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Lignocellulosic biomass as potential substrate for the White Biotechnology

Joachim Venus

Deutsch-Russisches Jahr der Bildung, Wissenschaft und Innovation 2011/12
Российско-Германский год образования, науки и инноваций 2011/12

BIO TECHNICA
Hannover, 11–13 October 2011

German-Russian Cooperation Network Biotechnology
Federal Ministry of Education and Research

History

- 1927 Experimental farm of the Agricultural University Berlin
- 1933 Independent research center on agricultural mechanization
- 1952 Central institute of agricultural engineering of East Germany
- 1992 Reestablished after the reunification of Germany

Today:

Leibniz Institute for Agricultural Engineering Potsdam-Bornim

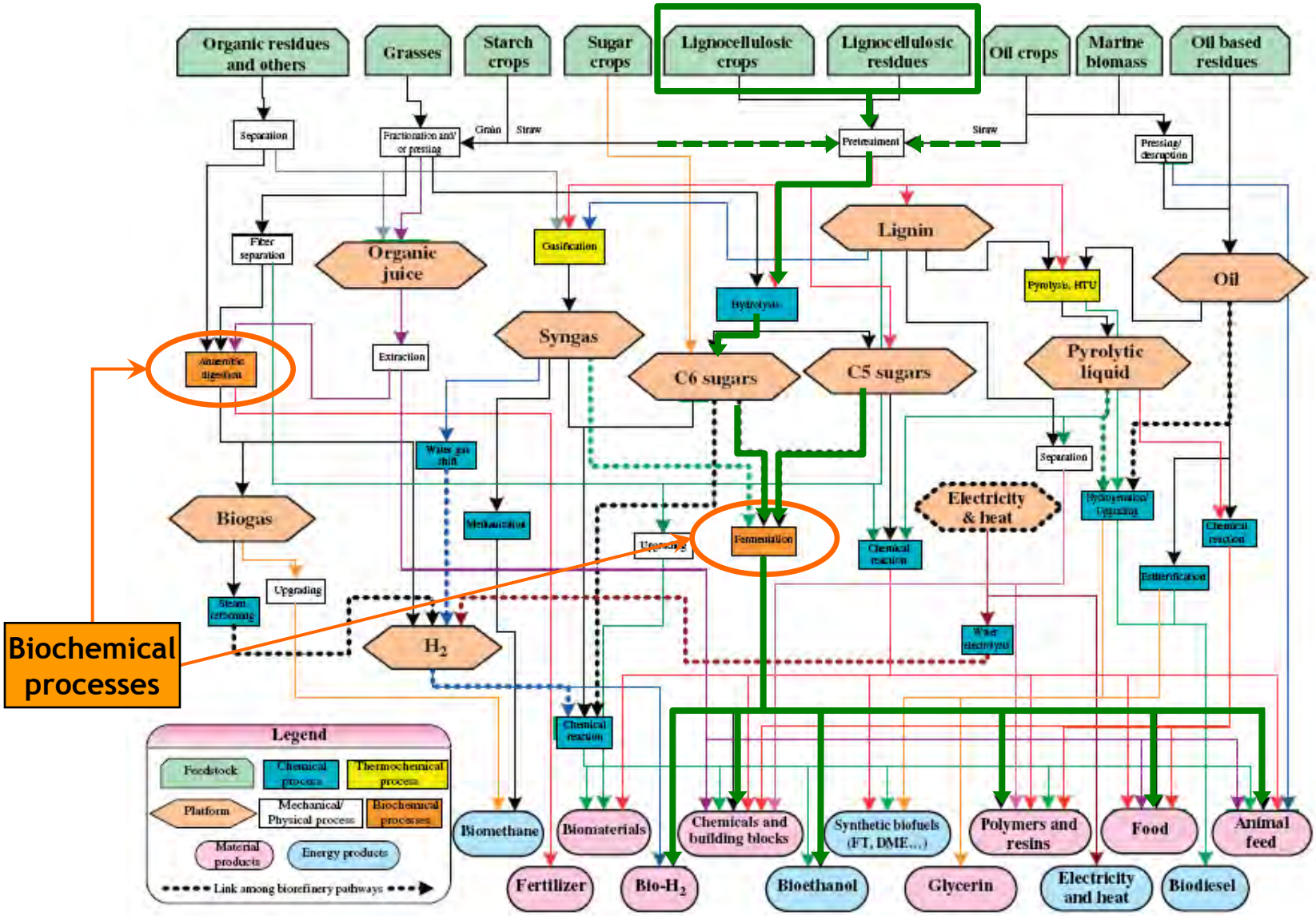
- member of the Leibniz Association

Leibniz Gemeinschaft

Using renewable resources for industry

Biobased products and processes from renewable resources not only help preserve the environment and climate, but also make a significant contribution to the structural change from a petrochemical to a **biobased industry**, with related opportunities for growth and employment. **Industrial biotechnology, also known as white biotechnology**, is an important driving force in this transition.

