Biorefinery: concept to reality

EU-India Brokerage Event on Bio-Economy and SAHYOG Stakeholder conference

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FOOD & BIOBASED RESEARCH
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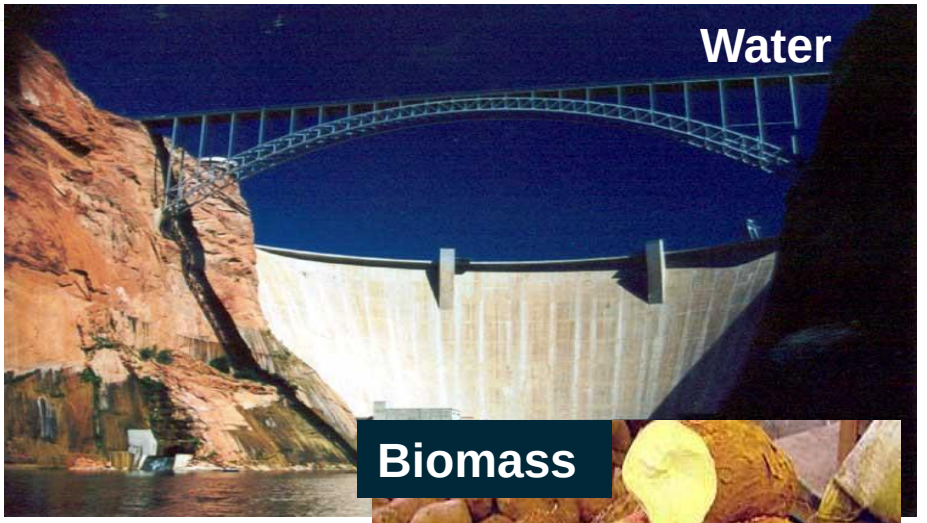
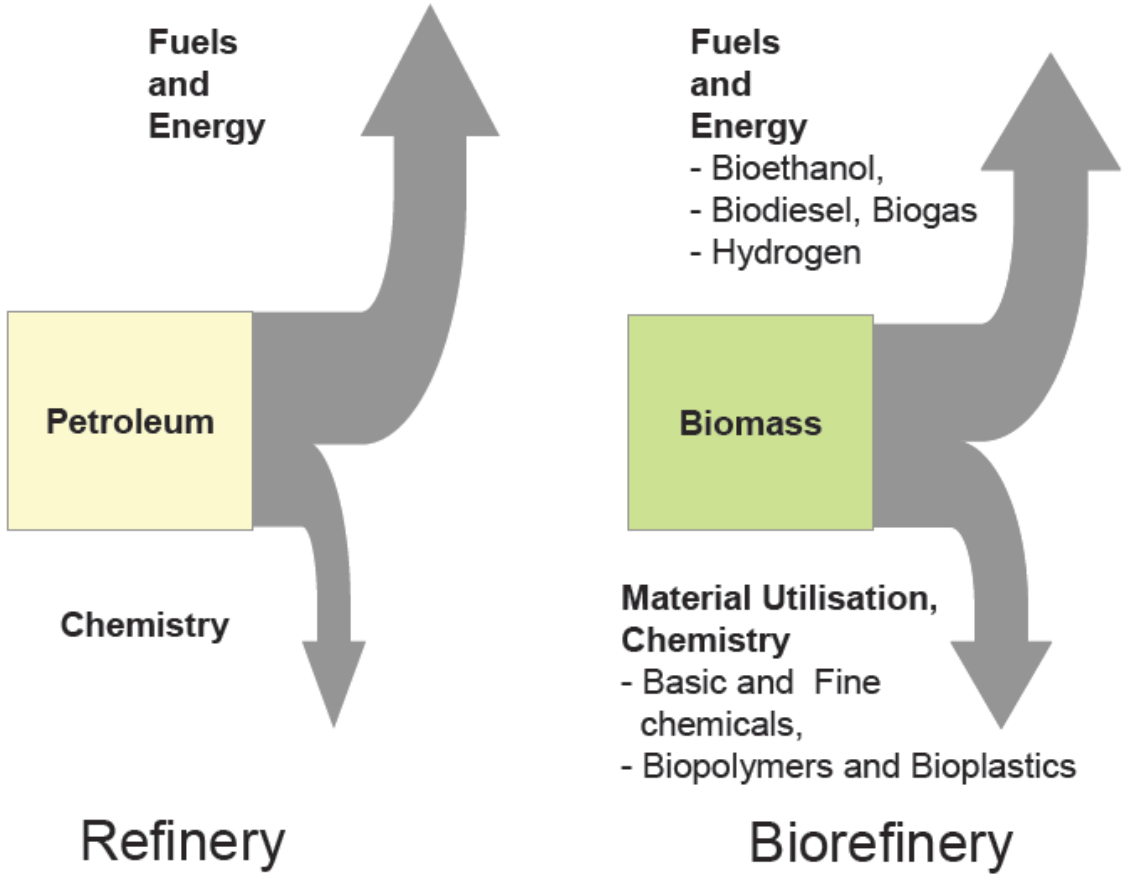
Contents

- Drivers and importance of biomass
- Biorefinery & biomass pretreatment: concepts
- Examples from industry and research
- Recommendations

