PyNE 2
Pyrolysis Network for Europe
ISSUE 2 OCTOBER 1996

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Contents

ASTON UNIVERSITY

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

LIQUIDS FROM WOOD BY FAST PYROLYSIS

Renewable energy is of growing importance in satisfying environmental concerns over fossil fuel usage. Wood and other forms of lignocellulosic biomass are one of the main renewable energy resources available and provide the only source of liquid, solid and gaseous fuels. Wood and biomass can be used in a variety of ways to provide energy:

- by direct combustion to provide heat for use in heating, for steam production and hence electricity generation
- by gasification to provide a fuel gas for combustion for heat, or in an engine or turbine for electricity generation,
- by fast pyrolysis to provide a liquid fuel that can substitute for fuel oil in any static heating or electricity generation application.

Thus only fast pyrolysis can directly produce a liquid fuel from biomass which is important when biomass resources are remote from where the energy is required as a liquid can be readily stored and transported.

Fast Pyrolysis

Fast pyrolysis is a medium temperature process in which the wood is rapidly heated in the absence of air, vaporises and condenses to a dark brown mobile liquid which has a heating value about half that of conventional fuel oil. While it is related to the traditional pyrolysis processes for making charcoal, fast pyrolysis is an advanced process which is carefully controlled to give high yields of liquid, known as "bio-oil".

The essential features of a fast pyrolysis process are:

- very high heating and heat transfer rates which require a finely ground biomass feed,
- a carefully controlled temperature of around 500°C,
- rapid cooling of the pyrolysis vapours to give the bio-oil product.

The main product, bio-oil, is obtained in yields of up to 80% wt on dry feed, together with by-product char and gas which is used within the process so there are no waste streams.

While a wide range of reactor configurations have been operated, fluid beds and circulating fluid beds are the most popular configurations due to their ease of operation and ready scale-up. A typical fluid bed configuration is depicted in Figure 1 with utilisation of the by-product gas and char to provide the process heat.

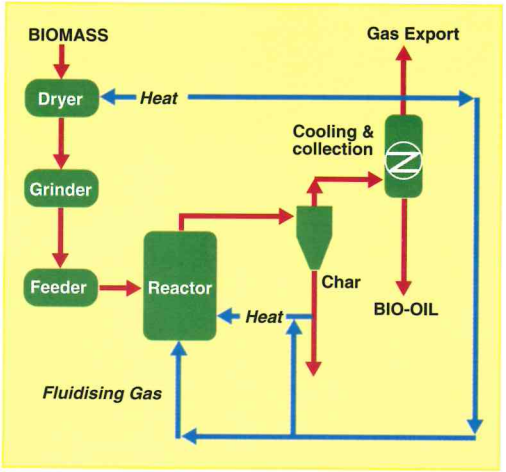


Figure 1

The figure includes the necessary steps of drying the feed to less than 10% water to minimise the water in the product bio-oil, and grinding the feed to typically less than 2 mm to give sufficiently small particles to ensure rapid reaction.

Pyrolysis Liquid - Bio-oil

Fast pyrolysis liquids have a higher heating value of about 18 MJ/kg compared to around 42-44 MJ/kg for conventional fuel oil. The liquid is often referred to as "bio-oil" or "bio-crude" although it will not mix with any hydrocarbon liquids. Bio-oil is also sensitive to elevated temperatures when it undergoes chemical change so it cannot be distilled.

Applications for Bio-oil

Bio-oil can substitute for fuel oil or diesel in many static applications including boilers, furnaces, engines and turbines. There are a range of chemicals that can be extracted or derived including food flavourings, specialities, resins, agri-chemicals, fertilisers, and emissions control agents. Upgrading bio-oil to transportation fuels is not currently economic, although feasible.

Fast Pyrolysis thus offers significant contributions to reducing CO_2, SOx, and NOx emissions; it enables agricultural wastes to be re-used; and provides new industrial and employment opportunities.

Further details of fast pyrolysis processes can be found on pages 6.

PYNE MEETING PROGRESS

PyNE Steering Committee

The PyNE Steering Committee met in July this year. Membership of the Committee is made up of the Network Co-ordinator, the Network Administrator, plus the Convenors of the four Specialist Working Groups. The Committee's purpose is to review the Network's progress, developments, communications and publicity. It also formulates future plans and strategies. The Committee agreed unanimously that good progress had been made, and that the Network's Objectives were being met. It was recognised that the biomass pyrolysis community has considerable potential and PyNE has a major role to play in providing a forum for interaction and, as a major source of useful information. If you would like any further information, please contact Tony Bridgwater.

▲ Left to right.
Back: Dietrich Meier, Eric Rensfelt, Tony Bridgwater, Yrjo Solantausta, Angél Cuevas
Front: Rosanna Maggi, Karen Dowden

PyNE Network Meeting

Following two previous meetings in the UK and Spain, Network members met for the third time in Pisa, Italy, from 7 to 12 September 1996.

In addition to a thorough review of the PyNE Network activities and, active discussions on the four specialist technical areas, visits were made to the ENEL laboratories at Livorno where the CIRO circulating fluid bed fast pyrolyser is being developed, and to Bastardo where the new 650 kg/h pilot plant has been constructed (see page 6).

▲ PyNE Network - Visit to ENEL Pilot Plant, Bastardo, Italy

Observers are very welcome to join PyNE meetings. If you would like to attend the next meeting of PyNE, please contact your country representative (see back page for details).

New Members

We would like to welcome two new members to PyNE, Dr Jacques Lédé of CNRS, France (see profile on page 17) and Dr Carlo Rossi of ENEL, Italy. Dr Rossi has kindly provided an article regarding ENEL and its activities, details can be found on page 6

ROUND ROBIN OF BIO-OILS - ANALYSIS AND CHARACTERISATION

Dr Dietrich Meier - IWC, Germany

The Specialist Working Group "Analysis and Characterisation" agreed at the first meeting in May 1995 to start a round robin for bio-oil analysis. The background of this activity is the increasing interest in the utilisation of bio-oils produced by fast pyrolysis for energy and/or high-value added chemicals. A prerequisite for a successful market introduction of the new oils is the existence of reliable tools for their analysis and characterisation. Potential customers need correct data in order to accept the bio-oils as alternative for conventional petroleum-derived liquids.

As development of fast-pyrolysis in Europe is just beginning, only a few laboratories have gained experience with the analysis of bio-oils produced by pyrolysis. From the chemical point of view these oils have nothing in common with fossil fuels. Therefore, it is essential to modify existing methods or to develop new analysis methods.

As a first step there was an agreement at the first PyNE meeting to distribute samples for analysis to interested laboratories. Eight laboratories, distributed all over Europe, expressed their interest and received oil samples from two European laboratories. Both oils were produced by fast pyrolysis but with different reactor configurations.

The following analyses are performed by each laboratory:

- viscosity at different temperatures
- water content
- heating value
- elemental analysis
- pH
- solids content
- density

The laboratories were allowed to use any method without limitations in order to get familiar with the samples. Some laboratories used ASTM methods for petroleum products, others took their own methods. It was one intention of the group to first look at the performance of each method and then derive recommendations for the most appropriate method.

specialist subject groups

The first newsletter included two interim summary reports from the Upgrading and Characterisation Specialist Subject Groups. Interim reports on the remaining two Groups, Pyrolysis Technology and Applications provided are herein.

Pyrolysis Technologies Group

Mr Erik Rensfelt,
Convenor,
Pyrolysis Technologies Group

The objectives of the Technologies Group are to:-

- consider options available for the production of a clean liquid for use as a fuel,
- collect information on the current status of fast pyrolysis in the world,
- identify generic processes and unit operations,
- discuss problems, possibilities, share experiences and devise suitable or potential solutions,
- identify unit operations in the pyrolysis system (from feedstock reception to gas exiting the process),
- review actual processes and assess useful results and information which may be obtained for general use by the pyrolysis community.

The production of pyrolysis liquids is at the demonstration/ commercial scale of operation, although at present there is only one actual provider of a technology with a performance guarantee. There are still key problems to be resolved, with regards to producing a clean liquid for use as a fuel with minimal retrofitting of existing equipment, i.e. boilers, engines and turbines. The Technologies Group will therefore consider what technologies are available and identify areas where further developmental work is required and make suitable recommendations.

At present, there are two pilot plants operational in Europe for the bulk production of liquids although there are numerous laboratory scale activities producing liquids for analysis and assessment. Union Fenosa, Spain, have been operating a 200 kg/h pilot plant for over two years and ENEL, Italy, have recently commissioned a 650 kg/h unit which is reported on page 6

The major problems to be addressed are:

- removal of char from the liquid,
- production of a liquid with the requisite physical properties without significant post treatment,
- liquids collection,
- process integration (char and gas utilisation)

These topics are to be reviewed and conclusions summarised where relevant. An overall system analysis of the unit operation would then be linked to the other groups in the PyNE network.

Anticipated results

The anticipated result is an authoritative report covering the following areas:

- an extensive review of all current research on fast pyrolysis of biomass. A brief summary on the status of slow pyrolysis would also be included for information,
- heat transfer in fast pyrolysis-provision of heat to the reactor and heat transfer in the reactor,
- review of hot gas/vapour clean up and suggested technologies and improvements,
- review of liquids recovery systems at the bench, demonstration and commercial scale of operation,
- evaluation of the key problems and limitations to the commercial development of fast pyrolysis for liquids,
- list of key recommendations and areas for further research.

Applications Group

Mr Angél Cuevas, Convenor, Applications Group

As fast pyrolysis technology is still not well established industrially, it is difficult to comment authoritatively on the likely success of the technology or the applications that use the liquid product. Nevertheless, several ways of applying the technology and different approaches for using the products have been proposed and tested at both the research and demonstration scale.

This PyNE Specialist Subject Group will look at fast pyrolysis activities both inside and outside the EU and report on project objectives, activities and results. The main topics will be:-

- Discussion and comparisons of different products.
- Handicaps for applications.
- Strategies for introduction of bio-oil.
- Actions for the Group.

Alternatives proposed for applications

At the first PyNE meeting the Applications Group was formed to include both technology and economics. An initial discussion gave rise to the consideration of a spectrum of potential applications of pyrolysis systems and products.

These can be divided into several fields, including:

Energy - in various sectors such as electricity, heat and power, transport;

Chemistry - food: special sugars, flavourings, preservation, smoking; cosmetics, tanning.

Environment - activated charcoal, products to reduce emissions in conventional power plants and other fields of industrial activity, feed stock for cleaning products or devices, fuel additives for transport.

Other industry - as a basic raw matter for diverse chemicals such as acetic acid, aromatics, sugars, speciality chemicals, phenols, adhesives and lignin derived products.

continued overleaf

Applications Working Group (continued...)

