PyNe

April 2004 ISSUE 17

Fast Pyrolysis Studies at Lowa State University
on page 4

Bioware Process – a Fast Pyrolysis Technology for Biomass Developed in Brazil
on page 8

First Torrefied Wood Successfully Co-Fired
on page 12

New Ablative Pyrolyser in Operation in Germany

By Dr Dietrich Meier, BFH-Institute for Wood Chemistry, Germany; Mr Stefan Schoell and Mr Hannes Klaubert, PYTEC, Germany

PYTEC Plant.

A new private company was founded in 2002 to produce bio-oil from biomass – PYTEC Thermochemische Anlagen GmbH (www.pytecsite.com). PYTEC is based in Lüneburg, 30km south-east of Hamburg and is a subsidiary of TEC (www.tecsite.de). PYTEC has designed, built and now operates a new ablative pyrolyser at laboratory scale with a nominal capacity of 15 kg/h.

The pyrolyser consists basically of a rotating, vertically orientated, electrically heated disk. Solid wood boards with a cross sectional area of 10 x 47 mm and a length of approximately 350 mm are pressed against the disk by a piston. The pressure ranges between 30 and 50 bar, and the heated disk temperature is approximately 700°C. A special automated feeding system consisting of four supply towers, makes sure that four boards are introduced simultaneously into the reactor chamber. Ablation rates between 2.0-5.5 mm/s have been achieved so far. Gas cleaning and condensation is accomplished with standard techniques such as cyclone, spray tower and electrostatic precipitator. Oil yields are measured directly through weight sensors on the collection vessel and are between 55 and 70% on dry feed basis.

Continued on page 3.

Hannes Klaubert, Stefan Schoell and Dietrich Meier at the PYTEC Plant.

Don't forget the Science in Thermal and Chemical Biomass Conversion

Further details on page 5.

Contents

Co-ordinator
Tony Bridgwater

Events Organiser
Emma Wylde

Newsletter & Website Administrator
Claire Humphreys

Bio-Energy Research Group,
Aston University, Birmingham B4 7ET.
UNITED KINGDOM.
Tel +44 121 359 3611
Fax +44 121 359 6814

Email a.v.bridgwater@aston.ac.uk
c.l.humphreys@aston.ac.uk

Website http://www.pyne.co.uk

ISSN 1470-3521

Supergen on Bio-Energy

By Tony Bridgwater, Aston University, UK

Introduction

The SUPERGEN Biomass, Biofuels and Energy Crops Consortium was created by EPSRC (Engineering and Physical Sciences Research Council in the UK) to encourage the development of sustainable power generation and supply. The project, funded by a £3million (€ 4.5 million) EPSRC grant, will carry out research into renewable energy generation from biomass. The Consortium is managed by Aston University with the University of Leeds as the finance hub and the Universities of Cranfield, Sheffield, Ulster and UMIST, and Rothamsted Research and the Institute of Grassland and Environmental Research. The industrial partners are Powergen, Alstom, Rural Generation Ltd and Exus Energy Ltd.

Objectives

The overall objectives are:

- To undertake leading edge R&D initiatives in the bio-energy chain, from biomass production through conversion to utilisation with a particular focus on interfaces and optimisation of existing schemes and new concepts,
- To build closer and more effective bridges between the emerging bio-energy industrial sector and the wide ranging academic research so that rapid implementation and commercial exploitation can take place,
- To provide a well qualified pool of high quality expertise to service the bio-energy sector,
- To establish a forum to provide industry and academia with an opportunity to learn about new developments in bioenergy nationally and internationally.

SUPERGEN bio-energy provides a new opportunity to address the complete bio-energy chain that begins with biomass in the field or forest and progresses through all stages of handling, preparation, conversion and utilisation for electricity generation. It will enable all the interface issues that have been poorly considered in the past to be properly and thoroughly assessed and, through interactions with industry, will provide the UK with a unique opportunity to create a global centre of excellence in bio-energy.

The structure and content of the scope of work is described in Figure 1, in which the key themes are the interfaces between the three main components of a bio-energy system – biomass production, thermal conversion and utilisation of the resultant bio-fuels – and between each of these areas and the environment in its broadest sense.

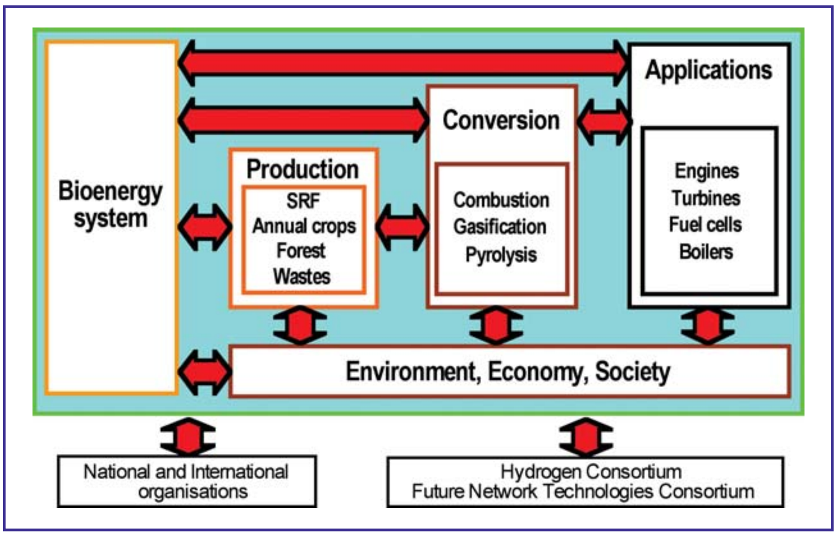

Figure 1: Structure and Content.

Pyrolysis

In the area of fast pyrolysis, the following activities will be undertaken:

- Establish pyrolysis characteristics of different forms of biomass to establish a relationship between the biomass and its pyrolysis products,
- Evaluate the pyrolysis characteristics of biomass that has been manipulated to have lower lignin content and lower ash content,
- Establish a relationship between bio-oil characteristics and process parameters to improve oil quality and derive relationships that lead to improved process and product control techniques,
- Improve bio-oil properties by developing the pyrolysis process, by including catalysts for managing lignin cracking and by fitting a hot vapour filter to a laboratory pilot plant to reduce char in bio-oil and crack lignin to a lower viscosity oil with enhanced stability,
- Carry out co-firing tests on bio-oil in a coal and gas fired boiler,
- Construct CFD and reaction models of fast pyrolysis to aid scale-up and process design and optimisation,
- Carry out technical and economic assessments of fast pyrolysis processes in stand-alone and co-firing modes that also consider the potential of decoupling liquid bio-oil production from utilisation in power generation systems.

British Bioenergy News

Fuller details are in British Bioenergy News, copies of which can be obtained from Aston University Bio-Energy Research Group or via the website www.SUPERGEN-bioenergy.net.uk.

