PyNe

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Pyrolysis Network.

Diebold
A review of the chemical and physical mechanisms of the storage stability of fast pyrolysis oils
on page 10

Schenkel
The Agricultural Research Centre
on page 11

Abeliotis
Agricultural University of Athens Laboratory of Farm Structures
on page 12

Liquid Smoke: A Natural Flavour from Hard Wood Pyrolysis

By Sreekumar Ramakrishnan, Hickory Specialties, Inc, U.S.A.

Smoking of foods has been traditionally achieved in smokehouses to impart flavour, colour and aroma to foods. Liquid smoke application has started replacing traditional smokehouse treatments as a more efficient and safe way of imparting characteristics similar to those obtained from natural smoking.

Contact details can be found on page 2.

Liquid smoke manufacture at Hickory Specialties Inc.

Hard wood sawdust is pyrolyzed in specially designed furnaces. The vapours from pyrolysis are condensed using water. This condensate then undergoes a settling period and is passed through a multi stage filtration process to remove water insoluble tars and PAH compounds. The aqueous product referred to as liquid smoke has a pH range of 2-3. This product can be used as produced or further processed into 3 forms: aqueous, oil based and powders, resulting in more than 75 distinct products.

Hickory Specialties: Technology driven

Liquid smoke reaction with meat proteins results in skin formation, brown colour development via Maillard type reactions and flavour perception due to certain set of compounds. The need for various degrees of colour and flavour intensities have resulted in new products based on functional group separations. In addition to flavour characteristics, certain liquid smoke fractions have anti-microbial and anti-oxidant properties. Thus to meet the needs of an evolving and changing industry, and to develop new applications, Hickory Specialties has a full-fledged technical centre involved in such research and development activities.

HICKORY SPECIALTIES INCORPORATED

Located in the rolling hills of Tennessee, one of the three facilities operated by Hickory Specialties.

DON'T FORGET

PITBC

17 to 22 September 2000, Tyrol, Austria.

Further details are available on page 3.

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Comments and contributions are most welcome on any aspect of the contents.
Please contact your country representative for further details or send material to Claire Humphreys.

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Biomass Pyrolysis Modelling – Status and Needs

Report from a PyNe Workshop held in Oakland, USA, August 1999

By Colomba di Blasi, University of Naples, Italy

A one day workshop on biomass modelling for fundamentals, design and implementation was held in Oakland, USA prior to the 4th Biomass Conference of the Americas. 35 delegates participated with 12 presentations from American and European researchers.

Particle Modelling

The workshop confirmed that several laboratories are interested in modelling the 'particle system'. The models, at least from the mathematical point of view, include a good description of physical and chemical processes, in some cases integrated by proper external (reactor) conditions. There are two critical points, which deserve further developments and/or improvements, before such models can be applied with confidence:

1. Determination of correct input data, especially property values, kinetic constants, heat and mass transfer coefficients.
2. Extensive model validation.

For point (1) reliable kinetic data are only available for cellulose pyrolysis. Published data on wood degradation kinetics do not give acceptable results for fast pyrolysis, even from the qualitative point of view. Such information should be obtained through laboratory experimentation. As pointed out in this workshop (Burnham and Reynolds), differences between different experimental devices and the subsequent analyses still exist and further efforts are needed in this direction. The approach based on the use of guessed values for the degradation kinetics of wood components, without any experimental basis, (Bellan) has limited validity. A posteriori (successive) validation through comparison with literature data (Bellan) cannot be considered conclusive because sample properties are not reported in the majority of these studies and the actual heating conditions are often largely unknown.

Large differences are shown in the predictions of fluid bed pyrolysis (Di Blasi) carried out by means of a detailed model for intra-particle transport phenomena and chemical reactions coupled with:

1. An infinitely fast external heat transfer rate (the particle surface temperature becomes instantaneously equal to the reactor temperature).
2. An external heat transfer model, taking into account fluid-bed hydrodynamics (Agarwal (1991)), h_A, which is the most accurate description of the process.

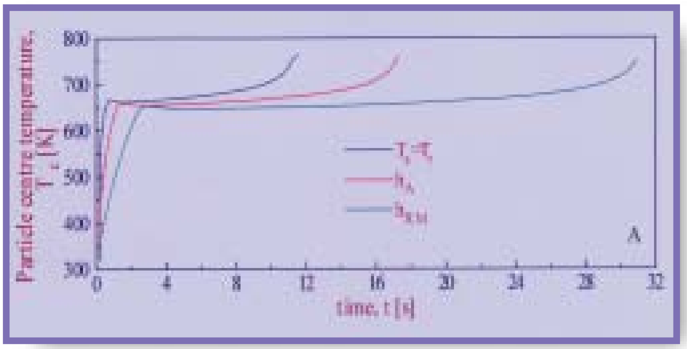

Figure 1a: Predictions of particle centre temperature for a cellulosic slab 1mm thick and a reactor temperature of 800K for different external heat transfer models.

From page 1.

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3. The widely used Ranz-Marshall correlation, h_{RM}.

As it appears from the example of particle dynamics (particle mass fraction, global devolatilization rate and particle centre temperature) shown in Figure 1a and 1b for a cellulosic slab 1mm thick and a reactor temperature of 800K, qualitative trends are the same in all cases. However, quantitative differences are very large, especially for the conversion times and the global devolatilization rate (up to factor of 2). Hence, temperature profiles and product distribution also present large variations.

Consequently 'ad hoc' selections of the percentage of the 3 wood components (without considering the influence of ash content and composition on reaction activity and selectivity) and the heat transfer coefficients can easily lead to agreement between theory and experiments. However, this does not mean that models can be applied (equations + input data) to other situations and assume that the model predictions are quantitatively correct.

Independent experiments are needed for:

a) Determination of input parameters (in particular, chemical kinetics should be determined in the absence of heat and mass transfer limitations).

b) Production of data for model validation (conditions where both chemical kinetics and transport phenomena are important).

It is important that experimental data for model validation are produced under very well defined conditions, such as properties of feedstock and heating conditions, which should be included in the model.

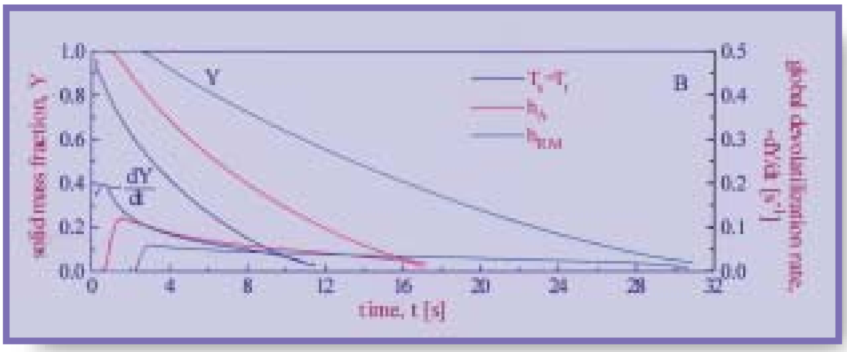

Figure.1b: Predictions of particle mass fraction and global devolatization rate for a cellulosic slab 1mm thick and a reactor temperature of 800K for different external heat transfer models.

Reactor Modelling

It was also clear from the workshop that different laboratories are interested in modelling the 'reactor system'.
The complexity of this system requires the introduction of simplifications and these should only be introduced in order to satisfy the objectives of the model development, that is, the aspects of the pyrolysis process that should be understood and predicted.
The considerations given above also apply for this system.

