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A New Start for Bio-oil Upgrading by Hydrogenation

By Douglas C. Elliott, Pacific Northwest National Laboratory, Richland, Washington, USA
As reported in the last issue, laboratory work has begun on upgrading by catalytic hydrogenation of fast pyrolysis oil produced from biomass. The work scope, funded by the U.S. Department of Energy at the Pacific Northwest National Laboratory in Richland, Washington, USA, involves testing and assessing the value of new catalyst formulations in hydrogenation using both batch and continuous-flow reactor systems. There is also an effort in updating the processing economics in light of new reaction conditions, products, and hydrogen requirements. The work involves collaborations with ENSYN Technologies, Inc. and DynaMotive Energy Systems, who are providing bio-oils for testing.

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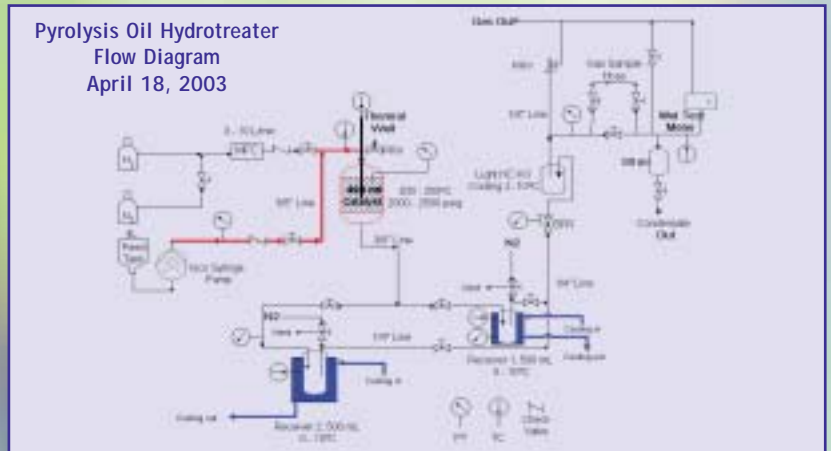


Figure 1: Pyrolysis oil hydrotreater flow diagram.

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**Science in
Thermal and
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Biomass
Conversion**



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Future New Developments

Forestera™ Liquefied Wood Fuel Pilot Plant see page 2 for details

New Ablative Pyrolyser in operation in Germany see issue 17 for details

Forestera™ – Liquefied Wood Fuel Pilot Plant



By J-P. Nieminen, * S. Gust, * T. Nyrönen, ** *Fortum Oil and Gas Oy, Finland **Vapo Oy, JYVÄSKYLÄ, Finland

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Figure 1: Forestera™ thermal cracker.

1.3 Forestera™ Process and Fuel

The fast cracking or thermal degradation of biomass in an essentially oxygen free atmosphere produces a combination of solids, condensable vapours and gases. The ratio of these three can be controlled by reaction conditions. The Forestera™ fast cracking process transfers heat to the feed material by a unique and proprietary combination of gases, bed materials and hot surfaces. A special feature of this process is the solids separation, where the very low levels of solids, on the order of less than 0.05 weight percent can be obtained. This has been found to improve stability, reduce particulate emissions during combustion and improve the durability and reliability of end use equipment and eliminate sludge formation during storage.

2. DESIGN AND CONSTRUCTION OF PILOT PLANT

2.1 Plant Size and Design

The size of the pilot plant was chosen to permit rapid scale up to commercial sizes with a capacity of 500 kilograms feed per hour. The process is based on a combination of various in-house related process development projects together with our experiences from pyrolysis projects over the past 10 years. Special features of the plant relate to safety aspects.

The plant is fully automated and has separate systems for operation and safety with manual override. The plant reactor is shown in Figure 1 and the drier in Figure 2.

2.2 Pilot Construction and Costs

The construction of the pilot plant at the Fortum Porvoo Refinery Technology Centre took about one year. It was mechanically ready in early 2002. Investment costs were approximately 3.5 M€.

1. BACKGROUND

1.1 Project Drivers

Finland together with other European Union countries have set goals to reduce greenhouse gas emissions. Emphasis is on increased use of renewable fuels. The main barrier to their expanded use is their relatively poor economic competitiveness compared to existing energy carriers. Governments are therefore offering various incentives in the form of fuel tax reductions and investment support in order to assist in their introduction and use.

1.2 Fortum and Vapo Project

Both Fortum (formerly Neste and IVO, now Fortum Oil & Gas and Fortum Power & Heat) and Vapo have been assessing fast pyrolysis technologies and fuel properties for over 10 years. In 1998, these companies entered into an agreement where they would jointly develop a pyrolysis process and related production technologies. Vapo with its expertise in solid fuels handling and logistics, Fortum Oil and Gas in process development and Fortum Power and Heat in heat and power plant operations cover the entire process chain. Forestera™ has been registered to cover both the process and the products.

Co-ordinator
Tony Bridgwater

Events Organiser
Emma Wylde

Newsletter & Website Administrator
Claire Humphreys

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

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

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

ISSN 1470-3521

3. COMMISSIONING AND PLANT OPERATION

3.1 Commissioning

Upon completion of construction, the pilot plant has undergone thorough and extensive commissioning during the spring of 2002. The Minister of Trade and Industry Sinikka Mönkäre officially opened the plant 14th May 2002. The commissioning consisted of testing of unit operations, warranty runs of purchased equipment, verification of safety systems and plant automation.

3.2 Operation Experiences

Subsequent to commissioning, early plant operations consisted of testing different feedstock such as sawdust, wood shavings, wood chips and forestry residues of different moisture contents. Based on these experiences, a variety of modifications have been made in order to extend operating time.

Experiences and conclusions from the first test runs are seen as:

- Reaction conditions are very stable.
- Process can be run on a continuous basis for 4-5 days.
- Depending on the feedstock, the main reason for coming off-line is coking of piping or agglomeration in cyclones.
- The yield is in the expected range of 60 to 70%.
- Further engineering work is needed to permit long duration runs and to achieve maximum capacity.

4. LIQUID PRODUCT

4.1 Fuel Properties

During this test period more than 15m³ of fuel grade liquids have been produced. Properties of the product from our test production are summarized in Table 1.

	Typical Value
Lower heating value (MJ/kg)	15
Lower heating value (MJ/l)	19
Viscosity (cSt)	
30 C°	20
50 C°	10
80 C°	4
Sulfur content (ppm)	300
Flash point (closed cup, C°)	45-65
Water content (wt-%)	23-28
Solids content original (wt-%)	<0.1
Solids content improved (w-%)	<0.05
Density (kg/l)	1.2

Table 1: Properties of Forestera™ product from test production.

