


Biorefinery Researcher

Issue 4

May 2010

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Sustoil

BIOREF-INTEG

SEVENTH FRAMEWORK PROGRAMME

Developing advanced biorefinery schemes to convert whole EU oil-rich crops into energy, food and bioproducts. This will make optimal use of the side streams generated during farming/harvesting, primary processing and secondary processing.

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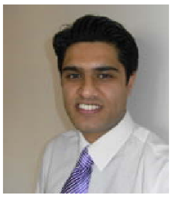

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SUSTOIL Partners

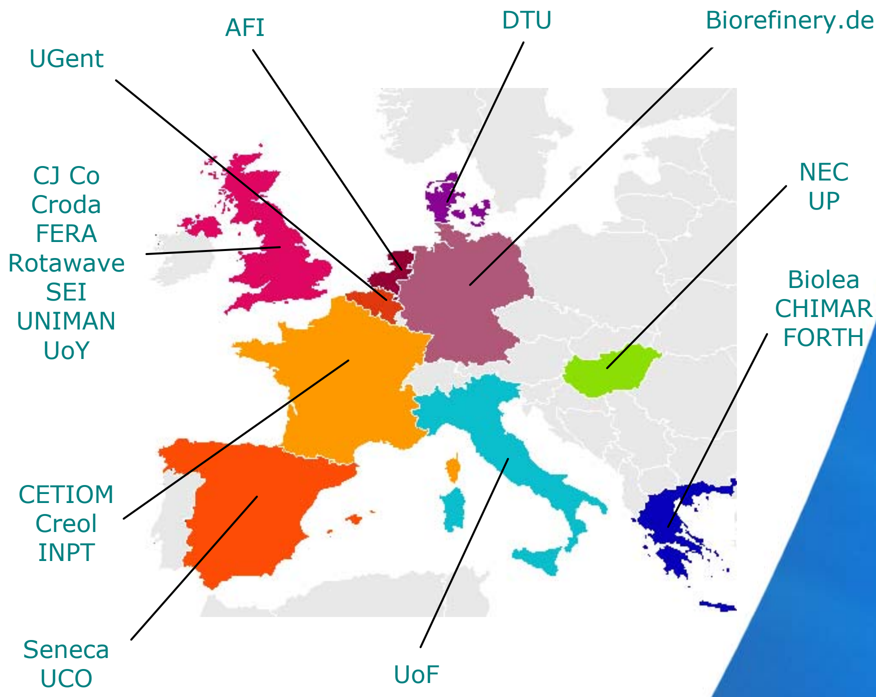
SUSTOIL will integrate the expertise of 22 project partners with the expertise of an Advisory Board composed of experts from the EU, US and beyond.

Economic, social and environmental costs benefits of optimal integrated schemes will be assessed and main technological challenges/knowledge gaps will be identified.

Resulting in recommendations of key activities for future collaborative projects.

The map below shows where the partners are located-

1. Agrotechnology and Food Innovations BV, The Netherlands
2. BioCentrum-DTU, Denmark
3. Biolea, Greece
4. Biorefinery.de GMBH, Germany
5. CETIOM, France
6. Charles Jackson & Co Ltd, UK
7. Chimar Hellas SA, Greece
8. Creol, France
9. Croda International PLC, UK
10. Food and Environment Research Agency, UK
11. FORTH, Greece
12. INP Toulouse, France
13. Nógrádi Erdökémia Co, Hungary
14. Rotawave Ltd, UK
15. Seneca Green Catalyst SL, Spain
16. Stockholm Environment Institute, UK
17. University of Cordoba, Spain
18. University of Foggia, Italy
19. University of Ghent, Belgium
20. University of Manchester, UK
21. University of Pannonia, Hungary
22. University of York (Coordinator), UK



June 2008—May 2010

Sustoil holds 2nd Workshop in Toulouse, France

Introduction
The Sustoil consortium held a successful second workshop in Toulouse in the first week of February 2010. The workshop was based on results from work packages five and six. The workshop was hosted by ENSIACET (Laboratoire de Chimie Agro-Industrielle) and the main organisers were Professor Carlos Vaca-Garcia and Dr Antoinne Rouilly. A special thanks was given by the entire consortium for their superb organization and making everyone feel very welcome!

The workshop was opened by Professor James Clark and then an update was given by Professor Ray Marriott. We were also delighted to have Dr Hamid Mozaffarian from the Energy research Centre of the Netherlands present who gave a detailed update on the Bioref-Integ project. The workshop also benefited greatly from having one of the Sustoil advisors, Dr Christophe Luguel, present for the all the work package talks. He is the head of international affairs at the French Competitiveness cluster "Industries and Agro-Ressources" and was the scientific coordinator for the EEC project "Biorefinery Euroview", supported by the European Commission (FP6).

Work Package Results
Work package five will ascertain the sustainability of the various developed schemes through a full life cycle assessment and computational modelling of the economic, social and environmental costs and benefits. Work package six will develop various policy scenarios to understand any potential environmental, economic and policy constraints the bioenergy and biorefinery sector could face within a sustainable development framework.

These work packages are led by experts from the University of Manchester, UK and the University of Foggia, Italy respectively. The workshop consisted of three days where the first two days were dedicated to the two work packages and on the third day the consortium visited a number of agro-material companies in the area of Tarbes. During lunch the partners also visited nearby Lourdes, the famous catholic pilgrimage site.

During the first day Dr Kostas Theodoropolous and Dr Michael Binns from the University of Manchester presented results from work package 5. The detailed analysis of several biorefinery schemes were presented and significant progress has been made. However the lack of data available for some of the industrial processes has been a consistent problem.

The following schemes have been modelled so far;

- Glycerol purification
- Glycerol to succinic acid (bioconversion)
- Glycerol to 1,3-propanediol (bioconversion)
- Biomass to biogas/methane
- Supercritical CO_2 extraction of waxes
- Protein extraction from rapeseed meal
- Cold pressing oil extraction
- Hexane-based oil extraction
- Thermomoulding for materials production

Work package six has been led by professor Piergiuseppe Morone who is based at the University of Foggia and Rome, and Dr Caterina De Lucia who is based in the University of Bari and York. Their work has been supported by a team of experts including Dr Maurizio Prosperi and Dr Antonio Lopolito both from the University of Foggia, and Dr Richard Taylor from the Stockholm Environment Institute, Oxford.

A number of key results from the work package were presented and the session started with Caterina discussing the macroeconomic view and policy options. Other interesting talks included a theoretical/applied model of innovation-niche creation in the province of Foggia and a social network study on SUSTOIL in the province of Foggia

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Assessing the development status of a bio-refinery niche in the South of Italy

As commonly agreed, the development of biofuels is considered a useful instrument, which could substantially contribute to reducing greenhouse gas emissions and increase energy security. The University of Foggia research unit, within the SUSTOIL project, has investigated the economic potential for land conversion to energy crops in the Province of Foggia. Specifically, the unit investigated which key steps are required for the creation of an innovation niche in the field of bio-refinery production. The development of such a niche was considered a fundamental prerequisite for a broader and more comprehensive conversion process to biodiesel production.

The Foggia district in brief – a suitable case study

The Foggia district is a large agricultural area located in the south-east of Italy, in the north of the Apulia Region and covers a surface of approximately 7.192 km². It is characterised by a heterogeneous landscape with different terrain morphologies and vast areas of intensive farming. The most important permanent crops are fruit orchards, olive groves and vineyards. There are also small-scale farming marginal lands, forest and semi-natural areas, wetlands, and agroforestry. Moreover the district contains some important protected areas and areas sensitive to erosion processes.

A large proportion of the available land (about 200,000 ha) is characterised by scarce water availability related to the semi-arid Mediterranean climate; however, no other relevant constraints, such as nitrogeon leaching risk (typical of agricultural areas), are present. Indeed, extensive agriculture characterises this land, which makes it particularly suitable for sugar or starch energetic crops such as wheat, barley and oats.

As a matter of fact, the agricultural sector of the district is very significant for the local economy and the sector can receive several benefits from the "take-off" of well -structured bioenergy supply-chains. As perceived by local stakeholders, an appropriate integration of agro-energy farming into the prevailing rural system may increase the opportunities of rural development and promote crop diversification and the multi-functionality of farms. Moreover, local public institutions perceive the establishment of a bio-refinery industry as a desirable policy target. In fact, it represents both a potential rural development policy able to revitalize the local economy and a chance to cope with the energy and environmental objectives of the European Commission.

All in all, this area represents a suitable case study for a broad investigation of the development of an innovation niche in the field of bio-refinery production both because of: (1) the high potential of the territory for producing energy crops and agricultural raw materials (wheat straw, tomato stems, residues from the processing of vegetable crops, arundo grass growing along the river sides, and algae from the natural lakes), and (2) the interest of local stakeholders in new uses of biomass (i.e. for energy purposes).

Assessing the readiness of a bio-refinery niche

The structure of a bio-refinery niche depends on the interdependency and interaction between various local social actors. A first step in assessing this aspect was identifying the local actors and their level of interest in the development of a bio-refinery niche. Indeed, a direct survey showed that a local network made out of 74 actors (39 firms and 35 institutions) is interested in the development of such a niche.

Furthermore, the development of a bio-refinery niche needs: (a) the convergence of expectations within actors involved in the technological transition process; (b) the presence of powerful actors as these actors would be able to provide the required resources to boost the technological change; and finally, (c) the occurrence of learning activities and knowledge sharing patterns among niche actors as an adequate level of knowledge is a key element in any technological transition. As a second step, these three requirements were assessed.

As far as the convergence of expectations, the group of actors investigated showed a certain convergence of expectations towards the bio-refinery niche. Setting equal to 100 percent the maximum level of convergence (i.e. a situation in which all interviewed actors have an identical high level of expectation), we observed, on average, a level of convergence equal to 63 percent. The most interested actors were 9 firms and 5 institutions.

Within the emerging niche, we also observed the presence of powerful actors. Specifically, all actors identified by their peers as powerful in the survey actually joined the network. Figure 1 shows the emerging social network, with triangles for institutions and blue circles for firms. Among institutions, red identifies local authorities, yellow research centres and green trade associations or civil society associations. Moreover, the dimension of the actors changes on the basis of their in-degree (the in-degree of an agent is equal to the number of connections – edges– incident to the agent excluding those connections departing from the agent him/ herself). In such a network, institutions play a crucial role being among the most powerful and central actors.