Overview of current platforms, products, feedstocks and conversion processes



www.IEA-Bioenergy.Task42-Biorefineries.com

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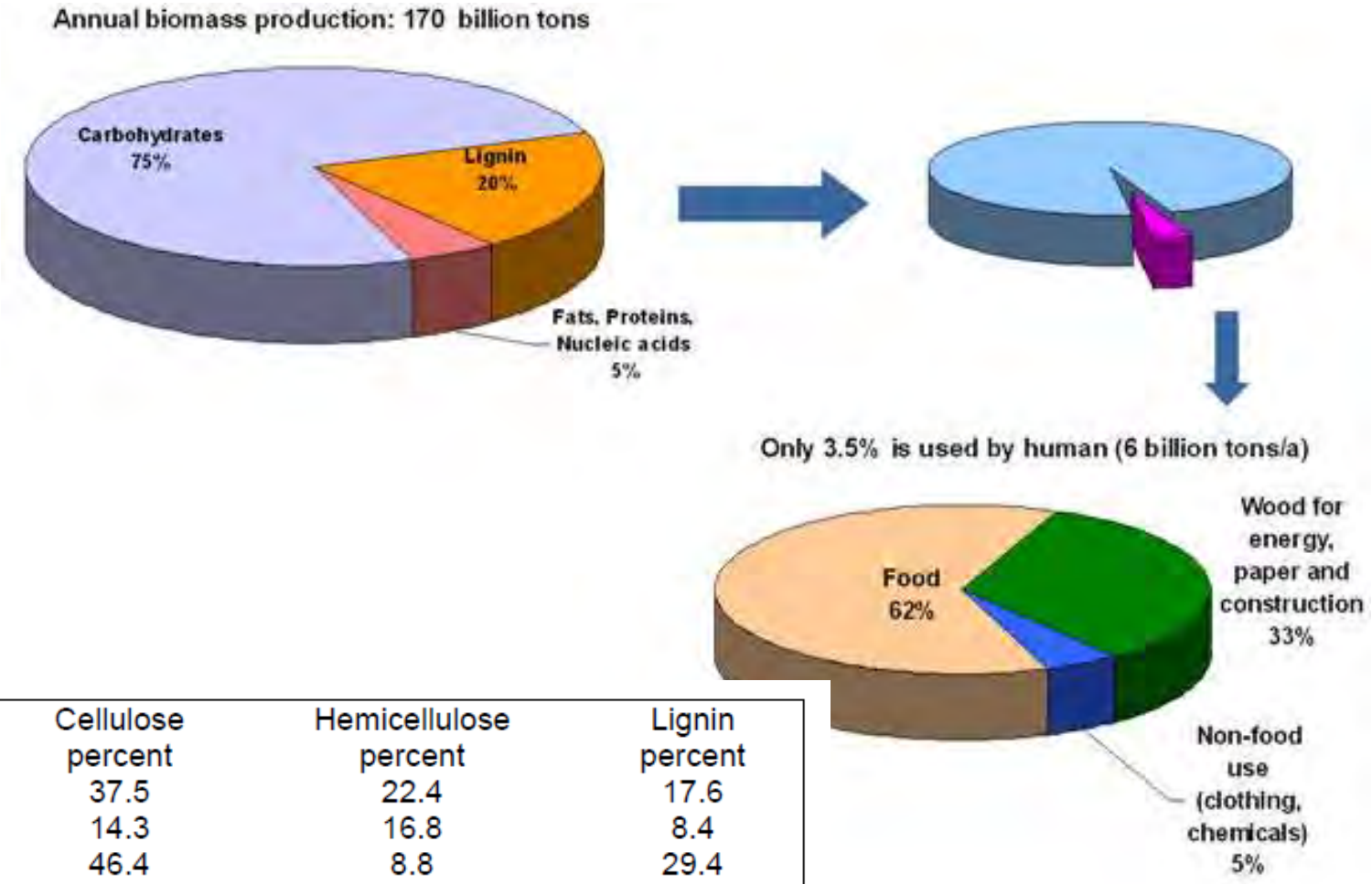
Biomass availability



Biomass	Cellulose percent	Hemicellulose percent	Lignin percent
Corn stover	37.5	22.4	17.6
Corn fiber	14.3	16.8	8.4
Pine wood	46.4	8.8	29.4
Poplar	49.9	17.4	18.1
Wheat straw	38.2	21.2	23.4
Switchgrass	31.0	20.4	17.6
Bagasse *	34.6	19.4	20.0

Source: Mosier et al.

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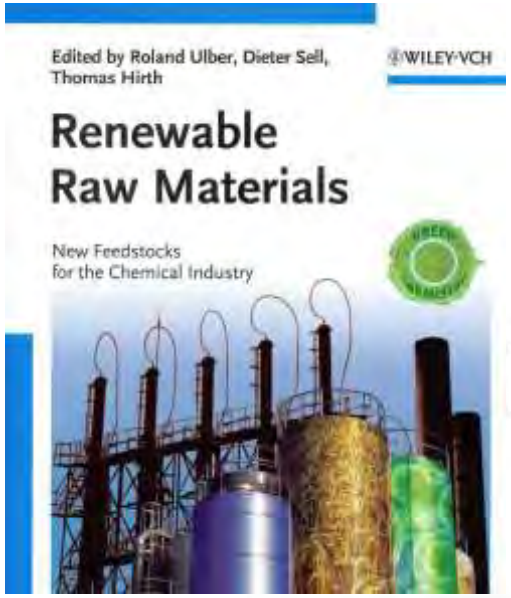
Lignocellulosic feedstocks



