The Biobased Economy and its opportunities for the Chemical Industry

Rimini, 7th November 2013

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What is the Biobased Economy?

**The knowledge base:** Advances in Life Sciences and Biotechnologies in convergence with other technologies such as nanotechnologies, chemistry, information technologies..

**The Bio-Economy:** Includes all industries and economic sectors that produce, manage or otherwise make use of biological resources including bio-waste.

The European Bio-Economy has an approximate **market size** of over 2.0 trillion €, employing more than 22 million people.

→ **4 Fs:** Food, Fees, Fiber and Fuel
What are the driving forces behind the Biobased Economy beyond competitiveness?

Global challenges like:

- Growing and aging populations
- Increased demand for high quality food and sustainable food production
- Increased incidence of food-related disorders (cardiovascular, obesity..)
- Increased demand for feed
- Increase in infectious animal diseases and zoonoses
- Danger of plant diseases, new pathogens and pesticides
- Limited resources of raw materials and energy
- Threat of global warming and other global changes (biodiversity loss etc)
What is the Biobased Economy offering?

- **Improved health**
  - Food with improved nutritional value, increased food safety, new treatments, diagnosis and vaccines against human and animal diseases, improved feed…

- **Sustainability and a cleaner environment**
  - Energy and water saving production and processes in agriculture and industry; decreased dependence of fossil resources;

- **Resource use efficiency**

- **Innovation strategy**

- **Support to rural development**
  - Use of “set-aside” land; cultivation of new crops; decentralised production facilities

- **Increased industrial competitiveness through innovative eco-efficient bio-based products**
Implementing Europe 2020

Moving to a low carbon economy
- Renewables vs. petrochemicals
- Avoiding and/or utilising biowaste and industrial by-products
- Setting-up biorefineries across the EU

Building competitive bio-based industries
- Enzymes, fine and bulk chemicals
- Pharmaceuticals, cosmetics, solvents, lubricants
- Food additives and nutrients
Innovating for Sustainable Growth: A Biobased Economy for Europe

The realisation of the potential of the Bio-Economy is also to be reflected through (amongst others):

- Horizon 2020: EU’s Framework Programme after 2013
- CAP after 2013

But also:

- Lead Market Initiative on Bio-based Products
- Common Fisheries Policies
- Integrated Maritime Policy
- Roadmap for a resource efficient Europe
Common Strategic Framework for Research and Innovation

Increasing the impact

- From different priorities in each programme and initiative to common strategic priorities, focusing on societal challenges, competitiveness and research excellence.

- From gaps between the stages (R&D, demonstration, market take-up etc.) to coherent support for projects and organisations across the innovation cycle from research to retail.

- From strong focus on research and technological development to stronger support for innovation, including non-technological innovation and market take-up.
Europe 2020 Priorities

Tackling Societal Challenges
- Health, demographic change and wellbeing
- Food sec., sust. agri., mar. res. & bioeconomy
- Secure, clean and efficient energy
- Smart, green and integrated transport
- Supply of raw materials, resource efficiency and climate action
- Inclusive, innovative and secure societies

Creating Industrial Leadership and Competitive Frameworks
- Leadership in enabling and industrial technologies (Biotechnology,...)
- Access to risk finance
- Innovation in SMEs

Excellence in the Science Base
- Frontier research (ERC)
- Future and Emerging Technologies (FET)
- Skills and career development (Marie Curie)
- Research infrastructures

Shared objectives and principles

International cooperation

Common rules, toolkit of funding schemes

Simplified access

Coherence with other EU and MS actions
Bio-Economy
HORIZON 2020

Specific Programme for Societal Challenge 2:

FOOD SECURITY, SUSTAINABLE AGRICULTURE, MARINE and MARITIME RESEARCH and the BIO-ECONOMY

5 Topics:

- Sustainable AGRICULTURE and FORESTRY
- Unlocking the potential of AQUATIC LIVING RESOURCES
- Cross-cutting MARINE and MARITIME RESEARCH
- Sustainable and competitive bio-based INDUSTRIES and supporting the development of an EUROPEAN BIO-ECONOMY
- Sustainable and competitive AGRO-FOOD sector for a safe and healthy diet
Sustainable and competitive bio-based industries

**Targets**
- Total resource efficient and optimal use of available biomass and biowaste
- Regional strategies to accelerate the development of integrated economic biorefineries
- Increase resource and energy efficiency in industries

**Actions**
- Regulatory framework that ensures the availability of biomass and biowastes
- Support the establishment of a wide network of bio-clusters
- Increase investments into pilot and demonstration infrastructures
- Facilitate the development of standards and labels for bio-based products
On 13th February 2012 publication of the first strategy of this kind for Europe:

“Innovating for Sustainable Growth: A Bioeconomy for Europe”
The Bioeconomy Strategy and Action Plan

### INVESTMENTS IN RESEARCH, INNOVATION AND SKILLS
- Ensure substantial EU and national funding for bioeconomy and innovation
- Increase the share of multi-disciplinary and cross-sectoral research and innovation
- Promote the uptake and diffusion of innovation in bioeconomy sectors; create feedback mechanisms on regulation and policy
- Build the human capacity required to support growth and integration of bioeconomy sectors

### REINFORCED POLICY INTERACTION AND STAKEHOLDER ENGAGEMENT
- Create a Bioeconomy Panel to enhance synergies and coherence between policies; foster participation of researchers, end-users, policy-makers and civil society
- Establish a Bioeconomy Observatory and develop forward-looking and modelling tools
- Support the development of regional and national bioeconomy strategies
- Develop international cooperation to jointly address global challenges (e.g. food security, climate change)

### ENHANCEMENT OF MARKETS AND COMPETITIVENESS IN BIOECONOMY SECTORS
- Provide the knowledge-base for sustainable intensification of primary production;
- Promote the setting up of networks for integrated and diversified biorefineries; establish a PPP for bio-based industries
- Support expansion of new markets; facilitate green procurement for bio-based products
- Develop science-based approaches to inform consumers about product properties
Sustainable and competitive bio-based industries

Fostering the bio-economy for bio-based industries

Developing integrated biorefineries

Supporting market-development for bio-based products and processes
What are the Perspectives for the Chemical Industry?
In 2009 the overall market for bio-based chemicals amounted to 37 Billion $

The overall market 2015 for bio-based chemicals is expected to rise to 76 Billion $

In Germany about 16 % of the raw materials used in the German chemical industry are bio-based

The annual biotech production of ethanol is 85 Billion liters

400,000 tons of lactic acid are produced each year bio-based

L-Lysine, a bio-based feed additive, is one of the major bio-based products with a global market of 1,5 Million tons per year

Already in 2010 Braskem achieved a commercial production of bio-based high density polyethylene (HDPE) in Triunfo with a capacity of 200,000 tons per year.
Raw material consumption in the chemical industry

- **Biomass**
  - Plant oils and animal fats: 1450 [1000 t]
  - Sugar and starch: 408 [1000 t]
  - Cellulose: 300 [1000 t]
  - Others: 549 [1000 t]
  - **Total**: 2707 [1000 t]

- **Natural gas**: 13% of total consumption
- **Petroleum**: 11% of total consumption
- **Coal**: 2% of total consumption
- **Biomass**: 74% of total consumption

Increase from 8% in 1991 to 13% in 2009

Increase to 20% in 2020-2030?

Source: FNR, meó consult, VCI
Bio-based Chemicals are expected to grow.

Renewable Feedstock:  
- Animal Fat
- Starch
- Sugar
- Cellulose
- Fibres
- Proteins
- Rosin & Waxes
- Other
- Vegetable Oils

Chemicals:  
- Fossil: 89%
- Biobased: 11%
  - Biobased Commodity: 1%
  - Specialty: 7%
  - Fine: 2%
  - Polymer: 1%

2010: 9-13% biobased
2025: 22-28% biobased

VCI; 2010
USDA; USA Biobased Products Market Potential & Projections through 2025 (modified)
Competitiveness – Cost split between raw materials and processing

- **Petroleum**
  - Past: Raw materials → Processing
  - Today: Raw materials → Processing
- **Renewables**
  - Today: Raw materials → Processing
  - Future: Raw materials → Processing
Change of raw materials, processes and catalysts

- HC≡CH

- Bi-Mo-Oxide
  - CO
  - Mo-V-Oxide
  - NiBr₂, CuI₂
  - O₂

- OH

- Microorganisms
  - Enzymes

- Zeolite, Enzymes

- OH

- - H₂O

Source: Sieber, TU München, Fraunhofer BioCat
Integration of chemical and biotechnological processes

Renewables

Upstream processing
- Grinding
- Extraction
- Fractionation
- Separation

Biotechnological Transformation

Chemical Transformation

Downstream Processing
- Platform chemicals
Biorefineries - Integration into the value chain

A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, heat, and value-added chemicals from biomass.