Conclusions

In conclusion, future developments are needed on the following points:

- Semi-global primary reaction mechanisms and kinetic constants are needed for wood and biomass under 'real conditions' and need to be determined in different experimental systems.
- Secondary reactions mechanisms and constants need to be identified and resolved.
- Heat and mass transfer coefficients need to be measured and refined for a wider range of conditions.
- Properties and data for model validation need to be obtained.
- Reactor models need to be applied to industrial scale processes for validation and improvement.

Reference

Agarwal P. K. (1991). Transport phenomena in multi-particle systems-IV. Heat transfer to a large freely moving particle in gas fluidised bed of smaller particles, Chemical Engineering Science 46, 1115-1127.

Progress in Thermochemical Biomass Conversion

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The Fifth International Conference on Thermochemical Biomass Conversion

17th – 22nd September 2000 – Tyrol, Austria.

For further details or registration of papers see our Website:

http://www.pyne.co.uk/PITBC2000

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PARSIM, a model for pyrolysis of large particles of biomass

By Gerhard Steiner and Gernot Staudinger, Graz University of Technology, Austria

Graz University of Technology has been concerned with biomass pyrolysis for more than a decade examining the complex processes, which occur during thermal conversion of large particles. A simulation routine, PARSIM, has been developed which predicts the transient behaviour of 1 single solid fuel particle with respect to drying and pyrolysis at slow and fast heating rates. The simulation routine takes into account the size, shape, species and moisture of the particle as well as the conditions in the particle's surroundings. PARSIM is useful for the design as well as for the optimisation of combustion plants.

Methods

In order to predict the process of devolatilization of a large fuel particle at rapid heating rates, the research activities are divided into 3 areas (see Figure 1):

- Development of the simulation routine.
- Determination of kinetic parameters for pyrolysis.
- Performance of validation experiments.

The simulation routine handles the conservation equations for mass and energy and considers non-isothermal material properties of the particle. Most material data are from the literature. Kinetic parameters for pyrolysis are derived from thermogravimetric analysis of small particles at slow heating rate with online analysis of the volatiles. Validation experiments with large particles quickly exposed to hot atmosphere complete the research activities and confirm the simulation results.

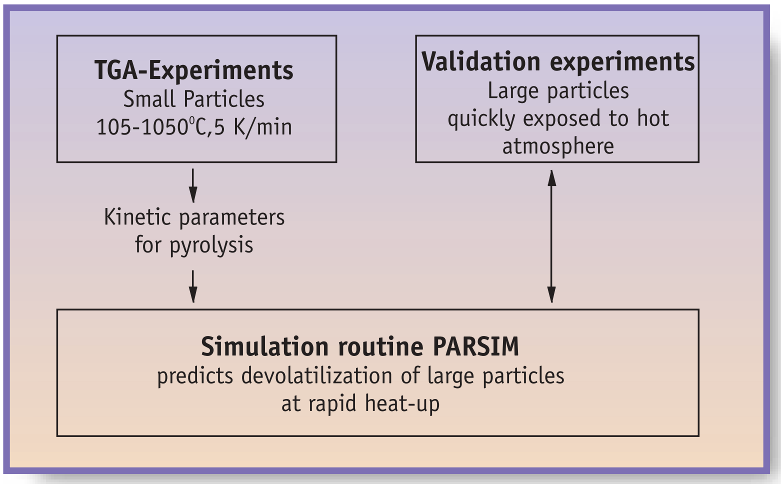

Figure 1: Development of the simulation routine PARSIM for prediction of drying and pyrolysis of a large fuel particle.

Validation

The comparison between experimental and calculated results shows excellent agreement for the mass loss and the temperature of a rapidly heated large particle (see Figure 2). The evolution of volatiles can also be predicted correctly. PARSIM only describes the evolution and transport of devolatilization products to the particle's surface but does not consider any secondary reactions of the volatiles after these have left the particle. Applying secondary cracking kinetics to primarily evolved gases and taking into account the residence time distribution of the gases inside the experimental furnace, the prediction of single gas species perfectly fits with measured data (see Figure 3).

Future research activities will extend the simulation routine from pyrolysis in inert atmosphere to pyrolysis in reactive atmospheres such as H_2O, CO_2 or air.

Support

The pyrolysis research activities at Graz University of Technology are supported from their own resources, and by the Fonds zur Förderung der wissenschaftlichen Forschung (FWF) and the EC JOULE Programme in projects JOR3CT980232 and JOR3CT980278.

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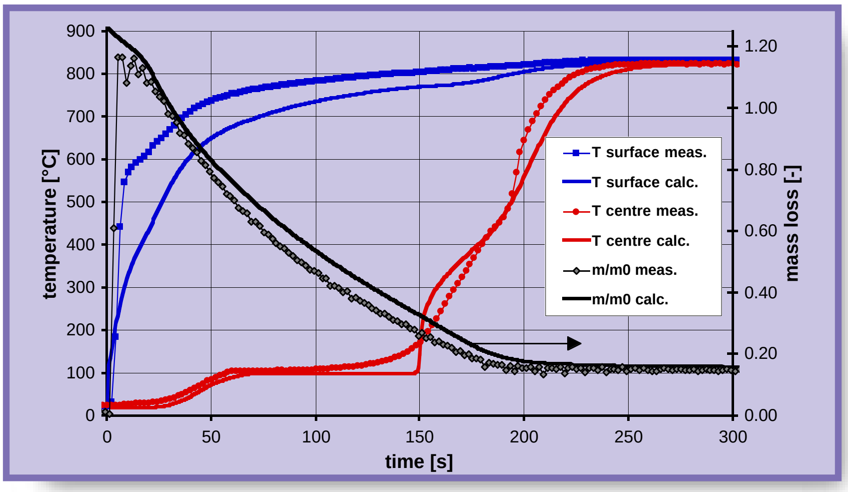

Figure 2: Calculated (lines) and measured (symbols) mass loss and temperature of a wet beech wood cube quickly exposed to hot atmosphere (size=20mm, moisture=25% dry basis, furnace temperature=825°C, atmosphere=100% N_2).

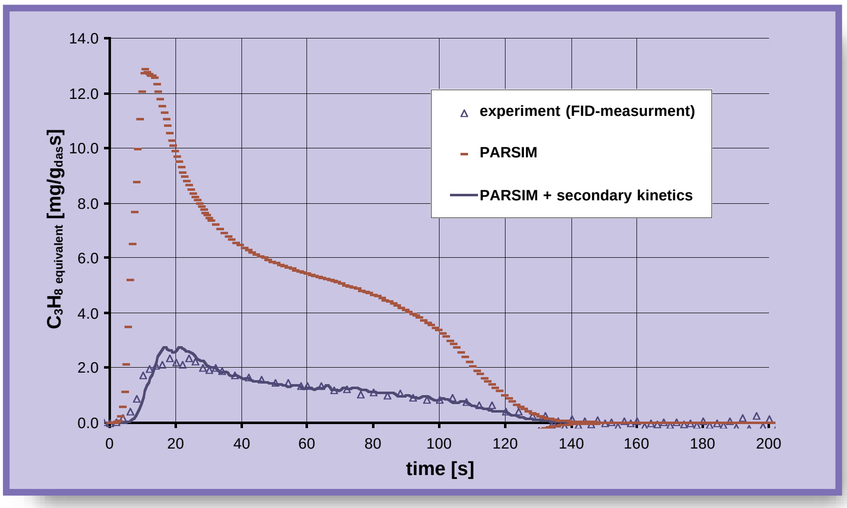

Figure 3: Calculated (lines) and measured (triangles) rate of formation tar of a dry beech wood cube quickly exposed to hot atmosphere (size=20mm, furnace-temperature=825°C, atmosphere=100% N_2).

