BIOMASS FUTURES

Chemical & Adhesives Industry Demand for Biomass

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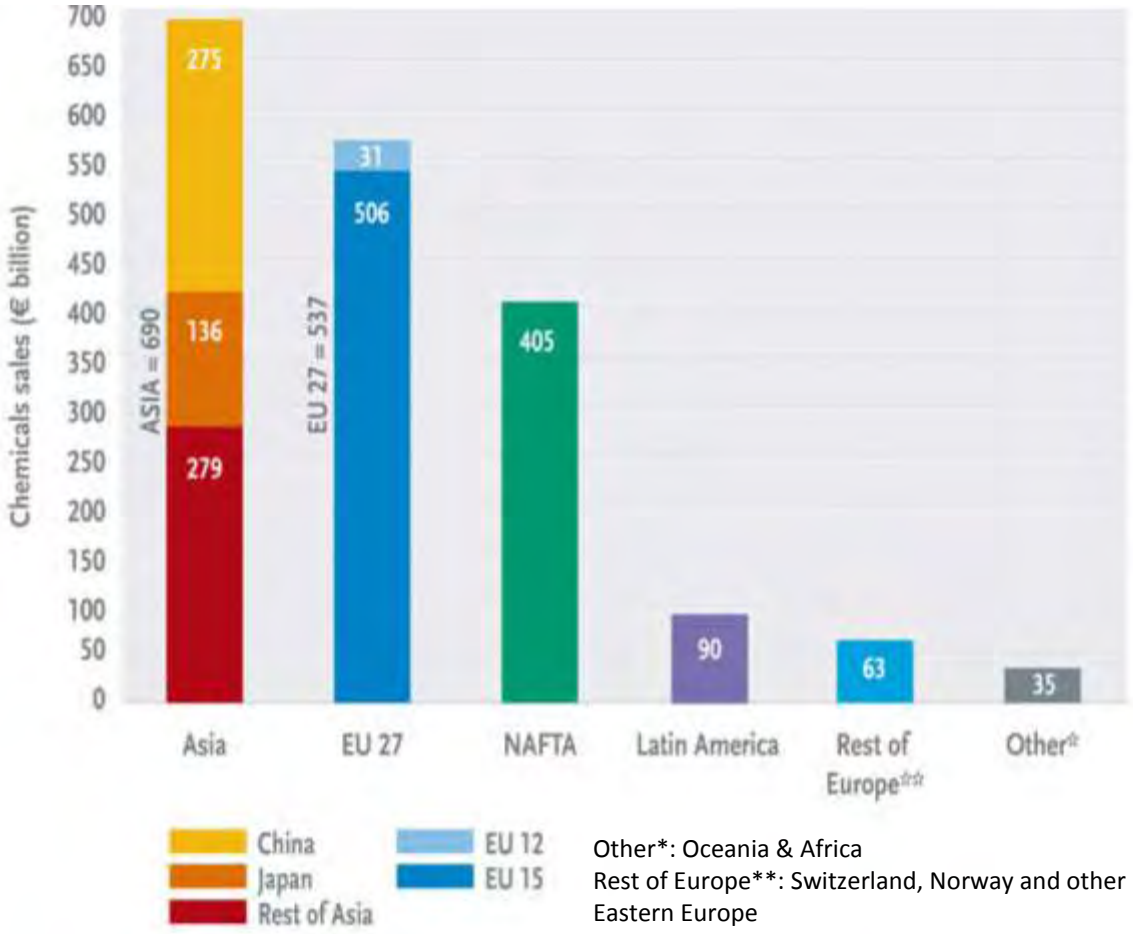
Eleftheria Athanassiadou

R&D Support and IP Protection Manager

CHIMAR HELLAS S.A.

