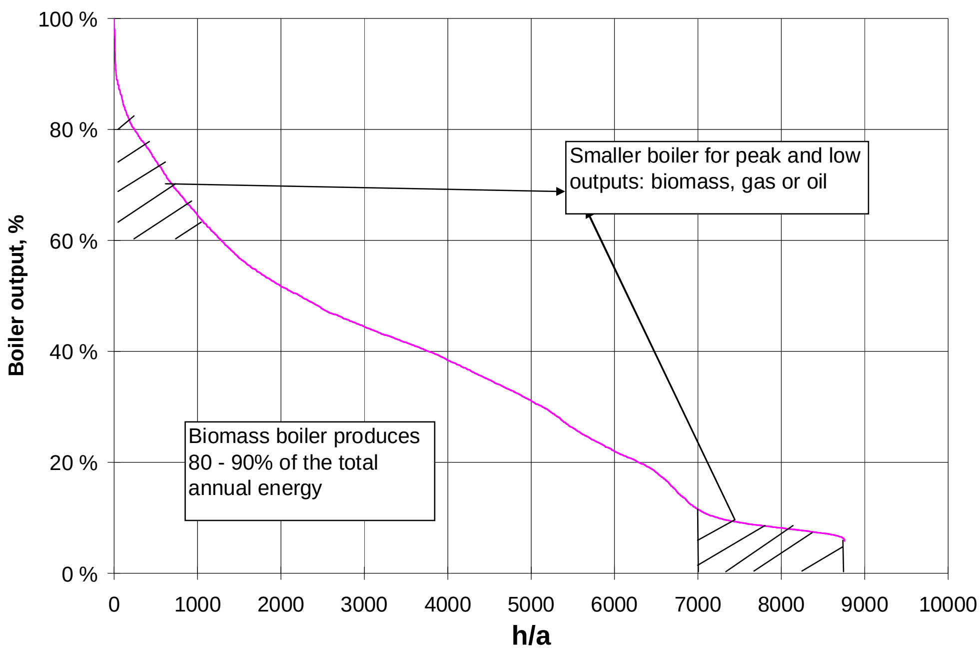

Figure 1. Heat consumption as a function of cumulative operating hours.

The size of the boiler is reasonable to choose to be clearly less than the peak load of the year. Firstly, the boilers normally do not work properly if the load is less than 20 % of its maximum output, and consequently another boiler should be in use for such loads. Secondly, the investment cost will be significantly lower. Figure 1 shows also an example when the maximum output of the boiler has been selected to be 60% of the boiler's peak load. In this case, if the required maximum peak load of the boiler is 240 kW as mentioned, **the maximum output** of the **biomass boiler** should be selected to correspond at least to 0.6 * 240 kW **= 150 kW**. The line-filled areas in Figure 1 represent the annual amount of energy that has to be produced using back-up boiler or other means. That amount is normally only 5 – 15 % of the total, as indicated in Figure 1. An oil boiler for instance can be used for that purpose. In this case, the capacity of such an oil boiler should be at least 240 – 150 = 90 kW.

Because the community center is just in a planning stage, the demand for heating energy and sizing of the boiler can also be calculated according to the cubic content, which is estimated to be about 10,000 m^3. About 20 W of boiler output for each m^3 is usually needed in new buildings to provide for the peak demand of heat. On top of this, there should be output capacity for heating water. On average it would be another 30-40 kW in this situation. Again if the biomass boiler is supposed to cover about 60% of the peak energy load, a 150 kW boiler should be sufficient ((200 kW+40 kW)*0.60=150 kW).

It is also recommended that an hot water accumulation tank would be included in the heating system because it is likely to have peaks in hot water consumption. The size of such a thermal store should be at least 1,500 liters, much depending on how much water will be consumed for example in the old people's home. Because the whole heating system needs a back-up, it is necessary to install also a new oil boiler that can back-up the whole network. Its capacity has to be therefore at least 250 kW.

Annual fuel input was calculated to be 930 MWh. Assuming that heating oil accounts for 10% of the fuel input, **the annual fuel costs** will therefore be 0.90 * 930 * 16.7 + 0.10 * 930 * 70 = **20,500 €**.

According to the discussions with the mayor of Sentrupert, the need for a **new district heating main** is 800 m. Estimated cost for that is **160,000 € (**200 €/m**)**.

Investment costs for **a 140 kW boiler** including the fuel storage, foundation, building, hot water accumulator, unloading and conveyor systems are according to discussions with boiler manufacturers about **90,000 €**. In addition, investment costs for an **oil fired boiler** are about **10,000 €**. **Total investment costs** would be therefore **260,0000 €**.

Following parameters have been used in annual calculations:

- Share of biomass and oil in annual energy use are 90 and 10%, respectively
- Interest rate is 3 %
- Investments will be paid in 10 years

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- Annual labour (operating) costs have been calculated according to 0.5 man year for the biomass boiler and 0.1 man year for the oil boiler

- Labour costs 1,200 €/person/month

- Maintenance costs correspond to 2% of the boiler plant and network investment, and 2 months labour per year

- Fuel prices: biomass 16.7 €/MWh, fuel oil 70.0 €/MWh,

- Losses: bioboiler 18%, oil boiler 10% and heating network 8%

- Total cost as energy supplied to the customers without taxes and profit

The annual costs are shown in Table 2. The third column shows a comparison, if only an oil boiler and heating network would be invested in and used for heating the Community center.

