

## Small Scale Biomass-Fired CHP Systems

### Participants

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### Project Summary

With the financial supports of UK EPSRC and German FNR via ERA-NET Bioenergy, School of the Built Environment, University of Nottingham (UK) and Institute of Technology of Energy Supply and Energy Conversion Systems, Department of Mechanical Engineering, University of Essen (Germany) joined forces to develop a novel 2 kWe biomass-fired Combined Heat and Power (CHP) system suitable for public and large domestic buildings' application. The specific objectives of the project were:

- To prove the applicability of biomass-fired CHP with Organic Rankine Cycle (ORC) in a small-scale system of 1-10kWe
- To design, construct and evaluate a 2kWe biomass-fired CHP system
- To develop a computer model for the 2kWe biomass-fired CHP system

The following conclusions had been obtained from the project modelling and experimental activities:

- A small-scale biomass-fired CHP with ORC has been developed, modelled and tested.
- Successful power generation with the experimental system indicates that ORC-based power generation can be applied to 1-10 kWe biomass-fired CHP
- Both modelling and laboratory testing indicate that the total CHP efficiency of the CHP system can be 80% or higher.
- With a thermal input of 20 kW to the boiler, the power output of the CHP system was predicted to be within the range of 1.5 to 2.71 kWe, depending on the ORC working fluid, the maximum and the minimum ORC fluid temperatures. This corresponds to an electrical efficiency of 7.5 – 13.5% for the CHP system.
- The highest achievable electrical efficiency of the CHP system which was calculated from the experimental results (obtained with the maximum ORC fluid temperature of 100 °C) on the ORC flow rate, ORC working fluid pressures and temperatures at the inlet and outlet of the turbine, and the thermal input of the boiler was within the range of 4.3 – 8.5%, depending on other experimental conditions such as ORC fluid, which was similar to those predicted by modelling.

- The electrical efficiency of the CHP system achieved with the existing turbine-pulley-alternator set was only about 1.1%. Three factors resulted in a lower electrical efficiency than those predicted by the modelling and calculated from the measured data at the turbine: (1) the turbines investigated were modified from compressors and hence had low efficiency; (2) the alternators were designed to run at high RPM but under the tested conditions, the alternators were running at low RPM which was just over their minimum RPM to generate any power; (3) the efficiency of the alternators was only in the region of 50 – 60%.