New Member

Yves Schenkel graduated as an Agricultural and Forest Engineer. He is also a graduate in Environmental Engineering and has a Master in Technology Innovation Management. Recently he developed a thesis in modelisation of mass and energy flows from wood carbonisation in retort kilns.

Presently, he is head of the Biomass Unit at the Agricultural Research Centre of Gembloux (CRA), where he is working on biomass energy since 1987. He has conducted many projects in biomass energy. The main area is on biomass briquetting and agglomeration for household fuels production, gasification of wood and briquettes, technology transfer of bioenergy equipment for heat and/or electricity production in agro and wood industries, construction and operation of a laboratory thermolysis reactor for biomass fuels and contaminated wood.

The PyNe Network would like to welcome Yves to the group who has replaced Rosanna Maggi and will now be the country representative for Belgium.

‘Bio-Oils’ to ‘Tars’

By Tom Milne and Bob Evans, NREL, USA

There is a systematic relationship between the primary organics released in biomass pyrolysis and the mature slate of organics after extensive thermal or oxidative treatment. The chemical history of this transformation is generally understood and is documented in numerous reports and publications (Refs. 1, 2, 3, 4). The nomenclature used for starting, intermediate, and mature organic product slates is not trivial and can be the subject of confusion, particularly in key-word searches. Perhaps the most confusing term is ‘tar’. This term has been used to encompass organics ranging from the first species to emerge in ‘fast’ pyrolysis, now commonly called ‘bio-oil’ (Ref. 5), to the final products of high-severity cracking, commonly called ‘tar’ (Ref. 6).

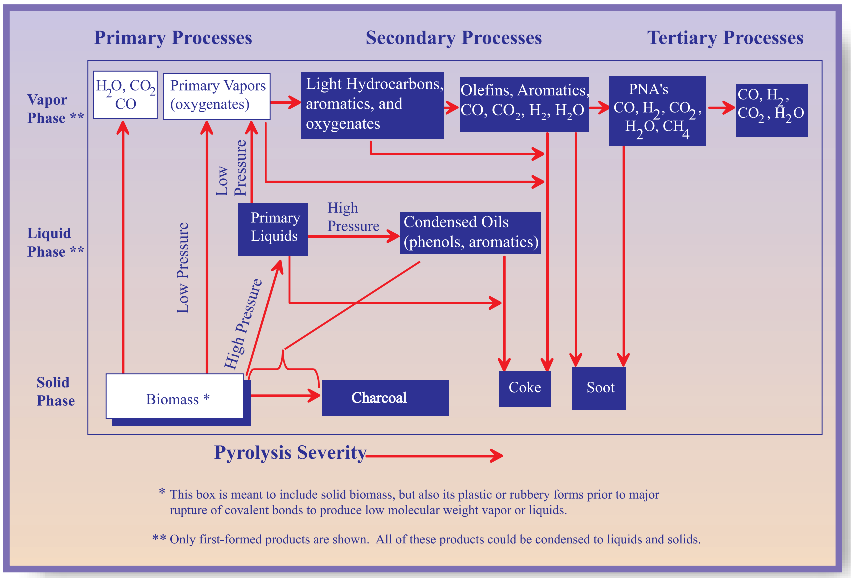

Figure 1: Pyrolysis pathways (Reference 2).

Outline of Organic Evolution

Figures 1-3 show 3 portrayals of the route to ‘tars’. Figure 1 gives a broad outline of product type (Ref. 2), Figure 2 generalizes the main organic product types (Ref. 3), and Figure 3 makes the useful distinction of primary, secondary, and tertiary organics (Ref. 6). Appendices in Reference 6 contain extensive lists of these 3 classes of organics together with a large bibliography on biomass gasifier ‘tars’, with annotations relevant to their formation, nature, conversion, and end-use tolerances.

Recommendations

A challenge to our community, working with the U.S., Canada, E.C. and the IEA, is to establish standard definitions for the main suites of organics from the thermal treatments of biomass.

In the interim, publications relating to biomass ‘oils’ or ‘tars,’ should give a footnote reference to the organic meaning of the terms as used in the study, and should always put quotation marks around the terms in the text to alert readers to the variability of definitions.

References:

1. Milne, T.A. Evans, R.J. and Abatzoglou, N. (1997). “Biomass Gasifier ‘Tars’: Their Nature, Formation, Destruction, and Tolerance Limits in Energy Conversion Devices,” in Proceedings of the 3rd Biomass Conference of the Americas, Vol. 1. Edited by R.P. Overend and E. Chornet. Canada: August 24-29, pp. 729-738.
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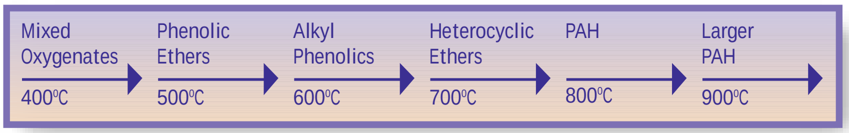

Figure 2: ‘Tar’ maturation scheme proposed by Eliott (Ref. 3)

5. Bridgwater, T. (1999). 'A Guide to Fast Pyrolysis of Biomass for Fuels and Chemicals.' 6 pp. PyNe Guide 1 in Pyrolysis Network, Issue 7, March. Published by Bio-Energy Research Group, Aston University Co-Ordinator, Tony Bridgwater.

6. Milne, T.A.; Abatzoglou, N. and Evans, R.J. (1998). Biomass Gasifier 'Tars': Their Nature, Formation and Conversion. November, NREL/TP-570-25357. 128 pp. Available from Thomas_Milne@NREL.Gov.

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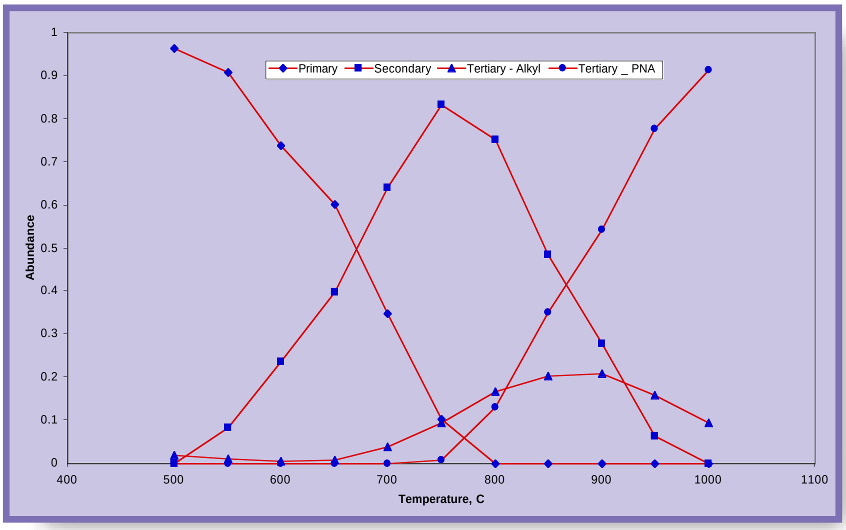
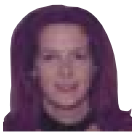


Figure 3: The distribution of the 4 'tar' component classes as a function of temperature at 300 ms (0.3 s) gas-phase residence time (Ref. 1).