Alternative energy sources



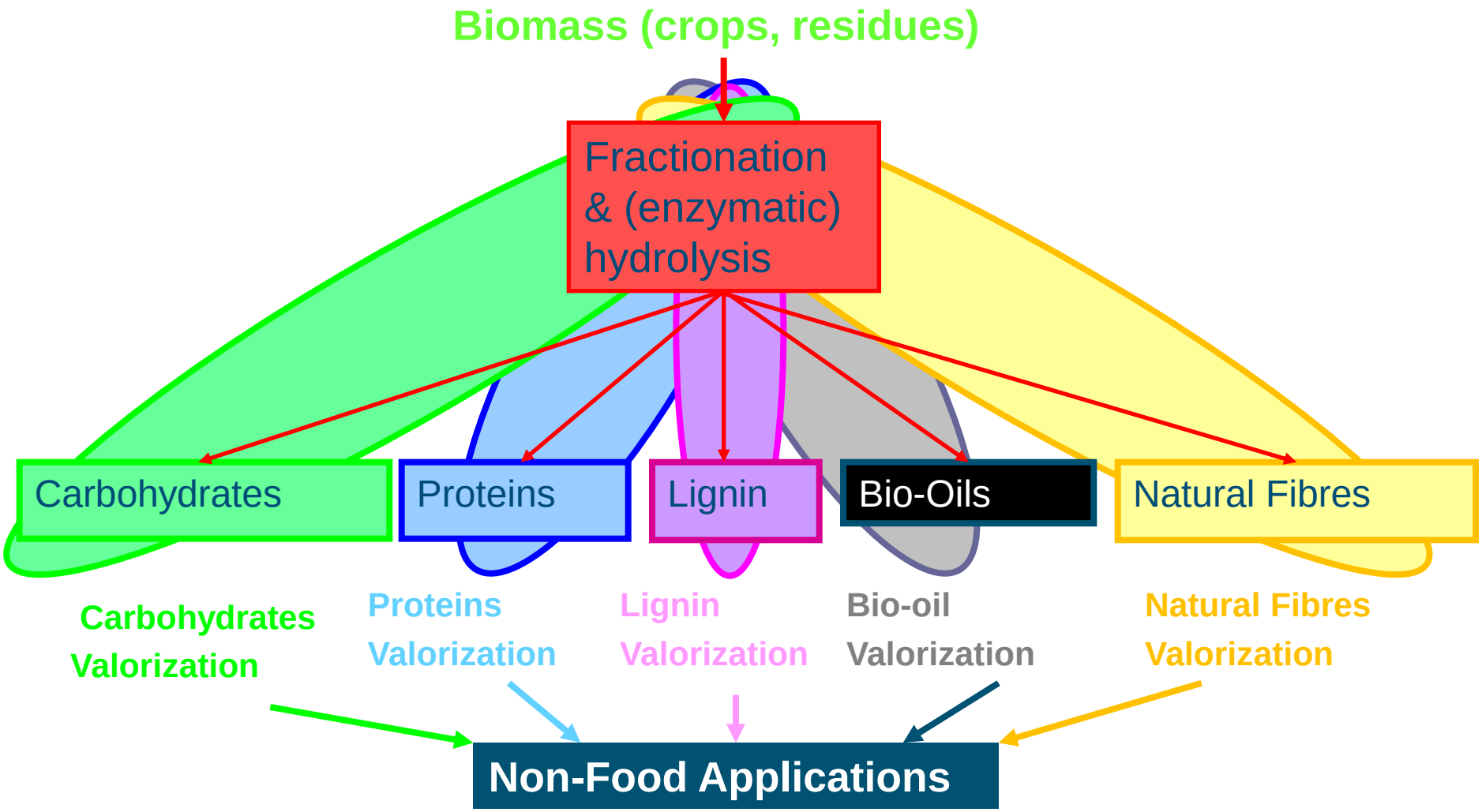
Comparison of the basic-principles of the petroleum refinery and the biorefinery



Summarising the concept

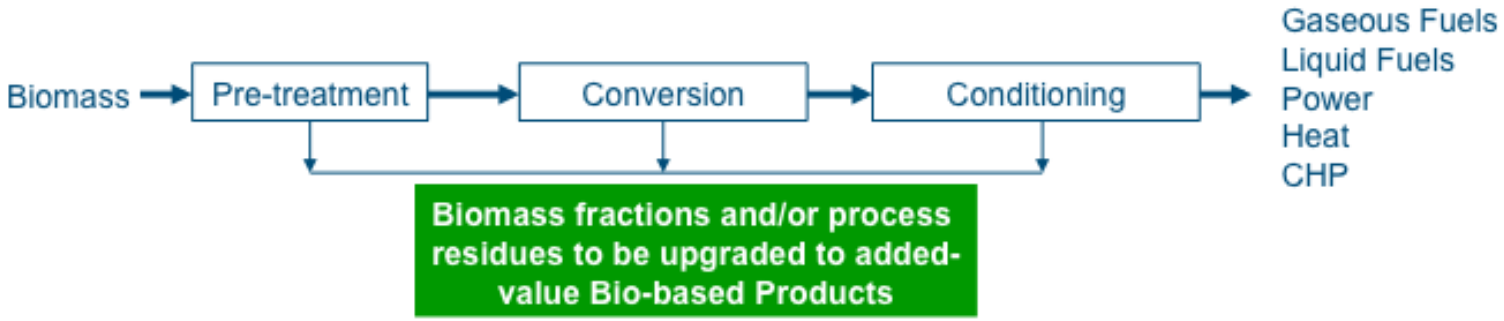
- **Biorefining is the Sustainable Processing of Biomass into a Spectrum of Marketable Bio-based, Products & Bioenergy**
- **Sustainable:** maximising profits, minimising environmental impact, socially acceptable, …
- **Processing:** integrated mechanical, (thermo)chemical, biological, … conversion
- **Biomass:** land/marine crops, primary/secondary residues, wood
- **Spectrum:** more than one product
- **Marketable:** current/future markets (volumes, prices)

Biomass valorization

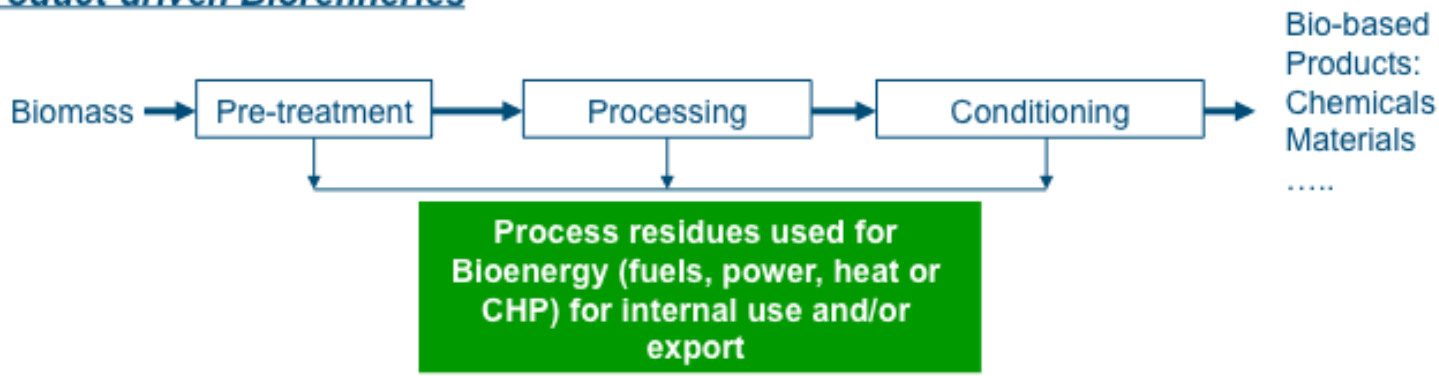


Energy or product-driven?

