Biorefinery Researcher

Issue 2
June 2009

In collaboration with SUSTOIL and BIOREF-INTEG, 2 Support Action projects funded by the European Commission through the Seventh Framework Programme (June 2008—May 2010)

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Introduction

The biorefinery concept inscribes within the widest context of the fight against global warming and EU energy security. It will contribute to the ambitious objectives stated in the EU *energy & climate change package* by developing processes which are able to increase efficiency and enhance sustainability of biofuel & bioenergy production.

Moreover, biorefineries will contribute to other important EU objectives, such as increasing industrial competitiveness, creating new opportunities for agriculture and rural areas, or permitting the valorisation of different organic wastes.

Therefore, the biorefinery concept seems to be the answer to a lot of prayers in many different policy areas. That is why the EC sees it as one of the most promising research topics and has put it high in the agenda. BIOREF-INTEG and SUSTOIL are two pioneering, prospective projects in this domain, to be followed soon by many others, when a specific Biorefinery call - launched in September 2008 - delivers its results.

Future biorefineries will most likely be developed from existing industries (sugar/ starch ethanol plants, oil-seed crushing / trans-esterification plants, pulp and paper mills, etc.), by optimisation of side streams, or by combination of existing processes. Hence the importance of identifying schemes with the highest potential to be integrated into competitive biorefineries. No doubt the conclusions of SUSTOIL and BIOREF-INTEG will be of high interest to the scientific and industrial community.

SUSTOIL and BIOREF-INTEG started on 1st June 2008, and is due to finish by May 2010. As both projects deal with the same topic, the information generated within each one is certainly of high interest to the other. In order to ensure that this cross-fertilization takes place, the EC has requested that a number of joint activities is organised. This joint newsletter is an important contribution towards this.

José Ruiz Espi
EC Project Officer,
European Commission

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.

Green Chemistry Centre of Excellence, University of York

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June 2008—May 2010

SUSTOIL holds its First Workshop

Sustoil: Developing advanced Biorefinery schemes for integration into existing oil production/transesterification plants. Writer: Dr Abbas Kazmi, Sustoil Project Manager, ak584@york.ac.uk

The Sustoil project which is coordinated by the University of York held its first workshop in Foggia, south Italy on the 24th of April 2009. As a coordination support action project it involves 23 partners from 10 EU countries. The workshop was arranged for three technical work packages to disseminate their findings to the consortium. (pictured above).

The region of Foggia has very fertile land producing oranges, lemons, olives, almonds, durum wheat, grapes and many other agricultural products on a large scale. By utilising its biomass, the region has potential to develop as a bioeconomy which could help reduce the unemployment rate of 30%. As well as having large areas of arable land, Foggia has beautiful mountainous landscapes and breathtaking unspoilt coastal areas. On the second day of the workshop the consortium visited a lagoon area where large volumes of Gracilaria macro-algae can be harvested and the Sustoil partners have been requested by the local government to find applications for the Gracilaria. Overall this region has great potential for development and growth.

The first workshop day started with a welcome by Antonio Pepe, the president of the Foggia region and was followed by Dr Pasquale Pazienza representing the University of Foggia, a Sustoil partner and the workshop hosts. After an introduction by Professor James Clark and an update by Professor Ray Marriott the first work package participants commenced with their presentations.

Work package 1: Optimisation of oil crops agronomy and oil yield, and utilisation of by-products

Work package one involves optimisation of oil crops agronomy and oil yield, and utilisation of by-products. The yield of oilseed rape can be increased by selective breeding, genetic manipulation and improving crop management practice. With optimised conditions high yields of up to 6.5tonnes/ha can be obtained which is considerably higher than the current average EU yields of 3.5 tonnes/ha. The sunflower crop is mainly affected by water and nutrient availability therefore yields can be improved by matching the cultivar with the water availability, replacing water-demanding crops with sunflower and making sure farmers conform to recommended practices. The by-products of these crops include the straw, stalk and the leaves which can contain numerous valuable chemicals such as hydrocarbons, wax esters, aldehydes, ketones, alcohols and acids. The yields of these components is only 0.3 -2% and the main extraction medium (supercritical CO_2) is expensive therefore further research is required. Other chemicals such as methane and levulinic acid can be obtained

from by-products using anaerobic digestion and green chemistry methods.

Alternatively the by-products can be pelletised and used as a direct fuel for energy production. The pelletisation process is also a pre -treatment method for supercritical CO_2 extraction and anaerobic digestion. The straws can contain large amounts of pectin and can also be used as a feedstock for producing various types of materials such as biosorbents, paper and particle boards.

The contributors to this work package are Alain Quinsac (CETIOM), Francis Flanet (CETIOM), David Turley (FERA), Ruth Leybourne (FERA), Ray Marriott (University of York), K. Stamatelatou (FORTH), Birgitt Kamm (Biorefinery.de), Antoine Rouilly (INPT) pictured below.

Work package 2: Optimisation of oil-rich crop primary processing i.e. the extraction of oil

The second work package focused on optimisation of oil-rich crop primary processing i.e. the extraction of oil. The 'hull' is an outer layer of seeds and by removing this, the protein content of the cake meal significantly improves. The hulls can be pelletised and used as a fuel as they have a high burning value of 8,100 BTU/Ib. The high burning value is partly attributed to the 3% of oil which is removed with the hulls during the dehulling process. Therefore removal of residual oil through the use of clean technologies such as supercritical CO_2 extraction and microwave processing is important. The oil refining process leaves behind free fatty acids (as soap stock), pigments, phosphotides, soaps, metals, phytosterol and tocopherol.

Some of these fractions can be converted into biodiesel and others can be used in the food additive, pharmaceutical and cosmetics industries. Rapeseed oil is mainly used for edible purposes and the rape meal that is left behind is used as a protein -rich animal feed additive. Larger amounts of rape meal additive cannot be used as it contains certain anti-nutritional substances. Therefore valuable extractives from rape meal have been identified such as bioactive proteins, biocidal, pesticidal and antioxidant compounds. After olive oil extraction the pulp can be valorised via anaerobic digestion to produce high yields of methane and hydrogen. The rapeseed and sunflower cakes have been shown to be promising raw materials for material production via thermo-mechanical processing due to the presence of lignocellulosic fibres.

The resulting materials exhibit natural resistance to water and the economics of the process are good. Further work needs to be conducted on removing the high levels of amino acids within sunflower and rapeseed and the cellulose content could be converted into Levulinic acid or ethanol.

The contributors to this work package are Patrick Carre (Creol), Camelia Echim

(University of Ghent), Wim Mulder (AFI), David Turley (FERA), Antoine Rouilly (INPT), Birgit Kamm (biorefinery.de)

Work package 3: Optimisation of secondary processing i.e. biodiesel production

The third and final work package of this workshop was regarding the optimisation of secondary processing i.e. biodiesel production. Clearly in order to make such biofuels competitive with mineral derived fuels it is necessary to valorise any waste streams. Glycerol is a by-product of biodiesel production and can cost companies significant amounts to dispose of. However there are a number of uses of this by-product and when simply purified the clean glycerol can have saleable value. Glycerol can also be used as a chemical building block to produce an array of chemicals such as propylene glycol, triacetin and succinic acid via chemical or biochemical routes.

Glycerol can also be used to produce additives for the production of wood panels.

Interestingly, novel routes to biodiesel have been identified which do not produce any glycerol by-product and are currently being commercialised by some of the Sustoil partners (UCO & Seneca).

The contributors to this work package are Rafa Luque (UCO & Seneca), Zsanett Herceski (UoP), Abbas Kazmi (UoY), Ilias Katsampas (Chimar Hellas) pictured above.

The next stage of the project will ascertain the sustainability of the various developed schemes outlined in the first three work packages through a full life cycle assessment and computational modelling of the economic, social and environmental costs and benefits. Furthermore various policy scenarios will be developed to understand any potential environmental, economic and policy constraints the bioenergy and biorefinery sector could face within a sustainable development framework.

Detailed reports on each of the work packages are available on the Sustoil website http://www.sustoil.org

Work Package 5: Social, environmental and economic cost-benefits analysis of biorefinery schemes

The objective of this work package is to construct integrated models of biorefinery plants starting from the raw material and combining the production of biofuels with the processing of waste streams, including a multitude of options: from purification and separation to the production of platform chemicals and bioplastics.

Different oilseeds will be taken into account as raw materials and their viability for the production of fuels and chemicals will be explored. To this effect, we have already constructed a simulator based on a commercial package together with home-made codes for the modelling of a plant, which includes the oil extraction from seeds, the chemical production of biodiesel and the biochemical processing of glycerol, the main by-product from biodiesel production, to obtain platform chemicals.

The model has been validated with both literature and experimental data.

In the second year of SUSTOIL, we are planning to simulate a number of biorefineries, considering the options reviewed in work packages 1-4 and to compare the viability of the different designs through economic analysis, including raw materials costs, capital costs and up-to-date product prices.

The environmental impact of these designs will also be taken into account from a waste minimization and emissions reduction point of view. Life Cycle Analysis (LCA) studies will then be employed to assess not only the environmental, but also the social impact of the schemes that the modelling studies will indicate as *viable*.

