



Biorefinery and the Pulp & Paper Industry

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Braz Demuner**

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Outline



- Pulp and Paper biorefinery concepts
- Technologies
- Overview of projects in the world

Definition

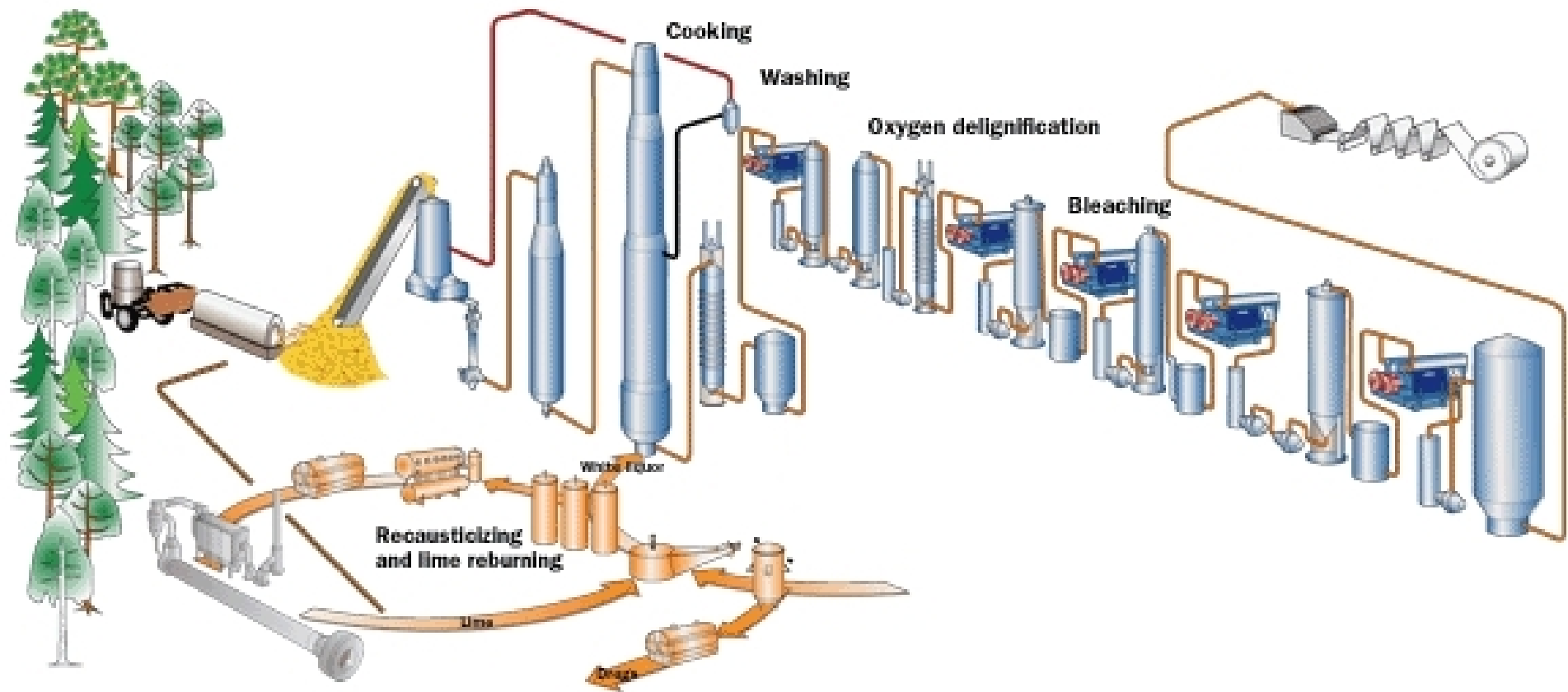


- A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. Industrial biorefineries have been identified as the most promising route to the creation of a new domestic biobased industry.

- The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum.

