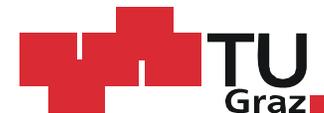




Project FutureBioTec – Future low emission biomass combustion systems – an overview

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project coordinator

bioenergy2020+



ERA-NET Bioenergy - International Workshop
Technologies for clean biomass combustion
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Background and intention

- The EU and its member states aim at an **increased use of renewable energy** as a measure for CO₂ emission abatement.
- Therefore, they actively **support the utilisation of biomass** for energy production.
- This aim must be achieved **without increasing other harmful emissions** such as fine particulate matter (PM_{2.5}) nitric oxides (NO_x), carbon monoxide (CO) and organic compounds (OGC, PAH).
- Therefore, especially regarding the small and medium-scale heating sector, the promotion of energy from biomass must be accompanied by **further technology development towards low emission combustion systems**.
- **FutureBioTec** aimed to provide a substantial contribution concerning the development of **future low emission stoves and automated small and medium-scale biomass combustion systems**.



Project key data

Project title: Future low emission biomass combustion systems

Acronym: FutureBioTec

Duration: 36 months
(1 October 2009 - 30 September 2012)

Overall Budget: 1,934,496 EUR

Overall ERA-NET funding: 1,492,216 EUR

Project coordinator: Prof. Dr. Ingwald Obernberger

BIOENERGY 2020+ GmbH (BE2020), Graz, Austria

in cooperation with

Institute for Process and Particle Engineering,
Graz University of Technology (TU Graz), Graz, Austria



Project partners (1)

- 9 scientific partners (1 from outside ERA-NET) and 2 industrial partners (1 from outside ERA-NET)

- **Austria**

- BIOENERGY 2020+ GmbH, Graz (**BE2020**)
- Graz University of Technology (**TUG**)
Institute for Process and Particle Engineering
(subcontractor of BIOENERGY2020+)




- **Finland**

- University of Eastern Finland (**UEF**)
Department of Environmental Sciences
Fine Particle and Aerosol Technology Laboratory
Kuopio



- **Germany (participation on own financing)**

- Technology and Support Centre in the Centre of Excellence for Renewable Resources (**TFZ**)
Straubing





Project partners (2)

■ Ireland

- Teagasc, Crops Research Centre (**Teagasc**)
Oak Park, Carlow



■ Poland

- Institute of Power Engineering (**IEn**)
Thermal Division Department
Warsaw



■ Sweden

- Umeå University (**UmU**)
Energy Technology and
Thermal Process Chemistry, Umeå
- Luleå University of Technology (**LTU**)
Division of Energy Engineering, Luleå
- SP Technical Research Institute of Sweden (**SP**)
Division of Energy Technology, Borås





Project partners (3)

- **Industrial partner from Finland**

- Warma-Uunit Ltd.



- **Industrial partner from Norway**

- Applied Plasma Physics AS



- Besides these industrial partners who are directly participating in the project, a considerable number of additional companies is engaged in the project via the national co-financing.

In Austria for instance 5 companies (furnace and boiler manufacturers) support the project.



Project objectives (1)

- **Development of primary measures concerning PM, OGC, CO and NO_x emission reduction for stoves (work package 1)**
 - Investigation of **new designs** (grate and air staging) and new control concepts for wood stoves.
 - Development of **guidelines for low emission wood stove design and control.**
 - Development of a “**low emission operation manual**” for wood stove users.



Project objectives (2)

- **Development of primary measures for PM and NO_x emission reduction in automated furnaces (work package 2)**
 - Systematic evaluation of effects of different **air staging strategies** and excess air ratios on the NO_x and PM emissions with a special focus on **extremely staged combustion**.
 - Development and test of a **low emission burner for pulverised fuels**.
 - Determination of the **behaviour of the critical ash forming elements** as a function of combustion conditions and fuel quality.
 - Elucidate and determine the **potential and suitability of using different additives and fuel blending** for low PM emission utilisation.
 - Compilation of a **guideline for low emission combustion concepts**.