The LCA investigations will be based on appropriate databases, mostly based on European studies, since we are obviously interested in developing an EC-relevant analysis. The results from LCA will be used to also evaluate upstream options, such as land use, transportation of raw materials and carbon foot-printing of the reviewed schemes.

We are planning to combine LCA with optimization techniques, to develop holistic biorefinery evaluations that satisfy combined socio-economic and environmental objectives. Our aim is to produce quantifiable multi-objective comparisons of biorefinery strategies that will provide comprehensive directions for the future.

Furthermore, the work from this package is naturally coupled with the objectives of work package 6, which is concerned with the interplay between governmental policies, economic and environmental impacts.

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WP6: Modelling stakeholder interplay and policy scenarios for biorefinery and biodiesel production – a brief outline for activities in 2010

In 2010, the main activities for WP6 will be the following:

In February, during the planned workshop II, the findings of the multi-country CGE model for the EU, based on the work by the UoY and the findings of the social network model, based on the work by the UoF, will be illustrated.

The details are briefly explained in the notes below:

Multi-country CGE model for the EU:

This model aims at representing policy scenario for biorefinery schemes in the EU and its subsequent effects on consumer welfare across EU member states. The model is built-up to represent economic, environmental and trade interactions across a multitude of agents such as households, firms and governments. The model's base case considers current technology of energy and biofuels inputs to production (based on information retrieved through the work of WPs 1-3), biodiesel consumption from households and governments, local and trans-boundary pollution emissions.

The model's policy simulation will consider the effects on consumer welfare and on the economic structure of a country, emissions reductions and trade across countries according to the following three main scenarios:

1) A change in technology to comply with the European Council independent commitments of renewable energy use post-2012 agreements.
2) The implementation of different tax (or subsidy) rates on energy inputs and on emissions, at either national or EU harmonised level.
3) A change in land-use if biodiesel is considered as input to production.

Social network model:
The objective of this model is twofold:

- To understand the extent to which various environmental, economic and policy constrains prevent biofuel and biorefinery energy from emerging as a new technological regime.

- To develop, through the analysis of heterogeneous agents interactions at macro, meso and micro levels, various policy scenarios and policy prescriptions compatible with a sustainable development approach.

In order to do so, a specific theoretical framework is adopted, namely the multi-level approach. This approach sees technological transitions as the outcomes of social-economic interplay within dedicated networks of actors committed to technological change.

The social network methodology allows to study such interaction more in depth. This will be done using network data gathered by means of a questionnaire distributed in May-June 2009 to various stakeholders in the province of Foggia (Capitanata, Italy) and designed to collect data for the analysis of the pre-conditions of technological change. Specifically, three main social mechanisms will be investigated. These are the convergence of actors' expectations towards a common view, the inclusion in the network of powerful actors with their resources, and the occurrence of effective learning interactions among agents in the niche. Then, various social network indicators will be used to provide a systematic analysis of the network. The data gathered will also offer the base to calibrate the agent based model directed to analyze the various stakeholders' interplay scenarios.

Finally, by May 2010, a final report of the two models explaining stakeholders interplay and policy scenarios for biorefinery and biodiesel production based on the feedback of participants in workshop II and future research suggestions will be provided.

Dr Caterina De Lucia

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Foggia, South Italy – A hotspot for investment

Figure 1: Some of the Sustoil partners visiting the beautiful Foggia coast

Italy is world renowned for its wine which is grown in the south, and in such fertile land it is not surprising that a wide range of other high quality produce such as olives, oranges, almonds and durum wheat are produced. In particular, the Foggia region has optimal conditions for biomass growth and has the potential to further develop its bio-economy.

Clearly with a region producing vast quantities of food it is important that any development has to be done in a sustainable manner. An issue which has been highlighted in south Asia is the damaging effect of indirect land use. When a unit of land which is not used for food growth is developed for biofuel crops such as Palm then it is quite likely that nearby forests or food crops will be deprived of some fresh water. This needs to be avoided, however, there are no strict international policies enforcing this currently.
The utilisation of non-food biomass removes many of the issues discussed above—however it is important to know that a large percentage of food produced in the EU goes to land fill. Foggia being a large food producer means there will be significant amounts of agricultural residues such as olive stones and waste straws. Foggia also has a large lagoon area where macro-algae (*Gracilaria*) is being harvested and the local government is encouraging novel biorefinery uses for this area.

Figure 2: Foggia Coast

The olive stone can be used as a renewable solid biofuel to generate electricity. The stones can be co-fired with fossil fuels such as coal and burned in power stations. A large power station (Drax) in the UK is currently co-firing palm kernels and olive residues to generate electricity. The alternative is to set up small biomass boilers which will burn the olive stones to generate electricity for a small number of farms and factories. These technologies exist today and therefore can be deployed relatively quickly. However market information is required on how much olive stone waste exists in the region and what its current use is.

The availability of durum wheat straw and potential quantities need to be known to assist the development of this resource. Wheat straw can be processed into useful products such as paper and boards. Furthermore it can contain valuable waxes which are used in the cosmetics industry.

Much research has been conducted on conventional wheat straw and there is an opportunity for researchers to conduct similar studies on durum wheat. The straw has potential to be used as a solid biofuel to generate electricity and due to its high cellulose content it could be used to produce biofuels or chemicals in the future.

Macro algae such as *Graciliaria* can be abundantly grown in the Foggia lagoon and is a promising feedstock for anaerobic digestion as shown by an EPOBIO report published in 2007 (http://www.epobio.net/news/news070917.htm). The resulting methane gas could supply energy to the region. Further work is required to identify how much macro-algae can be grown seasonally in the lagoon and the potential methane yield. Further studies on the economics and initial capital costs need to be conducted.

The region of Foggia is generally is under-developed and there is potential for significant growth. With unemployment at around 30% the government will back initiatives for revenue generation and job growth.

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Biomass Companies on the Stock Exchange

Academics have the primary ambition to generate world-class research and publish their work in peer-reviewed journals. However in projects such as Sustoil where academics work closely with large industrial companies such as CRODA, the target is not always to publish work. Many universities and institutes in the world, such as MIT believe that research should be focused on commercialisation. Indeed many of the technological advancements we observe in society today are due to such research. A novel commercial product can make the inventors very wealthy and increase their reputation within a university or research community.

The Sustoil project has identified many research areas which could lead to commercial development. More information on these developments can be found on the Sustoil website. When a researcher has identified or developed a new product then the first step tends to be a patent. This secures the researcher's intellectual property and the product can be licensed to companies which in return pay royalties. When a product requires constant R&D support and is capital intensive to start-up, many researchers source capital from investors. Investors have a rigorous approach to which companies to invest in and can take a considerable chunk of the ownership. If a company requires further capital then listing on a stock exchange can be a good move. Institutional or retail investors buy shares on the stock exchanges and pick companies based on several criteria. These include potential growth forecasts, price to earnings ratios, dividend yields, discounted cash flows, share price performance and senior management quality.

One such company is called Thenergo (http://www.thenergo.eu/) which is listed on the Euronext Brussels stock exchange. Thenergo is an independent developer and operator of sustainable energy projects using biogas, natural gas, bio-oil, woody biomass and secondary fuels. The company creates value for its partners and shareholders as a one-stop provider of sustainable energy solutions, converting biomass into electricity and heat. The company has an integrated approach and helps clients from initial concept design through to the final selling of electricity. The growth in the company is reflected by the increase in the number of employees from 13 in 2006 to 176 in 2008.

There are many other companies on stock exchanges throughout the world creating wealth from biorefinery principles. More information will be available in the next newsletter.

For further information please contact:

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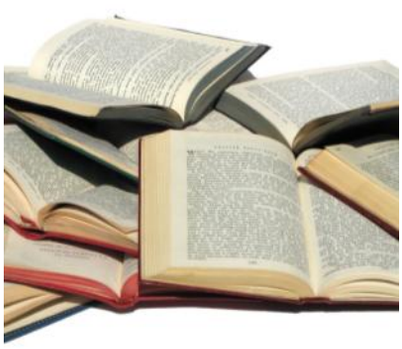
Sustoil: A lasting legacy?

Many EU projects last for a few years and during that period produce high quality research which has to be disseminated widely through websites, conferences and publications. Presentations and stands at conferences distribute the knowledge to a wide scientific community - however these events only last for a few days and the delegates may not be able to absorb the information fully.



Publications in an EU project can effectively disseminate parts of the research, but the integrated research approach may not be effectively transmitted. It seems that the best approach for such projects may be the publication of a book by a respectable publishing company.

The Sustoil management team have received an offer from a world renowned publishing company to use some of the Sustoil results to write a world-class book. This will ensure that most of the results are available for a long time after the end of the project. We hope to have some good news on this subject in the next newsletter. If you are interested in contributing to a book on EU oil-rich plant oils then please contact:

Dr Abbas Kazmi
ak584@york.ac.uk.

Featured Advisor

Professor Dermot J Roddy, CEng, FIET

Dermot Roddy joined Newcastle University as Science City Professor of Energy in 2008 after a period of some 20 years in the energy industry and petrochemical sectors. He is also Director of the Sir Joseph Swan Institute for Energy Research, which integrates energy research across Newcastle University and links with a powerful external industrial base in the energy sector.