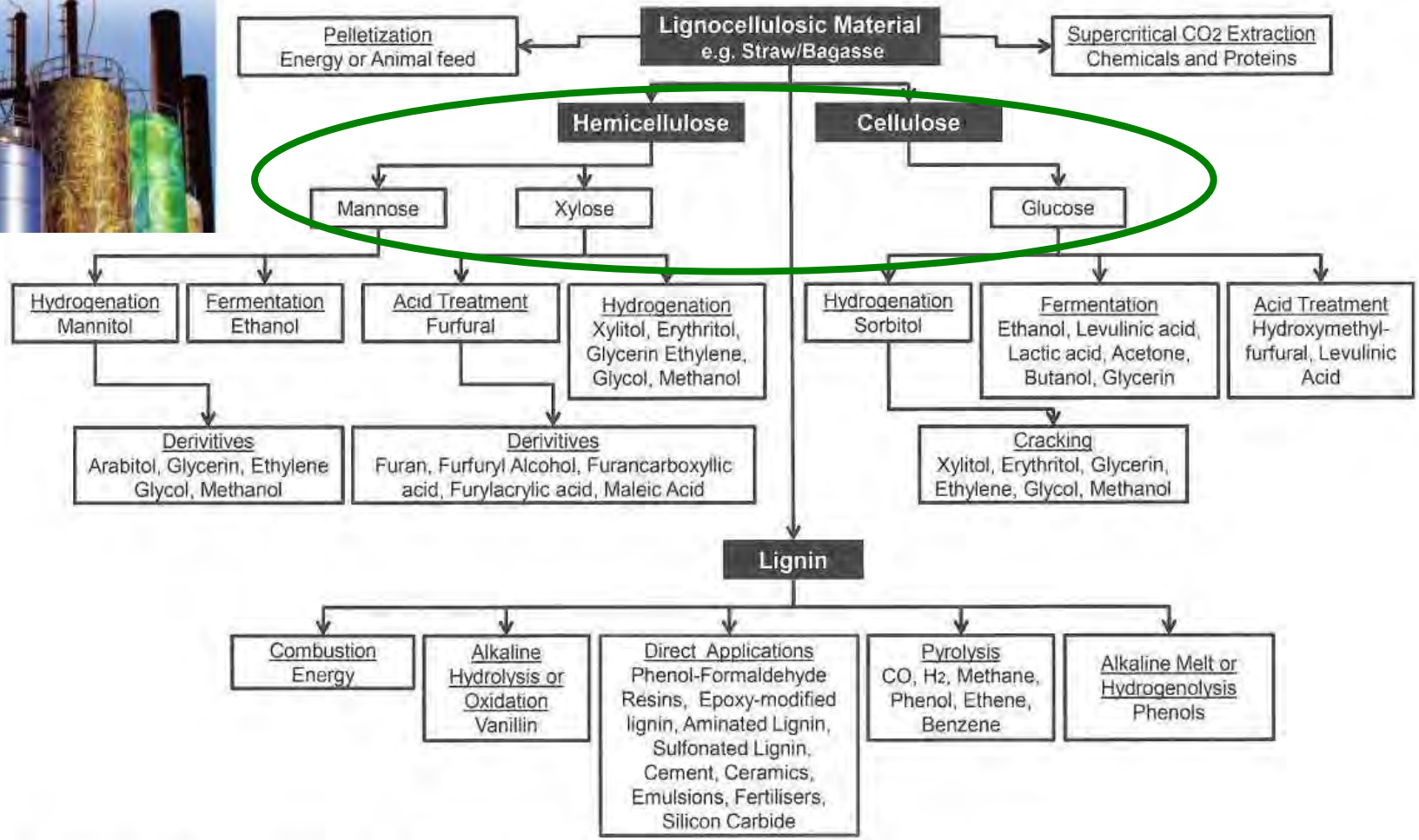


Figure 6.5 Examples of chemicals that can be derived from lignocellulosic feedstocks.

Examples of biomass resources

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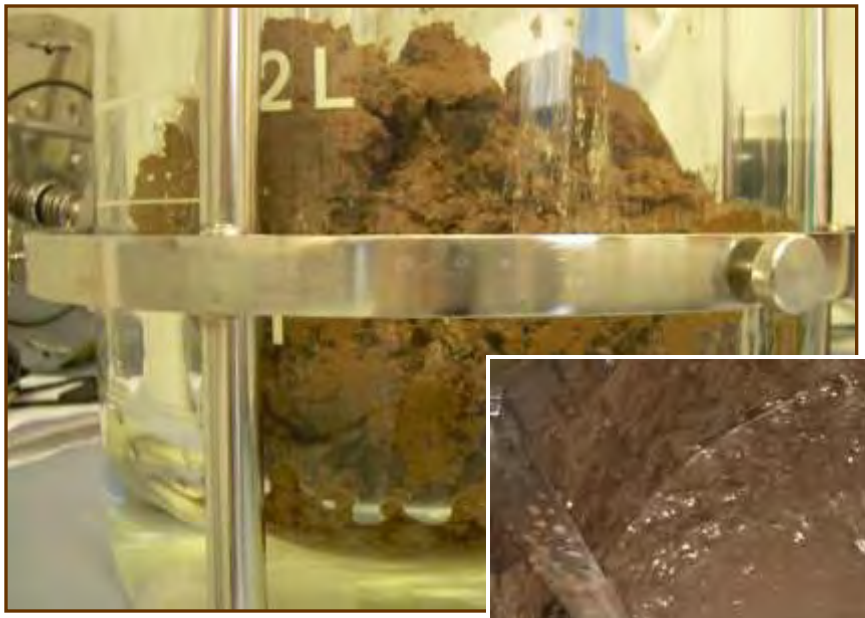
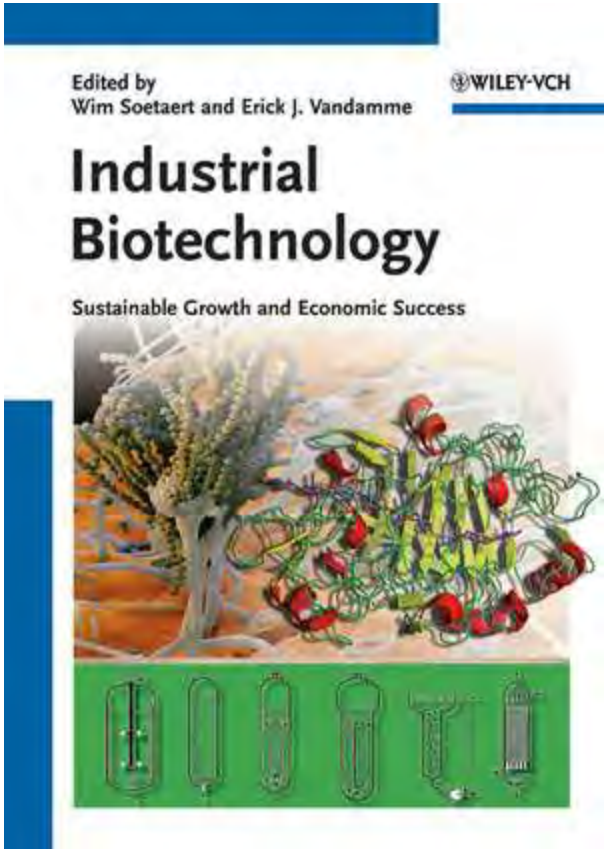

2 L


4
3
2L

Production figures and prices for fermentation products



2010	World production (ton/year)	World market price (€/kg)
Bio-ethanol	50.000.000	0,40
L-Glutamic acid	1.500.000	1,50
Citric acid	1.500.000	0,80
L-Lysine	800.000	1,50
Lactic acid	**250.000**	**1,50**
Vitamin C	80.000	8,00
Gluconic acid	50.000	1,50
Antibiotics (bulk products)	30.000	150,00
Xanthan	20.000	8,00
L-Hydroxyphenylalanine	10.000	10,00
Antibiotics (specialities)	5.000	1.500,00
Dextran	200	80,00
Vitamin B12	3	25.000,00

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Top Value Added Chemicals from Biomass

