

Clean biomass combustion in
residential heating:
particulate measurements,
sampling, and physicochemical and
toxicological characterisation
(BIOMASS-PM)

Jorma Jokiniemi
University of Kuopio



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Fine Particle and Aerosol
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Contents

- § General presentation of the project
- § Presentation of partners
- § Recent results: emissions from wood combustion



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General presentation of the BIOMASS-PM project



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Concerted action project

§ Duration: 15 months (1.1.2007-31.3.2008)

§ Project Coordinator:

Jorma Jokiniemi, PhD, professor (UKU)

§ General Secretary:

Kati Hytönen, MSc, research scientist (UKU)



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External funding by the national funders participating in the ERA-NET Bioenergy Programme

Country	2007	2008	Total
Finland (3 partners)	98 074	59 925	157 999
Austria (1 partner)	76 674	20 797	97 471
Germany (2 partners)	65 000	20 000	85 000
Sweden (4 partners)	89 775	31 050	120 825
Total (10 partners)	329 523	131 772	461 295



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Partners in BIOMASS-PM

FINLAND

- § Jorma Jokiniemi, Kati Hytönen & Jarkko Tissari, **University of Kuopio (UKU)**, Dept. of Environmental Science, Fine Particle and Aerosol Technology Laboratory, Kuopio, Finland
- § Raimo O. Salonen, Maija-Riitta Hirvonen, Marko Vallius, Arto Pennanen & Pasi Jalava, **National Public Health Institute (KTL)**, Dept. of Environmental Health, Kuopio, Finland
- § Risto Hillamo, Aki Virkkula, Sanna Saarikoski & Anna Frey, **Finnish Meteorological Institute (FMI)**, Air Quality Research, Helsinki, Finland

AUSTRIA

- § Ingwald Obernberger, Thomas Brunner & Joachim Friesenbichler, **Graz University of Technology (TUG)**, Institute of Resource Efficient and Sustainable Systems, Graz, Austria



