BIOENERGIESYSTEME GmbH

Your partner for energy utilisation from biomass and energy efficiency
Research • Development • Engineering

Research and Development




8020 Graz, Hedwig-Katschinka-Straße 4, AUSTRIA
T: +43 (316) 481300
office@bios-bioenergy.at | www.bios-bioenergy.at

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BIOS BIOENERGIESYSTEME GmbH
Key information

- Founded in 1995 as a spin-off of the Graz University of Technology
  Re-organisation to a limited liability company in 2001
- 2015 opening of the
  BIOS Innovation Centre
- General manager:
  Prof. Dr. Ingwald Obernberger
- Present staff: 25 (21 graduated engineers)
- Annual turnover in 2020: approx. 5.0 Mio €
- Markets: Austria, Germany, Italy, Switzerland but also Belgium, Denmark, Estonia, France, Greece, United Kingdom, Ireland, Croatia, Montenegro, The Netherlands, Norway, Serbia, Slovakia, Spain, Czech Republic, Hungary, Bangladesh, Barbados, Belarus, Chile, Honduras, Canada, Russia, South Africa, Taiwan, USA

Since its foundation BIOS has established itself as a technology development partner of Austrian and international companies alike.

This is proven by more than 50 projects funded by Austrian funding organisations 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 and is performing self-financed technology development projects to pave the ground for revolutionary innovations.

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

- **Technology development at BIOS 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 conversion processes, for the simulation of aerosol and deposit formation in biomass conversion processes).
  - In-house developed databases concerning chemical and physical properties of biomass fuels, ashes, substrates and condensates.

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Research and Development

- **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
  - Biomass gasification technologies
  - Biomass pyrolysis technologies
  - Primary and secondary measures for emission control in biomass conversion plants
  - New and innovative biomass based combined heat and power (CHP) systems
  - New control strategies for biomass conversion plants
  - Technologies for the reduction respectively avoidance of ash related problems in biomass conversion systems

Fuel characterisation and fuel specific technology development

- **Especially when new biomass fuels, of which the specific characteristics are not well known, should be utilised, a fuel evaluation regarding conversion and emission related issues is needed as a basis for the correct selection of an appropriate conversion 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) respectively in a specially developed lab-scale reactor.

  Step 3: Test runs, optionally performed at small-scale boilers or at pilot plants at the client

- **Based on these analyses and test runs basic data are gained concerning**
  - the thermal decomposition of a biomass fuel
  - relevant emissions (NO_x, HCl, SO_2, PCDD/F, tars, soot, etc.)
  - ash related problems (deposit formation, slagging, corrosion),

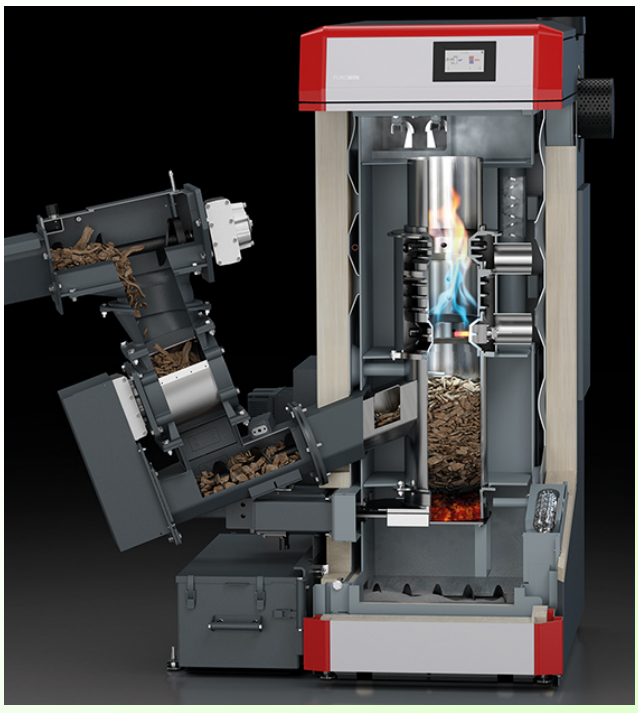
  which are directly applied during the conception of a conversion plant which is tailored to the demands of the fuel.