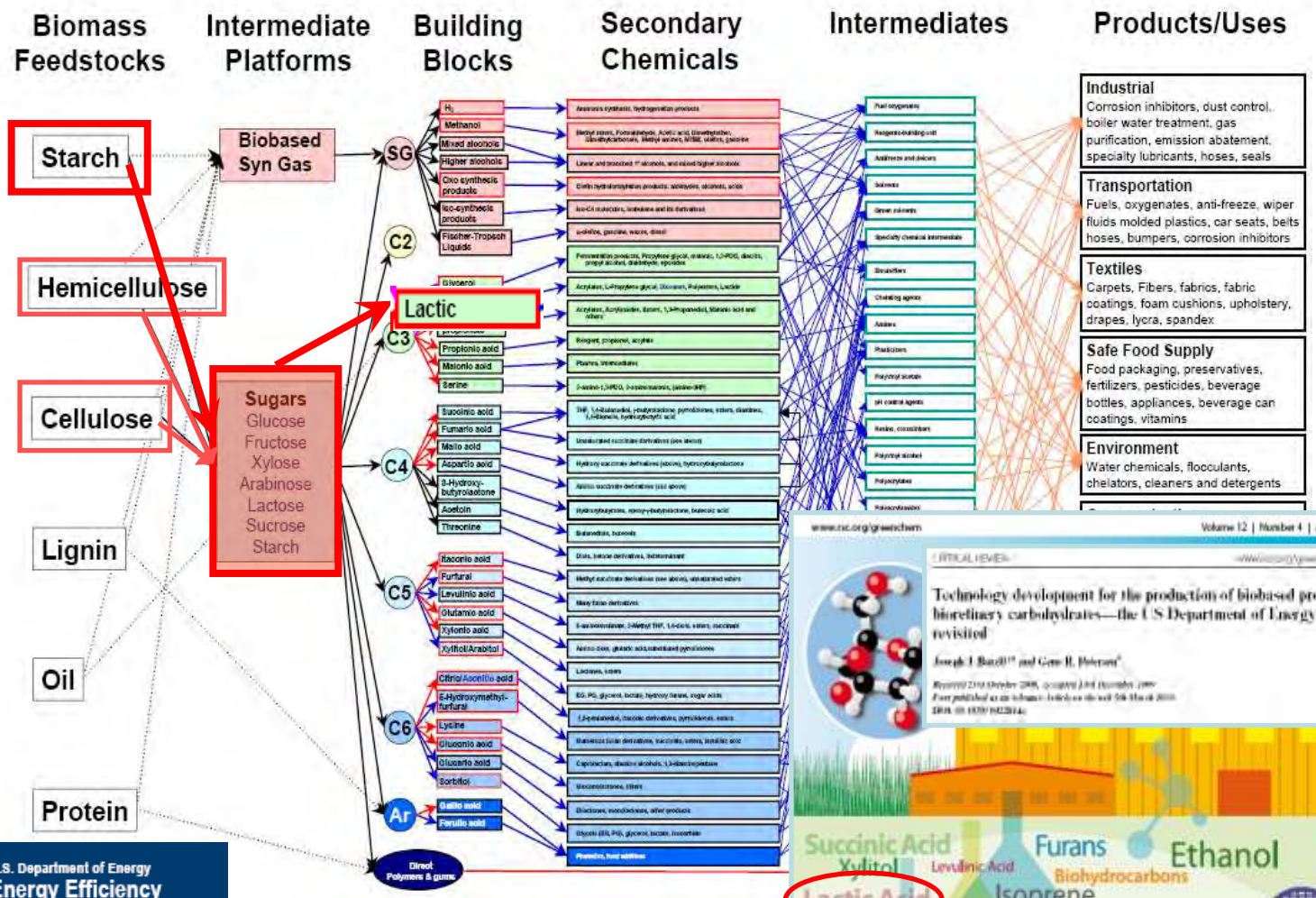


Figure 3 – Analogous Model of a Biobased Product Flow

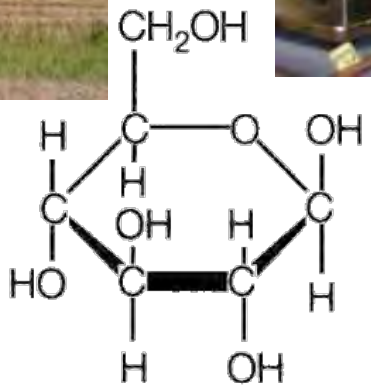
U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Volume I — Results of Screening for Potential Candidates from Sugars and Synthesis Gas (August 2004)

Biorefinery-concept for (1st, 2nd, 3rd…?) biomass feedstocks

- BIOCONVERSION -

Vodnar, D.C.; Venus, J.; Schneider, R.; Socaciu, C.: Chem. Eng. & Technol. 33(2010) 468-474



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Leibniz-Institut für Agrartechnik
Potsdam-Bornim e.V.

SynRg®

A cluster of 17 partners will explore the recycling of vegetable raw materials along the complete value chain
Start of project: July 1st, 2009
http://www.synrg-cluster.de/index.html

