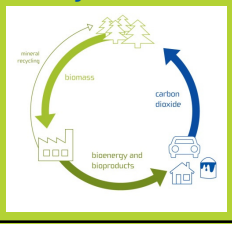
Integrated Project BIOSYNERGY (FP6)
Development of Lignocellulosic feedstock biorefinery for co-production of transportation fuels, chemicals, electricity and heat

J.H. Reith, R. van Ree, R. Capote Campos, R. R. Bakker, P.J. de Wild, F. Monot, B. Estrine, A.V. Bridgwater, A. Agostini



BIOSYNERGY Workshop 'ADVANCED BIOREFINERY CONCEPTS AND TECHNOLOGIES'
17th European Biomass Conference & Exhibition,
2nd July 2009, Hamburg, Germany.

Contents

- Background Lignocellulose Biorefinery
- Outline EC Integrated Project BIOSYNERGY (FP6)

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Lignocellulose as feedstock

- Low-cost feedstock (~50-60 € / ton d.w.; 3-4 € /GJ) e.g straw, wood
- Alternative source of sugars to replace starch and sugar agro feedstock
- High availability / Limited competition with food production
- High CO2 reduction when used for 2-G biofuels and biobased products
- Challenging feedstock: complex mixture of biopolymers (cellulose, hemicellulose, lignin) with differential behaviour to thermochemical and bioprocessing

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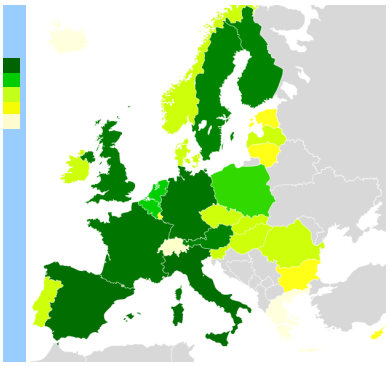
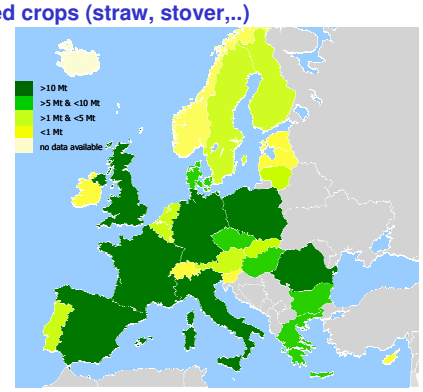
Availability of lignocellulose in the EU-27

1) **Residues from wood & wood products, pulp and paper production**
2) **Agricultural residues of food and feed crops (straw, stover,..)**



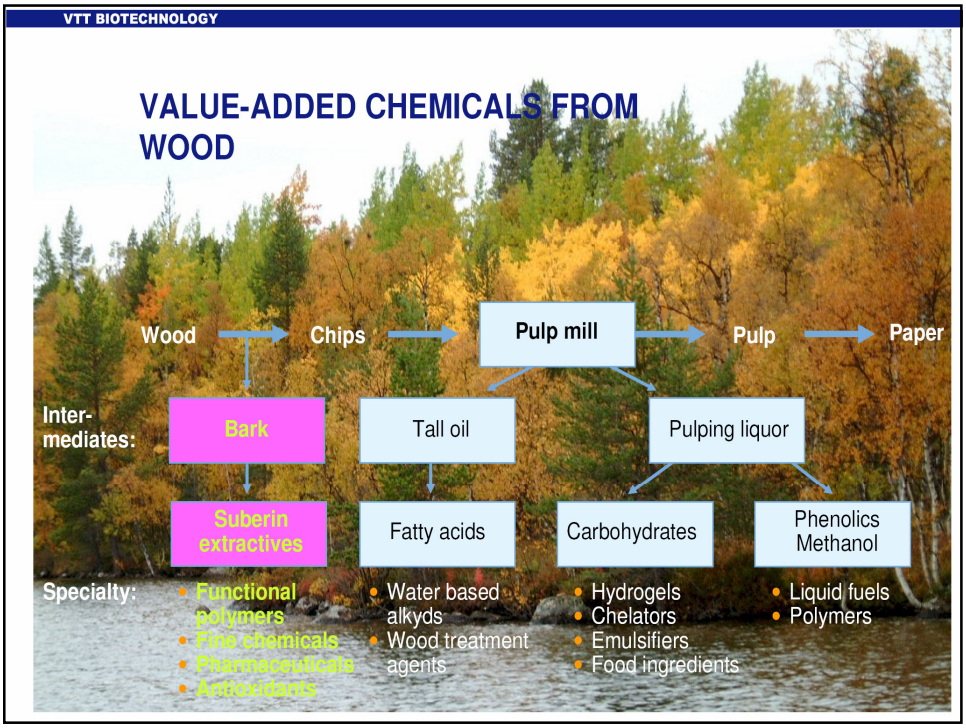
Production of wood and wood products, pulp, paper and paper products in EU27; Data 2004, Eurostat)



Agricultural residues of food and feed crops (data for 2000) in EU27+, Source: Refuel,2007

Environmentally compatible bio-energy potential EU-25: 7,950 PJ / 530 Mton d.b.(2010) to 12,350 PJ / 820 Mton d.b. (2030). Source: EEA, 2007.