It can clearly be seen that the future could be very bright for the liquid product from biomass fast pyrolysis. Nevertheless, its introduction into highly competitive markets will not be easy. Although these chemical possibilities seem to offer substantial opportunities, it seems to be more likely that energy or environmental applications will provide the real short term opportunities. This will also allow the development of complementary improvements such as modified pyrolysis, catalytic pyrolysis and upgrading of the bio-oil.

Comparison with alternative technologies and products.

In any of the fields where pyrolysis and its products (mainly bio-oil) have a potential application, there are other competing processes, already established or being introduced which include the following:

Energy:

Due to the wide availability and low price of conventional fuels such as fuel-oil and natural gas, the introduction of pyrolysis bio-oil into the energy market will be impeded. However, government subsidies and environmental concerns will favour its use. There are also other bio-fuels trying to enter the energy market. These include methanol; ethanol from biomass residues or plants like cereal, sugarcane, beet or sweet sorghum etc; oil from seeds such as rape, sunflower or palm, with the esterification process for quality improvement; and even bio-oils from parallel technologies such as slow pyrolysis, liquefaction, and other biological conversion processes.

Chemistry:

Most of the chemicals present in pyrolysis liquids from fast pyrolysis already have commercially available alternatives, in many cases based in the petrochemical industry.

Environment:

Active charcoal is at present widely produced, although in a very controlled market. The production of charcoal as a pyrolysis by-product could be an opportunity in certain applications. Acid rain reduction is already provided for by a variety of technologies in conventional power plants, but they are either expensive or have other impacts in efficiency, availability, or generation of other by-products. Therefore, chemically modified pyrolysis products could have an opportunity to enter a field that offers a very wide potential in the coming years, as long as fossil fuels play a substantial role in meeting world energy needs.

Handicaps

In the discussion held in the La Coruña meeting it was concluded that there are several obstacles that are impeding introduction of fast pyrolysis technology into the market. These were identified by:-

a) Products. Standardisation of the bio-oil or char is needed, by establishing characteristic values, depending on the specific applications, as is the case with other fuels orindustrial products.
b) Equipment. The further development and demonstration of technology along the various lines described above is necessary in order to obtain experience and expertise in materials and equipment selection, in scale up capability, and in the choice of feed stocks etc.
c) Economics. The above mentioned measures to improve production as well as technology will help to bring fast pyrolysis to a similar level of competence as the established conventional alternatives. But an economic analysis of these opportunities and prices is also necessary in order to predict the economic barriers, limitations and opportunities for pyrolysis.

Strategies for introduction

From the various possibilities of application of fast pyrolysis products, it is clear that some are closer to commercialisation while others are clearly still at a development stage and need continued work. Energy applications of bio-oil from fast pyrolysis will have a clear opportunity in the near future through combustion in engines and gas turbines. These applications should be given a high priority, not only because of its short term potential, but also because the market size and growth.

Conclusion

It is concluded that environmental use of pyrolytic products will have great opportunities, given the potential of this field in energy production or use (such as transport) and also given the favourable characteristics of charcoal or bio-oil for applications in reducing rain acid emissions in power plants and other energy converting systems.

A second priority was given to the production of chemicals, not because of the their smaller potential , but due to a more difficult integration of the very diverse applications of each of the different components (or groups of them) derivable from pyrolytic liquid. On the other hand, it is feasible that these chemical applications could achieve a greater commercial success, given the high specific value of some of the products. In the energy field the prices and competitiveness are so well controlled that fast pyrolysis will have obstacles to overcome unless any of the following will apply:

- feedstocks can be obtained at a very marginal or low cost,
- specific production is very high,
- there are environmental advantages (intrinsically or from penalisation of conventional fuels),
- there is a new progressive or drastic rise of prices in conventional fuels.

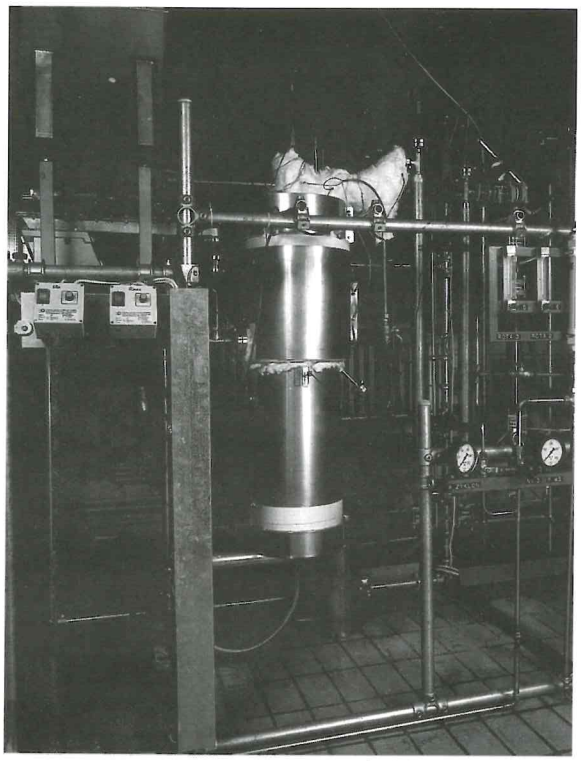
The Group has agreed the following actions:-

a) A uniform System and Material Data Sheet (SMDS) will be drafted and distributed to PyNE members for comment and correction. The SMDS will collate specific information on possible pyrolysis applications throughout Europe.
b) The finalised SMDS will be distributed to all the possible interested or active companies, bodies, groups, etc., in the production, utilisation, manufacturing of related equipment; authorities responsible for inspection, permits, etc; and finally, to anyone that could affect or be affected by the final application of fast pyrolysis products in the European industry.
c) Actively obtain responses on the opportunities offered by fast pyrolysis, evaluate the information and derive conclusions on problems which could impede introduction of fast pyrolysis products in the various applications.
d) Discuss and prepare the structure of the final report.

new developments

Pilot plant - flash pyrolysis of biomass

by Dr Dietrich Meier, at BFH-IWC, Hamburg, Germany



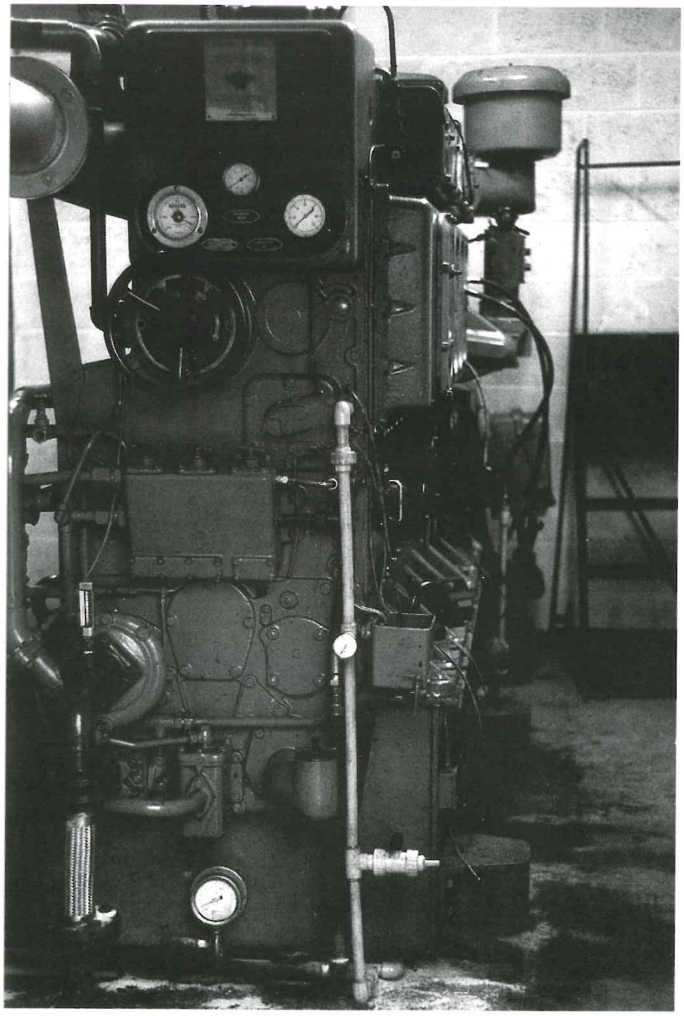
3 kg/h fluid bed at BFH-IWC

Since August 1996 a 3 kg/h pilot plant with a fluidized-bed reactor for flash pyrolysis of biomass is operating at the Institute for Wood Chemistry (IWC), a sub-division of the Federal Research Centre for Forestry and Forest Products (BFH) in Hamburg, Germany. The plant works with gas recycling and is primarily used to convert contaminated wood wastes into pyrolysis oil (bio-oil). The continuously operating test facility is equipped with two gas preheaters, two heat exchangers, one intensive cooler, and two electrostatic precipitators. Based on results from laboratory fluidized-bed reactors the oils are free from heavy metals. Within several EU-funded projects the plant will also be used for testing new feedstocks and catalysts. For more information please contact Dr. Dietrich Meier (address see last page), or see profile of BFH in newsletter 1.

250 kWe diesel engine

by Mr John Leech, Ormrod Diesels

Ormrod Diesels have now achieved over 140 hours of operation on fast pyrolysis oil supplied by Union Fenosa. Early work was carried out on blends of bio-oil and methanol or ethanol but blending was found to be unnecessary and the last 50 hours of runs has been carried out on raw bio-oil. Several continuous runs of up to 9 hours duration have been achieved on load. The engine and fuel feed systems are currently being modified to provide comprehensive instrumentation and analysis.



250 kWe dual fuel diesel engine under test at Ormrod

The Bastardo pyrolysis plant for bio-oil production from biomass

by Dr Carlo Rossi, ENEL, Italy

An R&D biomass fast pyrolysis plant has been realised in Italy by ENEL-Thermal Research Centre of the Research Department and the Agency ARUSIA of Umbria Region, within the framework of a JOULE Project, and partially financed by the EU. The plant has been erected in a dedicated area inside the ENEL Bastardo (Perugia) power station, located in the Umbria Region. ENEL has designed and constructed all the auxiliary facilities necessary to complete the plant. Commissioning and first runs have already been performed in June 1996, so that the plant should be fully operational by September 1996. The first experimental campaigns will be carried out with biomass supplied by ARUSIA, namely hardwood sawdust.

This demonstration plant will be utilised for in depth investigations on the fast pyrolysis technology of vegetable biomass, to assess its commercial potential. The size of the plant, capable of processing 15 tonnes per day of dry feedstock, makes it the largest experimental facility of this kind in Europe The pyrolysis plant has been supplied by Ensyn, which has developed the patented advanced RTP process, and is capable of converting biomass into bio-oil at a yield of 70 wt%. The liquid product can, in principle, find several applications in the energy sector, as a substitute for traditional fossil fuels.