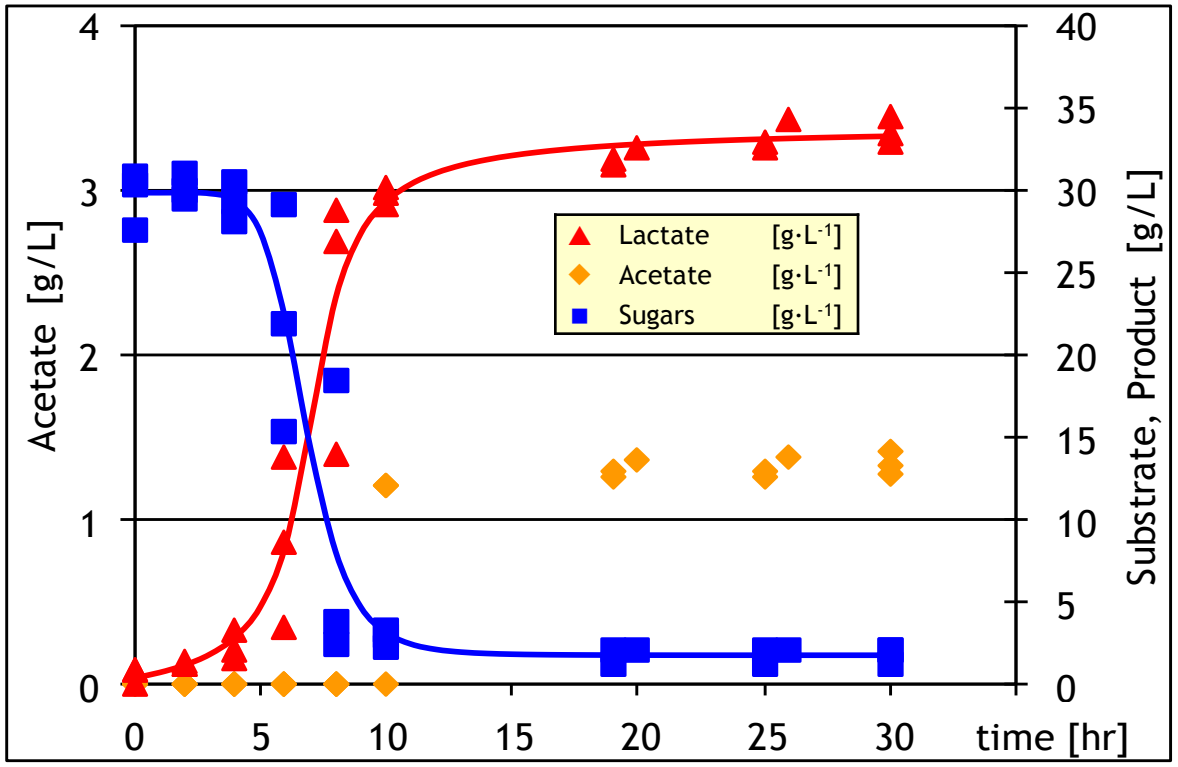
FACHAGENTUR NACHWACHSENDE ROHSTOFFE e.V.

WP2: Technologies and Processes for the harvest, pre-treatment, and purification, in particular: utilization of (oilseed) residues

Gene | Pflanzen | Anbau | Ernte | Trennung | Produktion

TP1 | TP2 | TP3

Substrate uptake & product formation of strain A32 (fermentation broth based on rapeseed meal)



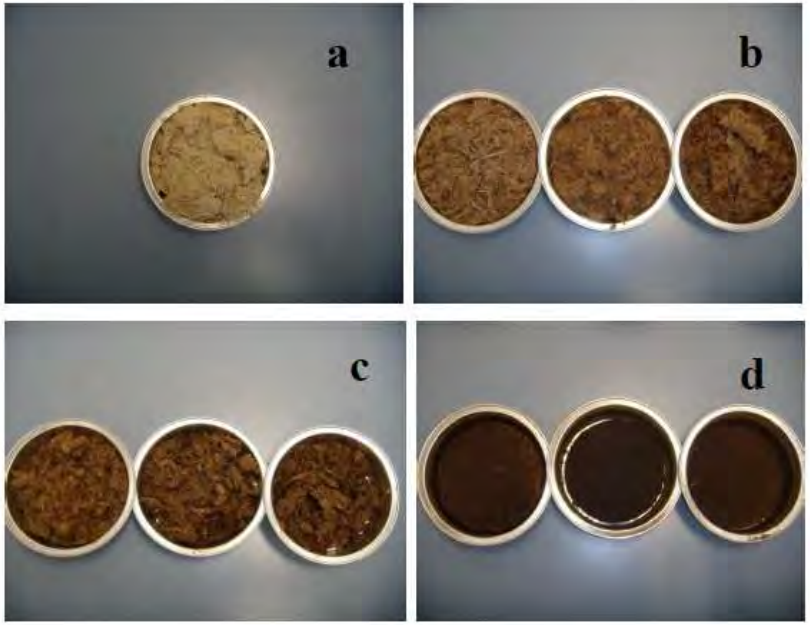


Figura 1 – Fotos de bagaço da cana de açúcar: **(a)** sem tratamento térmico; **(b)** 180°C; **(c)** 200°C e **(d)** 220°C por 5, 10 e 15 minutos (da esq. para dir.).

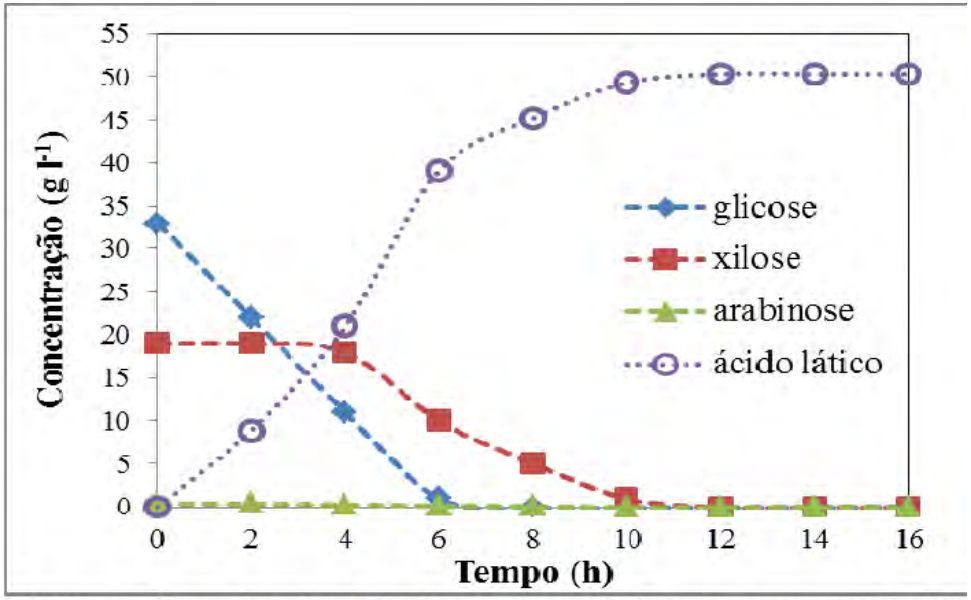


Figura 4 – Produção de ácido lático e consumo de açúcares presentes no meio MRS modificado contendo hidrolisado de bagaço (glicose 33 g l^{-1}, xilose 19 g l^{-1}, arabinose 0,4 g l^{-1}, extrato de levedura 15 g l^{-1}, K_2HPO_4 2 g l^{-1}, $MgSO_4$ 0,1 g l^{-1} e $MnSO_4$ 0,04 g l^{-1}).

