Contribution to Topic 3

ORC-, steam motor- or steam turbine-technology: Which one fits best for combined district heating and power supply from biomass? A feasibility study for a municipality in Southern Germany

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Abstract

Purpose of the work and background. For the municipality Ostfildern, Scharnhauser Park in the county Esslingen near Stuttgart, Germany it was decided to establish a wood fired CHP-plant for district heating of a residential area and for power production fed into the grid. Wood chips from landscape conservation measures are foreseen as major fuel source. To give advice, which biomass-CHP-technology would fit best into the given district heating requirements, a feasibility study was carried out jointly by IER and IBS. Three promising technologies were taken into consideration:

- Grate furnace, 6550/8770 kW_{th} combustion capacity, with thermo oil boiler and ORC module of 700 or 1000 kW_{el} nominal load respectively
- Grate furnace, 5600/8400 kW_{th} combustion capacity, with steam motor of 700 or 1000 kW_{el} nominal load respectively
- Grate furnace, 9000 kW_{th} combustion capacity, with classical steam turbine process of 1000 kW_{el} effective load at maximum steam extraction (1470 kW_{el} at minimal steam extr.)

Approach and relevance. This contribution aims to give an insight into practical decision making for CHP bioenergy solutions for municipalities. The feasibility investigations were based on calculated data of expected end energy demand at partial and full district heating capacity respectively, as the residential area under study will be in continuous extension until 2008. The expectable investment costs were taken from industrial tenders. ORC-technology as a pilot installation for Baden-Württemberg was expected to be supported by public grants. Maintenance costs were assessed by professional experiences. The economic considerations were focused on comparisons of capital costs, specific costs of energy production and annual surplus funds.

Results and conclusions. The overall capital costs related to usable heat capacities with 1072 €/kW_{th} were the highest for the 700 kW_{el} steam motor solution, followed by the steam turbine solution (at 1000 kW_{el}) with 976 €/kW_{th} and the lowest for the ORC 1000 kW_{el} solution with 800 €/kW_{th}, due to its low electrical overall effectiveness. Related to the installed electrical capacity the ORC 1000 kW_{el} solution turned out to be almost as capital cost intensive as the steam turbine solution (5122 €/kW_{el} and 5357 €/kW_{el} respectively; steam turbine rated at maximum steam extraction mode), whereas the 1000 kW_{el} steam motor option with 4839 €/kW_{el} had the lowest capital costs in that way. With regard to annual surplus funds the ORC 1000 kW_{el} solution turned out to provide the highest amounts, presumed that public grants were included into the considerations and the device was operated at full district heating capacity mode and with thermal load priority. If power production was set to have priority, the profitability of the ORC solution became even better. At the other hand the overall annual energy efficiency factor for this case turned down from about 81 % to 57 %. The costs of electricity production were calculated with 3,6 and 3,7 €ct/kWh_{el} for the 700 and 1000 kW_{el} ORC solution respectively by taking additional costs for power production into account only in comparison to sole heat supply. The costs for heat supply were lowest for the steam turbine solution with 1,49 €ct/kWh_{th}, closely followed by the 1000 kW_{el} steam motor and the 1000 kW_{el} ORC solution with 1,55 and 1,56 €ct/kWh_{th} respectively at nominal electrical load mode and full district heating capacity.

A sensitivity analysis showed that the overall cost effectiveness compared to the substituted gas heating solution may be most importantly influenced by future gas prices (the lower the worse).

As conclusion of the feasibility study the ORC 1000 kW_{el} solution was realized. The ORC-CHP plant will be in operation during the first quarter of 2004.