In the future the plant could be fed with different sorts of feedstock, including energy crops such as sorghum, kenaf, miscanthus etc.

Inside view of the Bastardo plant

Description of the process

The plant includes three main sections: the feedstock feeding system, the pyrolysing section and the condensation stage of pyrolytic vapours. The feedstock, with a maximum size of 6 mm and maximum moisture content of 8%, is transported to the plant via trucks, from which it is pneumatically transferred to a storage silo. The biomass is then sent to a surge bin, with a capacity sufficient for 5 hours of operation, and afterwards to a feed bin equipped with a variable speed screw feeder, that permits continuous biomass feeding to the pyrolysis reactor. The biomass feeding system is blanketed with nitrogen, in order to prevent possible explosions.

The pyrolysis process occurs inside the circulating fluidised bed reactor, where the biomass enters radially and is contacted with the heat carriers, namely hot sand and recirculated non-condensible pyrolysis vapours. The pyrolysis reactor is divided into three main zones: a rapid mixing zone, a transportation zone and a separation zone.

The conversion of the solid feedstock into a raw product vapour begins in the mixing zone and continues through the other two zones.

General view of the Bastardo (Perugia) plant. Industrial building and feedstock Silo (100 m3)

The separation of the solids, namely sand and char entrained by the gaseous stream coming out from the pyrolyser, is accomplished by means of a short residence time high-efficiency cyclone. The operating temperature inside the pyrolyser is 525°C. The sand is reheated in a direct contact heat exchanger, where the heat produced by the combustion of char and a fraction of pyrolysis gas is utilised. The temperature inside the sand reheater is around 760°C. The char in the flue gas from the sand reheater is removed with high efficiency cyclones, and fines are returned to the reheater.
The gaseous stream from the pyrolyser cyclone, made up of condensible and non-condensible products at a temperature of around 500°C, is sent to the condensation sections, which consists of two separate columns. The condensed liquid collected at the bottom of the two columns is the useful product that is sent to the storage tanks.

The gas from the first column is sent to the second condenser and after a slight heating up, the gaseous stream is sent to a demister and afterwards to a filter located upstream of the blower that sends it in part to the pyrolyser and partly to the sand reheater. Before discharge to the atmosphere, the flue gas from sand reheater is cleaned by a filter-bag.

The effluents from the plant consist of a small flow of ash mixed with sand. One of the most important features of the plant is the possibility of utilising the gaseous and solid pyrolytic products inside the process, with the advantage of reducing the disposal problem of waste. For start up it is necessary to provide some bio-oil for the condensing columns and propane for heating up the system; afterwards the plant is self-sustaining and fully automated.

Design data

The plant has been designed for a reference biomass, namely hardwood sawdust, for which the following performances are guaranteed:

dry biomass processed	625 kg/h
bio-oil yield	70 wt% (on feed as received)
minimum HHV of liquid product	15 MJ/kg

The plant is designed for continuous operation, on the basis of 330 days per year (7920) hours. It will be also possible to run the plant at intervals, both for the set up and the experimental research needs.

Typical chemical and physical characteristics of bio-oil are shown in Table 1.

Working plan

The main aim of the tests is to assess the RTP process in terms of reliability, flexibility and quality of bio-oil when processing different sorts of feedstock. Another important goal is the economic analysis of this technology, to evaluate the potential penetration into the market. Furthermore, operation of the Bastardo plant will enable bio-oil to be supplied at relatively low cost, to researchers interested in carrying out experimental activities that are still necessary for investigating the possible applications of bio-fuels in the electricity production sector.

The research at ENEL will focus on the utilisation of bio-oil in furnaces, in gas turbine combustion chambers and in diesel engines, taking into account the peculiar characteristics of bio-oil and the previous combustion tests already carried out by ENEL.

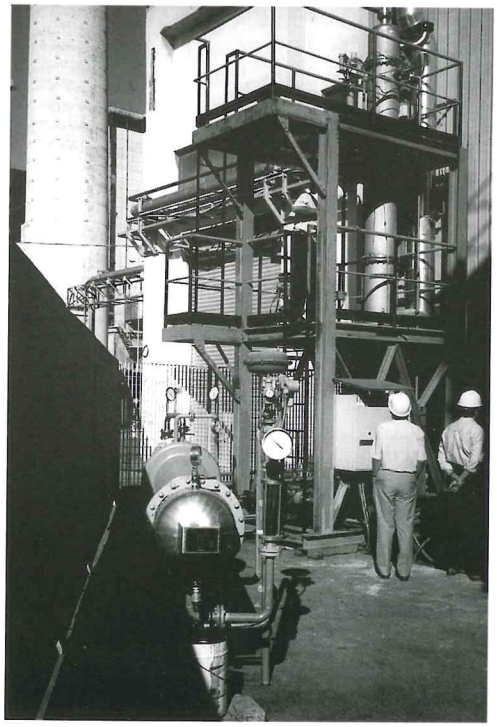
Table 1 Characteristics of typical RTP™ bio-oil

Bio-fuel properties	Range of values	Typical values
Moisture (%)	15 - 31	23
Specific gravity	1.15 - 1.25	1.20
HHV (MJ/kg)	15 - 18	17.5
LHV (MJ/kg)		16.2
Viscosity at 40°C (cSt)	35-53	40
Acidity (pH)	2.8-3.8	3.2
Elemental (%WT)		
Carbon	51.5 - 58.3	54.5
Hydrogen	5.5 - 6.8	6.4
Nitrogen	0.07 -.0.40	0.2
Sulphur	0.00 - 0.07	0.0005
Oxygen (by difference)	34.4 - 42.9	38.9
Ash (%)	0.13 - 0.21	0.16

Pasquali fast pyrolysis reactor - CIRO

by Dr Carlo Rossi, ENEL, Italy

ENEL and PASQUALI are developing a circulating fluid bed fast pyrolysis reactor referred to as CIRO. The system includes integral char combustion at the base of the circulating fluid bed riser to provide the heat for pyrolysis. The unit aims to study the fast pyrolysis of biomass and provide information on the process. The nominal capacity is 100 kg/h. The unit is situated at the Livorno laboratory of ENEL. The photograph shows the condensation system of the plant.



CIRO Circulating fluid bed fast pyrolysis being developed by ENEL and Pasquali

Developments on Thermochemical Biomass Conversion

Banff, Canada, May 1996

The fourth IEA Bio-energy Conference on Thermochemical Biomass Conversion was held in Banff, Canada from 19 to 24 May 1996. All aspects of thermal biomass processing were included from pre-treatment, through pyrolysis, gasification and combustion to system studies and environmental considerations. Pyrolysis was the major topic with over 35% of the 210 papers that were offered.

Ninety percent of the world's active researchers in this field from industry, commerce and academia were there, together with many representatives of policy making bodies. Altogether nearly 200 delegates attended from 30 countries.

There had been many encouraging developments since the last conference held in Switzerland in 1992, which focused on research and development activities. At this year's conference it was very gratifying to see that many research activities had progressed to commercial or near commercial reality. This suggests that there is extensive potential for developing these thermochemical conversion processes.

Copies of proceedings are available from Blackie Academic & Professional, Chapman and Hall, 2-6 Boundary Row, London, SE1 8HN, UK, Tel: +44 (0)171 865 0066, Fax: +44 (0)171 522 9223
ISBN 07514 03504 - "Developments in Thermochemical Biomass Conversation", Bridgwater and Boocock (Editors).

The fifth Conference entitled "Progress in Thermochemical Biomass Conversion" is planned for May in the year 2,000.

Poster Award Ceremony *Eva Bjorkman, TPS, Sweden with Tony Bridgwater and David Boocock, Conference Co-Chairs*

Energetic and Material Utilisation of Waste & Renewable Feedstocks Conference

This conference took place in Velen, Germany, from 22 to 24 April 1996. There were 23 Oral Presentations and 22 Posters. The main subjects discussed were: Combustion, Gasification, Pyrolysis, Hydrocracking of Wastes and Renewable Feedstocks. The conference language was German. The following oral presentations are believed to be of relevance to PyNE:-

C. Nielsen, A. P. Houmoller
Energetic and Chemical Use of Waste Material and Renewable Energies
D. Meier, S. Wehlte, O. Faix
Flash Pyrolysis - A Possibility of Substance Recycling of Waste Wood
A. Reichel, P. Lamp, R. Funk
Energetic Use of Biomass, Especially Wood, in Bavaria
S. Becher, M. Kaltschmitt
Environmental Life Cycle Assesment of Biomass for Energetic Use
W. Klose, W. Wiest
Pyrolysis of Sweet Corn in a Rotating Kiln

The Proceedings of this conference will be edited by DGMK Tagungsbericht 9603 - ISBN 3-931850-02-1

9th European Bioenergy Conference

This conference took place in Copenhagen, Denmark, 24-27 June, 1996.The conference included an exhibition. The aims of the exhibition were to display a broad selection of demonstrated or fully commercialised bio-energy technologies and to provide the opportunity for the exchange of experience between the bio-energy research community and the bio-energy industry. The exhibition and the conference dealt with the most important aspects related to the utilisation of bio-energy, from research to the commercialisation of biomass technologies. This conference was organised by the Danish Energy Agency and the DIS Congress Service Copenhagen A/S.

The programme was divided into 7 main areas with oral presentations and posters:-

1. Primary Production of Biomass
2. Processes for Large Central Power Plants
3. Processes for Decentralised Heat and Power Production
4. Processes for Production of Transportation Fuels
5. Provision and Production of Solid Biomass Fuels
6. Market, Economic and Environmental Aspects
7. Policy Measures to Overcome Non-technical Barriers

A total of 77 oral presentation and 418 posters were included in the conference. The proceedings will be published early 1997 by Elsevier.

diary

of events by K. Pedeser, Denmark.

Environmental Impact of Biomass for Energy

Venue: Utrecht, Nl
Date: **4-5 November 1996**
Contact: Edo Biewinga, Centre for Agriculture and Environment, P.O. BOX 10015, 3505 AA Utrecht, The Netherlands
Fax: +31 30 244 13 18
E-mail: clm@clm.nl

Renewable Energy Sources - A Major Contributor?