XVIII Simpósio Nacional de Bioprocessos
Caxias do Sul/RS - 24 a 27 de julho de 2011
SINAFERM 2011

Hidrólise Térmica de Bagaço da Cana-de-açúcar para Produção Homofermentativa de L-Ácido Lático

Giselle de Arruda Rodrigues[1], Joachim Venus[2] e Telma Teixeira Franco[1]

ATB

„Enzymes for lignocellulosic feedstock degradation and production of sugars (C6, C5) and value added products“ (2010-1.1-203-070-026, 2010 - 2013)

Bundesministerium für Bildung und Forschung

BMBF / DLR

FKZ RUS 10/128

DLR Deutsches Zentrum für Luft- und Raumfahrt

A.N.Bach Institute of Biochemistry of Russian Academy of Sciences, INBI
www.inbi.ras.ru
Leninsky Prospect, 33-2
119071 Moscow

- *Targets of Russian Partner (INBI):* **Enzymes** for **lignocellulosic feedstocks degradation** and production of sugars (C6, C5) and value added products

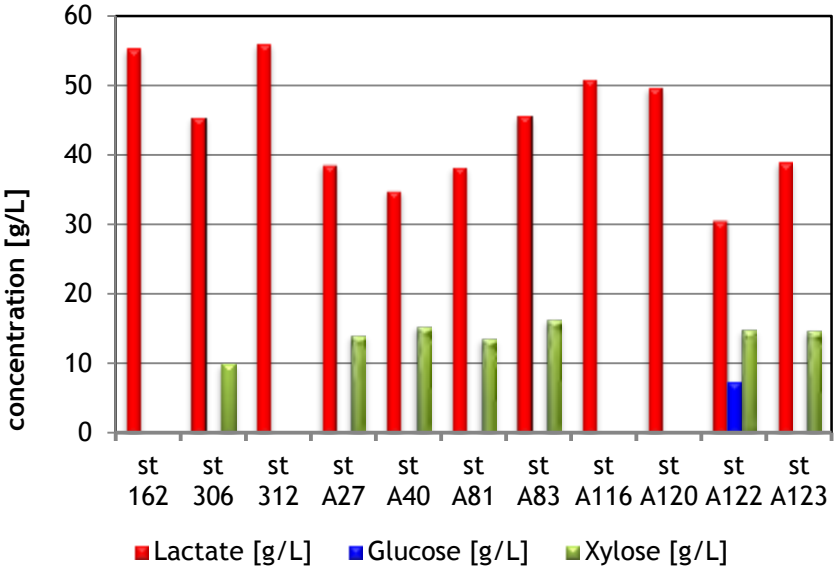
Leibniz-Institut für Agrartechnik Potsdam-Bornim e.V., ATB
www.atb-potsdam.de
Max-Eyth-Allee 100
D-14469 Potsdam

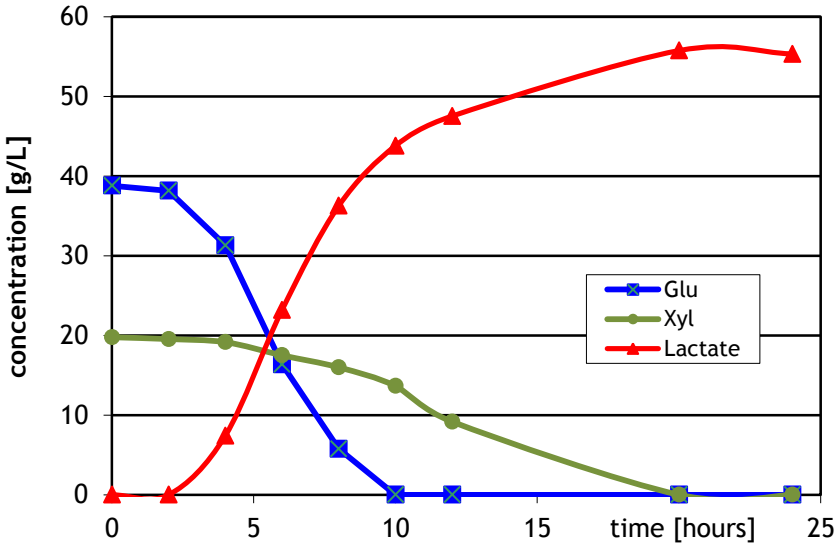
- *Targets of German Partner (ATB):* **Conversion** of simple sugars (C6, C5) to added value products – fuels, solvents, **organic acids**, biopolymers, misc. organics

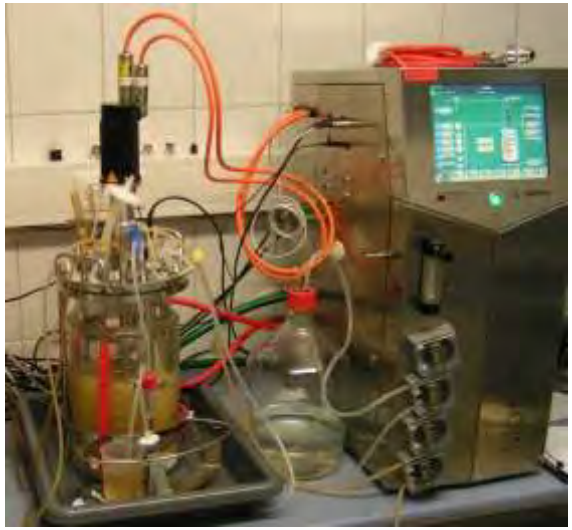
ATB

Sugar uptake & product formation in lab-scale

(broth based on synthetic medium containing glucose and xylose)







The Knowledge Based Bio-Economy (KBBE) in Europe: Achievements and Challenges

Full report

4.5.2.2 Demo projects as a tool to shorten time to market

…demonstration projects that facilitate the development of **flexible, research-oriented pilot plants to validate the concept of integrated and diversified biorefineries**. Pilot infrastructures to demonstrate the technologies and to test new feed-stocks and pre-treatment processes already exist to some extent but these need to be complemented by **larger scale demonstrators to verify scale-up** of processes. The initial construction of **biorefinery pilot and demonstration plants is not only a costly undertaking but it also involves bringing together market actors along a new and highly complex value chain**…

