CASE LEPOGLAVA IN CROATIA

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.

A pre-feasibility study of possibilities of installing biomass district heating and CHP systems in the town of Lepoglava was done by OKit consulting and engineering company (Zagreb) in 2007. Finnish experts visited the town and discussed different possibilities of generating heat and power from biomass. Based on the visit and the pre-feasibility study of OKit they draw conclusions of the study and suggest some viable options for further development of the project.

Fuel availability and costs

Lepoglava is in the county of Varazdin in northern Croatia which has large woodland areas. According to the Agency for the Development of the Varazdin County (AZRA), there is about 50,000 m^3 of fuelwood (including firewood) directly from forests and about 8,000 m^3 of wood residues from local wood industry annually available in the vicinity of Lepoglava (<30 km). If neighboring counties are included (Krapina-Zagorje and Zagreb), the total estimated woodfuel potential is as high as 200,000 m^3. Extensive management plans have been made and wood fuel exploitation assessment has been done for the region, as for the whole of Croatia. This assessment shows good balance with annual increment in the growing stock of forests. Wood fuel utilization plans and strategies have been made in a sound and sustainable way.

In this study it is estimated that the total maximum wood fuel demand of the plant would be 145,000 MWh equaling 46,800 tonnes (60,000 solid-m^3, 30-35 %-w) of wood chips. Thus it can be concluded that there is enough woodfuel resources available in the region. The price of wood

VTT
P.O.Box 1603
FIN - 40101 Jyväskylä
firstname.lastname@vtt.fi
Tel + 358 20 722 111

chips in the study of OKit was only 13 €/MWh. However, in this study the price of 17 MWh was used based on other studies and interviews of local experts.

Preliminary techno-economic assessment of given options for biomass boiler plant

In the OKit study it was estimated that the total highest energy demand would be about 86,000 MWh (44,000 MW_{th} and 42,000 MWh_{el}). It is assumed that the new boiler would be running at full capacity (16 MW) 8,000 h/year. It is also assumed that the boiler would work in a CHP mode for 4,600 h, and in a condensing mode for another 3,400 h, and its maximum output would be 16 MW. In the CHP use the boiler would produce 11.8 MW of heat and 4.2 MW of electricity. In the condensing mode, the boiler would generate 6 MW of electricity. The annual heat and power productions are therefore (taking into account the network losses 8%):

- Heat 4,600 * 11.8 * 0.92 = 49,900 MWh
- Electricity 4,600 * 4.2 + 3,400 * 6.0 = 39,700 MWh

On the other hand, the annual heat demand is 44,000 MWh. The variation of the heat load within a year is presented in Figure 1.

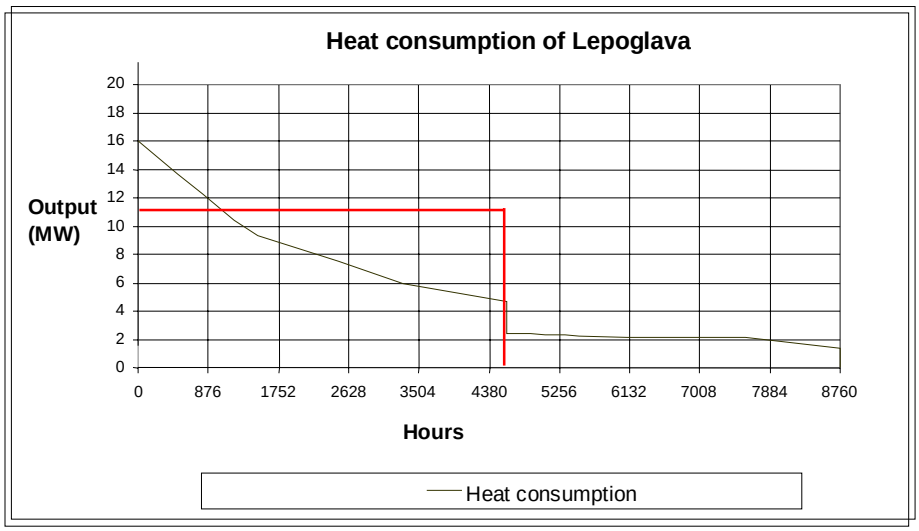

Figure 1. Heat load variation during one year.

Figure 1 indicates that if the boiler is producing heat 4,600 h/year at 11.8 MW output delivering 0.92 * 11.8 MW = 10.9 to the customers (network losses 8%), the heat load is higher than 10.9

VTT
P.O.Box 1603
FIN - 40101 Jyväskylä
firstname.lastname@vtt.fi
Tel + 358 20 722 111

MW about 1,100 h/year, and additional heat should be produced with the existing gas boilers. In addition, during the 4,160 h when the heat load (obviously only hot water and/or steam use) is about 2 MW, additional heat should also be produced with the existing gas boilers, since during that period the biomass boiler is running in the condensing mode (3,400 h) or is maintained/serviced (760 h). The required additional heat production using existing boilers can be estimated from Figure 1. When the heat load is higher than 10.9 MW, about 2,800 MWh additional heat is required. When the heat load is about 2 MW, about 8,300 MWh additional heat will be needed. All in all, about 11,100 MWh of heat has to be delivered annually using the existing boilers.