For further details contact:

Professor Tony Bridgwater
Aston University
Bio-Energy Research Group
Chemical Engineering and Applied Chemistry
Aston Triangle
Birmingham
B4 7ET
UK
Tel: +44 121 359 3611 ext 4647
Fax: +44 121 359 6814
Email: a.v.bridgwater@aston.ac.uk

Continued from page 1.

New Ablative Pyrolyser...

Based on these encouraging results, a project was started early in 2004 to design and construct a pilot plant with a capacity of 6 tonnes per day on a site of a sawmill to process wood wastes. The oil will be combusted in an engine of a small CHP plant.

The project is financially supported by Germany's foundation for environment (DBU) Osnabruck, and the Ministry for Environment of the federal state government of Lower Saxony, Hannover. Commissioning is planned for the end of 2004. A schematic picture of the total system is shown in Figure 1.

The motivation for PYTEC to start pyrolysis business are the promotion of biomass for energy, the attractive incentive programmes for power production from renewable sources and the participation in new German projects for bio-oil gasification with subsequent synthesis to methanol or Fischer-Tropsch hydrocarbons for renewable transportation fuels.

For further details contact:

Mr Stefan Schoell, (Manager),
Mr Hannes Klaubert, (Engineer),
Bahnhofstr. 7
D-21337 Lüneburg
Germany
Tel: +49 (0)40 734 30 808
Fax: mail@pytecsite.de
Email: www.pytecsite.com

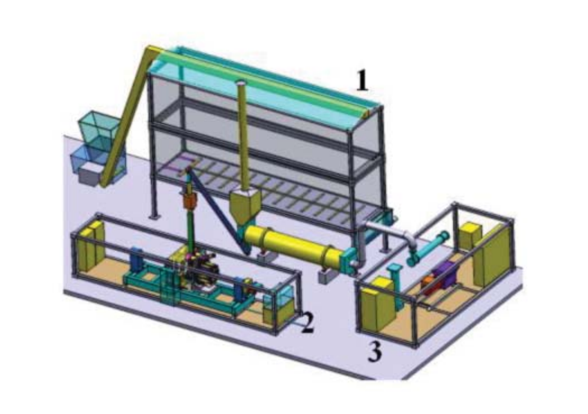

Figure 1: Schematic of the feeding system (1), ablative pyrolyser (2) and CHP plant (3).

Fast Pyrolysis Studies at Iowa State University

By Robert C Brown, Iowa State University, USA

The Centre for Sustainable Environmental Technologies (CSET) at Iowa State University (ISU) is conducting research on fast pyrolysis using a small pilot-plant reactor system that processes about 5 kg/h of biomass. As illustrated in Figure 1, the system consists of a dual auger feed system, a 16.2 cm diameter pyrolysis reactor, a gas burner to externally heat the reactor to 450°C, a pair of gas cyclones to remove particulate matter, and a novel selective condenser designed to fractionate the oil. A number of feedstocks have been tested including pine and oak wood, cornstover, oat hulls, and corn starch achieving bio-oil yields up to 70 wt-%. The system is located at the Biomass Energy Conversion Facility (BECON), a research facility owned and operated by the Iowa Energy Centre that is conveniently located near the ISU campus (www.energy.iastate.edu).

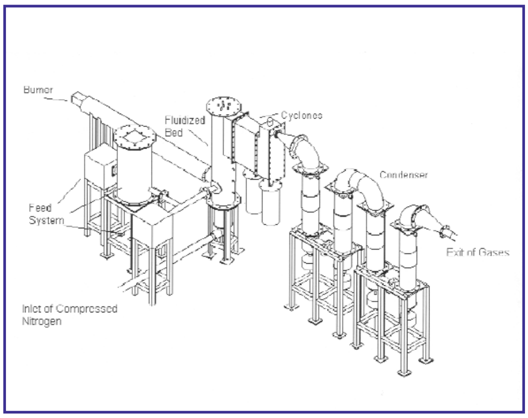

Figure 1: Drawing of fast pyrolysis system.

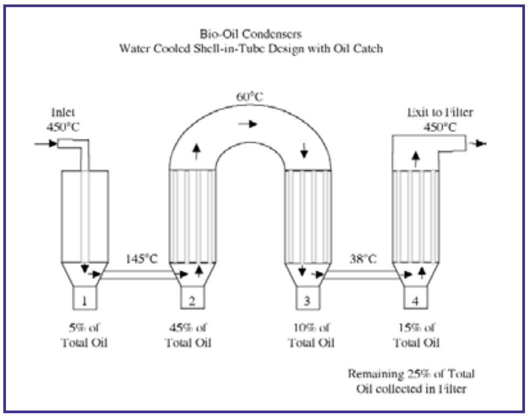

Figure 2: Drawing of condensers with operating conditions.

Recent experimental studies have investigated the enthalpy for pyrolysis of various feedstocks, the transport phase of bio-oil the pyrolysis reactor, the feasibility of hot vapour filtration of particulate matter from the bio-oil, and the behaviour of the selective condenser. Enthalpy for pyrolysis was determined through mass and energy balances on the pilot plant, with careful accounting of energy loss from the system. This study revealed enthalpies for pyrolysis ranging from 0.78 MJ/kg for oat hulls to 1.64 MJ/kg for pine wood (dry basis).[1]

Measurements of pressure drop across a section of pipe exiting the pyrolyzer have been used to deduce whether bio-oil is transported as aerosols or vapour before being collected as liquid, a question that has been debated in the pyrolysis community for several years. These experiments found that starch yielded mostly vapours while lignin-containing feedstocks released bio-oils predominately as aerosol.[2] Interestingly, the installation of screens in the freeboard of the reactor appeared to promote vapourisation of this aerosol. We are developing moving bed granular filters for removing particulate matter from hot vapour/aerosol streams before the bio-oil is condensed. Success in this endeavour is expected to improve quality and stability of bio-oil.[3] As shown in Figure 2, preliminary studies with the selective condenser give encouragement that it can fractionate bio-oil in the process of recovering it. Although detailed analysis of oil fractions have yet to be performed, we have observed that the most viscous fractions are recovered in the first stage of condensing while most of the water is recovered in the third stage.

We have also performed system studies of fast pyrolysis technology. An early study investigated the feasibility of pretreating biomass to maximise the production of anhydrosugars followed by hydrolysis and fermentation to ethanol. The economics of this process appear to be comparable to acid or enzymatic hydrolysis of holocellulose.[4] Another study was a preliminary design assessment of an integratedpyrolysis/combined cycle (IPCC) power plant. The efficiency and cost of such a system in the10 MW_e size range was attractive compared to steam cycles.[5]

Our research has been supported by the Iowa Energy Centre, the U.S. Department of Energy, and the U.S. Department of Agriculture. Industry partners include Alliant Energy, Black and Veatch, Dynamotive Corporation, John Deere Company, and Cargill. More details can be found at www.csetweb.me.iastate.edu.