- Expansion of existing plants for renewable raw materials (sugar mill, starch mill, oil mill, pulp mill) – bottom up approach
- Development of new integrated plants – top down approach
Biorefineries focus on early steps in the Value Chain

**Agri- & Silviculture**
- Sugarbeet
- Corn
- Plant-Biomass
- Seed
- Lignocellulose

**Feedstock-Industry**
- Sugar
- Starch
- Syngas
- Isoprene
- Syngas

**Bio-Chemical Precursor**
- Amino Acid
- Sphingosine

**(Bio-)Chemical Industry**
- L-tert.-Leucine
- Pharma-Active Protein
- Dermatolog. Active
- Rubbergum
- Pharmaceutical
- Adhesive
- Implant
- Cosmetics
- Earring
- Tire
- Bottle
- Trash bag
- Film
- Bulk Chemistry

**Consumer Industries**
- Plastics 1
- Plastics 2
- Plastics 3
- Plastics 4

**Value Chain**
Driver for the bioeconomy - feedstock flexibility

Chemical industry feedstocks - Germany 2010

- Oil 72%¹
- Natural gas 14%¹
- Biobased 13%¹
- Coal 1%¹

Emerging fields

- Second generation biorefineries
- Feedstock agnostic processes (biotech, catalytic, thermo-physical)

1 Fachagentur Nachwachsende Rohstoffe

20.06.12 | Frankfurt a.M., Dr. Achim Marx, Industrial side streams provide competitive carbon sources to the bioeconomy
Lignocellulose feedstock biorefinery project

Lignocellulose

Extraction /Fractionation/ Separation

Cellulose

Glucose

Lactic acid/PLA

Hemicelluloses

Xylose

Xylit/Furan resins

Lignin

Lignin/Phenols

Phenol resins

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Practical examples for innovative biobased products out of the C-toolbox of nature (1)

- Polyethylenfuran (PEF) bottles by YXY-technology, replacing hitherto used PET bottles, 100% biobased, reaching the market until 2016

  -> spectacular competition Coca-Cola – Pepsi.
Practical examples for innovative biobased products out of the C-toolbox of nature (2)

- **Succinic Acid**: basis for a multitude of bioplastics, plastizisers, biosolvents, polyethylene
  -> Strong competition who builds the first and largest demonstration facility (DSM, Roquette, BASF, Lanxess (Sarnia location in Canada) etc.

- Bio-PA Fischer plug: the first 100% biobased Fischer-plug on the market, made of polyamides from castoroil residues
Practical examples for innovative biobased products out of the C-toolbox of nature (3)

- **Biobased phthalat-free plastizisers** for plastics, construction, automotive industries by Evonik

- **Essential amino acids** as feed additives (methionine, lysine) by Evonik

- **Acrylic acid**: BASF, Cargil, Novozymes
Practical examples for innovative biobased products out of the C-toolbox of nature (4)

- Biobased BDO (1,4-Butandiol und -Butandien) for automotive and chip industries (BASF, Genomatika)
- Biokerosine (biobased marine diesel and aviation gas) and Biorubber (Russian dandelion)
- Biopolymers and Biomonomers as basic chemicals
- New fibres („Cellulosic chemicals“) for clothing industries, adhesives and other purposes
Larger portfolio for feedstocks and products in biorefineries

Bran, new fibres, lignin, even glycerine as feedstock

• Innovative resins
• Plastizisers
• Biosurfactants
• Sponges
• New cosmetics
• De-icing materials for aviation
Value chain for bio-based products

Cultivation
- Seed
- Planting
- Harvest
- Transport

Land based and aqueous

Supply Optimization

Feedstock processing
- Disintegration
- Conversion
- Separation
- Cleaning

Energy use

Bio-fuels, -energy

Further material conversion: chemical & biotechnological downstream processing

Bio-Chemical processing

Manufacturing
- Application testing

Feed

Food

Processing

Universities, R&D Institutions
- Universities, R&D Institutions
- Supplier of seedlings
- Agricultural industry

Processing Industry
Raw materials, processes and products

**Feedstock**
- Special materials, media
- Vegetables oils and fats
- Sugary feedstock
- Starch-containing feedstock
- Cellulosic feedstock
- Lignocellulose-containing feedstock
- Aquatic biomass
- Gaseous feedstock, e.g. CO₂

**Conditioning**
- Direct sugarification
- Multi-stage sugarification
- Processing, Fractioning
- Optimization
- Cultivation, growth

**Value generation**
- Production of value-added chemicals by biocatalysis and fermentation
- Conversion of value-added materials via physical, chemical and biocatalytical approaches
- Separation of value-added products and purification

