BIOENERGIESYSTEME GmbH

Research, Development and Design of Plants
for Heat and Power Production from Biomass

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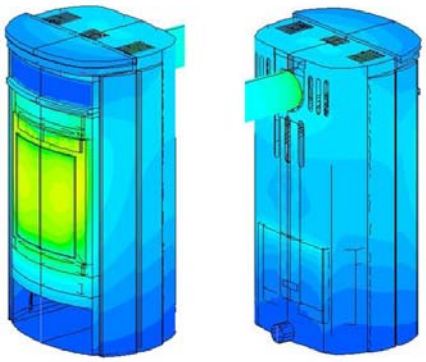
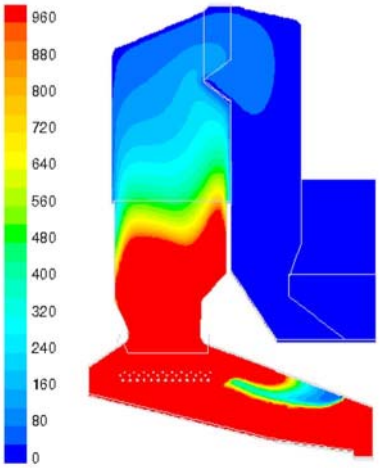
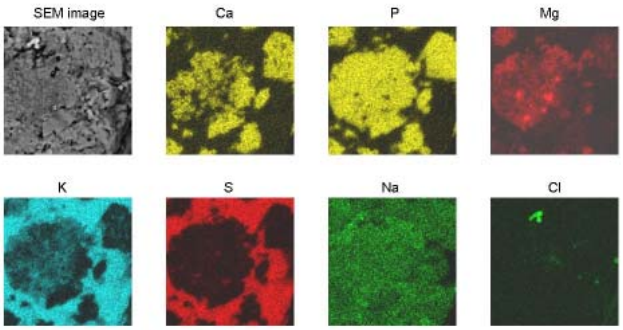
Research and Development

Key Information

BIOS BIOENERGIESYSTEME GmbH







Technology development

Since its foundation BIOS has established itself as a technology development partner of Austrian and international companies alike. This is proven by more than 20 projects funded by the Austrian Research Promotion Agency (FFG) and the European Commission, where BIOS participated as a scientific partner during technology development, as well as a considerable number of research and development orders of industrial clients. Additionally, BIOS has performed several self-financed technology development projects in the past few years.

Due to the high educational standard of BIOS employees (almost exclusively academics) as well as due to close contacts with national and international research organisations and universities, ideal basic constraints for the development of new and innovative technologies are given at BIOS.

At BIOS technology development is based on:

- Specific know-how concerning energetic biomass utilisation based on long-term experience.
- Considerable practical experience regarding plant operation gained from test runs and long-term plant operation monitoring.
- Well educated, experienced and competent specialists.
- State-of-the-art analytical and measurement equipment for the performance of experimental development work.
- State-of-the-art simulation tools (e.g. CFD simulation routines, software and databases for high-temperature multi-phase equilibrium calculations for ash forming species).
- In-house developed expert codes (e.g. for the simulation of thermal as well as anaerobic biomass conversion processes, for the simulation of aerosol and deposit formation in biomass combustion processes).
- In-house developed databases concerning chemical and physical properties of biomass fuels, ashes, substrates and digests.

The activities of BIOS in the field of technology development thereby primarily focus on:

- Biomass combustion technologies in the small, medium and large capacity range
- Primary and secondary measures for emission control in biomass combustion plants
- New and innovative biomass based combined heat and power (CHP) systems
- New control strategies for biomass combustion plants
- Technologies for the reduction respectively avoidance of gas related problems in biomass combustion systems
- Biogas plants
- Biomass gasification plants

Fuel characterisation and fuel specific technology development

Especially when new biomass fuels, of which the combustion related characteristics are not well known, should be utilised, a fuel evaluation regarding combustion and emission related issues is needed as a basis for the correct selection of an appropriate combustion and flue gas cleaning system.

BIOS applies a three step strategy for biomass fuel characterisation.

- Step 1: Fuel evaluation based on chemical analyses.
- Step 2: Performance of test runs concerning the thermal decomposition behaviour in a thermogravimetric analyser (TGA) and concerning the combustion behaviour in a specially developed lab-scale reactor.
- • Step 3: Test runs, optionally performed in a 180 kW pilot-scale combustion plant (grate-fired unit with a hot water boiler) or a biomass furnace coupled with a drop-tube.