Anaerobic Digestion of Bio-Oil

By Jody Barclay, CANMET, Natural Resources Canada, Canada

Bio-oil has proven to be an attractive alternative to petroleum based products with new opportunities for its use being discovered all the time.

The RTI team with Professor Don Scott (left) and Ed Hogan, Natural Resources Canada (right).

It has been demonstrated that fast pyrolysis bio-oil is biodegradable under aerobic conditions and recent studies suggest that it can be digested under anaerobic conditions as well. During the pyrolysis process, biomass undergoes extensive polymer degradation and this is likely to increase its biodegradability. Also, bio-oil contains a range of oxygenates including acids, sugars, aldehydes, ketones, etc. which may, in fact, enhance biological activity.

Anaerobic digestion of bio-oil could produce a wide range of fuels, chemicals and animal feeds including: acetic and butyric acid; acetone, ethanol and butanol; and, hydrogen and methane.

With the support of the Canadian Government, Resource Transforms International Ltd., is currently conducting a preliminary assessment of the anaerobic digestion of bio-oil to determine both biological activity and metabolic products.

It is hoped that as a result of this work, even more opportunities to use bio-oil will be discovered.

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Bio fuel oil –
Upgrading by hot filtration and novel physical methods
JOR3-CT98-0253

By Yrjo Solantausta, VTT Energy, Finland

Objectives and tasks

The primary objective of the work is to support demonstration of a bioenergy scheme, where bio fuel oil (BFO) is employed as boiler or engine power plant fuel. BFO has potential in becoming a competitive bioenergy alternative in these markets.

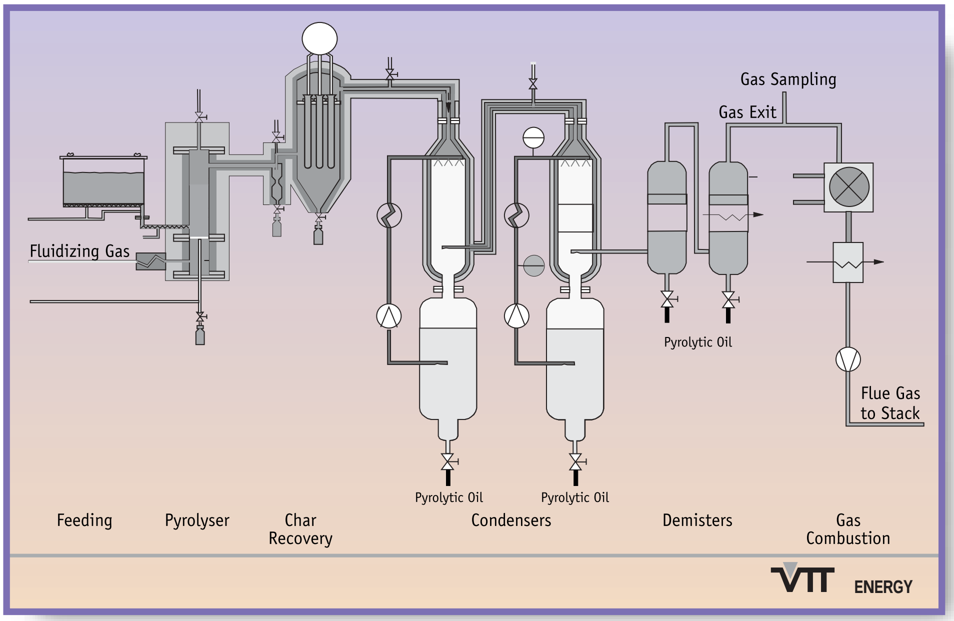

Figure 1: Candle filters installed at the 1 kg/h pyrolyser.

The following objectives for the R&D project have been defined:

- To increase the market value of BFO by improving BFO quality as fuel.
- To improve the utilisation of BFO in power plants and boilers.

These objectives are pursued in following tasks:

- Development of hot filtering for pyrolysis.
- Microemulsion production from BFO and mineral oil.
- BFO production in PDU scale for utilisation tests and characterisation.
- Handling and storage of BFO, and heath and safety issues related to BFO.
- Fundamental behaviour of BFO in combustion.
- Medium size boiler tests.
- Engine tests.
- BFO markets.

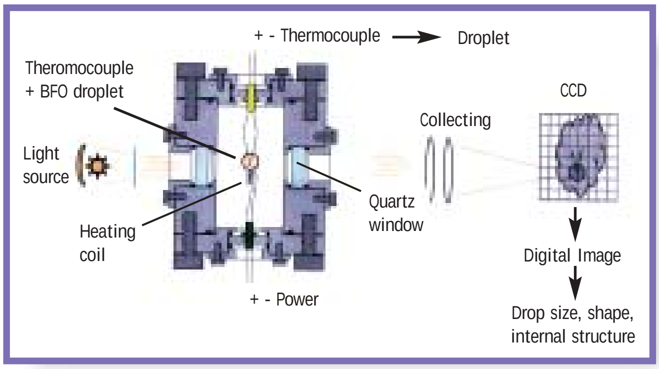

Figure 2: Experimental set-up at Istituto Motori.

Conversion of biomass to BFO

Hot vapour filtration (HVF) tests

The objective is to develop hot vapour filtration to remove solids from BFO. The present solid content will be reduced to less than 0.1 wt%. The HVF work is a continuation of an earlier project JOR3-CT95-0025, where the technology has been initially studied.

Hot gas filtration is a method which is capable of removing particulates very effectively from product gases of gasifier, combustor and some other high temperature processes. Filters applied for hot gas filtration are made of ceramic materials and they are operated as surface filters.

HVF tests will focus on long term stability of the filter system. The aim is to carry out continuous long term filtration tests with 1 kg/h pyrolyser (Figure 1) with HVF system using real pyrolysis vapours at VTT. Schumacher is supplying the filters. The next step in R&D of hot vapour filter is to use a slip-stream filter for the PDU scale pyrolyser at VTT.

Microemulsions from BFO

The objective is to develop microemulsion technology, which would make it possible to use BFO and mineral oil mixtures in existing heat and power generating systems without major modifications. Three emulsions will be manufactured by CETC (CANMET Energy Technology Centre) and characterised in laboratory analysis.

BFO quality improvement

The first objective is to determine optimum values for key process parameters for pyrolysis of 3 feedstocks (forest residues, pine sawdust, and straw). The organic yield is expected to be above 65 wt% for pine sawdust without the hot vapour filter (HVF). The second objective is to find such operating conditions that the HVF may be operated continuously maintaining a high organic yield in the VTT PDU.

The stability of 2 oils will be improved by using solvents. Stability of BFO will be studied in aging tests, varying storage temperature and time (laboratory tests), and in storing the oil for longer periods under realistic conditions (in containers). Hot filtered oils are included in the study. Effects of several parameters on phase separation will be studied. The aim is to produce phase-diagrams for BFOs to be able to avoid phase-separation occurring. Economic and practical aspects are the major consideration in stability improvement.