Now the annual fuel demand and costs can be calculated:

- Biomass: 16 * 8,000/0.88 = 145,000 MWh that costs 145,000 * 17 €/MWh= 2,470,000 €
- Natural gas: 11,100/0.80 = 13,900 MWh that costs 1,390,000 m^3 * 0.3 €/m^3 = 420,000 €

It has been assumed in these calculations that the boiler losses are 12% for all boilers, and the network losses are 8% of the fuel input. Total fuel costs would therefore be 2,890,000 €.

The OKit study discusses four different biomass boiler plant options:

- Biomass boiler and steam turbine
- Biomass boiler with ORC system
- Biomass gasification and gas/steam turbine (Integrated Gasification Combined Cycles)
- CHP systems with gas turbines (ENITEH)

The third and fourth options are not proven, commercial-level technologies for biomass, and will therefore be omitted. There are manufacturers of ORC systems for biomass boilers, but the biggest plants delivered so far are < 2 MW by power output. Therefore here only the first option is discussed. The biomass boiler plants total output is as mentioned 16 MW. Such boiler plants investment cost is in a range of 15 – 25 million € according to the manufacturers. Therefore 20 million € is used here as an estimate for the investment costs. Table 1 shows the total energy production costs in two options. The production costs if the new biomass boiler plant will be invested and used are compared with the existing situation (existing gas boilers used to produce heat only). Following assumptions have been used:

VTT
P.O.Box 1603
FIN - 40101 Jyväskylä
firstname.lastname@vtt.fi
Tel + 358 20 722 111

- Share of biomass and gas in annual fuel use of the first option are 91% (145,000 MWh) and 9% (13,900 MWh)
- Interest rate is 8 %
- Investments will be paid in 10 years
- Annual labour costs have been calculated according to 1.0 man year for the biomass boiler plant and 0.2 man year for the gas boiler(s)
- Labour costs 800 €/person/month
- Maintenance costs correspond to 2 % of the boiler plant investment and 4 months labour per year
- Fuel prices: biomass 17 €/MWh, gas 30 €/MWh (0.3 €/m^3)
- Losses: boilers 12% and network 8% of the fuel input
- Total cost as supplied to the customers without taxes and profit

Table 1. Annual energy production costs.

Costs, €/year	**Biomass boiler plant and existing boilers: biomass 91%, gas 9%**	**Existing boilers: gas 100% (heat/steam production only as presently)**
Investment	**2,590,000**	**0**
Labour	**13,800**	**1,800**
Fuel	**2,900,000**	**1,650,000**
Maintenance and service	**407,000**	**3,100**
Electricity	**176,000**	**42,000**
Total	**5,090,000**	**1,700,000**
Cost, €/MWh	**73**	**39**

VTT
P.O.Box 1603
FIN - 40101 Jyväskylä
firstname.lastname@vtt.fi
Tel + 358 20 722 111

When comparing the figures in Table 1, it should be noted that in the first option the total energy production (44,000 MWh of heat and 39,700 MWh of electricity) is higher than in the second option (44,000 MWh of heat only).

Finally, Table 2 compares the profits in the two options. It has been assumed that:

- Electricity generated from biomass gets an incentive of 90 €/MWh
- Heat sales price is assumed to be 60 €/MWh
- Electricity sales price without an incentive is 158 €/MWh

Table 2. Profits from energy production (new biomass plant vs. existing system).

Revenue, €/year	**Biomass boiler plant and existing gas boilers: biomass 91%, gas 9%**	**Existing gas boilers: gas 100%**
Heat sales	**2,640,000**	**2,640,000**
Electricity sales	**6,270,000**	**0**
Support/electricity	**3,570,000**	**0**
Total	**12,480,000**	**2,640,000**
Annual costs	**5,090,000**	**1,700,000**
Annual profit	**7,390,000**	**940,000**

The comparison indicates that the investment in the biomass plant is clearly more profitable than just continuing to use the existing boilers because of the high incentive for electricity generated from biomass.

VTT
P.O.Box 1603
FIN - 40101 Jyväskylä
firstname.lastname@vtt.fi
Tel + 358 20 722 111

Conclusions

Investments for a new 16 MW biomass CHP boiler plant were studied and compared with an option that no new boiler investment will be made but the heating energy will be produced with the existing gas boilers.

This study discussed only the new biomass power plant option to produce energy and compared it with the existing system and energy production. The capacity of the new boiler plant was selected to be 16 MW. The use of the plant was fixed so that 4,600 h/year the boiler plant will be working in the CHP mode, and 3,400 h/year in the condensing mode. This was based on the heat consumption curve that shows that the consumption load is between 5 and 16 MW during the mentioned 4,600 h and only about 2 MW during the rest of the year (4,160 h). This comparison showed that the investment in the biomass CHP boiler plant would be very profitable. However, a more extensive study should be made in order to find most profitable combination of the boiler capacity, annual hours of the CHP mode use and annual hours of condensing mode use. In this study these were fixed, and therefore it is possible that there could be even a more profitable concept to use. This would need optimization for these parameters. In addition, hot water production and use could be still optimized also during the period when the biomass boiler is in the condensing mode.

28.10. 2010 Jyväskylä

Jyrki Raitila
Research Scientist, M.Sc. (For.), MA
Technical Research Centre of Finland
Team Leader
Biomass Fuel Production
Tel. +358-40-7195117
Email: jyrki.raitila@vtt.fi

Veli-Pekka Heiskanen
Senior Research Scientist, Lic.Sc. (Tech.)
Technical Research Centre of Finland
Multifuel Operations
Tel. +358-40-547 8960
Email: veli-pekka.heiskanen@vtt.fi