Outside of the university he is Chairman of North East Biofuels, Finance Director of the UK Hydrogen Association and Vice President of the Northern England Electricity Supply Companies Association.

Prior to coming to Newcastle University he was Chief Executive of Renew Tees Valley Ltd – a company which he set up in 2003 to create a viable and vibrant economy in the Tees Valley based on renewable energy and recycling – where he was instrumental in a wide range of major renewable energy and low-carbon projects relating to biomass, biofuels, hydrogen, carbon capture & storage, wind and advanced waste processing technologies. From 1998 to 2002 he ran the crude oil refinery on Teesside as site director for a $5 bn-turnover facility before moving to the Netherlands to work on Petroplus' international growth plans.

Dermot's experience in the petrochemical industry began in 1985, involving a variety of UK and international roles in operations, engineering and technology with ICI and others. Prior to that he developed leading-edge technology at Queen's University, Belfast, for optimisation and control in aerospace applications.

SUSTOIL Web Site

The SUSTOIL website can be found at:

www.sustoil.org

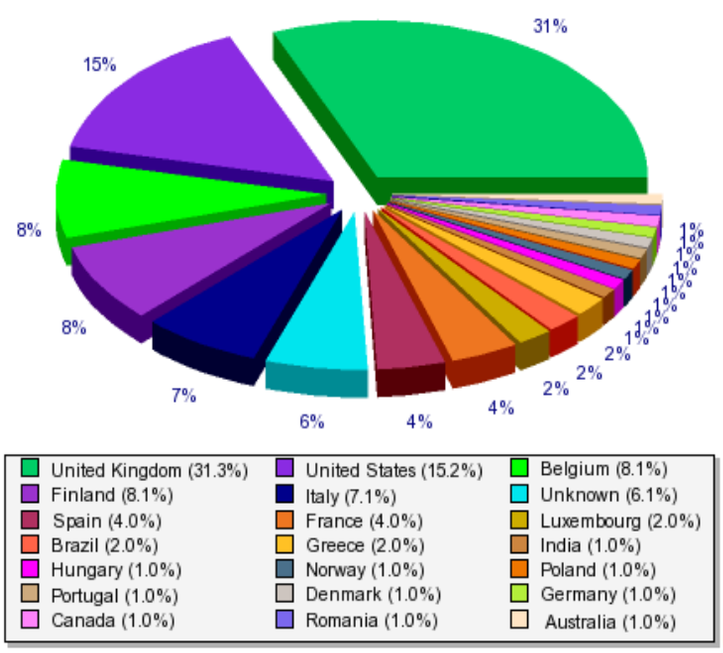
Here you will be able to find a definitive overview of SUSTOIL and its objectives.

Other useful information includes a variety of publications, the latest news, details about forthcoming events, as well as links to other biorefinery projects.

Statistics to Date:

- Total Visits: 3,155
- Total Page Views: 17,625

Our dedicated intranet system for all project partners is also live. Please sign yourself up to take full advantage of this service - **www.york.ac.uk/res/sustoil/Pages/Login.html**



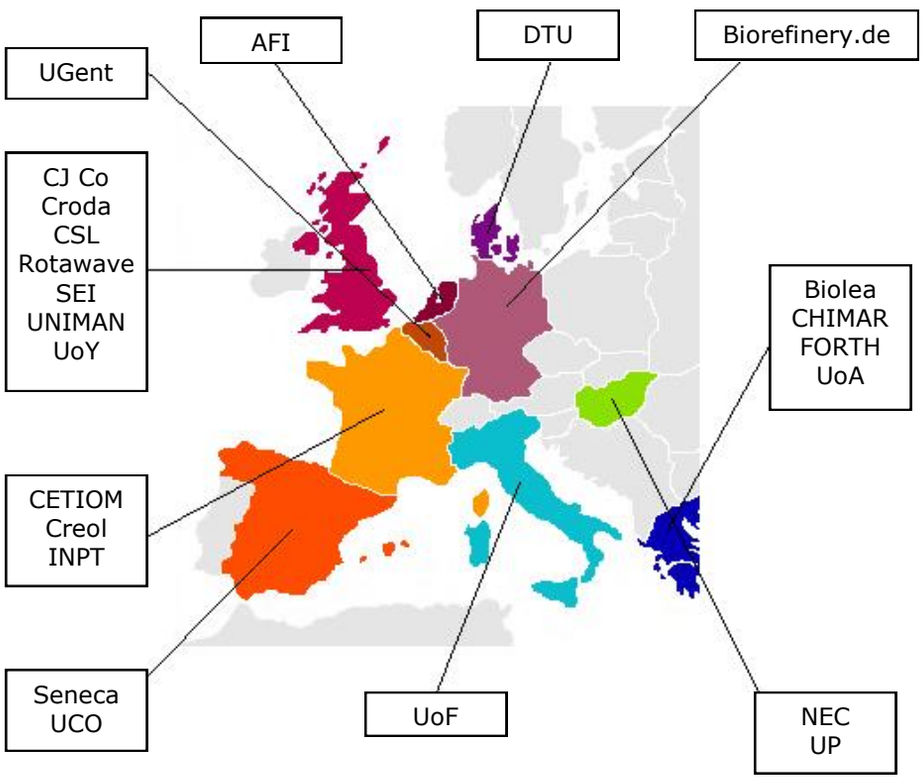
SUSTOIL Partners

SUSTOIL will integrate the expertise of 23 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-



Our Partners

1. Agricultural University of Athens, Greece
2. BioCentrum-DTU, Denmark
3. Biolea, Greece
4. Biorefinery.de GMBH, Germany
5. Central Science Laboratory, UK
6. CETIOM, France
7. Charles Jackson & Co Ltd, UK
8. Chimar Hellas SA, Greece
9. Creol, France
10. Croda International PLC, 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
23. Agrotechnology and Food Innovations BV, The Netherlands

BIOREF-INTEG

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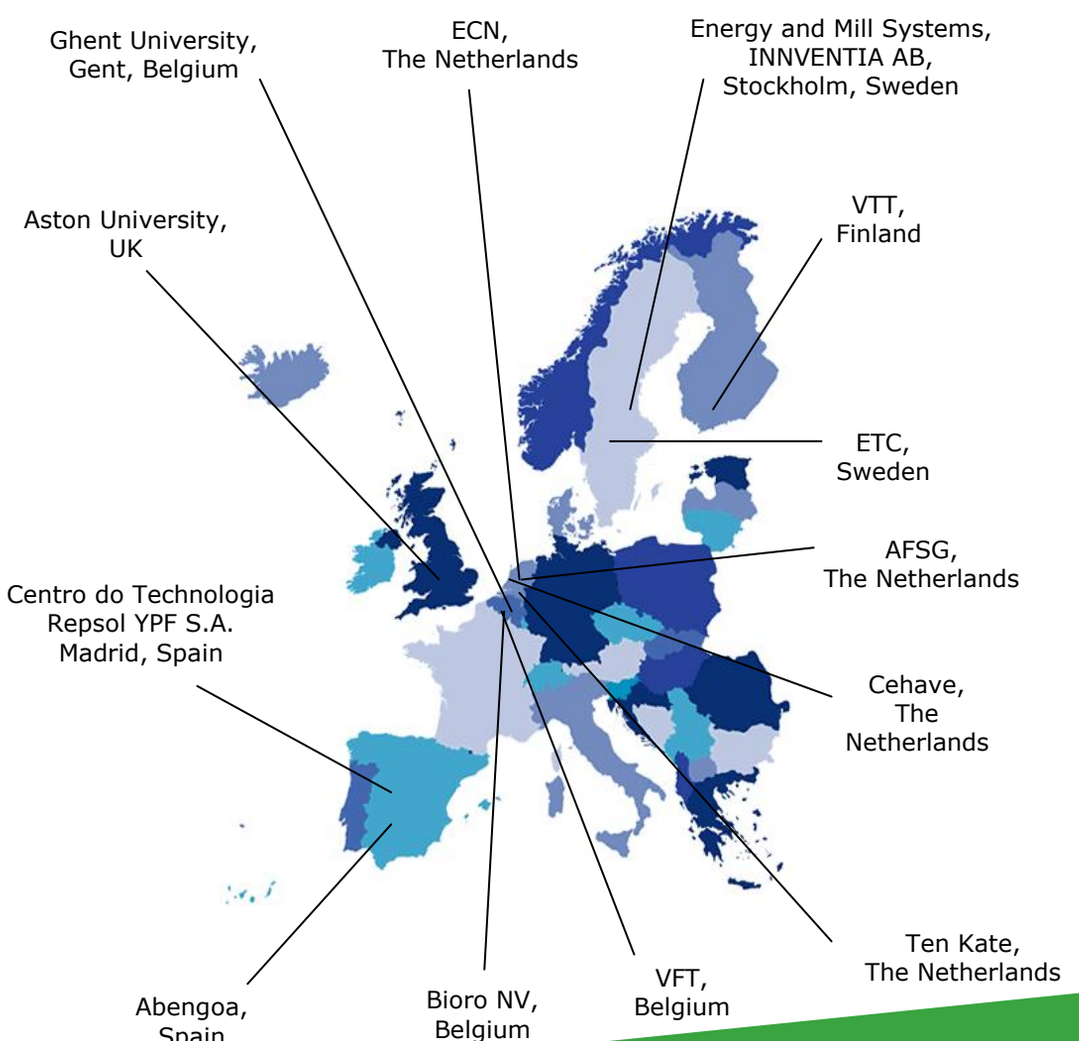
Project Web Site
www.bioref-integ.eu