Venue: London, UK
Date: **4-5 November 1996**
Content: *Key issues include: Enhancing the exploitation of renewable energy and the current positions in the UK and Europe.*
Contact: Emma Tamlyn
Fax: +44 171 453 2058
Email: emmah-tamlyn@ibcuklon.ccmail.compuserve.com

11th International Conference on Solid Waste Technology Management

Venue: Philadelphia, USA
Date: **12 - 15 November 1996**
Tel: + 1 610 499 4042
Fax: + 1 610 499 4059

III Conference on Industrial Thermal Engineering

Venue: Cuba
Date: **18 - 20 November 1996**
Content: *The main scientific and technical theme is Energy Management in the Sugar Industry, including: Steam generation, Process, steam. Mass and energy balances. Co-generation of heat and electricity. Utilisation of agricultural wastes as energy carriers.*
Contact: Dr Pablo Roque Diaz, Centro de Estudio de Termonergetica Azucarera
Universided Central de Las Villas CP 54830
Santa Clara, Villa Clara, Cuba
Tel: +53 422 81194/81630
Fax: +53 422 81608/4623

Fourth International Workshop on Carbohydrates as Organic Raw Materials

Venue: Vienna
Date: **20-21, March 1997**
Contact: Werner Praznik, IFA Tulln, Centre of Analytical Chemistry
K. Lorenz Strasse 29, 3430 Tulln, Austria
Fax: +34 2272 662 804 03
E-mail: praznik@ifa1.boku.ac.at

Gasification and Pyrolysis in Europe; and The third meeting of the EU-Canada Collaboration on Thermal Biomass Conversion

Venue: Universty of Stuttgart, Germany
Date: **9-11, April 1997**
Content: *Review of biomass technology conversion developments in the EU and Canada*
Contact: M. Kaltschmitt
Institute for Energy, Economics & the rational use of Energy (ER), Hessbruehlstrasse 49a, Stuttgart, Germany DE-70565
Tel: +49 711 780 6116
Fax: +49 711 780 3953

Third European Works on Chemistry, Energy & the Environment

Venue: Portugal
Date: **25-28 May 1997**
Contact: Prof. C.A.C. Sequeria, Instituto Superior Technico
Av. Rovisco Pais, 1096 Lisboa Codex, Portugal
Tel/Fax: + 351-1-7783594

The World Waste-to-Energy Conference and Exhibition

Venue: Amsterdam
Date: **27-28-29 May 1997**
Contents: *The conference will address the main issues of power generation from waste materials with particular emphasis made on flue gas emission and waste ash, and the impact of waste-to-energy on recycling initiatives.*
Tel: +44 171 582 7278
Fax: +44 171 793 8007

Sustainable Agriculture for Food, Energy & Industry

Venue: Germany
Date: **22-28 June 1997**
Content: *The aim of the conference is to discuss, disseminate and utilize results obtained by scientists from different countries and regions to develop appropriate strategies towards sustainable management of natural resources. Emphasis will be put on aspects related to integrated agriculture production systems for food and raw materials for industrial and energy uses.*
Contact: Federal Agricultural Research Centre (FAL), Institute of Crop Science
Bundesallee 50, D-38116 Braunschweig, Germany
Fax: +49 531 596 365

Fifth Brazilian Symposium on the Chemistry of Lignin and other Wood Products.

Venue: University of Paran·, Brazil
Date: **August 31 - September 4, 1997**
Content: *Biomass to ethanol; modification enzymes for fibre and lignin; Chemical and structural characterisation and lignin and other wood components; alternative uses of biomass.*
Contact: Jack Saddler, IEA activity leader, Forest Products Biotechnology, The University of British Columbia, 2357 Min Mall - Vancouver, B.C. Canada
Tel: +55 (604) 2223267
Fax: +55 (604) 2223220
E-mail: saddler@unixg.ubc.ca

Third Biomass Conference of the Americas

Venue: Montreal, Canada
Date: **August 1997**
Contact: Mr. E Hogan, Natural Resources, 580 Booth Street 7th Floor, Ottawa, Ontario, Canada, K1A OE4
Tel: +1 613 996 6226
Fax: +1 613 996 9416

CURRENT AND RECENT EURO
CONTRACTS RELATED TO PYR

ELBION - ELECTRICITY FROM BIOMASS NETWORK. DEVELOPMENT OF BIO-ELECTRICITY THROUGH THE ADOPTION OF ADVANCED TECHNOLOGIES AND APPRAISAL OF PERSPECTIVES FOR THE UTILISATION OF BIO-CRUDE OIL (BCO) IN ENGINES (APAS/RENA-CT94-0071)

Co-ordinator
NA

Other partners
Cesvit - L. Frattali
Agricultural University of Athens - M. Ioannidou
University Stuttgart - M. Jager
ZSW - R. Schmidt
University of Florence - G. Gabrielli
ENEL - B. Bellagamba
Proel Tecnologie - A Matucci
Pasquali Macchine Agricole - P. Vangi

Summary
The principal aim of the project is the improvement of bio-crude-oil for its use in the development of bioelectricity and its potential perspectives.

Status
Completed

CATALYTIC PYROLYSIS OF BIOMASS FOR IMPROVED LIQUID FUEL QUALITY (JOR3-CT95-0080)

Co-ordinator
Angel Cuevas
Union Fenosa
Capitan Haya 53
ES-28020 Madrid, Spain

Partners
Aston University - A V Bridgwater
Twente University - W Prins
CPERI - M Samolada
IWC - D Meier
Naples University - C Di Blasi
Sapemus - A Hatjussaak
Santiago University - M Boa

Summary
The objective of this Contract is to explore a variety of ways of catalytically and chemically modifying the fast pyrolysis process and the pyrolysis liquids to improve their properties and characteristics and thus make them amenable to utilisation. Subsidiary objectives include minimising the cost of improvement, modelling the pyrolysis process, recovering valuable components, and testing the more promising results on a large scale.

Status
On-going

PRODUCTION, TREATMENT AND UTILIZATION OF BIO-OILS FROM PYROLYSIS, FOR ENERGY AND ALTERNATIVE FUELS AND CHEMICALS (AIR2-CT93-1086)

Co-ordinator
Angel Cuevas
Union Fenosa
Capitan Haya 53
ES-28020 Madrid, Spain

Other partners
Universitè Catholique de Louvain- R. Maggi
Veba Oel - W. Baldauf
CPERI - M. Samolada
VTT Energy - A. Oasmaa

Summary
The objectives:
- *The optimisation of the Waterloo Flash Pyrolysis Process (WFPP) at the pilot plant level, enabling a techno-economic evaluation of this technology.*
- *The search for practical and sound applications of the pyrolytic oil, also investigating its possible energetic and industrial uses.*

Status
On-going

INTEGRATED CHEMICALS AND FUELS RECOVERY FROM PYROLYSIS LIQUIDS GENERATED BY ABLATIVE PYROLYSIS (AIR2-CT93-0889)

Co-ordinator
A.V. Bridgwater
Aston University
Aston Triangle
UK-Birmingham B7 4ET

Other partners
Universit· degli Studi Napoli - C. Di Blasi
University of Twente - W. Prins
Institute of Wood Chemistry - D. Meier

Summary
The objectives of the work are to operate and optimise the performance of two laboratory scale pyrolysis reactors in order to derive an optimum configuration and jointly develop a common modelling procedure for scale-up.

Status
On-going

DEVELOPMENT OF AN INTERNAL COMBUSTION ENGINE FOR USE WITH CRUDE BIO-OIL AND EVALUATION OF ASSOCIATED PROCESSES (APAS/RENA-CT94-0070)

Co-ordinator
John Leech
Ormrod Diesels
Skelmersdale - WN8 9PT
United Kingdom

Other partners
Aston University - A.V. Bridgwater
Union Fenosa - A. Cuevas
UCL - R Maggi

Summary
The overall objective of this project is to develop a modified engine fuelled with crude bio-oil produced by fast pyrolysis of biomass for electricity production, to investigate upgrading crude bio-oil and to evaluate opportunities for implementation of the resultant technologies for electricity generation.

Status
On-going

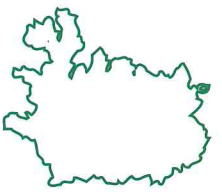
ADVANCED BIOMASS PYROLYSIS FOR ELECTRICITY PRODUCTION USING ELECTRON BEAM IRRADIATION (JOU3-CT93-0417)

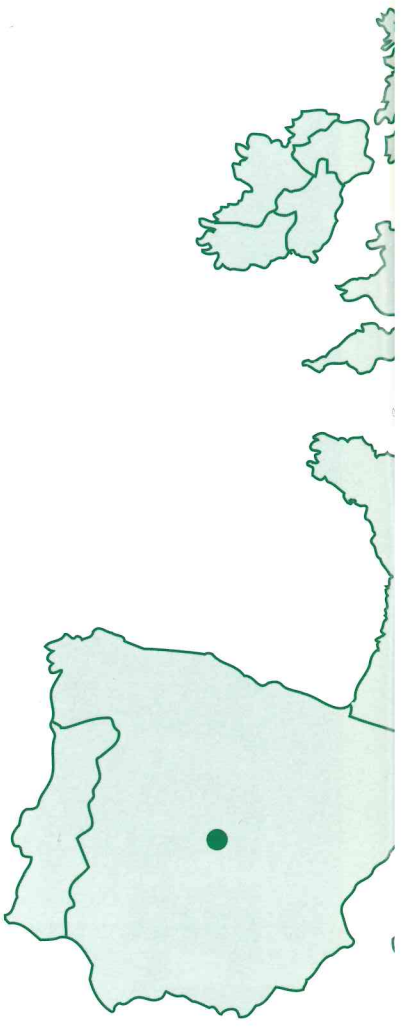
Co-ordinator
Ubaldo Bizzarri
Hitesys - High Technology Sistems SpA
Via dell¥Industria 1/A
IT-04011 Aprilia, Italy

Other partners
Zentrum für Sonnenenergie und Wasserstoff-Forschung - W. Bloss
University of Aston - A.V. Bridgwater

Summary
Electron beam simulation of chemical reactions has been successfully applied for flue gas cleaning, for demolition of organic compounds, polymerisation, crosslinking and other similar applications. Scope of the project is the investigation of the electron beam interaction with the organic compounds more common in pyrolytic fuels, in order to assess the feasibility of processes based on chemical reaction bringing to a reduction of the C/H ratio and O_2 content.

Status
Completed





EAN UNION
LYSIS

by
Y Solantausta, Finland

TAIRA: THERMAL AIR APPLICATIONS: A PYROLYSIS NETWORK FOR EUROPE (PYNE) (AIR3-CT94-1857)

Co-ordinator
A.V. Bridgwater
Aston University
Aston Triangle
UK-Birmingham B7 4ET

Other partners
Numerous

Summary
The objective is to establish a European network of active technology researchers and developers of biomass pyrolysis processes and related technologies.