National Renewable Energy Laboratory, USA, 2007

Pulp and Paper Typical Fiberline

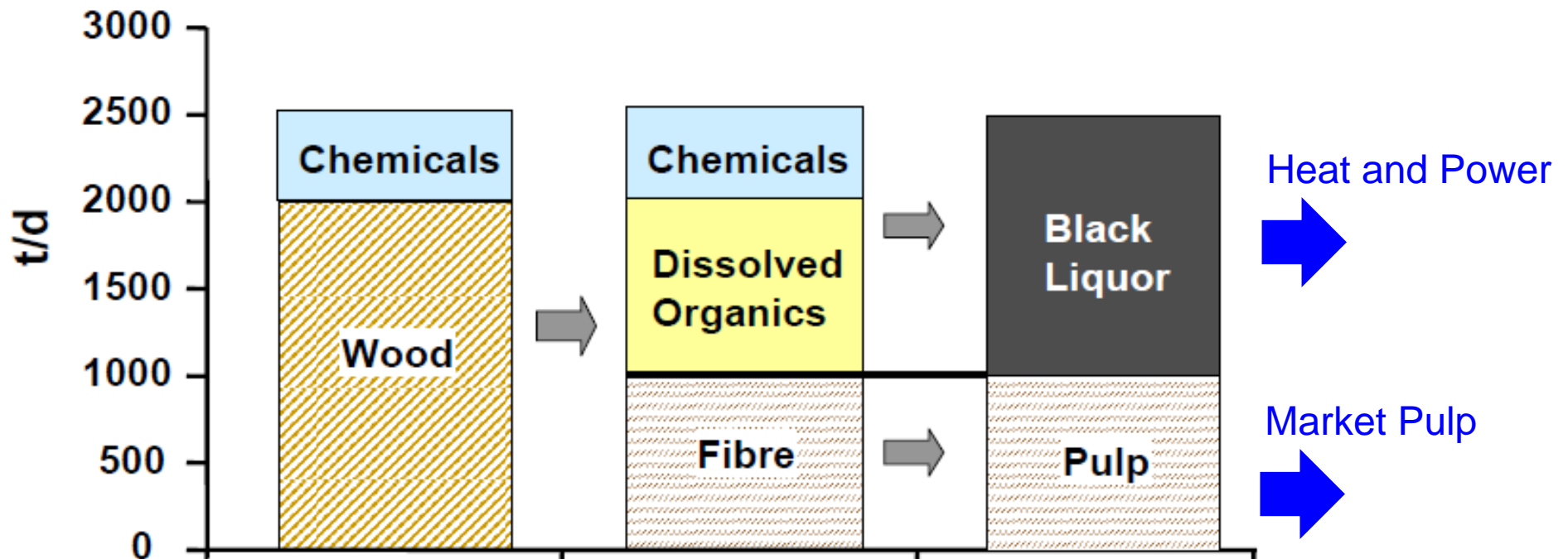


Pulp and Paper Typical Balance



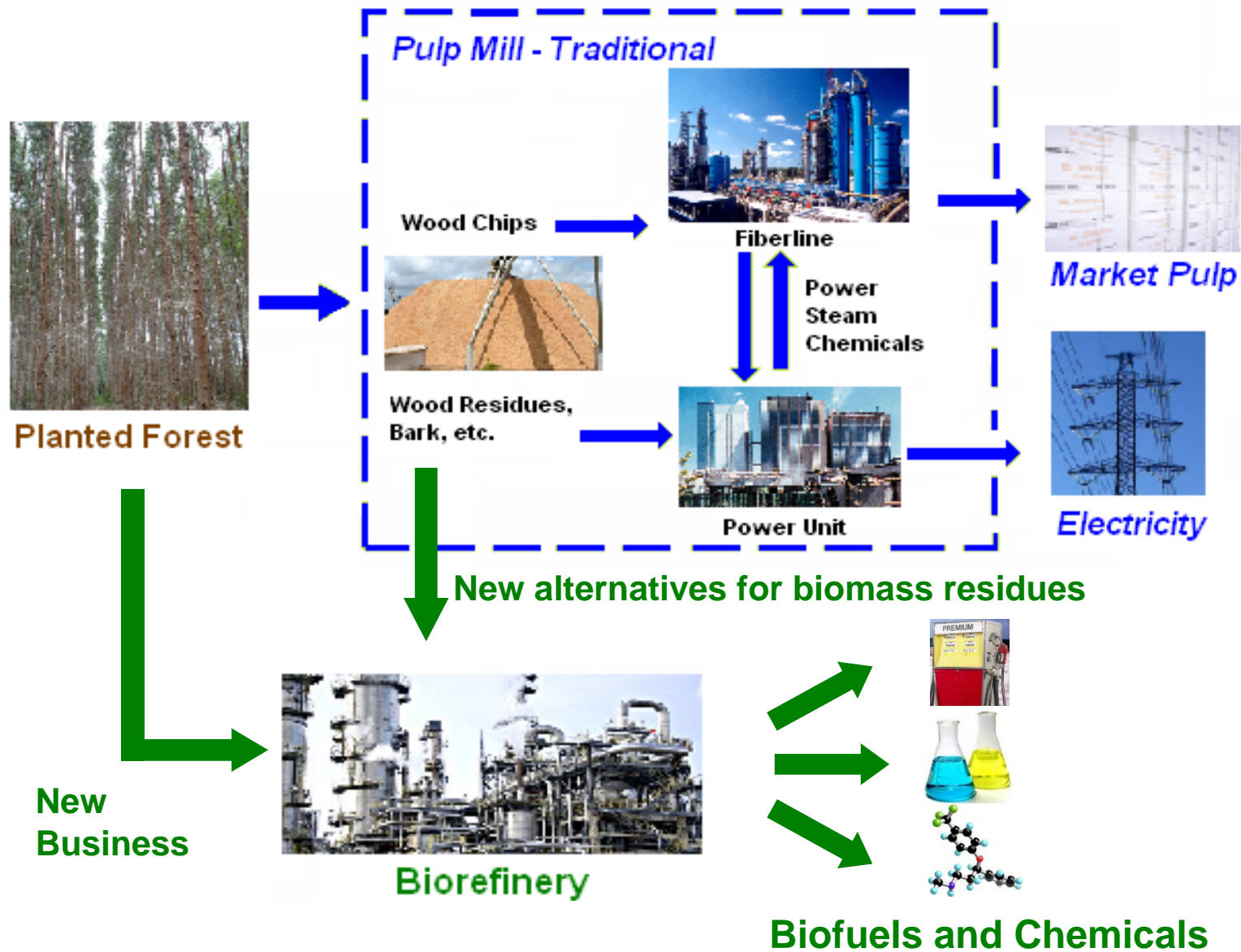
A 1000 t/d Kraft Pulp Mill produces 1500 t/d BL d.s.