From our experiences from combustion field tests it was concluded that it is beneficial to further lower the solids content from the original goal of 0.1 weight percent. We have reduced solids content to less than 0.05 weight percent with further reductions are possible. We also concluded that the type and size distribution of solids should be controlled. The main solid constituents found in pyrolysis liquids are: micro char, ash, and sand from feedstock.

4.2 Preliminary Toxicology Results

The toxicity and eco-toxicity of the Forestera™ fuel has been tested and preliminary conclusions from these tests are shown in Table 2 in comparison with conventional heating oil.

	Forestera™ Liquefied Wood Fuel	Tempera™ Light Heating Oil
Flammability explosivity	Combustible liquid (flash-point >40°C)	Combustible liquid (flash-point >55°C)
Health hazard	May cause sensitization by skin contact Acidic liquid irritates skin Contains little quantities constituents that have limited evidence of carcinogenic effect Very low toxicity when swallowed	Not sensitizing Repeated exposure may cause skin dryness. May have potential to cause skin cancer
Environmental hazard	Partially soluble in water Evaporates slowly Slowly biodegradable Harmful to aquatic organisms Data not available about accumulation	Very low toxicity when swallowed Slightly soluble in water Evaporates slowly Slowly biodegradable. Toxic to aquatic organisms Possibly accumulative

Table 2: Forestera™ liquefied wood fuel vs Tempera™ heating oil; preliminary hazard identification.

5 PRODUCT USE

5.1 Field Trials in Heating Oil Boiler at Saarijärvi

Combustion field trials have been carried out with an industrial partner Thermia Oy at their manufacturing plant at Saarijärvi in an existing light fuel oil boiler.

Oilon Oy prepared the prototype burner and fuel handling system for the test. The burner head was the result of 2 to 3 years co-operation between Fortum and Oilon. The system is a dual fuel system, where start up shut down steps can be done with heating oil and actual heat generation with Forestera™.

A total of more than 8000 litres of Forestera™ was combusted and the boiler ran more than 1500 heating cycles. The emissions from the prototype burner in the Saarijärvi boiler were very low, approaching those of a heating oil boiler. They are summarized in Table 3.

Emission	Typical good value
CO	30 ppm
O2	4,5 %
Particulate	No organics, only ash

Table 3: Typical good emission values from Thermia, Saarijärvi, field tests with Forestera™.

The burner head and fuel handling systems operated well throughout the duration of the tests. These early field trials have demonstrated that in order to ensure trouble free combustion, it is important to have very low solids content. Thus we have revised downward our original goal of 0.1 weight % solids to < 0.05%. The ultimate solids level will be determined upon further testing.

These tests proved that the prototype is well suitable for Forestera™ and with this kind of system Forestera™ can be combusted in existing heating oil boilers with low emissions.

5.2 Large Boiler Field Tests at Stockholm

Combustion tests in large boilers will be initiated in Stockholm, Sweden in the fall of 2003. A first shipment of 4000 l of Forestera™ has been shipped to Stockholm where the required permitting for these test trials has been completed.

6 CONCLUSIONS

In conclusion it can be said that Forestera™ is viable fuel for heating fuel oil boilers and that the production process we have designed is suitable for this purpose. Results so far have been encouraging, but both the process and the product still require some development work.

For further details contact:

Mr Steven Gust
 Fortum Oil and Gas
 Technology Centre
 PO Box 310
 Porvoo
 Fin – 06101
 Finland
 Tel: +358 10 45 23738
 Fax: +358 10 45 26691
 Email: steven.gust@fortum.com



Figure 2: Forestera™ process flue gas drier.



Bio-oil Upgrading....

Continued from page 1.

Project Summary

The project will focus on process experiments to evaluate product quality as a function of processing conditions and their effect on process costs. Bio-oil composition will be considered in relation to the process, with development of the fundamental chemistry as a key issue in producing value-added products from bio-oil. As indicated by the highlighted components in the figure above, the work will focus on the upgrading steps but process integration with the fast pyrolysis step will also be studied. A key process interaction will be the development of the recovery and separation requirements following the pyrolysis and before the upgrading.

Project Strategy

The current work builds on the earlier process development research in hydrodeoxygenation of biomass liquefaction products. The earlier strategy was based, for the most part, on petroleum processing technology using sulfided catalysts in exhaustive hydrogenation to produce liquid hydrocarbon fuel products, which were highly aromatic in nature. This processing strategy resulted in high levels of hydrogen consumption, which was expensive. The present work will seek to optimize the hydrogenation process for biomass pyrolysis oil products. The experiments will investigate non-sulfided catalysts with controlled hydrogenation for liquid fuel and chemical products. The attempted chemistry will not focus on aromatic products, but will target hydrogen consumption to produce the best value.

Project Scope

New catalyst systems and strategies are being evaluated. Catalysts and process conditions are being tested in a small batch reactor with chemical analyses performed on the products.

The potential for improvements to process economics is being assessed by reviewing earlier techno-economic assessments, determining the economic impact of new processing systems, and determining the value of new value-added products.

Recent Accomplishments

A better understanding has been developed of the properties of current bio-oil products and analytical procedures have been fine-tuned. Process chemistry modeling has been carried out in batch reactor tests. The continuous-flow catalytic reactor system has been reassembled and experimentation started. The task of updating the process economics has also begun.

The batch reactor tests have included bio-oil model compounds to better elucidate the chemical mechanisms being catalyzed. Three test matrices are being compared:

- hydroxyacetaldehyde
- acetol
- ethyl guaiacol
- eugenol

- furfural
- guaiacol
- homovanillic acid
- isoeugenol

- methylcyclopentenone
- methyl guaiacol
- acetovanillone
- oleic acid

--- all at 10 wt% in water.

The products are being analyzed by gas chromatography with mass spectrometric detector (GC-MS) and a flame ionization detector (GC-FID), as well as carbon-13 nuclear magnetic resonance (NMR) analysis.

Reactor tests in both batch and continuous-flow systems are being performed to evaluate ruthenium metal catalysts at moderate processing conditions of 150 to 225°C and 135atm of pressure. Typical batch tests run for 4 hr with multiple liquid samples recovered and analyzed by the methods noted. Continuous-flow tests using a 400-mL catalyst bed reactor system, shown in the diagram below, are operated for 8-12 hr to generate data on 2-3 steady-state conditions.