For further details contact:

Robert C. Brown
Bergles Professor in Thermal Science
Department of Mechanical Engineering
Professor, Department of Chemical Engineering
Director, Centre for Sustainable Environmental Technologies
Iowa State University
286 Metals Development Bldg.
Ames, IA 50011
Tel: +1 515-294-7934
Fax: +1 515-294-3091
Email: rcbrown@iastate.edu
Websites: http://www.me.iastate.edu/rcbrown
www.csetweb.me.iastate.edu/

References

[1] Daugaard, D. E. and Brown, R. C., 'Enthalpy for pyrolysis for several types of biomass,' Energy and Fuels 17, 934-939, 2003.

[2] Daugaard, D. E. and Brown, R. C., 'The transport phase of pyrolytic oil exiting a fast fluidized bed reactor,' Science in Thermal and Chemical Biomass Conversion Conference, Victoria, B.C., Canada, Aug. 30 – Sept. 2, 2004.

[3] Ritzert, J., Brown, R. C., and Smeenk, J., 'Filtration efficiency of a moving bed granular filter,' Science in Thermal and Chemical Biomass Conversion Conference, Victoria, B.C., Canada, Aug. 30 – Sept. 2, 2004.

[4] So, K. and Brown, R.C., 'Economic analysis of selected lignocellulose-to-ethanol conversion technologies,' Applied Biochemistry and Biotechnology, 77-79, 633-640, 1999.

[5] Sandvig, E., Walling, G., Daugaard, D. E., Pletka, R., Radlein, D., Johnson, W., Brown, R. C., 'The prospects for integrating fast pyrolysis into biomass power systems,' International Journal of Power and Energy Systems, to appear 2004.

Figure 3: Sample of bio-oil produced in pilot plant.

Figure 4: Fast pyrolysis pilot plant.

Science in Thermal and Chemical Biomass Conversion

Fairmont Empress Hotel, Victoria, BC, Canada

30 August to 2 September 2004, Victoria Conference Centre and Fairmont Empress Hotel Victoria, Vancouver Island, BC, Canada

This sixth international conference in the thermo-chemical biomass conversion series follows on from Tyrol in 2000, Banff in 1996, Interlaken in 1992, Scottsdale in 1988 and Estes Park in 1982. It is now well established as the premier international research meeting in all aspects of thermal and chemical biomass conversion, and serves to provide a global forum in this area for all those involved in research as well as those interested in following developments in this increasingly important topic.

This conference will reflect the progress made since the last meeting in Tyrol four years ago, concentrating this time on the science that underpins all successful bio-energy projects. Topics will include all scientific, technological, environmental, economic and commercial aspects of thermal and chemical biomass conversion.

210 abstracts have been offered in feed preparation, combustion, gasification, pyrolysis, supercritical and hydrothermal processing, bio-diesel, and system studies which will result in a comprehensive an exciting programme. Details are on the website.

Conference Chairs

Tony Bridgwater, UK
(a.v.bridgwater@aston.ac.uk)
David Boocock, Canada
(boocock@chem-eng.utoronto.ca)

Conference Secretariat

Emma Wylde, UK (e.wylde@aston.ac.uk)
Bio-Energy Research Group, Aston University,
Birmingham B4 7ET, UK
Tel: +44 (0)121 359 3611,
Fax: +44 (0)121 359 6814
Website: http://www.stcbc.com

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Fast Pyrolysis of Biomass with a Twin Screw Reactor – a First BTL Step

By Edmund Henrich, Forschungszentrum Karlsruhe GmbH, Germany

Two-step BTL process

In larger central plants the economy of scale makes biomass conversion into tailored synfuels more economic. However, the low bulk density of straw bales or wood residues causes high transport and handling costs. This problem is being considered in a two-step process under development at the Karlsruhe research centre. Biomass is first liquefied by fast pyrolysis in distributed or decentralised facilities. Surplus pyrolysis char is pulverised and suspended in the pyrolysis liquid. The dense but pumpable slurries are easily stored, transported and finally pumped into a pressurised entrained flow gasifier for syngas generation and use.

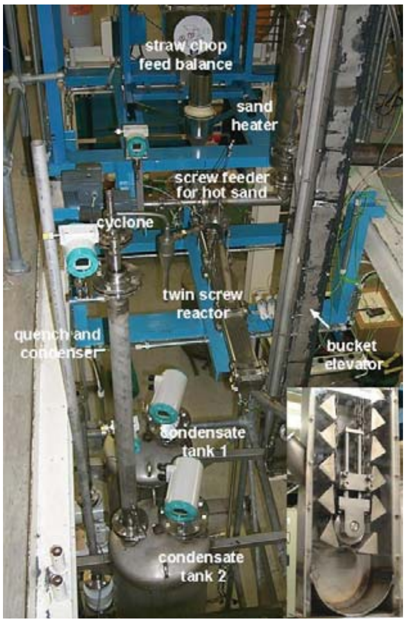

Figure 1: Fast pyrolysis (FP) process demonstration unit (PDU) for up to 10 kg/h biomass throughput and 200 kg/h sand circulation; during the construction phase.

New objectives for fast pyrolysis

The usual objective of fast pyrolysis is a high yield of stable, clean and ash-free bio oil for direct use in boilers, diesel engines or turbines. For gasification however, high purity is not needed. Any slurry with a LHV above about 10 MJ/kg which can be pumped and pneumatically atomised with oxygen is suited for the gasifier. A new aim of fast pyrolysis is the production of sufficient organic and aqueous liquid to suspend the pyrolysis char. Reduced bio oil quality and yield requirements permit fast pyrolysis process simplifications. Slurry gasification tests up to 0.5 tph throughput have been successfully performed with the FUTURE ENERGY company at Freiberg, Germany.

Choice of a FP reactor type

The twin screw or LR (Lurgi-Ruhrgas) mixer reactor has never been tested for fast pyrolysis of biomass.
But there has been experience for several decades with technical applications such as ‘flash coker’ or ‘sand cracker’ for town gas and olefin production as well as for fast pyrolysis of tar sand and vacuum residue. If this transported bed type reactor is also suitable for biomass, the available experience will both simplify and shorten further development to a large commercial scale.

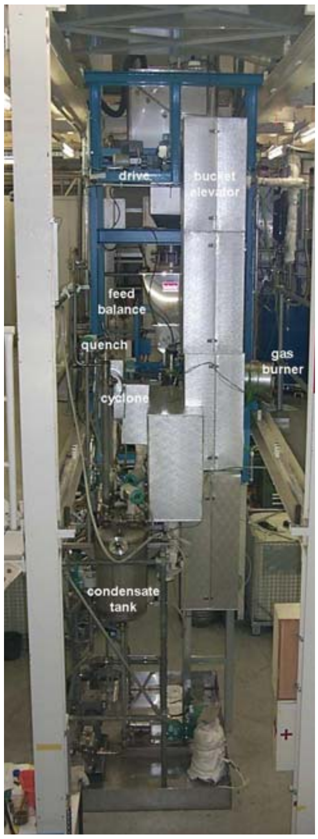

Figure 2: PDU with twin screw reactor for fast pyrolysis; components in the hot sand loop are thermally insulated.