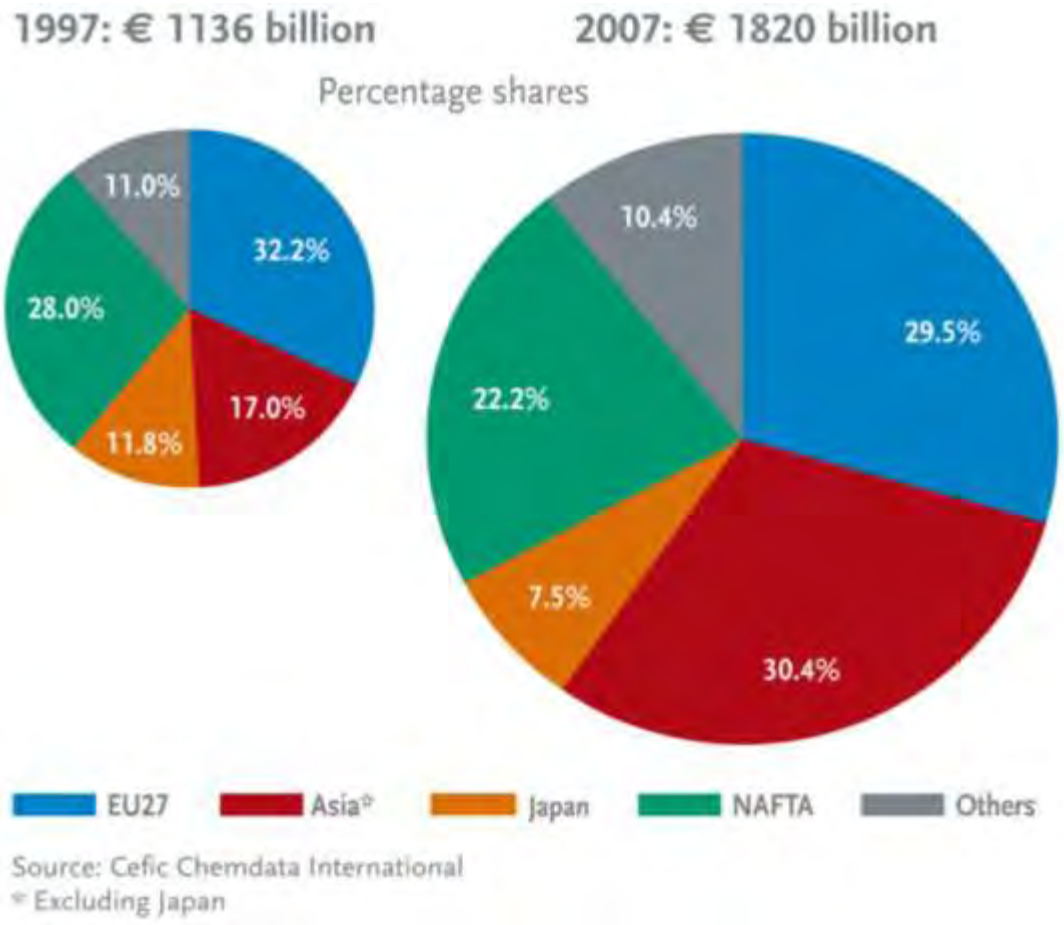
World Chemicals Sales (2007)



SOURCE: CEFIC, Facts & Figures, Jan. 2009

Other*: Oceania & Africa
Rest of Europe**: Switzerland, Norway and other Central & Eastern Europe

World Chemicals Sales (1997 vs 2007)



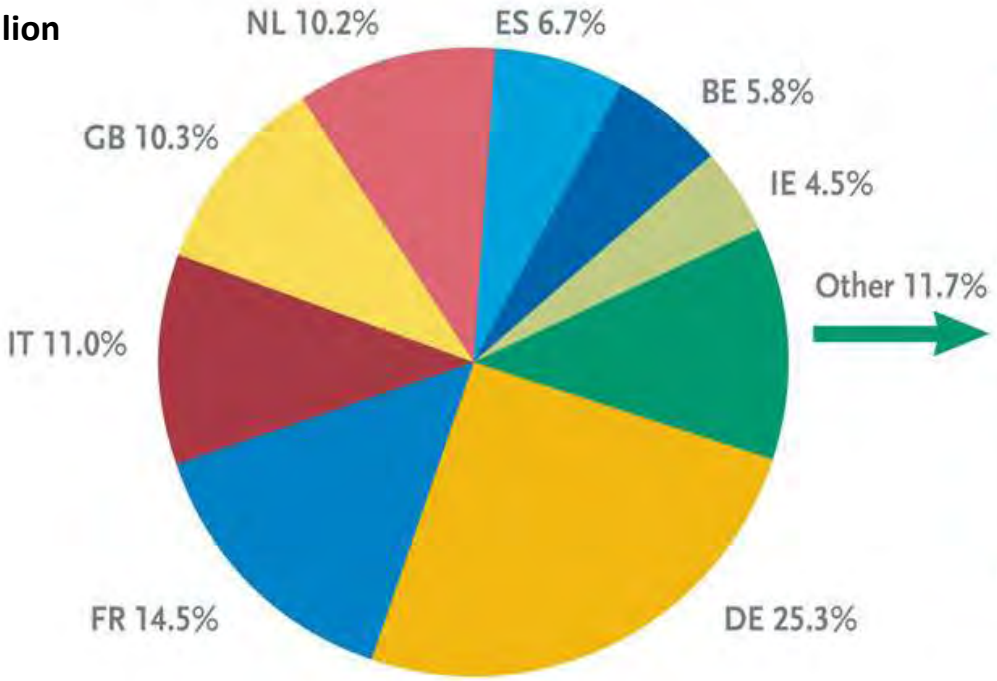
SOURCE: CEFIC, Facts & Figures, Jan. 2009