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:
Windhager PuroWIN

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)
  - residues from the agricultural and food industry (kernels, husks, digestates).
- **Identification of technological bottle necks by plant operation monitoring and dedicated test runs including measurements 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).**

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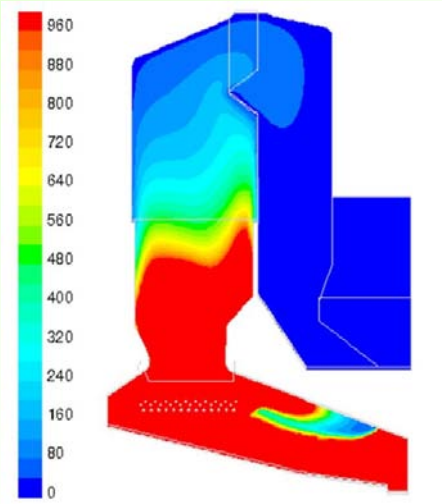
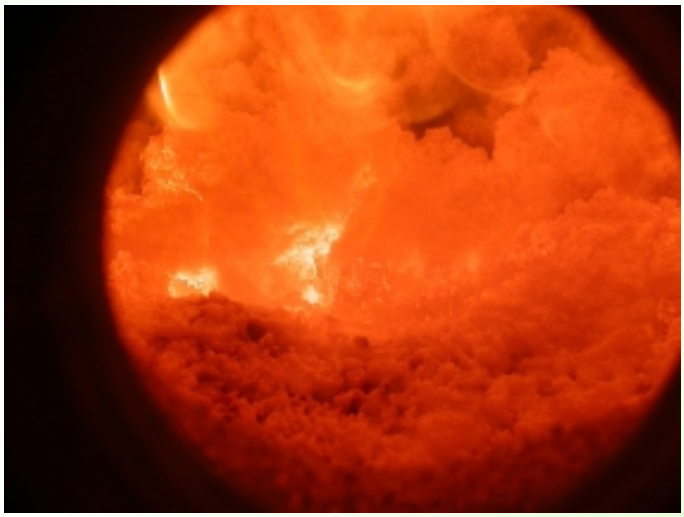
Research and Development –
Development of biomass combustion plants



CFD-supported furnace development: CO-profile [ppmv] in the 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 a test run

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 NOx-emission reduction
  - Development and application of catalysts for emission reduction

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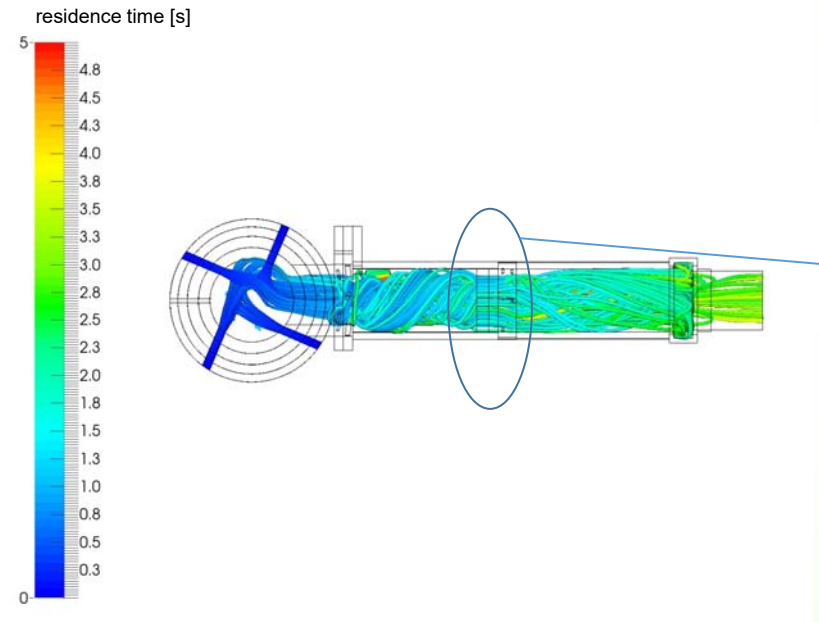
Research and Development –
Emission reduction in biomass combustion plants