FP process demonstration unit (PDU)

To test the suitability of the LR-mixer reactor, a PDU for 10 kg/h biomass throughput was designed, built and put into operation in 2003. The facility includes all essential components for continuous operation. Figures 1 and 2 give an overall view with and without thermal insulation. The central part is a 500°C **hot sand loop** with bucket elevator, sand heater, a controlled screw feeder for sand and the LR-reactor. Pneumatic sand transport is also being studied. Cold dry straw particles are fed to the circulating hot sand stream in the LR-reactor with a screw feeder, with a sand-biomass ratio between 5 and 20.

The **sand heater** is a vertical shell and tube type vessel. The loop sand flows down inside the tubes and is heated up with a fluidised sand bed on the shell side, heated and agitated with hot flue gas from the combustion of pyrolysis gas or methane. The **LR-mixer reactor** is mechanically fluidised. The main characteristic is two parallel screws which rotate at a few revolutions per second in the same direction and clean each other with intertwining flights. In Figure 3 the reaction principle is also shown: Transport with poor axial and good radial mixing is combined with rapid cross-current vapour removal from a shallow sand bed. A **hot cyclone** removes the fine char powder carried out with the pyrolysis gas and vapours. Downstream from the cyclone, **two sequential quench condensers** recover a mainly organic and a mainly aqueous condensate respectively, which are operated at decreasing temperature.

Initial results

With the LR-mixer reactor shown in Figure 3, a maximum throughput of 200 kg/h sand together with 10 kg/h fine straw particles has been obtained at screw speeds of several revolutions per second. Total condensate yields are about half of the feedstock weight. The bulk of the char could be removed as a very fine powder from the hot cyclone. Only a small char fraction is carried over into the quench condensates.

Outlook

Investigations are being continued to improve equipment design details and operating conditions especially for long-term operation. We expect that further operating experience will harden and substantiate the suitability of the LR-mixer reactor for biomass fast pyrolysis. In this case, the available industrial experience will enable rapid progress through design, construction and operation of a larger pilot facility to a commercial demonstration plant with a feedstock throughput in the order of 10 t/h.

For further details contact:

Dr Edmund Henrich
Forschungszentrum Karlsruhe GmbH
Institut für Technische Chemie
Chemisch-Physikalische-Verfahren
PO Box 3640
Karlsruhe
D-76021
Germany
Tel: +49 7247 822271
Fax: +49 7247 822244
Email: edmund.henrich@itc-cpv.fzk.de

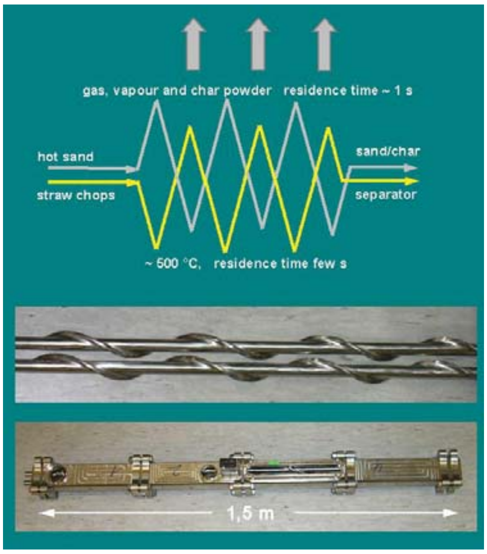

Figure 3: Principle and construction of the twin screw (LR) reactor with low axial and fast radial mixing in a shallow hot sand/biomass particle bed.

Feature

Bioware Process – a Fast Pyrolysis Technology for Biomass Developed in Brazil

By J.D. Rocha, E. Olivares Gómez, J.M. Mesa Pérez & L.A.B. Cortez, Bioware Tecnologia Ltd & Universidade Estadual de Campinas (UNICAMP), Brazil

Introduction

Bioware Tecnologia is a spin-off company from the University of Campinas dedicated to processing forest and agro-industrial residues into high added-value products using innovative and environmentally friendly technologies. Its main activity is to develop biomass fast pyrolysis technology in a continuous atmospheric bubbling fluidized bed reactor to produce bio-oil and charcoal. The pilot plant is the result of almost a decade of research carried out by the Biofuel Group at UNICAMP at the University of Campinas, Brazil (Figure 1). The plant is located in the town of Piracicaba about 80 km from Campinas.

The Bioware Process

The Bioware fast pyrolysis process is non-catalytic thermal degradation of ligno-celullosic materials in an atmospheric pressure bubbling fluidized bed. The company has a patent application and a process patent has been claimed. Elephant grass, cane trash and bagasse are the main feedstocks that have been successfully processed. The reactor bed temperature is typically in the range of 480-500°C, and the fluidisation gas/feedstock mass ratio is 0.4 (dry basis). With the reactor operating at these conditions the wet scrubber is able to recover about 40 wt% bio-oil on dry feed.

The pilot plant has a nominal capacity of 300 $kg.h^{-1}$ (dry feed basis) and is fully automated and operated to produce bio-oil samples to be tested in laboratory and industrial applications. The facility is also used to generate and validate process variables and for R&D (Figure 2). Our group carries out a scale-up project and a 500 to 1,000 $kg.h^{-1}$ plant is planned to be built next year.

Figure 3 shows a picture of our biofuel group, from left to right J.M. Mesa Pérez, J.D. Rocha, L.A.B. Cortez, E. Olivares Gómez.

PRODUCT CHARACTERISTICS

Bio-oil and charcoal properties

Bio-oil and fine charcoal are produced during pilot plant operation as co-products. Some of their main physico-chemical properties are reported in Tables 1 and 2 respectively. Figure 4 shows a picture of the bio-oil produced. Product analyses have been carried out in co-operation with R&D centres including Centro de Tecnologia Copersucar, Institute of Chemistry at Unicamp, USP (University of São Paulo), and IPT (Technology Research Institute in São Paulo).

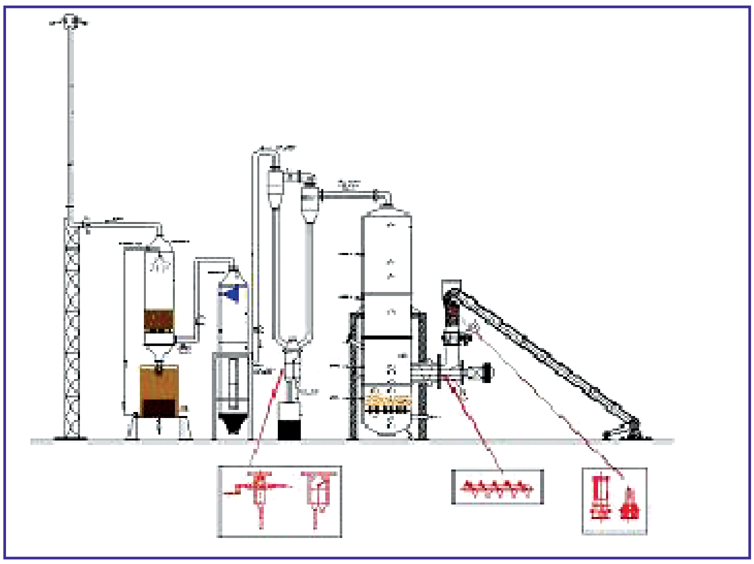

Figure 1: Flowsheet of Bioware Process Technology.