Chemicals Sales Growth Rates 1997-2007

SOURCE: CEFIC, Facts & Figures, Jan. 2009

EU Chemicals Industry Sales per Country

Sales 2007: € 537 billion
Percentage shares



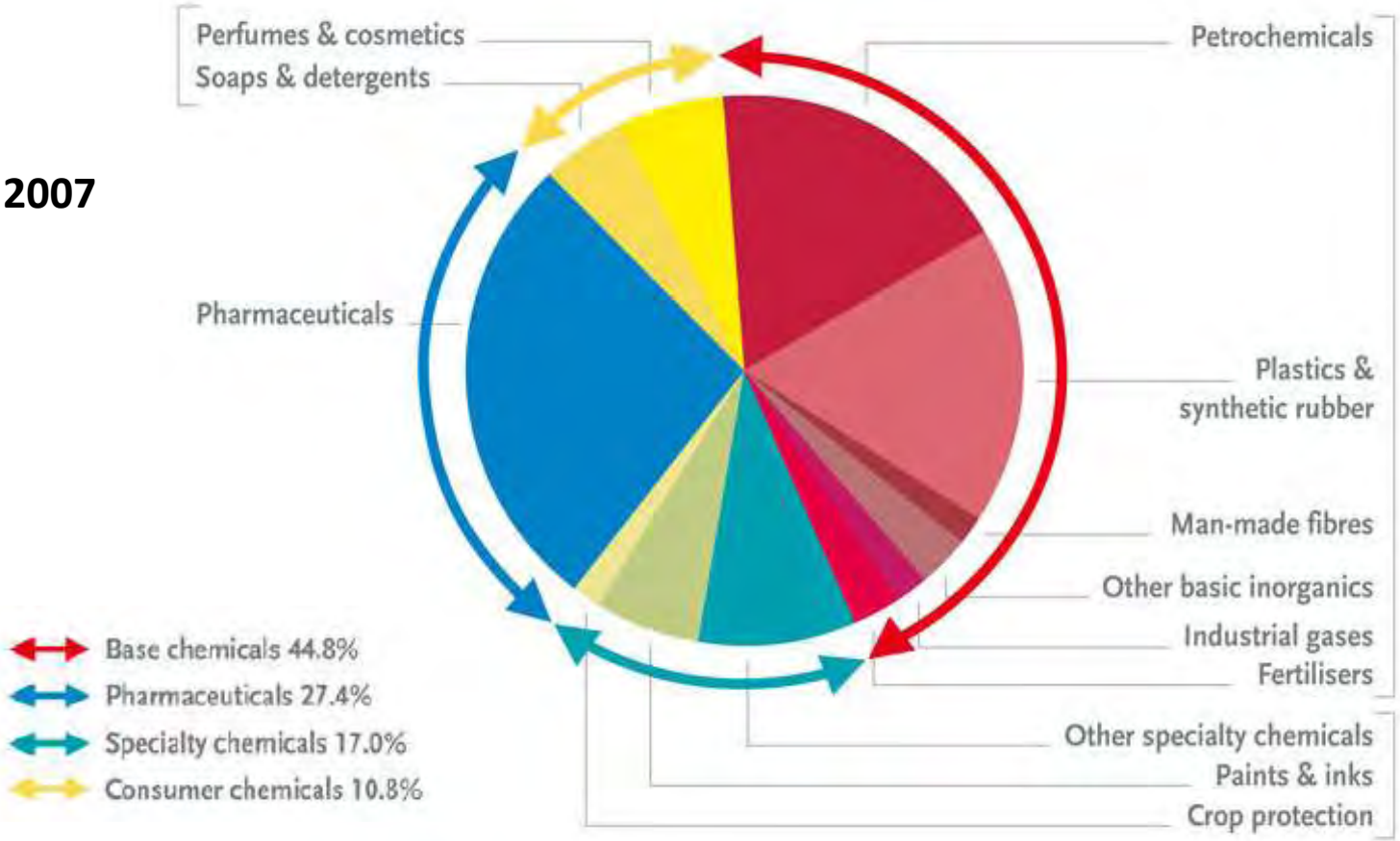
PL	2.3%
SE	1.7%
AT	1.3%
FI	1.3%
CZ	0.9%
HU	0.7%
PT	0.7%
RO	0.6%
Others	2.2%

SOURCE: CEFIC, Facts & Figures, Jan. 2009

Source: Cefic Chemdata International
Big 8 = Germany, France, Italy, United Kingdom, Netherlands, Spain, Belgium and Ireland