Status
On-going

BIO FUEL OIL FOR POWER PLANTS AND BOILERS (JOR3-CT95-0025)

Co-ordinator
Kai Sipila
VTT Energy
PO Box 1601
FIN-02044 VTT, Espoo, Finland

Other partners
Neste Oy - S. Gust
Union Electrica Fenosa SA - A Cuevas
ARUSIA - N. Tommasini
Université Catholique de Louvain- R. Maggi
BFH Institute of Wood Chemistry and Chemical Technology of Wood - D. Meier
ENEL CRT - P. Barbucci
CNR Instituti Motori - P. Massoli
Wartsila Diesel International Ltd. - S Gros
Finesport Engineering Srl - G. Berna
Helsinki University of Technology - O. Krause

Summary
The project is aimed at: 1) generating performance, emission and cost data for flash pyrolysis oil (bio fuel oil) utilisation schemes focusing on the market quality of the oil for two applications: as stationary medium-speed diesel engine power-plant fuel, and as a fuel in medium scale oil boilers, 2) developing downstream units of oil production, improving the oil quality, and establishing fundamental understanding of biomass pyrolysis, and 3) establishing a network of potential oil producers and users. The co-operation includes potential pyrolysis oil producers and users, biomass producers, power and energy companies, universities and research institutions.

Status
On-going

LIQUID FUELS AND CHEMICALS BY ADVANCED FLASH PYROLYSIS IN A CIRCULATING FLUIDIZED BED AIR BLOWN PYROLYZER (JOU2-CT93-0338)

Co-ordinator
S. Kyritsis
Agricultural University of Athens
Iera Odos 75
GR-11855 Athens. Greece

Other partners
CRES - I. Boukis
University of Aston - A.V. Bridgwater

Summary
The objective of the project include, among others: Demonstration of stable and reliable operation of the existing CFB unit and identification of operating conditions to maximise the oil yield.

Status
Completed

IMPROVEMENT OF THE FLASH-PYROLYSIS PROCESS AND PILOT PLANT FOR BIO-OILS UPGRADING (AIR1-CT92-0216)

Co-ordinator
Emilio Constantini
ESAU (presently ARUSIA)
Via Mario Angeloni 63
I-06100 Perugia, Italy

Other partners
ENEL - G. Trebbi
Sassari University - L Conti
Union Fenosa - A. Cuevas

Summary
The primary objective of the project is the design, construction, testing and evaluation of a pilot plant to hydrotreat fast pyrolysis bio-oils for the production of hydrocarbon fuels.

Status
On-going - Scheduled for completion May 1997

IMPROVEMENT OF AGRICULTURAL ECONOMICS THROUGH INTEGRATION OF SMALL SCALE HEAT AND POWER PRODUCTION WITH NON-FOOD VALUE-ADDED PRODUCTS (AIR2-CT94-1162)

Co-ordinator
Y. Solantausta
VTT Energy
PO Box 1601
FIN-02044 VTT, Espoo, Finland

Other partners
Neste Oy - S. Gust
CRES - I. Boukis
Elkraft - E. Winther
Union Fenosa - A. Cuevas

Summary
The primary objective is to establish and verify cost (investment and operating costs) and performance parameters (e.g. mass and energy balances, efficiencies) for integrated concepts in which agricultural products are utilised both as feedstocks for production of non-food value-added products and for small scale heat and power production.

Status
On-going

Handbook of advanced technologies for Energy Conversion of Biomass

Edited by R Sala
Sponsored by CEC Programme "Renewable Energies"
MATEC srl, via Rondoni, 11, 20146 Milan, Italy

This book will help in searching for information in the fields of bio-fuel and biomass technology. It has been written for several audiences, like engineers, researchers, manufacturers and technicians. It provides an overview of the field, focusing on new and developing technologies, with a list of the main European companies involved in the biomass field.

Contents:
Biomass Feedstock, Systems for Power Generation, Gasification Process, Flash Pyrolysis, Pyrolysis Oils, Bio-oil, Upgrading, Economic and Social Impact of Different Technologies for Power Production, Forecast for Biomass Technologies

Bio-oil Production and Utilisation

Edited by A V Bridgwater and E N Hogan
Newbury 1996, 266 pp., UK £30 Can $60
CPL Scientific Information Services Limited, 43 Kingfisher Court, Newbury, RG14 5SJ, UK

There have been significant developments in the science, technology and applications of pyrolysis liquids in recent years, particularly with respect to the utilisation of the bio-oil for heat and power production and as a source of traditional and new chemicals.

The book reports the proceedings of the second EU-Canada workshop on bio-energy held in Toronto, May 1995. After an overview, in which the activities in bio-energy in Canada and Europe are reported, subsequent sections are dedicated to the communications about the technologies of production, characterisation and applications of the bio-oil.

In particular:

- In the Pyrolysis chapter several techniques relating to the production and the recovery of the bio-oil are reviewed.
- In the chapter related to chemicals from pyrolysis oils, the formation of valuable chemicals such as anhydrosugars, hydroxyacetaldehyde, phenols, carbonilic compounds, is discussed.
- The third chapter is dedicated to the analysis and characterisation of the bio-oils.
- The last two chapters cover the upgrading (hydrotreating) and some applications of the pyrolysis oil, as fuel in boilers or in gas turbines and as source of hydrogen by catalytic steam reforming process.

The book is a further contribution to the dissemination of the latest results in the conversion of biomass in a more valuable fuel and it will be welcomed by researchers and technicians involved in the utilisation on biomass for energy.

Alkali Deposits found in Biomass Power Plants

Edited by L L Baxter, T R Miles, T R Miles JR, B M Jenkins, D C Dayton, T A Milne, R W Bryers and L O Oden
February 1996 Part I 82 pp, March 1996, Part II 452 pp
The book is available from the National Technical Information Service (NTIS), U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161, Tel: +1 703 487 4650

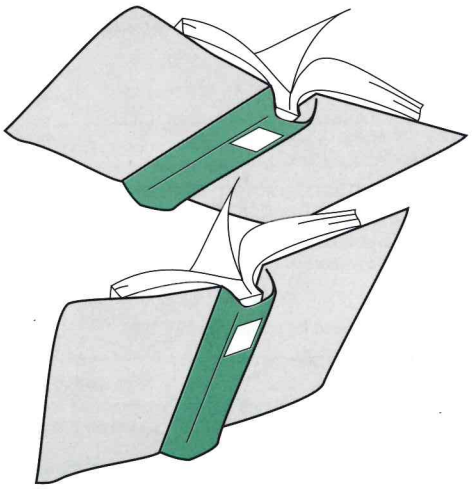
The ashes and in particular the alkali species contained in biomass contaminate the fuels, bio-oil or gas, obtained by thermochemical processes as gasification or flash pyrolysis causing many problems in the combustion in boilers, diesel engines and gas turbines.

Although the book reports mainly the results of a study on the formation of alkali deposits in the direct combustion of biomass in boilers, there are many arguments of general interest. In particular, the book contains a useful database of fundamental characteristics of bio-fuels and their ashes obtained with a variety of methods for proximate, ultimate and elemental analyses.

Results of analyses obtained with more sophisticated techniques as X-Ray, diffraction, SEM analysis. Thermogravimetric analysis, microwave or low temperature thermal ashing are also reported.

Finally, a useful list of recommended standards for biomass and a summary of analytical methods, makes this book interesting for anyone in research or technical development to convert biomass into energy.

Contents:
Executive Summary, Introduction, Fuels Analyses, Bench-Scale Combustion Investigations, Ash Deposit Formation Background, Pilot Scale Deposition Results, Commercial Scale Deposition Results, Summary and Conclusions, References, Appendices



book reviews

CONTRIBUTIONS **If you wish to submit a review of a book, please contact Professor L. Conti** *(address at end of newsletter)* **who is the co-ordinator of this task.**

SWEDEN AS A MARKET FOR BIO-OIL

by Erik Rensfelt,
S.TERMISKA PROCESSER AB

Introduction of New Biomass Technologies

Development of new biomass energy technology to commercial scale is a troublesome path of up-scaling and commercial verification. Investment support is often available for new technology e.g. up to 40-50% of the investment. This is usually necessary, to cover the high cost of the first unit as well as the technological risk involved.

If the new technology is also coupled to a new fuel source without an established traditional market e.g. short-rotation coppice in Europe, additional costs and risks are associated with the fuel supply. When the product, the energy carrier such as bio-oil is also new on the market, a strong burden of verification is put on the new energy system. When each demonstration project has to cover all these risks and other risks, then introductory incentives other than solely investment support are necessary.

Thus, at an early stage, process developers look for niches and markets offering high product price and/or maximum incentive or minimum risk. In countries with an established biomass fuel market such as Sweden, any single bio-oil demonstration plant would not affect the biomass fuel price and availability. Minimum risk regarding fuel supply is thus at hand. On the market side, the options for bio-oils are transportation fuel, power generation, heating purposes and special chemicals. Special chemicals have been successful as a niche market in the first application of fast pyrolysis in the US/Canada. In Sweden, the energy market seems to be a possibility for introducing bio-oil.

Energy Fees and Taxes in Sweden

The energy market in Sweden is to a great extent governed by fees and taxes. The transportation sector is, despite heavy taxes on fossil fuel, unlikely to use bio-oil due to technological reasons (economical up-grading to gasoline/diesel has not yet been solved).

The Swedish incentives for biomass in industry and for power generation is still rather weak. The situation for power generation might, to some extent, be due to new political beliefs which may of course change in the future. The Swedish State has chosen to put the strongest tax burden on the domestic heating sector, including district heating. The reason is that this can be applied without the risk of this energy sector moving abroad.

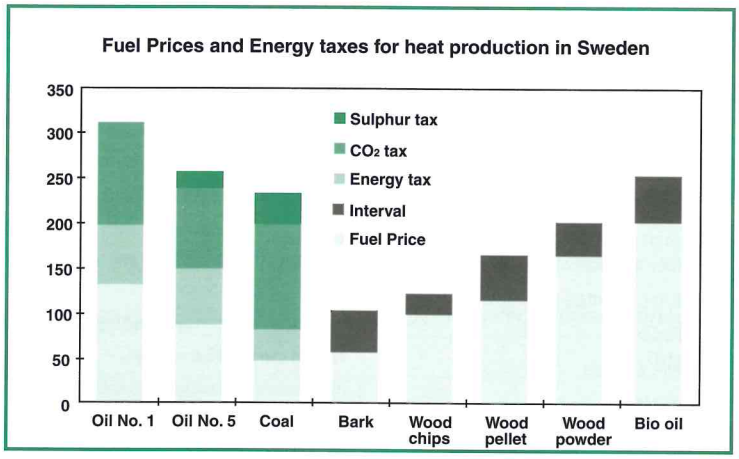
The current structure of fuel-related environmental taxes is presented in Figure 1 (ECU 1- SEK 8.4). As can be seen the oil price has more than doubled and the coal price is four times as high as the fuel price without taxes. Biomass is not subject to these taxes. The fuel cost of biomass ranges from as low as SEK 50/MWh for waste bark, to approximately SEK 110/MWh for fuel chips. Refined bio-fuels are of course more expensive. For the small consumer all fuels are more expensive than for a large consumer on a contract basis.