Future Plans

In line with the support of the U.S. Department of Energy for the bio-refinery concept, evaluations will be carried out of new catalyst formulations and processing conditions for efficient conversion of bio-oil to value-added fuel and chemical products. Catalyst lifetime issues will also be investigated. It is intended to produce sufficient hydrogenated product for product tests, such as fuel testing and chemical product testing, both of which will require some purification.

For further details contact:

Mr Douglas C Elliott
Pacific Northwest National Laboratory
902 Battelle Boulevard
PO Box MSIN K2-12
Richland
Washington
99352 USA
Tel: +1 509 375 2248
Fax: +1 509 372 4732
Email: dougc.elliott@pnl.gov

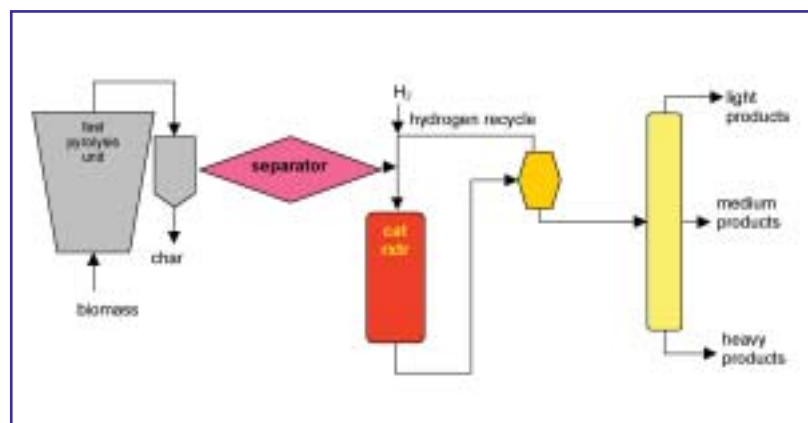


Figure 2: Biomass pyrolysis to value-added products.



Large Volume, Low Cost Biomass Production from Environmental Tree Crops in Australia

By John Bartle, Department of Conservation and Land Management, Western Australia.

In PyNe Newsletter 15 Colin Stucley mentioned the salinity problem in Australian agriculture and the need for environmental tree crops. What is this problem and how can tree crops help?



Figure 1: Mallee crop in the field in Western Australia.

Extensive agricultural development in Australia has only occurred in the last 100 years. During this time 70 million ha of low relief, winter dominant rainfall (300-600 mm/year) land in the southern half of the continent has been converted to cropland. The shallow rooted agricultural crops permit a tenfold increase in deep infiltration of water compared to what occurred under the deep-rooted perennial native bush. This extra inflow exceeds the internal drainage capacity of the landscape and water is accumulating in groundwater systems. In many regions this groundwater has reached the surface and begun to discharge into streams and at the soil surface. Unfortunately, the groundwater mobilizes otherwise harmless stored salts and emerges as brackish or saline water degrading land and streams. It is estimated that 5 million ha of land has been damaged so far and this will treble over several decades until a new hydrologic equilibrium is established. Damage is not confined to land and water resources. Hydrologic change and salinity on whole river systems is also causing loss of biodiversity, amenity, increased flood risk and damage to infrastructure.

Better knowledge has stimulated a strong national resolve to arrest, or if possible, reverse the problem. There are two types of remedial treatment. The recharge rate can be reduced by wider use of perennial plants in agriculture, or discharge can be enhanced by drainage or pumping and safe disposal. Solutions will incorporate both types of treatment.

Tree crops will be an important part of the perennial plant component. Tree crops will be required on more than 20% of the 70 million ha of cereal cropping land or 14 million ha. Experience with mallee eucalypts indicates yields of 7 tonnes dry weight/ha/year could be achieved in belt planting configuration (see picture) or ~100 million tonnes dry weight biomass per year.

New research aims to determine if it is feasible to grow and market this amount of biomass. Initial results indicate the following desirable crop/product specifications:

- Several new species will be required to provide diverse production and market options.
- Short harvest cycle (2 to 4 year) crops used in belt planting configuration will be best.
- Multiple product species will be desirable (i.e. harvest whole plants and use all biomass).
- Native species have good biological potential to be bulk biomass crops.
- Every major product area will need to be developed and large-scale development of bioenergy (fuels for electricity generation and transport) will be essential.
- Higher value biomass fractions (extractives and wood chip) will underwrite a competitive residue price improving bioenergy opportunities.
- The highly mechanized, large scale practices of Australian cereal growers will enable them to deliver biomass feedstocks of ~1 million dry tonnes/year to local district (50 km radius) processing centres for <\$60Aust/tonne dry weight.

There is considerable interest in pyrolysis as shown in the previous article by Colin Stucley in PyNe Newsletter 15. Conversion of low value residues into higher value liquids offers an alternative to electricity generation. This would be attractive in the substantial agricultural areas where grid transmission capacity is too low for significant export of power.

For further details contact:

John Bartle
 Manager Re-vegetation Systems Unit
 Department of Conservation & Land Management
 Locked Bag 104
 Bentley Delivery Centre
 Western Australia 6983
 Tel: +61 2 9334 0321
 Email: johnb@calm.wa.gov.au
 Websites: <http://www.calm.wa.gov.au/>
 and www.crcsalinity.com





Latin America Thematic Network on Bio-Energy – LAMNET

By Dr Rainer Janssen, LAMNET, Germany.

The project 'Latin America Thematic Network on Bio-Energy – LAMNET' is engaged in setting-up a trans-national forum for the promotion of the sustainable use of biomass in Latin America, Europe, China and Africa. Currently, the global network LAMNET consists of 48 institutions (Knowledge Centres and SMEs) from 24 countries worldwide, thereby involving a large number of members with excellent expertise in the field of biomass.

LAMNET supports the elaboration of recommendations for the development and implementation of policy options for the promotion of biomass and bioenergy as well as the identification of commercially available and reliable biomass technologies worldwide.

The web site of this global network on bioenergy was established early in 2002 under www.bioenergy-lamnet.org. It provides detailed information on the objectives, activities and scientific publications of this trans-national forum as well as the contact details of all network members. Further dissemination activities of the LAMNET project include the publication of a periodic newsletter (2 issues per year), a project database providing information on the energy demand and the energy resources in Latin America and other selected emerging economies as well as the organisation of several bioenergy workshops.