Brussels, 14 September 2010

Universities, Research Institutes, SMEs
Applied &
basic research

Industry
Industrial application
Large-scale production

Pilot plant facility

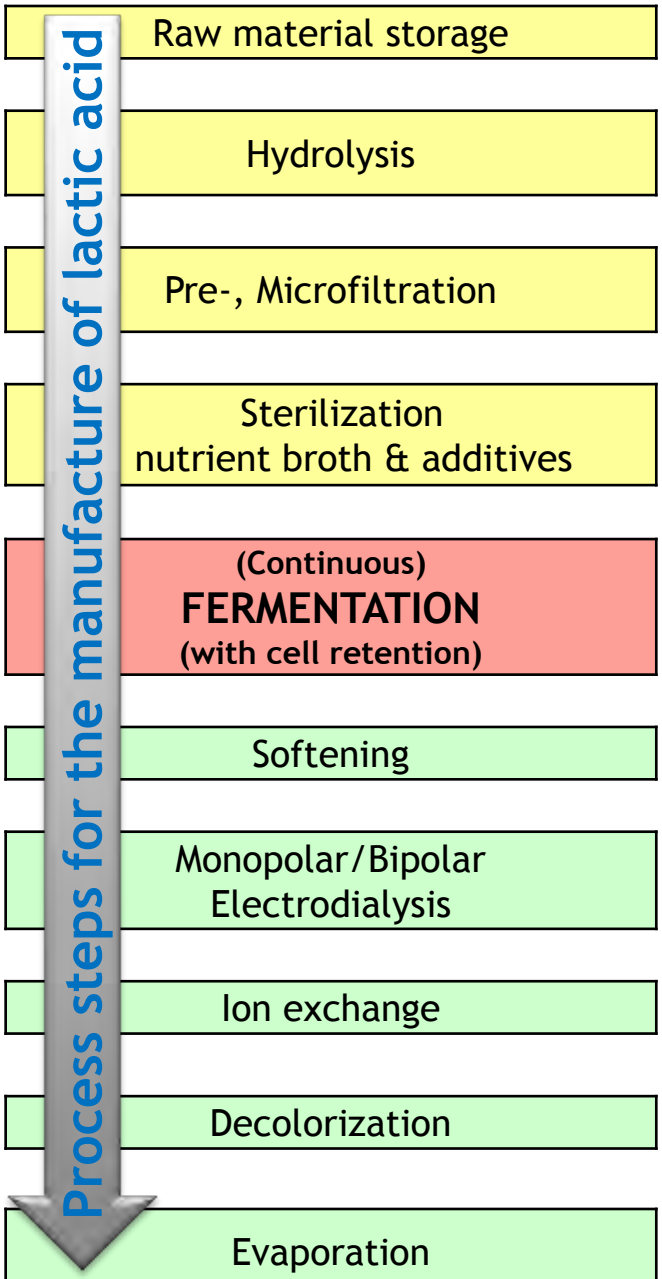
- swift transfer of new biotechnological processes into practice often fails due to the lack of a reference facility that can be used for multiple applications
- pilot facility for production of lactic acid at the ATB consequently fills a gap in the various phases of bioprocess engineering
- provision of product samples is intended to open up the possibility of interesting partners in industry with specific product requirements in the various applications

BIOSTAT® Bplus (Sartorius BBI Systems GmbH, Germany) equipped with a digital control unit DCU for the continuous fermentation with cell recycling

scale up

Pilot fermentor Type P, 450 L (Bioengineering AG)

Venus, J.; Richter, K.: Eng. Life Sci. 2007, 7, No. 4, 395-402



Raw material storage	5 m^3 (Trevira®UV-silo, HIMEL Maschinen GmbH & Co. KG)
Hydrolysis	1 m^3 stirred vessel; 0.5 m^3 storage tank (Apparate & Behältertechnik Heldrungen Gmbh)
Pre-, Microfiltration	0.8 mm coarse filter (Sommer & Strassburger GmbH & Co. KG), Microfiltration (ZrO_2-TiO_2 CeRAM®INSIDE, TAMI Industries France)
Sterilization nutrient broth & additives	2 x 400 L, 2 x 250 L stirred vessels (Apparate und Behältertechnik Heldrungen Gmbh)
(Continuous) **FERMENTATION** (with cell retention)	Pilot fermentor Type P, 450 L (Bioengineering AG) MOLSEP®Hollow fibre PES membrane (FS10-FC-FUS50E2, MICRODYN-NADIR GmbH/Daicen Membrane Systems Ltd.)
Softening	2 x 135 L PUROLITE, 1,5 m^3/h (UIT GmbH Dresden)
Monopolar/Bipolar Electrodialysis	FT-EDR/ ED4-15; 7,68 m^2 monopolar/3,2 m^2 bipolar (FuMA-Tech GmbH Vaihingen)
Ion exchange	Cationic resin, 50 L; Anionic resin, 2 x 90 L (UIT GmbH Dresden)
Decolorization	Activated carbon, several specific resins
Evaporation	«chemReactor» CR15 (Büchi AG Uster/Switzerland); Rotary Evaporator LABOROTA 20 S (Heidolph Instruments)

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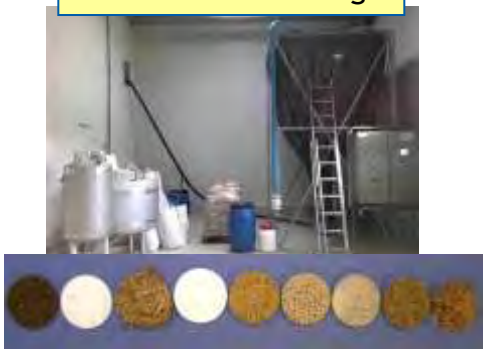
Bioconversion of renewables

feedstock	pretreatment bioconversion	products
cereals (e.g. rye), wholemeal, lignocellulosics (straw, residues), green biomass	cereal‘s hydrolyzate press juice fermentation, down-stream	(raw)lactate, lactic acid, biomass... ...bioplastics

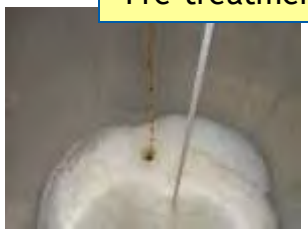
Venus, J.: Biotechnol. J. 1(2006) No. 12, 1428–1432