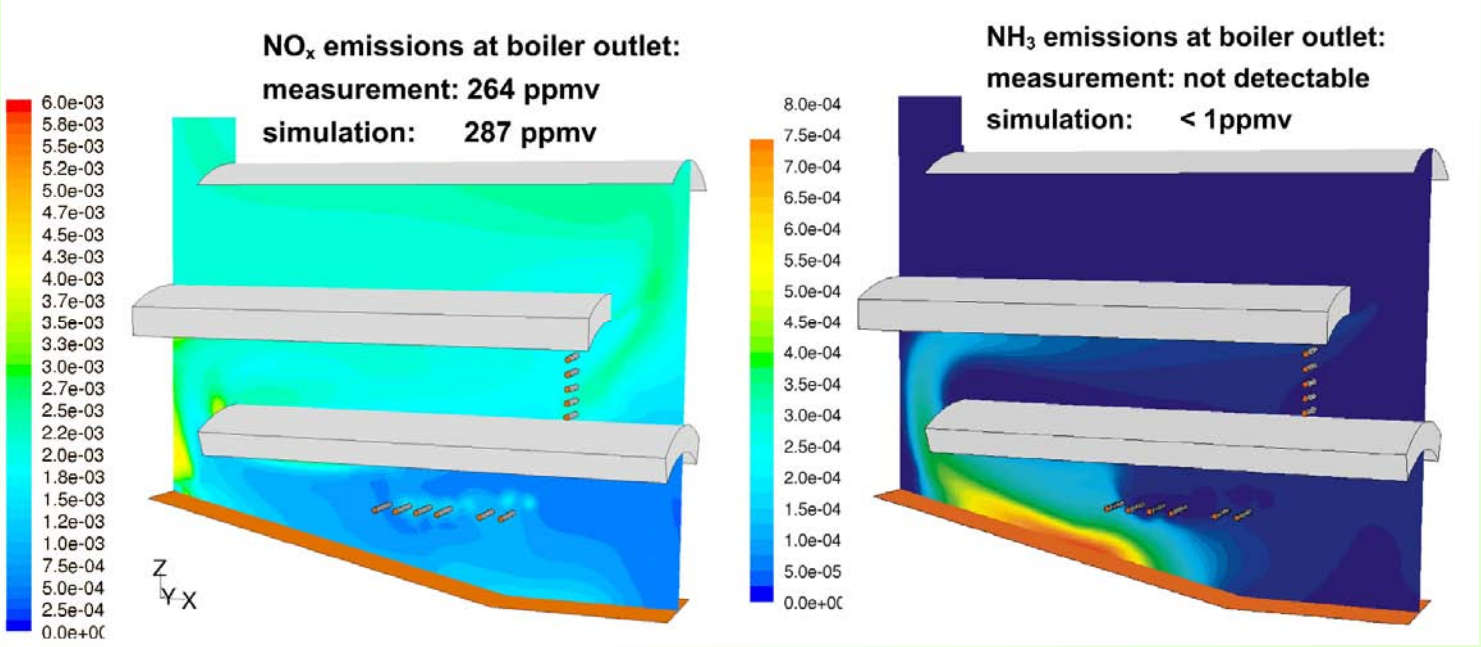


CFD-supported optimisation of the gas flow up- and downstream a catalyst positioned in the flow channel downstream a combustion chamber

