BIOMASS
CHP

FORSSA
(Finland)

If the share of renewable energy in Europe until 2010 is to be increased to 12%, one has to consider an increase in the use of biomass, both for heat and for electricity production. Wood, wooden waste and straw are anything but rare; but they need rather heavy investments if they are to be fully exploited. That is why the use of wood and straw as a real renewable energy source (keeping the sustainable use and growth in mind!) is still subordinate in comparison to other renewable energy sources. Nonetheless, some cities, many of them in Scandinavia, have carried out useful experiments as in the city of Forssa in Finland, where the municipal owned utility took the initiative of building the first 100% biomass fired combined heat and power plant in Finland.

THE CITY

Forssa is a city in the Southwest of Finland and has approximately 19,000 inhabitants. It is the centre of a region with approximately 36,000 inhabitants. The city is situated one hour away from the capital, Helsinki, and from two major Finnish cities, Turku and Tampere. The town was founded in 1923, and textile industry was the most important source of employment until the seventies. Today, major employment is in building material-, foodstuff- and graphic industries.

Climatic data:
Degree days (17 °C): 4585
Annual mean temperature: 3.9 °C

CONTEXT

In Finland the resources for use of biomass are huge. The Finnish Forest Research Institute (METLA) has studied the sufficiency of Finland's wood resources. Finland's forestry land is 26.3 million hectares, which is 78% of the total area. The total amount of Finland's forests is estimated to be 1,880 million m^3, and the annual growth of forest biomass about 110 million m^3. The potential of forest residues for energy production is estimated to be about 30 million m^3/a, which is equal to an energy content of approximately 72 TWh. For years, Finland has exploited the combination of utilisation of biomass and simultaneous generation of heat and electricity (CHP). The proportion of the combined generation is among the highest in the world. – About 76% of the all district heating is produced by co-generation.

The municipality in Forssa is working actively in energy questions. Forssa is a member of the Energy Agency of South Western Finland, an agency funded partly through the SAVE 2 Programme. During the setting up of this agency a remarkable local process took place regarding the use of biomass. Apart from the erection of the new biomass-fired CHP plant, the small, neighbouring district heat companies have completed their investments in wood fired heating plants.

EXPERIENCE OF FORSSA

Development of combustion technologies has enabled a significant addition to the use of various types of biomass and wastes in power and heat production. It has even become feasible to build small scale combined heat and power plants (CHP) in the range of 4 to 20 MW of electricity production. This proven, conventional thermal co-generation power plant concept has been used with excellent results for as long as 15 years in the Nordic countries.

Forssan Energia power plant

The local, municipality owned utility (Forssan Energia Oy) needed to increase the production of district heat and electricity and to replace oil-fired plants. The objective was to produce self efficient power which ensured energy supply with the minimum of operating interruptions. Wood was locally available from quite a few different sources to feed the entire power plant, so that consumption of imported oil could be minimised. Today, most of the wood is obtained from the immediate vicinity (less than 50 kilometres) of Forssa. The design of the Forssan Energia power plant project started in February 1995, and the plant started operating in September 1996. This was the first co-generation district heating power plant in Finland to use 100% wood as fuel. The fuel consists of bark, saw dust, wood chips and other wood residues. Reservations are also made for the use of REF (Recovered Fuel). In Finland peat is normally the main fuel in such power plants, but this type of fuel is only used in cold periods at wintertime in Forssa. By feeding the boiler partly with peat, it is possible to keep the burning surfaces cleaner, thus, the power plant works more efficiently. On a yearly average, 20% of the biomass is peat. One of the main ideas in building a small co-generation power plant – compared to other CHP-plants in Finland - is to improve the profitability by simultaneous production of electricity and district heat. Features of such a power plant are:

- High total efficiency;
- Capable of burning a wide variety of fuels in an environmentally acceptable manner;
- Low investment costs;
- Short construction time due to standard design;
- Low operating costs due to the high degree automation;

Fuel handling is one of the critical parts of the plant if successful and reliable operation is to be insured. If the fuel handling system is not properly designed and manufactured, it may become the main reason for plant shut-downs. The fuel handling system normally includes equipment for receiving, sorting, shredding or crushing solids, as well as stone and iron removal, conveying and storage. The boiler is the key component of the whole power plant and therefore many requirements and conditions must be taken into consideration in order to reach good availability, efficiency, low emissions and a high turn out ratio of the power plant. A Bubbling Fluidised Bed (BFB) boiled is preferred when biomass or similar low-grade fuels containing highly volatile matters are used. BFB is a cheaper solution than a Circulating Fluidised Bed (CFB). In most cases of biomass power plants BFB is technically and economically the right solution.