Based on these analyses and test runs basic data concerning the thermal decomposition, the combustion behaviour, relevant emissions (NO_x, HCl, SO_2, PCDD/F etc.) as well as regarding ash related problems (deposit formation, slagging, corrosion) are gained, which are directly applied during the conception of a combustion plant which is tailored to the demands of the fuel.

cotton residues

rejects (paper industry)

olive residues

Miscanthus

Switchgrass

straw

waste wood

rape press cake

Development of biomass combustion plants

Traditionally, BIOS is successfully working as a development partner for furnace and boiler manufacturers. The activities in this field range from

- the optimisation of existing combustion plant concepts with respect to specific targets (e.g. increase of efficiency, emission reduction) over the
- development of combustion plant technologies for, in terms of combustion related issues, problematic biomass fuels (e.g. biogenic residues from industry, new energy crops) to the
- support in the development of new product lines.

BIOS covers the whole capacity range starting at residential heating systems for heat production up to industrial large-scale combustion plants. CFD-supported development approaches as well as experimental R&D are thereby applied.

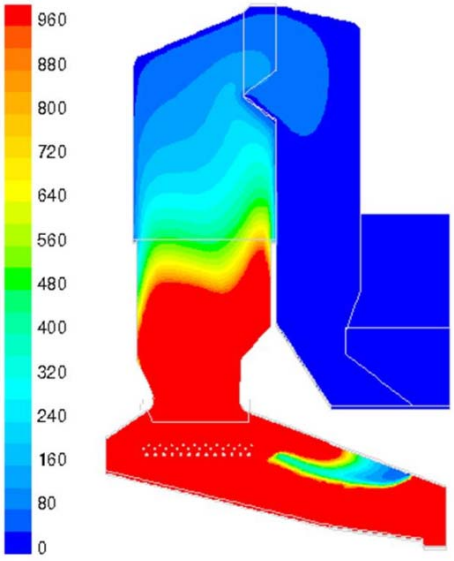
Small-scale combustion systems

- R&D regarding pellet, wood chip and logwood boilers as well as stoves.
- Adaptation and optimisation of existing small-scale combustion concepts regarding emission reduction, increased efficiencies and increased fuel flexibility.
- Development of new combustion technologies for pellets, wood chips and logwood.
- Development of new product lines for small-scale biomass boiler manufacturers.

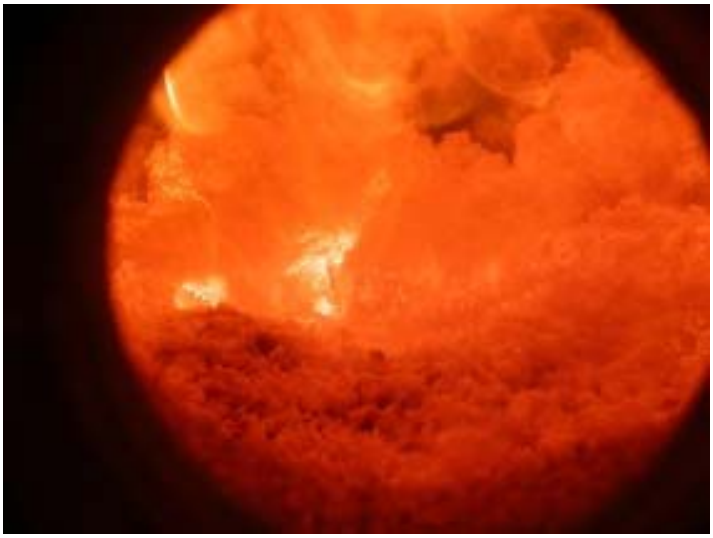
Product line development: KWB TDS Powerfire 150

Medium and large-scale combustion systems

- Furnace and boiler development for conventional biomass fuels (wood chips, bark, waste wood, straw) new biomass fuels (agricultural biomass fuels, energy crops) and residues from the agricultural and food industry (kernels, husks, digestates).
- Identification of technological bottle necks by plant operation monitoring and dedicated test runs including measurement and analyses at existing biomass combustion plants.
- Further development and optimisation of existing combustion concepts with the targets emissions reduction, increased efficiencies and reduction of ash related problems (slagging, deposit formation, corrosion).