Table 1: Properties of Bioware bio-oil.

Property	Unit	Bio-oil
Specific gravity, 20/20°C	–	1.1493
Cinematic viscosity @ 37°C	cSt	9,500
Cinematic viscosity@ 65°C	cSt	1,100
Higher heating value	$MJ.kg^{-1}$	31.41
Copper corrosion, 3h @ 100°C	–	1b
Pour point	°C	9.0
pH		2.2
Total number of acids	mg $KOH.g^{-1}$	30.4
Ash	% (wt)	0.55
Moisture content (Karl Fischer method)	% (wt)	2.21
Elemental Analysis (%)	Carbon	70
	Hydrogen	7.1
	Oxygen (by difference)	21.05
	Nitrogen	1.7
	Sulphur (total)	0.15

Table 2: Properties of Bioware charcoal and elephant grass raw material.

Property	Elephant Grass	Charcoal Fines
Bulk density, $kg.m^{-3}$	76	140
Volatiles, % (d.b.)	73.5	7.4
Fixed carbon, % (d.b.)	20.2	61.9
Ash, % (d.b.)	6.4	30.7
Moisture, % (d.b.)	10.1	2.7
Higher heating value, $MJ.kg^{-1}$ (d.b.)	17.03	22
Particle average diameter, *μm*	2.24	75

Product Uses

The following applications are being considering for bio-oil:

1. Emulsifying agent for heavy petroleum and fractions;
   Bio-oil provides the basis for an additive to emulsify heavy petroleum and heavy petroleum fractions. The bio-emulsifier made from bio-oil acts as a surfactant to form emulsions of water and heavy hydrocarbons that improves pumping, transportation, refining and combustion. This offers a major opportunity for processing large quantities of heavy oil production.

2. Additive for cellular concrete;
   Cellular concrete is a kind of non-structural, acoustic and insulating cement that uses an additive based on bio-oil to trap air bubbles and form a low density filling in buildings. It can be applied directly during construction and this is the main difference from other similar additives that have to be autoclaved.

3. Partial substitution of phenol in PF resin formulations;
   It is well-known that bio-oil contains phenol derivatives from the phenolics presented in lignin. Our research has proved that 50-wt% of pure phenol may be replaced by bio-oil in resoles. Brazil has a phenol-formaldehyde resin production of 60 000 tons annually.

4. Biofuel to replace fuel oil and diesel for energy generation;
   The use of bio-oil as fuel is less attractive but it is very strategic for isolated communities such as villages in Amazon region. In that region it is very common to burn four litres of diesel to deliver one litre of fuel. The economic and the environment costs are very high for the country in places where biomass is largely available. Some blended fuels are also being studied such as bio-oil plus ethanol, bio-oil plus diesel, and bio-oil plus bio-diesel.

Figure 2: Pilot plant overview.

Figure 3: Biofuel group at Unicamp.

The applications being evaluated for the fine charcoal produced during biomass fast pyrolysis are:

1. Pelletisation for use as fuel in barbecue, boiler, and ovens;
2. As a pre-reducer for iron ore pellets. Brazil is the largest iron ore pellet exporter in the world. This application has been successfully tested;
3. Activated carbon;
4. Catalytic substrate.

Pyrolysis gas is burned on site to provide heat for the process. The acid water phase separated from bio-oil has applications in organic agriculture.

Conclusions

This technological development has found strong support from both public and private sectors in Brazil due its characteristics to recycle residues to produce high added value fuels and materials in a social and environmentally friendly way.

There are many cheap raw materials that are suitable as feed for the Bioware process. In particular, the Brazilian sugar cane industry is very supportive and interested in this technology for processing bagasse. The pulp and paper, sawmill and rice industries are also interested in partnership and the company cooperates with many national groups and companies, as well as some international co-operation in Cuba and Spain.

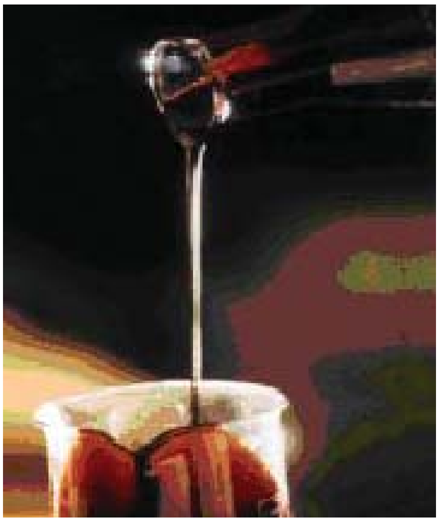

Figure 4: Bio-oil sample.

Funds for this development comes from the federal government Ministry of Mines & Energy under co-operation agreement # 007/2002-MME/FUNCAMP and from FAPESP under numbers 98/15448-5, 01/10841-5, 01/08152-7, and 02/02166-9 (PIPE). The authors thank their financial support.

For further details contact:

J.D. Rocha
Bioware – Tecnologia de Termoconversão de Biomassa Ltda
CP 6086, Campinas, SP
13084-971,
Brazil
Tel: +55 19 3788-4996
Fax: +55 19 3788-5030
Email: bioware@ct.unicamp.br
Websites: http://www.bioware.com.br

Pyrolysis Process Development at Advanced Fuel Research, Inc. (AFR)

By Michael A. Serio, AFR, East Hartford, CT USA

AFR has been involved for several years in R&D on the pyrolysis-based conversion of biomass into fuels, chemicals and materials [1]. More recently, this work has also involved process development, such as a prototype waste pyrolyzer for spacecraft use [2-4] and the pyrolysis processing of animal manure for remote power generation [4,5].

A schematic of the NASA prototype reactor system is shown in Figure 1. That project is studying the pyrolysis of mixed solid waste streams, including paper, soap, plastic, and inedible plant biomass, which are relevant to long term space travel. During the initial processing step, the first stage is the primary pyrolysis zone, for thermal decomposition of the sample into gases, liquids and a char residue, while the second stage contains a catalyst bed for decomposition of the liquids. Each of these stages are heated independently (~673-873 K for the first stage, 873-1273 K for the second stage). During the second-processing step, the purge gas is switched to CO_2 (or H_2O) and gasification of the char can occur in the first stage (if desirable) while gasification of the carbon deposits from the cracked oils will occur in the second stage. Alternatively, the conditions in the first stage can be adjusted to provide activation of the char or no reaction at all, in which case the char can be removed and used for some other purpose. A picture of the current prototype reactor is shown in Figure 2.