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GERMANY

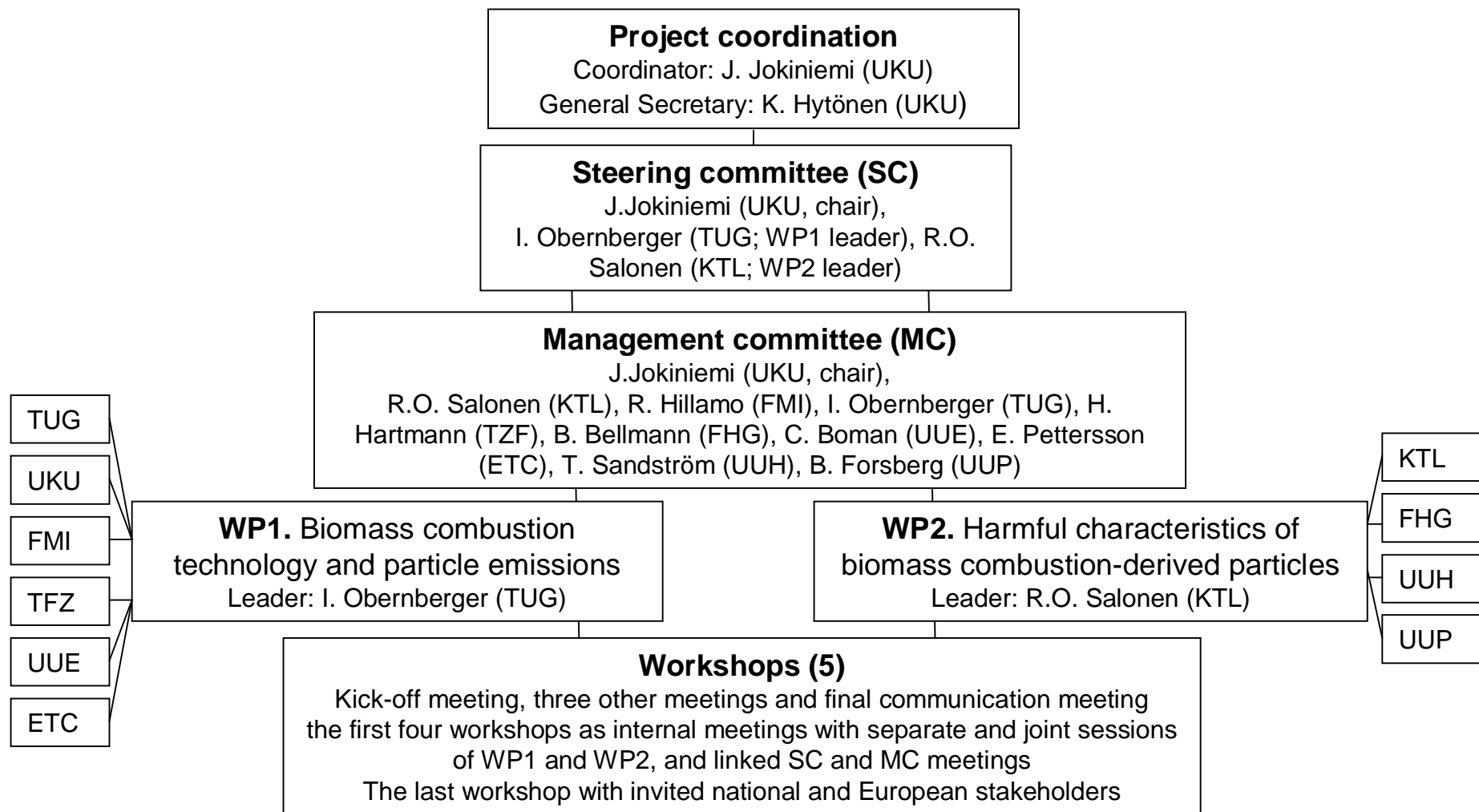
- § Hans Hartmann, Peter Turowski & Frank Ellner, **Technologie- and Förderzentrum Straubing (TFZ)**, Straubing, Germany
- § Bernd Bellmann, **Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V (FHG)**, Institute of Toxicology and Experimental Medicine, Hannover, Germany

SWEDEN

- § Christoffer Boman & Anders Nordin, **Umeå University (UUE)**, Energy Technology and Thermal Process Chemistry, Umeå, Sweden
- § Esbjörn Pettersson & Henrik Wiinikka, **Energy Technology Centre (ETC)**, Piteå, Sweden
- § Thomas Sandström, Anders Blomberg & Maria Sehlstedt, **Umeå University Hospital (UUH)**, Department of Respiratory Medicine and Allergy, Umeå, Sweden
- § Bertil Forsberg, **Umeå University (UUP)**, Department of Public Health and Clinical Medicine, Umeå, Sweden



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Background

- § Domestic biomass combustion has substantial contribution to $PM_{2.5}$ emissions in Europe
 - § Health effects associated with ambient $PM_{2.5}$ concentration
 - § Pressures in the EU to start regulation of combustion emissions
- § No common European test standards or regulatory limits
- § Source-specific characteristics of particulate matter harmful to health not well known
- § ***Focus of the project:*** residential biomass heating systems (<200 kW_{th})
 - § Mainly woody biomass, but also straw and other cultivated plants