In addition to the taxes in table 1, most boilers also are subject to a NOX fee which means that boilers with high emissions 'pay' to the boilers with low emissions of NOX.

Replacing Oil in Boilers

For large-scale boilers, greater than 5 MW, chips are normally the most economical for district heating. A company with large boilers can take the increased operational and capital costs for solid fuels, and can also usually afford to install a new purpose-built boiler. In some cases, due to the local situation, conversion of old coal/oil boilers to refined biomass, is of interest.

Figure 1.



The current economical choice is biomass powder sometimes transported as pellets/ briquettes, but crushed and used for power burners in the plant. Examples of this are Uppsala (peat and biomass briquettes), and Stockholm, Haesselby (pellets).

In the future, a first application for bio-oil can be to replace heavy fuel oil in this type of installation in cases where powder fuels might be a problem, in the old boilers e.g., due to the limited storage and handling area available. Bio-oil will probably have a problem in competing with the price of pellets/briquettes, which are probably slightly cheaper and more efficient to produce than bio-oil. The difference in transportation costs between bio-oil and pellets/powder is low, as both have a similar heating value per ton. The difference in handling costs during transportation and especially in the boilers favours bio-oil, but this is not too important in large boilers. In smaller boilers of 1-5 MW, the importance of handling costs and retrofit costs increases, and can make up for as much as SEK 30- 50 MWh in fuel cost. This is thus a likely market for bio-oil with properties at least similar to heavy oil.

The large market for replacing light fuel oil in small district heating boilers and in the long run in domestic boilders, needs further improvement of the quality of the bio-oil to approach the light fuel oil properties. The domestic heating market is today, to a large extent based on either oil or electricity. With the probable increase in the cost of electricity in Sweden and the taxation of oil, relatively high prices can be accepted for the use of bio-oil for this market up to SEK 300/MWh.

Power Generation in Engines

With the future increasing cost of electricity, bio-oil will also have a market in small-scale co-generation of up to 5MW heat demand. Conventional steam-based cogeneration as well as gasification combined cycle is not competititve in this small size range. Gasification/engine combinations in small-scale might be interesting in the 1-5 MW scale, but this still needs to be proved both technically and economically. Production of bio-oil in reasonably-sized plants with 20-50 MW fuel input and distribution of bio-oil to small cogeneration plants based on engines (and perhaps also on gas turbines in the long run), can be a very competitive small scale alternative. This technology has also to be demonstrated. The de-coupling of fuel production and fuel use makes it possible to produce bio-oil in rural areas with lower biomass price, and transport the bio-oil for use in other areas. This is already happening with peat and wood briquettes in Sweden, with transportation by train and by boat of more than 350 km...

Industrial Applications

Some industries in Sweden such as the pulp and paper industry, have been leading in biomass production and its use for energy. They also have a wish to adapt the paper production to be fully renewable and to get rid of the small quantities of fossil fuel (oil) still used: bio-oil could be such a replacement. The fee and tax structure for industry presently give a very weak incentive to do this.

In the future, bio-oil might play a role, but for the long-term the need for new high-efficiency large-scale power production and steam cogeneration, will probably be based on black liquor and biomass gasification, coupled to gas turbines (IGCO).

Conclusions for Sweden

Sweden is possibly a good market for the short-term demonstration of bio-oil technology with boilers for the heating sector, and in the long term also with excellent opportunities for CHP/engines in small-scale applications. It is thus important that the current pilot projects prove the technical readiness to apply bio-oil in burners and engines. Scale up of the production facilities will be an important part of demonstration projects. A few projects are under consideration in Sweden today.

Table 1 Energy Taxes (valid 1 September 1996) Fuel Taxes for the heating sector in Sweden

User	Industry							Others		
Fuel	Energy	Co2	Sulphur	Total	kr/MWh	Energy	Co2	Sulphur	Total	kr/MWh
Oil No.	-	264	-	264	27	654	1054	-	1708	173
Oil No.5	Fuel	264	108	372	34	654	1054	108	1816	168
Coal	-	229	150	379	50	278	916	150	1344	178
LNG	-	276	-	276	22	127	1105	-	1232	96
Natural Gas	-	197	-	197	18	212	788	-	1000	93
Peat	-	-	40	40	15	-	-	40	40	15
Wood	-	-		-	-	-	-	-	-	-

- For power production only sulphur tax
- •• Energy tax reduced with 50% in CHP plants

IEA BIO-ENERGY
Pyrolysis Activity (PYRA)

The current list of official members is as follows:

- T Bridgwater, Aston University, UK
- S Czernik, NREL, USA
- D Meier, IWC, EC (Germany)
- A Oasmaa, VTT, Finland
- J Piskorz, RTI, Canada

In addition, a number of observers also participate and industry is well represented as follows:

- S Gust, Neste, Finland
- D Huffman, Ensyn, Canada
- J Leech, Ormrod, UK
- C Rossi, ENEL, Italy

Fast Pyrolysis for liquid fuels is still a fledgling industry with currently limited commercial applications. Industrial interest is thus mostly related to an exploration of the possibilities and potential in order to identify and evaluate the opportunities and to the supply of appropriate technology.

The work programme devised has been formulated to address the needs of companies involved in producing and using bio-oil in a constructive and unique way through establishment of standards and assessment and development of test methods. These have been agreed as meeting the demands of an industrial exploitation policy as well as improving necessary links between researchers and industry to ensure a successful transition from science to technology.

Activities

The following four tasks for the basis of the Activity work programme:-

Task One: Product Characterisation

The objective is to review, assess and develop methods for the characterisation and analysis of bio-oil and derived products. The scope of the product characterisation topic area includes all physical and chemical analyses and characteristics. In particular, new tests are being "invented" or developed to measure some of the more peculiar properties of bio-oil including an ageing test, stability test, tar content, odour, lubricity and miscibility with hydrocarbons.

A round-robin exercise will help to better define methods and properties. This has selected suitable bio-oils and sent samples to volunteering laboratories. Agreed properties are being measured (such as water, ultimate analysis, proximate analysis, ash, char, inorganics, viscosity, surface tension, chemical classes, distillation, ageing etc.) according to specified methods. The results, observations and summary of the method used are returned to the co-ordinator, and will be statistically analysed and reported.

Task 2: Environment and Health

The objective to review and assess the environmental, health, safety and related issues arising from the production, handling and utilisation of bio-oil. There are three areas of concern; production, storage handling and transport and utilisation by combustion.

The identified problems are summarised below:

Production	**Storage, handling, transport, combustion**	
Ash and char	Flammability	Ash
Air emissions	Leakage - see spills & exposure	Air
emissions		
Gas leaks	Exposure (short & long term)	
Liquid spills	Liquid spills	Liquid spills

The activity will provide a detailed analysis of all the emissions that may arise from production, handling and utilisation of bio-oil and identify specific concerns and methods of remediation or control. This will include recommendations for additional work that may be necessary.

SMDS sheets will be collated and reviewed and a comprehensive recommended SMDS published. Relevant health and safety regulations will also be provided where possible.

Task 3 Upgrading

The objective is to review and evaluate the two main aspects of upgrading - physical and chemical. Physical upgrading is concerned with use of physical processes to improve the oil quality while chemical upgrading deliberately causes chemical changes to occur to improve the oil quality. Examples of physical upgrading include char removal, ash removal, water adjustment and viscosity adjustment. Chemical upgrading can range from mild thermal processing to effect chemical changes through mild hydrogenation to improve stability and all the way to complete oxygen rejection and production of hydrocarbons. The production of chemicals is another way of upgrading the bio-oil. In all cases there may be small or significant quantities of wastes to be managed.

Until there is a better understanding of the quality requirements and standards, this aspect will focus on a review of methods available.

Task 4 Mechanisms

The objective is to derive a more comprehensive view of the science of pyrolysis to stay in front of pyrolysis developments and technology and to provide more robust support to the development and optimisation of pyrolysis processes.

Methodology and Work Programme

A review of the following topics is being carried out:

1 fundamentals of kinetics and mechanisms and heat requirements,
2 improved definition or understanding of ablative and non-ablative pyrolysis,
3 collation of "good" kinetic data applicable to fast or near fast pyrolysis conditions,
4 study the influence of key process parameters on product yield and quality,
5 secondary vapour cracking kinetics,
6 how pyrolysis technologies exploit these phenomena,
7 comparison of the differences between pyrolysis processes and how these affect the products,
8 consideration of new concepts such as linear pyrolysis and pause or staged phase pyrolysis and examine the implications of these new concepts on reactor design, analytical methods and sampling selectivity.

Supplementary Tasks

Each working group member will compile a country report. Information on recent and newly published reports that are not always analysed and abstracted, the so-called 'Grey Literature', in all areas covered by the scope of the activity will be collated. An expertise table or matrix will be produced by each working group member for him/herself and their organisation so that all the group is aware of the expertise and facilities that can be utilised in some way in the project. Finally, a database of thermal biomass conversion processes has been established and will be updated to provide a more valuable resource.

PUBLICATIONS

Members of the Activity have contributed to a number of publications as a result of the work programme:

JP Diebold, T A Milne, S Czernik, A Oasmaa, AV Bridgwater, A Cuevas, S Gust, D Huffman, J Piskorz, *Proposed specifications for various grades of pyrolysis oils,* Developments in Thermochemical Biomass Conversion, Eds. AV Bridgwater and DGB Boocock, (Blackie 1996)

J Lédé, JP Diebold, GVC Peacocke, J Piskorz, *The nature and properties of intermediate and unvaporised biomass pyrolysis materials,* Developments in Thermochemical Biomass Conversion, Eds. AV Bridgwater and DGB Boocock, (Blackie 1996)

D Meier, A Oasmaa, GVC Peacocke, *Properties of fast pyrolysis liquids: Status of test methods,* Developments in Thermochemical Biomass Conversion, Eds. AV Bridgwater and DGB Boocock, (Blackie 1996)

JP Diebold, A V Bridgwater, *Overview of fast pyrolysis of biomass for the production of liquid fuels,* Developments in Thermochemical Biomass Conversion, Eds. AV Bridgwater and DGB Boocock, (Blackie 1996).

Tony Bridgwater.

Supplementary & Modified Internet addresses to newsletter 1.