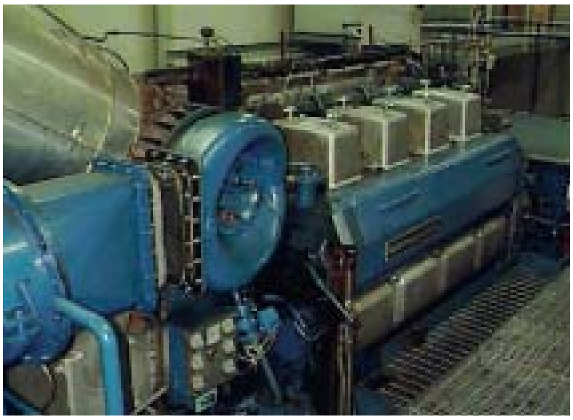

Figure 3: The 1.5 MWe Wärtsilä engine at VTT Energy, Espoo, Finland.

Utilisation of BFO

Handling and storage of BFO

The objective is to develop bio fuel oil handling and storage procedures for industrial applications, and to study the health and safety issues related to industrial use of BFO.

The work is a continuation of an earlier project JOR3-CT95-0025, where the issues have been studied.

Fundamental behaviour of BFO in combustion

BFO and its derivatives will be employed in laboratory scale equipment at Istituto Motori (Figure 2) to characterise their fundamental combustion behaviour.

As utilisation of BFO is foreseen in diesel engines or boilers, attention has to be given to the problem of formation and behaviour of unburned solid material, in order to avoid intolerable particulate emissions and operational problems.

The 2 mechanisms of formation of carbonaceous particles in the combustion of heavy oil spray flames (pyrolysis in the gaseous phase of the evaporated compounds and pyrolysis in the liquid phase of heavier fraction of fuel) are well documented in literature. The same degree of comprehension is far from being established in the case of BFO, as the published studies appear yet sparse and/or limited to specific operating conditions. Therefore, the systematic study of the physical and chemical properties of biomass derived fuels, undergoing heating and/or combustion, appears as a necessary support to the development of techniques and strategy of BFO utilisation.

Medium size boiler tests

Fortum (formerly Neste Oy) have for the past 3 years been assessing and developing a combustion system which takes into account the special physical properties (viscosity, solids content, lubricity, autoignition) and chemical (stability, acidity) characteristics of pyrolysis liquids. The main goal has been to modify existing systems using commercially available parts. This would lower the development costs and increase acceptance for prospective customers.

Modifications include a heat reflecting refractory to assist ignition, acid resistant pumps and fuel lines and a special oil preheater. The main remaining problem is a consequence of the instability of pyrolysis liquids during storage, under exposure to air and at high temperatures. With good quality pyrolysis samples, the current level of emissions is acceptable except possibly for particulates which is still higher than that for light fuel oils. Both improvements in fuel atomization and fuel quality (solids and viscosity) are required to achieve acceptable levels.

Laboratory scale engine tests

The aim is to support the development of a BFO as power plant engine fuel by generating basic engine performance and emission data.

To achieve this aim, BFO will be tested in a single cylinder direct injection diesel engine by IM. For comparison, a commercial diesel fuel and a reference fuel will also be used in the same conditions. The engine is a completely commercial one and it is applied to power small machines used in agriculture. More relevant, its displacement is close to the unitary displacements met in larger diesel engines. In addition, the same engine was also previously characterised from the fluid dynamic point of view by means of laser Doppler velocimetry measurements.

Modifications for the existing engine have been made, and tests have been carried out.

Market opportunities for bio fuel oil

The successful introduction of a new liquid fuel on the energy market will be very difficult because of the low quality of the present BFOs. At this stage quality improvement (mainly solids & stability) of the BFO is technically the critical factor. Replacing both heavy (HFO) and light fuel oils (LFO) in boilers is considered, although it is likely that the first alternative is only economically viable in some exceptional circumstances. Replacing LFO in heating is emphasised in the project, as this application may be feasible in medium term (within approximately 2-3 years) and shows better economics.

Using BFO as power plant fuel is technically less developed. There is very little data available currently using BFO as engine fuel. Within this project, valuable basic data concerning the use of BFO in engine power plants is generated. It is believed that the engine application will take longer to commercialise than the boiler application.

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Stability of Bio-Oil

A review of the chemical and physical mechanisms of the storage stability of fast pyrolysis oils

By James Diebold, Thermalchemie, Inc, USA

Introduction

In an effort jointly funded by the Pyrolysis Network (PyNe) and the National Renewable Energy Laboratory in the USA, Jim Diebold has returned to the field of fast pyrolysis oils made from biomass (bio-oils). In his latest work, he reviews in great detail the organic and physical chemistries of bio-oil that are responsible for its reported widely varying chemical compositions, viscosities, phase separations, and aging characteristics. This review distills 108 references into a comprehensive 51-page summary.

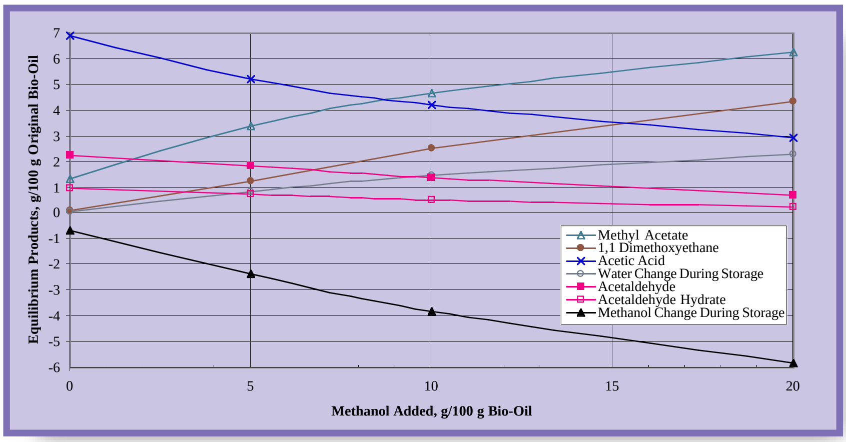

Figure 1: Calculated Equilibrium Composition of Psuedo Bio-Oil with Added Methanol (25% Water, 3% Acetaldehyde, 2% Methanol, and 8% Acetic Acid in Original Bio-Oil).

Bio-oil aging

Aging data from several sources are presented that show a wide variance in the viscosity and aging rate of different bio-oils. However, from a kinetic rate perspective, the aging rates reported fall into a relatively tight group of data when presented in an Arrhenius format. The accelerated aging rates of bio-oil at elevated temperatures are shown to be predictive of aging rates at storage temperatures. In research that prevented the loss of volatiles, the increase in viscosity of a bio-oil during aging was shown to be well correlated with the increase in average molecular weight.

Diebold has searched the literature archives of over 2 generations ago to find thermodynamic equilibrium constants and relative kinetic rates for many of the hypothesized chemical reactions that occur when bio-oil ages. The resulting picture shows a dynamic mixture of organic compounds that are constantly reacting to adjust to changes in the equilibrium variables of concentration and temperature. To illustrate these interactions, equilibrium compositions of a pseudo bio-oil are shown as a function of added water or methanol. The kinetics of many of these reactions are shown to be sensitive to pH and to the presence of catalysts, e.g. alkali metals commonly found in biomass chars.