CFD-supported furnace development: CO-profile [ppmv] in der symmetry plane of the furnace and boiler of a 20 MW_{th} biomass combustion plant



View into the furnace of a pilot-scale grate-fired combustion plant during test runs with a new biomass fuel in the course of combustion plant development

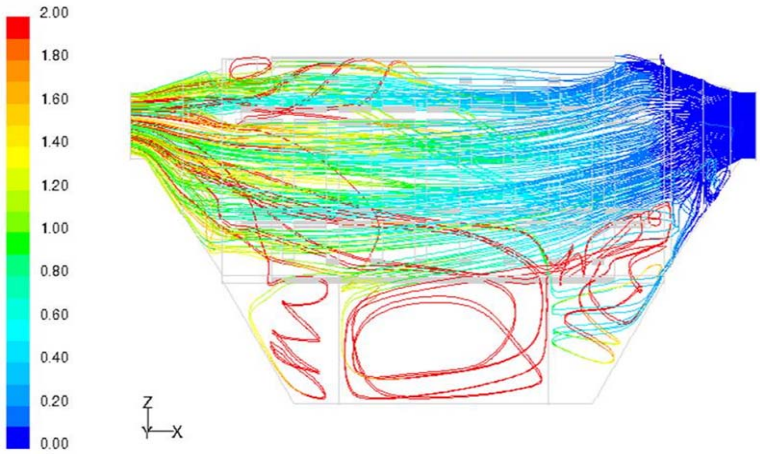
Emission reduction

Optimisation of existing combustion concepts and development of new combustion technologies for all capacity ranges with special respect to the reduction of CO-, OGC-, NO_x-, dust- and fine particulate emissions by the application of primary measures.

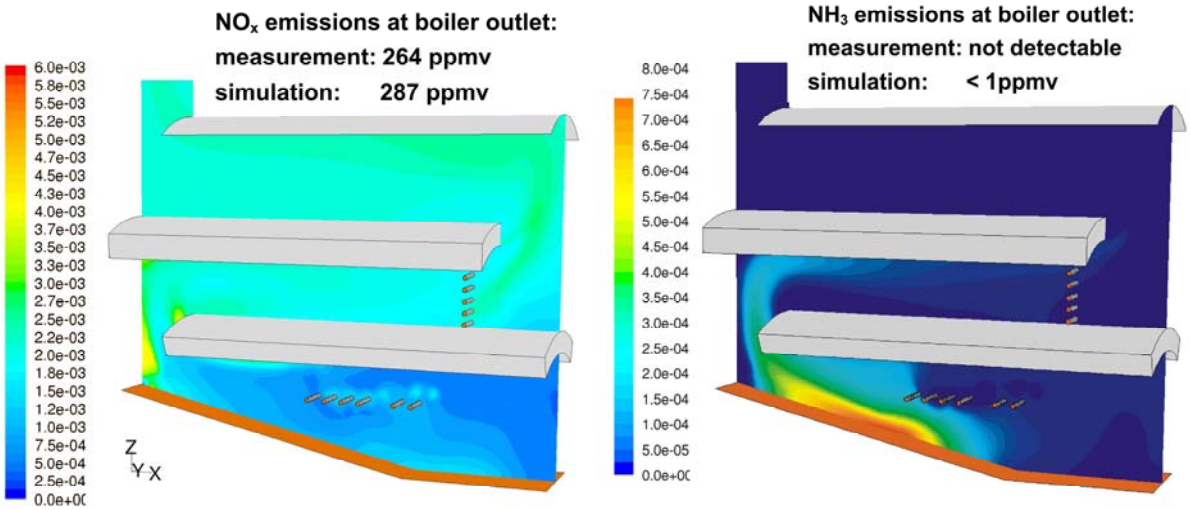
- CFD-supported technology development and optimisation.
- Experimental R&D based on test runs at prototypes, pilot-scale and real-scale combustion plants.

Development and optimisation of secondary measures for emission reduction as well as their integration into combustion plant concepts:

- Development of fine particulate matter precipitation devices.
- SNCR-systems for NO_x-emission reduction.