Government

STO's Internet Patent Search System	http://sunsite.unc.edu/patents/intropat.html
Research and Development Bulletin-Canadian Government	http://w3.pwgsc.gc.ca:80/rdbullet/text/martoc.html
Natural Resources Canada (NRCan)	http://www.emr.ca/home/nrcanhpe.htm
Access US Patent Database	http://patents.cnidr.org:4242/access/text-access.html
Energy Efficiency and Renewable Energy Network	http://www.eren.doe.gov/ee-cgi-bin/ee_renen-fuel.pl
Department of Energy and Environmental Technology. The Netherlands	http://www.teodin.nl
BIOMASS.National Renewable Energy Laboratory	http://www.rredc.nrel.gov/biomass/

Research Organisations

Biofuels database search-all USA DoE and NREL publications in the last 15 years	http://www.afdc.nrel.gov:70/0/biofuel/search.html
University and Research Institute NRI Home Page	http://www.nri.org/
Pyrolysis Network for Europe Newsletter	http://www.ceac.aston.ac.UK/PyNE/
NREL database search - now taken off line	http://www.doe.gov/html/eren/eren.html
Information Service of the Centre for Renewable Energy and Sustainable Technology	http://solstice.crest.org/index/html
Forum for discussion of Advance Industrial Waste Treatment	http://aln.coe.ttu.edu/distance/disted.html
Biomass Users Network Newsletter. Vol. 1.1 (India)	http://144.16.73.100/-mukunda/home.html
Biomass Energy Allianceís Web	http://www.biomass.org/biomass/
European Forum for Renewable Energy Sources (Eurofores)	http://ourworld.compuserve.com/homepages/Juan_Fraga/
Institut fur Thermische Energietechnik ITE	http://www.uni-kassel.de/fb15/ite.html
Centre of Biomass Technology	http:www.sh.dk/~cbt/sh/fluidbed.html
Envirosense	http://es.inel.gov
Research Activities of CPERI	http://www.2.cperi.forth.gr/Pages/Services/
National Microelectronics Research Centre, IRELAND Renewable Energy Multimedia System	http://nm2C.ucc.ie/biomass/bmintro.html
Alternative Development Asia Ltd	http://www.hk.supernet/-altdev/ada.html
Lulea University. Energy Department	http://www.luth.se/depts/mt/ene
IEA Bioenergy	http://www.abdn.ac.uk/ieaenergy

Industry

T R Miles - Home Page	http://www.teleport.com/~tmiles/index.html

EC

I*M Information Market EUROPE (DG XIII)	htttp://www2.echo.lu/
European Union's goals and policies	http://europa.eu.int
Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET)	http://www.ornl.gov.CADDET/caddet.html

Please send additional items for inclusion to Karen Dowden, (see back page).

PYNE SPONSORED EXCHANGE VISITS

As part of PyNE's continued mission to increase awareness of Pyrolysis activities throughout Europe, funds have been set aside to pay for young researchers from PyNE organisations, to visit other laboratories to gain experience and exchange information and ideas. Progress reports are filed with Tony Bridgwater and will be published through this newsletter.

Dr Christophe Lahousse, Universite Catholique Louvain (UCL), Belgium

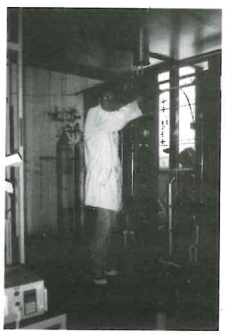
One of the first exchange visits was undertaken by Dr Christophe Lahousse of The CATA laboratory (UCL). Christophe spent two weeks at Professor Leonetto Conti's laboratory at the University of Sassari, Italy.

Christophe's work at UCL involves the development of new hydrotreating catalysts adaptable to the upgrading of bio-oils. Working with model compounds in an autoclave type reactor, UCL have already designed new catalysts using activated carbons instead of aluminas as supports which avoid coke formulation. UCL have also performed hydrotreatment of whole bio-oil in a fixed bed reactor.

Leonetto Conti and his research group at the University of Sassari are demonstrating the feasibility of bio-oil hydrotreatment, in a continuous operation. In particular, they have found suitable reactionconditions including temperature gradients that suit alumina supported catalysts that avoids plugging of the reactor.

As a result of the co-operation, a UCL NiMo/Carbon catalyst has already been tested in Sassari and a CoMo/Carbon will be tested soon. Some valuable results have already been obtained and more results are still to come when the analysis of the hydrotreated oil is completed. The carbon supported catalysts behaviour appears clearly different from the alumina supported HDS classical catalyst. However, the conditions of reaction of suitable for alumina are certainly not the best for this type of catalyst, since after a period of deactivation the reactor plugged. The catalyst has been recovered and is being analysed at UCL.

The exchange has not only strengthened the co-operation between the two groups working in the upgrading of bio-oil, but it has also served to identify the future main routes of the process improvement.



Dr Christophe Lahousse

Aston University

http://www.ceac.aston.ac.uk/

From its early roots in the late 1800s, Aston University has developed to become a dynamic, progressive technological university. It has an enviable reputation for applied learning and meeting the demands of industry and commerce. More than 4,000 undergraduate students follow Aston's unique mix of applied courses in business, languages, life and health sciences and engineering, applied sciences and computer science.

Aston has seven Academic departments, including the Department of Chemical Engineering and Applied Chemistry (CEAC)

Energy Research Group (ERG)

ERG is one of the research groups in CEAC. Under the leadership of Dr Tony Bridgwater, the Group applies chemical engineering science and technology to the development of advanced processes for the production of electricity, liquid fuels and gaseous fuels, and chemicals from natural resources.

Pyrolysis

Ablative plate fast pyrolysis
A novel 5 kg/h ablative pyrolyser has been designed, built, commissioned and successfully operated with liquid product yields of up to 80% wt. which is comparable to the best achievements of any other group. This concept is being redesigned and scaled up.

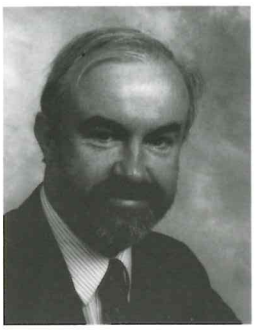
Fluid bed fast pyrolysis
A 1.5 kg/h shallow fluid bed fast pyrolysis reactor is operated for feed characterisation and screening trials, for investigation of in-bed catalytic pyrolysis and for production of samples for evaluation. A smaller scale but otherwise similar 100 g/h fluid bed reactor has also recently been commissioned which will be used for feed and catalyst screening as well as being close coupled to the above reactor as a secondary catalytic reactor. (see photo 3)

Secondary cracking
A hypothesis that the time-temperature envelope that the product vapours pass through on completion of primary pyrolysis strongly influences the chemical and physical characteristics of pyrolysis liquids is being investigated.

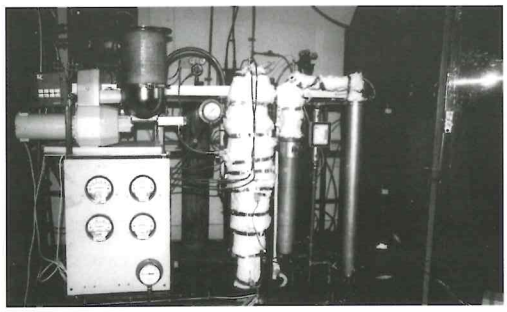
Biomass pretreatment
Speciality chemicals such as levoglucosan and hydroxyacetaldehyde can be selectively produced by adding or removing cations from biomass feed materials. This is being studied to explore the feasibility and viability of chemicals production, through experimentation, design studies and technoeconomic evaluation.

Liquid product characterisation
Work is in progress to devise new tests for measurement and prediction of bio-oil stability and quality as a contribution to the IEA Bio-energy Pyrolysis Activity. Existing fuel quality tests are also being evaluated.

Dr Tony Bridgwater



Research staff at Aston



Fluid bed fast Pyrolysis Unit 1.5kg/h capacity

Upgrading pyrolysis liquids

Liquid product upgrading
A recent EC project is supporting for the development of a dual fuel engine to run on bio-oil. This work is being carried out by a UK engine re-manufacturer, and the Energy Research Group is supporting the characterisation and standardisation of the bio-oil for use in an engine. This includes development of special test procedures and chemical and physical upgrading processes.

Chemicals extraction
Individual chemicals such as levoglucosan and groups of chemicals such as polyphenols may be recovered. A key requirement is the integration of chemicals and fuels recovery to give a least cost process. Both separation techniques and process optimisation using process synthesis techniques are being explored. New processes will be devised and technoeconomically assessed.

Gasification
A unique downdraft biomass gasifier has been developed and tested that improves gasifier specific capacity and turndown without sacrificing the simplicity of an open core gasifier which avoids the need for lock hoppers.

Chemical Analysis
A dedicated HPLC system has recently been installed with IR and DAD detectors for pyrolysis liquids pyrolysis liquids. An extensive range of other relevant facilities is available.

ASTON UNIVERSITY

profiles by P. Girard, France

Process simulation and evaluation

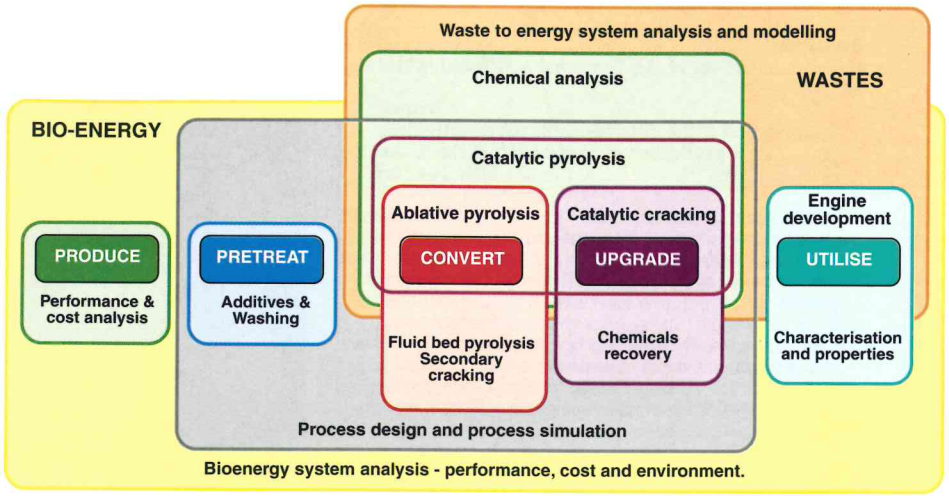
Biomass pyrolysis and upgrading
Original models of flash pyrolysis and hydrotreating were constructed and validated and incorporated into a comprehensive process simulation, and economic analysis package. Work is in progress to develop improved heat and mass transfer models for biomass pyrolysis to optimise reactor performance, provide better reactor designs for the ablative and fluid bed reactors, and derive more robust predictive models for the evaluation and process synthesis aspects of the work.