Pathlines of the air, colored by residence time

Honeycomb catalyst

Research and Development – Emission reduction in biomass combustion plants

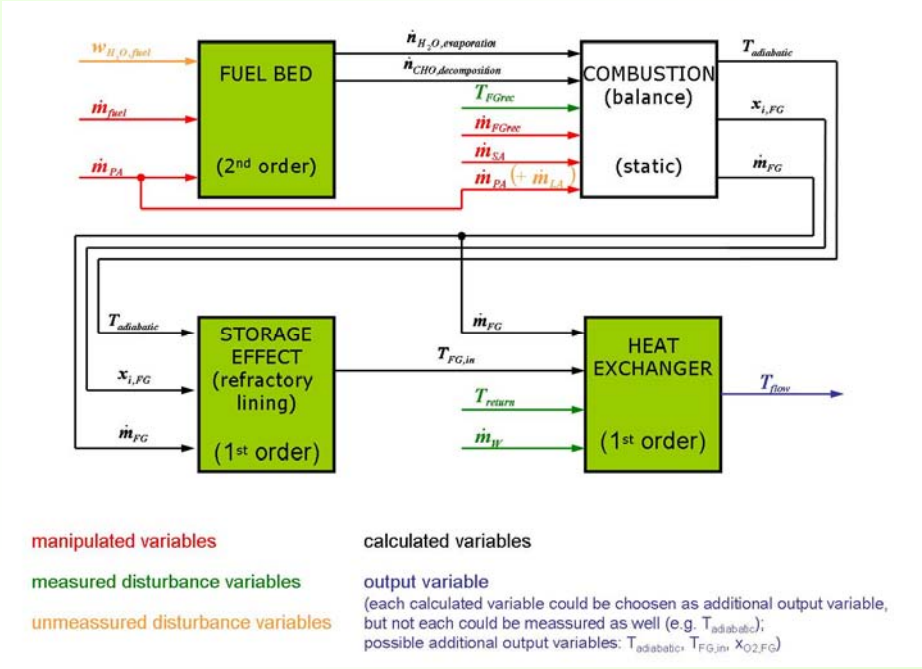


Simulated mole fraction profiles of NH_3 (right) and NO (left) in the symmetry plane of a pilot-scale biomass grate furnace and comparison of measured and simulated NO_x emissions at boiler outlet

Research and Development – Process control concepts

Development of process control concepts for biomass combustion, gasification and pyrolysis plants

- **Functional analyses, identification of malfunctions and elaboration of proposals for optimisation for existing control concepts**
- **Development of control concepts based on innovative model based tools**
- **Control system development and optimisation based on CFD simulations**



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

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Research and Development –
Process control concepts

- **Evaluation of new, innovative and cheap sensors regarding their application in thermal biomass conversion systems**

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

Within national and international research and development projects BIOS has been contributing to the development and demonstration of innovative decentralized combined heat and power technologies.

- **ORC process**
- **Screw-type steam engine**
- **Micro gas turbine**
- **Thermoelectric generators**
- **Solid Oxide Fuel Cells (SOFC)**

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Research and Development –
Development of CHP technologies

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

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

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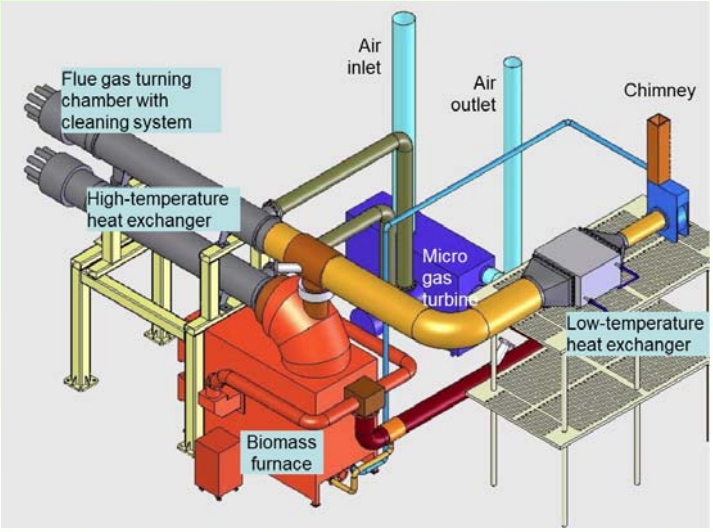
Research and Development – Development of CHP technologies



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

Biomass gasifier coupled with a solid oxide fuel cell (SOFC) system 6 kW_{el} testing plant at BIOS

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Research and Development – Ash related problems in biomass conversion plants

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**

Hard super heater deposits in a waste wood fired boiler

Molten ash agglomerations formed during the combustion of herbaceous fuels

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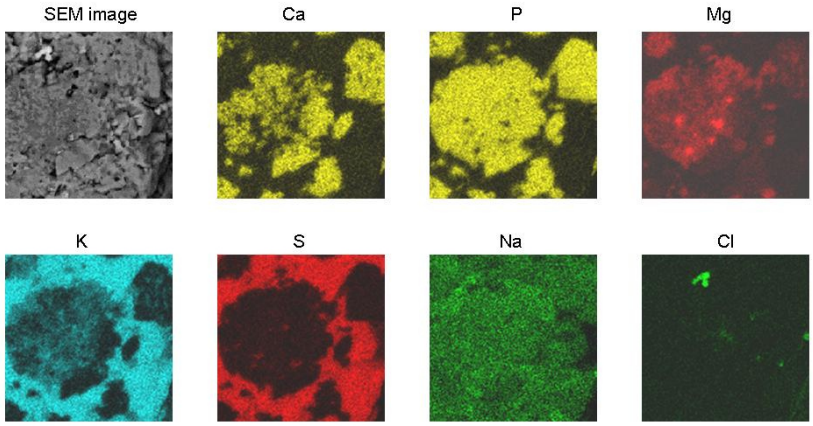
Research and Development – Ash related problems in biomass conversion plants

- **For that purpose BIOS applies:**
  - Plant operation monitoring and test runs including accompanying measurements and analyses for problem identification at existing conversion 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.