LAMNET project workshops organised in 2002 include a Conference Related Event on the occasion of the 12th European Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection in Amsterdam on 19 June 2002, a workshop on 'Biomass, Rural Energy and the Environment' in Durban organised one week prior to the WSSD in Johannesburg (August 2002) as a joint event of the three Thematic Networks CARENSA, SPARKNET and LAMNET and a workshop on 'Bio-Energy Policies and Innovative Bioenergy Technologies' in São Paulo and Brasília, 2-4 December 2002.

With respect to bioenergy technologies and systems it is the main objective of the LAMNET project to identify currently available, efficient, cost-competitive and reliable bioenergy technologies which provide opportunities for the conversion of biomass to energy services in Latin America, Europe, Africa and China. Relevant technologies and systems are selected on the basis of maturity of the technology, cost-effectiveness, simplicity of maintenance, social acceptability and the impact on development. Moreover, opportunities for international co-operation, technology transfer and joint-ventures in the field of bioenergy technologies are identified and promoted by the LAMNET network.

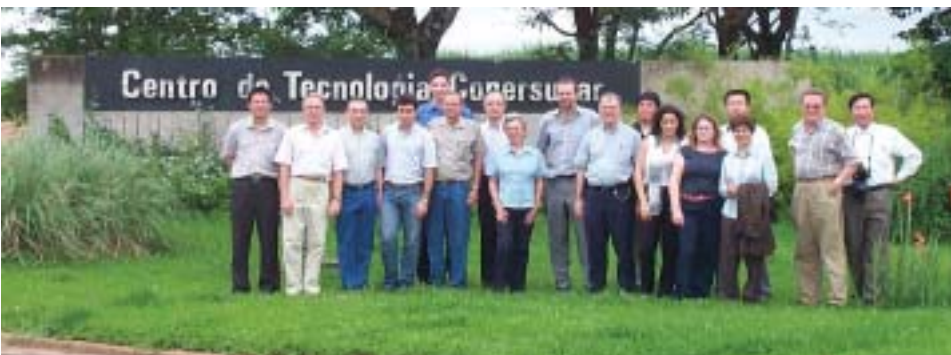
Finally, the analysis of the current energy policy framework and support for the elaboration of policy options for the promotion of the sustainable use of biomass follows three main lines within the framework of this global network on Bio-Energy:

- Involvement in major international events and initiatives focussing on Renewable Energies and Sustainable Development.
- Monitoring of the national/regional policy frameworks and the elaboration of advice and recommendations for the development and implementation of policy options for the promotion of bioenergy in close cooperation with the national network members.
- Active networking with other organisations, institutions and multilateral initiatives engaged in the field of Renewable Energies and Sustainable Development.

For more information on the LAMNET project activities, see the project web site www.bioenergy-lamnet.org or contact the project coordinator Dr. Rainer Janssen rainer.janssen@wip-munich.de

For further details contact:

Dr Rainer Janssen
LAMNET Project Coordinator
WIP – Renewable Energies
Sylvensteinstr. 2
D-81369
Muenchen
Germany
Tel: +49-89-720127 43
Tel: +49-89-720127 35
Fax: +49-89-720127 91
Email: rainer.janssen@wip-munich.de
Email: wip@wip-munich.de
Website: www.wip-munich.de



In the framework of the 3rd LAMNET project workshop a technical tour has been organised to the Copersucar Technology Center in Piracicaba/SP, Brazil, one of the most advanced research centres of the world in the cane, sugar and ethanol production sector.



Opportunities for Bio-oil in European Heat and Power Markets

By Maximilian Lauer,* John Brammer** and Tony Bridgwater,**
*Joanneum Research, Austria, **Aston University, UK

Competitiveness

The opportunities for use of bio-oil in heat and power applications across Europe have been evaluated by measuring its competitiveness to conventional alternatives. Economic competitiveness is a relative issue and the overall costs of a technology meeting a given duty should be at the same level or lower than the overall costs of a competing technology meeting the same duty.

In order to provide a measure of competitiveness, a non dimensional index *cF* (competitiveness factor) is introduced, which is defined as the ratio of the total annual cost of meeting the required duty using conventional energy to that of meeting the same duty using a purpose-built bio-oil or biomass plant:

$$cF = \frac{\text{total annual cost of conventional energy}}{\text{total annual cost of bio-oil or biomass plant}}$$

A value of *cF* < 1 means that bio-oil is not competitive while values > 1 mean that bio-oil is more attractive than the conventional alternative.

Approach

Calculation of the Competitiveness Factor requires knowledge of the costs associated with the bio-oil production process and with the bio-oil or biomass utilisation process, the latter being split into technology-related elements and location-related elements. By standardising the conventional alternative across all applications, then it is possible to compare options that are different in scale, location and service provided.

- Technology related elements (investment cost, O&M cost, labour requirements, efficiencies etc. for a set of bio-oil applications and biomass applications (combustion and gasification);
- Location specific data acquisition by using a questionnaire asking all European PyNe country representatives to describe the national situation by answering the questions on feedstock available, cost situation for energy and labour in industry etc.; Data acquisition and data processing done by Joanneum Research with the help of PyNe country representatives.
- Bio-oil production cost calculation by using relations based on assumptions (single bio-oil production facility in an area of high biomass availability) and location specific parameters.

Table 1 lists the feedstocks specified by PyNe country representatives, and Table 2 outlines the range of technology options considered.

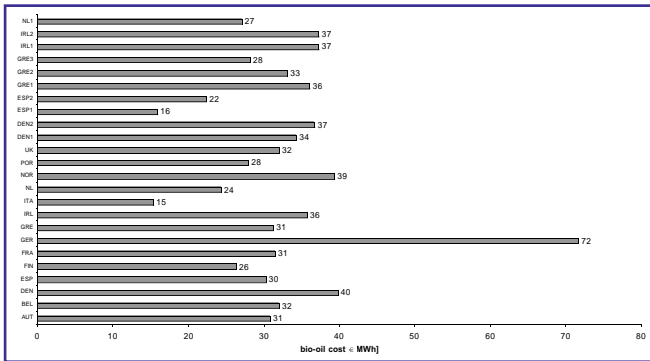


Figure 1: Bio-oil cost across Europe (see Table 1 and Table 2 for further specification of feedstock).

