



**Hilton Hotel, Innsbruck, Austria
Tuesday 27 September – Friday 30 September 2005**

Meeting Report



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Health, Safety and Environment in Biomass Gasification

Joint Workshop in Innsbruck on September 28, 2005

By Stefan Fürnsinn, TUV, Austria and Ruedi Bühler, Umwelt and Energie, Switzerland

Biomass gasification is a promising technology, which has the potential to make a significant contribution to the development of tomorrow's energy systems. To this end, however, renewability and conversion efficiency must be supplemented by operational safety as well as environmental compliance, in order to attract investors and bring biomass gasification to the stage of broad commercialisation. Today, health, safety and environmental (HSE) issues are recognised as a major barrier in the deployment of the technology, since dealing with HSE risks currently lacks adequate understanding by virtually all actors involved. The judgement of risk along with precautionary measures and effective counteraction in cases of emergency must therefore be systematically analysed.

For these reasons, both task 33 of IEA Bioenergy (Thermal Gasification of Biomass) and GasNet health, safety and environmental aspects of biomass gasification have received growing attention. In a joint effort, IEA Bioenergy and GasNet aim to create awareness of HSE issues, with the goal of eventually establishing a "state of the art procedure" to assess and improve operational safety and long-term reliability of gasification plants. To this end, it was decided to organise a joint workshop, which would review the status quo of HSE and interrelated aspects in biomass gasification, collect and organise existing information, as well as enhance mutual understanding of manufacturers, permitting authorities, engineers and scientists. Concerning the scope of discussion, the investigation of biomass gasification plants up to a thermal power of up to 5 MW was chosen.

The workshop was held at the Hilton Innsbruck on September 28, 2005 to coincide with the last ThermalNet meeting. Contributions from various European countries addressed topics ranging from the impact of gaseous emissions, liquid waste formation, treatment and avoidance, as well as risk assessments to aspects concerning the legal basis and required documentation for permitting procedures. The workshop was split into three sessions, including presentations and panel discussions.

Especially within these panel discussions, much insight into the actual problems of producers and operators of gasification facilities was gained and future activities were addressed. Specifically in relation to gaseous emissions such as CO and NO_x regulations differ within Europe. While strict limits certainly prevent environmental harm, they severely restrict the commercialisation of gasification plants, as cleaning requirements may have negative effects on profitability. Moreover, the discussion

showed that complete knowledge of the exact damage gaseous emissions cause to the environment is scarce and that analytical methods currently in use may need revision in the future.

Similarly, there was consensus on the expediency of concise and clear standards concerning risk management of gasification plants. In addition, adequate documentation on permitting requirements which could be utilised by operators and producers and thus facilitate commissioning, is not currently easily available or accessible. Since risk is difficult to standardise, documentation is typically either incomplete or voluminous and therefore hard to use. However, as more gasification plants enter large-scale operation, authorities will become more familiar with the technology and knowledge of both risk assessment as well as permission requirements, which will therefore become more easily available, giving further impetus to the commercialisation of this promising technology.

Please note: Full proceedings of the workshop are available as a pdf if required and will soon be available on the GasNet website

WP3C Education & Training workshop Minutes of the meeting held in Innsbruck

David Chiaramonti

The meeting was opened by Dr. Chiaramonti with a presentation about the WP. The main issues presented were the following:

ThermalNet Objectives

Overview on WP 3C Education and Training

Survey of existing needs

Overview of Educational Activities

Report about meeting with UN – FAO

Collaboration with NoE

Activities of UNESCO

Pro-Aere Leonardo Project

Thermalnet Education and Training Web Site

Education and Training in Italy

The presentation was followed by a discussion among the ThermalNet partners, that offered their availability to contribute to the surveys as well as to disseminate the information among their contacts.

A separate meeting with the experts was then implemented. Participants were: Tony Bridgwater, Crystal Luxmore, Colomba di Blasi, Morten Groenli and the WP 3C coordinator David Chiaramonti.

The content of the two surveys (Existing needs in Education and Ongoing educational activities) was discussed and partners' comments taken into account in reviewing the structure of the surveys.

The possibility of sending the surveys by fax/email or installing the entire questionnaires on the web in an interactive form was discussed. After having considered pro and contra of each solution, it was finally decided for the second option (web). The reviewed questionnaires will be therefore the basis for the subsequent implementation on the web of these forms.

A draft web page for the WP 3C, linked to the main ThermalNet home page, was also presented.