A set of experiments was done under similar conditions in the NASA prototype reactor with wheat straw and poultry litter; see Table 1, samples and these results are shown in Table 2. The yields for char were about 10wt % higher for poultry litter than for wheat straw, which is consistent with the higher amount of ash in the starting material (see Table 1). The yields of H_2 are somewhat lower from poultry litter than from the wheat straw sample, which is probably due to the fact that much of the hydrogen in the starting sample ends up as NH_3 in the product gas. The yields of CH_4, CO, and CO_2 were generally similar in either case.

AFR will continue to pursue scale-up of the NASA prototype pyrolyzer for terrestrial applications to produce fuel gases for distributed power generation.

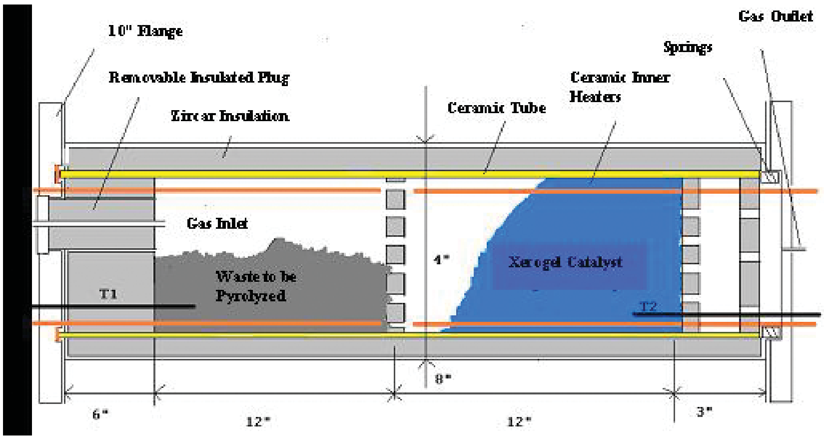

Figure 1: A schematic of the NASA prototype reactor system.

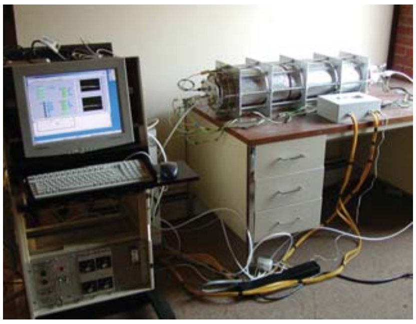

Figure 2: Current prototype reactor.

References

[1] Serio, Michael. A., 'Pyrolysis Research at Advanced Fuel Research, Inc. (AFR),' PyNe Newsletter, Issue 12, September 2001.

[2] Serio, MA., Kroo, E., Bassilakis, R., Wójtowicz, M.A., and Suuberg, E.M., 'A Prototype Pyrolyzer for Solid Waste Resource Recovery in Space,' 31st International Conference on Environmental Systems, Orlando, FL, July 9-12, 2001, SAE paper No. 2001-01-2349.

[3] Serio, M.A., Kroo, K., Wójtowicz, M.A., Suuberg, E.M., and Filburn, T., 'An Improved Pyrolyzer for Solid Waste Resource Recovery in Space,' 32nd International Conference on Environmental Systems, San Antonio, TX, July 14-18, 2002, SAE paper no. 2002-01-2402.

[4] Serio, M.A., Kroo, E., and Wójtowicz, M.A., 'Biomass Pyrolysis for Distributed Energy Generation,' ACS Division of Fuel Chemistry Preprints, 48(2), 584 (2003).

[5] Serio, M.A., Bassilakis, R., Kroo, E., and Wójtowicz, M.A., 'Pyrolysis Processing of Animal Manure to Produce Fuel Gases,' ACS Division of Fuel Chemistry Preprints, 47(1), 588 (2002).

For further details contact:

Dr. Michael A. Serio, President
Advanced Fuel Research, Inc.
87 Church Street
East Hartford, CT 06108-3728
Tel: 860-528-9806
Fax: 860-528-0648
Email: mserio@AFRInc.com
or Dr. Marek A. Wójtowicz, Vice-President, Clean Energy
marek@AFRInc.com
or Mr. Kenneth A. Wexler, Director, Business Development
kwexler@AFRInc.com

Table 1: Composition of various waste samples used in prototype pyrolyzer (wt. %, dry, ash-free basis).

Sample	Ash[a]	C	H	O	N	S
Local Wheat Straw	6.0	49.0	6.1	42.9	1.8	0.20
Poultry Litter	22.1	47.4	6.5	39.5	5.6	1.0
Notes:	a=dry basis					

Table 2: Typical Results from Pyrolysis of Wheat Straw or Poultry Litter (wt. %, as-received basis).

Product	Sample Type	
	Wheat Straw	Poultry Litter
Char	30.8	40.8
H_2O	7.8	14.3
Carbon	3.3	4.9
Trap & Filter	7.6	3.4
Total Gases	50.2	38.2
H_2	2.0	0.8
C_2H_4	0.2	0.3
CH_4	2.9	3.3
CO_2	24.9	20.3
CO	16.4	13.5

First Torrefied Wood Successfully Co-Fired

By Andries Weststeyn, Essent Energie BV, The Netherlands

Introduction

The production method and market potential of Torrefied Wood (TW) were discussed by James Arcate in a previous issue of the PyNe Newsletter (PyNe newsletter 16, September 2002). At the time, a development was underway in The Netherlands and the UK aimed at producing sufficient TW to allow for friability testing in a full scale coal pulveriser at a power plant. This development was supported by the Dutch government agency Novem to stimulate green power generation. The first Torrefied Wood has now been produced in tonnage quantities using the circulating atmospheric superheated steam method, and first pulverising and co-firing results have become available.

Results

Last summer, 20 tonnes of TW from forest chips were delivered to EPZ's 400 MWe PC-plant unit BS12, located at Borssele, The Netherlands, and operated by Essent Energie, for co-pulverisation and co-firing testing. At the plant, TW was fed into a single coal pulveriser to reach the highest possible mix percentage given the limited TW supply at hand. This pulveriser was a CE model with conical rollers and rotating classifier, with a capacity sufficient to supply 100 MWe.

TW was progressively mixed with coal up to 9% content on an energy basis, while operating personnel were allowed adequate time for observing pulveriser behaviour at the gradually increasing mix percentage. Whereas Essent operating personnel at Borssele have gained extensive experience with co-firing of a wide variety of biofuels, there is a proven empirical basis for judgment whether pulveriser limits are about to be reached. During testing no such limits were reached and the consensus was that there was adequate "room for growth." Samples of pulverised coal/TW mix were taken at

Figure 1: First TW ever to arrive at a power plant.

the pulveriser exit and studied under a stereo-microscope for size distribution and shape, which showed good overall pulverisation results. The calorific value of the TW was analysed at about 20 MJ/kg at 7% moisture content.