EU Chemicals Industry Sales by sector

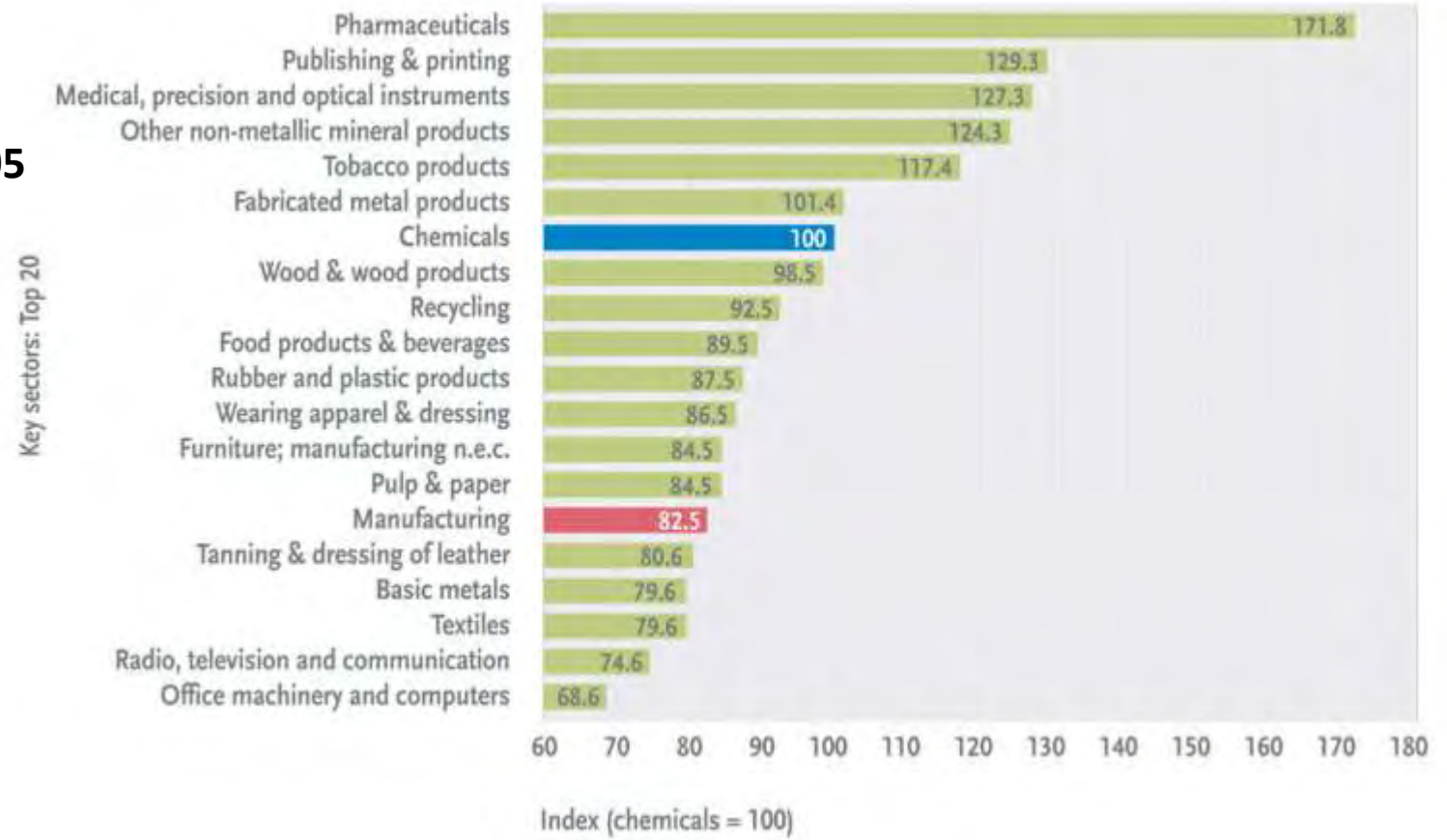
2007



SOURCE: CEFIC, Facts & Figures, Jan. 2009

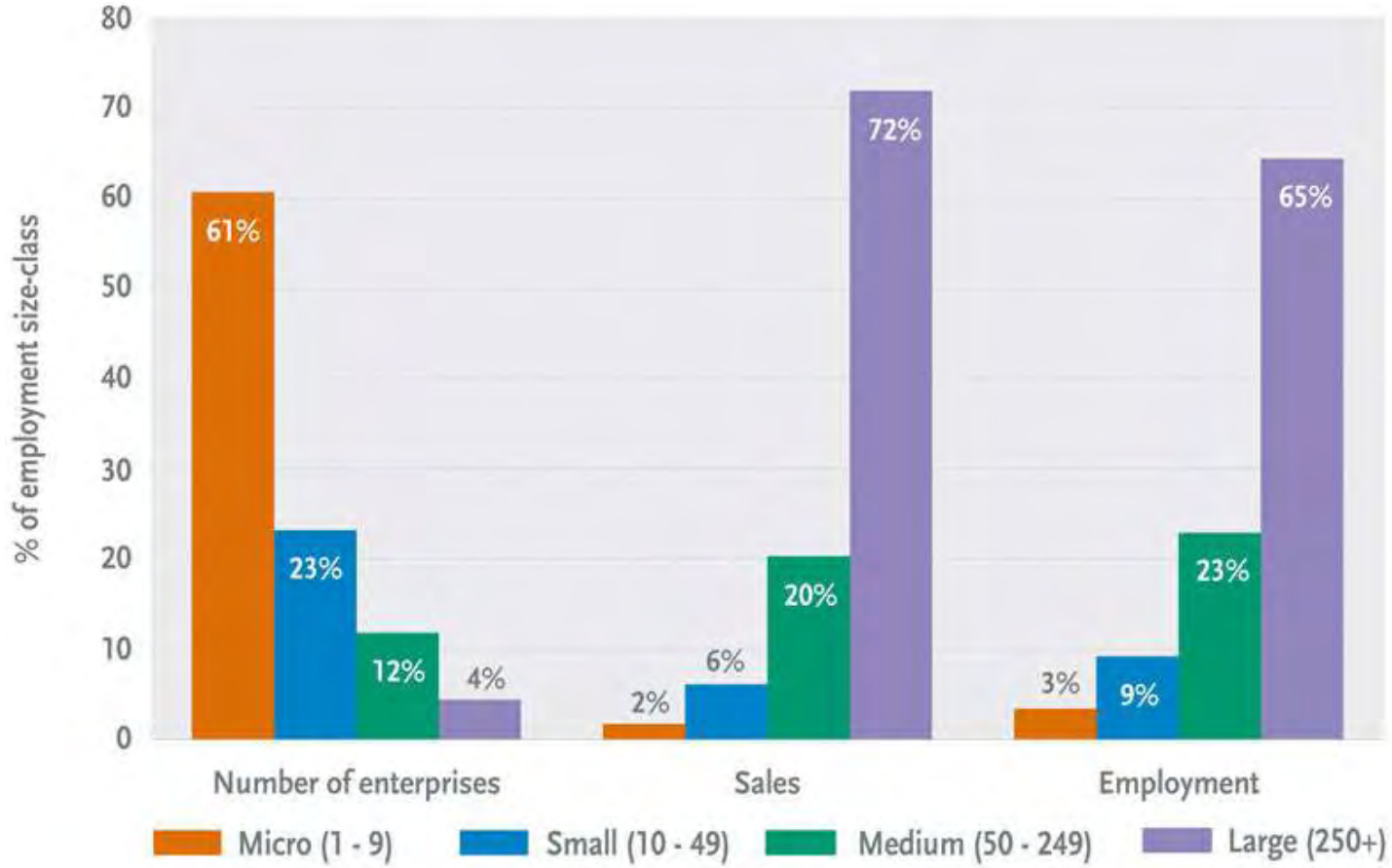
EU Manufacturing Industry: Gross operating surplus/turnover

2005



SOURCE: CEFIC, Facts & Figures, Jan. 2009

EU Chemicals Industry: enterprises



SOURCE: CEFIC, Facts & Figures, Jan. 2009

EU Chemicals Industry: employment

- Chemical and pharmaceutical companies (~29,000) employ 1.84 million people = 6% of the manufacturing industry total workforce
- Labour force is better qualified (in skills, education & training) than the average of other manufacturing sectors and labour productivity increases faster
- Chemical Industry employment decreased by 2% in the EU and by 2.8% in the USA between 1997-2007