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

BIOREF-INTEG Partners



BIOREF-INTEG Progress

An introduction from Hamid Mozaffarian, BIOREF-INTEG Coordinator

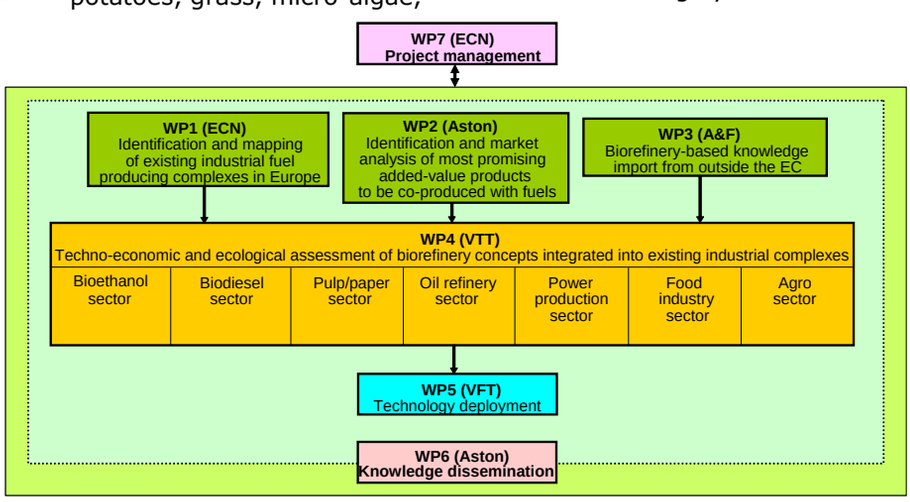
The first issue of 'Biorefinery Researcher' focused on presenting the BIOREF-INTEG Consortium, the project objectives and its work packages. This second issue will begin with a brief presentation of the progress achieved per work package during the first year of the project. After that, a summary will be presented of the first project workshop held at the beginning of this year in Osnabrück, Germany. Then three articles will follow regarding the activities of some of the project partners (Ten Kate, Bioro, Ghent University and AFSG) in the field of biorefinery.
Also three biorefinery-related projects, with participation of a number of project partners (VTT, AFSG, Ghent University and ECN), will be presented: one ongoing (Biocoup) and two recently concluded (Biopol and Biorefinery Euroview).

Work package 1

For each of the seven biomass-related market sectors (see figure below), the existing industrial (fuel producing) complexes for the six partner-related countries (Finland, Sweden, UK, Belgium, Spain and the Netherlands) have been identified. Based on the achieved results, at least one reference case per market sector has been defined as a realistic representative of the sector. The reference cases are briefly described, including a block diagram with main overall mass and energy balances. The reference cases will be evaluated in WP4, where they will also be upgraded to high efficiency advanced biorefinery schemes, co-producing added-value products and fuels.

Work package 2

A literature analysis has been conducted within the field of biomass-derived products in order to identify current and potential materials and chemicals. The analysis has been based on the composition of the raw materials of the selected reference cases within WP1, i.e. wood, straw, sugar beet, wheat, potatoes, grass, micro-algae, rapeseed, pulp/paper residues, food industry residues and agro residues. Also a literature and web-analysis on current market prices and volumes of the materials and chemicals identified is ongoing. The longer-term potential market developments affecting directly the future market volume demand and market price of these products will also be roughly assessed.



BIOREF-INTEG Progress...continued

Work package 3

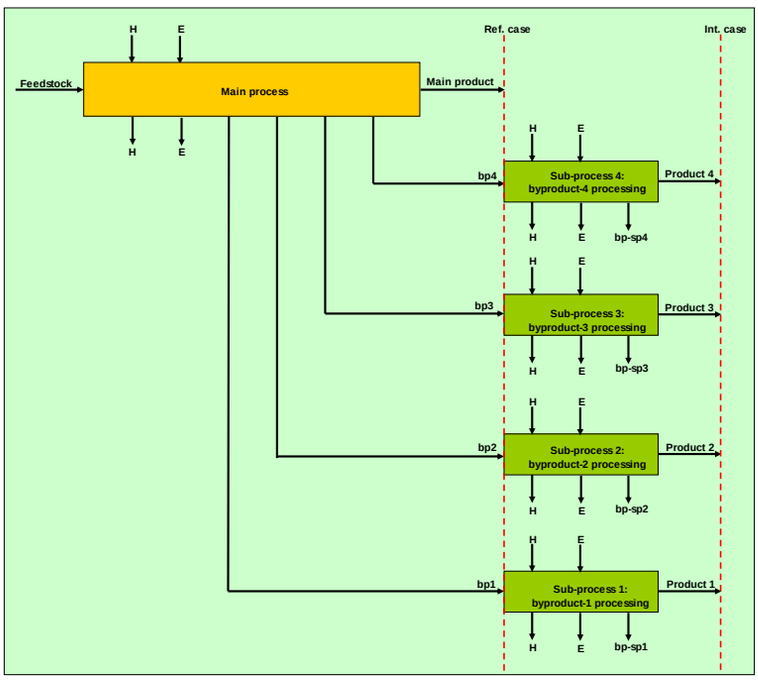
The workshop 'Knowledge import from outside EU on advanced biorefineries' was organised by AFSG on 29th January 2009 in Osnabrück, Germany (see page 16 for a summary of the workshop). Work on biorefinery views and activities outside the EC, based on the analysis of conference proceedings and websites on biorefinery-related information, including information from the IEA Task 42 on biorefinery (coordinated by AFSG) is ongoing.

Work package 4

Economic data of the selected reference cases within WP1 have been gathered from the partners by VTT. This data, together with the data on the mass and energy balances of the reference cases—resulted from WP1, will be used for techno-economic assessment of the selected cases. In the next step, the results of WP1 to WP3 will be used to define the integrated biorefinery schemes for each selected biomass-related sector. ECN has developed a biorefinery cashflow model for modelling purposes within WP4. Based on the gathered mass, energy, and economic data, the cashflow model will calculate the production cost of the main product of each selected sector for both the reference case, as well as for the integrated biorefinery scheme (see figure above). The objective is to evaluate how far the co-production of added-value products from by-products of each reference case could enhance the economic competitiveness of the main product (fuel). Later on the model would be further improved, in order to be used for the ecological assessment of both the reference and the integrated cases.

Work package 5

The objective of WP5 is to evaluate the maturity of business models for the most promising integrated biorefinery processes. Activities within this WP will be based on the results of WP4 and will start from August 2009, using a "portfolio evaluation model" developed by VFT.



Work package 6

Work performed within this WP includes the development of the project website[1] (ECN), project brochure (AFSG), and the first two joint newsletters with the Sustoil project[2] (Aston University). Another activity, performed within this WP has been the establishment of the project Advisory Board (ECN). The Board consists of four members from Spain (Dr. Carlos Alberto Fernández López from IDAE, www.idae.es), Belgium (Mr. Yves Verschuren from Essenscia, www.essenscia.be), Finland (Professor Kai Sipilä from European Biofuels Technology Platform, www.biofuelstp.eu / VTT, www.vtt.fi), and the Netherlands (Ir. Kees Kwant from SenterNovem, www.senternovem.nl). We also organized our first workshop, as mentioned in WP3. We presented a poster at the Biorefinica Conference (January 2009, Osnabrück, Germany)[3], we joined the first Sustoil Workshop, held on April 2009 in Foggia, Italy[4], and we shall present a poster at the RRB5 Conference (10-12 June 2009) in Ghent, Belgium.

Work Package 7

Activities within this WP consists of general project management, organisation of the project meetings, coordination of the work packages and the project Advisory Board. Our third project meeting together with the first project Advisory Board meeting will be held on 9-10 June 2009 in Ghent, Belgium.

Hamid Mozaffarian
BIOREF-INTEG Coordinator, ECN

[1] See: http://www.bioref-integ.eu
[2] See: http://www.bioref-integ.eu/publications
[3] For presentations of the conference see: http://www.dbu.de/550artikel28045_147.html
[4] See: page 4

Workshop: 'Knowledge Import from outside EU on Advanced Biorefineries'

As part of the BIOREF-INTEG project, a workshop 'Knowledge Import from outside EU on Advanced Biorefineries' was organised on 29th January 2009 in Osnabruck, Germany. The aim of the workshop was to provide an overview of the current status of biorefineries outside the EU - through participation of representative scientists from Japan, Brazil and USA. Professor Shiro Saka (Kyoto University), Professor Telma Franco (University of Campinas) and Professor Bruce Dale (Michigan State University) presented their views and activities on biorefineries in their countries.

Topics discussed in the presentations covered a wide range of techniques for extracting valuable chemicals and materials from biomass. Current status quo in commercial biofuels production with conventional bioethanol and biodiesel technologies was presented. Novel approaches in the treatment of biomass were also discussed, involving efficient methods for conversion of lignocellulosic materials into already known and also novel chemicals and materials. A strong focus was set on the utilisation of waste materials for the production of conventional and advanced biofuels.