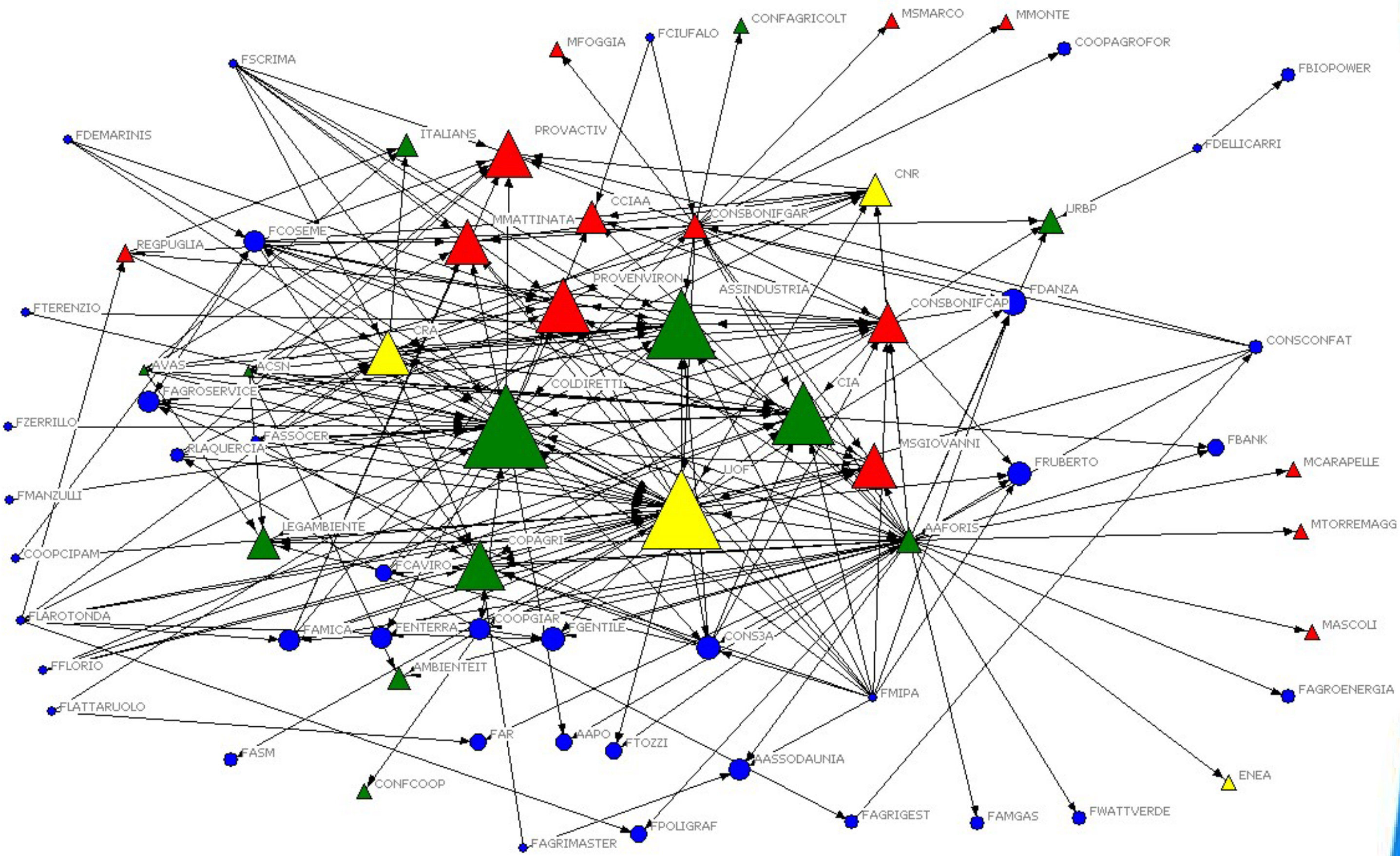

Figure 1 – Networking with powerful actors in the area of Foggia

Triangles = Institutions

- **Red triangles** represent local authorities
- **Yellow triangles** represent research centres
- **Green triangles** represent trade associations or civil society associations

Blue Circles = Companies

The size of the icon changes on the basis of their in-degree (the in-degree of an agent is equal to the number of connections –edges– incident to the agent excluding those connections departing from the agent him/herself)

Finally, as far as knowledge flows, that is the communication relations with a knowledge content existing among any pair of actors, the analysis has showed a knowledge network highly sparse and disconnected: in fact, only a small proportion of the agents are actively involved in knowledge exchanges (figure 2).

The study has revealed that the bio-refinery innovation niche in the area of Foggia has reached the status of a proto-niche – i.e. a niche not yet fully completed but on a promising way. More specifically, data showed how overall involved actors have a certain interest in the new technology and are already involved in networking activities, which involve powerful actors. On the whole, we observed a good potential to develop a bio-refinery niche. However, as knowledge creation and sharing is still lacking, efforts in such direction are required in order to reduce uncertainty surrounding the niche technology and promote the development of a full-niche.

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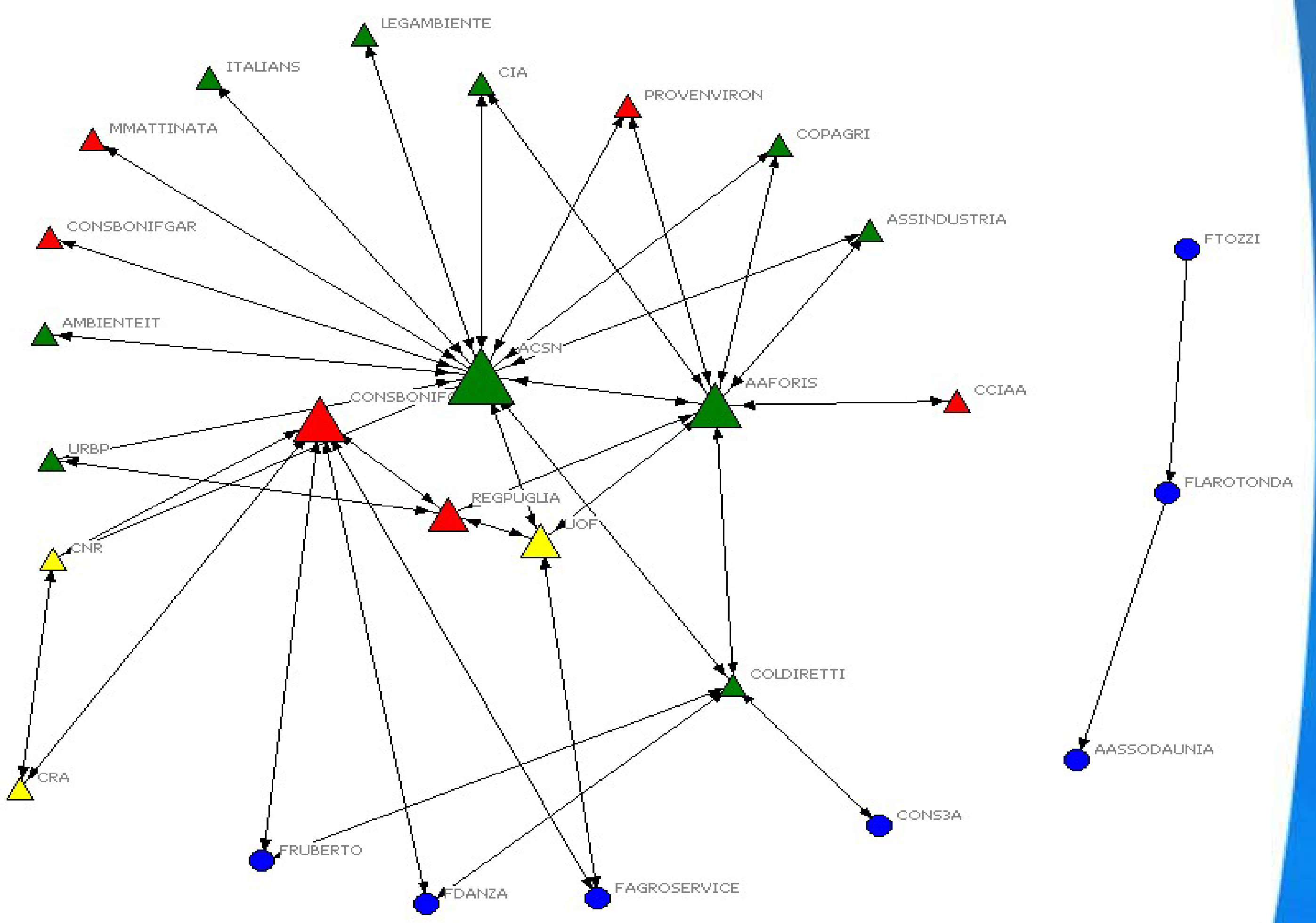

Figure 2 – The knowledge network connecting Foggia's actors

Triangles = Institutions

- **Red triangles** represent local authorities
- **Yellow triangles** represent research centres
- **Green triangles** represent trade associations or civil society associations

Blue Circles = Companies

Defining a set of suitable policy actions to promote the development of a bio-refinery niche

The need for active policy actions aiming at promoting the development of bio-refineries has become a relevant topic in the EU's policy agenda. This is due to the fact that this kind of production, if adequately developed, can potentially enhance both environmental and economic sustainability.

The bio-refinery industry is conceived as an integrated system of bio-based firms, able to produce a wide range of goods (chemicals, bio-fuels, food and feed ingredients, biomaterials, including fibres and power) from biomass raw materials, using a variety of technologies and maximising the value of the input. In rural areas, the establishment of new industrial firms, such as a bio-refinery, can be seen as an opportunity to revitalize the local economy and to revert the negative demographic trend, which often characterises those areas. Thus, the bio-based production can present European countries with both a chance to cope with their energy objectives, i.e. a substantial reduction of the overall dependence on petroleum feedstocks in the next decade, as well as with a direction for their rural development policy.

A calibrated agent-based model for investigating policy scenarios

The development process of a bio-refinery presents several degrees of complexity as it involves various types of heterogeneous actors operating under a high degree of uncertainty. In order to cope with such complexity, we used a calibrated agent-based simulation approach which allowed us to model the bio-refinery as a collection of autonomous decision-making heterogeneous entities called agents (Lopolito et al., 2009a). More specifically, agents represent the set of local actors (firms and local authorities) involved in the implementation of the bio-refinery. With this methodology we were able to model the bio-refinery system, despite the current lack of data, and to determine the most suitable policy actions for promoting the development of the bio-refinery niche.

We collected the data needed to calibrate the model by means of interviews (questionnaires) and a Fuzzy Cognitive Map (FCM) study (Lopolito et al., 2009b; Grimaldi et al., 2009). Questionnaires allowed us to gather basic data concerning the actors involved: we collected data on their level of power within the social network, on their level of knowledge related to bio-refineries as well on their web of interactions. The FCM approach, on the other hand, was implemented to identify a set of possible policy measures, perceived as relevant by key actors participating in the bio-refinery niche development.

Basically, the FCM is an empirical methodology capable of drawing the causal relationship among the most relevant variables, describing the behaviour of a complex system. The assumption underlying this methodology is that since the real world is complex, knowledge on a certain issue can be obtained by looking into the perceptions of people involved in it.

Assessing various policy mixes - a case-study analysis

As already discussed in the previous article, as a specific case study we focused on the development of a bio-refinery in a large agricultural area located in the South-east of Italy (i.e. the Foggia Province – Apulia Region). Its high potential for producing agricultural raw materials and the interest showed by local stakeholders in new uses of biomass makes this area suitable for our purpose. The study has highlighted in particular two important drivers for the emergence of a bio-refinery in such a rural area: the availability of information on the new technology and the use of subsidies as an incentive.

The diffusion of adequate information is one of the most important forces for the development of new technologies. Its absence can leave people with a vague, and potentially distorted, understanding of the new industry, in a way that may obstruct its complete development. Private entrepreneurs would need reliable information necessary for evaluating their business opportunities, such as details about the market structure and its outlook, the marketing of raw materials (e.g. opportunities from suppliers offering alternative raw materials), and the marketing of the processed products (e.g. threats from competing firms producing substitute products). In a new emerging sector, such information can be difficult to obtain for a small-scale producer; therefore, a public intervention is crucial in facilitating its symmetric diffusion.

Government subsidies, on the other hand, are a typical incentive for bio-refinery schemes (Mayfield et al., 2007; Gilbertson et al., 2008).

Such incentives are conceived as important especially at the start-up stage, for industrial research and for investments, and as such appear as the most influential force for the development of bio-refinery industry. Specifically, tax breaks and direct support to bio-refinery enterprises are among the most used policy measures. Such incentives are justified on the grounds that bio-refinery production could bring local environmental and socio-economic benefits.

However, if they last for a long time, they might cause market distortions, as well as competitiveness loss for the firms not involved in the bio-refinery sector.

These policy measures have been accounted for in our agent-based model in order to identify possible scenarios, in terms of firms entering the new industry, related to various policy-mix. The policy scenarios analysis allowed us to conclude that the preferred policy-mix would be one with an intermediate amount of information spread by public institutions and a low level of subsidy. Such policy-mix would guarantee the emergence of a clear and stable converging trend towards the bio-refinery niche within a ten-year timeframe, and would ensure an efficient allocation of public resources.

Interestingly, we also observed that whenever firms showed too high expectations of the niche option, a slower trend of bio-refinery emergence was generated. We explained such features of the model referring to the fact that firms with too high expectations might incur in a feeling of disappointment if such expectations are unfulfilled, and therefore abandon the new technology option.

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Sustoil

Partner Focus: National Polytechnic Institute of Toulouse (INPT)

The National Engineering School Of Chemical and Technological Arts (ENSIACET) offers a large training range in the transformation of matter: discovering molecules, imagining products, conceiving processes, controlling equipments and managing projects. It belongs to the National Polytechnic Institute of Toulouse (INPT).

Every year 230 French and international students enrol in five departments: Chemistry, Materials Engineering, Chemical Engineering, Process Engineering and Industrial Engineering. Thirteen senior engineering specialisation programs are proposed: e.g. green chemistry, analytical chemistry, bioprocesses and fine chemistry and functional materials.