Process steps for the manufacture of lactic acid

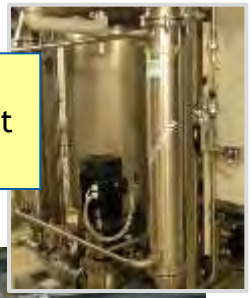
Raw material storage



Hydrolysis, Pre-treatment



Pre-, Microfiltration; Sterilization of nutrient broth & additives

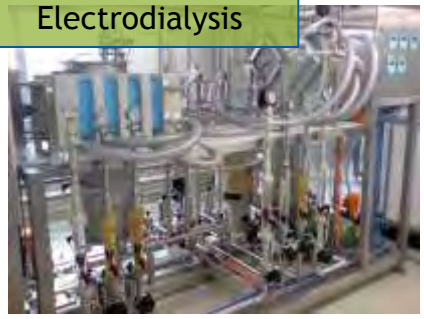


Fermentation with cell retention (Hollow fibre membranes)

Biomass separation (Micro-/Ultrafiltration)

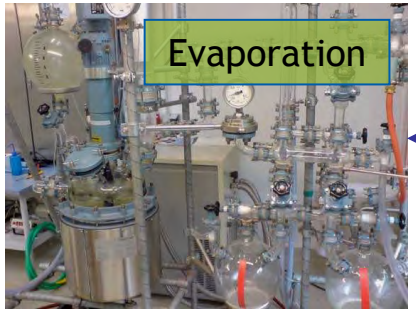
Softening

Monopolar/Bipolar Electrodialysis



Ion exchange Decolorization

Evaporation



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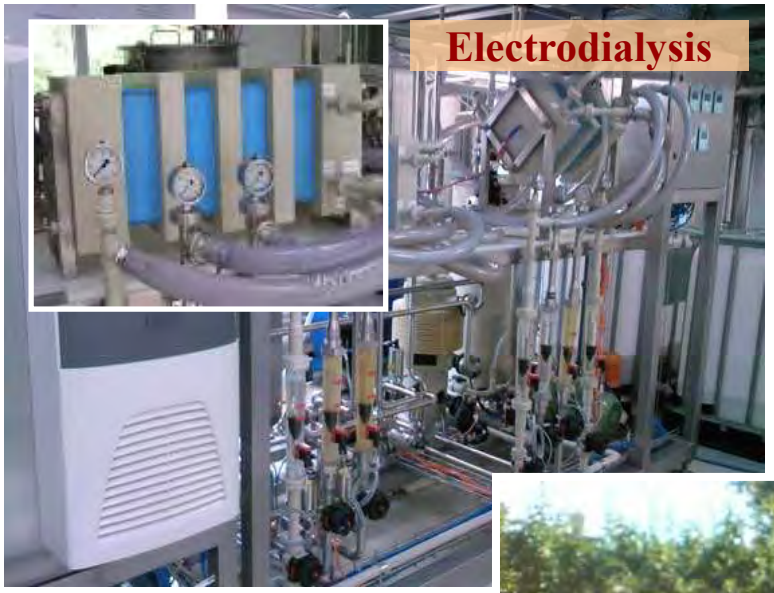
Downstream processing of raw lactates & lactic acid



Electrodialysis

Ion exchange

Softening

Evaporation unit

Bundesministerium
für Bildung
und Forschung

Nationale Forschungsstrategie
BioÖkonomie 2030
National Research Strategy
BioEconomy 2030

Unser Weg zu einer bio-basierten Wirtschaft (Kurzfassung)
Our Route towards a biobased economy (Short version)

Thank you very much for your attention!

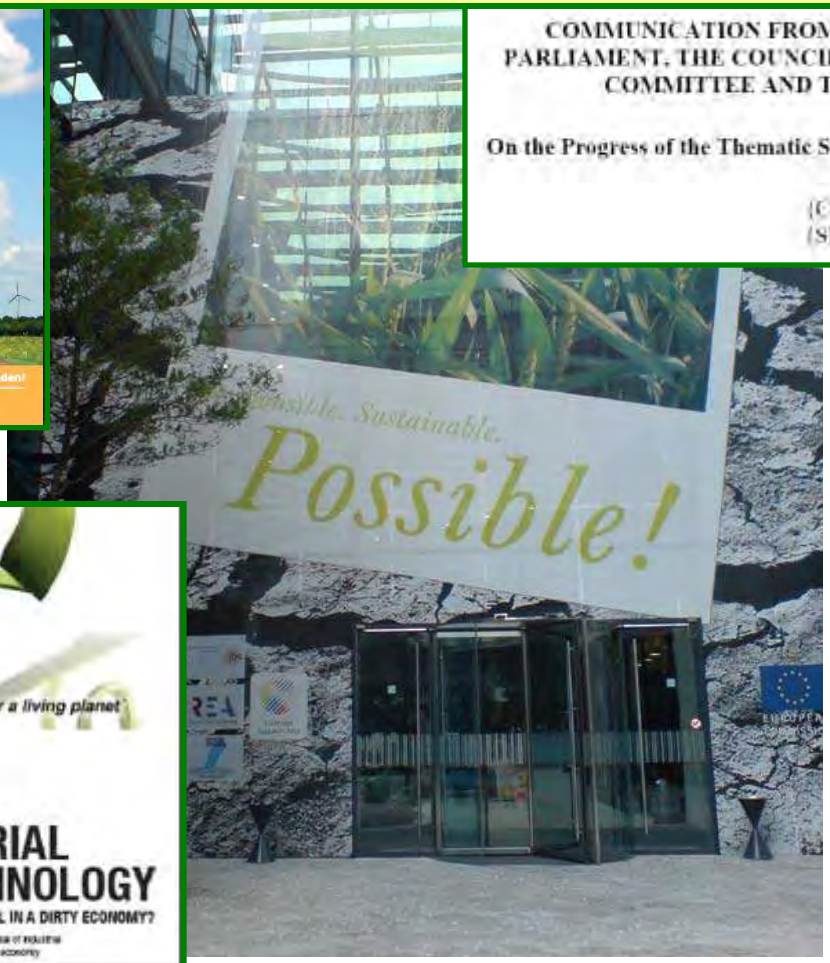
EUROPEAN COMMISSION

Brussels, 20.9.2011
SEC(2011) 1068 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

On the Progress of the Thematic Strategy on the Sustainable Use of Natural Resources

{COM(2011) 571 final}
{SEC(2011) 1067 final}



USDA

U.S. Biobased Products
Market Potential and
Projections Through 2025

ATB