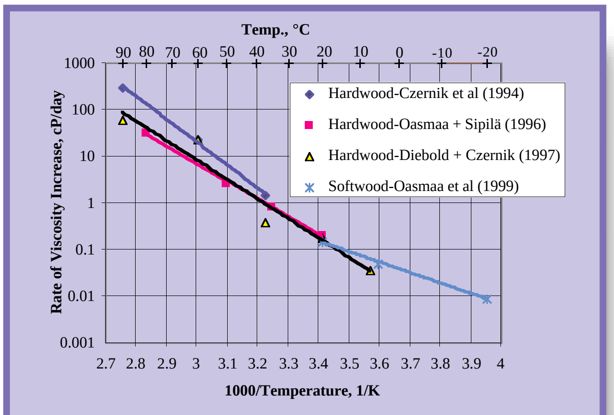

Figure 2. Rate of Viscosity Increase with Temperature During Storage of Bio-Oils

Figure 2: Rate of Viscosity Increase with Temperature During Storage of Bio-Oils.

Because bio-oil is a mixture of so many compounds, chemical changes are difficult to follow. However, ester formation has been reported to occur in liquid smoke over the course of several weeks without the addition of catalysts. Other reactions have been verified to occur during the aging of bio-oils.

Control of aging

Reported methods to combat aging of bio-oil have included mild hydrogenation and solvent addition. Unfortunately, reported mild hydrogenation experiments have led to phase separation, (an organic laden aqueous phase and a viscous organic tar). The addition of small amounts of solvents, e.g. methanol, has been shown to be very successful in lowering the initial viscosity and to slowing the aging rates very significantly. It is thought that methanol probably reacts to form chain-terminated low-molecular-weight dimers and oligomers, retarding the formation of high molecular-weight polymers.

As the chemical reactions take place in bio-oil during aging, the mutual solubility of water and the oxygenated organics decreases, which can lead to phase separation. This loss of mutual solubility is believed to be due to polymerization reactions that form relatively insoluble polymers, as well as to the change in solvent power of the lower molecular-weight products formed during aging. The Hansen solubility parameters are useful to visualize these changes in mutual solubility, as they employ the relative polarity, dispersivity, and hydrogen bonding of the various solutes and the solvent.

For further information, please contact:

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The Agricultural Research Centre

By Yves Schenkel, CRA, Belgium

The Agricultural Research Centre (Centre de Recherches Agronomiques, CRA) at Gembloux, Belgium, is a government-funded multidisciplinary research institution affiliated with the Agricultural Research Administration of the Belgian Ministry of Middle Classes and Agriculture.

Figure 1: A 150 kWe Martezzo gasifier tested and operated at CRA.

Figure 2: Briquettes production with a screw press.

The Centre's research activities lie in basic, applied and developmental research and cover the following disciplines:

- Biotechnology.
- Crop production.
- Biological control and genetic resources.
- Pesticide research.
- Agricultural engineering.
- Animal production and farming systems.
- Quality of agricultural products.
- Biometry.
- Data processing.
- Agrometeorology.

The Agricultural Engineering Department carries out research and experimentation in 2 main sectors, corresponding to 2 units:

1. Agricultural mechanisation.
2. Energy and industrial use of biomass.

The unit 'Energy and Industrial Use of Biomass' studies the possibilities of using biomass as a renewable source of energy and industrial products.

The 4 main areas covered are:

1. Biomass fuel supply (harvesting techniques).
2. Machines utilisation cost, (optimisation of biomass supply chains).
3. Conditioning of biomass (comminution, drying, storage, briquetting, agglomeration).
4. Energy (thermochemical conversion) and industrial (fibres) uses.

The thermochemical conversion techniques studied at CRA include combustion, gasification, slow pyrolysis and thermolysis. Commercial fixed bed gasifiers have been tested in the range 25-150 kWe (Figure 1) on various biomass fuels such as wood chips, wood blocks, briquettes made of wood, agricultural and agro-industrial residues (Figure 2). These experiences have led to the development of a major demonstration project on a fully automated 150 kWe gasifier fed on short rotation coppice wood chips in collaboration with several partners.
Slow pyrolysis experiments have been conducted in a 30 litre retort kiln and show the importance of wood moisture content regarding mass and energy flow (Figure 3). The other physical properties of density, dimension and shape are of secondary importance. A model has been built and applied to an industrial pilot kiln developed at CRA, confirming the major effect of wood moisture content upon the economics of carbonization. The system is now used to conduct tests on demolition and contaminated wood thermolysis treatment (Figure 4).

Figure 4: Contaminated wood in a thermolysis reactor.

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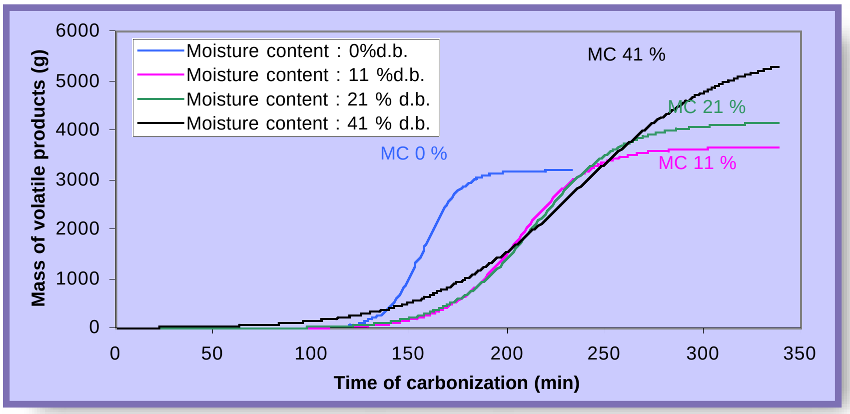
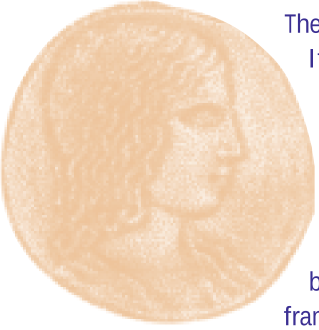


Figure 3: Wood moisture content.

Agricultural University of Athens Laboratory of Farm Structures

By Konstadinos Abeliotis, AUA, Greece

Introduction



The Agricultural University of Athens (AUA) was established in 1920. Its personnel currently include 200 faculty and administration members and approximately 2000 students. In addition, experienced researchers and engineers participate full-time in its research activities.

The laboratory of Farm Structures of AUA, under the direction of Prof. Sp. Kyritsis, has been very actively involved in the field of renewable energy applications during the past 15 years. This is proven by its involvement in a variety of national and EU contracts in the framework of programmes like MIP, AIR, Valoren, JOULE I, II, and III, APAS, AVICENNE and their successful completion.

Biomass Exploitation for Energy Purposes

During its involvement in research and consulting activities in the field of biomass exploitation for energy purposes, the laboratory of Farm Structures has acquired vast experience in the following fields:

- Biomass characterisation and pre-treatment.
- Thermochemical conversion of biomass via flash pyrolysis and gasification.
- Rural electrification utilising biomass.

More specifically, the AUA laboratories are equipped with UV-VIS-NIR, FTIR, and atomic absorption spectrophotometers, which are utilised for the characterisation of biomass properties. In terms of biomass pretreatment and size reduction AUA personnel has access to:

- A rotary drum chipper.
- A mill.
- An automated sieving system.