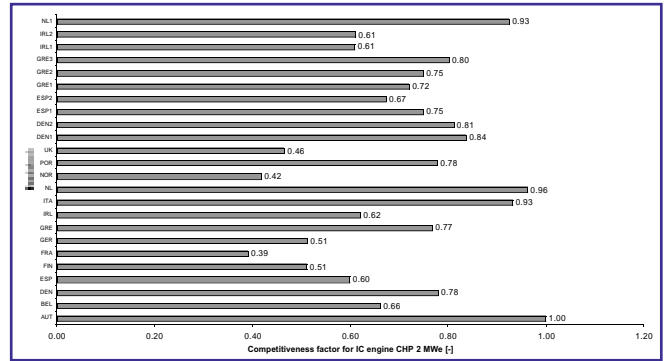


Figure 3: Competitiveness Factor of bio-oil IC-engines for CHP (2 MWe) across Europe; (see Table 1 and Table 2 for further specification of feedstock).

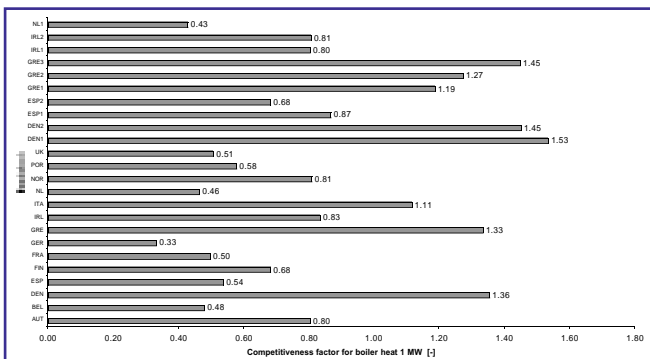


Figure 2: Competitiveness Factor for bio-oil boilers for heat production (1 MWth); (see Table 1 and Table 2 for further specification of feedstock).

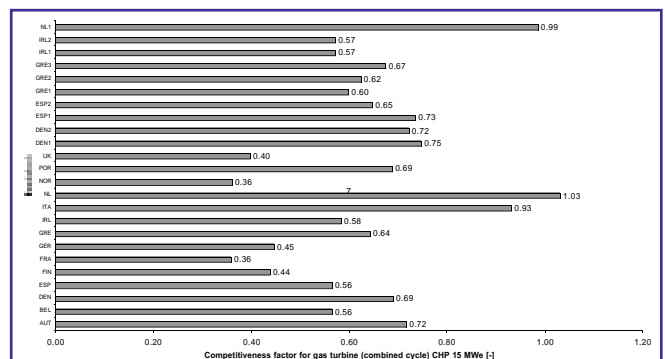


Figure 4: Competitiveness Factor of bio-oil GTCC for electricity (15 MWe) across Europe; (see Table 1 and Table 2 for further specification of feedstock).

Country	Standard Feedstock Source
Austria	Sawmill Residues
Belgium	Industry By-Product
Denmark	Forestry Residues
Finland	Forestry Residues
France	Forestry Residues
Germany	Industry By-Product
Greece	Forestry Residues
Ireland	Forestry Residues
Italy	Industry By-Product
Netherlands	Industry By-Product
Norway	Forestry Residues
Portugal	Forestry Residues
Spain	Fruit Tree Prunings
United Kingdom	Forestry Residues

Table 1: Feedstocks considered.

No.	Technology	Product
Standard Applications – Bio-oil		
1	Bio-oil boiler	Heat
2	Bio-oil IC engine (dual fuel diesel)	Electricity
3	Bio-oil IC engine (dual fuel diesel)	CHP
4	Bio-oil gas turbine (simple cycle)	Electricity
5	Bio-oil gas turbine (simple cycle)	CHP
6	Bio-oil gas turbine (combined cycle)	Electricity
7	Bio-oil gas turbine (combined cycle)	CHP
8	Bio-oil boiler (Rankine cycle)	CHP
Standard Applications – Biomass		
9	Biomass boiler	Heat
10	Biomass gasifier IC engine (SI)	Electricity
11	Biomass gasifier IC engine (SI)	CHP
12	Biomass gasifier gas turbine	Electricity
13	Biomass gasifier gas turbine	CHP
14	Biomass IGCC	Electricity
15	Biomass IGCC	CHP

Table 2: Standard applications.

Results

The results show a wide variation across Europe, in both the levels of competitiveness and in the rankings of the various applications. A total of six countries had at least one bio-oil application which was economically competitive ($CF \geq 1$). They are listed below, together with for each country the percentage of applications found to be competitive, and the competitive technologies in descending order of competitiveness.

- **Italy** 55% of applications competitive gas turbine (CHP), Rankine (CHP), IC engine (CHP), boiler (heat), gas turbine combined cycle (CHP)
- **Netherlands** 43% of applications competitive gas turbine (CHP), IC engine (CHP), gas turbine combined cycle (CHP), gas turbine (electricity), IC engine (electricity), Rankine (CHP)
- **Denmark** 32% of applications competitive boiler (heat), Rankine (CHP), gas turbine (CHP), IC engine (CHP)
- **Greece** 24% of applications competitive boiler (heat), Rankine (CHP), gas turbine (CHP), IC engine (CHP)
- **Austria** 15% of applications competitive IC engine (CHP) only
- **Spain** 15% of applications competitive boiler (heat), IC engine (CHP), gas turbine (CHP)

With regard to specific applications and technologies, some general results can be observed:

- Heat applications are the most economically competitive with the lowest specific cost of greenhouse gas mitigation, followed by CHP applications, with electricity applications only very rarely competitive.
- Within a given technology, the larger the scale, the better the economic competitiveness and the lower the specific cost of greenhouse gas mitigation.
- The boiler for heat applications showed on average the best economic competitiveness across Europe, followed by the bio-oil IC engine for CHP and the bio-oil Rankine cycle for CHP.