~ 5000 t steam/day ----- ~ 650 MW/day (rough estimate)

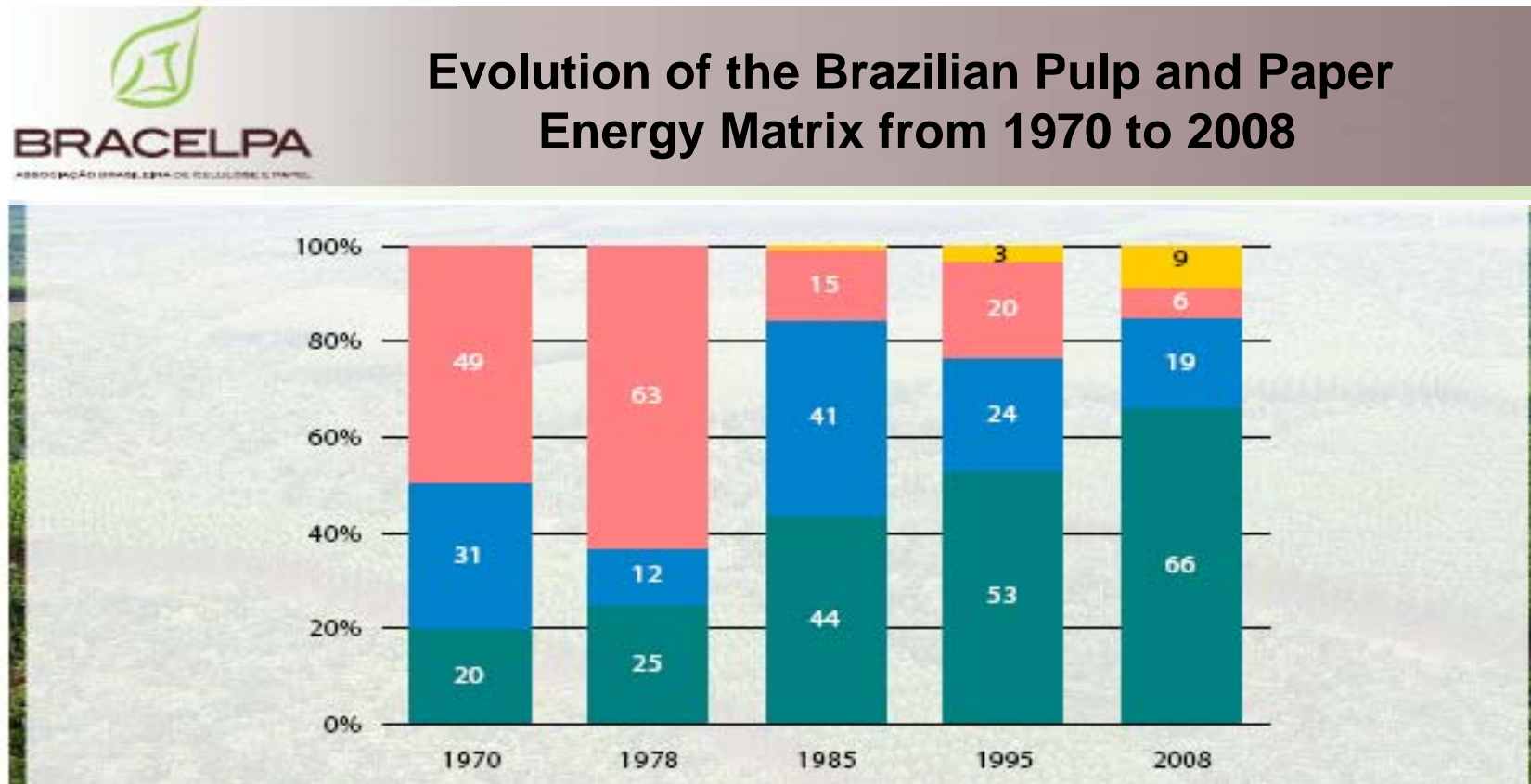


A modern pulp mill: 4300 t/d => 21500 t steam/day and ~2800 MW/day

Biorefinery Concept



Energy – Brazilian P&P Industry

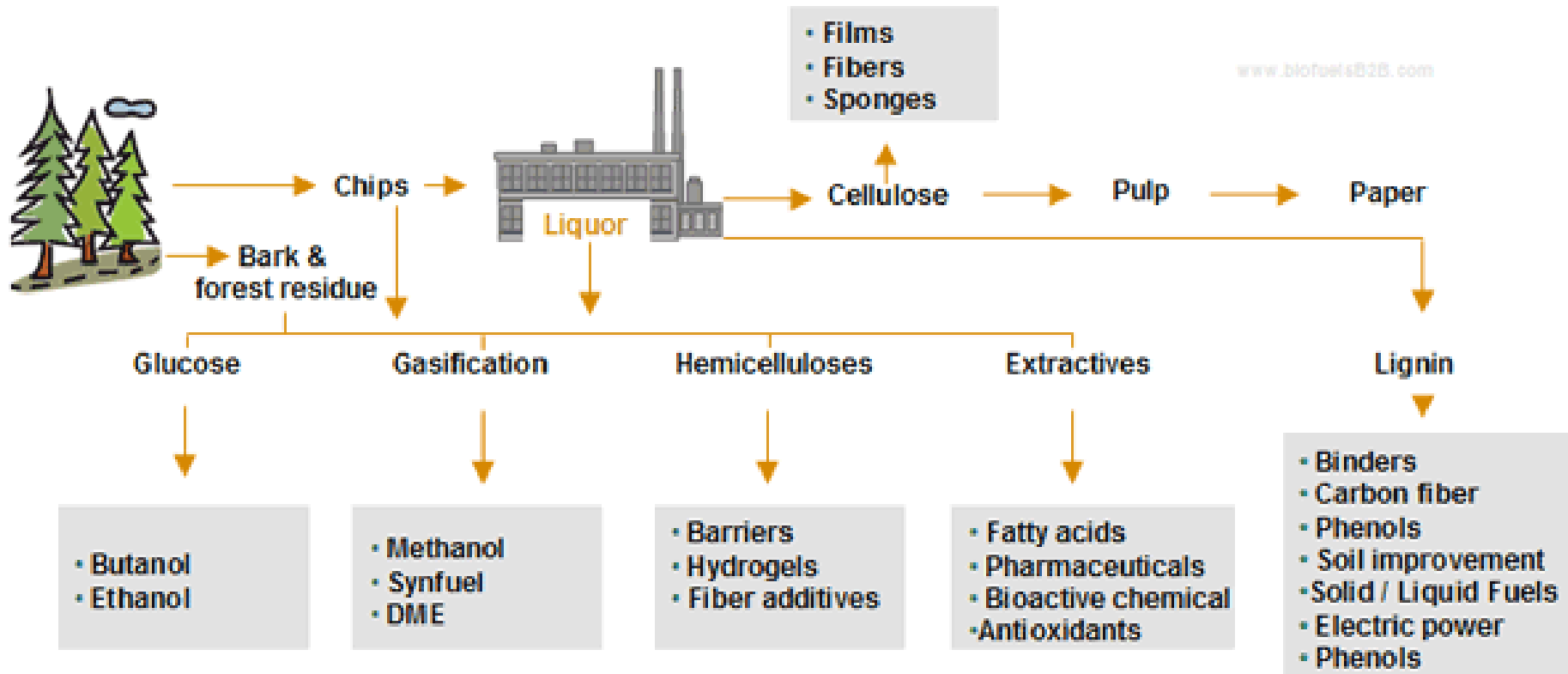