Summary of workshop on technical and non-technical barriers to bioenergy implementation Innsbruck, 28-30 September 2005

Patricia Thornley

Around 40 people participated in the workshop, mainly from the academic research community; but with some industry representation. There were 3 main elements to the workshop:

Interactive identification, classification and prioritisation of barriers by the participants

Presentation of a literature survey of previous work on bioenergy barriers

Discussion of key barriers and how they could be addressed

By the end of the afternoon the following key barriers had been prioritised by the Thermalnet group:

Government policy - inconsistent, incompetent etc.

Perceived lack of economics

Competing with conventional energy prices

Economic uncertainty

Awareness of importance

It was noted that not all of these barriers apply to all of the technologies and there are national differences. Further discussions concluded that participants considered a long term, stable policy environment to be the key barrier to bioenergy implementation, which could provide an economic climate conducive to further bioenergy development. Technical and environmental issues were not considered particularly significant barriers, as progress was already being made in these areas. Although not rated particularly highly in the plenary session, a number of social issues were identified by a smaller group which were considered important, particularly in the UK and US. These revolved around public perceptions and misconceptions related to bioenergy and included associations with waste and a lack of awareness and enthusiasm. Again national variations were noted, but improved industry communications and public education were considered important. Closer consideration of economic issues led to the conclusion that currently high oil prices were helping improve bioenergy competitiveness, but that plant capital expenditure was still an issue, particularly for more complex plants and when financial support was required for “first of their kind plants”. Related to this, another group focused on the lack of successful market implementation to date, which impinged both on economic and social perception issues. Improved links with industry were considered important here.

ThermalNet/IEA Bioenergy/OptiComb workshop Modeling and process control of grate furnaces September 28, Innsbruck, Austria

Introduction, Sjaak van Loo

Sjaak van Loo, coordinator of the combustion technology section of ThermalNet (CombNet), welcomed all participants (approx. 25) and speakers to the workshop. In this workshop, recent developments in the modelling and process control of grate furnaces are presented.

This workshop was organised with key inputs from the EU-OptiComb project and IEA Bioenergy Task 32 (Biomass Combustion and Cofiring). The coordinator of OptiComb (Robert van Kessel) is also active as expert in CombNet.

Over the whole project duration (2005-2007), CombNet will facilitate and co-organise at least three workshops, as shown below:

Organisers	Topic	Date, venue
ThermalNet Opticomb IEA Bioenergy Task 32	Modelling and process control of grate furnaces	September 28, 2005, Innsbruck, Austria
ThermalNet IEA Bioenergy Task 32	Small combustion systems	October 21, 2005, Paris, France
ThermalNet IEA Bioenergy Task 32	Biomass/coal co-firing	Autumn 2006, Glasgow, UK

By far the largest share of all combustion installations for biomass and/or waste are equipped with a grate furnace. Grate furnaces are appropriate for biomass fuels with a high moisture content, varying particle sizes (with a downward limitation concerning the amount of fine particles in the fuel mixture), and high ash content. In practice the variability of the fuel may however result in fluctuations in combustion conditions, which may in return lead to ash related problems and fluctuations in steam production.

In order to further lower emissions and costs while increasing combustion efficiency and stability of the combustion process, it is important that the combustion process is understood in detail. Recently detailed static and dynamic combustion models have been developed that describe the combustion of the fuel layer on the grate, as well as the reactions in the gas phase. Using this knowledge it is possible to design advanced combustion control mechanisms that significantly improve the combustion process.

Combustion on a grate: dynamic modelling, process identification and process control

Robert van Kessel, TNO, the Netherlands

Robert van Kessel (R&D manager at TNO Science and Industry, Netherlands) presented the work done in the European OPTICOMB project, which provided significant inputs to this workshop, and then focused on work done at TNO. The overhead sheets presented are included in **Error! Reference source not found..**

The EU OptiComb project aims at improving the design of grate furnaces, in order to improve efficiency, lower emissions and improving controllability of the combustion process. TNO coordinates this project, in which 7 partners participate, including an equipment manufacturer Vyncke and an actual combustion unit in the Netherlands. The majority of the work that is presented in this ThermalNet workshop is derived from this EU project.

TNO's role in OptiComb is related to the development, validation and application of a dynamic model for grate systems. TNO has an extensive background and experience on

this topic, particularly in the area of incinerators for municipal solid waste. Having available a reliable and accurate dynamic model for grate furnaces makes it possible to design more accurate control systems, leading to stabilized combustion conditions and steam production.

An interesting spin-off of the work done is the development of an on-line calorific value soft sensor, which can be applied to evaluate the calorific value of the fuel instantaneously as it is burning on the grate. While conventional control systems are based on the steam production, having data on the heating value available earlier makes it possible to anticipate future process variations and effectively interact with the process to further stabilize the process.