Energy-driven Biorefineries



Product-driven Biorefineries

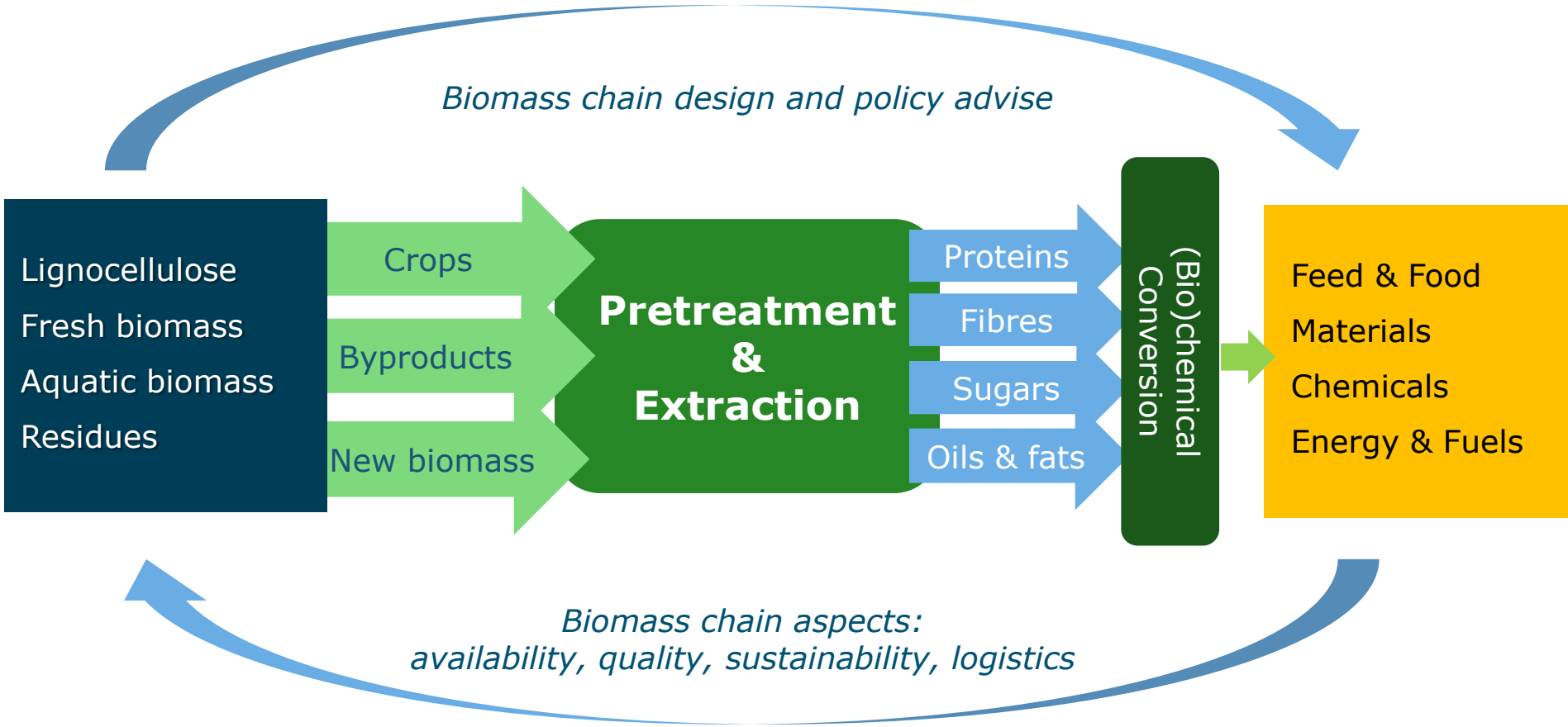


Main RTD Aspects: Biomass Pre-treatment, Biomass Fractionation and Enzymatic Hydrolysis, Advanced Anaerobic Fermentation, Advanced Gasification, Valorization Processes for Biomass Fractions and Process Residues, Full Biomass-to-Value Chain Design/Optimization and Sustainability Assessment, …..

Approach in Biorefinery development

- Keep **functionality** of components as much as possible
- **Integrate** pretreatment with further downstream processes (e.g. separation, fermentation, catalysis)
- **Product-driven** pretreatment and fractionation
- Use insight in biomass **composition** and **supply chain**
- **Biomass choice**: crops, lignocellulose, fresh biomass, algae, residues
- Use technology know-how as input for developing **sustainable value chains** and vice versa

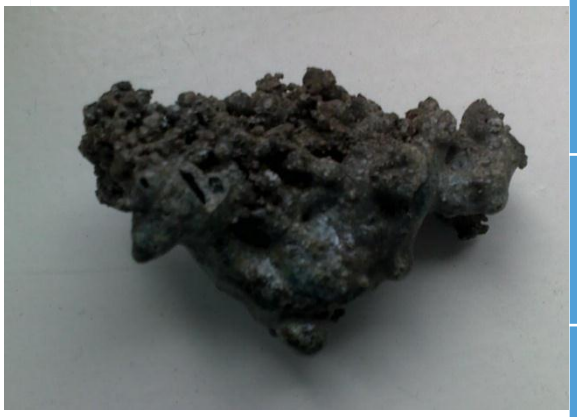
Our strategy in Biorefinery



Biorefineries: characterisation

- Starch- and sugar biorefineries
- Green biorefinery
- Plant oil (bio-)refineries
- Lignocellulose biorefineries
    - Wood-based
    - Agricultural residu and crops-based
- Microalgae and Seaweeds
- (civilisation biorefineries: waste valorisation)

Low Quality?



Parameter	Effect
Ash ☹	Cost of transport . Cost of ash removal. Higher dust emissions. Clogging ash removal system
N ☹	Easily volatile and release in gas phase during combustion at temperatures between 800 – 1100 C - NOx emissions – corrosion? - Loss of nutrients
S ☹	Easily volatile and release in gas during combustion. Produces gaseosus compounds SO3and SO4 - SOx emissions - Corrosive effects
Cl ☹	Easily volatile and release in gas during combustion - HCl formation → corrosion - Cl influences the formation of polychlorinated dibenzodioxins and furans (PCDD/F) - Agglomeration (with K)
Ca ☺	- Increase the melting temperaturte of ash - Relevant plant nutrient, ash can be recycled as a fertiliser
Mg ☺	- Increase the melting temperature of ash
K ☹	Lowering ash melting point: - Slagging and deposit formation in furnaces and boilers Main aerosol forming during combustion - Lowering of the efficiency, higher operating cost KCL formation in the gaseous phase - Raise emission of fine PM and increases fouling in the boiler. - KCL causes corrosion of heating surfaces and it is a catalyst of NOx Can be recycled as fertiliser
Na ☹	Lowering ash melting point: - Slagging and deposit formation in furnaces and boilers Main aerosol forming during combustion - Raise emission of fine particulate matter PM - Increases fouling in the boiler