Students can obtain post-graduate training in one of the four research laboratories: Agro-industrial Chemistry, Chemical Engineering, Coordination Chemistry and Materials Science.

With 700 students, 160 PhD students and 300 faculty and staff, ENSIACET represents the biggest European centre in this area.

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Figure 1: The ENSIACET building located in Toulouse, France
Figure 2: Some scale-up equipment for chemical reactions
Figure 3: Professor Carlos Vaca-Garcia, head of the department, showing an extruder in the labs.

Sustoil : RRB6 Special One Day Ticket

Sustoil : Developing advanced Biorefinery schemes for integration into existing oil production/ transesterification plants
www.sustoil.org

Dissemination conference 9 June 2010
Separate tickets available for the day

Time	Title	Speaker
8.30 - 9.00	Sustoil project summary	Abbas Kazmi, University of York, UK
9.00 - 9.30	WP 1: Optimisation of oil crops agronomy and oil yield and utilisation of by-products	Katerina Stamatelatou, FORTH, Greece
9.30 - 10.00	WP 2: Optimisation of primary processing (e.g. oil extraction and refinery)	Wim Mulder, A+F, Netherlands
10.00 – 10.30	WP 3: Optimisation of secondary processing (i.e. biodiesel production)	Zsanett Herceski, University of Pannonia, Hungary
10.30 – 11.00	Break	Tea/Coffee
11.00 – 11.30	WP 4: Development of integrated biorefinery schemes to be incorporated into existing vegetable oil production/ transesterification	Ray Marriott, University of York, UK
11.30 – 12.00	WP 5: Social, environmental and economic cost-benefits analysis of developed biorefinery schemes	Kostas Theodoropoulos and Michael Binns, University of Manchester, UK
12.00 - 12.30	WP 6: Modelling stakeholders interplay and policy scenarios for bio-refinery and bio-diesel production	Piergiuseppe Morone, University of Foggia, Italy

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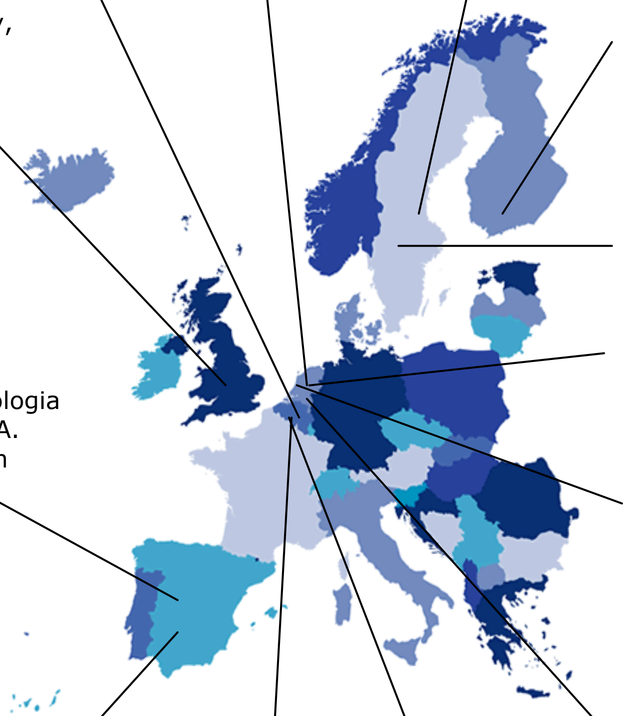
Project Web Site
http://www.bioref-integ.eu

Development of Advanced **BIOREF**inery Schemes to be **INTEG**rated into Existing Industrial Fuel Complexes
June 2008 - May 2010

BIOREF-INTEG Partners



Final results of BIOREF-INTEG project

Hamid Mozaffarian, BIOREF-INTEG project Coordinator, provides a comprehensive overview of the final project results.

The main objective of the project was to develop advanced BIOREFinery schemes to be INTEGrated into existing industrial (fuel producing) complexes.

For each of the considered biomass processing sectors 1 to 2 reference case(s), and up to 3 integrated biorefinery cases are defined. This has resulted in 10 reference cases and 14 integrated biorefinery cases, as presented below:

Bioethanol
The reference case is a conventional grain-to-ethanol plant, with the following 2 integrated cases:

- lactic acid production from C6 sugars;
- ethanol production from DDGS via AFEX pre-treatment.

Biodiesel
A rapeseed-based trans-esterification process is the reference case, with 2 integrated cases to be:

- production of 1,3-propanediol from glycerine;
- production of epichlorohydrin from glycerine.

Pulp & paper
The reference case is a chemical pulp mill with three integrated cases:

- lignin extraction from black liquor;
- DME production via black liquor gasification (BLG);
- ethanol production from softwood pulp.

Conventional oil refinery
The reference cases consist of 2 subprocesses of a conventional oil refinery: the Fluid Catalytic Cracking process (FCC) and the Hydrodesulfurisation process (HDS). The integrated cases are:

- vegetable oil as partial feed of FCC unit;
- vegetable oil as partial feed of HDS unit.

Power production
The medium-scale reference case is a conventional CHP power plant fuelled with peat or biomass. For large-scale power plant an IGCC fuelled with biomass is considered. The following integrated cases are defined:

- fast pyrolysis integrated in CHP;
- chemical recovery in gasification process.

Food industry
The reference case for food industry is taken from the dairy sector, more specifically from cheese manufacturing, and the considered integrated case is:

- lactic acid production from whey.

Agro sector
Finally, two reference cases are considered for the agro sector. The first reference case is a sugar beet refinery. The second reference case is a CHP system based on anaerobic co-digestion of grass and manure. The integrated cases for this sector are:

- decentralised sugar beet biorefinery;
- grass biorefinery.

Within this issue of 'Biorefinery Researcher' you will find a case study focusing on the pulp and paper sector, plus a series of project updates from BIOREF-INTEG partners. A review of last December's public BIOREF-INTEG workshop can be found on pages 31 and 32.

The BIOREF-INTEG seminar on the final project results will be held at this year's international RRB6 conference on June 9th—see page 17 for further details.

Case study: the pulp and paper sector

The reference case for the pulp & paper industry is a softwood sulphate pulp mill, as presented in Figure 1. The incoming wood is chipped, mixed with cooking chemicals (minerals), digested and fractionated in a cellulose fraction (pulp) and a black liquor, containing mainly lignin, hemicellulose and cooking chemicals. This black liquor is partially concentrated by evaporation and burned to recover the energy (electricity and steam). The cooking chemicals are also recovered and recycled. Other co-products are bark (burned) and tall oil (separated from the black liquor before evaporation).

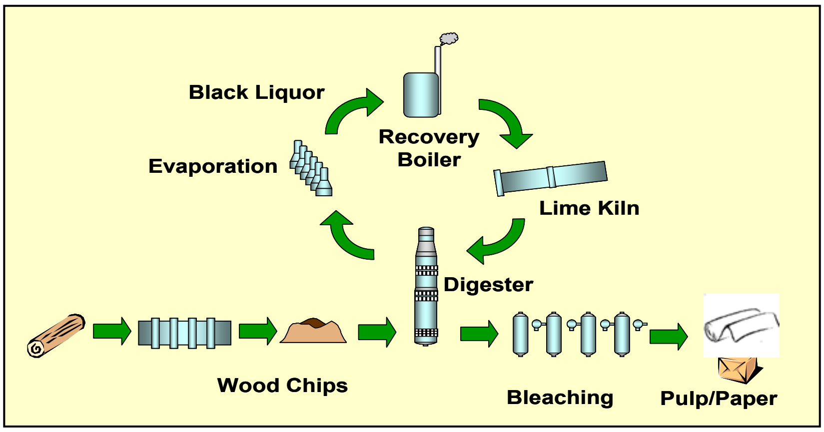


Figure 1: Reference case pulp & paper sector: chemical pulping process

It is important to notice that the recovery boiler (where the concentrated black liquor is burned) is frequently a bottleneck in the process: all options that can de-bottleneck this recovery boiler (e.g. by reducing the black liquor amount entering the recovery boiler) can increase the overall capacity of the mill.

A first potential improvement is the extraction and drying of lignin from the evaporated black liquor. This dry lignin can be sold as solid fuel. As this operation will de-bottleneck the recovery boiler, the mill capacity can be increased by 25%.

DME production via gasification of black liquor is a second option to drive more value out of black liquor, and to (partially) de-bottleneck the recovery boiler. DME is traditionally used as propellant in aerosols. DME is also a liquid fuel that can be used as alternative biofuel for transport (alternative to diesel or LPG).

A third alternative is to use some of the pulp (almost pure cellulose) as feedstock for ethanol production. The logic behind this scheme is that the demand for paper is stagnating and with this the demand for pulp.

Economic data gathered within the Consortium have been used for the assessment of different cases. Using a cost calculation model, the production cost of pulp for both the reference case as well as for the integrated biorefinery schemes were calculated. In the latter cases a credit was taken into account for the added value products lignin, DME, and ethanol. The objective was to evaluate to what extent co-production of the added value products could enhance the economic competitiveness of pulp as the main product.

Table 1 below shows the calculated production cost for all cases. Also the current market price of pulp is presented in the table. As can be seen, co-production of lignin and DME will result in lower production costs

Continued overleaf...

Table 1: Pulp production cost, current market price, and the sales price at an IRR of 20%. Colour code: ***black*** *for reference cases,* ***green*** *for improvement compared to reference,* ***red*** *for worse compared to reference*

IRR 20% analysis	Current market price	Required sales price increase	New target sales price	% change vs market price	Pulp production cost
Pulp & Paper: reference	€500/T	€130/T	€630/T	26%	€398/T
Pulp & Paper: lignin	€500/T	€50/T	€550/T	10%	€347/T
Pulp & Paper: DME	€500/T	€210/T	€710/T	42%	€367/T
Pulp & Paper: ethanol	€500/T	€490/T	€990/T	98%	€586/T

for pulp. This is however not the case, when co-producing ethanol. Table 1 also shows the required sales prices in order to achieve an IRR (Internal Rate of Return) of 20% for each considered case. Co-production of lignin not only leads to a lower production cost for pulp, but it also leads to an IRR of 20%, at a sales price only 10% above the current market price for pulp. This is much more suitable compared to the reference case, by which an IRR of 20% could only be achieved at pulp sales prices of 26% above the current market price. In other words, co-production of lignin seems a very promising integrated biorefinery option for the pulp & paper sector. In case of the DME option, although the production cost of pulp is lower compared to the reference case, a much higher sales prices (compared to the reference case) would be required for an IRR of 20%. In case of the ethanol option, both the pulp production cost as well as the required sales prices for an IRR of 20% are worse, compared to the reference case.

The above-presented results are based on the facts & figures gathered amongst the sector specialists, and they can therefore be considered as 'objective'. Within the project attention has also been paid to the analysis of more 'subjective' aspects of each biorefinery case, such as:

- How feasible are the proposed processes?
- Are the commercial considerations (market prices, proposed volumes...) realistic?
- What are the strong and weak points of each case? What are the underlying trends influencing potential success? (SWOT analysis).

In order to assess the technical and commercial feasibility of the integrated biorefinery cases, a set of criteria influencing these aspects was edited as statements, as presented in Table 2 on the following page. These were assessed by the partners of the Consortium according to their importance. Based on the ranking made, each statement received a weight factor. In both cases the sum of the weight factors is 50. The statements regarding technical feasibility were clustered around process development and application development of the selected products. The statements regarding the commercial feasibility were clustered into project characteristics, market characteristics, competitive advantages, social & environmental impact, and regulatory impact.

Each statement can be answered as: I agree (score=2); I'm neutral or 'don't know' (score=1); I disagree (score=0). The technical or commercial feasibility is then the sum of the products of the weight factor and the answer for each statement, and varies between 0 and 100. For each biorefinery scheme, a questionnaire has been completed by different partners. The final feasibility score is computed as the average score given by the respondents multiplied by the weight factor. The overall feasibility of the three integrated biorefinery cases for the pulp & paper sector is presented in Figure 2 on page 16, with axis crossing set at the average feasibility for the whole set of 14 integrated cases defined for the seven considered sectors. Finally, Table 3 (see page 16) summarises the results of the SWOT analysis of the integrated biorefinery schemes for the pulp & paper sector.

