

## **CASE HIGHFIELD SCHOOL IN ENGLAND**

### **Background**

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 practise from experinced 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.

### **Comments on feasibility study of Woodfuel Solutions**

Since for this case a detailed and meticulous feasibility study was already done, just some minor comments are presented here.

#### ***Boiler and thermal store sizing***

The biomass boiler size has been optimised to be 400 kW. On the other hand, the peak thermal demand is 575 kW. Taking into account that average heating network losses have been estimated to be about 8%, the 400 kW biomass boiler can deliver about 370 kW at maximum to the consumers. Biomass boiler's maximum output accounts thus for about 64% of the peak thermal load. This is technically very well in balance with the annual heat consumption since the hourly heat demand exceeds 370 kW only quite short periods of time. Those excess loads account for about 5 – 10% of the total annual heat demand. That is just a rough estimation based on Figure 5 in the feasibility study. On the other hand, the biomass boilers do not usually work effectively if the boiler output is less than 20% of the rated output. In this case it would mean 80 kW output from the boiler and almost 75 kW delivered to the consumers. This fits again quite well with the minimum heat demand that is the second half of July (see Fig. 5), when the heat demand is about 70 kW.

It has been estimated in the feasibility study that the biomass boiler with a 20 m<sup>3</sup> thermal store could deliver 99.8% of the annual demand. This may be slightly too an optimistic estimate. Taking into account that the thermal store capacity is roughly 0.7 MWh, it corresponds only to a little over one hour back-up during the peak heat demand 575 kW, and

less than two hours of biomass boiler's peak output. The widest and highest of the peaks in Figure 5 in January – March exceed the 370 kW heat demand approximately during 5 days by 50 - 100 kW on average. During each such period the heat store should deliver 6 - 12 MWh of heat in addition that the biomass boiler is running at maximum output. Such periods are quite many and they follow each other quite soon preventing the thermal store to fill the gap. Oil consumption was estimated to account only for 0.2% of the total fuel consumption on an energy basis, being annually about 3 MWh (see page 12 and Table 4 on page 23; a slight error on page 3 where it has been stated to be 0.8%). Anyhow, this 3 MWh of oil and utilisation of 0.7 MWh thermal store cannot back up and fill the gaps between the heat demand and biomass boiler's maximum capacity during the mentioned peaks that account for about 70 – 150 MWh on an annual basis.

One option to improve user-friendliness of the system could be buying of a clearly larger thermal store, like one with 100 or even 300 m<sup>3</sup> volume. The heat in the store would correspond to 3.5 – 10.5 MWh, respectively. This would enable to decrease significantly oil use during the beforementioned peak load periods. In addition, oil use could be avoided or significantly decreased during the boiler annual down times, which typically are several in case of biomass boilers. In addition, it would even enable to stop the biomass boiler for the weekends between the period 1 June and 31 October. The total heat consumption during the weekends in question is roughly 8 MWh per weekend (estimated from the Figure 5, calculating 64 hours' weekend). Therefore larger thermal store would result also in lower costs not only because of the decreased oil use but because of lower operational costs, and would significantly increase user-friendliness of the whole system. As to increased losses due to the larger size of the thermal store, they can be roughly estimated to increase in relation to the square root of the volume. Heat losses for the 20 m<sup>3</sup> thermal store has been estimated for about 10 MWh/year (see page 3 in the feasibility study). Thus heat losses for the 300 m<sup>3</sup> store would be  $\sqrt{15} * 10 \sim 40$  MWh, accounting for about 2.7% of the annual fuel input on an energy basis ( $\sim 1,500$  MWh). The price of the thermal store would increase but not in the ratio of the store volumes but rather in the ratio of their square root like the heat losses. The sizing of the thermal store is finally an optimisation between the increased and decreased costs and user-friendliness and depends also on how much the plant user values user-friendliness.

### *Annual savings in CO<sub>2</sub> emissions*

The annual savings of 288 CO<sub>2</sub> tonnes on page 4 seem to refer more to CO<sub>2</sub> emissions from natural gas than to fuel oil emissions. The emission factors for natural gas and fuel oil are about 54 and 74 t/TJ, respectively. The feasibility study has estimated the annual decrease of fossil fuel on an energy basis to be 1,400 MWh that corresponds to 5.04 TJ. Thus the annual CO<sub>2</sub> emissions from natural gas and fuel oil would be 272 and 373 tonnes, respectively.

## *Fuel storage and supply*

In general, in the study fuel storage and supply of wood fuel is covered consistently and taking important points into consideration. Basically storing and processing of all wood fuels is planned to take place at the heating plant. Although there are some advantages of doing this, e.g. chipping can be done directly into the store, some questions are raised:

- Is it convenient to have all wood fuel (timber, whole trees, etc.) at the plant? It takes a lot of space, may attract insects, etc.
- Is it desirable to make wood chips at the plant? Chipping is noisy and leaves the area untidy.
- Is there going to be a chipper available at any time? Is the school going to invest in the chipper or is the chipping going to be done by a contractor? If a contractor is used, the chipping can easily be done elsewhere.
- Does the school have a tractor or a front-end loader for moving the chips? Double handling is needed in any case because the feeding system (= spring agitator) requires the moving of wood chips in the store.
- Is it safe enough to have an 'open' store in the school premises?