Table 2 indicates that biomass boiler plant could supply heat at a significantly lower cost than oil-based system. It does not include the investment grant. If the investment grant would cover 50% of the wood fired boiler investment 250,000 € (= 125,000 €), the annual total costs for the biomass boiler plant option would be only **51,000 € (75 €/MWh)**.

Table 2. Comparison of annual energy costs of new biomass and oil boiler plants.

Costs, €/year	Biomass boiler plant: Biomass 90%, fuel oil 10%	Oil boiler plant: Fuel oil 100%
Investment	**30,500**	**20,000**
Labour (operation)	**8,500**	**1,400**
Fuel	**23,400**	**61,200**
Maintenance and service	**6,700**	**5,800**
Electricity	**1,300**	**400**
Total	**67,400**	**88,700**
Cost, €/MWh	**97**	**125**

Conclusions

An investment for a new 150 kW biomass boiler plant with a 250 kW oil boiler back up and 800 m new heating network was studied and compared with an option that the heating energy will be produced with a new oil boiler only. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 97 and 125 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 75 €/MWh. All in all, the investment for the biomass plant seems very profitable.

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Preliminary techno-economic assessment of a woodheat system at the prison Dob

A Slovenian engineering company did a pre-feasibility study of building a biogas plant at the prison Dob. According to this study a $1MW_{el}$ (0.99) biogas plant would be feasible. This plant could produce 7,980 MWh power and 8,380 of heat. The total need for heat energy for heating and hot water is 6,063 (based on consumption in 2009), of which 4,296 MWh could be got from the biogas plant. The rest 1,767 MWh should be produced in another biomass heating plant or with the existing oil boilers (two boilers with 5MW total output). Also in this case the biomass fuel would be wood chips.

The sizing of the biomass boiler can be done in the same way as for the town center. The average consumption can be calculated by dividing the total energy demand with the total number of hours in one year; 1,767,000 kWh/8,760h = 202 kW. Having calculated this, **the peak consumption** is 202/0.38 = **530 kW.** Since the efficiency of the district heating system is 92%, **the peak load of the boiler** is 530/0.92 = **580 kW,** and **the maximum fuel input** 580/0.82 **= 700 kW.** Again to avoid oversizing the boiler, only 60 % of the peak energy load is calculated to be the nominal output of the new boiler. Thus, it would be 0.6 * 580 kW = **350 kW**. The existing oil boilers would serve as a back up and also provide for peak loads.

Annual fuel input is 1,767MWh/0.82/0.92 = 2,342 MWh. Assuming that heating oil accounts for 10% of the fuel input, **the annual fuel costs** will therefore be 0.90 * 2,342 * 16.7 + 0.10 * 2,342 * 70 = **51,600 €**.

Investment costs for **a 350 kW boiler** including the fuel storage, foundation, building, hot water accumulator, unloading and conveyor systems, and installing are about **350,000 €** based on discussions with boiler manufacturers.

Following parameters have been used in annual calculations:

- Share of biomass and oil in annual energy use are 90 and 10 %, respectively
- Interest rate is 3%
- Investments will be paid in 10 years
- Annual labour (operating) costs are included in the costs of the biogas plant because the same person can take care of both plants
- Maintenance costs correspond to 2 % of the boiler plant and network investment, and 2 months labour per year

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- Labour costs: 0 €, it is assumed that the same staff taking care of the biogas plant can operate the biomass plant and/or oil boiler

- Fuel prices: biomass 16.7 €/MWh, fuel oil 70.0 €/MWh

- Losses: bioboiler 18 %, oil boiler 10 % and heating network 8 %

- Total cost as energy supplied to the customers without taxes and profit

The annual costs are shown in Table 3. The third column shows a comparison if the existing oil boilers are used to provide for the heat demand.

Table 3 indicates that biomass boiler plant could supply heat at a significantly lower cost than the oil-based system. It does not include the investment grant. If the investment grant would cover 50% of the wood fired boiler investment 350,000 € (=175,000 €), the annual total costs for the biomass boiler plant option would be only **80,000 € (48 €/MWh)**.

Table 3. Comparison of annual energy costs of new biomass plant and existing oil boilers.

Costs, €/year	**Biomass boiler plant:** **Biomass 90%, fuel oil 10%**	**Existing oil boilers:** **Fuel oil 100%**
Investment	**41,000**	
Labour (operation)		
Fuel	**52,300**	**152,700**
Maintenance and service	**8,600**	**2,400**
Electricity	**1,300**	**900**
Total	**103,000**	**156,000**
Cost, €/MWh	**60**	**88**

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Conclusions

An investment for an additional 350 kW biomass boiler without any new heating network was studied and compared with an option that the heating energy will be produced with an existing oil boiler only. This comparison showed that the total costs for heat production delivered to the customers without taxes and profit would be 60 and 88 €/MWh, respectively. In addition, if there will be an investment grant accounting for 50% of the total investment costs for the new biomass boiler plant and network, the total costs for the biomass option would be only 48 €/MWh. All in all, the investment for the biomass plant seems very profitable.

Because the original investment plan included the installation of a CHP system at the prison, it would be very interesting to do a sensitivity analysis with regard to power generation during the year. By optimizing the power production first, the sizing of the additional biomass heating plant would be easier and more realistic. However, such calculations require more information and are time consuming, and by nature are beyond the scope of this project.

15.2. 2011 Jyväskylä

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