Based on the achieved results it can be concluded, that lignin extraction also with respect to technical and commercial feasibility looks a promising integrated option. DME production via BLG looks promising with respect to commercial aspects, while there are still some technical gaps to be fulfilled. Finally, ethanol production from softwood pulp is technically feasible. However, commercially it looks promising only in some specific cases, for example in a mill that is about to close down, and where the investment cost is close to zero.

Hamid Mozaffarian
BIOREF-INTEG Coordinator, ECN

Case study...continued

Technical feasibility related statements	Commercial feasibility related statements
Process Development	**Project characteristics**
The integrated concept does not require significant downstream processing	The integrated concept is leading to 1 new product
All steps of the integrated concept are well identified	The product(s) can be used in several applications/markets
Required technologies are already developed for the targeted products	**Market characteristics**
Required technologies are proven on industrial scale for the targeted products	The integrated project addresses existing product/ market combinations
Process does not require toxic or hazardous auxiliaries	The addressed markets are innovative (= open for new products/concepts)
The integrated concept does not generate additional waste that has to be treated	The targeted markets are large enough to absorb the foreseen volumes
Application development	**Competitive advantage**
Most of the selected applications are already existing	Introduction of the new product(s) will lead to an economical benefit for the user
Products can be used in most of the selected applications	The new product(s) have functional benefits
Products are referenced in most of the selected applications	There are specific benefits related to the integrated concept compared to the conventional processes
Secondary products are referenced in the applications	**Social impact**
	The new product(s) is an alternative to fossil-based products
	The integrated concept is not in competition with food supply
	The integrated concept does not require large quantities of fresh water
	The integrated concept is leading to additional renewable energy production
	The integrated concept is 'LCA positive'
	The integrated concept improves the European competitive position in a global market
	Regulatory impact
	There are no regulatory barriers affecting the market introduction of the product(s)
	There is a supporting EU directive promoting the integrated concept

Table 2: Statements used to determine the technical and commercial feasibility of different options

Case study...continued

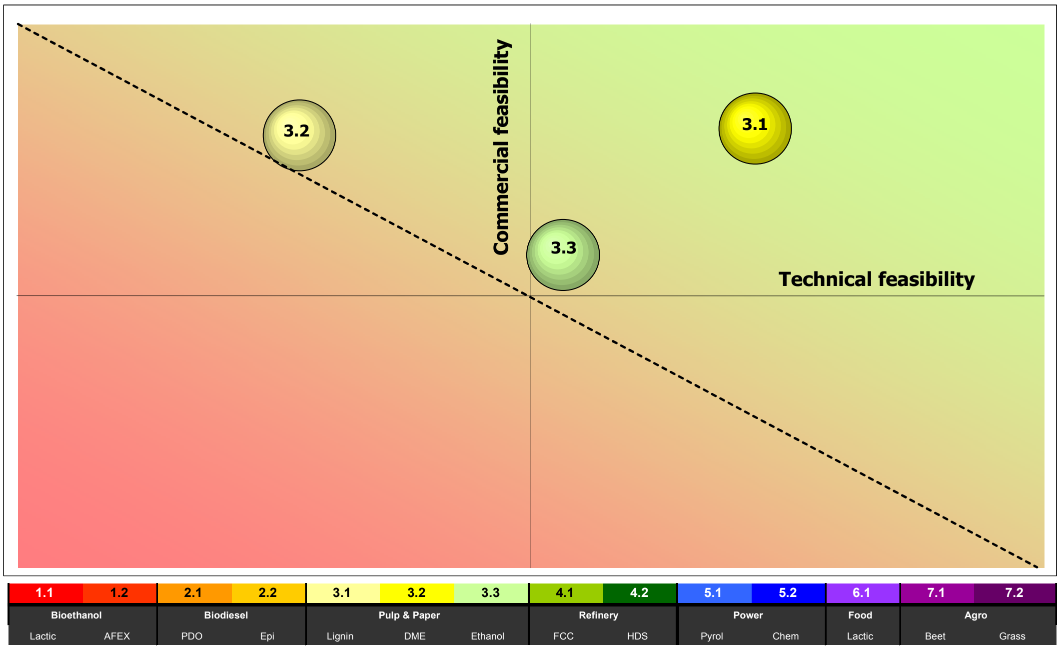


Figure 2: Overall feasibility of the integrated biorefinery schemes for the pulp & paper sector

Table 3: SWOT analysis of the integrated biorefinery schemes for the pulp & paper sector

SWOT	Lignin extraction from BL	DME via BLG	Ethanol from softwood pulp
Strength	production of lignin in demonstration plant	economics of integrated concept is promising	platform for 2nd generation fermentation
	25% pulp production increase possible	two products – pulp and DME	this concept can be applied to old pulp mills
	small investment and promising economics		
Weakness	increased chemical costs	complex technology	less efficient process (yield wood-to-ethanol via pulp)
	lower electricity export	large investment costs required	more by-products to take care of (CO_2, organic residues)
Opportu-nity	increased oil price	increased oil price	increased oil price
	does not compete with food resource	does not compete with food resource	does not compete with food resource
		acceptance of DME by EU countries as biofuel	
Threat	pulp demand decreasing which makes the capacity increase less relevant	high biomass and electricity price	enzymes to hydrolyse wood to sugars are not commercially available
		no acceptance of DME by EU countries as biofuel	alternative routes to biofuels from wood

Detailed results achieved for the seven considered biomass processing sectors will be presented at the joint BIOREF-INTEG/ SUSTOIL Seminar, that will be held on 9 June 2010, as a side event of the RRB6 Conference (7-9 June 2010) in Düsseldorf, Germany (see the programme of the Seminar on the next page). These results will later on also be available on the project website (www.bioref-integ.eu/publications).

BIOREF-INTEG Seminar on Final Project Results

9 June 2010, Rheinterrasse, Düsseldorf, Germany

Open to all RRB6 Participants

13.30 – 13.35	Introduction to the Bioref-Integ Project **Hamid Mozaffarian,** ECN, the Netherlands
13.35 – 13.45	Introduction to PortfolioScan **Philippe Willems**, VFT, Belgium
13.45 – 14.05	Case 1: Bioethanol sector Integration of different biorefinery concepts into existing bioethanol plants **Laura Bermúdez Lopéz**, ABNT, Spain
14.05 – 14.25	Case 2: Biodiesel sector Evaluation of integrated biorefinery schemes based on valorisation of glycerol **Sofie Dobbelaere,** Ghent University, Belgium
14.25 – 14.45	Case 3: Pulp and paper sector Evaluation of innovative biorefinery concepts entering the pulp & paper industry **Christian Hoffstedt**, Innventia**,** Sweden
14.45 – 15.05	Case 7: Food sector Evaluation of cheese whey biorefinery **Koen Meesters**, WUR-FBR, the Netherlands
15.05 – 15.20	Coffee Break
15.20 – 15.40	Case 4: Oil Refinery sector Co-production of biofuels in existing refinery units **Rubén Miravalles Gutiérrez,** Repsol, Spain
15:40 – 16:00	Case 5: Power sector Evaluation of integrated biorefinery technologies in power industry **Herman den Uil,** ECN, the Netherlands
16.00 – 16.20	Case 6: Agro sector 6a. Evaluation of integrated biorefinery technologies in the sugar industry 6b. Evaluation of small scale power production vs. grass biorefinery **Koen Meesters**, WUR-FBR, the Netherlands
16.20 – 16.30	PortfolioScan of integrated biorefineries **Philippe Willems**, VFT, Belgium
16.30 – 16.50	Panel discussion/concluding remarks

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BIOREF-INTEG

Market insight on potential bio-based products

A very large number of chemicals and materials can be produced from biomass using a wide range of processes. The major production processes include fermentation, pyrolysis, gasification and transesterification. The market survey carried out by Aston University as part of the BIOREF-INTEG project identified over 320 chemicals that can be produced from biomass by different processes in the bio-based industries.

The objective of the market survey contributed by Aston University was to identify possible products from biomass based industries and biorefineries and estimate the market size and product price. The results are summarised in Figure 1 in which the products identified are mapped to different biomass and conversion technology and categorised as commodity, specialty, polymers and fine chemical based on the current volume production and price (see Figure 2). The most interesting value added products have been identified and a more detailed market analysis has been provided. They are 1,2-Propanediol (Propylene glycol), Epichlorohydrin, Lactic Acid, Biodiesel, Biogasoline, Biokerosene, Bio-Ethanol, Methanol, DME, Bio-tar, Lignin pellets (Renewable solid fuels), Animal feed, Lignin as a Chemical Feedstock, 1,3 Propanediol, Carbon dioxide in Merchant Markets.

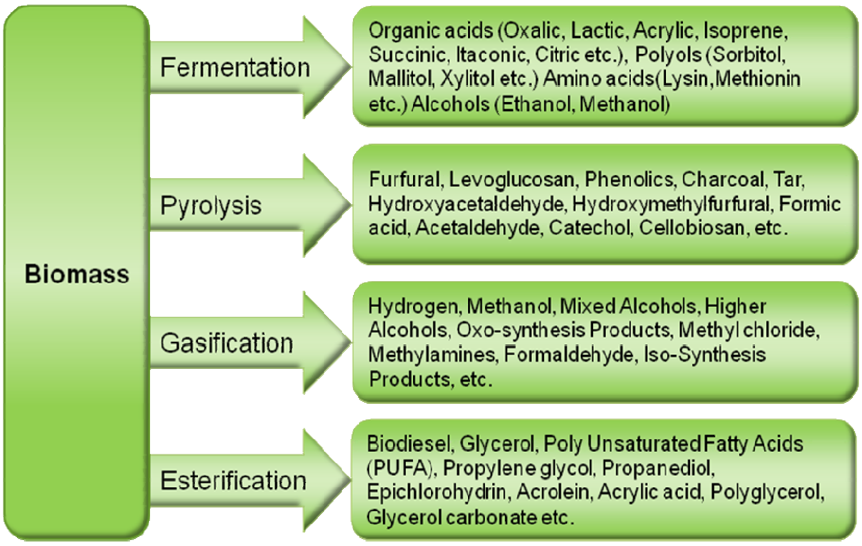

Figure 1: Biomass derived products using different technologies

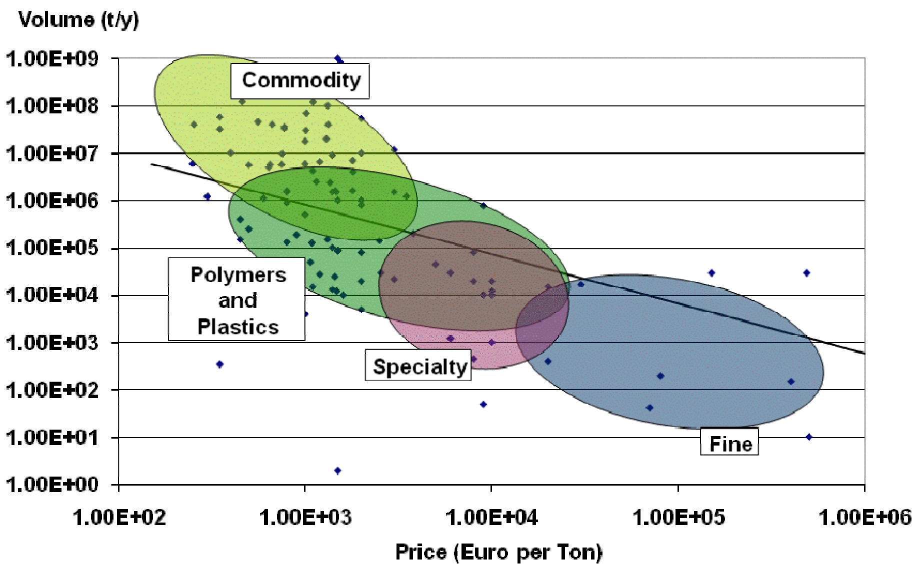

Figure 2: Biomass derived products, prices and market volumes

Market insight on potential bio-based products…continued

Table 1: A condensed market survey of lactic acid as an example of the products surveyed

Properties	Specific gravity at 20°C 1.249 Melting point 17°C Boiling point 252°C Water solubility ∞
End Uses	Bio-degradable plastics, Food additives, Anti-microbial compounds, Flavouring agents, Substitute for hazardous solvents, pH balancer in shampoos and soaps and other alpha hydroxy acid applications.
Manufacturers	Archer-Daniels-Midland, CSM NV, Purac, Galactic SA, HenanJindan, Masachino, Jianxi
Market Overview	The use of lactic acid in bio-degradeable plastics is expected to gather momentum, given the rising demand for environmentally friendly packaging.
Market Location	USA, Europe, Asia-Pacific The largest European market is Germany, followed by France and Italy.
Market Volume	Production is forecast to reach 259,000 tonnes/year by 2012
Market Price	Many products, typical variation between €0.7 - €3.0 /kg spans food grade to higher pharmaceutical grade.