Electron microscopic analyses of molten superheater deposits (element mapping; picture width: approx. 22 µm)

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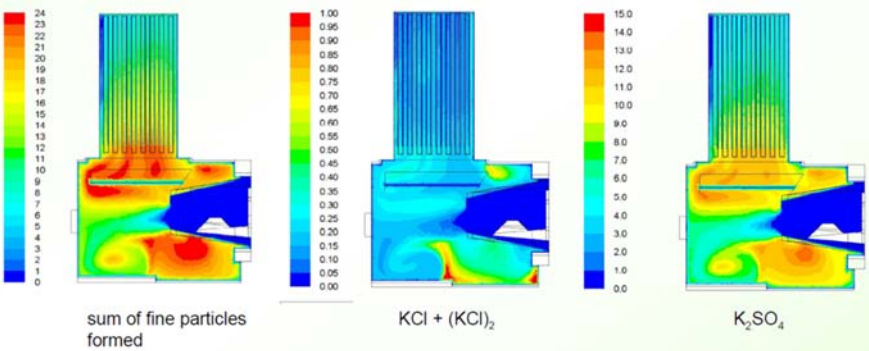
Research and Development – Formation and reduction of coarse fly ash and fine particulate matter emissions in biomass conversion plants

- **Formation of coarse fly ash and fine particulate matter (PM) emissions**
  - CFD simulations regarding fly ash and fine PM formation as well as particle deposit formation
  - High-temperature (up to 1,000°C) measurements with a purpose built high-temperature low-pressure impactor for the fuel and plant technology specific investigation of fine PM formation
  - Based on this, process and fuel-specific development of primary measures to reduce dust and fine dust emissions



Simulation of aerosol formation in a combustion plant:

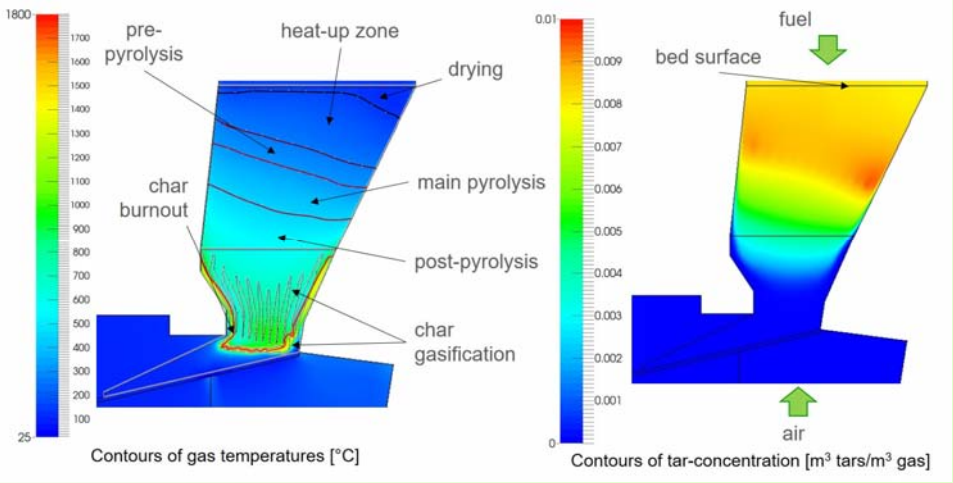
left: total particulate matter concentration [mg/Nm³]

centre: PM from nucleation/condensation of KCl [mg/Nm³]

right: PM from nucleation/condensation of K_2SO_4 [mg/Nm³]