 **Black Liquor Biomass Product**  **Biomass**  **Natural Gas**  **Oil**

We are already a biorefinery!

Source: Bracelpa

Biorefinery – Possible Products

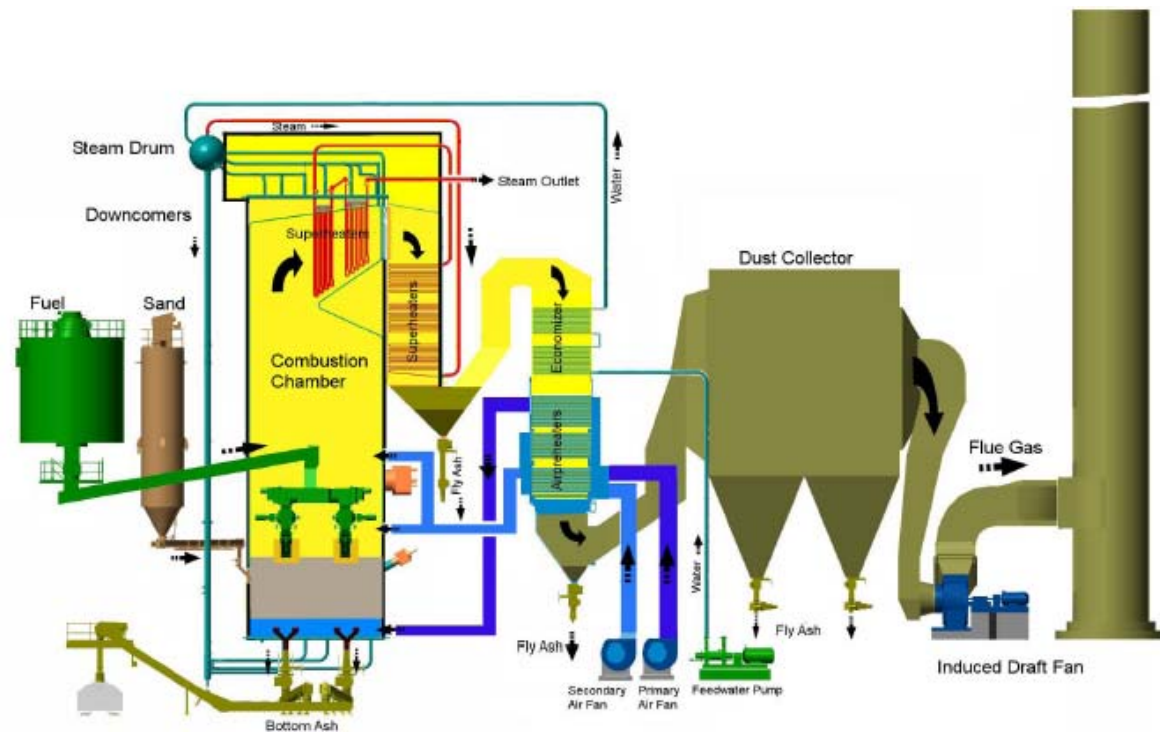


Available Technologies

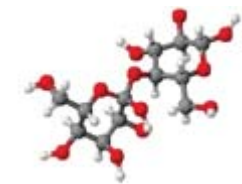
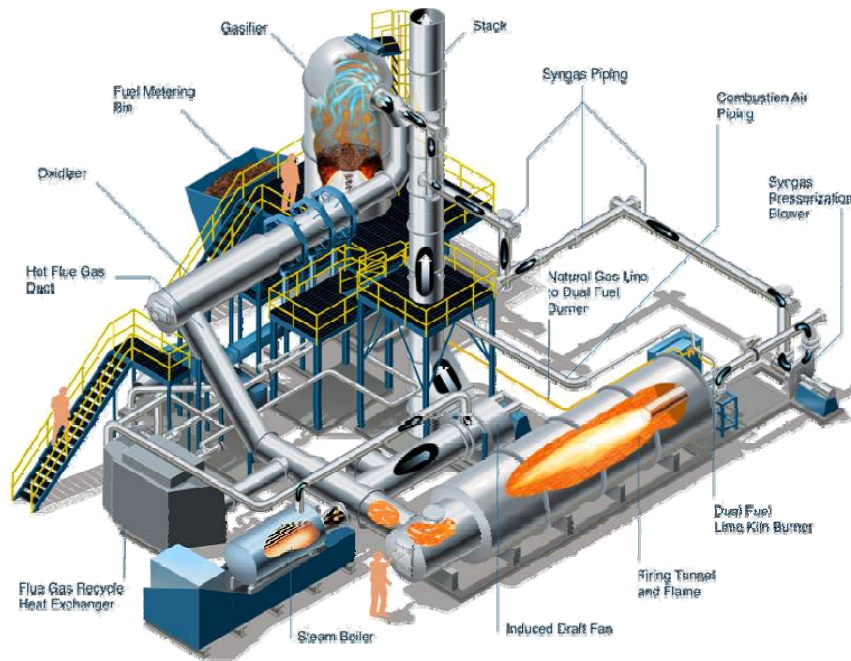