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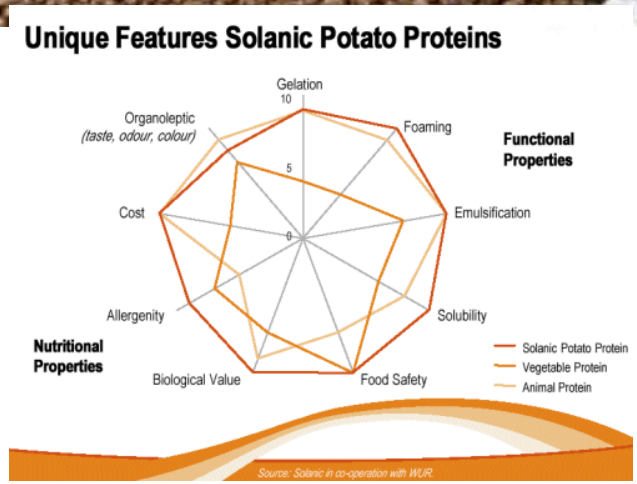
Starch Biorefinery (AVEBE)



Source: www.avebe.com; www.solanic.eu

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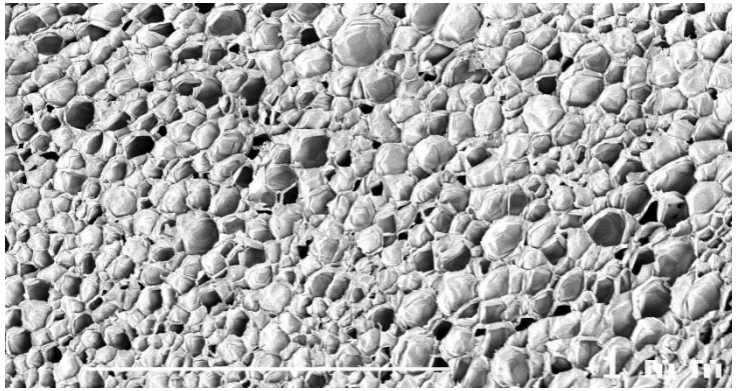
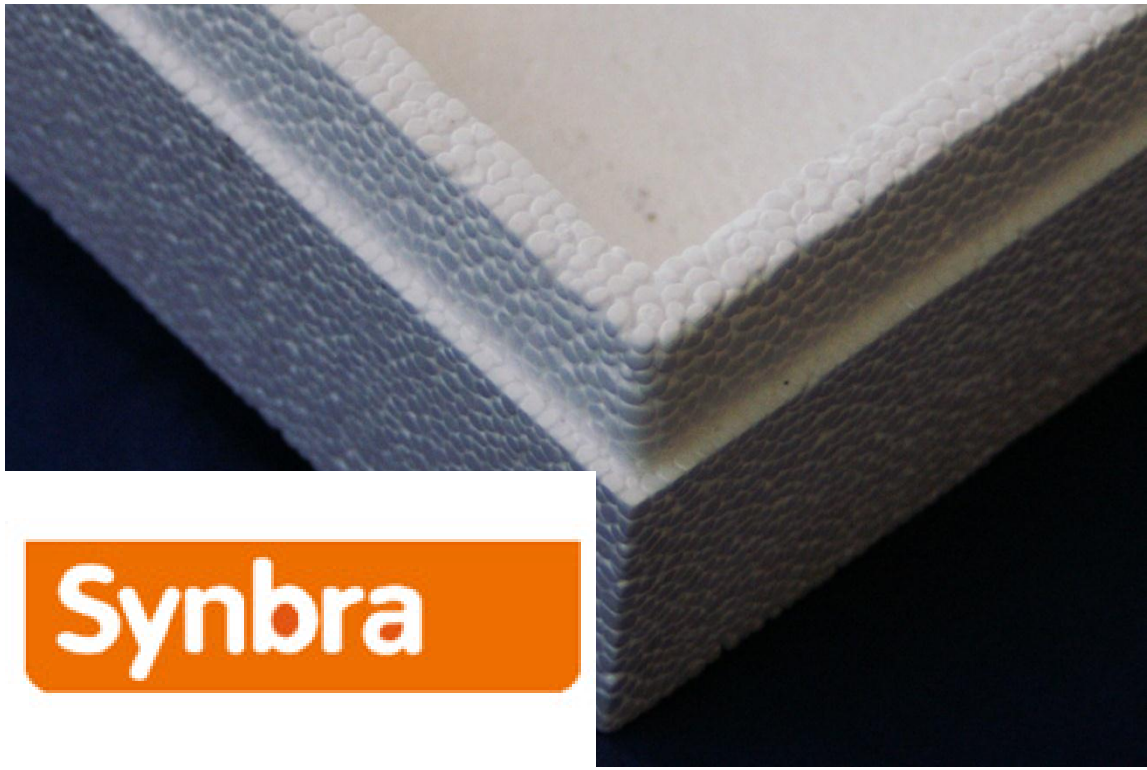
Expanded polystyrene