Conclusions

Today's chemical industry is moving towards a low carbon economy cutting across every aspect of the sector. The chemical industry as a primary industrial sector is playing a pivotal role to deliver carbon dioxide reduction solutions to other industries. This is being achieved through process and product optimisation, increased efficiency of conversion, minimisation of wastes and greater recycling.

Generally feedstock availability and price variability is expected to be solved in different ways: some companies will move more rapidly to a biomass based structure while others will remain wedded to traditional feedstocks and processes. There are limited opportunities for new bio-based products which will always have to compete with existing products on price and performance.

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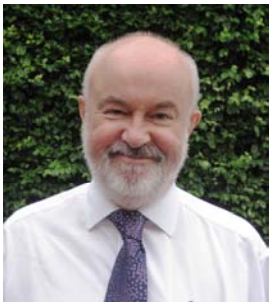

BIOREF-INTEG

Biorefinery: opportunities and challenges

Abengoa's Mission
Abengoa Bioenergy New Technologies, subsidiary of Abengoa Bioenergy, was established in 2003 with the objective of researching and developing innovative solutions for technology development in the bioenergy sector, especially for ethanol and other co-products production.
Abengoa Bioenergy, a subsidiary of Abengoa, is dedicated to the development of biofuels for transport, including bioethanol and biodiesel, to support sustainable development.

Through different subsidiaries, Abengoa Bioenergy owns and operates facilities for producing and marketing bioethanol throughout the United States and Europe.

Abengoa is a technology company that applies technology solutions for sustainable development in the infrastructure, environment and energy sectors. It is present in over 70 countries worldwide, where it operates through five different business units: Solar, Bioenergy, Environmental Services, Information Technology, Industrial Engineering and Construction.

Biorefinery is understood as the sustainable processing of organic matter (biomass) for production of a broad range of bioproducts such as biofuels, power, heat and other high added-value products. Development of biorefinery concepts for further industrial implementation seems of high interest when considering the strong potential that these technologies show for use of organic residues.

Therefore, different processes of biomass conversion are being developed at laboratory or pilot scale to determine the opportunities that biomass use entails, making possible a reduction in the dependence on fossil energy sources at lower raw material cost, and leading to important environmental benefits.

Core Processes
Production of ethanol from lignocellulosic residues may be considered the starting point for the development of the Biorefinery Business. In that sense, search for technological solutions that make possible revalorization of lateral streams of the main process, as well as the improvement of its economic feasibility is of special interest for Abengoa Bioenergy.

The core processes on which Abengoa Bioenergy, through its subsidiary Abengoa Bioenergy New Technologies (ABNT), is focusing most efforts are based on biochemical (Enzymatic Hydrolysis process) and thermochemical (Gasification and Catalysis) biomass conversion processes.

The Enzymatic Hydrolysis process is an alternative to the traditional production of ethanol from grain, using a wider range of raw materials at lower cost and is not linked to the food and feed market. This technology is currently being tested at pilot and demonstration scale by operation of a pilot plant in York, NE, US (1tonne/day d.b.) and a demonstration plant in Salamanca, Spain (70tonne/day d.b.), both owned by Abengoa Bioenergy.

Biorefinery: opportunities and challenges...continued

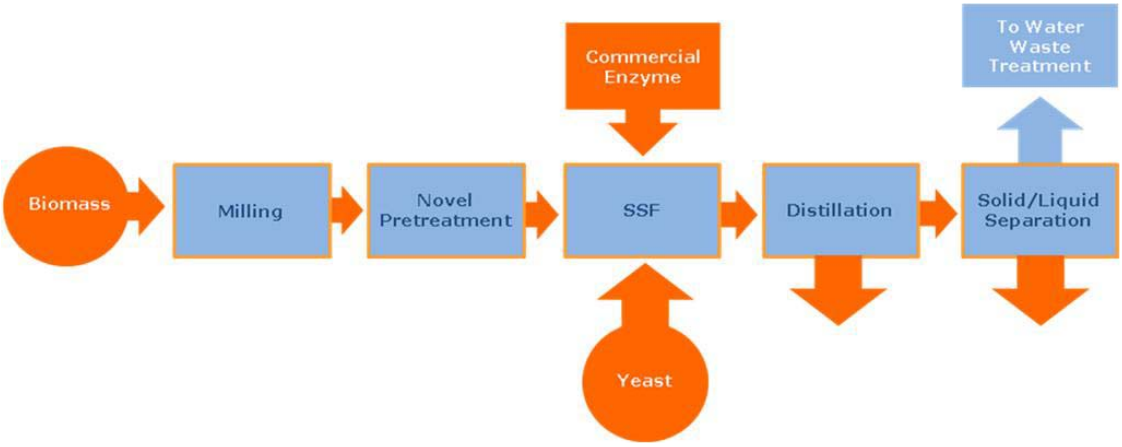

Figure 1: Biochemical conversion of lignocellulosic biomass (http:www.abengoabioenergy.com)

On the other hand, the Gasification and Catalysis process is another option for the conversion of any kind of biomass into ethanol at low production cost and high energetic yields, while co-producing electricity.

Innovation Required
The introduction of both the Enzymatic Hydrolysis and Gasification & Catalysis processes into the market is a key goal for Abengoa Bioenergy, whose efforts and investment are devoted to research and development that enable the scale-up of both technologies until commercial scale.

Reduction of severity in the pre-treatment step, optimization of biomass fractionation, development of high-activity enzyme mixtures at competitive cost, and improvement of pentose-fermenting microorganisms are major challenges that must be overcome for industrialization of the Enzymatic Hydrolysis technology. Furthermore, catalyst improvement at laboratory scale and up-scaling of the thermochemical process until pilot and demonstration size are needed to obtain further information about its performance, thus providing guidance for optimization of operating conditions.
All these issues are major priorities for Abengoa Bioenergy and therefore R&D activities carried out by ABNT are focused on searching for solutions that overcome the various process bottlenecks which have been identified.

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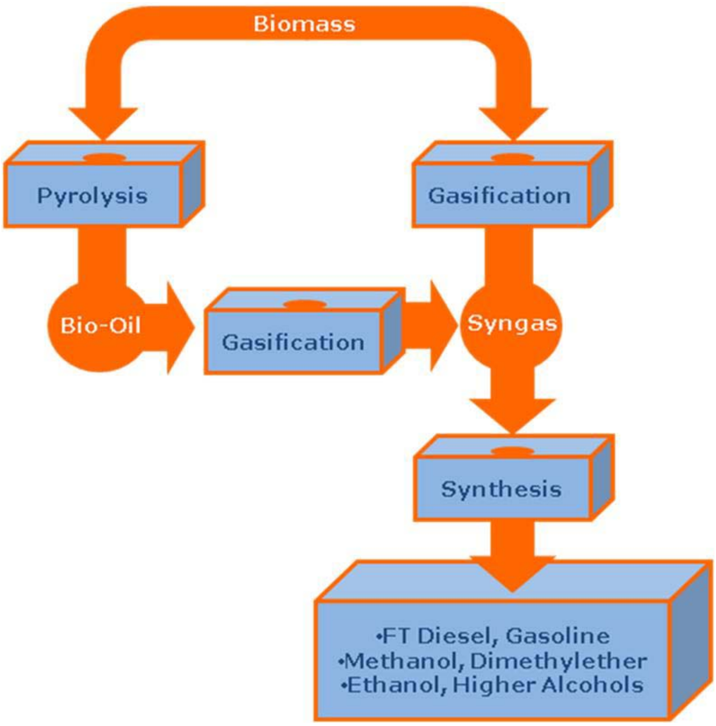

Figure 2: Thermochemical conversion of biomass (http:www.abengoabioenergy.com)

Bio Base Europe – the European centre for the biobased economy

In 2009 Biopark Terneuzen in the Netherlands and Ghent Bio-energy Valley in Belgium joined forces to form a cross-border project known as 'Bio Base Europe'.

Bio Base Europe has an overall budget of 21 million Euros and is financially supported by the European Union, Belgium and the Netherlands within the framework of an Interreg program*. Never before has such an ambitious project of this size been supported.

BIOREF-INTEG partners, Professor Wim Soetaert of Ghent University and Fons Maes give an insight into why these two regions are rapidly moving towards a biobased economy.

Professor Soetaert, a founder of Ghent Bio-energy Valley and a joint-initiator of the European project highlights the reasoning behind this innovative project.

Question: In your opinion, why will Bio Base Europe become the most important centre for the biobased economy in Europe?
Wim Soetaert: Biobased production has already transformed a wide range of industries including chemical, energy and agro-industrial sectors. Examples of such products include biofuels, bioplastics, biodetergents, vitamins and biopigments. Further development of the biobased economy is crucial to build bridges between scientific research and large-scale industrial production.

Today a lot of innovations are stopped because of the large gap between scientific feasibility (lab scale) and industrial practice. There is a need for an intermediate step, namely a pilot plant. The building of the Bio Base Europe Pilot Plant will help to close this gap.

Question: So when will the pilot plant become operational?
Wim Soetaert: The Bio Base Europe Pilot plant is located in a former fire station in the port of Ghent and will scale up and optimise biobased processes to prepare them for industrial applications. It will serve as an open innovation centre for commercial companies and research institutes looking to develop new biobased activities. It will be accessible to clients from all over Europe and will be operational mid-2010.

Question: What facilities will be available at the plant?
Wim Soetaert: The plant will act as a 'one-stop-shop'. There will be a wide range of equipment, including bioreactors for fermentation and biocatalysis, as well as chemical reactors for green chemistry. It will also contain a variety of technologies for plant fractionation and biomass pre-treatment next to techniques for Down-Stream Processing, the isolation and processing of the final product to the desirable purity. This means amongst others equipment for evaporation, crystallization, electrodialysis, extraction, membrane processes, ion exchange, drying etc.

It will also offer the necessary facilities for process and quality control and will have its own team of specialist personnel. Up-scaling of developed processes will be possible from 10 litre lab scale to 10 cubic meters pilot scale – meaning that we will be able to produce many tonnes of product. Alongside scale-up and optimization of new bioprocesses, the pilot plant will also perform custom manufacturing pilot production at ton scale, allowing clients to test their new product on the market, perform elaborate application tests or start other new developments.

Question: Will you be offering any training facilities?
Wim Soetaert: Yes, 8 million Euros is currently being invested into a new Bio Base Europe Training Centre in Terneuzen in the Netherlands, which will help to address the industry-wide shortage of skilled process operators and technical maintenance specialists for biobased industries. The new facility will be fully operational in 2011.

The synergy between the training centre and the pilot plant is clear – together they will help the Ghent-Terneuzen area become recognised as the leading centre of the biobased economy in Europe.

Bio Base Europe...continued

Fons Maes, an active member of the Belgian Biodiesel Board, looks back at the formation of Ghent Bio-energy Valley in 2005, and the key part it will play in the future of Bio Base Europe.

Question: Who were the founders of the Bio-energy Valley and why was it formed?

Fons Maes: It all started in 2005 when Ghent University, the city, the province, the harbour and several companies took the initiative to create 'Ghent Bio-energy Valley' - a vehicle to launch an ambitious plan to become a leader in the biobased economy.

Question: So how was the Bio-energy Valley created?

Fons Maes: At the time, the focus was on bioenergy – not only biofuels, biodiesel and bioethanol, but also biomass. We used the existing infrastructure located at the Rodenhuize dock to optimize investments, to be able to create synergies to maximize CO_2 reduction and to create a basis for further and more diverse activities.

Question: How does it operate today?