The following thermochemical conversion of biomass systems exist at AUA:

- A 10 kg/h flash pyrolysis unit which is based on the circulated fluidized bed technology, which has been designed, constructed and operated in close co-operation with CRES during the framework of 3 different JOULE projects.
- A 50 kg/h air-blown atmospheric fluidized bed gasifier for biomass and municipal solid wastes designed, installed and fully operated.
- A 400 kg/h atmospheric fluidized bed biomass gasifier has been designed, constructed and tested in the framework of the Mediterranean Integrated Program.

The well-equipped machine workshop of the Laboratory of Agricultural Structures has long gained experience in the construction and set-up of thermochemical conversion equipment of different sizes.

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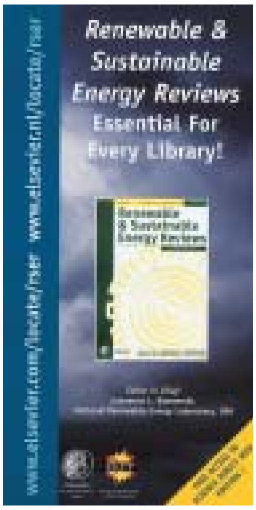
Figure 1: The 50kg/h atmospheric gasifier at AUA.

Book News



Renewable & Sustainable Energy Review

The importance of renewable energy is growing as the global demand for 'clean' energy continues to increase.
Recently introduced as an international review journal, Renewable and Sustainable Energy Reviews is designed to be of interest to a wide audience of users, investors, financiers, researchers, planners and decision makers. Whether a research specialist or a non-technical follower of technology trends, the reader will find in-depth coverage of research in renewable and sustainable energy sciences and technologies, their economics and feasibility, their thrusts, developments, and their applications – as well as the experiences and opinions of experts in these energy sectors worldwide.

This book aims to provide a highly readable and valuable addition to the literature, serving as an indispensable reference tool for years to come. It takes pride in building itself into one of the world's more important review resources. It publishes both contributed and specially commissioned review articles.

Edited by: Lawrence L Kazmerski, National Renewable Energy Laboratory, USA

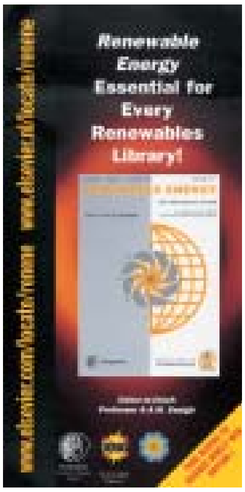
ISSN: 1364-0321
Published by: Pergamon

Renewable Energy

The international journal of Renewable Energy is an essential source of primary research information – reporting on the latest technical advances which help to make renewable energy an increasingly feasible contender in the energy market.

This book seeks to promote and disseminate knowledge of the various topics and technologies of renewable energy and is therefore aimed at assisting researchers, economists, manufacturers, world agencies and societies to keep abreast of new developments in their specialist fields and to unite in finding alternative energy solutions to current issues such as the greenhouse effect and the depletion of the ozone layer.

Edited by: *Professor A A M Sayigh,*
ISSN: *0960-1481*
Published by: *Pergamon*



Further Complementary Publications

Bioenergy UPDATE

Providing current information on bio-resources around the world

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Entec Bulletin

(Quarterly Newsletter)

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SAREIN News Flash

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Fax: +27 11 403 8023
Email: reinsa@mepc.org.za

Diary of Events

Information compiled by Claire Humphreys, Aston University, United Kingdom and Filomena Pinto, INETI, Portugal

SCAPE-10 – The 10th European Symposium on Computer Aided Process Engineering

Venue: Florence, Italy
Date: 7–10 May 2000.
Contract: AIDIC, ESCAPE-10
Secretariat, Piazza
Morandi,2, 20 121
Milano, Italy.
Tel: +39 02 760 211 75
Fax: +39 02 799 644
Email: aidic@aidic.it
Website: http://www.aidic.it

Biomass for Energy and Industry 1st World Conference and Technology Exhibition **(a merger of):**
11th European Biomass Conference and Technology Exhibition
5th Biomass Conference of the Americas
Canadian Biomass Conference

Venue: Conference and
Exhibition Centre,
Sevilla, Spain
Date: 5-9 June 2000
Contact: EnergiaTA – Florence,
Dr David Chiaramonti,
Piazza Savonarola 10,
I-50132, Florence, Italy
Tel: +39 055 5002 174
Fax: +39 055 5734 425
Email: eta.fi@etaflorence.it
Website: http://www.etaflorence.it
http://www.wip.tnet.de

R'2000 – Recovery, Recycing, Re-integration

Venue: Ontario, Canada
Date: 5-9 June 2000
Contact: PEAK Ltd, Ms Maria
Buhler, R'2000 Executive
Director, Seefeldstrasse,
224, CH-8008, Surich,
Switzerland
Tel: +41 1 386 44 44
Fax: +41 1 386 44 45
Email: buehler@peak.ch

World Engineers' Convention

Venue: Hannover, Germany
Date: 19–21 June 2000
Contact: Congress Organisation
P.O. box 10 11 39, D-40002
Duesseldorf, Germany
Tel: +49 211 6214-400
Fax: +49 211 6214-167
Email: tagungen@vdi.de
Website: http://www.vdi.de/wec

XVII Symposium Ibero-American of Catalysis

Venue: Porto, Portugal
Date: 16–21 June 2000,.
Contact: SPQ – Porto Delegation,
A/c Prof. José Luís
Figueiredo, DEQ-FEUP,
Rua dos Bragas,
4050-123 Porto, Portugal
Tel: +351 22 2041662
Fax: +351 22 2000808
Email: sic17@fe.up.pt
Website: http://www.fe.up.pt/
deqwww/sic17

Renewable Energy 2000

Venue: Metropole, Brighton, UK
Date: 1-3 July 2000
Contact: Reed Exhibition Companies

ISWA 2000 8th World Congress of ISWA

Venue: Paris, FRANCE
Date: 3-7 July 2000
Contact: Secretariat pour le 8e
Congrés Mondial de l'ISWA
c/o AGHTM 83, Avenue
Foch – BP 39 16 75761,
Paris Cedex16, France
Tel: +33 1 53 70 13 53
Fax: +33 1 53 70 13 40

EUROCARBON 2000 – 1st World conference on Carbon

Venue: Berlin, Germany
Date: 9–13 July 2000
Contact: DKG Deutsche Keramische
Gesellschaft e. V. Am
Grott 7, D-51147 Koln,
Germany
Tel: +49 (0) 2203/69069
Fax: +49 (0) 2203/69301
Email: blum@dkg.de
Website: http://www.dkg.de/
carbon2000

ENERGEX 2000 8th International Energy Forum

Venue: Las Vegas, USA
Date: 23-28 July 2000
Contact: Dr. Chenn Q. Zhou, Purdue
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Engineering, Hammond
IN 46323, USA
Tel: +1 219 989 2665
Fax: +1 210 989 2898
Email: qzhou@calument.
purdue.edu
Website: http://www2.regina.ism.ca
/ief/index.htm
http://www.energysource.
com/ief/updates/