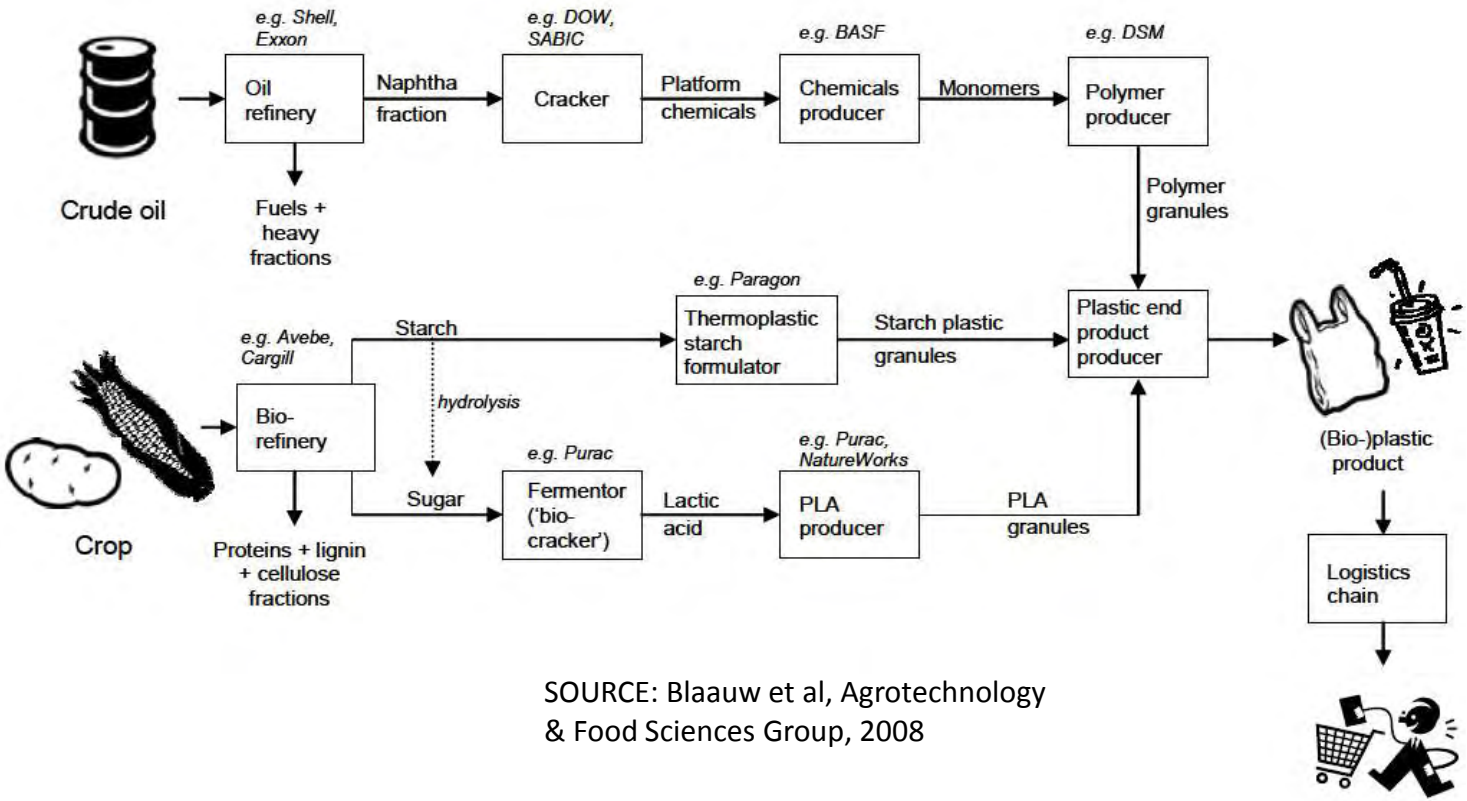
European Chemical Industry: highlights

- ✓ One of the largest and most competitive industries
- ✓ Millions of jobs are dependent on it
- ✓ Supplies virtually all other sectors of industry
- ✓ Importance quite likely to grow
- ✓ Still leading and growing

Opportunities for industrial biochemicals

- Organic materials form an important part of the chemicals annually produced
- Synthetic organic materials are predominantly produced from fossil resources (mostly crude oil & natural gas) of limited availability
- Diverse and renewable biomass feedstocks can be converted into a variety of chemical products
- Development of industrial biochemicals in biorefineries will help to
  - Reduce the dependence on oil imports
  - Address climate change
  - Stimulate growth

Chemical value chain of petrochemical- vs biomass-derived plastics



SOURCE: Blaauw et al, Agrotechnology & Food Sciences Group, 2008

Production of biochemicals

Three different technology platforms:

- **Dedicated production:** biotechnology route involving the production of chemicals using enzymes through biocatalysis and whole cells through fermentation
- **Biofuel-derived:** involves the production of chemically useful products as a by-product of biofuel (bioethanol and biodiesel) production
- **In plants:** production of chemicals by crops (possibly genetically modified) or algae, and extracting these after harvesting