- Fully recycable packing or insulation material

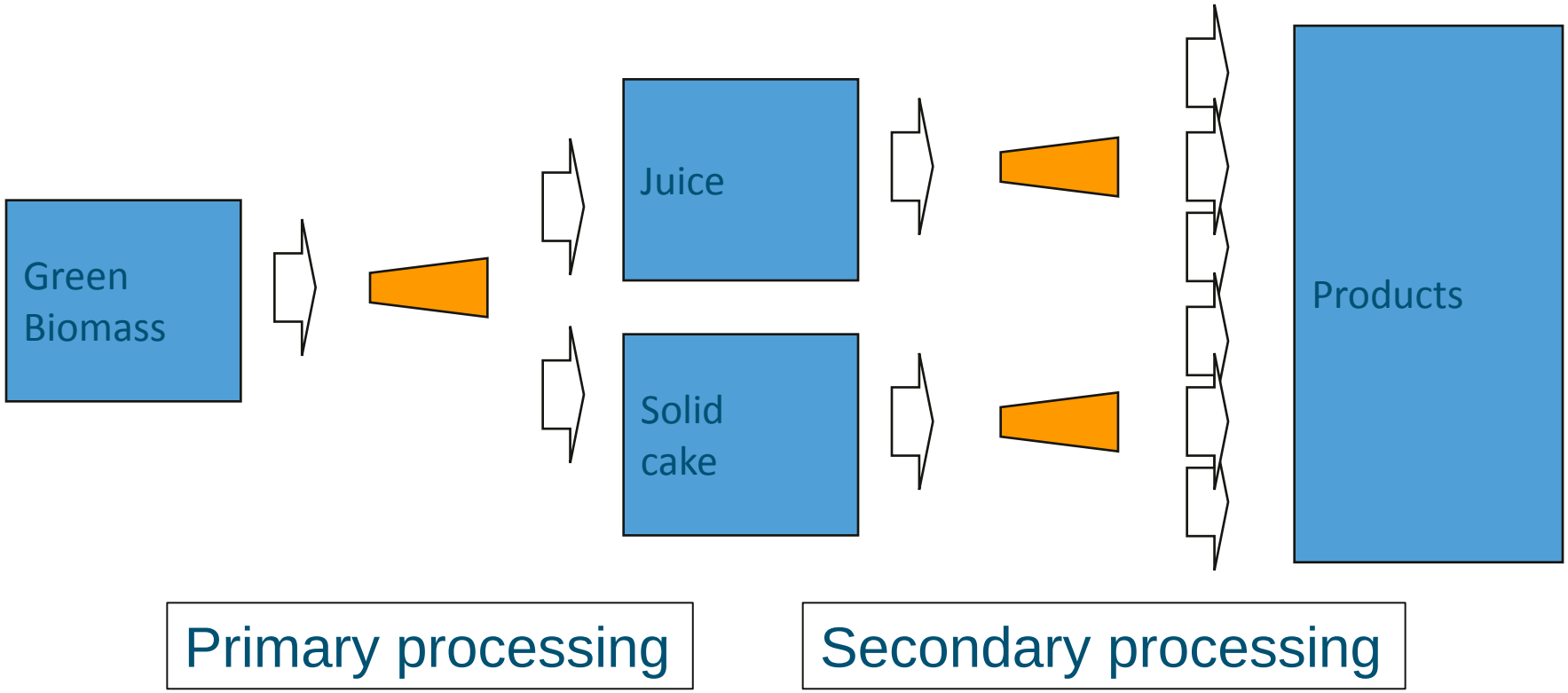


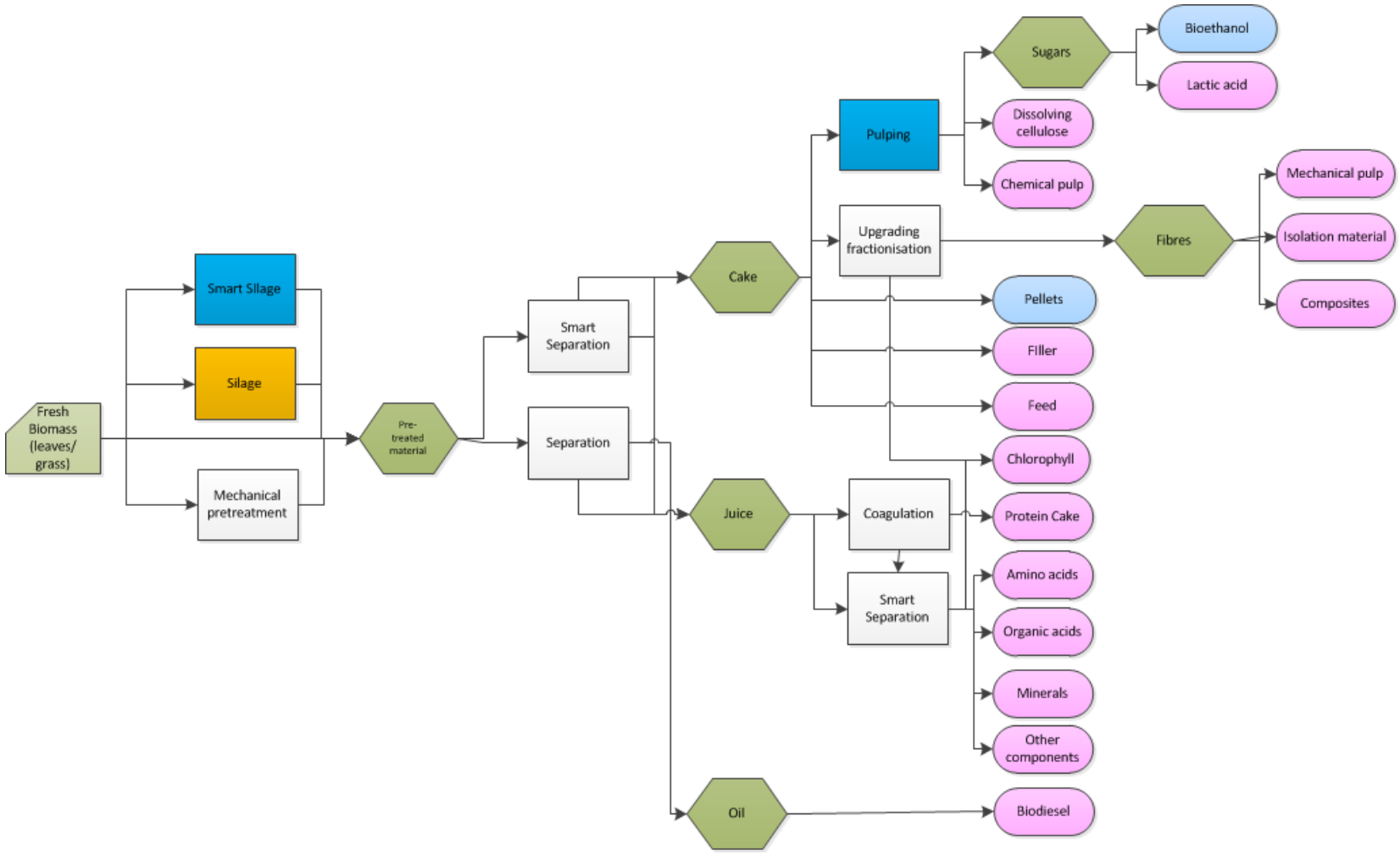


Synbra

Green Biorefinery

A Green Biorefinery processes (fresh) green biomass to an array of products

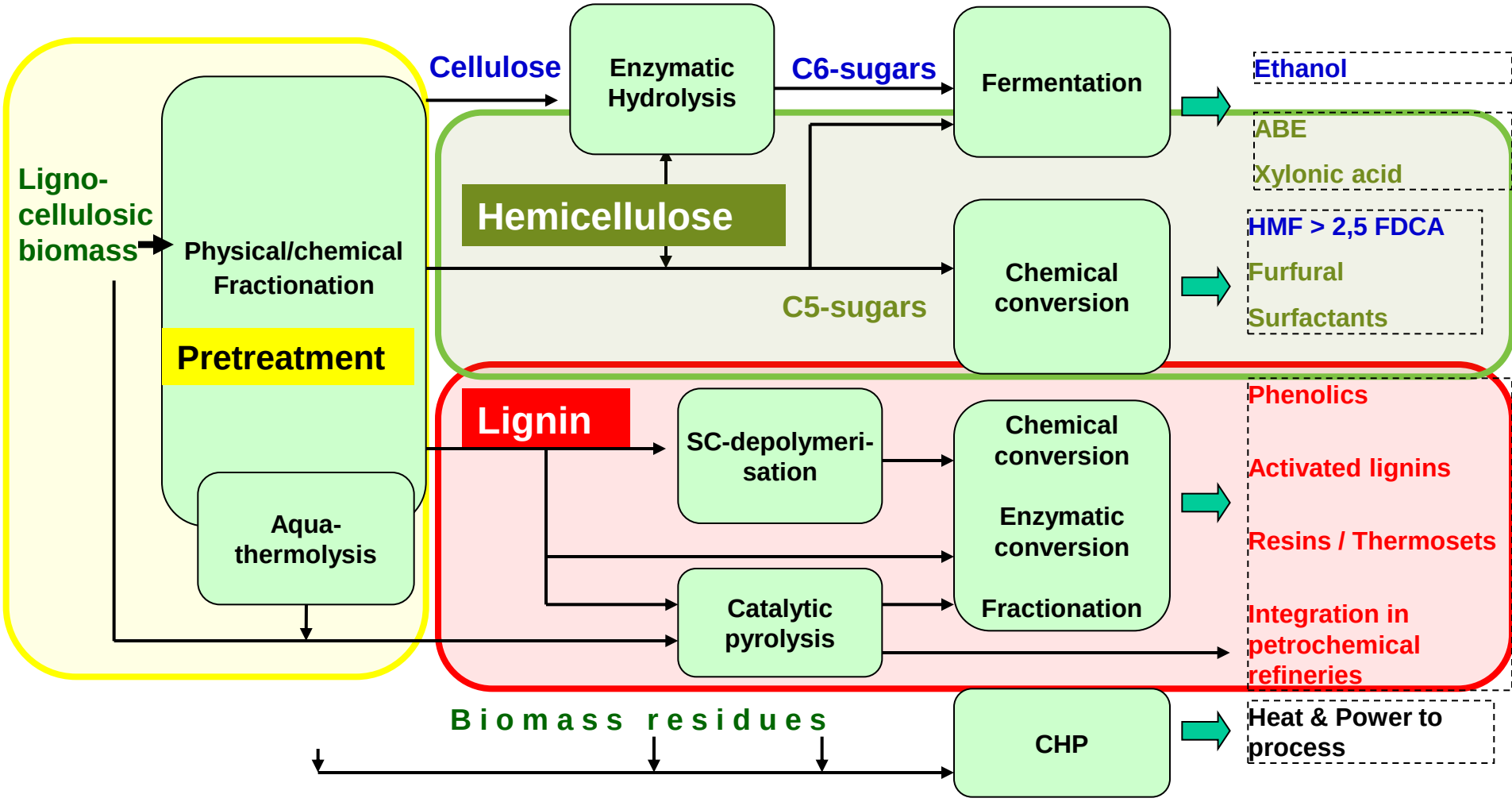



Fresh Biomass (leaves/ grass)
Smart Sllage
Silage
Mechanical pretreatment
Pre-treated material
Smart Separation
Separation
Cake
Juice
Oil
Pulping
Upgrading fractionisation
Coagulation
Smart Separation
Sugars
Dissolving cellulose
Chemical pulp
Pellets
FIller
Feed
Chlorophyll
Protein Cake
Amino acids
Organic acids
Minerals
Other components
Biodiesel
Fibres
Bioethanol
Lactic acid
Mechanical pulp
Isolation material
Composites

BIOSYNERGY

Integrated Lignocellulose BioRefinery

Multi-product biorefinery, focus on residues cellulose ethanol: **C5 and lignin valorisation**



From straw to fermentable sugars & lignin

Wheat straw

Pretreatment

Lignin

Polymeric sugars

Enzymatic hydrolysis

Monomeric sugars

Fermentation

Ethanol

Fractionation efficiency

- Delignification up to 70 - 80%
- Improvement of enzymatic degradability

Enzymatic hydrolysis

Conversion of glucan and xylan to monomeric sugars, with low fermentation inhibitors

BIOSYNERGY

Lignin application in wood-based panels

Particleboards produced with PF resins where phenol was replaced by straw lignin at various levels

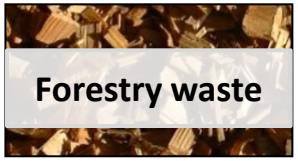
Step of plywood panels production.