- Wood biomass has a potential energetic content to produce beyond pulp, the following products:
 - Power/ thermal energy
 - Industrial fuels (lime kilns, boilers)
 - Superior fuels (automotives)
 - Other Bioproducts (renewable)
- The forest based industry had just realized that it is well positioned on the renewable energy market.

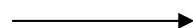
Biomass Boilers



Biomass gasification - Syngas



Biomass



Conditions

$T > 800^{\circ}\text{C}$, air
 O_2 and steam

Product

$\text{CO} + \text{H}_2$

Liquid

5%

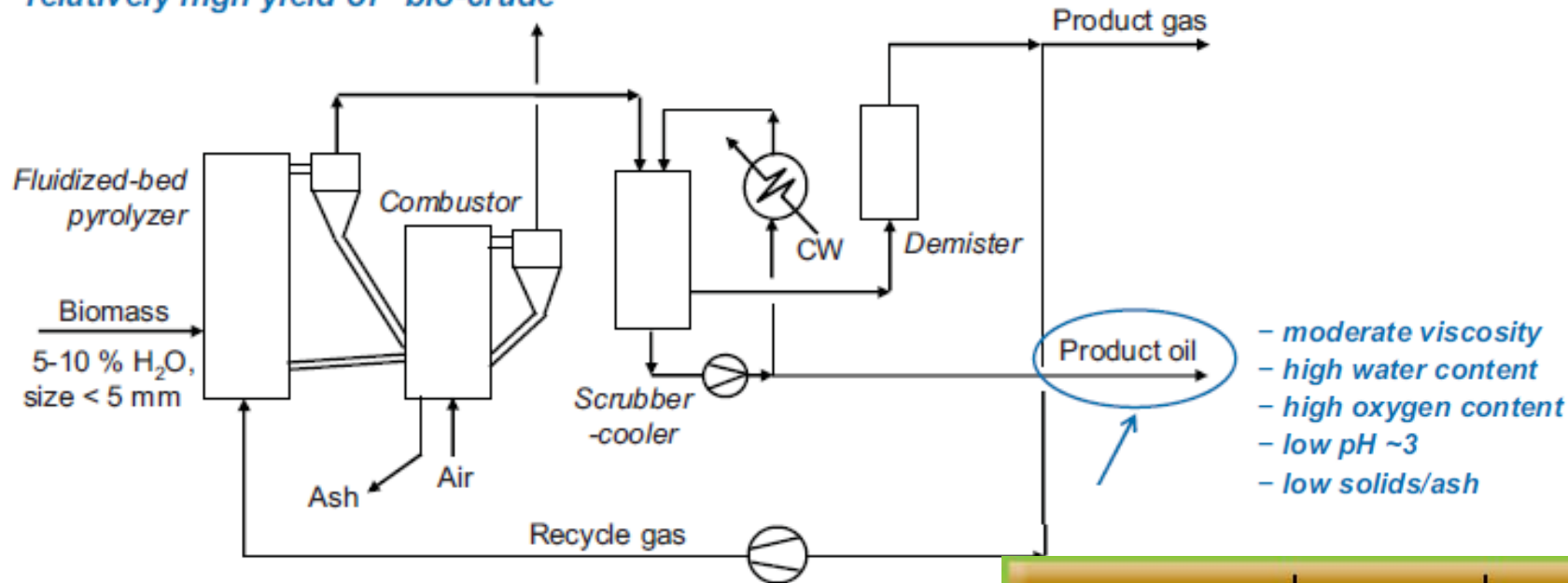
Gas

85%



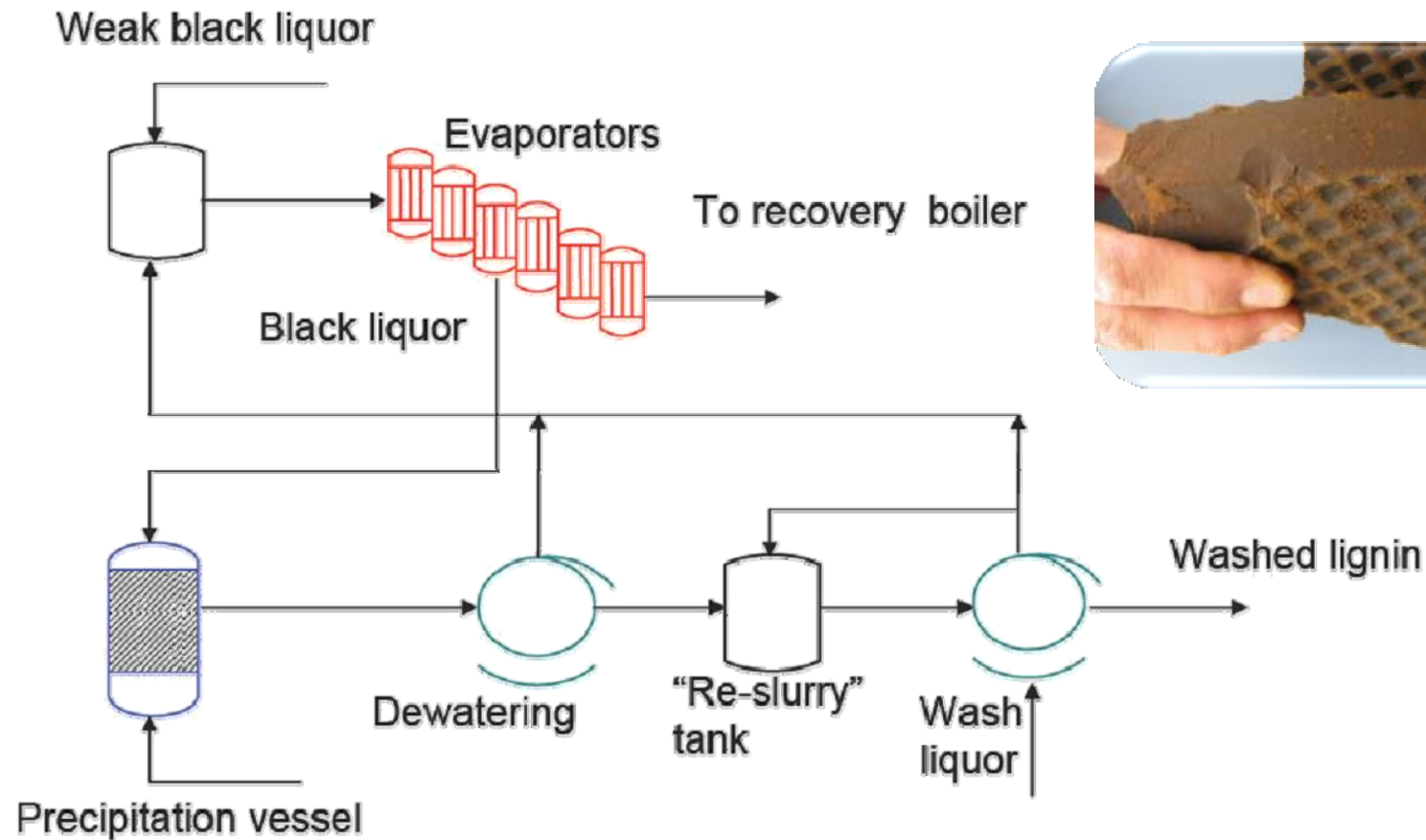
Fast Pyrolysis

*Rapid pyrolysis: ~500 °C, gas residence time ~1 s;
relatively high yield of "bio-crude"*



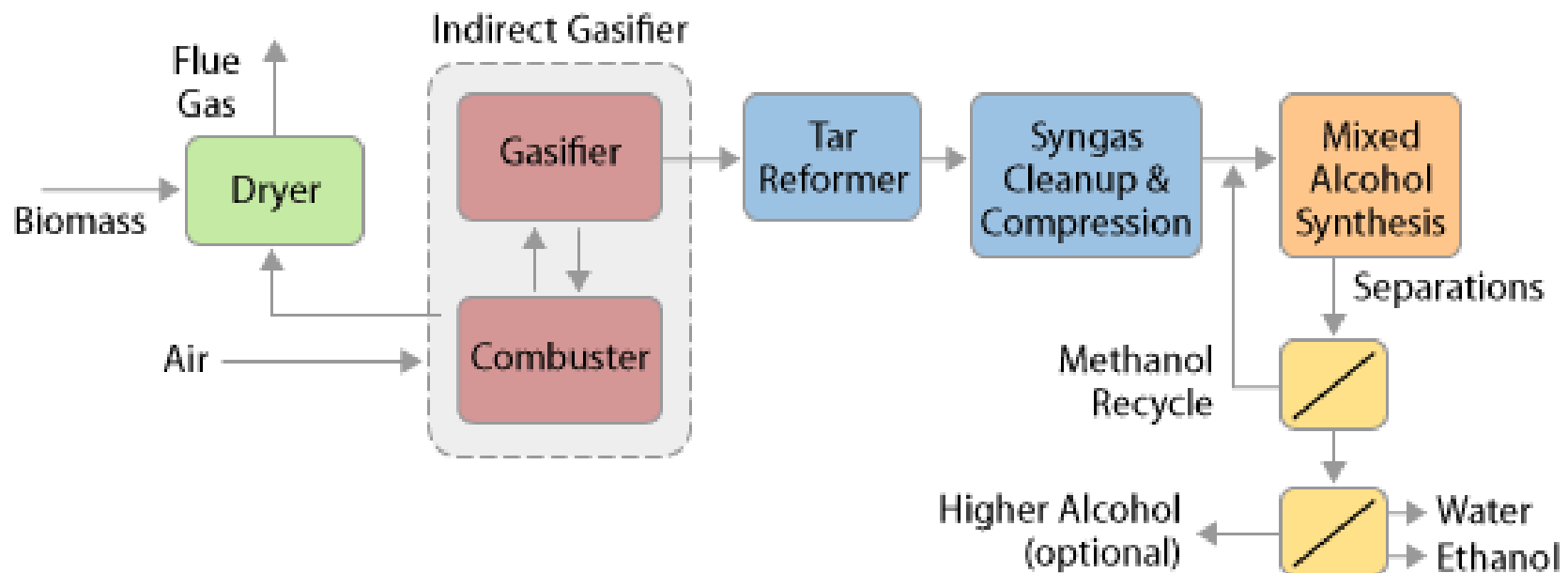
BIOMASS MATERIAL	YIELD (WT%)	HIGHER HEATING VALUE (BTU/LB)
Hardwood	70-75	7,400-8,200
Softwood	70-80	7,300-8,000
Hardwood Bark	60-65	7,180-8,680
Softwood Bark	55-65	7,180-8,500
Corn Fiber	65-75	7,570-8,680
Bagasse	70-75	8,100-8,200
Waste Paper	60-80	7,300-7,400