Characterisation of N-release from a biomass fuel layer by pot furnace experiments and derivation of release functions

Selma Zahirovic, Graz University of Technology, Austria

Selma Zahirovic presented the results of experimental work performed on a pot furnace, in order to derive relations of nitrogen release as a function of different parameters such as process conditions and fuel composition. This work was done using a pot furnace, to simulate what is actually happening in a (packed-bed) grate furnace. The work aimed at obtaining information about the flue gas composition above the fuel layer, and quantifying the rate of production of flue gas species dependent on variation of bed parameters with special attention on the release of NO_x precursors. The overhead sheets presented are included in **Error! Reference source not found.**

In the experiments, NH₃ was found to be the main NO_x precursor when MDF board and bark were used as fuel. In case of sawdust, NH₃ and HCN were found to be the main precursors.

Good quality experimental data was obtained that enabled the correlation of release of NO_x precursors as a function of fuel and bed parameters. The empirical N-release functions that were obtained were of great value to develop both CFD models to describe the gas phase, as well as the fuel layer models of TU Graz and TNO.

CFD modelling of NO_x formation in biomass grate furnaces with detailed chemistry

Selma Zahirovic, Graz University of Technology, Austria

In her second presentation, Selma Zahirovic presented a 3D CFD NO_x postprocessing model which was developed particularly for biomass grate furnaces. Initially an existing empirical model for fixed beds was extended by describing release of N species which are relevant for NO_x formation, based on pot furnace experiments. The CFD model that

describes the gas phase formation of NO_x in a postprocessing calculation module was based on the Eddy Dissipation Concept and includes the Kilpinen 92 mechanism.

The resulting computer model describes both release of NO_x precursors from the fuel bed as well as NO_x formation in the gas phase. Validation of the model using FTIR measurements in a 440 kW_{th} pilot scale furnace with horizontal boiler passes showed very good agreement of measured and calculated NO_x emissions at the boiler outlet for different primary air ratios. Validation in a 7.2 MW_{th} industrial scale plant with vertical boiler passes showed that measured NO_x emissions are lower than calculated NO_x emissions. An anticipated reason is be calculation errors in the Eddy Dissipation Model for the primary combustion zone, resulting in wrong prediction of hot spots which cause thermal and/or prompt NO_x. Still, model prediction showed better results than literature data.

It was concluded that the newly developed NO_x postprocessing calculation unit gives results which are in good qualitative agreement with measurements under different operation conditions. To shorten calculation time, a reduced NO_x mechanism is currently being developed.

Biomass combustion on grates and NO_x formation mechanisms

Claes Tullin, SP, Sweden

Whereas most of the work on NO_x formation in fixed bed furnaces sofar has focused on the gas phase, Claes Tullin (SP, Sweden) presented recent work done on formation of NO_x inside the fuel bed. An experimental rig was used to describe the properties of the propagating ignition front in terms of temperature and gas composition inside the bed.

Concentrations of different gas components (both major species as well as nitrogen compounds) were obtained using a suction probe inside the bed. These measured concentrations were confirmed by mass balance calculations, assuming that hydrogen, nitrogen and tar concentrations (which were not measured) close the mass balance.

The measurements concluded that fuel nitrogen is the major source for NO_x formation, with NH₃ as major precursor. This observation was also made in the work of TUG. At the temperatures measured inside the bed, thermal and prompt NO_x formation mechanisms are much less relevant.

Please note: A full report and copies of all the presentations are available on the CombNet website

Liquid Fuels Workshop

Harold Boerrigter

- Prospects of upgrading bio-oil to transport fuel quality, Tony Bridgwater
- Economics of large-scale synthetic biofuel production, Harold Boerrigter

In the ***second meeting (Innsbruck)*** the technology option to upgrade pyrolysis oil and bio-crude to car engine diesel fuel specifications was discussed in more detail based on a presentation of Tony Bridgwater. It was concluded that it is not (yet) a technically feasible approach (*i.e.* suitable for large commercial systems) to upgrade pyrolysis oil and bio-crude to car engine diesel fuel specifications and therefore, these routes would also be given less attention.

Harold Boerrigter organised a mini-workshop with an interactive model to study the effect of scale on the production costs of Fischer-Tropsch fuel from biomass. It was shown that scales over 1-2 GW are required to cost effectively produce transport fuels for biomass. The simple reason for this is that the capital costs of synthetic fuel production (either FT, MeOH, DME, etc.) are the dominant factor in the final fuel costs (*i.e.* one billion dollar for a 34,000 bbpd GTL plant). As capital costs decrease with a scale-factor of ~ 0.7 , it is clear that small(er) plants are economically unfavourable. Feedback from the workshop was incorporated in the ECN report "*Economy of Biomass-to-Liquids (BTL) plants; An engineering assessment*".