Plywood panels

Testing of plywood at CHIMAR premises

biocore

Varied biomass



Fractionation

Intermediates

Chemistry Biotechnology

Hemicellulose

Cellulose

Lignin

Final products

2nd generation fuels

Ethanol

Thermoplastics

PVC, polyolefins, polyurethanes, polyesters

Resins/Adhesives

Food additives

Detergents

Wood panels

Application sectors

Energy

Materials

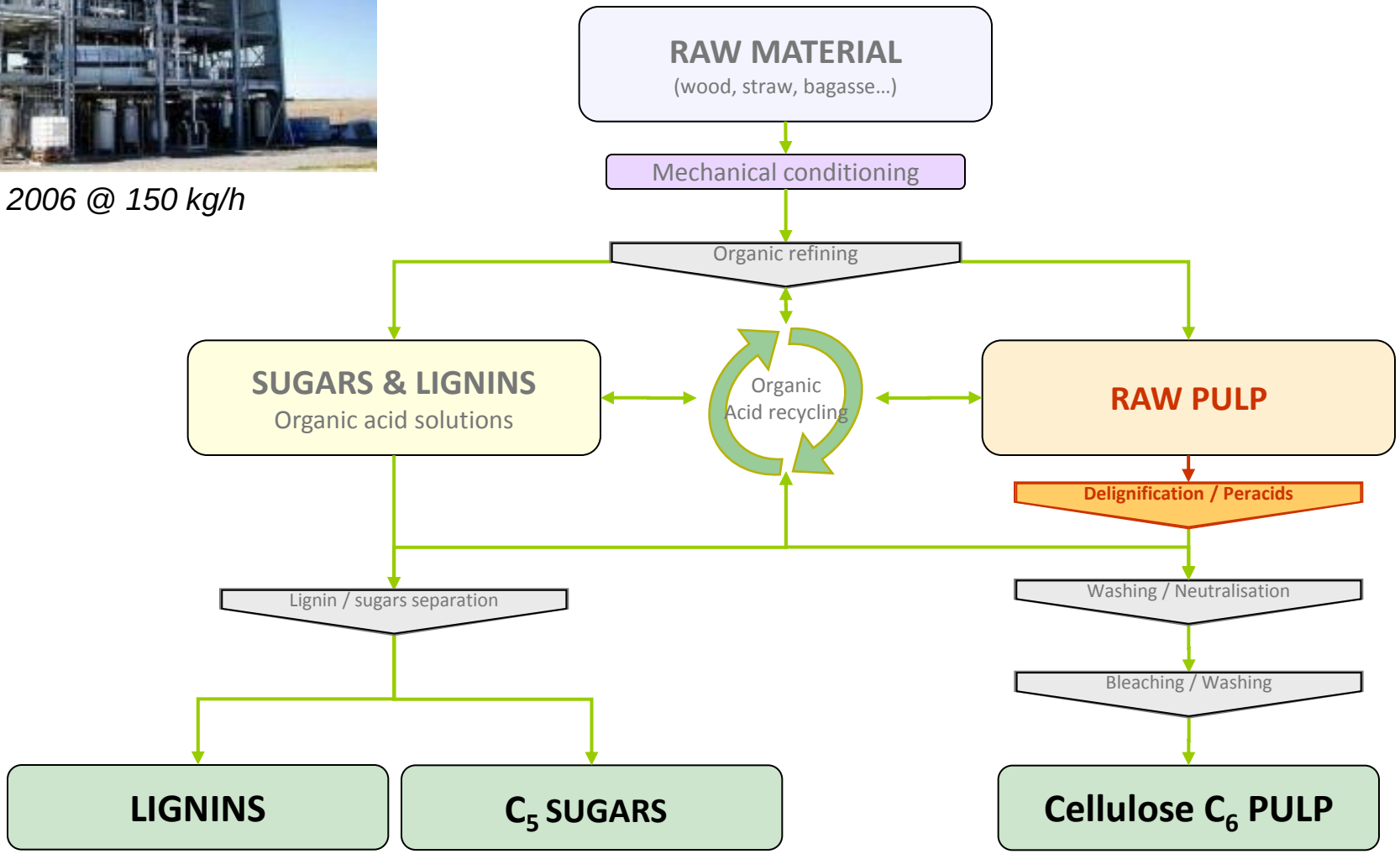
Packaging

Building

Adhesives and paints

Since 2006 @ 150 kg/h

CIMV organosolv fractionation process
Acetic/formic acid, 105°C



M. Delmas, Chem. Eng. Technol. 2008,31,No.5,792-797

Lignin valorization

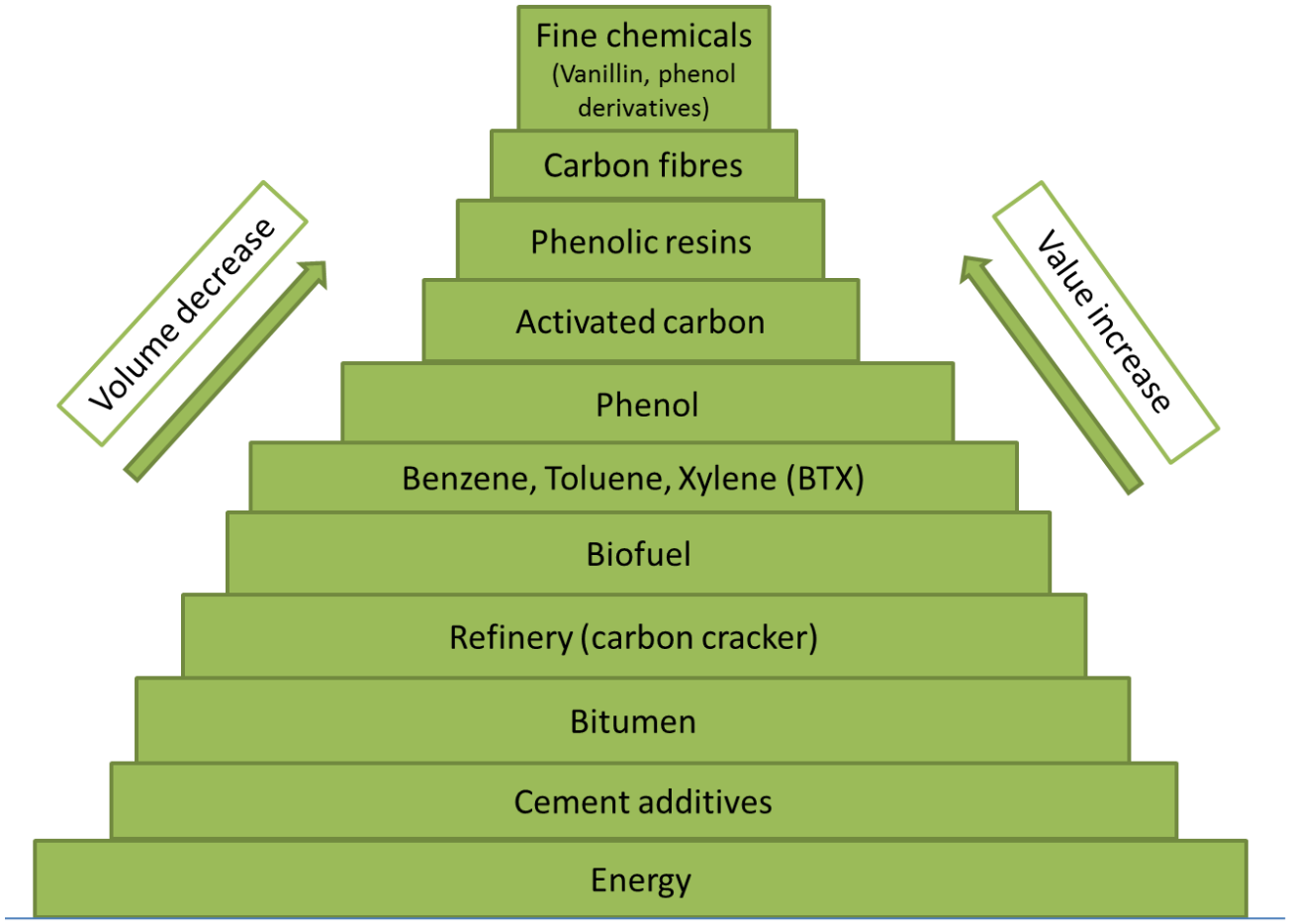
- Abundantly available at relatively low costs
- Energy source
- Versatile raw material for many applications