VTT BIOTECHNOLOGY



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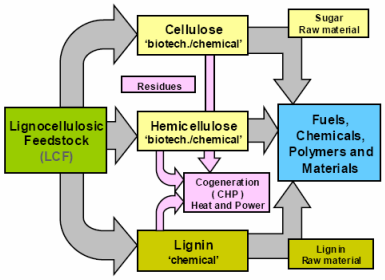
Lignocellulosic Feedstock Biorefinery

Biorefinery is the sustainable processing of biomass into a spectrum of marketable products and energy (IEA Definition)



- **Low-cost feedstock**: wood, straw, corn stover, residues and waste
- **Multiple products** : transportation fuels, chemicals, polymers, materials electricity and heat
- **Aim is to optimize revenues and minimize environmental impact**

Source: Kamm et al., Wiley-VCH, 2006

- Physical-chemical pre-treatment & fractionation of lignocellulose
- Enzymatic hydrolysis of (hemi)cellulose
- Fermentation / chemical conversion of intermediates
- System integration
  - CHP from process residues
  - Heat integration, water recycle

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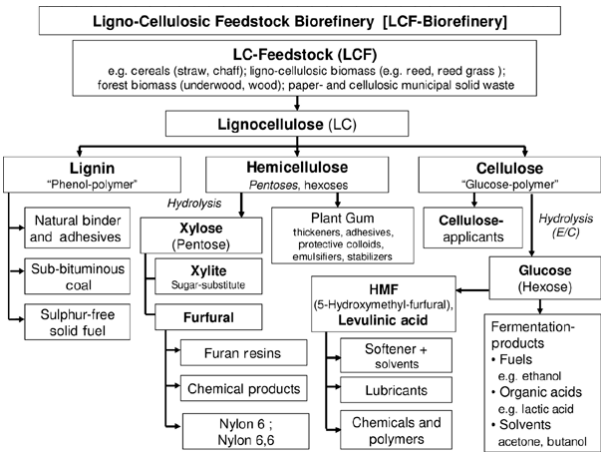
Potential products Lignocellulose Biorefinery



Kamm, B.; Gruber, P.R.; Kamm, M.; Biorefineries, Industrial Processes and Products, Wiley-VCH, 2006

Products generated via

- **Fractionation**
- (Thermo)chemical conversion and bioprocessing

Natural monomer structure largely preserved

Products have a good position in the market as "building blocks" e.g.:

- Furfural
- HMF/Levulinic acid
- Fermentation products

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Integrated Project BIOSYNERGY

BIOmass for the market competitive and environmentally friendly **SYN**thesis of bio-products – chemicals and/or materials – together with the production of secondary en**ERGY** carriers – transportation fuels, power and/or CHP – through the biorefinery approach.

- Development of integral cellulose-ethanol based LC Biorefinery
- Bioprocessing and thermochemical pathways combined
- Process development from lab-scale to demonstration at pilot-scale.
- Focus on valorisation of residues from cellulose ethanol production to make the production of this biofuel more cost competitive

EU FP6 Program: Contract No. 038994 – SES 6. EC Officer: Silvia Ferratini
Duration: 1-1-2007 – 31-12-2010 (48 months).
Budget: 13.4 M€, EC grant 7M€

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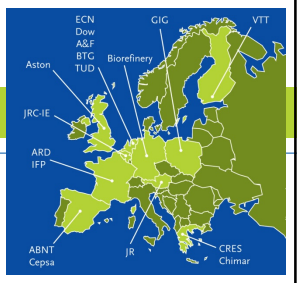
Consortium