Project objectives (3)

- Development of **secondary measures for PM emission reduction** in small-scale biomass combustion systems (work packages 3 and 4)
 - Compilation of the **European state-of-the-art** concerning particle precipitation devices for residential biomass combustion systems.
 - **Techno-economic evaluation** of different particle precipitation devices for residential biomass combustion systems.
 - Compilation of **design and application guidelines** for particle precipitation devices for residential biomass combustion systems.
 - Development of a new technology for a **condensing heat exchanger** as device for combined heat recovery and particle precipitation based on thermophoretic and diffusiophoretic effects.



Work packages and partners involved

	Work package	start	end	BE2020	UEF	TFZ	Teagasc	IEA	UmU	LTU	SP	APP	Warma
1	Reduction of PM, CO, OGC and NO _x emissions from wood stoves by primary measures	1	36	x	x	x*			x		x		x
2	Reduction of PM and NO _x emissions from automated boilers by primary measures	1	36	x*	x		x	x	x	x	x		
3	PM emission reduction by secondary measures	1	36	x	x	x	x				x*	x	
4	Development of a specially designed condensing heat exchanger	1	36		x*								
5	Coordination and dissemination	1	36	x*	x	x	x	x	x	x	x		

x* ... work package leader

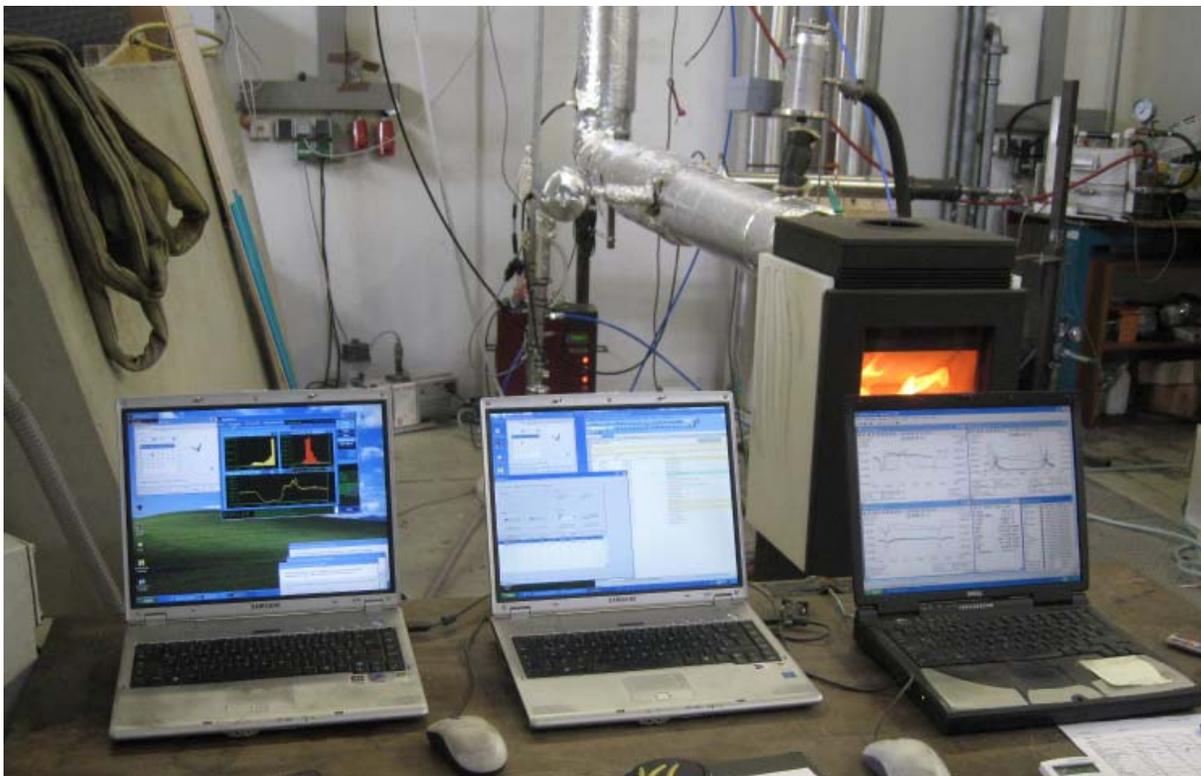


Methodology

- **The work performed was based on the following approach**
 - Literature surveys as well as summary and evaluation of data already existing at the project partners in order to define the present state-of-the-art.
 - Dedicated experimental work defined based on the research need resulting from the state-of-the-art surveys.
 - Evaluation of the test runs supported by the utilisation of calculation / modelling tools for process design, optimisation and evaluation.
 - Techno-economic evaluation of the new technologies.
 - Compilation of guidelines.