Acknowledgements

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For further details contact:

Dr Maximilian Lauer
Joanneum Research
A-8010 Graz, Elisabethstrasse 5,
Austria
Tel: +43 316 876 1336
Fax: +43 316 876 1320
Email: max.lauer@joanneum.at



Energy

By John Brammer, Bio-Energy Research Group,
Aston University, UK

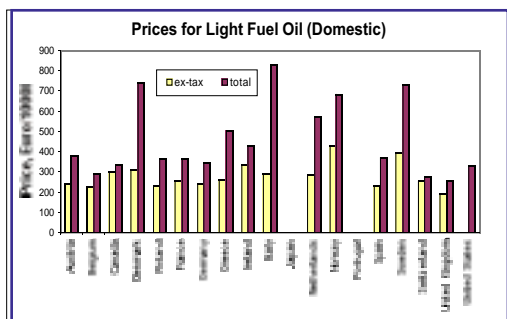
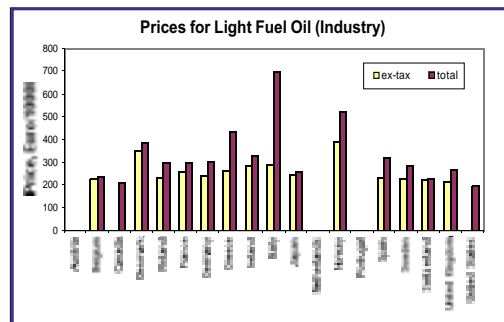
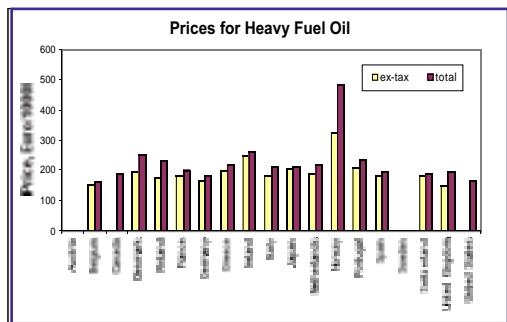
- Average prices over 2002, except *2001, **2000
- All liquid fuel prices in Euro per 1000 litres
- All gas and electricity prices in Euro per 100 kWh (or cents per kWh), gas on GCV basis
- All currency conversions based on exchange rates only
- 1 Euro = 0.895 US\$

Principal source: IEA Energy Prices and Taxes, 2nd Quarter 2003 (ISSN 0256-2332)
Brazil omitted as no data available

FUEL OILS

Country	Heavy Fuel Oil			Light Fuel Oil (Industry)			Light Fuel Oil (Domestic)		
	ex-tax	tax	total	ex-tax	tax	total	ex-tax	tax	total
Austria							242	140	382
Belgium	156	6	162	226	13	239	226	64	290
Canada			190			212	301	34	335
Denmark	199	52	251	352	33	385	314	432	746
Finland	177	57	234	232	68	300	232	134	366
France	182	18	200	256	42	298	256	108	364
Germany	165	18	183	241	61	302	241	110	351
Greece	203	19	222	262	171	433	262	243	505
Ireland	249	14	263	284	47	331	335	95	430
Italy	181	31	212	291	404	695	291	542	833
Japan	204	10	214	246	12	258			
Netherlands	188	32	220				283	289	572
Norway	326	158	484	393	126	519	429	259	688
Portugal	209	28	237						
Spain	182	14	196	234	85	319	234	136	370
Sweden				226	59	285	392	341	732
Switzerland	183	6	189	220	6	226	253	26	279
United Kingdom	152*	44*	196*	218	50	268	191	62	253
United States			168			195			332

Heavy fuel oil is low sulphur, except Canada, Ireland, Japan, Portugal, Spain, UK and US (high sulphur).
Heavy fuel oil density 0.97 kg/l.

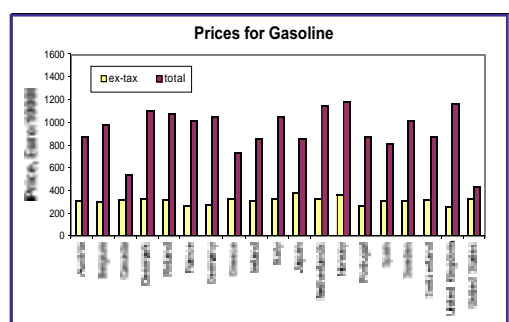
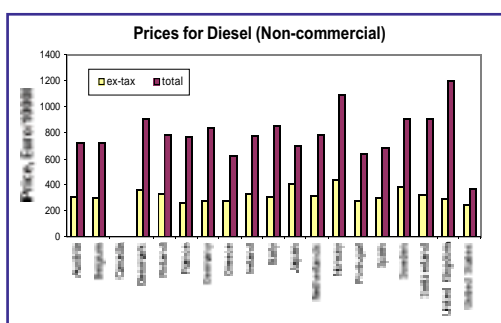
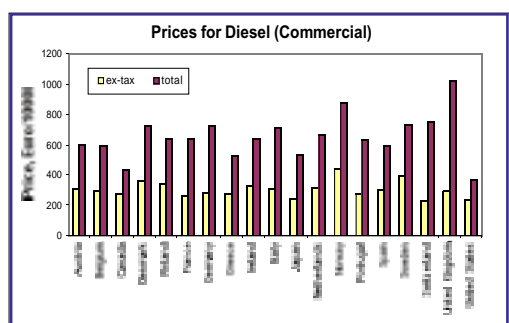


Prices & Taxes 2002

TRANSPORT FUELS

Country	Diesel (Commercial)			Diesel (Non-commercial)			Gasoline		
	ex-tax	tax	total	ex-tax	tax	total	ex-tax	tax	total
Austria	310	290	600	310	409	719	314	560	874
Belgium	295	304	599	295	431	726	302	677	979
Canada	282	148	430				323	211	534
Denmark	361	370	731	361	553	914	335	768	1103
Finland	339	304	643	338	446	784	322	753	1075
France	262	383	645	262	509	771	267	747	1014
Germany	284	440	724	284	556	840	279	769	1048
Greece	282	245	527	282	340	622	327	408	735
Ireland	336	304	640	336	438	774	307	548	855
Italy	310	403	713	310	546	856	331	717	1048
Japan	249	284	533	409	292	701	384	475	859
Netherlands	320	344	664	320	470	790	333	811	1144
Norway	440	433	873	445	644	1089	357	833	1190
Portugal	277	354	631	277	368	645	273	604	877
Spain	300	294	594	300	389	689	306	508	814
Sweden	391	341	732	392	524	916	308	708	1016
Switzerland	232	522	754	324	586	910	315	567	882
United Kingdom	293	728	1021	293	908	1201	262	902	1164
United States	243	125	368	243	125	368	329	108	437

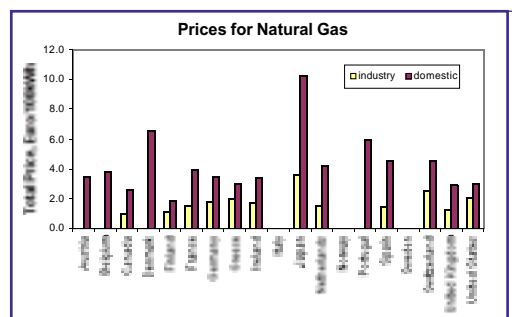
Gasoline is premium unleaded 95 RON, except Canada (97 RON), Denmark (98 RON) and Japan (Regular).