Recent Progress in Biorefineries as Introduced by Supercritical Fluid Science and Technology

Shiro Saka presented several novel processes based on supercritical conversion technologies. Besides water, methanol can also be used as a solvent in this process. The advantage of the supercritical processes is the elimination of the pretreatment step, which consumes lots of energy and requires expensive equipment.

Another advantage of the supercritical treatment is compatibility of waste oils as feedstock. Free fatty acids present in the waste oils, to a higher extent than in the raw vegetable oils, are converted to biodiesel, and the process is both more environmentally friendly and more efficient.

Another feature of the proposed processes is the conversion of glycerin to biofuels or biochemicals, which eliminates current overproduction of this by-product of biodiesel production.

A variety of chemicals could be obtained from lignin when supercritical treatment is applied, instead of burning lignin for energy purposes, which is the current practice. Finally, the presentation concluded with an option for integrated biorefinery that uses various waste materials, converting them to biofuels/ chemicals/energy, while making use of proposed supercritical technologies.

Advances and opportunities towards a biobased industry in Brazil

Telma Franco gave a general overview of the Brazilian biofuels industry with the focus on sugarcane processing. Brazil is the world's largest bioethanol producer with about 6 million cubic metres production in 2008. Only 15% of this amount is exported and the rest is used internally.

Ethanol in Brazil is produced from sugarcane in a combined process with sugar production. Today, the main challenge of the processing of Brazilian sugarcane is the development of 2nd generation technology for the conversion of fibrous residue (bagasse) into ethanol. At the moment bagasse is burned to provide the required process energy, while the surplus energy is converted to electricity and sold on the market.

Another component of the sugarcane plant is the cane trash, which is the field residue, dry leaves and tops of the plant. Current harvesting practice includes burning the sugarcane field prior to harvesting, where the cane trash is burned and the stalks are used for ethanol production. This practice is gradually being abandoned, and more and more mechanised harvesting is used. Cane trash represents one third of the whole plant on an energy basis. Using bagasse and cane trash in the process could lead to a doubling of ethanol capacity, which means a significant increase in the process efficiency.

In addition, activities of the large petrochemical companies and other biotech SME's in Brazil were discussed, with the most interesting development being the production of bioplastic by Braskem. Braskem initiated a project on production of green polyethylene from sugarcane ethanol. Such polyethylene is essentially the same as fossil based polyethylene. The only difference is that green polyethylene is produced from renewable resources.

Finally, some activities of Dedini, the largest process design and engineering company in Brazil, were discussed. Dedini is the supplier of almost 80% of the Brazilian market. They provide integrated solutions in sugarcane processing, so called turn-key system with the wholly integrated system of sugarcane crushing, extraction, fermentation, separation, as well as cogeneration plants with the option of selling extra electricity to the public grid.

One of the new plant concepts is the combination of ethanol and biodiesel production into one fully integrated plant. Biodiesel and ethanol are produced in the campaigns, with ethanol being used for esterification instead of currently used methanol.

BIOREF-INTEG

Current Status of Cellulosic Biofuels in the US

Bruce Dale's presentation discussed the incentives of the US Government, with the main objective being to reduce US dependency on foreign oil. Renewable resources, including biomass, are the key priorities in this regard. Dale points out the importance of pretreatment in the lignocellulosic ethanol as the central point of the ethanol processing. Currently sugarcane and corn processing to produce ethanol are well established processes, while lignocellulose-to-ethanol technology is at about half the way to commercialisation. Cost drivers in the 2nd generation ethanol production are raw materials with about 30% of the total processing costs, and the enzyme for hydrolysis with estimated 10% of the total costs, but only after the optimisation of the enzymes production.

The structure of the investments in the development of second generation ethanol in the US reveals that private and corporate funding schemes represent a major share in the investments. Dale predicts shifting of the research focus from processing to more pretreatment and upstream activities in the biomass chain.

In addition, Dale shows some details on the pretreatment method developed at Michigan State University. AFEX (Ammonia Fiber EXpansion) is an advanced method for pretreatment of lignocellulose, which uses ammonia in combination with high pressure and temperature for efficient preparation of the biomass for subsequent enzymatic hydrolysis. An economic objective of AFEX pretreatment is to produce free fermentable sugars at the cost of 0.13$/kg, which should be a reasonable starting point for further ethanol production.

Finally, Dale presented a biorefinery logistic scheme, with regional pretreatment and processing centres that are expected to result in sustainable rural economy, producing clean fuels from renewable resources.

All the presentations are available on: http://www.bioref-integ.eu/publications/

From left to right: Mladjan Stojanovic (AFSG), Shiro Saka (Kyoto University), Ray Marriott (University of York), Telma Franco (University of Campinas), Marc Londo (ECN), Bruce Dale (Michigan State University) and Hamid Mozaffarian (ECN)

Ten Kate Process

In 1998, the production activity of Ten Kate Vetten, one of the partners of the BIOREF-INTEG Consortium, was based on a standard rendering process; processing pig slaughter fats into pig fat and by-products, such as proteins and protein water.

Since 2002, a sustainable cooperation has been built between Ten Kate and three neighbouring companies Gelita, AFB and AVEBE. Below is a schematic overview of this industrial eco-cluster. Compared to the previous standard process, this industrial eco-cluster could be considered as an improved biorefinery.

The by-products; proteins and protein water are now integrated as raw materials for Gelita, a gelatin producing company. They are delivered at high temperatures to the neighbour Gelita, so no additional cooling and heating is necessary. Moreover, the by-products are upgraded to more valuable products, an important driving force for designing sustainable clusters. The pork proteins and fats, by-products of Gelita, are delivered back to Ten Kate for further processing into products.

The transport of the materials between Ten Kate and Gelita is achieved by a short pipeline without any involvement of trucks. AFB produces aromas and flavours from proteins from Ten Kate. The industrial cluster Ten Kate, Gelita and AFB receive their electricity and steam from the Dobbestroom CHP plant of the potato starch company AVEBE. The effluent from Gelita is treated at the AVEBE waste water treatment installation.

The produced lard oil at Ten Kate is used as a biofuel (comparable to rapeseed and sunflower oil), while the produced fats are sold to biodiesel producers who use it as a raw material.

Based on the above-mentioned cooperation, Ten Kate saved 52% in steam consumption in 2002, compared to 1998. The electricity consumption decreased by 36%, and the CO_2 emissions decreased by 55%.

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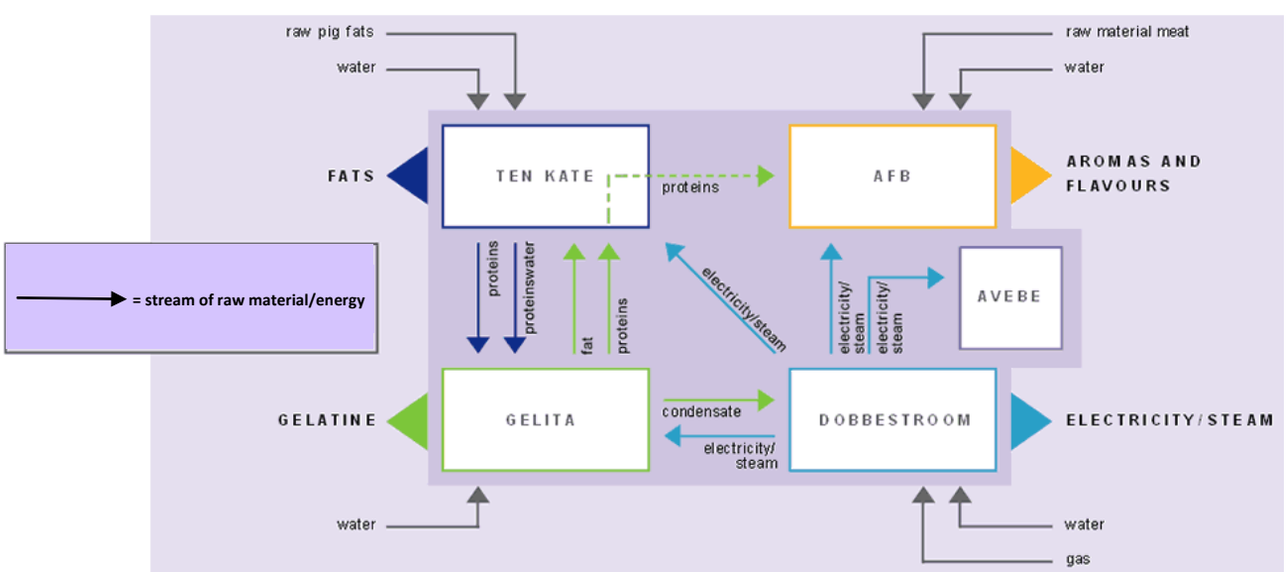

IEA Bioenergy Task 42 Biorefinery

Within IEA Bioenergy, the abbreviated name for the international bioenergy collaboration within the International Energy Agency (IEA), Task 42 covers the exciting field of biorefining.