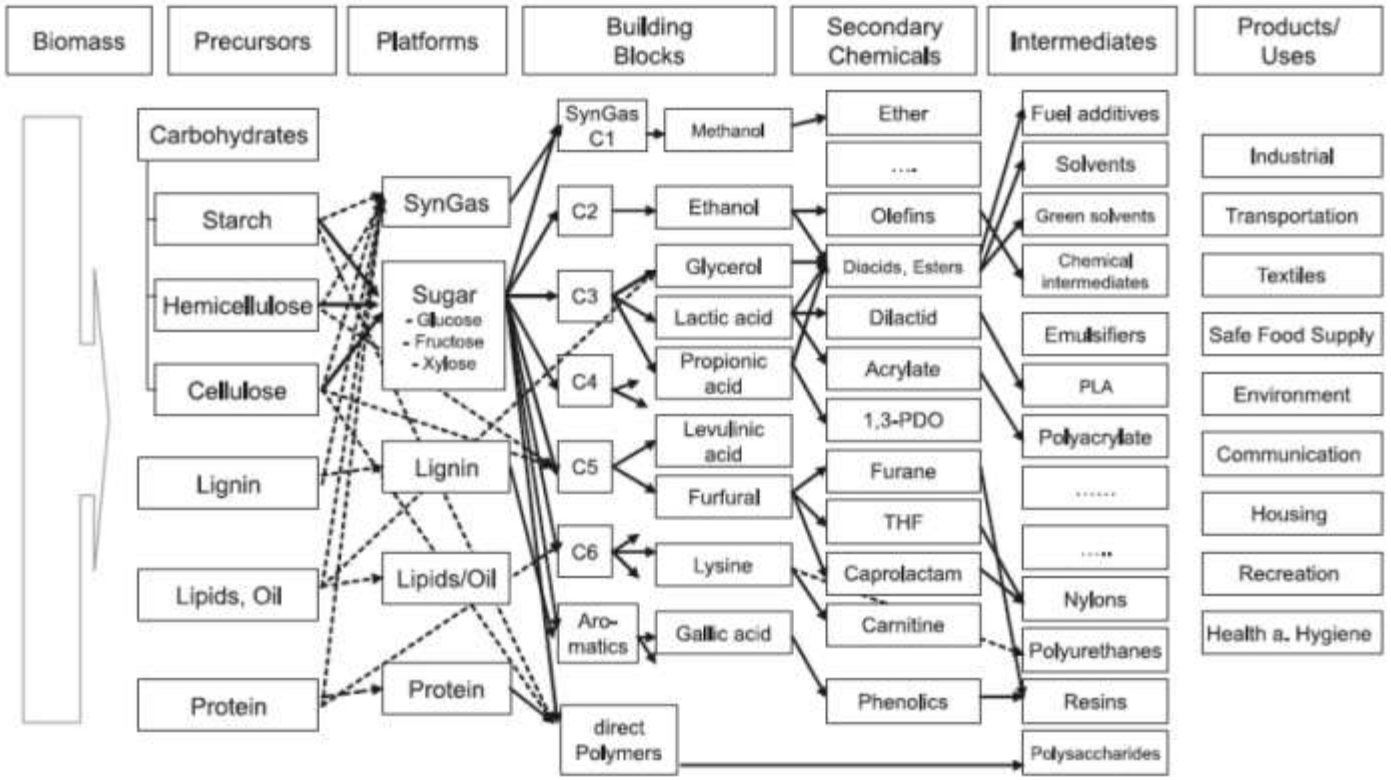
Potential bioproducts:

medicines, vitamins, cosmetics

polymers, adhesives, solvents, coatings, paints, inks, detergents,

organic acids, alcohols

Selected current and future biomass transformations



SOURCE: Kamm, 2007

Market share projection

Nieuwenhuizen/Little, 2010

- ✓ Estimated current size of the biochemicals market €51bn-77bn, or 3-4% of total global chemical sales - pharmaceuticals constitute the most of today's sales
- ✓ By 2025, the biochemical market predicted to be worth €175bn-420bn, equal to a chemical production market share of 7-17%

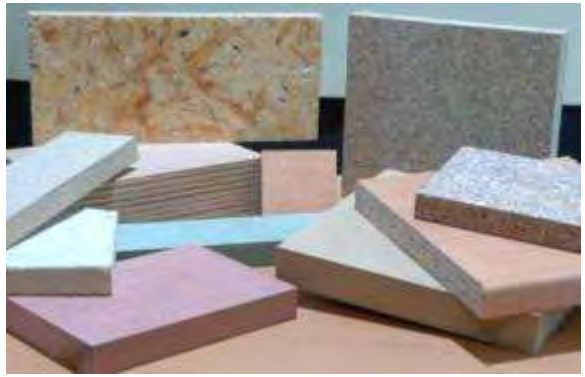
Examples of bio-based chemical plants

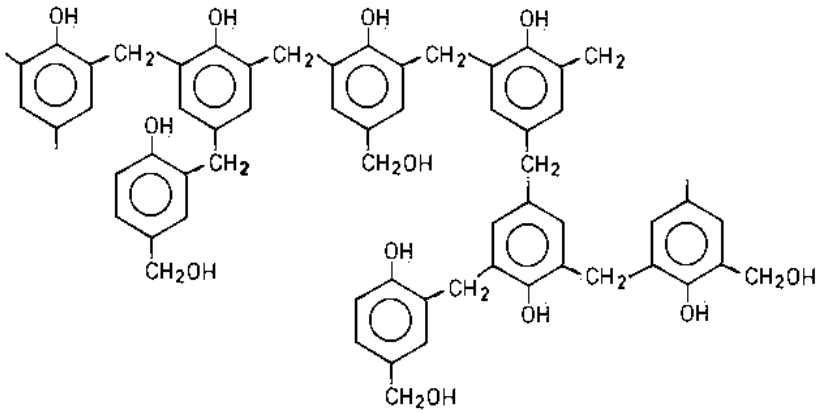
- Sugar-based butanol, 1mgal/y, Gevo, Missouri, USA
- Bio-based succinic acid, BASF-Purac, Spain
- Biosuccinic acid, 300 tonne/y, DSM-Roquette, France
- Polyhydroxyalkanoate, 10,000 tonne/y, DSM-Tianjin GreenBio, China
- Biomass derived acetic acid, 500 tonne/y, WACKER, Germany
- Corn-based 1,3-propanediol, 45,000 tonne/y, DuPont Tate & Lyle BioProducts
- Sugarcane derived polyethylene, 200,000 tonne/y, Braskem, Brazil
- Sugarcane derived polyethylene, 350,000 tonne/y, Dow, Brazil
- Algae derived polyethylene, Dow-Algenol Biofuels, Texas, USA