Fons Maes: The raw material is discharged and stored by the existing grain silo, Euro Silo. The latter stores the rapeseed and wheat or maize. The silo is connected with belts to the crushing plant of Cargill, which produces the crude oil for the newly built refinery, which is connected with a pipeline to the biodiesel plant, Bioro. Euro Silo is also connected by belt to the bioethanol plant, Alco Biofuel. Both biofuel producers are connected with a pipeline to Oiltanking, who stores the biofuels and delivers them to customers. In addition, Oleon, a green chemical and biodiesel producer, is located close to the site.

The above demonstrated "clustering" avoids unnecessary transport, resulting in less consumption of energy and CO_2 reduction. This "complete integration" resulted in a good volume of the Belgian quotum for biofuels.

Electrabel, one of Europe's front-ranking energy companies and a market leader in the Benelux, located at the other side of the Moervaart (next to the Rodenhuize dock) decided to join our initiative and produces electricity out of biomass. The biomass is discharged and stored as close as possible to the power plant to avoid transport.

Question: What part will the Ghent Bio-energy Valley play in the future?

Fons Maes: Under the umbrella of Ghent Bio-Energy Valley and Biopark Terneuzen, a new child was born in 2009, namely Bio Base Europe. The main objective of Bio Base Europe, of which the Ghent Bio-energy Valley plays a crucial part, is to help the transition from a fossil resource-based economy to a biobased economy.

The Bio Base Europe pilot plant is located within the Valley next to the Moervaart and the Rodenhuize dock. It is a flexible and diverse pilot plant that operates at ton scale and in future will undoubtedly serve as an important innovative centre for companies and research organizations developing biobased products and activities.

**Interreg IV is a 2007 – 2013 program funded by the European Union from the European Regional Development Fund (ERDF), to advance cross-border co-operation and stimulate sustainable social-economic development in European border regions.*

For further information about the Ghent Bio-energy Valley visit www.gbev.org.

See also Issue 2 of Biorefinery Researcher – Biorefinery Rodenhuize Dock – Ghent (page 25)

Co-processing of vegetable oil in conventional oil refinery

Repsol leads a demonstration project to produce renewable diesel from vegetable oil

Introduction
Nowadays, there is a growing interest in Europe in reducing greenhouse gas emissions from the road transport sector, as well as reducing the global dependency on the use of traditional fossil-based energy. To face these two important challenges, EU governments have introduced measures to promote a greater use of more environmentally-friendly fuels in road transport.

One example of these measures is the EU Directive 2003/30/EC that promotes the mandatory incorporation of a minimum amount of biofuels in road transport fuels— 5.75% in 2010 on energy basis. By 2020, the proposal is to increase this participation up to 10%.

Another example is the EU Directive 2009/30/EC ('Fuel Quality Directive') that promotes the mandatory monitoring and reporting of life cycle greenhouse emissions from fuels as of 2009, and an obligation for fuel suppliers to ensure that greenhouse gases produced by their fuels throughout their life cycle (i.e. production, transport and use) are cut by 1% per year between 2011 and 2020.

Besides incorporating a minimum amount of biofuels, road transport fuels must comply with the European quality standards, EN-228 and EN-590 for diesel. Some specifications included in these standards limit the incorporation of high volumes of conventional biofuels (bioethanol and biodiesel), as for example, the maximum vapour pressure (60 kPa), oxygenated compounds (10 vol% ethanol) and distillation curve in gasoline and maximum amount of FAME (7 vol%) in diesel. This assumes a barrier to reach 10% contribution (energy base) of biofuels only with conventional biofuels (bioethanol and biodiesel).

Co-processing of vegetable oil in refining unit for biofuels production
Co-processing of vegetable oil in process units of a conventional oil refinery is an excellent opportunity to integrate biofuels inside the production scheme and to produce biofuels with

Co-processing of vegetable oil...continued

properties very similar to fossil-based fuels. Repsol started to develop this alternative several years ago; at first stage working in research and development at laboratory and pilot plant scale and progressing to demonstrate at industrial scale during this project.

The project, led by Repsol, started at the beginning of 2009 with the formation of a consortium between Repsol, CIEMAT, IDEA and Castilla La Mancha University. Later, the project received the support of the Ministry of Science and Innovation, being considered as a Strategic Project. The total budget of the project is €2,143,000 from which €967,000 are granted by the Ministry of Science and Innovation in the 'Plan E' framework (plan for the incentive of economy and employment).

The main objective of the project is to demonstrate at industrial scale the technical feasibility of producing biofuels, specifically diesel and propane, by co-processing vegetable oil in conventional hydrotreating units. Besides, other activities of the project expect to establish sustainability criteria (activity led by CIEMAT), quantify the 'renewable' content in the co-processing products and the later development of a model to calculate this content by process correlations (activity led by Castilla La Mancha University).

During the project, two industrial trials in different Repsol refineries (Puertollano and Cartagena) have been carried out. The first trial took place in Puertollano's refinery in November 2009. 400 m^3 of soya oil were co-processed in a middle distillates hydrotreating unit without any technical incident and none of the unit constraints were reached. Results of the trial were very promising, confirming the results obtained in previous studies at pilot plant scale by Repsol R&D Division. In 2010, a second industrial trial was carried out in Cartagena's refinery, with the objective of optimising operating factors and energy consumption. In this case, a higher percentage of vegetable oil was co-processed.

The introduction of this technology for hydrotreating vegetable oils will enable the production of renewable fuel which meets the European specifications for these products, with its quality guaranteed by Repsol, and which is fully accepted by car manufacturers for its exceptional properties in diesel engines: high cetane, low density and low sulphur.

Production of this 'green diesel' from hydrotreated vegetable oils will constitute a complementary route to conventional biodiesel (FAME), allowing the company to comply with the mandatory incorporation of renewable components in road fuels. Due to its excellent properties and similarity to fossil-based fuel, the product can be incorporated without problems to the diesel production, complementing the maximum 7 vol% of conventional biodiesel (FAME) currently allowed in commercial diesel.

For further information, please visit:
http://www.repsol.com
http://www.repsol.com/es_en/corporacion/conocer-repsol/innovacion-tecnologia/grandes-proyectos/otros/

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Animal Feed Production

How can we deal with the changing environment in raw materials?

The use of some of the energy and protein sources now commonly used for feeding animals is expected to reduce significantly. This market change is caused mainly by the pressures of food for human consumption and biofuel application. This forces Cehave landbouwbelang u.a. to source alternative raw materials.

The core activity for BIOREF-INTEG project partner Cehave Landbouwbelang u.a., both in the Netherlands and abroad, consists of the production and marketing of high-quality (ingredients of) animal feed. CCL Research, subsidiary of Cehave investigates the potential in the pre-treatment of vegetable biomass to create added value. The added value of Cehave will be to optimise the feeding value of these products mainly by new technologies, feeding strategies and guarantees for food safety.

In terms of R&D, there are two main areas of focus: firstly, improving the feeding value of existing and new raw materials by technology, and secondly, improved feed evaluation.

One of the innovative feed concepts Cehave is working on is the upgrade of low value raw materials by technological treatments. Many lignocellulosic rich materials, like straw and cornstover, can be eaten by livestock but contain as such little or no feeding value related to their price. This means that the gross energy (mainly in the form of carbohydrates) in those raw materials is not utilized/ digested. Improvement of digestion can be achieved by processing the biomass. Mostly, 'processing of biomass' is used for the conversion to bioethanol, or that the biomass is burned directly. These technologies are regarded as sustainable applications, but using biomass for feed purposes is a much more sustainable application.

Traditional biomass treatment for bioethanol production is conducted under severe conditions: high temperature, pressure and acidity. Acids like sulphuric acids favour the formation of toxic sugar degradation products, such as furfural. CCL Research developed, in co-operation with Wageningen University, a process that utilizes weak organic acids. This process decreased unwanted residues and reaction products. A further advantage of using weaker organic acids is that some of these acids have a feeding value for the animal. Furthermore, partially converted lignocellulose can be hydrolysed with enzymes to glucose and fermentable carbohydrates, which creates feeding value for the animals.

The effects of conversion of lignocellulosic rich materials to higher value feed components are already demonstrated by CCL Research within animal feeding trials. Nowadays the company is working on upscaling the technology to incorporate it into a feed plant.

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Cehave Landbouwbelang

CCL RESEARCH The Feed Innovators

BIOREF-INTEG

Bioenergy Markets

IEA Bioenergy Summary Review

In August 2009, the International Energy Agency (IEA) published an Executive Summary containing a review of the entire bioenergy sector aimed at policy and investment decision makers. This issue of 'Biorefinery Researcher' contains a selection of some of the key findings of the summary relating to Bioenergy Markets. *(See also Issue 3 of 'Biorefinery Researcher' which contains summary findings on global energy consumption, supply and demand).*

Biomass today

Nowadays, the predominant use of biomass consists of fuel wood used in non-commercial applications, in simple inefficient stoves for domestic heating and cooking in developing countries, where biomass contributes some 22% to the total primary energy mix. This traditional use of biomass is expected to grow with increasing world population, but there is significant scope to improve its efficiency and environmental performance, and thereby help reduce biomass consumption and related impacts. See Figure 1 below.

In industrialised countries, the total contribution of modern biomass is on average only about 3% of total primary energy, and consists mostly of heat-only and heat and power applications. Many countries have targets to significantly increase biomass use, as it is seen as a key contributor to meeting energy and environmental policy objectives. Current markets, growing as a result of attractive economics, mostly involve domestic heat supply (e.g. pellet boilers), large-scale industrial and community CHP generation (particularly where low cost feedstocks from forest residues, bagasse, MSW etc. are available), and co-firing in large coal-based power plants. The deployment of dedicated electricity plants has been mainly confined to low cost feedstocks in relatively small-scale applications, such as the use of biogas and landfill gas from waste treatment.

Globally, the use of biomass in heat and industrial energy applications is expected to double by 2050 under business -as-usual scenarios, while electricity production from biomass is projected to increase, from its current share of 1.3% in total power production to 2.4 – 3.3% by 2030 (corresponding to a 5 - 6% average annual growth rate).

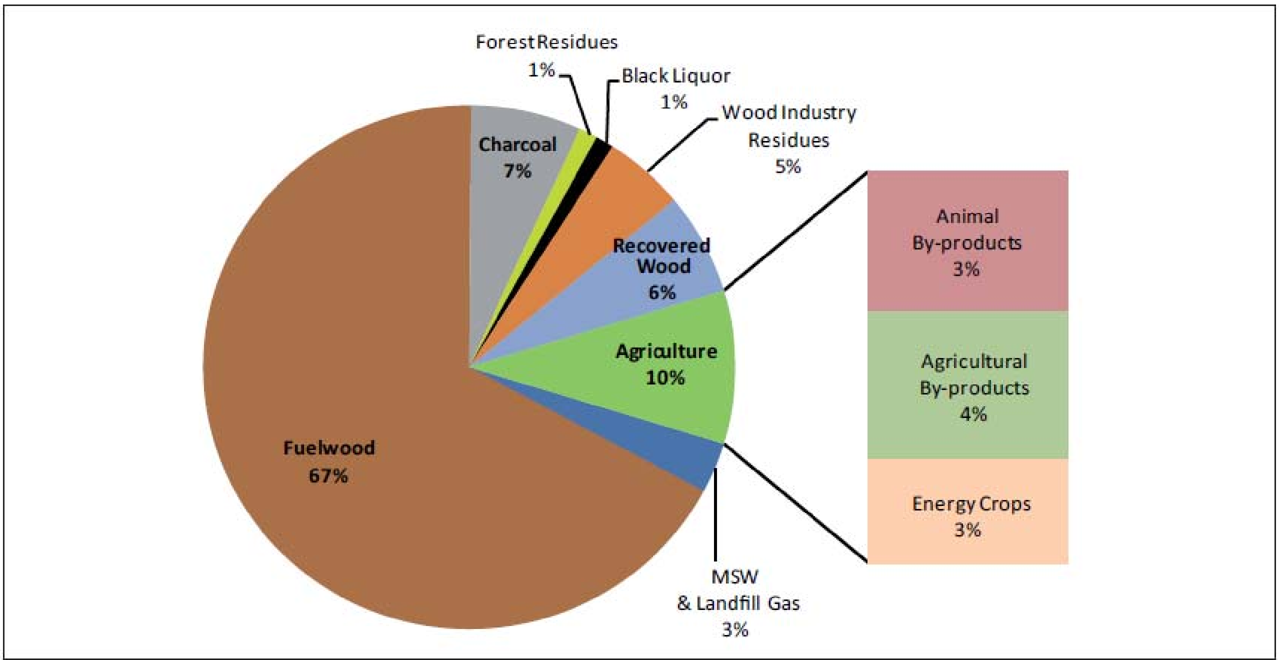


Figure 1: Share of the biomass sources in the primary bioenergy mix. Source: based on data from IPCC, 2007

Transport fuels
Transport biofuels are currently the fastest growing bioenergy sector, receiving a lot of public attention. However, today they represent only 1.5% of total road transport fuel consumption and only 2% of total bioenergy. Nonetheless, they are expected to play an increasing role in meeting the demand for road transport fuel, with 2nd generation biofuels increasing in importance over the next two decades. Even under business-as-usual scenarios, biofuel production is expected to increase by a factor of 10 to 20 relative to current levels by 2030 (corresponding to a 6 - 8% average annual growth rate).

