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

Johannes Moerschner¹, Jens Maier² and Claus Schmidt²

¹ IER – Institute of Energy Economics and the Rational Use of Energy, University of Stuttgart, Heßbrühlstr. 49a, D-70565 Stuttgart, Germany; Phone: +49-711/780 61 65, Fax: +49-711/780 61 77, E-Mail: jm@ier.uni-stuttgart.de

² IBS – Ingenieurbüro Schuler GmbH, Flösserstrasse 60, D - 74321 Bietigheim-Bissingen, Phone: +49-7142/93630, Fax: +49-7142/936350, E-Mail: kontaktibs@ing-buero-schuler.de

**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 kWₜₜ combustion capacity, with thermo oil boiler and ORC module of 700 or 1000 kWₑₑ nominal load respectively
- Grate furnace, 5600/8400 kWₜₜ combustion capacity, with steam motor of 700 or 1000 kWₑₑ nominal load respectively
- Grate furnace, 9000 kWₜₜ combustion capacity, with classical steam turbine process of 1000 kWₑₑ effective load at maximum steam extraction (1470 kWₑₑ 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 €/kWₜₜ were the highest for the 700 kWₑₑ steam motor solution, followed by the steam turbine solution (at 1000 kWₑₑ) with 976 €/kWₜₜ and the lowest for the ORC 1000 kWₑₑ solution with 800 €/kWₜₜ, due to its low electrical overall effectiveness. Related to the installed electrical capacity the ORC 1000 kWₑₑ solution turned out to be almost as capital cost intensive as the steam turbine solution (5122 €/kWₑₑ and 5357 €/kWₑₑ respectively; steam turbine rated at maximum steam extraction mode), whereas the 1000 kWₑₑ steam motor option with 4839 €/kWₑₑ had the lowest capital costs in that way. With regard to annual surplus funds the ORC 1000 kWₑₑ 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/kWhₑₑ for the 700 and 1000 kWₑₑ 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/kWhₜₜ, closely followed by the 1000 kWₑₑ steam motor and the 1000 kWₑₑ ORC solution with 1,55 and 1,56 €ct/kWhₜₜ 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 kWₑₑ solution was realized. The ORC-CHP plant will be in operation during the first quarter of 2004.