Development of innovative small(micro)-scale biomass-based CHP technologies

Coordinator:
BIOS BIOENERGIESYSTEME GmbH (BIOS)

Partners:
- **RIKA Innovative Ofentechnik GmbH (RIKA)**
- **RISE Research Institutes of Sweden AB (RISE)**
- **Umeå University, Dept. Applied Physics and Electronics (UmU)**
- **Luleå University of Technology, Division of Energy Engineering (LTU)**
- **Chalmers University of Technology, Division of Fluid Dynamics (CTH)**
- **ENERTECH AB / OSBY PARCA (EOP)**
- **Ecergy AB (Ecergy)**
- **Technology and Support Centre of Renewable Raw Materials (TFZ)**
- **Orcan Energy AG (ORCAN)**
- **Institute of Power Engineering (IEn)**
- **Wektor Marek Gasiorowski (Wektor)**

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For more information please visit our website
Contact: bios-bioenergy

Introduction

Electricity generation from solid biomass is mainly realised in combustion based medium and large-scale CHP plants (> 200 kWel). Especially in large-scale systems the limited heat demand often reduces the total plant efficiencies. In order to gain a maximum utilisation of the biomass fuel power, a fully heat controlled operation is definitely of advantage. Moreover, biomass is a locally available energy source and should therefore preferably be utilised in decentralised applications due to transport and logistic reasons. These arguments clearly support the idea of making the large electricity production potential from small-scale biomass heating systems in Europe available.

So far no technologically sound (in terms of efficiency and reliability) and economically affordable micro- and small-scale biomass CHP technologies are available. Therefore, the project aimed at the further development and test of new CHP technologies based on small-scale biomass combustion in the electric capacity range between some W and 100 kW, based on basic research and development work already performed for promising new technologies and aimed at the achievement of a technological level which allows a first commercial demonstration after the end of the project.

Results

Due to the high diversity regarding thermal capacities and applications, the project focused on three CHP concepts suitable for different types and sizes of small-scale biomass combustion systems.

- Pellet stoves with a thermoelectric generator (TEG): The pellet stove with TEG is suitable for stove owners who want to cover their need for auxiliary energy by own electricity production and thereby facilitate grid-independent operation. With a TEG heat is directly converted into electricity. The system is a wear- and maintenance-free as well as noiseless technology and thus ideally suitable for applications in living rooms. The electricity produced by the TEG system is stored in an accumulator and covers the energy demand for operation and start-up of the pellet stove. The surplus electricity produced can be used to charge mobile phones or other small consumers via an USB-port. In addition, due to the water cooling system of the TEG, a second living room can be heated by the new technology. Within the project appropriate system components have been selected and two testing plants have been constructed, manufactured, tested and optimised. The electricity demand of the pellet stove could be reduced by more than 50% and the electricity production of the TEG has been optimised by adjusting the TEG position and cooling

system. The final design of the new micro CHP technology and long-term testing of the new components is currently ongoing. Its market introduction is planned within the next two years.

- Small-scale biomass boilers with a micro-ORC process: With a thermal power of 10 to 30 kWth, residential/public buildings or micro-grids can be heated by the new micro-ORC. The electric output of 0.4 to 1.3 kWel is suitable to cover the base electricity demand of the customers. To achieve high electric efficiencies a high temperature difference between input and output is needed. Thus, the micro-ORC system is especially suitable for customers with low temperature heating systems (e.g. floor heating). The micro-ORC has a very compact design and can be directly mounted in the boiler room. Due to the add-on solution only minor adaptations of the biomass boiler are needed and thus, in addition to new installations of biomass boilers with the micro-ORC also retrofitting of existing boilers becomes possible. Within the project the new micro-ORC technology has been tested and optimised. Thereby, a special focus was put on the optimisation of the hydronic integration and the control strategy in order to maximise the electric output of the CHP technology. This work has been supported by monitoring data regarding heat and electricity demand for residential buildings and transient system calculations to optimise the control strategy. Currently, tests with the final design of the ORC are ongoing, a market introduction is planned within 2018.

- High temperature heat exchanger (HT-HE) for an externally fired gas turbine (EFGT): With a thermal capacity of about 1,500 kWth the CHP technology based on a biomass boiler and an EFGT is suitable for district heating systems (base load), or process heat consumers (e.g. wood manufacturing industry). The electricity produced by the gas turbine (up to 100 kWel) can be used to cover the own electricity consumption of a company and/or fed into the grid. Within the project the HT-HE which represents the core component of the system has been designed, constructed and successfully tested at flue gas temperatures up to 900°C. Thus, appropriate guidelines for a compact design of the HT-HE and recommendations have been worked out to minimize thermal stresses as well as ash related problems regarding ash deposit formation and high temperature corrosion. Furthermore, different concepts for the overall EFGT system have been worked out and evaluated. A first testing plant shall be installed and assessed within the next two years.

Acknowledgment

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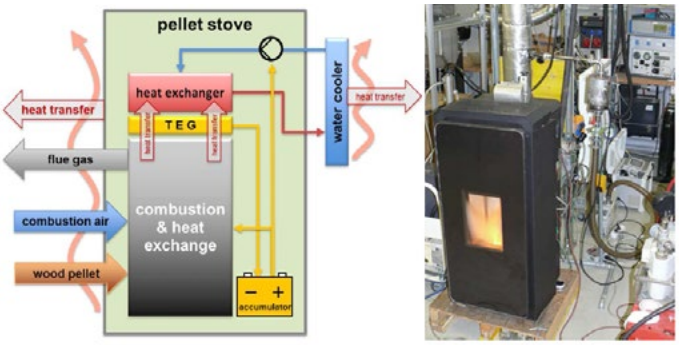

Figure A: General approach of the new micro-CHP pellet stove technology with TEG as well as picture of the testing plant investigated

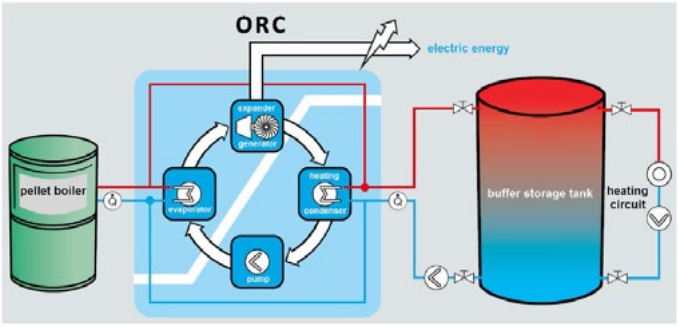

Figure B: Hydraulic scheme for coupling the micro-ORC system with an existing small-scale biomass boiler

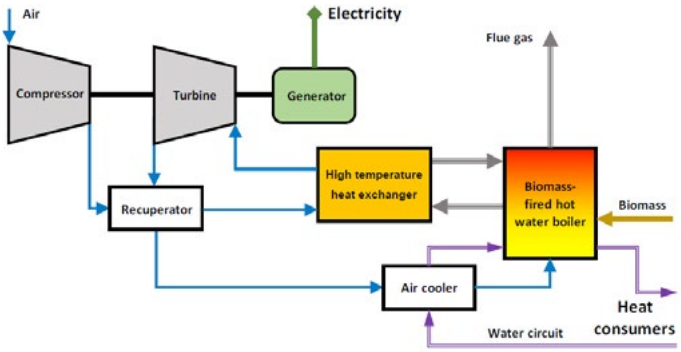

Figure C: Scheme of the optimised EFGT system for biomass fired boilers

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