World trade
Global trade in biomass feedstocks (e.g. wood chips, vegetable oils and agricultural residues) and processed bioenergy carriers (e.g. ethanol, biodiesel, wood pellets) is growing rapidly. Present estimates indicate that bioenergy trade is modest – around 1 EJ (about 2% of current bioenergy use). In the longer term, much larger quantities of these products might be traded internationally, with Latin America and Sub-Saharan Africa as potential net exporters and North America, Europe and Asia foreseen as net importers. Trade will be an important component of the sustained growth of the bioenergy sector. See Figure 2 below.

The quest for a sustainable energy system will require more bioenergy than the growth projected under the business-as-usual scenarios. A number of biomass supply chain issues and market risks and barriers will need to be addressed and mitigated to enable stronger sustained growth of the bioenergy sector. These include:

- Security of the feedstock supply;
- Economies of scale and logistics;
- Competition with other energy sources;
- Public and NGO acceptance.

The industry, however, is confident such challenges can be met as similar challenges have been addressed in other sectors and appropriate technologies and practices are being developed and deployed.

The IEA Executive Summary 'Bioenergy – a Sustainable and Reliable Energy Source' can be downloaded from **www.ieabioenergy.com**

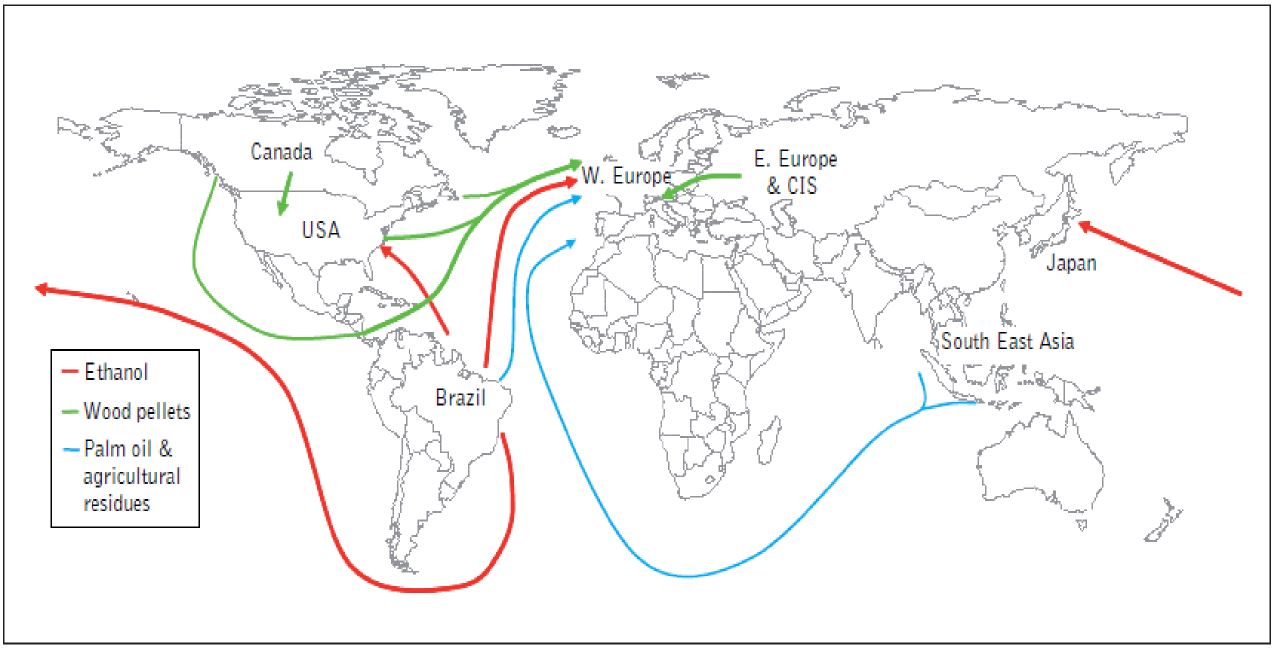


Figure 2: Main international biomass for energy trade routes. Source: Junginger and Faaij, 2008

IEA Bioenergy: main report now available

The full report 'Bioenergy - a sustainable and reliable energy source; a review of status and prospects' is now available and can be downloaded from the IEA website.

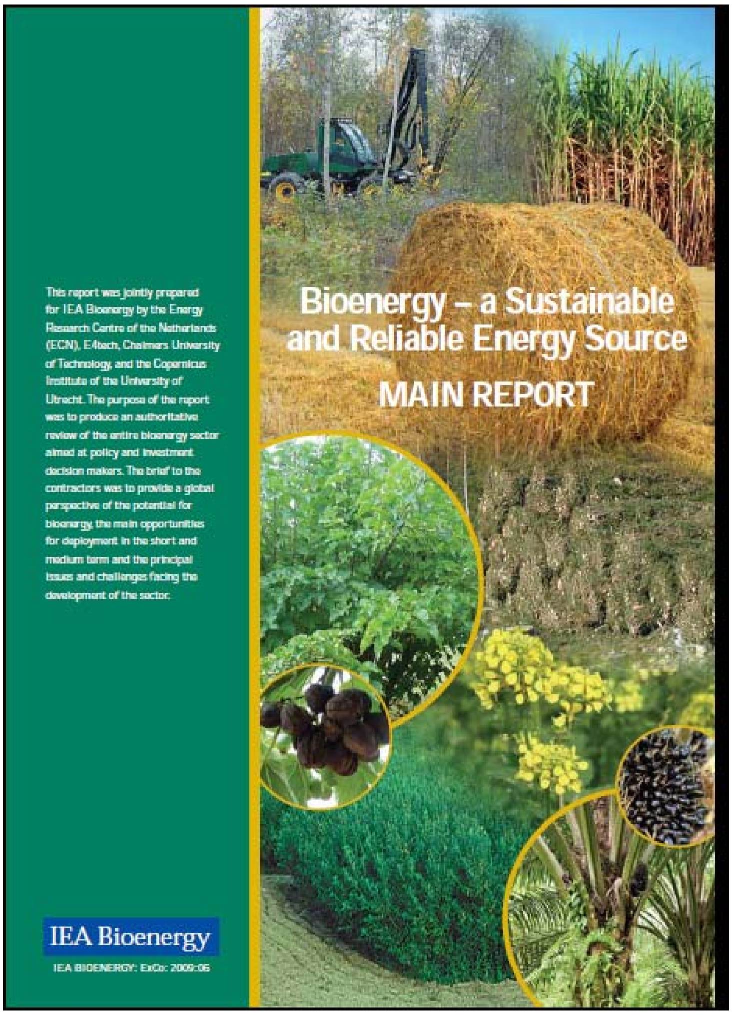
It was jointly prepared for IEA Bioenergy by the Energy research Centre of the Netherlands (ECN), E4tech, Chalmers University of Technology, and the Copernicus Institute of the University of Utrecht. The purpose of the report was to produce an authoritative review of the entire bioenergy sector aimed at policy and investment decision makers.

The brief to the contractors was to provide a global perspective of the potential for bioenergy, the main opportunities for deployment in the short and medium term and the principal issues and challenges facing the development of the sector.

Consisting of over 100 pages, the report contains six main chapters as follows:

- Introduction;
- Biomass Resources and Potentials;
- Bioenergy Routes and Conversion Technologies;
- Biomass Trade and Bioenergy Markets;
- Bioenergy and Policy Objectives;
- Making Policy for Bioenergy Deployment.

To download the full main report visit:
www.ieabioenergy.com/LibItem.aspx?id=6479



IEA Bioenergy's vision is to achieve a substantial bioenergy contribution to future global energy demands by accelerating the production and use of environmentally sound, socially accepted and cost-competitive bioenergy on a sustainable basis, thus providing increased security of supply whilst reducing greenhouse gas emissions from energy use.

Training course: new date announced

The IEA Bioenergy Task 42 Biorefineries/ BIOREF-INTEG training course 'Biorefinery' which was originally planned to be held on 20 April 2010 in Amsterdam was postponed owing to the disruption caused by the volcanic ash from Iceland.

The course was scheduled to run alongside the 'International Biomass Valorisation Congress', 21-22 April 2010, Amsterdam which was cancelled for the same reason.

New date
The training course has been rescheduled and will now be held on September 13th, 2010 in De Zilveren Toren, the Netherlands.

See below for further details regarding the programme and how to register.

BIOREF-INTEG

IEA Bioenergy
Task 42 Biorefineries

www.biorefinteg.eu

www.IEA-Bioenergy.Task42-Biorefineries.com

Training Course Biorefinery

13 September 2010, "De Zilveren Toren", Amsterdam, the Netherlands
Info/registration: www.biomass-valorisation.com

Programme

- General Introduction to Biorefineries
- Current Status and Developments
- Lignocellulosic Feedstock Biorefinery (EC IP Biosynergy & EC IP Biocoup)
- Upgrading Existing Industrial Infrastructures
- Biorefinery Opportunities in Specific Industrial Sectors
- Biorefinery in Practice
- Green Biorefinery
- Marine (algae) Biorefinery
- Sustainability Aspects
- Policy Issues

General News

BIOREF-INTEG Public Workshop

On December 2nd 2009, the BIOREF-INTEG consortium held a workshop in Solihull, UK focusing on 'Preliminary results assessments and innovative biorefinery concepts'. The event was attended by 45 delegates from all around Europe and included representatives from 12 partner organizations and the European Commission, plus 28 external contacts from various energy and biorefinery related companies, as well as several educational institutes.

The event consisted of a series of updates on the preliminary results of the various project Work Packages, as well as a number of interesting presentations from external speakers focusing on various biorefinery projects around Europe. The day concluded with a topical round table. A detailed summary of the external presentations, including other consortium updates can be found below. For further information on the BIOREF-INTEG Work Package updates see the final results article on page 12.

Other Consortium Updates

IEA Bioenergy Task 42 Biorefineries
René van Ree, WUR, Netherlands provided an overview of IEA Bioenergy's background, strategic plan, tasks and contracting parties. He also presented the aims, focuses and results from the Task 42 Biorefineries. A new classification system for biorefinery is in progress which identifies biorefineries with a unique name unlike the existing ones. He also explained the strategic plan for 2010-2016, to provide a platform for international collaboration and information exchange in bioenergy research, development, demonstration and information exchange.

Sustoil
Abbas Kazmi, Sustoil Project Manager, UK explained the background of the Sustoil project and its association with BIOREF-INTEG. Sustoil is an EU funded 7th framework project which has a similar start and end date as BIOREF-INTEG. Sustoil's partners range from universities to small and medium companies, and government bodies to multi-national companies. The aim of the project is to develop advanced biorefinery schemes to convert whole EU oil-rich crops into food, fuels, chemicals, materials and energy.

Biosynergy
Hans Reith, ECN, the Netherlands explained the background, overview of the technology and preliminary conclusions and perspectives of the project. IP Biosynergy, an EU FP6 programme consists of 17 partners from the industry, R&D institutes and universities from 10 EU countries. The project concentrates on the BIOmass for the market competitive and environmentally friendly SYNthesis of bio-products (chemicals and/or materials) together with the production of secondary enERGY carriers (transportation fuels, power and/ or CHP) through the biorefinery approach.

Focus is mainly on valorising lignocellulose raw materials, especially straw using different advanced physical and chemical fractionation processes, innovative thermochemical processes to value added chemicals and materials.