Technical specifications

The power plant comprises a Foster Wheeler BFB boiler with a maximum capacity of 66 MW and with steam parameters of 60 bar, 510 °C and a rate of 22.8 kg/s. The 17,2 MW back bleeding pressure turbine is supplied by Asea Brown Boveri. The plant is equipped with a high level of emission control. The district hot water is heated in two stages. The first stage is supplied with back pressure steam. To raise the temperature of the district heating water the water is heated slightly more in the second stage with steam directly from the turbine. This special solution enables a fairly high power to a heat ratio of 26.3 % at full load and 28.8 at 40 % load. The plant is provided with an auxiliary water cooler to maximise the annual power production, and to supply sufficient cooling on hot summer days where the demand for district heating is at its minimum. Even in the Finnish conditions the share of district heated houses in Forssa is high – Around 13,000 people – or about 70% of the inhabitants in the city live in houses heated by the district heating network. The total length of the district heating system is 52 kilometres. The consumers are divided into:

- Dwelling houses 317, (60% of the heat demand)
- Industrial consumers 20, (6% of the heat demand)
- Other consumers 112, (34% of the heat demand)

Requirements for low operation costs and high availability put high demands on the control system. During the last few years the automation systems have improved while the suppliers have been able to reduce the prices.

Energy and environment

This proven conventional thermal co-generation power plant concept used in the Forssa Energian co-generation power plant will for along time remain the most economical power plant concept especially for medium and small size biomass power plants.
The annual production is:

- Co-generation power: 54 GWh
- District heat: 161 GWh
- Total annual requirement fuel: 240 GWh

These figures are equal to the entire heat demand in the district heating system in Forssa, and to one third of the electrical power required by Forssa. The plant is running 24 hours except for a short summer maintenance period. The overall efficiency is 88 % and the percentage of produced electricity, when producing in CHP-mode is 25,1. These figures are not exceptional, but when keeping in mind that the fluidised bed technique is used in combination with biomass of quite different kind, it is however quite outstanding. Emissions of Fluidised Bed Combustion (FBC) are low compared to conventional combustion methods due to minimised formation of thermal NO_x because of lower combustion temperature. The NO_x species formed in FBC originate mostly from the fuel nitrogen. SO_2 can be effectively captured by feeding limestone into the bed. The total annual amount of biomass based energy is 235 GWh. If it is assumed that amount of energy is replacing electricity and heat based on oil, the following environmental figures can be calculated:

- Saved CO_2-emmision: 66,000 tons/a
- Saved SO_2-emmision: 300 tons/a

The annual wood fuel demand is around 400,000 m^3. In wintertime, the demand for fuel is 24 truckloads per day (one each hour!) The owner of the plant has a one-hectare site for fuel in case of seasonal variations in fuel production and use. There is however an environmental issue with the disposal of the waste product of the wood-fuelled CHP-plant – the ash is currently used as structure for the neighbouring landfill. It is intended that the ash, in the future, will return to the forests as a part of the natural recycling of the nutrient.

Economy

Thanks to the compact design, and as the power plant equipment was purchased under more than one hundred separate contracts, the total investment costs for the Forssa plant were as low as 16.6 million Euro, of which 2 million Euro were granted by the Finnish Ministry of Trade and Industry. The price of electricity sold is very competitive even in Finland, where the price of electricity is among the lowest in Europe.

EVALUATION AND OUTLOOK

The production and use of bio energy plays a significant role in regional employment. In 1999, the owner – the municipality - sold the utility to the private company Vapo Oy. This has been a direct consequence of the liberalised energy market combined with a municipal wish to concentrate its effort on fewer areas. In disposing of the energy utility the City of Forssa sought to normalize its finances and secure the town's future development. The town council also wanted to provide a solid foundation for energy production using indigenous fuels in Forssa. The acquisition of Vapo was part of profound changes in the heat and electricity production of Finland. One part of the changes is that many municipalities have created or are in the process of creating their own heat and electricity production.

FURTHER INFORMATION

Markku Miettinen
Vapo Oy
PO Box 22
FI – 40101 JYVÄSKYLÄ
Tel: +358 14 623 56 38
Fax: +358 14 623 57 07
E-mail: Markku.Miettinen@vapo.com
http://www.vapo.com

Erkki Vähätalo
Forssan Energia Oy
PO Box 111
FI – 30101 FORSSA
Tel: +358 3 412 6700
Fax: +358 3 412 6750
E-mail: erkki.vahatalo@forssanenergia.fi
http://www.forssanenergia.fi

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