Co-firing in the PC-boiler did not deliver any measurable negative effects. The quantity of TW at hand was obviously too small for long duration testing in the boiler. It is expected, however, that the overall combustion behaviour of pulverised TW will not differ very much from untorrefied sawdust combustion, with which Essent has plenty of experience. In short, the basics of pulverising and co-firing of TW were successfully tested, thereby proving TW as a viable option for direct co-firing.

The significance of introducing torrefied biofuels is that it will allow a much wider slate of biomasses (both woody and otherwise) to be conditioned for direct co-pulverising and co-firing. However, for successful market introduction, production costs of torrefied biofuels need to be competitive with alternate bio-conversion products. This aspect will have to be proven during scaling-up of the technology.

Further development

To investigate optimal torrefaction technology and it's associated cost price, a follow-up project was started by the same project partners, Stramproy, BGP and Essent of The Netherlands and CDS/APS of the UK. The purpose of this follow-up project is to produce several thousand tonnes of TW for long duration testing of TW manufacturing and co-firing, as well as to perform scale-up studies. This project is again supported by Novem.

In a parallel development in The Netherlands, scientific support studies on torrefaction have been started at ECN and Eindhoven Technical University, while applications other than direct co-firing are also being investigated.

For further details contact:

Mr A Weststeijn
Essent Energie BV
Engineering & Maintenance / Projects Department
PO Box 158
4930 AD Geertruidenberg
The Netherlands
Tel: +31-113-356259
Fax: +31-113-35 2361
Email: andries.weststeijn@essent.nl
Websites: http://www.essent-finance.nl

Figure 2: TW to be pulverised and co-fired.

Figure 3: TW stored on site at the power plant.

Figure 4: Bucket loader feeding TW onto the biomass distribution conveyor.

Figure 5: EPZ power plant site at Borssele, The Netherlands.

2nd International Workshop on Pyrolysis, Perth, Western Australia, December 2003

By Paul Fung, CSIRO Forestry & Forest Products, Australia

This is the second Australian workshop on biomass pyrolysis which was held on 15-17 December 2003 at the University of Notre Dame, Fremantle Western Australia on the theme: *Thermal Conversion Opportunities for New Wood Products through Research and Development*. There were a total of eleven presentations covering the development of Mallee Eucalypt feedstocks, bioenergy prospects, integrated wood processing, slow and fast pyrolysis of wood, bio-oil production and its combustion characteristics, liquid transport fuels and potential wood charcoal applications in bath smelting and for sinking atmospheric carbon dioxide in soil.

Figure 1: Wood to energy demonstration plant.

The highlight of the meeting was a tour of the South Western region of Australia. This contains the wheat belt food basket of Western Australia which is degrading through dry-land salinity caused by a rising, saline water table. It has already affected two million hectares of productive farmland. Caused by the substantial removal of perennial trees in establishing the original farms, the effect has been the removal of the natural, effective water pumps that had controlled the ground water recharge. John Bartle, who established the concept of vegetative control of salinity using Oil Mallees, presented this work as the keynote speaker. He is actively promoting and implementing these plantations with the farmers, and their activities were viewed on this workshop tour.

and allow intercropping with cereals, see Figure 1. These trees, which are indigenous to the area, blend well into the environment and are able to prosper. They offer shelter for grazing animals that find the leaves unpalatable as the leaves are loaded with essential oils. The trees are now grown for fast rotation coppice harvesting. The tour saw a novel demonstration plant, which has been constructed to process whole trees to produce electricity, activated carbon and Eucalyptus oil in an integrated operation, see Figures 2 and 3. Also visited was a silicon metal production operation that used metallurgical wood charcoal. The plant produced its charcoal requirements from waste wood in two vertical shaft retorts and is the largest wood carbonisation operation in Australia. In addition, delegates saw a coal-fired power station in the process of undertaking co-firing trials with wood waste.

The Institutions involved in the organisation of the workshop were: CSIRO, CALM, PyNe, Western Power Corporation, SIMCOA Operations and Universities of Notre Dame, Monash and Melbourne.

For further details contact:

Paul Fung
CSIRO
Forestry and Forest Products
Bayview Avenue, Clayton, Vic
Private Bag 10
Clayton South
Vic
3169
Australia
Tel: +61 3 9545 2487
Fax: +61 3 9545 2448
Email: paul.fung@ffp.csiro.au

Figure 2: Mallee plantation

Figure 3: Tour of wood to energy demo plant.

Diary of Events

Information compiled by Claire Humphreys, Aston University, UK

2004 Asia Renewable Energy Conference & Conference & Exhibition (REAsia 2004)

Venue: China, Beijing
Date: 7-9 April 2004
Contact: Ms Vivian Li, Project Assistant
of Renewable Energy Fairs
Grace Fair International Limited
Room 1311, Tower A,
Shongyun Building
Wangjing New Industrial Zone,
Chaoyang District
Beijing 100102, China
Tel: +86 10 6439 0338
Fax: +86 10 6439 0339
Email: Vivian@gracefair.com
Website: www.gracefair.com

2nd World Conference and Exhibition on Biomass

Venue: Rome, Italy
Date: 10-14 May 2004
Contact: Gianluca Tondi
Florence, 2nd World Biomass
Conference 2004,
Piazza Savonarola, 10
50132 Florence, Italy
Tel: +39 055 500 2174
Fax: +39 055 57 3425
Email: biomass.conf@etaflorence.it
Website: www.conference-biomass.com/abstracts

WASTE 2004

Venue: Malta
Date: 12-14 May 2004
Contact: Joanne Brincat
TRITON, Level 1,
Monument Services Centre
National Road, Blata I – Bajda HMR
02 – MALTA
Tel: +356 21 241 881
Fax: +356 21 241 882
Email: conference@tritonmalta.com
Website: www.integrated-waste-solutions.com

16th Internation Symposium on Analytical & Applied Pyrolysis

Venue: Alicante, Spain
Date: 23-27 May 2004
Contact: Viajes Hispania, conference Dept,
Avda. Maisonnave, 11-70,
Alicante, Spain
Tel: +34 965 22 83 93
Fax: +34 965 22 98 88
Email: ctrives@vhispania.es
Website: www.pyrolisis2004.org

World Bioenergy 2004 – Conference & Exhibition on Biomass for Energy

Venue: Jönköping, Sweden
Date: 2-4 June 2004
Contact: (SVEBIO for the Conference)
(Elmia for the exhibition)
Tel: +46 8 441 7080 (SVEBIO)
Fax: +46 36 15 2000 (Elmia)
Website: www.svebio.se/worldbioenergy

International Conference on New and Renewable Energy Technologies for Sustainable Development

Venue: Portugal
Date: 28 June – 1 July 2004
Contact: Maria Fernanda Afonso
Instituto Superior Tecnico
Mechanical Engineering Department
Av. Rovisco Pais, 1049-001 Lisbon
Portugal
Tel: +351 21 841 7378/841 7186
Fax: +351 21 847 5545
Email: renewables@navier.ist.utl.pt
Website: http://navier.ist.utl.pt/renewables2004