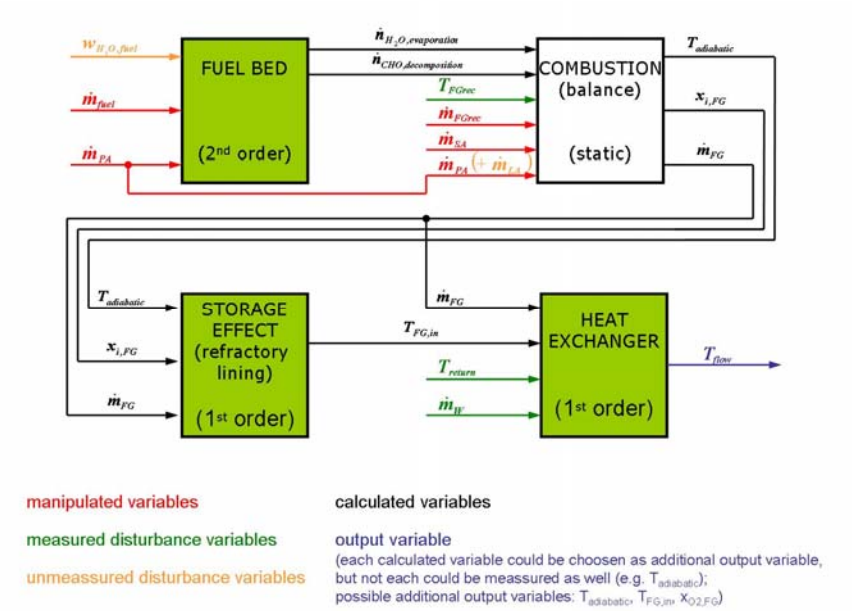
CFD-supported optimisation of the gas flow in an ESP (electrostatic precipitator): path lines of the air, coloured by residence time, starting from the filter inlet



Simulated mole fraction profiles of NH_3 (right) and NO (left) in the symmetry plane of a pilot-scale biomass grate furnace and comparison of measured and simulated NO_x emissions at boiler outlet

Development of process control concepts for biomass combustion plants

- Functional analyses, identification of malfunctions and elaboration of proposals for optimisation for existing control concepts
- Development of control concepts base on innovative tools such as Fuzzy-Logic and model based routines for
  - stoves
  - small-scale combustion systems
  - medium and large-scale combustion systems.



Structure of the mathematical model of a grate-fired combustion plant, which acts as the basis for the development of model based controller

- Evaluation of new, innovative and cheap sensors regarding their application in biomass combustion systems.

Testing stand for the evaluation of the performance of different devices from the determination of flue gas and air velocities

Development of new and innovative combined heat and power technologies

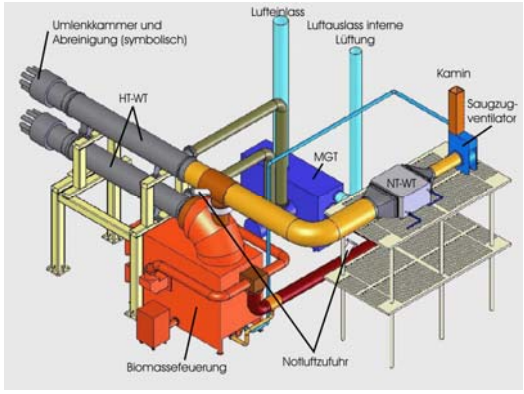
Within national and international research and development projects BIOS has contributed to the development and demonstration of innovative combined heat and power technologies which can be applied in decentralised energy sector.

- ORC-process
- Screw-type steam engine
- Stirling engines
- Micro gas turbine

ORC module in container design (400 kW_{el}) at ist delivery at the CHP plant

Screw-type steam engine (730 kW_{el}) at the biomass CHP plant Hartberg (A)

35 kW_{el} pilot plant based on a Stirling engine



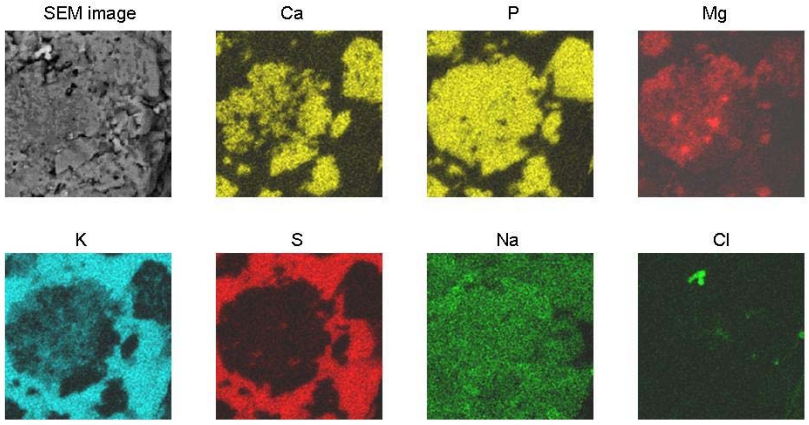
Biomass CHP plant consisting of a 100 kW_{el} microgasturbine (MGT) internally fired with natural gas and externally fired with biomass

Ash related problems in biomass combustion plants

- Elaboration of solutions for fuel and plant specific problems:
  - ash melting and slagging
  - deposit formation
  - corrosion
  - coarse and fine particulate emissions reduction
- For that purpose BIOS applies:
  - Plant operation monitoring and test runs including accompanying measurements and analyses for problem identification at existing combustion plants.
  - Evaluation and characterisation of ashes, slags and deposits based on wet chemical analyses and electron microscopy, ash melting tests as well as thermodynamic multi-component multi-phase equilibrium analyses for the investigation of the ash melting behaviour.
  - Preparation of tailored solutions based on the data gained with the methods mentioned above.