Lignin precipitation (from black liquor)



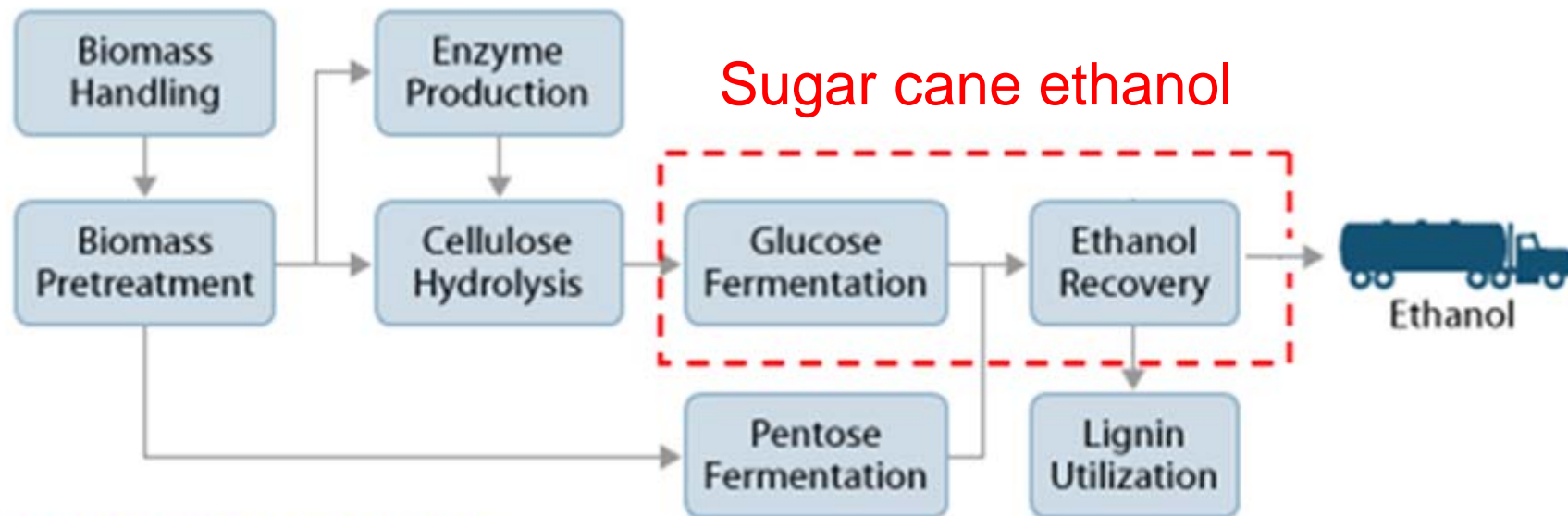
Thermochemical process

Ethanol Production Process



Source: Research Advances—Cellulosic Ethanol

Wood ethanol production – Enzymatic Process



Source: [DOE Biomass Program](#)

Potential Kraft/Soda Lignin Applications

Lignin in fuel oil



Lignin fuel in lime kilns



Lignin pellets



Dispersants



Kaolin/Water

Lignin to carbon fibres



Spun lignin fibres

Other applications

- Binders
- Benzene/Phenols
- Activated carbon

Other Bioproducts – From Carbohydrates



Table 1-2 Products from Hydrocarbons Versus Carbohydrates

Product	Total Production (million tons)	% Derived From Plants
Adhesives	5.0	40
Fatty Acids	2.5	40
Surfactants	3.5	35
Acetic Acid	2.3	17.5
Plasticizers	0.8	15
Activated Carbon	1.5	12
Detergents	12.6	11
Pigments	15.5	6
Dyes	4.5	6
Wall Paints	7.8	3.5
Inks	3.5	3.5
Plastics	30	1.8

Source: ILSR 1992

Table 1-5 Production of Selected Bioproducts

Products/ Intermediates	Annual Production (million lbs)	Estimated Value (million \$)
Wood & Gum Chemicals *	3,268	890
Cellulose Fibers	360	760
Cellulose Derivatives **	2,140	1,400
Industrial Corn Starch and Corn Chemicals	6,500	2,200
Glycerine	400	320
Industrial Ethanol	408	115
Oils and Resins ***	1,214	550
Activated Carbon	254	220

*Rosin, tall oil, sulfate turpentine

**Regenerated cellulose, cellulose ethers, ethyl cellulose

***Soy oil, peppermint, spearmint, other plant oils

Sources: CMR 2002, DOC-ASM 1999, Corn Annual 2001, Chem Expo 2002, EI 2001.

Potential to replace oil based products!