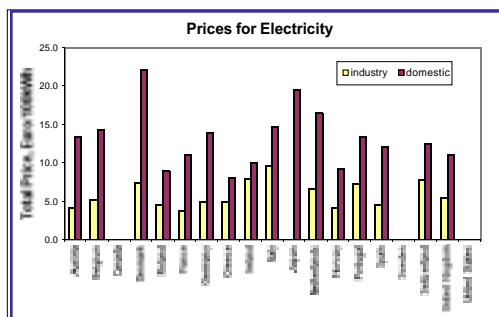
GAS

Country	Natural Gas (Industry)			Natural Gas (Domestic)		
	ex-tax	tax	total	ex-tax	tax	total
Austria				2.52	0.94	3.46
Belgium				3.02**	0.78**	3.80**
Canada			0.98*			2.65*
Denmark				2.66	3.91	6.57
Finland	1.00	0.16	1.16	1.34	0.50	1.84
France	1.57		1.57	3.31	0.66	3.97
Germany	1.53**	0.22**	1.75**	2.65**	0.83**	3.48**
Greece	1.97*		1.97*	2.75*	0.22*	2.97*
Ireland	1.68		1.68	3.05	0.38	3.43
Italy						
Japan	3.43*	0.17*	3.60*	9.84*	0.49*	10.33*
Netherlands	1.44	0.10	1.54	2.62	1.55	4.17
Norway						
Portugal				5.69	0.28	5.97
Spain	1.51		1.51	3.90	0.63	4.53
Sweden						
Switzerland	2.53	0.03	2.56	4.16	0.35	4.51
United Kingdom	1.20	0.09	1.29	2.75	0.14	2.89
United States			2.07			2.95

GAS



ELECTRICITY



ELECTRICITY

Country	Electricity (Industry)			Electricity (Domestic)		
	ex-tax	tax	total	ex-tax	tax	total
Austria	4.15**		4.15**	9.48	4.00	
Belgium	5.18**		5.18**	11.72**	2.63**	
Canada						
Denmark	6.37	1.02	7.39	8.81	13.34	
Finland	4.09	0.43	4.53	6.66	2.32	
France	3.89		3.89	8.75	2.34	
Germany	4.90*		4.90*	11.92*	1.90*	
Greece	4.90		4.90	7.56	0.60	
Ireland	7.97		7.97	10.09		
Italy	8.18**	1.47**	9.65**	11.34**	3.36**	
Japan				18.26**	1.31**	
Netherlands	5.93*	0.62*	6.55*	9.33	7.10	
Norway	3.29*	0.79*	4.07*	6.28	2.97	
Portugal	7.26		7.26	12.82	0.64	
Spain	4.37	0.25	4.59	9.95	2.18	
Sweden						
Switzerland	7.78		7.78	11.57	0.88	
United Kingdom	5.04	0.40	5.44	10.63	0.52	
United States	5.15			8.91		



Science in Thermal and Chemical Biomass Conversion



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

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

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

PROGRAMME

The conference will include formal presentations, posters, workshops, discussions and a varied social programme. There will be an emphasis on scientific interaction and discussion in order to take full advantage of the international nature of the meeting. A number of workshops will be arranged to address topical problems under the chairmanship of an expert in that area. A social programme will enable participants to sample the flavour and scenery of Victoria – a unique and relaxing town at the southern tip of Vancouver Island, British Columbia, Canada.

All papers will be subjected to peer review before the conference in order that edited, camera ready manuscripts can be submitted very quickly after the conference to enable rapid publication of the proceedings. A provisional timetable is given below. To provide for greater interaction between participants and to provide all authors with the opportunity to present their work, there will be a substantial emphasis on poster papers with themed group presentations.

OUTLINE PROGRAMME

The outline programme is summarised below:

Sunday 29 August	Poster set up and welcome reception.
Monday 30 August	Orals, poster presentations, workshops and social excursion to Butchart Gardens.
Tuesday 31 August	Orals, poster presentations, workshops.
Wednesday 1 September	Orals, poster presentations, and workshops afternoon free for sightseeing.
Thursday 2 September	Orals, poster presentations and workshops with evening Gala Dinner to conclude the conference.

Workshops will be held on a variety of themes to meet interests of delegates such as feeding systems, tar cracking, transport fuel synthesis, bio-diesel in North America, economic assessment methodologies.

TIMETABLE AND DEADLINES

30 November 2003	Deadline for submission of abstracts
29 February 2004	Provisional programme and registration details published
31 March 2004	Deadline for submission of manuscripts
February – April 2004	Refereeing of papers
30 AUGUST – 2 SEPTEMBER 2004	CONFERENCE
31 October 2004	Deadline for submission of final paper
31 March 2005	Publication of proceedings

Conference Chairs

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

Conference Secretariat

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

Sponsors

IEA Bio-Energy, Natural Resources Canada, European Commission.

For further details:
or to register a paper please see our
website www.stcbc.com or contact
Emma Wylde (e.wylde@aston.ac.uk)

Pyrolysis and Gasification of Biomass and Waste

Pyrolysis and Gasification of Biomass and Waste provides an authoritative review of the current state of thermal biomass conversion technologies, and their implementation now and in the future. These proceedings include over 70 papers and case studies presented by leading experts from Europe and North America in Strasbourg in October 2002.



The meeting covered a wide range of raw materials and processes, addressing topics such as small and large scale gasification, fast pyrolysis of biomass, liquefied wood fuel, full-scale application of sewage sludge pyrolysis, ammonia production and reduction, gasification of sorted MSW, green diesel, gas engines, gas cleaning and process design, as well as technical and non-technical barriers to commercial exploitation.

A key aim of the meeting was to create recommendations for strategies and policies in these areas that the European Commission can use in its forward planning, especially with regard to sustainable energy supply, greenhouse gas mitigation and associated environmental issues.

The event was sponsored by EC Altener, CIRAD and CEA, and supported by PyNe and GasNet.