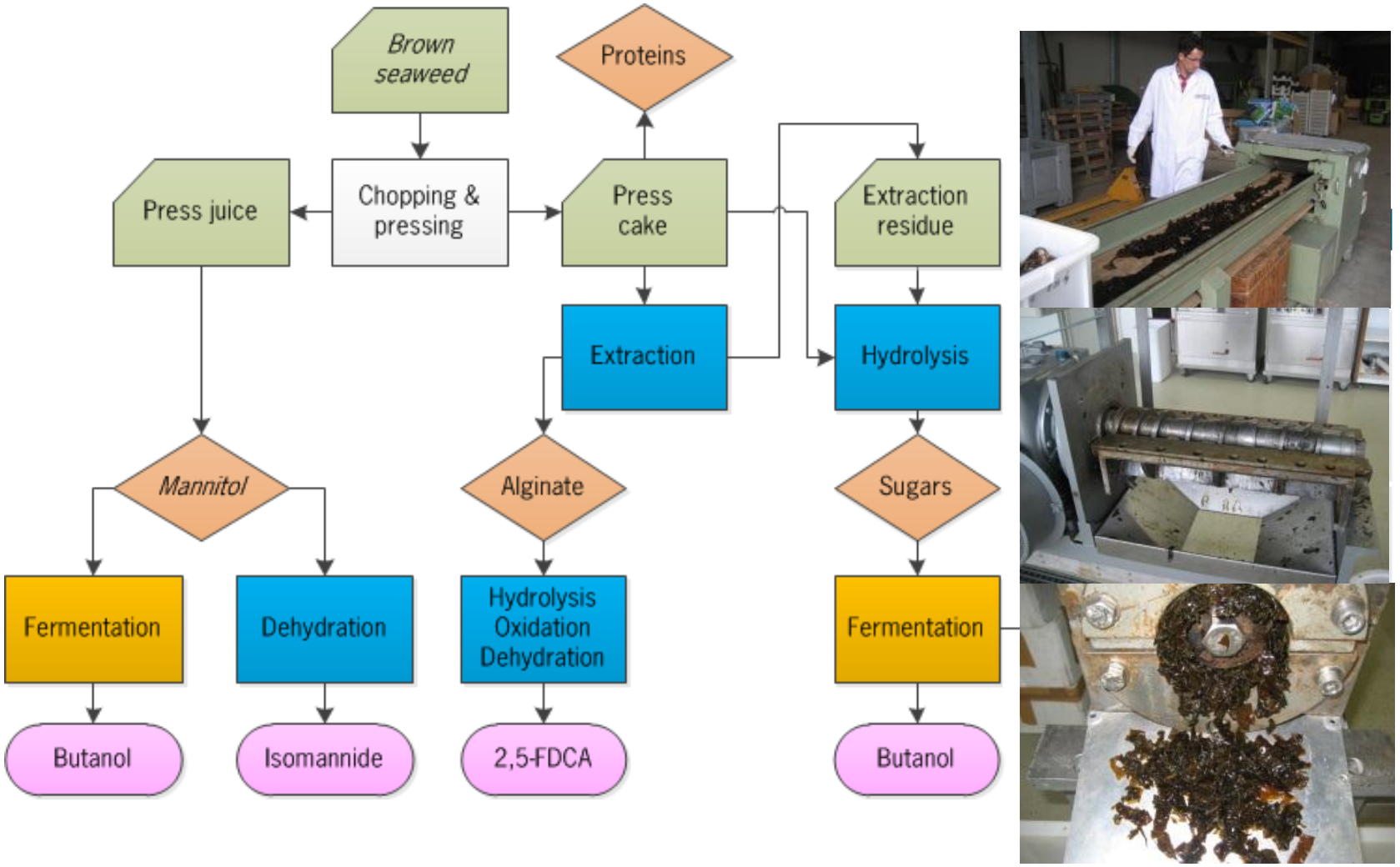


- Additional revenues for Pulp&Paper industry and 2nd Generation Biorefinery industry
- Limited industrial applications due to complex structure

Lignin valorization



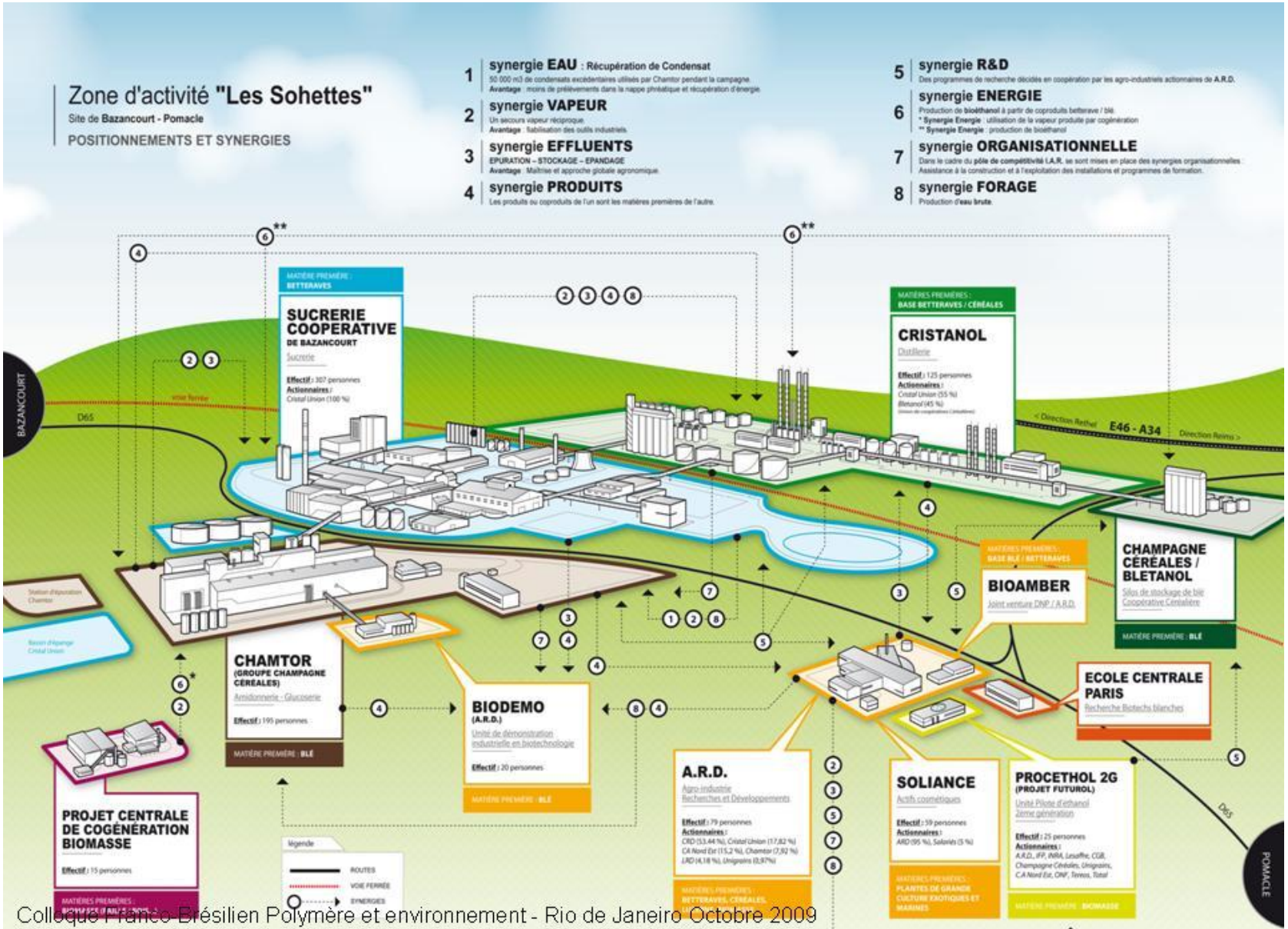
Biorefinery of (brown) seaweeds



Recommendations

- Integrated approach: not biofuels versus biobased products, but biofuels AND biobased products (+ food)
- Current bioenergy production is important in supply chain development of many feedstocks
- There should be a level playing field in applying biomass to different sectors (energy, chemical sector)
- First integrated biorefineries will develop around current agro-industrial industries, and pulp & paper industries
- Clustering of different industries is important

Biorefinery cluster in N. France



Thank you for your attention