WP1: Reduction of PM, CO, OGC and NO_x emissions from wood stoves by primary measures





WP1: Reduction of PM, CO, OGC and NO_x emissions from wood stoves by primary measures – objectives (1)

- A systematic study on the effects of the following operational parameters on fine particles (soot, organic matter, inorganic compounds) and gaseous emission (CO, OGC, NO_x) of stoves has been conducted:
 - enhanced air staging
 - decreased primary air supply through the grate
- The work focused on logwood chimney stoves.
- Research regarding the influence of the grate system on the PM emission formation behaviour.
- Research regarding the influence of different fuel qualities and particle sizes on the emissions.
- Influence of early and late recharging on the emissions.
- Investigation of different options concerning automated control systems for natural draught systems.

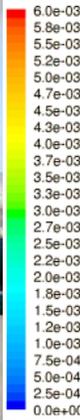


WP1: Reduction of PM, CO, OGC and NO_x emissions from wood stoves by primary measures – objectives (2)

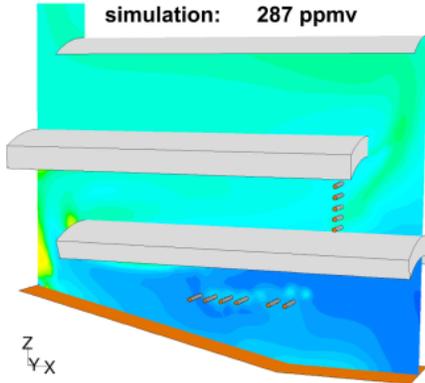
- Since the user behaviour plays an important role concerning the stove operation, a **“low emission operation manual”** for stove users has been compiled, which has to be seen as a further important primary measure for emission reduction from stoves.
- The results of the different tasks of WP 1 have been summarized in a **“guideline for low emission stove design and control”**.



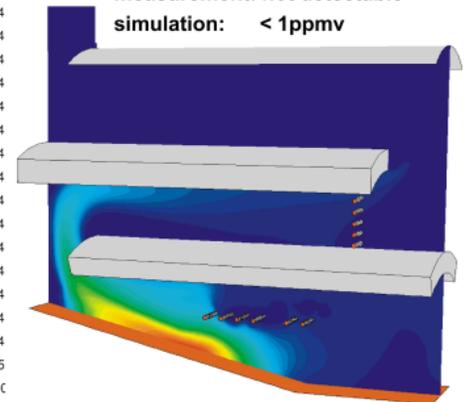
WP2: Reduction of PM and NO_x emissions from automated boilers by primary measures



NO_x emissions at boiler outlet:
measurement: 264 ppmv
simulation: 287 ppmv



NH₃ emissions at boiler outlet:
measurement: not detectable
simulation: < 1ppmv





WP2: Reduction of PM and NO_x emissions from automated boilers by primary measures – objectives (1)

- Performance of basic research (experimental and chemical equilibrium modelling) on the **residual ash formation and release behaviour of fine PM forming matter during single pellet/fuel particle combustion** as a basis for further investigations concerning the effects of combustion conditions and fuel parameters on PM and NO_x emissions.
- Performance of **systematic studies on the effects of advanced air staging on PM and NO_x emissions**. Respective test runs focused on **fixed-bed combustion systems** in the residential heating sector as well as on furnaces in the capacity range of up to some MW_{th}.
- Investigation of the **effects of additive addition and fuel blending** on PM, CO, OGC and NO_x emissions reduction.
- A wide range of biomass materials have been tested including wood, fibreboard, SRC (willow), straw, miscanthus and different grasses.