**Scale-up and process development**

**Products**
- Vegetable oils and fats
- Fatty acid products
- Industrial enzymes
- Bulk chemicals
- Aromatics
- Technical gases
- Oils, surfactants
- Proteins
- Complex chemicals
- Others…

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Chemical-Biotechnological Process Centre (CBP) in Leuna

Important element of the „BioEconomy“ cluster

- Concept for the efficient and waste-free use of biomass for the chemical industry
- Opening up new avenues for climate protection and resource efficiency
- Overall 50 Mio. €
  BMBF, BMELV and BMU, Saxony-Anhalt, Fraunhofer Society (scientific lead) plus more than 20 partners from industry
- Start-up of the first facilities – October 2nd, 2012

Source: InfraLeuna GmbH
NFSB 2030 – BioEconomy Cluster

**Duration:** 5 years (2012-2017)

**Cofinancing of R&D projects**
- **BMBF:** 40 Mio. €
- Industry Partners will invest equal amount

<table>
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<tr>
<th>Cluster</th>
<th>Count</th>
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<tr>
<td>Large Enterprises</td>
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<tr>
<td>SMEs</td>
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<tr>
<td>Research Institutions</td>
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<tr>
<td>Universities</td>
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Vision and strategy

• Sustainable maximisation of value creation for the non-food biomass WOOD

• Combined production and cascade utilisation for the production of chemicals, new materials and supplies as well as energy

• Acceleration of innovation through integrated and spatially and temporally synchronised scaling of processes and facilities from bench to pilot and demo scale
Extending the existing stable chemical Verbund to biomass

Sachsen-Anhalt

Verbund chemicals/plastics

Wood cluster Rottleberode

DBFZ BioEnergy Leipzig

Unternehmen Forschung

Sachsen

Leuna

Bitterfeld

Schkopau

CBP Leuna

Böhlen
### Strategic approach of the BioEconomy Cluster

#### 1. Maximize value creation

- **Non-food Biomasse**
  - Dis-integration utilizing several alternative technologies
  - Material value chain
    - Olefine-Chemicals
    - Aromatic-Chemicals
    - Integration in den vorhandenen Raffinerie- und Chemieverbund

- **BioEnergy**
  - Innovative wood based products
    - Biobased Products
      - Intermediaries
      - Special chemicals
      - Biopolymeres
      - Biocompounds
      - WPCs
      - Drop-in fuels

#### 2. Accelerate Innovation

<table>
<thead>
<tr>
<th>Scale</th>
<th>Research Lab scale</th>
<th>R&amp;D pilot-scale</th>
<th>Development demonstration scale</th>
<th>Industrial production</th>
<th>Markets</th>
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<td>Unit</td>
<td>g</td>
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Cascading utilization
Topic areas of the cluster

TG 1: production and material utilization of non-food biomass (wood production, -logistics and -manufacturing; innovative timber construction)

Material flows:
Wood, Residues

TG 2: production of base chemicals from non-food biomass

Flows:
Ethylene, Hydrogen, Aromats, ...

TG 3: Polymers, materials and products from biomass

Flows:
e.g. Biophenole foams, wood fibre

TG 4: Energetic utilization and optimization in the overall context of the cascading value chain

Residue streams
Energy
Energetic optimization of processes

TG 5: Management of the BioEconomy

Parameters, methods, optimization

TG 6: Education for the BioEconomy

Source: Cluster BioEconomy
Conventional Petrochemistry tends towards Concentration and even Monopolies –

Biobased Chemistry stands for Decentralisation and maybe even more Competition
Conclusions

1. The perspectives of “biotechnologies” for health and medicine, agriculture, food and feed, chemistry, energy, new materials, steel and construction (industrial uses), and aquaculture within the context of a bio-based economy are very promising, and chemical industry is evidently prepared to widely use its potentials.
Conclusions

2. Various possibilities exist for combining biotechnological and chemical processes to synthesize chemicals from renewable raw materials.

3. One goal is to integrate the processing of non-food biomass in biorefineries to produce chemicals, materials, biogas and biofuels.
Conclusions

4. Biotechnologies and biological renewable resources in the chemical industry may form a new powerful tandem for offering responses to the grand challenges of today, ranging from food and feed security to combating climate change, from fighting hunger and undernourishment to adding years to a healthy life.

5. The bioeconomy will demand for new, innovative and sometimes unusual partnerships and/or networks, in research but also business activities.
Conclusions

6. This requires however large efforts in demonstration and pilot activities, including manifold up-scaling activities from lab to market, a challenge, scientists and researcher are normally not used to.

7. The key question as a unique chance for the chemical industry will be: where, at what costs can we add value?