Air Pollution 2000 – 8th International Conference

Venue: New Hall, Cambridge, UK
Date: 24–26 July 2000
Contact: Conference Secretariat,
Sally Walsh, air Pollution
2000, Wessex Institute of
Technology, Ashurst Lodge,
Ashurst, Southampton SO40
7AA, United Kingdom
Tel: +44 (0) 238 029 3223
Fax: +44 (0) 238 029 2853
Email: wit@wessex.ac.uk
Website: http://www.wessex.ac.uk

Urban Transport 2000 and the Environment for the 21st Century

Venue: Cambridge, UK
Date: 26–28 July 2000
Contact: Conference Secretariat, Urban
Transport 2000, Wessex Institute
of Technology, Ashurst Lodge,
Ashurst, Southampton
SO40 7AA, United Kingdom
Tel: +44 (0) 238 029 3223
Fax: +44 (0) 238 029 2853
Email: wit@wessex.ac.uk
Website: http://www.wessex.ac.uk

GHGT 5 – 5th International Conference on Greenhouse Gas Control Technologies

Venue: Australia
Date: 13–16 August 2000
Contact: GHGT 5 Secretariat, Colin Paulson,
CSIRO Energy Technology,
PO Box 136, North Ryde, NSW
1670 Australia
Tel: +61 2 94 90 8790
Fax: +61 2 94 90 8819
Email: c.paulson@det.csiro.au

Comprail 2000-Computer Aided Design, Manufacture and Operation in the Railway and Other Advanced Mass Transit Systems

Venue: Bologna, Italy
Date: 11–13 September 2000
Contact: Conference Secretariat,
Comprail 2000, Wessex Institute
of Technology, Ashurst Lodge,
Ashurst, Southampton SO40 7AA,
United Kingdom
Tel: +44 (0) 238 029 3223
Fax: +44 (0) 238 029 2853
Email: wit@wessex.ac.uk

ECCOMAS 2000 – European Cong. on Computational Meth. in Appl. Sciences Engin.

Venue: Barcelona, Spain
Date: 11–14 September 2000
Contact: ECCOMAS Congress Org., Spanish
Ass. for Numerical Meth. in Engin.,
Edif. C1, Campus Norte UPC, Gran
Capitán, s/n, 08034 Barcelona,
Spain
Tel: +34 93 401 64 87
Fax: +34 93 401 65 17
Email: ECCOMAS2000@etseccpb.upc.es
Website: http://cimne.upc.es/cimne/
congresos/eccomas.htm

Progress in Thermochemical Biomass Conversion

Venue: Tyrol, AUSTRIA
Date: 17-22 September 2000
Contact: Prof. Tony Bridgwater or
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Aston University, Birmingham,
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(Ext. 4647 or 4633)
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Email: a.v.bridgwater@aston.ac.uk
ahrendtn@aston.ac.uk
Website: http://www.pyne.co.uk

9th International Symposium on Heterogeneous Catalysis

Venue: Varna, Bulgaria
Date: 23–27 September 2000
Contact: Prof. L. Petrov, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria
Tel: +359 2 702 181
Fax: +359 2 756 116
Email: petrov@ic.bas.bg

Bioenergy 2000 – The 9th Biennial Bioenergy Conference

Venue: Adam's Mark Hotel, Buffalo, New York
Date: 15-19 October 2000
Contact: Christina Caffo, Northeast Regional Biomass Program, CONEG Policy Research Centre, Inc, 400 North Capitol St., NW, Suite 382, Washington, DC 20001
Tel: +1 202 624 8464
Email: nrbp@sso.org

2000 International Environmental and Renewable Energy Exhibition & Symposium

Venue: Beijing, P.R. China
Date: 23-26 November 2000
Contact: China International Science Centre, No. 1 Sandaojie, Jianguomenwai, Chaoyang District, Beijing 100022, P.R. China
Fax: +86 10 6515 7760, 8442
Email: cisc@midwest.com.cn

Bioenergy Networks

Compiled by Elma Gyftopoulou, CRES, Greece

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Fax: +358 14 672 598
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Description: A European network, partially sponsored by the EC, to co-ordinate information exchange between national biomass energy programmes on agricultural and forestry biomass and to stimulate the commercial and industrial exploitation of biomass energy in Europe.
End of the project: 31/7/2000

Title: Non-Technical Barriers – NTB Phase IV
Co-ordinator: ADEME, France
Contact: Sophie Labrousse, Etienne Poitrat
Tel: +33 1 47 65 22 26 / 20 19
Fax: +33 1 46 45 52 36
Email: etienne.poitrat@ademe.fr

Description: A European network, partially sponsored by the EC, to collect and exchange information on the non-technical barriers to the development of liquid biofuels.
End of the project: 31/5/2000

Title: European Energy Crops InterNetwork (EECIN)
Co-ordinator: BTG
Tel: +31 53 48 92 897
Fax: +31 53 48 93 116
Email: btg@ct.utwente.nl

Description: The latest developments on the production, pretreatment and utilisation of energy crops are collected and presented on an Internet web site (www.eeci.net). The web site will probably run during the year 2000, although the project and the sponsorship by the EC ended on 31/7/99.

Title: Waste for Energy Network – WfE Nett Phase V
Co-ordinator: Bio-Energy Department Syddansk Universitet, Denmark
Contact: Jens Bo Holm-Nielsen
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Fax: +45 79 14 11 99
Email: jhn@suc.suc.dk

Description: A European network, partially sponsored by the EC, for information exchange in industrial exploitation of waste for energy.
End of the project: 31/10/2000

Title: Pyrolysis Network – PyNe
Co-ordinator: Bio-Energy Research Group, Aston University
Contact: Prof. Tony Bridgwater
Tel: +44 121 359 3611
Fax: +44 121 359 6814
Email: a.v.bridgwater@aston.ac.uk
Website: http://www.pyne.co.uk

Description: A biomass pyrolysis network, sponsored by the EC and IEA Bioenergy, has been established to discuss and exchange information on scientific and technological developments on biomass pyrolysis and related technologies for the production of liquid fuels, electricity and chemicals.
End of the project: IEA 31/12/00
EC 31/05/01

Title: OPET Network / Sector: Renewable energy sources
Contact: OPET central unit (Brussels)
Tel: +32 2 743 8930
Fax: +32 2 743 8931
Email: opet_cu@ecotec.com

Description: A European network of organisations, initiative of the EC, for the dissemination of information, promotion of benefits and market penetration of successful new innovative energy technologies.

Title: Energy Efficiency and Renewable Energy Network (EREN) / Bioenergy Information Network
Co-ordinator: Maintained by the US Government
Contact: Anna Ehrenhart
Email: are@ornl.gv
Website: http://www.bioenergy.ornl.gov

Description: A gateway to information about fast growing trees, grasses and residues for fuels and power. Newsletter, articles, fact-sheets, papers and reports outlining the potential and detailing research and analysis.

Title: European Energy Network / Renewable Energy Sources Working Group
Co-ordinator: A yearly rotating Presidency and Secretariat
Contact: Victor Olmos, IDEA, Spain
Tel: +34 9 1 45 64 955
Fax: +34 9 1 55 51 389
Email: vog164@idea.es

Description: A working group aiming to contribute to the implementation of renewable energy strategies in the EU and in the Member States by providing a leading forum for communication and co-operation.

PyNe Membership

Please contact your country representative for further information.

Co-ordinator

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PyNe Group in Semmering, Austria, January 2000.

IEA Bioenergy

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