WP2: Reduction of PM and NO_x emissions from automated boilers by primary measures – objectives (2)

- Development of a new burner system for pulverised biomass fuels including prototype testing and its evaluation
- Compilation of design guidelines for biomass furnace manufacturers for low PM/NO_x emission fixed-bed furnaces of the future
- Increased knowledge about the suitability of (new) biomass fuels for small-scale combustion with respect to combustability, high efficiency, low operational problems (e.g. slagging tendencies) and low formation of gaseous and particulate emissions.
- Techno-economic analyses of the technologies and comparisons with present state-of-the-art combustion technologies

WP3: PM emission reduction by secondary measures





WP3: PM emission reduction by secondary measures – objectives

- **Compilation of the present state-of-the-art of particle precipitation devices** for residential biomass combustion systems (based on a literature survey and on data available to the partners from national projects).
- **Test runs with different ESP systems**, which are either already available or close to market introduction. Most systems selected have been tested with old and in new biomass combustion systems.
- **Techno-economic analyses** of different filter technologies.
- **Compilation of application guidelines** for particle precipitation devices for residential biomass combustion systems.



WP4: Development of a specially designed condensing heat exchanger





WP4: Development of a specially designed condensing heat exchanger - objectives

- **Development of an appropriate calculation/simulation tool**
- **Design of the new condensing heat exchanger concept including a scrubber unit.**
- **Performance of test runs to evaluate the new technology.**
- **Techno-economic evaluation as well as comparison with conventional systems.**



Advantages of the international cooperation within the project

- **Retrospectively it has been confirmed that a project like FutureBioTec only can be performed on a broad international basis**
- **The intensive cooperation of 11 partners from 7 countries provided a clear benefit for all partners and the project as well**
 - **Broad knowledge and information basis for the compilation of the state-of-the-art reports**
 - **Intensive exchange regarding measurement and analyses methods and test stand setups**
 - **Consideration of the national constraints in different European countries**
 - **Knowledge and experience transfer between the partners**
 - **Merging of results of test runs performed with harmonised methods at the single partners as an output multiplier**



Acknowledgement

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Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten



Swedish Energy Agency



NCBiR – National Centre for Research and Development, Poland



Sustainable Energy Authority of Ireland





***Interested in the results achieved?
→ The workshop will show you***

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Workshop Programme (1)

SESSION 1: Reduction of PM, CO, OGC and NO_x emissions from wood stoves

- 09:40 Low emission operation manual for chimney stove users
(H. Hartmann, Technology and Support Centre of Renewable Raw Materials, DE)
- 10:10 Guidelines for low emission stove concepts
(J. Jokiniemi, University of Eastern Finland, FI)
- 10:40 Coffee break

SESSION 2: Reduction of PM and NO_x emissions from automated boilers

- 11:10 Strategies for low emission biomass furnaces based on advanced air staging
(T. Brunner, BIOENERGY2020+ GmbH, AT)
- 11:40 Low emission pulverised biomass fuel combustion systems
(T. Golec, P. Bocian, Institute of Power Engineering, PL)
- 12:10 Lunch



Workshop Programme (2)

SESSION 2: Reduction of PM and NO_x emissions from automated boilers (continued)

- 13:10 Relevant findings concerning the application of additives and fuel blending (*C. Boman, Umeå University, SE*)
- 13:40 Application of fuel blending and additives – results of test runs (*J. Finnan, J. Carrol, Teagasc, Crops Research Centre, IE*)
- 14:10 **Coffee break**

SESSION 3: PM emission reduction by secondary measures for residential biomass combustion systems

- 14:40 *State-of-the-art concerning particle precipitation devices for residential biomass combustion systems*
(*C. Mandl, BIOS BIOENERGIESYSTEME GmbH, AT*)
- 15:10 *Particle precipitation in a specially designed condensing heat exchanger* (*O. Sippula, University of Eastern Finland, FI*)
- 15:40 *Concepts for the design and application of particle precipitators for residential biomass combustion*
(*F. Niklasson, SP Technical Research Institute of Sweden, SE*)
- 16:10 *Summary and Conclusions*