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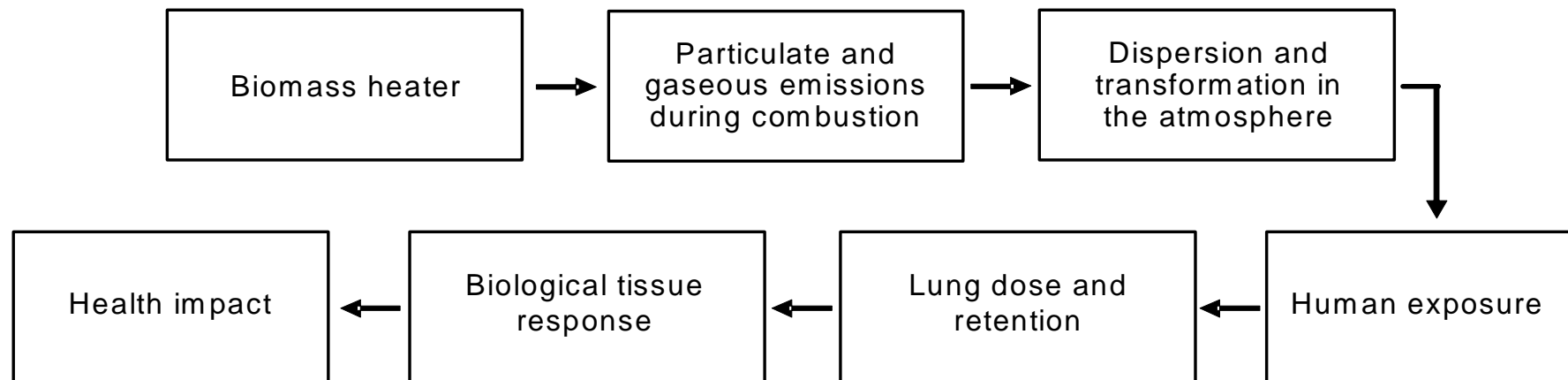
Objectives

- § Strengthen the interdisciplinary scientific evidence on the advantages of new combustion technologies and after-treatment in small-scale biomass heating systems
 - § Evaluate the present data on particle emissions and their health effects
 - § Evaluate current research methods used in this area
 - § Prepare **best practise procedure** for interdisciplinary evaluation of particle emissions



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Chain of events from heater emissions to health impact



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Workplan

Date:	Jan-April 2007	May-Aug 2007	Sept-Dec 2007	Jan-March 2008
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Workpackage	Period 1-4 months	Period 5-8 months	Period 9-12 month	Period 13-15 months
WP1: Biomass combustion technology and particulate emissions	Definition and division of tasks. Country reviews on current methods , protocols and data available on measurement, sampling and physicochemical analysis of particulate emissions.	Evaluation of the current methods and protocols used for measurement, sampling and physicochemical analysis of particulate emissions. Assessment of interfaces with ambient air quality impacts.	Definition of feasible methods and protocols to be used in future measurement, sampling and physico-chemical analysis of particulate emissions. Assessment of interfaces between the methods and with WP2.	Definition of the best practise guideline for the methods and protocols in measurement, sampling and physico-chemical analysis of particulate emissions. Setting targets for future research collaboration.
WP2: Harmful characteristics of biomass combustion-derived particles	Definition and division of tasks. Country reviews on ambient air quality and human exposure and health impacts as well as on current methods, protocols and data used in toxicological characterisation of particulate emissions.	Evaluation of the current methods and protocols used in toxicological characterisation of particulate emissions. Assessment of interfaces with ambient air quality and human exposure and health impacts.	Definition of feasible methods and protocols to be used in future toxicological characterisation of particulate emissions. Assessment of interfaces between the methods and with WP1.	Definition of the best practise guideline for the methods and protocols in future toxicological characterisation of particulate emissions. Setting targets for future research collaboration.