17 partners from industry, R&D institutes and Universities from10 EU countries

1	Energy research Centre of the Netherlands (ECN)	The Netherlands	NL
2	Abengoa Bioenergía Nuevas Tecnologías S.A. (ABNT)	Spain	ES
3	Compania Espanola de Petroles S.A. (Cepsa)	Spain	ES
4	DOW Benelux B.V. (Dow)	The Netherlands	NL
5	VTT Technical Research Centre of Finland (VTT)	Finland	FI
6	Aston University (Aston)	United Kingdom	UK
7	WUR Agrotechnology and Food Innovations B.V. (A&F)	The Netherlands	NL
8	Agro Industrie Recherches et Développements (ARD)	France	FR
9	Institut Francais du Pétrole (IFP)	France	FR
10	Centre for Renewable Energy Sources (CRES)	Greece	EL
11	Biomass Technology Group (BTG)	The Netherlands	NL
12	Joanneum Research Forschungsgesellschaft m.b.H. (JR)	Austria	AT
13	Biorefinery.de (Biorefinery)	Germany	DE
14	Glowny Instytut Gornictwa (GIG)	Poland	PL
15	Joint Research Centre – Institute for Energy (JRC-IE)	The Netherlands	NL
16	Chimar Hellas S.A. (Chimar)	Greece	EL
17	Delft University of Technology (TUD)	The Netherlands	NL

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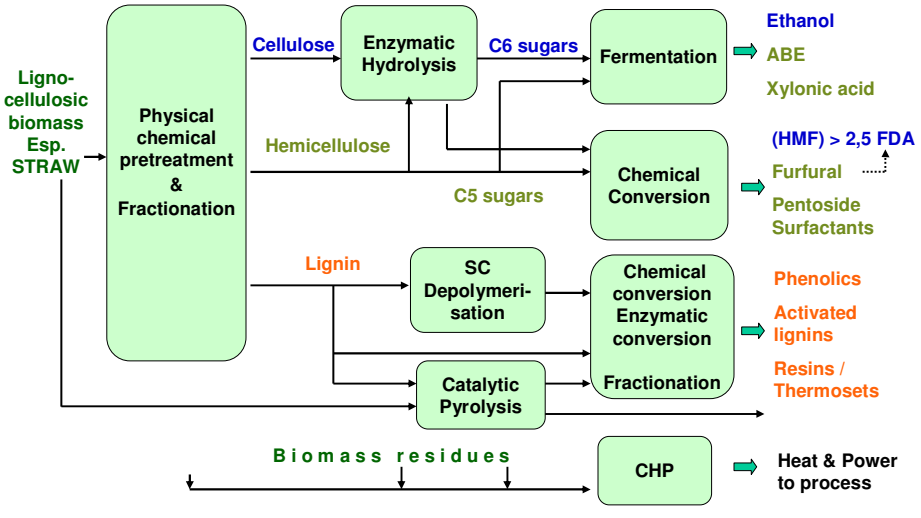
Product lines in the IP BIOSYNERGY

Multi-product biorefinery, Focus on residues cellulose ethanol i.e. C5 and lignin valorisation



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Conceptual design biorefinery plant (WP5)

Basic design for integral lignocellulose biorefinery plant at an existing cellulose ethanol site: AB BCyL demonstration plant, Salamanca.

BCyL cellulose ethanol pilot plant AB, Salamanca, 5 Million L EtOH / year

- Targeted outputs:
  - bio-ethanol,
  - chemicals & materials
  - CHP
- maximized revenue and minimized environmental impact

Partners: ABNT, Aston, ECN

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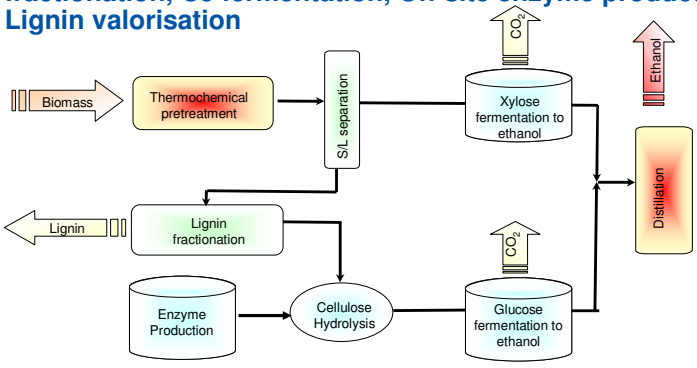
Conceptual design biorefinery plant (WP5)

- **Integral model for the BCyL lignocellulose to bio-ethanol process scaled-up to 400 ton/day of wheat straw incl. biomass fractionation, C5 fermentation, On-site enzyme production, Lignin valorisation**



- **Economic model to evaluate design concepts and scenarios**

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Work Packages

Man — WP 0 – Management activities

RTD
- WP 1 – Advanced physical/chemical fractionation
- WP 2 – Innovative thermo-chemical conversion
- WP 3 – Advanced biochemical conversion
- WP 4 – Innovative chemical conversion and synthesis
- WP 5 – Conceptual design Biorefinery pilot-plant BCyL of ABNT in Salamanca
- WP 6 – Integral biomass-to- products chain design, analysis and optimisation