Biorefinery is the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, and chemicals), and energy (fuels, power and heat). The implementation of biorefineries will contribute to the increased competitiveness and prosperity by responding to the need to supply a wide range of bio-based products and bioenergy in an economically, socially and environmentally sustainable manner. Biorefineries show promises for both industrialised and developing countries. New competences, job opportunities and markets are expected to be achieved; whereas biorefineries will contribute to the implementation of worldwide policies and initiatives.

The main activities of Task 42 are:

- Mapping of international biorefinery activities acting as an international stakeholder platform.
- Fostering necessary RD&D trajectories.
- Accelerating the deployment of developed technologies.

The activities, however, focus mainly on the countries participating in this specific Task within the international framework. Countries currently participating are: Austria, Canada, Denmark, France, Germany, Ireland, Italy, the Netherlands, plus the European Commission.

For further information visit: www.IEA-Bioenergy.Task42-Biorefineries.com

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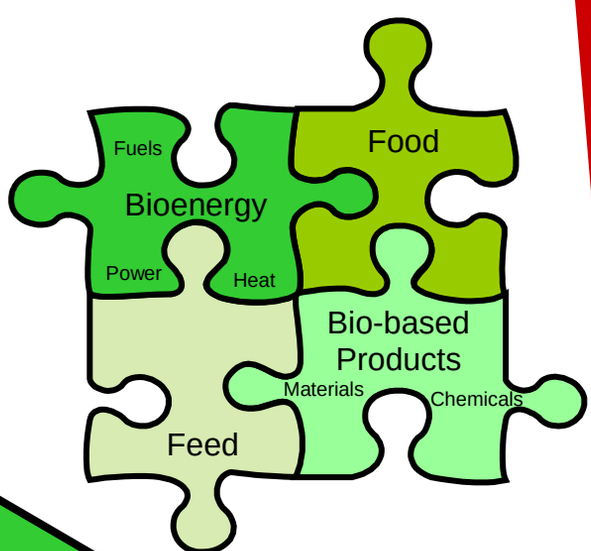
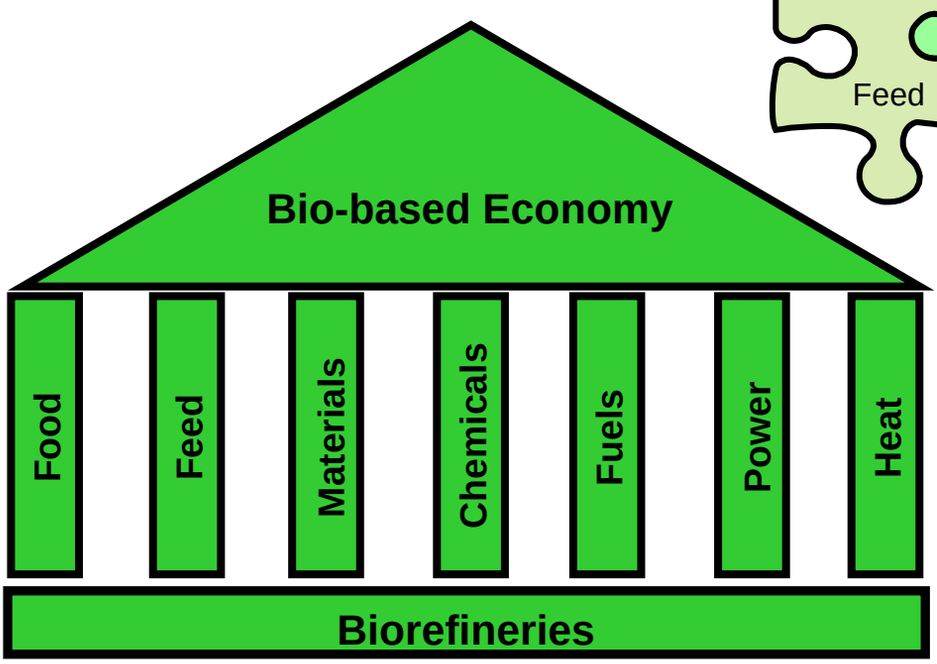




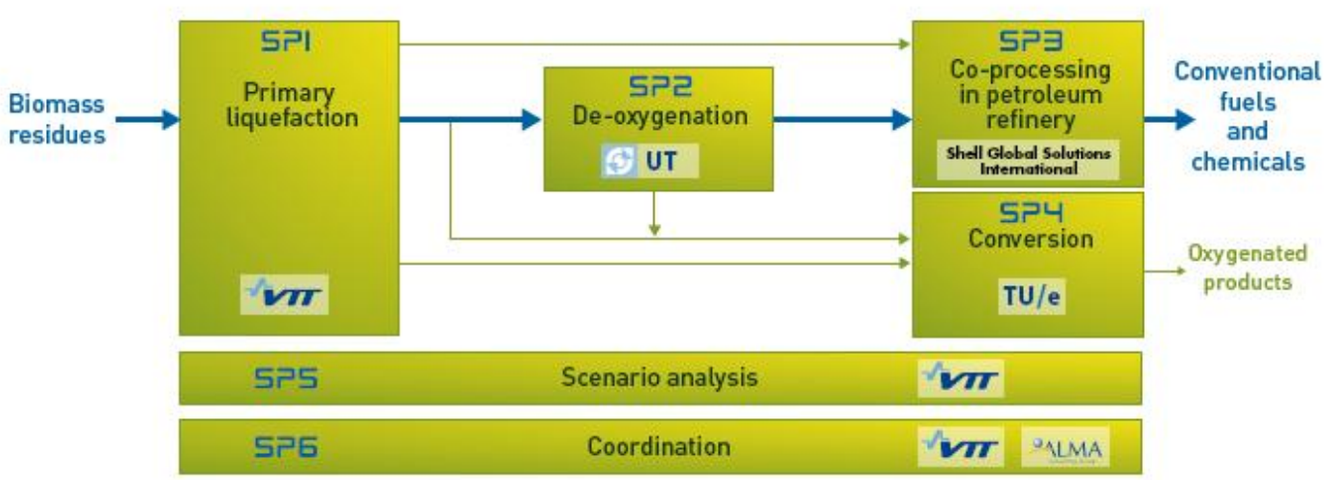
BIOCOUP

The BIOCOUP Integrated Project, coordinated by VTT in Finland is aimed at developing a chain of process steps to allow a range of different biomass feedstocks to be co-fed to a conventional oil refinery to produce energy and oxygenated chemicals.
The overall objective is to respond to the increasing demand of biofuels with a new innovative processing route.

The overall innovation derives from integration of bio-feedstock procurement with existing non-food industries (energy, pulp and paper) and processing of the upgraded biomass in existing mineral oil refineries. This will allow a seamless integration of biorefinery co-processing products to the end-consumers for products such as transport fuels and chemicals, and thus provide an important stimulus to biomass acceptance and further technological development of biomass production routes.

The project is organised as 6 Sub-Projects as shown below. An international consortium has been established to explore this innovative route calling for cogeneration of biofuels and chemicals.

www.biocoup.eu



Biorefinery Euroview

Biorefinery Euroview is an EU Specific Support Action (SSA) funded under the 6th European Framework Programme for Research (FP6). The project had a duration of two years and concluded in April 2009. The project was designed to assess the current status of biorefinery activities in Europe and to explore future scenarios for development. By systematically accounting for potential technical, political, social and industrial impacts of such scenarios, the output has been translated into policy formulations in this area.

Biorefinery Euroview involves 6 partners from 4 countries (France, Belgium, Hungary and Finland), plus 2 Europe-wide industry organisations representing the pulp and paper, as well as biotechnology sectors. The main results achieved include:

- An overview of the different biorefinery concepts.
- A survey of existing European and non-European biorefineries.
- An overview of current policies and socio-economic factors (worldwide and European) that could foster or limit the development of biorefineries in Europe.
- A range of forecasting scenarios for biorefinery development.
- Recommendations for biorefinery development support policies, including appropriate development support tools.

Policy Recommendations

The emerging concept of an integrated biorefinery is strongly cross-disciplinary. It is based on the use of biomass feedstock for fuels, chemicals and materials, along with several key developments in science and engineering. Currently, there are still a range of obstacles to the realisation of the potential of the biorefinery concept in Europe.

In order to further develop and implement this concept, it is crucial to have a policy environment that is conducive to both technology improvements and commercialisation. Qualitative as well as quantitative results of the Biorefinery Euroview project have been used to provide the foundations for sound policy advice.

This has resulted in the development of several recommendations that have been presented by Camille Burel (Europabio, Brussels) at the BioreFuture 2009 workshop in Brussels. These recommendations include standardised LCA methodologies for marketing biobased products, studying the need and impact of targets for bioproducts in specific sectors such as mulching films, taking a strategic approach to funding infrastructure projects, and addressing public concerns.

Overall, there is a clear indication that the EU would benefit from a cohesive legislation strategy to develop the fragmented existing markets for bio-based products, such as plastics and vitamins.

More information on these recommendations and other results of the Biorefinery Euroview project can be found on the Biorefinery Euroview website (http://iarpolefr.nexenservices.com/biorefinery/public/workshop3.html).