In Finland storing and chipping of timber/whole trees is usually done in the woods. In most cases it is not only the most convenient way but also the most cost-effective way to do it. These are some of the benefits:

- No need to store wood (timber, etc.) at the plant
- Energy wood can be seasoned (= air dried) while in the woods
- Both energy wood and timber can be harvested at the same time with the same machines (or manually) and stacks can be left in the woods (on the forest road side)
- Harvesting and chipping can be done with effective machines by using professional contractors
- If the road transport distance is relatively short (<35 km), delivery of chips can be done with a combination of tractor and trailer

Typical Finnish (and Nordic) wood chip supply chains for small-scale plants are presented in the picture below. Both professional forests machines and agricultural tractors equipped for harvesting operations are used in mechanized harvesting. Manual harvesting is mainly used on sites of cleaning type thinning or where an average diameter of felled trees is very small (<9 cm).

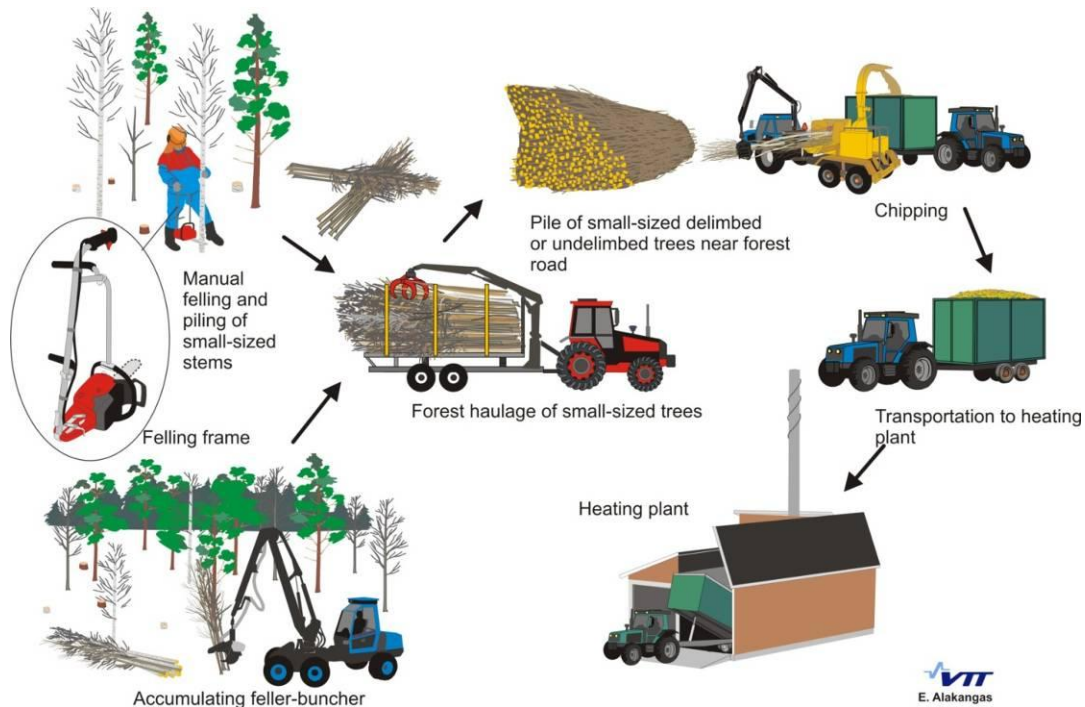


Figure 1: Typical Finnish supply chains of wood chips for small-scale heating plants.

Because storing and chipping are usually done in the woods, heating plants can be made very simple and thus cost-effective. Both the boiler and store are put in the same building, yet in different compartments separated with a wall. It is very common to use a so called ‘walking floor’ for conveying chips to the main auger. This kind of floor can be installed onto the whole storage area, and therefore no handling of chips is needed after delivery. Chips are simply dumped on the floor directly from a truck or tractor which makes delivery fast and easy. If tipping trucks are used, the store including the door needs to be of a significant height, at least 5-6 meters high or to have an opening roof.

The following pictures show typical heating plant solutions in Finland.



Figure 2: A 0.7 MW heating plant. Photo: Jyrki Raitila, VTT.



Figure 4: A walking floor consists of horizontal bar dischargers moving back and forth. Photo: Jyrki Raitila, VTT.



Figure 3: A chip store (boiler right behind the wall). Photo: Jyrki Raitila, VTT.



Figure 5: Chips being delivered; the truck has bar conveyors for unloading. Photo: Jyrki Raitila, VTT.



Figure 6: Energy wood stacks on the road side, covered with water proof paper to prevent from rain and snow. Photo: Jyrki Raitila, VTT.

Jyväskylä 7.7.2010

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](mailto: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](mailto:veli-pekka.heiskanen@vtt.fi)