SOURCE: Guzman, 2010

Case Study: Bio-Adhesives for Wood Panels

- Thermosetting formaldehyde-based resins used primarily as adhesives (binders) in the production of wood panels (particleboards, medium density fibreboards (MDF), plywood, oriented strand boards (OSB))
- Derived by the condensation polymerization of formaldehyde (F) with either urea (U) or melamine (M) or phenol (P) or their combination. Main representatives: urea-formaldehyde (UF) and phenol-formaldehyde (PF) resins.
- The monomers or polymers can be replaced by bio-based compounds





CHIMAR HELLAS Profile

- **Global technology provider** for the resin & panel industries
- **Formaldehyde resins, resin additives, processes:** technology licensing, manufacturing support
- **Turnkey plants:** formaldehyde, UFC, resins, additives
- **Research & Development**
- **Training**
- **Technical support** remotely & on-site

CHIMAR HELLAS R&D on bio-based resins

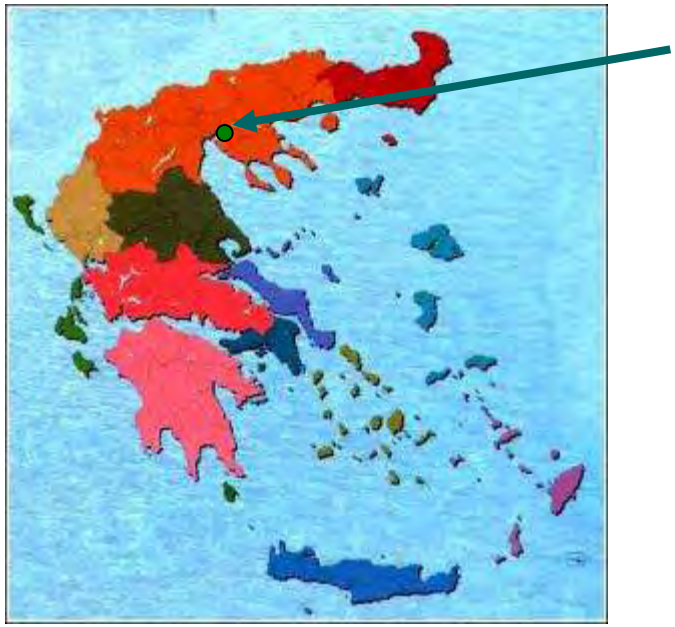
- Development of methods for **the preparation of binder resins** using as components: natural products, natural derivatives, by-products from processing of natural materials, products from the treatment of forest biomass or agricultural residues
- **Partial or total replacement of petrochemical** raw materials
- Non-exhaustive list of **natural components** used: wood pyrolysis oil, lignin pyrolysis oil, pyrolysis oil fractions, lignin, pulping spent liquor, lignosulphonate, tannin, cellulose, lignocellulose, soy protein, cardanol, cashew nut shell liquid, liquefied olive stone, liquefied wood, vinasse, mastic gum.
- Achievements at **laboratory, pilot and industrial scale**
- Participation in collaborative European projects

Considerations for biochemicals

- Biomass diversity and complexity
- Biomass availability & lack of developed supply chain
- Immature conversion technologies
- Feedstock storage & product shipment
- Integrated development of bioproducts
- Performance of biochemicals
- Lack of standards
- Companies to produce bio-chemicals
- Costs

Thank you!!!

"…. the use of renewable resources makes an important contribution to climate change mitigation and environmental protection, saving fossil resources, broadening the domestic resource base and strengthening rural areas…. The chemical industry is dependent on carbon based materials in the production of organic compounds. Renewable resources are the only renewable source of carbon." (BMELV 2009)



Location & Contact Details

Sofouli 88, 55131 Thessaloniki, GREECE

Tel: +30 2310 424167, Fax: +30 2310 424149

e-mail: office@ari.gr

www.chimar-hellas.com