The proposed recommendations are:

1. Bring European research closer to industrialisation.
2. Development of Public Private Partnership for biorefinery demonstrators.
3. Take into account biobased carbon as CO_2 savings in the new climate legislation.
4. Allow Member States to reduce taxes for certain sustainable product categories: Eco- incentives at EU and national level.
5. Develop policies/incentives to support the reconversion of existing conventional production facilities to biobased ones.
6. Study the use and impact of targets for certain biobased product categories.
7. Accelerate approval process and shorten time to market.
8. Increase mobilisation of resources to support & optimise infrastructure & logistics.
9. Find alternative support to the starch "production refund".
10. Improve land productivity in- and outside EU (yield increase, reuse of degraded land, use of unused land, land management, cropping system, etc.) in a sustainable way.

BIOPOL

BIOPOL

www.biorefinery.nl/biopol

Whereas most of us in the biorefinery research community are clear about what we mean by "biorefining", there are many in industry, policy and academia for whom it means something slightly different, or even nothing at all. No doubt we can all recall conversations where we have struggled to precisely define even the term "biorefineries", let alone feel confident about exactly how they will become established as a new industrial model.

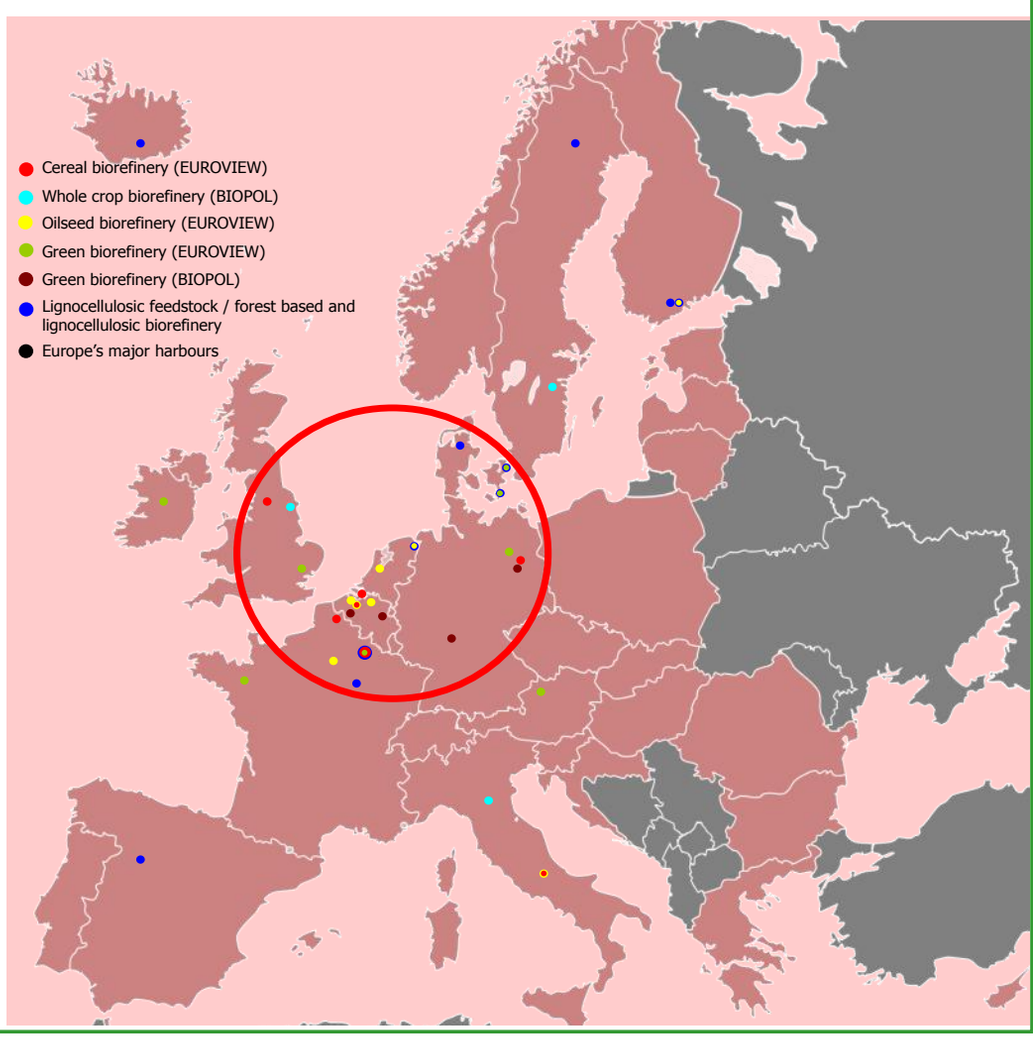
BIOPOL is a 2-year European Commission FP6 project. It was launched in 2007 to address the fact that the wider expectations for biorefineries have not yet yielded clear definitions for biorefinery concepts, or an understanding of the current status and prospective benefits of biorefining in Europe. Its work packages have assessed the status (technical, social, environmental, political and implementation) of innovative BIOrefinery concepts and the implications for agricultural and forestry POLicy.

The first task of the project was to survey existing biorefinery definitions and to adopt a set of working definitions and concepts. A common challenge with biorefinery definitions is to capture the spirit of advanced and integrated facilities without excluding exciting new independent developments in the production of biofuels, bioplastics or even foodstuffs. The broad definition that has been adopted by the BIOPOL project is the following:

> 'The sustainable processing of biomass into a spectrum of marketable products including energy'[1]

This definition encompasses three separately defined concepts that provided a working basis for the project: Green biorefineries using grass and wet feedstocks; Lignocellulosic feedstock

Continued overleaf...



BIOPOL ...continued

biorefineries using straw and woody biomass; and Whole Crop biorefineries using both lignocellulosic and grain fractions. Typical Green and Whole Crop biorefinery systems have been modelled and shown to have good energy balances and industrial potential[2].

To help understand the motivations and knowledge of influential actors, 4 important groups were surveyed for the project: Industry, Consumers, NGOs and policymakers. The main results of the industry survey showed a positive attitude, with 80% of the interviewed companies considering the biorefinery concepts to be promising[3]. Consumers were especially optimistic about the eco-friendliness and potential economic benefits of biorefineries. In general, it was found that biorefineries are a fairly new area for NGOs, many of whom are currently developing their position on the subject.

Policy-makers demonstrated a good working knowledge of biorefinery concepts and were positive, but slightly cautious, about the environmental and social contributions that biorefining can make[4]. Policies that currently focus on energy, forestry, agriculture and environment all showed potential overlaps, conflicts and synergies in the biorefinery area, but very few specifically refer to biorefineries.

To assess the implementation status of different biorefinery concepts in Europe, 34 existing or planned biorefineries were identified and mapped (see map on page 23), along with 45 biorefinery-related major R&D projects, pilot and demonstration projects[5]. By comparing these enterprises with the available feedstock resource across Europe it was found that only the Green Biorefineries and Scandinavian Lignocellulosic Feedstock Biorefineries have a strong correlation between location and locally available raw material.

The issue of plant location was further investigated by modelling the impact of various factors identified in the other work package that are considered to influence biorefinery establishment. Factors included: local land use, presence of oil and chemical plants and transport links. Comparing with the mapping, it emerges that the current policy regime favours establishment of larger biorefineries near ports and existing areas rather than in areas of rural regeneration.

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[1] Adopted from the IEA Task 42 Biorefinery
[2] See: Kamm *et al.* (2009) Biorefining of green biomass - technical and energetic considerations. *CLEAN.* 37(1) 27-30. Kamm *et al.* (Forthcoming) The Whole Crop Biorefinery - technical and energetic considerations. *Biofpr*. [submitted]
[3] See: Menrad *et al.* (2009) Interest of Industrial Actors in Bioreifnery Concepts in Europe. *Biofpr*. 3(3)384-394.
[4] See: Peck *et al.* (2009) Understanding, acceptance, and support for the biorefinery concept among policy-makers. *Biofpr*. 3(3)361-383.
[5] In collaboration with the Biorefinery Euroview project – see page 22 for more information.

BIOREF-INTEG Web Site

The BIOREF-INTEG website can be found at:

www.bioref-integ.eu

Here you will find a comprehensive overview of the project, including further details about all partners.

It also contains links to useful publications including:

- Previous issue of Biorefinery Researcher newsletter (Issue 1).
- Material from the following workshop: 'Knowledge Import from Outside EU on Advanced Biorefineries' (see page 16 of this issue for overview of the event).

Biorefinery Rodenhuize Dock – Ghent

The industrial site at the Rodenhuize dock in the port of Ghent (Belgium) is hosting the largest integrated bioenergy production complex in Europe. Six different companies collaborate in what can be seen as an excellent example of an integrated biorefinery: the complete value chain from raw material to different biofuels is present on a single production site.

AlcoBioFuel is producing 150,000 m^3 of bioethanol per year, using cereals and sugar by-products as raw materials. BIOREF-INTEG Consortium partner, Bioro produces 250,000 tonnes of biodiesel per year out of rapeseed oil. The oil is produced by the neighbouring American agricultural concern Cargill. Handling and storage of the raw materials such as grains and rapeseed is done by Euro-Silo. Also at the same site, fuel storage and blending facilities are provided by Oiltanking, which incorporate the produced biofuels into regular gasoline and diesel to supply the consumer. The energy required for the production process is supplied by Electrabel, producing heat and 80 MW biomass-derived green electricity.