Science in Thermal and Chemical Biomass Conversion

Venue: Vancouver Island, BC, Canada
Date: 30 August to 2 September 2004
Contact: Emma Wylde
Bio-Energy Research Group,
Aston University
Birmingham, B4 7ET. UK
Tel: +44 121 359 3611 Ext 4633
Fax: +44 121 359 6814
Email: e.wylde@aston.ac.uk
Website: www.stcbc.com

2nd International Ukrainian Conference on BIOMASS FOR ENERGY

Venue: Kyiv, Ukraine
Date: 20-22 September 2004
Contact: Dr Georgiy Geletukha
Institute of Engineering
Thermophysics of National Academy
of Sciences of Ukraine
2a Zhelyabov str., 03057,
Kyiv Ukraine
Fax: +38 044 456 6091, 456 9462
Email: conference@biomass.kiev.ua

II International Scientific Conference on Mechanical Engineering (COMEC 2004)

Venue: Cuba
Date: 9-11 November 2004
Contact: Raul Perez Bermudez
Universidad Central 'Marta Abreu' de
Las Villas
CP: 54830, Santa Clara. V.C.
Cuba
Tel: +53 42 281630/281194
Fax: +53 42 281608
Email: evento@fim.uclv.edu.cu
Comec2004fim@yahoo.com

7th Asian Pacific International Symposium on Combustion and Energy Utilisation

Venue: The Hong Kong
Polytechnic University
Date: 15-17 December 2004
Contact: Profess C W Leung, Dept of
Mechanical Engineering, The Hong
Kong Polytechnic University,
Hung Hom, Kowloon, Hong Kong
Email: mmcwl@polyu.edu.hk

PyNe Membership

Please contact your country representative for further information.

Co-ordinator

Tony Bridgwater
Bio-Energy Research Group
Aston University
Birmingham
B4 7ET
UNITED KINGDOM
Tel: +44 121 359 3611
Fax: +44 121 359 6814/4094
Email: a.v.bridgwater@aston.ac.uk

Austria

Maximilian Lauer
Institute of Energy Research
Joanneum Research
Elisabethstrasse 5
A-8010 Graz
AUSTRIA
Tel: +43 316 876 1336
Fax: +43 316 876 1320
Email: max.lauer@joanneum.at

Belgium

Yves Schenkel
Centre for Agricultural Research (CRA)
Chaussée de Namur, 146
Gembloux
B–5030
BELGIUM
Tel: +32 81 627148
Fax: +32 81 615847
Email: schenkel@cragx.fgov.be

Denmark

Karsten Pedersen
Danish Technological Institute
Julsoevej 6
DK-8600 Silkeborg
DENMARK
Tel: +45 8684 5822
Fax: +45 8684 5811
Email: kp@chemidan.dk

Finland

Anja Oasmaa
VTT Energy
New Energy Technologies
PO Box 1601
Espoo, FIN-02044 VTT
FINLAND
Tel: +358 9 456 5594
Fax: +358 9 460 493
Email: Anja.Oasmaa@vtt.fi

France

Philippe Girard
Cirad Forêt
Energy Environmental Unit
TA 10/16
73 Rue Jean Francois Breton
Montpellier Cedex 5
34398
FRANCE
Tel: +33 467 61 44 90
Fax: +33 467 61 65 15
Email: philippe.girard@cirad.fr

Germany

Dietrich Meier
BFH-Institute for Wood Chemistry
Leuschnerstrasse 91
D-21031 Hamburg
GERMANY
Tel: +49 40 739 62 517
Fax: +49 40 739 62 502
Email: d.meier@holz.uni-hamburg.de

Greece

Ioanna Papamichael
C.R.E.S. – Biomass Department
19th km Athinon Marathonos Ave
GR 190 09
Pikermi – Attikis
GREECE
Tel: +30 10 660 3389
Fax: +30 10 660 3301
Email: ioannap@cres.gr

Ireland

Kevin Healion
Irish Bio-Energy Association
c/o Tipperary Institute
Clonmel, Co.
Tipperary
IRELAND
Tel: +353 504 28105
Fax: +353 504 28111
Email: khealion@tippinst.ie

Italy

Colomba Di Blasi
Universitá degli Studi di Napoli
'Federico II'
Dipartimento di Ingegneria Chimica
P. le V. Tecchio
80125 Napoli
ITALY
Tel: +39 081 768 2232
Fax: +39 081 239 1800
Email: diblasi@unina.it

Netherlands

Wolter Prins
Business & Science Park
Pantheon 12
7521 PS Enschede
NETHERLANDS
Tel: +31 53 486 2282
Fax: +31 53 432 5399
Email: prins@btgworld.com

Norway

Morten Gronli
SINTEF Energy Research
Thermal Energy and Hydropower
7034 Trondheim
NORWAY
Tel: +47 73 59 37 25
Fax: +47 73 59 28 89
Email: Morten.Gronli@energy.sintef.no

Portugal

Filomena Pinto
INETI-ITE-DTC
Edificio J
Azinhaga dos Lameiro
Estrada do Paço do Lumiar
1699 Lisboa Codex
PORTUGAL
Tel: +351 1 716 52 99
Fax: +351 1 716 65 69
Email: Filomena.Pinto@ineti.pt

Spain

Jesus Arauzo
Universidad de Zaragoza
Chemical & Environmental Engineering
Department
Centro Politecnico Superior
María de Luna 3
E 50015 Zaragoza
SPAIN
Tel: +34 97 676 1878
Fax: +34 97 676 1879
Email: qtarauzo@posta.unizar.es

Sweden

Erik Rensfelt
TPS Termiska Processer AB
Studsvik
S-611 82 Nykoping
SWEDEN
Tel: +46 155 221385
Fax: +46 155 263052
Email: erik.rensfelt@tps.se

USA

Stefan Czernik
NREL
1617 Cole Boulevard
Golden, Colorado,
80401, USA
Tel: +1 303 384 7703
Fax: +1 303 384 6363
Email: Stefan_Czernik@NREL.Gov

Associate Members

Søren Houmøller
FORCE Technology, Søborg
Energy and Environment Technology
and Processes
Gladsaxe Mollevej 15
Søborg DK-2860
Denmark
Tel: +45 39 555 919 (direct)
Fax: +45 39 696 002
Email: sho@force.dk

David Chiaramonti
University of Florence
Department of Energetics "Sergio Stecco"
Faculty of Mechanical Engineering
Via di S.Marta 3,
Florence 50319
Italy
Tel: +39 055 4796 239
Fax: +39 055 4796 342
Email: d.chiaramonti@ing.unifi.it

PyNe meeting, Copenhagen, Denmark, October 2003.

IEA Bioenergy

The PyNe newsletter is published by the Bio-Energy Research Group, Aston University, UK and is sponsored by TREN of the European Commission and IEA Bioenergy.

For further details or offers to contribute, please contact Claire Humphreys (see inside front cover for details). Any opinions published are those of the contributors and do not reflect any policies of the EC or any other organisation. EoE

Designed and produced by: WAA +44 (0)121 321 1411