Management: - progress and cost reports to national funders as requested	Kick-off Workshop in Month 1 and 2 nd Workshop in Month 4; Consortium agreement on IPR.	3 rd Workshop in Month 8.	4 th Workshop in Month 12. Presentation of a mid-term progress report in ERA-NET Workshop in autumn 2007.	5 th Workshop in Month 15. Draft of a common Final Report in English.
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Milestones:	Country reviews completed.	Methodological evaluation completed.	Definition of feasible methods and protocols.	Best practise guidelines for studies on biomass combustion technology, particulate emission and toxicology
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Deliverables:	Establishment of public website, PowerPoint presentations to stakeholders.	Update of website information according to project progress.	Project mid-term report at the website and as PowerPoint presentations to stakeholders.	Common Final Report in English (public) and its wide communication.
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Innovative contribution of the project

- § Multidisciplinary scientific basis for a European-wide harmonisation of the emission test methods and procedures for residential biomass heating systems
- § Future research collaboration between partners in the 7th Framework Programme of the European Commission



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Communication of project outcomes

- § Website (www.biomasspm.fi)
 - § objectives, work content, funders, progress
- § National advisory committee meetings
 - § final communication workshop
- § European-wide harmonisation of the emission test methods and procedures
 - § CEN; e.g. EC-DG Environment, EC-DG Research, WHO, Nordic Council of Ministers, scientific congresses
- § Conference abstracts and articles
- § Final report, review papers, media



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Progress so far

- § I Kick-Off workshop in Kuopio 8.-9.2.2007
 - § 9 partners participated, 21 participants
 - § overview of partners' research related to workpackages
- § Web site www.biomasspm.fi
- § Co-operation agreement
 - § signed

- § II workshop in Straubing, Germany 12.-13.6.2007
- § III workshop in Umeå, Sweden 8.-9.10.2007
- § IV workshop in Graz, Austria 18.-19.1.2008
- § Final workshop in Helsinki, Finland 27.-28.3.2008



Final report by end of June 2008

Public Final Report on:

Recommendations of Best Practices to
Measure Fine Particle Emissions and Properties
as well as Health Related Issues from Small
Scale Biomass Combustion



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Presentation of the partners in BIOMASS-PM project



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Graz University of Technology
**Institute for Resource Efficient
and Sustainable Systems**



Research Group: Thermal Biomass Utilisation

Project leader: Ingwald Obernberger
Scientific personnel involved: Thomas Brunner
Joachim Friesenbichler

Working fields:

- § Biomass fuel and ash characterisation
- § Development as well as technological and ecological optimisation of biomass combustion and CHP plants
- § Research on formation and control of emissions, especially particulate and NO_x emissions, from biomass combustion
- § CFD simulation of biomass combustion and gasification plants
- § Research on the behaviour of ash forming elements in biomass combustion / gasification processes
- § Development of measurement devices especially for high temperature in-situ gas phase measurements and high temperature particle sampling



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University of Kuopio, Finland

Jorma Jokiniemi, Kati Hytönen, Jarkko Tissari

We study emissions from wood combustion

- § various appliances
(eg. masonry heaters, sauna stoves)
- § various fuel
(eg. logs, pellets, new biofuels)
- § reduction of particle emissions
(eg. heat exchanger)
- § measurement techniques
(eg. sampling, dilution)



Laboratory test stand at Microteknia, Kuopio

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Aerosol Research

Air Quality, Finnish Meteorological Institute (FMI), Finland
Risto Hillamo, Karri Saarnio, Anna Frey, Hilikka Timonen

We study chemical and optical properties of aerosol particles

- § Chemical methods in wood burning measurements
 - § Thermo-optical carbon analysis for determination of elemental and organic carbon (EC/OC)
 - § Water-soluble organic carbon (WSOC) analysis by TOC- V_{CPH}
 - § Inorganic ions and some organic acids analyzed by ion chromatography (IC)
 - § Determination of monosaccharide anhydrides (e.g. levoglucosan) by LC-MS
 - § Elemental analysis by ICP-MS



Cleanroom laboratory for IC and WSOC analyses at FMI, Helsinki

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Technology and Support Centre (TFZ) Straubing, Germany

Hans Hartmann, Peter Turowski, Frank Ellner, Paul Roßmann

Combustion related research topics:

- § characterisation of fine particles from biomass combustion (pellet, wood chips, logs, grain, straw, etc.)
- § reduction of particle emissions (by flue gas condensation, filtration, electrostatic precipitation)
- § fuel and user-specific impacts on particle and gas emissions
- § measurement techniques (e.g. dilution, rapid testings)



Laboratory test stand at TFZ,
Straubing

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Energy Technology and Thermal Process Chemistry

University of Umeå, Sweden

Christoffer Boman

Research activities related to (PM) emissions from residential biomass combustion

- § Emission measurements (gases and particles)
- § PM characterization (inorganic and organic)
- § Ash chemistry/transformation (slag, deposits, aerosols)
- § Technology and fuel testing/development
- § Human exposure and toxicology studies



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Energy Technology Centre

Piteå, Sweden

Esbjörn Pettersson, Henrik Wiinikka

Particles from wood combustion

- § Detailed studies of particle formation mechanism (soot and ash)
- § Influence of process/fuel parameters on the chemical and physical characteristics of combustion aerosols
- § Practical minimisation of particle emissions from small scale appliances (design optimisation and additives)
- § Methods for reduction of particle emissions (e.g. with a centrifugal separator)



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National Public Health Institute (KTL)

Department of Environmental Health, Kuopio, Finland

Raimo O. Salonen, Maija-Riitta Hirvonen, Marko Vallius, Arto Pennanen, Pasi Jalava, Mikko Happonen

- § Development and validation of a high volume cascade impactor with Harvard and the Finnish Meteorological Institute (FMI) for large-capacity, size-segregated PM sampling
- § Ambient air PM sampling campaigns (PAMCHAR-EU, PAMCHAR-FI) together with the Finnish Meteorological Institute (FMI)
(eg. Impacts of small-scale wood heating, long-range transport of forest fire smoke, European regional and seasonal contrasts)
- § Controlled wood combustion experiments with the UKU emission team in the FINE laboratory in Kuopio
(eg. Good vs. poor combustion in one masonry heater)



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Department of Respiratory Medicine and Allergy

Umeå University Hospital, Sweden

Thomas Sandström, Anders Blomberg, Maria Sehlstedt

Experimental studies in humans

- § ozone, diesel exhaust
 - § respiratory and cardiovascular end points

- § pilot studies with wood smoke
 - § chamber set-up developed
 - § PM deposition
 - § oxidative stress in airway lavage fluid



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Dept. of Public Health and Clinical Medicine

Umeå University, Sweden

Bertil Forsberg

We study epidemiology of air pollution health effects

Participation in several European multicentre panel studies on the exposure-response relationships of air pollutants (mostly PM)
(eg. Mortality, hospital admissions etc.)

Air quality monitoring campaigns and follow-up of asthmatic subjects in Lycksele, SE, favouring domestic wood combustion



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Department of Inhalation Research

Fraunhofer Institute of Toxicology and Experimental Medicine, Hannover, Germany

Bernd Bellmann, Otto Creutzenberg, Jan Knebel

Studies on toxic and carcinogenic effects in rodents

§ Complex aerosols
(eg. Flyash samples, car exhaust, asphalt fumes)

In Vitro Studies

§ Complex aerosols
(eg. flyash of biomass combustion, diesel exhaust)



Nose-only inhalation unit for rats

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Muita aiheeseen liittyviä projekteja

- § PUPO+PUPO-Terveys, Rahoitus: Tekes-ministeriö-yritykset, Tutkimusosapuolet: KTL, VTT, IL, KY
- § PUPO-Poltto (2008-2010), Rahoitus: Tekes-ministeriö-yritykset
Tutkimusosapuolet: KY, KTL, IL
- § BioHer (2008-2011), Rahoitus: Suomen Akatemia-SusEn
Tutkimusosapuolet: KY, KTL, IL
- § Biodiesel+Biodiesel-Terveys (2006-2009), Rahoitus: Tekes-ministeriö-yritykset, Tutkimusosapuolet: KY, VTT, TTY, KTL



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