The Rodenhuize dock is a classic example of excellent land use and a model of eco-efficiency and cost-efficiency. The industrial synergies between the companies are extensive in terms of supply of raw materials, energy exchange, waste management, logistics and economies of scale. The Rodenhuize dock can be reached by sea-going vessels of up to 80,000 tonnes and has excellent connections to its surroundings through a network of canal barges, railway freight and motorway connections. Next to the Rodenhuize dock is the Bio Base Europe Pilot Plant - a flexible and diversified pilot plant, capable of scaling up and optimising a broad variety of biobased processes up to the 10 m^3 pilot scale.

The Rodenhuize dock is the first site in Belgium that has reached such a scale of industrial integration and is destined to become a premium biorefinery site in Europe. With this development, the port of Ghent is rapidly progressing to pursue its ambition to become the prime bioport of Europe. This development is strongly supported by BIOREF-INTEG Consortium partner, Ghent University; a leading research and education centre with a strong research focus on industrial biotechnology and renewable resources. The city of Ghent provides further backing, with a strong policy towards sustainable development and focusing its development on green technologies. The whole development is further supported by Ghent Bioenergy Valley, a non-profit organisation supporting the development of sustainable bioenergy activities and resulting economic growth in the region of Ghent, Belgium.

For more info, please visit www.gbev.org.

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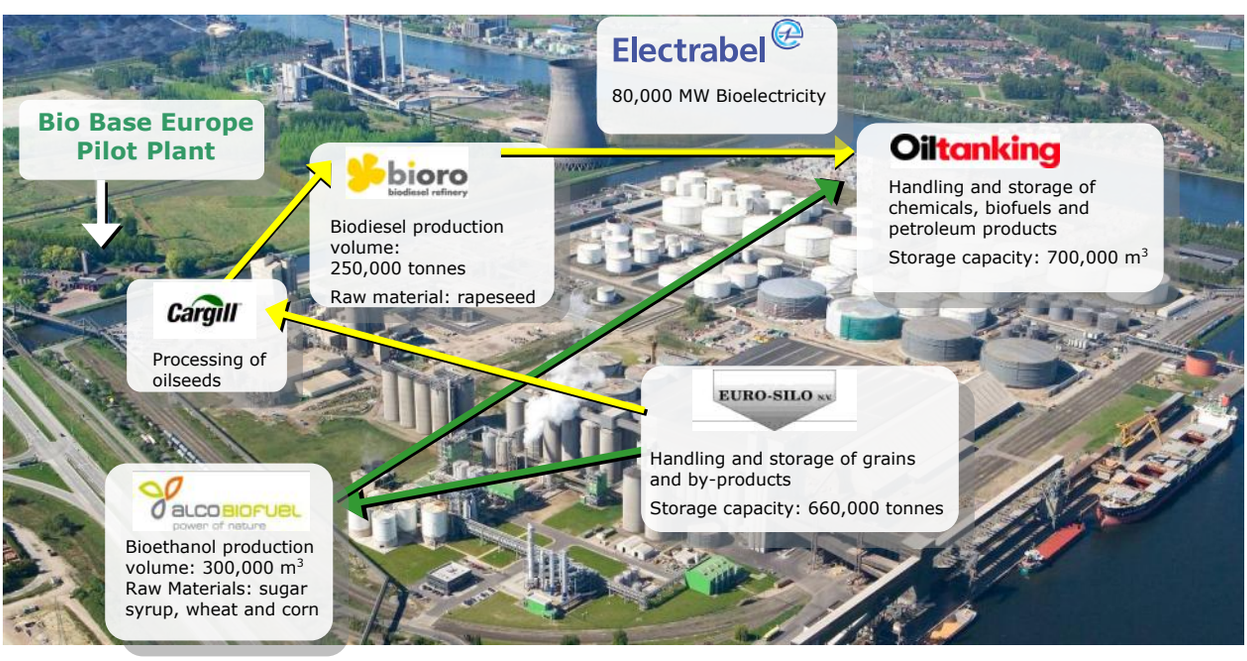

General News

Biorefinery Publications

A full list of Biorefinery Publications can be found on the SUSTOIL website—
http://www.york.ac.uk/res/sustoil/Pages/Publications.html

Biorefineries - Industrial Processes and Products, Status Quo and Future Directions
Birgit Kamm (Editor), Patrick R. Gruber (Editor), Michael Kamm (Editor), Wiley 2006

Coming Soon: Dr Abbas Kazmi and Professor James Clark are currently writing a chapter titled "Future Biorefineries" in a book called Renewable Raw Materials: feedstocks for the chemical industry, which will be published by Wiley

Sustoil sponsors RRB 5

Sustoil sponsors RRB 5: International Conference on

Renewable Resources & Biorefineries, 10-12th June 2009, Ghent, Belgium
http://www.rrbconference.com/

The fifth edition of the International Conference on Renewable Resources & Biorefineries will be held in Ghent, Belgium, from Wednesday June 10th till Friday afternoon June 12th 2009. Based on the previous RRB conferences, this conference is expected to attract about 300 international participants from more than 30 countries.

The three day international conference will consist of plenary lectures, oral presentations and a poster session and will take place at " De Bijloke" in Ghent. This conference aims at bringing together academic researchers, industrial experts, policymakers and venture capital providers to discuss the challenges emerging from the transition towards a biobased economy and to present new developments in this area. The conference will provide a forum for leading political, corporate, academic and financial people to discuss recent developments and set up collaborations. The conference further aims to provide an overview of the scientific, technical, economical, environmental and social issues of renewable resources and biorefineries.

The conference language will be English.

Last year RRB4 was held in Rotterdam, Netherlands and was a great success!

The conference organisers are seeking oral and poster contributions for the conference. Please submit your presentation proposal to the organising committee.

The conference program is organised in two parallel sessions and will cover the following topics:

- Policy
- Bioprocesses and Biorefineries
- Financing
- The Biobased Economy
- Sustainability
- Industrial Crops
- Biocatalysis
- Biobased Chemicals
- Industrial Fermentations
- Bioenergy
- Bioplastics and Biomaterials
  Thermochemical Processing
  Biomass

Events

JUNE 2009

5th - 7th
Rienergia 2009: Saving energy is not an option
Aosta, Italy

9th - 11th
Futuresource 2009 - Europe's sustainability event
ExCeL Centre, London, UK

10th
The Future of BioResources: Niche or Mainstream
SCI London, UK

10th - 11th
Cereals 2009
Vine Farm, Wendy, Nr Royston

10th - 12th
5th International Conference on Renewable Resources and Biorefineries RRB5
Gent, Belgium

14th - 16th
12th EuCheMS International Conference on Chemistry and the Environment
Stockholm, Sweden

14th - 17th
2nd International Congress on Green Process Engineering
Venice, Italy

15th - 16th
6th Green Chemistry and the Consumer Symposium
Kings Manor, York, UK

22nd - 23rd
Regions and Cities Implementing Sustainable Energy Strategies: The added-value of Satellite Information and Services
The Hague, The Netherlands

23rd - 26th
Green Week 2009: 'Climate Change: act and adapt'
Brussels, Belgium

25th - 26th
Citizens Generate Energy 2009; a Microgeneration Technology Exhibition
Parc Cinquantenaire, Brussels, Belgium

29th - 3rd
17th European Biomass Conference and Exhibition 2009
CCH-Congress Center, Hamburg, Germany

JULY 2009

6th – 10th
Green Technology
Entrepreneurship Academy
Incline Village, Nevada

18th - 24th
Green Chemistry Education Workshop
University of Oregon, USA

19th – 22nd
The World Congress on Industrial Biotechnology & Bioprocessing
Montreal, Canada

22nd – 23rd
ACS Summer School on Green Chemistry and Sustainable Energy
Colorado School of Mines
Golden, CO, United States

AUGUST 2009

3rd - 5th
1st International Conference on Green and Sustainable Chemistry
Furama Riverfront Singapore

31st - 4th
Bioenergy 2009. Sustainable Bioenergy Business. International Bioenergy Conference and Exhibition
Jyväskylä, Finland

SEPTEMBER 2009

2nd - 3rd
CISBAT 2009 - International Scientific Conference: 'Renewables in a Changing Climate: from Nano to Urban Scale'
Swiss Federal Institute of Technology (EPFL) in Lausanne, Switzerland

2nd - 4th
2nd Nordic Wood Biorefinery Conference
Finlandia Hall, Helsinki, Finland

16th - 18th
World Bioenergy & Clean Vehicles and Fuels
Stockholm, Sweden

18th - 20th
Hellenic Green Chemistry Network- 3rd Symposium Green Chemistry and Sustainable Development
Thessaloniki, Greece

21st - 22nd
eHYDROGENIA© - H2 Fuel Cells Millenium Convergence
Bucharest, Romania

21st - 25th
24th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC)
CCH Congress Center and International Fair
Hamburg, Germany

24th - 27th
RENEXPO®2009: International Trade Fair and Conference for Renewable Energy and Energy Efficient Building and Renovation
Fair and Convention Centre
Augsburg, Germany

OCTOBER 2009

20th - 22nd
European Forum for Industrial Biotechnology
Lisbon, Portugal

26th – 27th
Sustainable Innovation 09: Towards a Low Carbon Innovation Revolution
Farnham Castle, Farnham, UK

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