Demo — WP 7 – Demonstration at pilot-scale

T/Diss — WP 8 – Training and knowledge dissemination

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Workshop Programme

Workshop Programme, 02 July 2009

13:30-14:00	*Arrival of participants, registration,*
14:00-14:15	**Welcome and Project overview - J.H. Reith (ECN, NL), BIOSYNERGY Project Coordinator**
14:15-14:45	**Advances in physical and chemical fractionation of biomass – Rob Bakker (A&F, NL)**
14:45-15:15	**Innovative thermochemical conversion of biomass – Paul de Wild (ECN, NL)**
15:15-15:45	**The generation and evaluation of integrated bioenergy chains for second generation biofuels - Katie Chong and Tony Bridgwater (Aston University)**
15:45-16:00	*Coffee Break*
16:00-16:30	**Innovative chemical conversion and synthesis – Zoi Nikolaidou (CHIMAR, GR)**
16:30-17:00	**Advanced biochemical conversion of biomass (ABE fermentation) – Frédéric Monot (IFP, FR)**
17:00-17:15	**Discussion and closing - J.H. Reith (ECN, NL), BIOSYNERGY Project Coordinator**

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Conclusions & perspectives

- Development of LC Biorefinery –combining bioprocesses, chemical processes + CHP – offers good perspectives to fully exploit the potential of lignocellulose.
- Biosynergy RTD shows good progress and provides a basis for large-scale valorization of C5 sugars and lignin. Scale-up is planned for two C5 conversion routes.
- Pretreatment and enzymatic hydrolysis are critical for fractionation and therefore for the quality of the end products and techno-economic feasibility:
  - Pretreatment technologies need to be optimised toward a particular goal.
  - Enzymes are a major processing tool in the LC Biorefinery. Further development and cost reduction are needed.
  - Integrated development Feedstock-pretreatment-hydrolysis-fermentation is required.

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Conclusions & perspectives

- Lignin valorization (at least in part) to chemicals is an important tool for economic profitability and for reduction of the carbon footprint.
- Direct application of (organosolv) lignin, catalytic thermochemical processing (pyrolysis) and enzymatic lignin conversion show promising results for lignin valorization
- Separation technology development is vital for both biochemical and thermochemical processing technologies
- Development of integrated processes / chain optimisation is a major success factor and is also one of the major challenges. This includes process integration but also the integration of environmental and socio-economic aspects.

Participants IP BIOSYNERGY

Alessandro Agostini
Bert Annevelink
Ricardo Arjona Antolin
Eleftheria Athanassiadou
Philippe Aubry
Caroline Aymard
Rob Bakker
Cecile Barrere-Tricca
David Baxter
Bert van de Beld
Rolf Blaauw
Carmen Boeriu
Anthony Bresin
Tony Bridgwater
Reyes Capote Campos
José Caraballo
Marianna Charisi
Katie Chong
Myrsini Christou
Ioannis Eleftheriadis
Maria Fe Elia Miguel
Daan van Es
Boris Estrine
Silvia Ferratini
Antzela Fivga
Maria Georgiadou
Richard Gosselink
Gareth Griffiths
Pablo Gutierrez
Elma Gyftopoulou
Henk Hagen
Paulien Harmsen
Jacco van Haveren
Regina Heddes
Eline Heijnen
Yvon le Henaff
Bwee Houweling-Tan
Wouter Huijgen
Wiebren de Jong
Gerfried Jungmeier
Sjaak Kaandorp
Birgit Kamm
Richard op den Kamp
Boyan Kavalov
Kees van Kekem
Evert Leijenhorst
Marcel van der Linden
Raimo van der Linden
Angelika Lingitz
Ana María Lopez Contreras
Michael Lukas
Michael Mandl
Gianluca Marcotullio
Frederic Martel
Maija-Liisa Mattinen
Frederic Monot
Electra Papadopoulou
Miguel Pérez Pascual
Merja Penttila
Wolter Prins
Jacinta van der Putten
René van Ree
Hans Reith
Anna Rogut
Jan Rogut
Petra Schönicke
Philippe Schild
Agnes Maria Stepan
Jan Stoutjesdijk
Muzaffar Syed
Tarja Tamminen
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Arnoud Togtema
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Thank you for your attention!

More information: Hans Reith, coordinator IP BIOSYNERGY
+31-(0)224-564371
reith@ecn.nl
www.ecn.nl

www.biosynergy.eu

www.biobased.nl/lignovalue
www.biorefinery.nl
www.biorefinery-euroview.eu
www.biorefinery.nl/biopol