Molten ash agglomerations formed during the combustion of herbaceous fuels

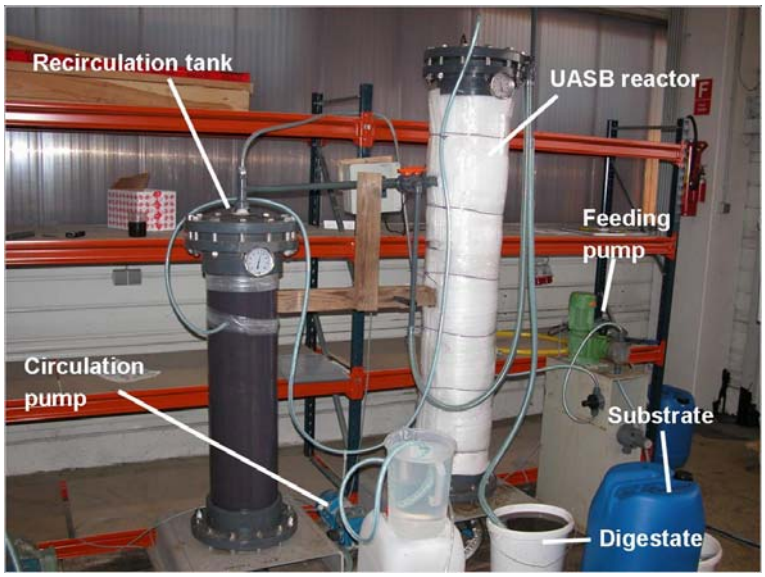
Hard super heater deposits in a waste wood fired boiler



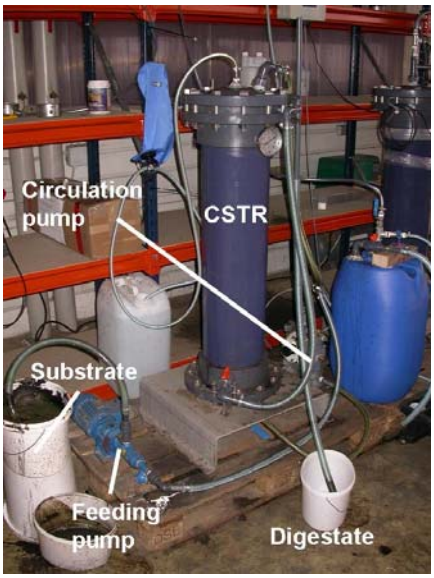
Electron microscopic analyses of molten super heater deposits (element mapping; picture width: ca. 22 µm)

Development of biogas plants

- Evaluation of new substrates regarding their applicability for anaerobic digestion
- Development of new CSTR (continuously stirred tank reactor) and high performance reactor concepts for special substrates
- Technology development for gas cleaning and gas treatment systems
- R&D concerning utilisation strategies for digestates



UASB pilot plant
(UASB: upflow unaerobic sludge blanket)



CSTR pilot plant
(CSTR: continuously stirred tank reactor)

Development of biomass gasification plants

- Comparison as well as technological and economic evaluation of different biomass gasification technologies as a basis for the correct technology selection.
- Evaluation and identification of weak points of existing gasifier concepts as well as their further development and optimisation.
- Development of new gasification technologies based on CFD supported calculations testing plants.

Performance and evaluation of test runs

- • performance of plant operation monitoring and test runs including accompanying measurement and analyses at biomass combustion plants (testing plants, pilot plants, real-scale plants) regarding various combustion related question such as
    - efficiency optimisation
    - emission reduction
    - ash related problems
    - as preparatory work for optimisation measures and in the course of plant revisions
    - for risk assessment during planned extensions of the fuel assortments applied
- Evaluation of the test runs and, depending on the objectives, CFD supported simulation and evaluation of the operation during the test run.
- Performance of batch digestion tests including accompanying measurements and analyses for the evaluation of the applicability of new substrates.
- Performance of plant operation monitoring and test runs including accompanying measurements and analyses in biogas plants.
    - Evaluation of the plant operation performance
    - Identification of weak points
    - Operation optimisation

Measurement campaign at a real-scale combined heat and power plant

Gas sampling during a test runs at a biomass pilot-scale combustion plant