Industry Presentations

Abengoa's bioethanol activities
Laura Bermúdez, Abengoa Bioenergía Nuevas Tecnologías, Spain gave an overview of the company's background and strategy to participate in biorefinery development. Major challenges key to the development of biorefineries include the processes (pre-treatment and C5 fermentation) and enzyme development. Abengoa is already in alliance with Natureworks and Dyadic to overcome the challenges. Abengoa is looking to integrate both the biochemical and thermochemical processes for the production of fuels, chemicals and energy.

Biorefinery within the pulp & paper sector
Christian Hoffstedt, INNVENTIA, Sweden, presented an overview of lignin and hemi-cellulose value

chains, bioethanol development, black liquor gasification and different potential biorefinery scenarios. His presentation concentrated mainly on the application of lignin and hemi-cellulose in fuel oil, dispersants, carbon fibres, hydrogels, emulsifiers and sugar acids. A scenario integrating black liquor, forest residues, and agricultural residues as a raw material to a biorefinery producing cellulose, heat and power, fuels and chemicals was discussed.

The opportunities for biorefineries

Martin Lersch, Section Manager, Borregaard biorefinery R&D, Norway, gave an overview of the Borregaard biorefinery, comparing it with the biorefinery model classified by IEA. He also explained the product overview and its role in the biorefinery markets. Ethanol, cellulose, lignosulfonates and vanillin were discussed in the product overview. He also highlighted the challenges to be overcome in cellulose ethanol technology and expressed Borregard's interest towards pyrolysis chemicals. The emphasis was also on the sustainable criteria of producing value added products from biomass and identifying markets.

Biorefinery opportunities in the UK

Geraint Evans, Head of Fuels and Energy, NNFCC, UK presented opportunities for biorefineries in the northeast of the UK. He suggested the short, medium and long term market scenarios for power, fuel and chemicals identifying the feedstock source and assuming a complete fractionation of lignocellulosic source.

Round Table

At the end of the day, a round table panel discussion was held focusing on a number of interesting topics including:

- If you had 100 Million Euros to invest in a biorefinery, what would you invest in?
- Algae have not been mentioned much – would you look at micro or macroalgae?
- Does the interest in biofuels create an opportunity for biochemicals?
- How would everyone cope with the food versus fuel debate?

Left to Right: Tony Bridgwater (roundtable chair), Geraint Evans (NNFCC), Abbas Kazmi (University of York), Martin Lersch (Borregaard), René van Ree (WUR), Hans Reith (ECN)

BIOREF-INTEG

The bio-materials industry in Toulouse, France

Sustoil

The Toulouse region is famous for being the location of a number of high-tech institutions such as the European aerospace industry, Airbus, Galileo positioning system, CNES Toulouse Space Centre and many others. With such a thriving industry it is welcome to know that Toulouse is at the forefront of education and research with over 97,000 students based on the university campus.

Figure 1: *Headquarters and manufacturing plant of Vegeplast in the surroundings of Tarbes.*

The Laboratory of Agro-Industrial Chemistry possesses 10 years experience in the thermo-mechanical transformation and processing of agricultural by-products to make new materials. Thanks to the Agromat project the laboratory now has a new and independent department dedicated to Agro-materials.

Funded by a grant from numerous partners (EU, French Ministries of Research, Agriculture and Army and some of the local communities) the Agromat project is dedicated to pure research as well as industrial development of plastic biopolymers and biocomposites. The research laboratory is equipped with the latest highly controlled processing facilities (twin-screw extrusion, single screw extrusion, calendering, micro-compounding, injection-molding, thermo-molding) and with all the characterization equipment developed for biopolymer analysis (DSC, atmosphere controlled DMA, universal testing machine, Dynamic Vapor Sorption, Melt-flow rheometer, PVT, Image analysis, electronic and optical microscopy). The brand new development building located in Tarbes will offer at an industrial scale all the processing and forming technologies to facilitate the industrial development of Agro-materials (grinder, dryer, mixer, twin screw extruder, complete extrusion line, high tonnage platen presses and injection molding machines).

To promote the development of the Agro-materials, Agromat offers on the one hand technological facilities and "know-how" to industrial partners and on the other hand research tools for scientific cooperation.

Figure 3: *An example of application, from the sunflower seeds to the planting out flower pot going through all intermediate steps: sunflower oil cake, crushed oil cake, extruded and plasticized pellets*

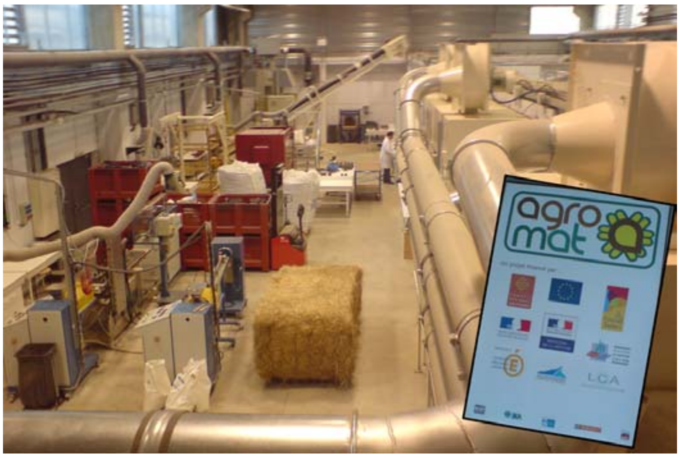


Figure 2: *View of the Agromat demonstration building in Tarbes*

Figure 4: *William, technical officer in Agromat, producing flower pots by injection-moulding*

VEGEPLAST is an independent French company leader in the field of transformation of renewable resources into 100% biodegradable plastic pieces by injection-molding. With its headquarters and manufacturing plant located near Tarbes (Midi-Pyrénées region), Vegeplast has an immediate access to the extensive cereal production of Southwestern France, and to guarantee non-GMO material.
The natural markets for VEGEPLAST are all plastic pieces with limited use in time. Among examples: golf tees, flavoured chewing bones, vine clips (Vegeclip), flexible tie for plant nurseries (Vegeflex), fireworks bombs, disposable cutlery and parachute ties. This year, VEGEPLAST is extending its markets and doubling its employees with two new applications: biodegradable Nespresso capsules (a market of 600 millions pieces/year) and soon biodegradable packagings for the regional food industry (meat and cheese).

Contact: Antoine Rouilly
E-mail: Antoine.Rouilly@ensiacet.fr

Figure 5: *The Agromat 400 tonnes hot press used to make 100% natural composites*

Figure 6: *Examples of containers obtained from agricultural by-products by compression -moulding*

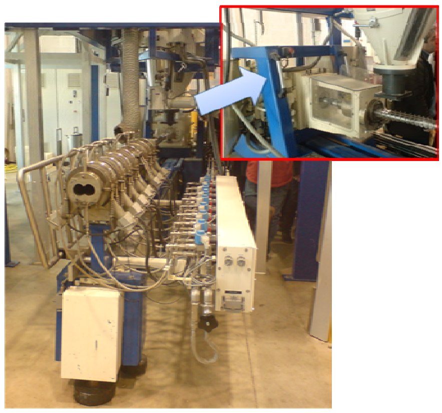


Figure 7: *The EV53 twin-screw extruder, the heart of the thermal and mechanical transformation of bio-based products to produce agromaterials.*

Biorefinery Publications

Books

The Biobased Economy—Biofuels, Materials and Chemicals in the Post-oil Era.
Edited By Hans Langeveld, Johan Sanders and Marieke Meeusen
(see earthscan.co.uk for further information).

Handbook of Bioenergy Crops—A Complete Reference to Species, Development and Applications
by N. El Bassam (see earthscan.co.uk for further information).

Other Publications

Biorefiney Euroview Consortium (2008) Biorefinery Euroview, Current Situation and Potential of the Biorefinery Concept in the EEC. Paper presented at 16th European Biomass Conference, 5/6/08, Valencia, Spain.

Gilbertson, T., Holland, N., Semino, S., Smith, K. (2008) Paving the way for agrofuels. EU policy, sustainability criteria and climate calculations. Discussion paper 2007, CEO.

Grimaldi A. – Lopolito A. – Monteleone M. – Morone P. - Prosperi M., Sisto R. (2009): "WP 6: Modelling stakeholder interplay and policy scenarios for biorefinery and biodiesel production - D 6.7: Detailed specification of the questionnaire to be delivered to various stakeholders", DSEMS Working Papers, University of Foggia, n. 15/2009 (pp. 1-21).

Lopolito A. – Prosperi M. – Sisto R. (2009b) "Socio-Economic Implication of a Bio-refinery: an Analysis with Fuzzy Cognitive Maps" DSEMS Working Papers, University of Foggia, n. 19/2009 (pp. 1-26).

Lopolito A. – Morone P. – Taylor R. (2009a): "WP 6: Modelling stakeholder interplay and policy scenarios for biorefinery and biodiesel production - D 6.7: Detailed specification of the theoretical social network model", DSEMS Working Papers, University of Foggia, n. 17/2009 (pp. 1-10).

Mayfield, C.A., Darwin Foster, C., Smith, C.T., Gan, J., Fox, S. (2007) Opportunities, barriers, and strategies for forest bioenergy and bio-based product development in the Southern United States. Biomass and Bioenergy, 31, 631–637.

Events

MAY 2010

3rd - 6th
Bio International Convention
Chicago, USA

3rd - 7th
18th European Biomass Conference and Exhibition
Lyon, France

4th - 6th
Biomass Conference and Exhibition
Minneapolis, USA

5th - 6th
Waste to Energy - International Exhibition & Conference for Energy from Waste and Biomass
Bremen, Germany

5th - 6th
Biomass to Liquids
London, UK

5th - 6th
Biofuels International Expo
Prague, Czech Republic

11th -13th
Bioenergy Markets Africa
Maputo, Mozambique

17th - 19th
Engineering for Waste and Biomass Valorisation
Beijing, China

19th - 20th
All - Energy 2010
Aberdeen, UK

25th - 27th
World Bioenergy 2010
Jonkoping, Sweden

JUNE 2010

7th - 9th
6th International Conference on Renewable Resources and Biorefineries RRB6
Düsseldorf, Germany

21st - 23rd
International Workshop on Wood Biorefinery and Tree Biotechnology
Örnsköldsvik, Sweden

30th June - 1st July
AEBIOM European Bioenergy Conference at RENEXPO Bioenergy EUROPE
Brussels, Belgium

JULY 2010

12th - 15th
Pyrolysis 2010: 19th International Symposium on Analytical and Applied Pyrolysis
Montreal, Quebec, Canada

20th - 21st
Biomass '10 Renewable Power, Fuels and Chemicals Workshop
North Dakota, USA

AUGUST 2010

22th - 26th
American Chemical Society Fall 2010 National Meeting & Exposition
Boston, USA

28th Aug - 1st Sept
19th International Congress of Chemical and Process Engineering CHISA 2010 and the 7th European Congress of Chemical Engineering ECCE-7
Prague, Czech Republic

31st Aug - 4th Sept
Forest Bioenergy 2010
Tampere and Jämsä, Finland

SEPTEMBER 2010

13th
Training Course Biorefinery
De Zilveren Toren, Amsterdam, The Netherlands

13th - 14th
FAME 2010 - Premier Event For The Sustainable Fuel Industry
Intercontinental Hotel, Berlin, Germany

15th - 19th
14th International Biotechnology Symposium and Exhibition - Biotechnology for the Sustainability of Human Society
Palacongressi, Rimini – Italy

21st - 23rd
Bioten – Biomass, Bioenergy, Biofuels and Biorefineries
Birmingham, UK

OCTOBER 2010

6th - 7th
European Bioenergy Expo and Conference
Stoneleigh Park, UK

7th – 10th
RENEXPO® 11th International Trade Fair for Renewable Energy & Energy Efficient Building and Renovation Messe
Augsburg, Germany

10th - 13th
10th International Workshop on Polymer Reaction Engineering
Hamburg, Germany

NOVEMBER 2010

10th—11th
Innovation Towards Sustainable Materials
London, United Kingdom

DECEMBER 2010

13th—15th
International Conference on Environment 2010
Malaysia

MARCH 2011

22nd - 24th
Nordic Wood Biorefinery Conference (NWBC)
Stockholm, Sweden

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