Development of biomass gasification plants

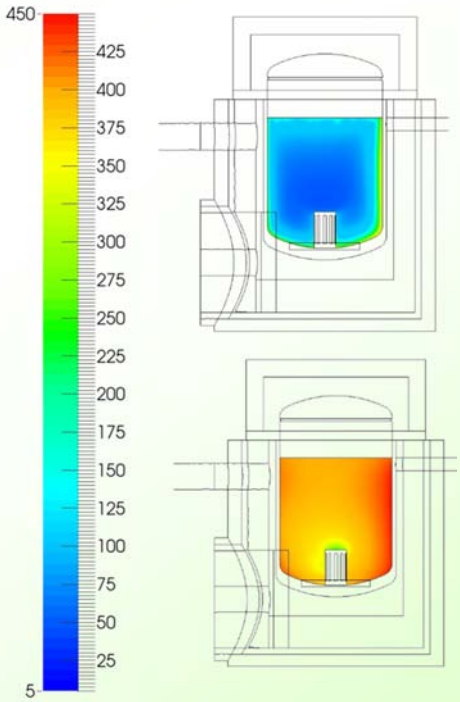
- Comparison as well as technological and economic evaluation of different biomass gasification technologies as a basis for the correct technology selection.
- Evaluation and identification of weak points of existing gasifier concepts as well as their further development and optimisation.
- Development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



CFD-simulation of a fixed-bed updraft gasifier

Development of biomass pyrolysis plants

- CFD-aided development of batch processes and continuous processes for biomass pyrolysis
- CFD-aided development of burners for pyrolysis gas and pyrolysis oil
- Experimental R&D for the optimisation of pyrolysis reactors including the chemical characterisation of the products (biochar, bio-oil, pyrolysis gases) as well as of pyrolysis gas and pyrolysis oil burners
- Development of biomass pyrolysis based biorefinery concepts



Iso-surfaces of temperatures of the solid material [°C] in a vertical cross section of a pyrolysis batch reactor at pyrolysis start (above) and after 2.75 hours (below)

Development of product gas cleaning technologies

- HCl and H_2S removal based on sorption
- Thermal and catalytic tar reforming
- Avoidance of soot formation and soot separation

Isopropanol solution with tars sampled upstream the catalyst

Wire-Mesh catalyst for tar reforming

Isopropanol solution with tars sampled downstream the catalyst

Performance and evaluation of test runs

- Performance of plant operation monitoring and test runs including accompanying measurement and analyses at biomass conversion plants (testing plants, pilot plants, real-scale plants based on combustion, gasification and pyrolysis) regarding various issues
  - efficiency optimisation
  - emission reduction
  - ash related problems
  - as preparatory work for optimisation measures in the course of plant revisions
  - for risk assessment during planned extensions of the fuel assortments applied
- Evaluation of the test runs and weak point analyses as a basis for plant optimisation

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

Gas sampling during a test runs at a biomass combustion plant

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Research and Development –
Performance and evaluation of test runs

Preparation and support of type tests for small-scale biomass combustion plants

- Installation of the respective system at the BIOS testing facilities which is suitable and equipped for such test runs
- Preparatory test runs with accompanying measurements of the relevant gaseous and dust emissions as well as evaluations of the plant efficiency
- Supervision of the plant operation during the type tests
- Preparation and support of the type tests performed by an accredited testing body

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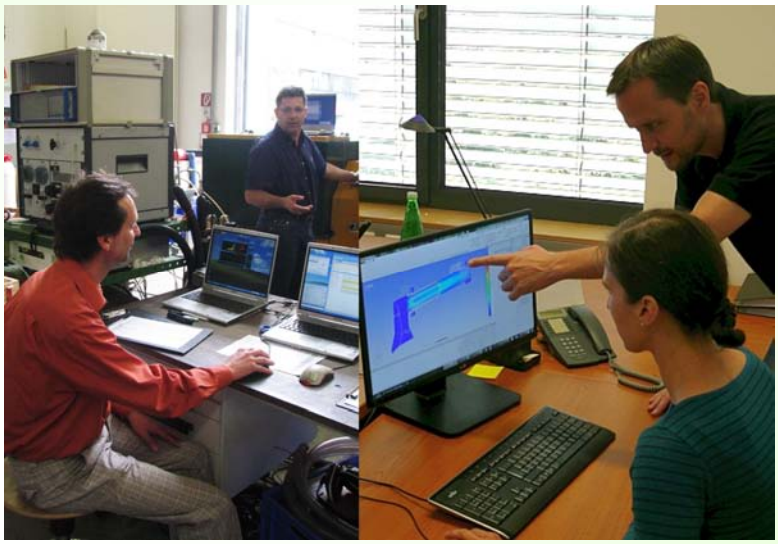

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