Biomass production
A project has recently been awarded to study how fiscal incentives influence the use of set aside and marginal land for biomass production for energy. The project is joint with the Aston Business School.

Integrated bio-energy systems
A total systems approach explores how biomass production systems interface with biomass conversion systems and what the optimum combination of production and conversion would be under different circumstances.

Research Group Structure

The full range of thermal research activities being undertaken in the Energy Research Group is summarised in the figure below.



Summary of Energy Research Group Projects in Biomass and Waste Processing showing Interactions and Complementarity

Chemical Engineering Science Laboratory (LSGC) of Nancy, France

Founded in 1975, the 'Laboratoire des Sciences du Genie Chimiqueï' (LSGC) of Nancy is a more than 200 people laboratory belonging to the CNRS. It is organised into 6 research groups developing fundamental researches in the field of chemical engineering and process technology. Inside the group "Chemical Reaction Engineering" a research team is more specifically devoted to the study of pyrolysis reactions and corresponding reactors. One of its topics deals with biomass thermal conversion for approximately 15 years. Two main approaches are considered:-

1. Use of the cyclone reactor for the ablative pyrolysis of wood sawdust. This is a very interesting reactor where heating, reaction and separation occur in the same vessel in approximately less than one second.

2. Fundamental study of the behaviour of pieces of wood reacting in conditions of ablative pyrolysis by experimental and theoretical approaches.

Experiments with rods of wood applied under pressure on a hot spinning disk. The apparent rate of reaction is directly measured as a function of operational parameters. Similar experiments expanded with rods of melting materials reveal the same behaviour. From a simple model it is concluded that biomass pyrolysis behaves as though it melts at a temperature of about 739°K.

Modelling of the chemical and thermal behaviour of solid particle undergoing an endothermal volatilisation under the influence of an external heat flux. The results show that a strong stabilisation of solid temperature is expected, the reaction being then considered as quasi isothermal. Derived reaction temperatures for cellulose are in close agreement with measured fusion temperature. The results reveal also the very important mistakes often made in the interpretation of fundamental measurements of kinetic constants when temperatures and heating rates of the solid are considered identical to the corresponding values of the heat source.

Current research includes:-

1. Modelling of the pyrolysis of solid particles in different experimental conditions,
2. Search of new experimental evidences for the presence of an initiation step in cellulose pyrolysis. The expected existence of active cellulose continues to be a much debated question,
3. Search of new efficient ablative pyrolysis reactors in connection with the previous results.

For further information contact
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Dr Jacques Lédé

EC Sponsored Networks

Yannis Boukis, CRES, Greece

A list of EC sponsored networks on bio-energy topics has been compiled. These are funded by the ALTENER, THERMIE, FAIR and JOULE Programmes in DGXV11 and DGX11 of the European Commission.

NETWORK 1

Title
NTB-Network: Non Technical Barriers to the development of liquid biofuels (used in engines and boilers) / ALTENER programme

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Description
The network is aimed at the establishment of a co-ordinated action for liquid bio-fuels:
- Identification of non technical barriers.
- Proposition of recommendations and solutions for promoting liquid bio-fuels.
- Setting up co-operation programmes to develop liquid bio-fuels.

The results will propose a European methodology aimed at the viable development of liquid biofuels, adopted by all scientist and users and also enhance the acceptability of liquid bio-fuels for use in modern engines and devices, compatibility with National environment regulations, and energy and economic efficiency on a total basis.

NETWORK 2

Title
TAIRA: Thermal AIR Applications: a Pyrolysis Network for Europe (PyNE)

Co-ordinator
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Energy Research Group
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Description
- to establish a European network of active technology researchers and developers of biomass pyrolysis processes and related technologies
- to establish a forum for the discussion and exchange of information on new scientific and technological developments on biomass pyrolysis and related technologies
- to review progress in technical areas of particular importance, identify significant obstacles to their implementation and produce authoritative reports for distribution
- to encourage and provide for interaction by exchange of personnel, information and ideas between laboratories and with industry
- to encourage the active involvement of industry in development and exploitation of the R&D being undertaken,
- to establish a database of relevant activities for information dissemination and improved co-operation,
- to disseminate information on individual activities from the database and results of meetings and common research activities by newsletter, reports and other publications, to those in the network and other interested parties in regional, national and international programmes.

NETWORK 3

Title
EC Gasification Network: Analysis and co-ordination of the Activities concerning gasification of biomass

Co-ordinator:
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Description
The main objectives of this Concerted Action within the Air-program are:

- Co-ordination of the different projects and activities concerning a gasification of biomass within the EU and the EFTA countries.
- Improvement of the information flow between the different working groups resp. different research programmes (eg. APAS) and research institution (eg. IEA) and development of a strategy to improve the information transfer within Europe.
- Identification of R&D-lacks and based on this the development of a research and development resp. a market introduction strategy for the EU resp. Europe. Also recommendations for future activities and promising projects will be formulated.

These goals will be achieved by the following activities: -

- The results of the different activities, projects, demonstration plants etc. carried out in the past in EU and EFTA-countries will be analysed, documented, compared, and evaluated.

  An economical evaluation of the present and future gasification technologies will be realised and the results are analysed on the background of the current and for the future expected energy system in Europe.
- Workshops of scientists and manufactures and an open seminar will be organised to collect the information, to develop the strategies and to discuss the results of this Concerted Action.

Compilation of a report of the national and international activities on the research field of biomass gasification during the last two decades, a characterisation of the different technologies and processes, a short summary of the project results and list of the groups active in this field within the EU and EFTA countries. Based on this a complete overview of the current state of the different technologies and processes will be given. The final goal is the publication of this information in a book.

NETWORK 4

Title
Non food agro-industrial research information dissemination (NF-AIRID) including development of an information network and CD-ROM based distribution

Co-ordinator
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Description
The objectives of this concerted action proposal is to collect and disseminate to the appropriate recipients, the ever-increasing amount of information available from CEC funded programmes and other sources relating to non-food uses of agricultural crops.
The targeted end users include small to medium sized enterprises that can utilize agricultural sources of raw materials such as the feed, fabric and paper industries, public interest and public sector groups as well as policy makers. The aim is to

networks

replicate the successful methods developed for food use under the Flair-Flow Europe activity, but applied to non-food use.

In addition to collecting and immediately disseminating information, it will also be collated, codified and organized in a purpose-built database. Immediate dissemination is proposed via printed media and workshops. However, by the end of the period the complete information system will be made available on CD-Rom.

NETWORK 5

Title
Development of standard methodology for integrating non-food crop production in rural areas with niche energy markets

Co-ordinator:
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Description
The partners in this Concerted Action will work together to develop a common methodology for analysing the costs of energy production from energy crops. The methodology will include all the costs from crop production through transportation to energy conversion. The partners will bring together data from their national programmes to investigate using the same methodology three niche markets:

- medium-scale heat markets (1-10MWth) including co-generation for light industry and district heating;
- liquid bio-fuels as substitutes for fossil fuels in transport, heat and power applications;
- small-scale heat markets (less than 1MWth) for agro-industry, domestic and commercial buildings.

The concerted work will cover not only the costs but technical and non-technical barriers to exploitation. The methodology will be modified to examine the impact of different grant regimes and technical options. The aim will be to identify how much support is required to take energy crops into different markets. Once this analysis is complete, the partners will formulate the strategies for R&D, promotion and stimulation of niche markets for energy crops.

The results will be presented in an open seminar in the U.K. in January 1996.

NETWORK 6

Title
Environmental aspects of biomass production and routes for European energy supply

Co-ordinator
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Fax: +31 30441318

Description
The objectives of this concerted action are to strengthen communication about the environmental aspects of biomass production and biomass routes, in order to; improve knowledge and insights of the participating organisations, identify differences national insights and causes of those differences, reach consensus where possible about guidelines for environmental analysis about major environmental issues and about possible solutions for environmental problems.

The concerted action focuses on analysis and assessment of the environmental impact of the most relevation biomass routes for energy supply in Europe the assessment of feasible ways to reduce negative environmental effects and increase positive environmental effects and the assessment of the extent biomass can play a role in European energy supply with respect to environmental impact, agricultural development and land use.

NETWORK 7

Title
EUREC Network on Biomass (Bio-Electricity)

Co-ordinator
Dr. Sean McCARTHY
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Description
The objective of this study are firstly to develop a methodology for the integration of biomass systems at a regional level and secondly to prepare business plans for the establishment of integrated biomass systems in four EU regions , namely: Lorraine (France), Aquitaine (France), Cork (Ireland), Leon Y Castille (Spain). A third part of the study will examine future scenarios for regional biomass systems based on the most promising biomass technologies and apply those to the four regions.

The expected achievements for the proposed work will be:

a) Methodology for the integration of biomass systems at a regional level.

b) Business plans for the establishment of integrated biomass systems in Lorraine, Aquitaine, Cork and Leon Y Castille.

c) Models of integrated biomass systems for 7 EU regions and five of the most promising biomass technologies. These will be used for sensitivity analysis to examine how the regional biomass systems would be affected by changes in economic policy, agricultural policy, social policy and new environmental legislation.

NETWORK 8

Title
BIOGUIDE

Co-ordinator
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Description
To establish a set of Pan-European Best Practice Guidelines to aid the development of environmentally acceptable biomass energy projects within the EU.

The formation of guidelines, is an ambitious task, particularly when there is no frame work on which to base the work. The first stage of this process will be to establish an environmental communications network in each of the partner countries. This will take its model from the successful UK Environmental Liaison Group (ELG) which has been established for over 5 years. This is composed of representatives from environmental pressure groups, academics, agricultural extension services and government representatives. The group provides a unique forum for discussion and meets regularly to consider the environmental interests and concerns to be recognised by the industry, and the needs of industry to be acknowledged by the group. Once established across Europe these groups will be fundamental in the development of Best Practice Guidelines.

In the UK the biomass industry and the ELG are keen to work together to form operating standards and specifications. As the UK ELG is now mature and established, the formation of Best Practice Guidelines will initially take place in the UK. During this first phase the new ELG's will be used in consultation to the UK work. In Phase II of BIOGUIDE the European partners will develop guidelines to meet their own national needs, using the UK Best Practice Guidelines as a framework. The issues which are relevant throughout Europe will then be identified, and a set of Pan-European Guidelines published.

Bioguide will operate alongside the established AFB-NETT, and work closely with other European networks and the IEA to ensure maximum value is gained.

PyNE Membership

Most EU countries have at least one representative who provides a centralised facility for collation and dissemination of information. Enquiries for further information or interest in participation should be directed to the national representative to ensure that this interest is properly co-ordinated. In case of difficulty please contact the Co-ordinator directly..

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Editorial

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PyNE meeting, Italy. (see page 2 for details)