*Edited by: A V Bridgwater,
ISBN 1 872691 77 3, Price £95.00*

2nd World Conference and Exhibition on Biomass

Rome, Italy 10th to 14th May 2004

Call for papers deadline is 10th October 2003

ETA-Florence and WIP-Munich are organising the '2nd World Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection'. The event, which will be held at the Palazzo dei Congressi in Rome from 10 to 14 May 2004, with the support of the European Commission, the DOE U.S. Department of Energy, UNEP-United Nations Environment Programme and the Italian Ministry of Environment, as well as Natural Resources Canada, IEA Bio-Energy and EUBIA European Biomass Industry Association.

Five days during which the subject of biomass will offer an excellent opportunity to discuss energy, energy sustainability, the possibilities for technological development and the reduction of climate impacts, by providing a space for experts from all over the world to gather and exchange know-how from their most successful experiences.

This international event comprises sessions dedicated to the state-of-the-art development in biomass evaluation technologies; poster sessions on the research, development, demonstrations and commercial projects in the field; as well as exhibition of conversion and exploitation products and technologies; thematic workshops and one conference day dedicated to Italy. In whole, an opportunity to evaluate the role played by biomass in the global process to reduce the impacts that human activity is having on our planet.

The main topics of the conference:

- Biomass resources.
- Research and development of bioenergy conversion technology systems.
- Demonstration and market implementation of bioenergy in the heat and electricity sector.
- Demonstration and market implementation of bioenergy in the transportation sector.
- Combined application of biomass for energy, industrial products for climate protection.
- Economics and benefits deriving from biomass process technologies, integration and simultaneous production.
- International biofuels trade.
- Strategy and policy issues.

- International Co-operation for accelerating the large-scale worldwide deployment of bioenergy.
- Biomass in the developing world.

Institutions, Universities, research centres, technicians, operators in the field will all be able to contribute to the international debate by submitting their abstracts to the Scientific Committee. The deadline for submitting abstracts is 10 October 2003.

For further details contact the Scientific Committee:

Ing. Gianluca Tondi, ETA – Florence,
2nd World Biomass Conference 2004,
Piazza Savonarola, 10, 50132 Florence, Italy.
Tel: +39 055 500 21 74, Fax: +39 055 57 34 25
Email: biomass.conf@etaflorence.it Website:
www.conference-biomass.com/abstracts



Diary of Events

Information compiled by Claire Humphreys, Aston University, UK

2003 Shanghai International Expo on Renewable Energies

Venue: Shanghai, China
Date: 10-12 October 2003
Contact: Ms Shyliva Chen
Worldwide Exhibitions Service Co., Ltd
Tel: +86 21 52340649
Email: wezhou@online.sh.cn

EnerEnv'2003 – The First International Conference on Energy and Environment

Venue: Changsha, China
Date: 11-14 October 2003
Contact: Wei Sun
Dept. of Environmental Science and Engineering
Hunan University
Changsha 410082
PR China
Tel: +86 731 882 1697
Fax: +86 731 882 3701
Email: sunwei@hnu.net.cn

Bio-Energy Enlarged Perspectives

Venue: Budapest Congress Centre, Hungary
Date: 16-17 October 2003
Contact: rtd-energy-ia@cec.eu.int

International Conference for Renewable Energy, Energy Saving and Energy Education

Venue: City of Havana, Cuba
Date: 28-31 October 2003
Contact: Dr Ing. Tomas Delgado Lopez
Secretary to the Conference
Email: cier2003@ceter.ispjae.edu.cu
Website: www.cujae.edu.cu/eventos.cier

European Bio-Energy Business Forum 2003

Venue: European Parliament, Brussels
Date: 13-14 November 2003
Contact: Mr Jean-Marc Jossart
Croix du Sud 2, bte 11,
1348 Louvain-la-Neuve
Belgium
Tel/Fax: +32 10 47 34 55
Email: jossart@ecop.ucl.ac.be
Website: www.ecop.ucl.ac.be/aebiom

Chemreactor-16

Venue: Berlin, Germany
Date: 1-5 December 2003
Contact: Tatiana Samulina
Organizing Committee
'Chemreactor-16'
5 Akad. Lavrentiev Ave.
Borestkov Institute of Catalysis
SB RAS, 630090 Novosibirsk
Russia
Tel: +7 383 234 1297
Fax: +7 383 234 3056
Email: zam@catalysis.nsk.su

Bioenergy Australia 2003 Conference

Venue: Novotel Bridgton Beach, Sydney
Date: 8-10 December 2003
Contact: Stephen Schuck
Bio-Energy Australia Manager
Tel/Fax: +61 2 9416 9246
Email: sschuck@bigpond.net.au

2nd International Workshop on Pyrolysis – Thermal Conversion Opportunities for New Wood Products through Research and Development

Venue: University of Notre Dame,
Fremantle WA
Date: 15-17 December 2003
Contact: Paul Fung,
Forest Products Laboratory,
Bayview Avenue,
Private Bag 10,
Clayton South,
Vc 3169, Australia
Tel: +613 9545 2487
Fax: +613 9545 2448
Email: Paul.Fung@csiro.au

Biodegradable and Residual Waste Management

Venue: Harrogate International Centre,
Harrogate, UK
Date: 18-19 February 2004
Tel: 01709 828181/0113 3002032
Email: vent@calrecovery-europe.com

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

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

2nd World Conference and Exhibition on Biomass

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

16th International Symposium on Analytical and Applied Pyrolysis

Venue: Alicante, Spain
Date: 23-27 May 2004
Contact: Viajes Hispania, Conference Dept.,
Avda. Maisonnave, 11-70,
Alicante, Spain
Tel: +34 965 22 83 93
Fax: +34 965 22 98 88
Email: ctrives@vhispania.es
Website: www.pyrolysis2004.org

World Bioenergy 2004 – Conference and Exhibition on Biomass for Energy

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

Science in Thermal and Chemical Biomass Conversion

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

7th Asian Pacific International Symposium on Combustion and Energy Utilisation

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

Please contact your country representative for further information.



Co-ordinator

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



Austria

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



Belgium

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



Denmark

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



Finland

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



France

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



Germany

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



Greece

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



Ireland

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



Italy

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



Netherlands

Wolter Prins
BTG
Business & Science Park
Pantheon 12
PS Enschede
7521
NETHERLANDS
Tel: +31 53 486 2282
Fax: +31 53 432 5399
Email: w.prins@ct.utwente.nl



Norway

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



Portugal

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



Spain

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



Sweden

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



USA

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



Greve in Chianti, Italy, April 2003.



IEA Bioenergy

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