Biorefinery Activities - USA



Source: DOE Biomass Program

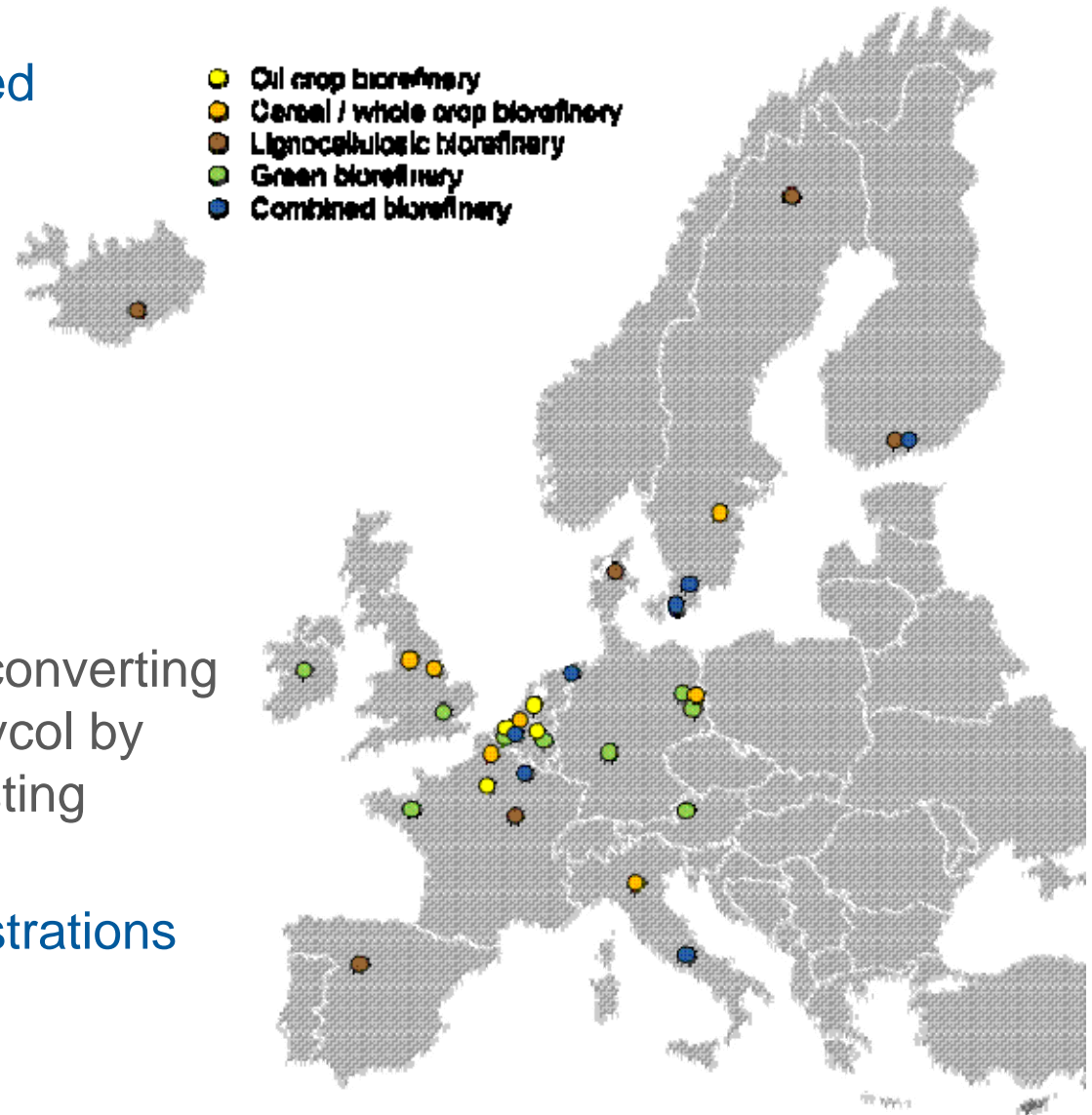
Modified January 2009

Recent advances: Agenda 2020 and Tappi RMC Nov. 3, 2010.

- **Biorefineries have been successfully running, in pilot and demo- plants;**
- **They have been using different types of lignocellulosic materials (wood, agri residues, sweetgrass, etc)**
- **Production of bioethanol and biobutanol;**
- **The amount of biomass need to meet the RFS2 mandate is one of the most important current concern.**

Biorefinery Activities - EU

- About 34 existing and planned biorefineries in the EU27+
- Types of biorefinery
 - 7 whole crop / cereal
 - 4 oil seed biorefineries
 - 9 green
 - 6 lignocellulosic
 - 7 combined biorefineries
 - 1 other biorefinery plant converting glycerine to propylene glycol by using glycerine of an existing biodiesel plant
- About 45 R&D, pilot, demonstrations projects with EU



Sources: DBFZ based on Euroview & Biopol, 2008; Reith & Steinmetz, 2009

Final Remarks

To evaluate the potential of the existing technologies, the following questions should be answered:

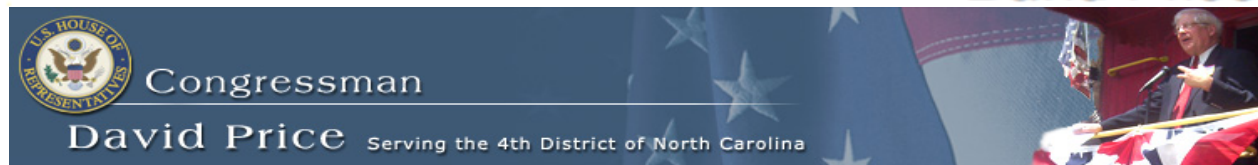
- Could it be technically done?
- Is it economically feasible (and competitive)?
- is it sustainable?

Final Remarks

- The main challenges for the companies on the biofuels market are the **technical and financial risks**;
- No one wants to be the **first to take the risk** – it would be a new business model and financial support from the government or a business partner might be an alternative;

There is no way the industry can develop biofuel without help. It needs partners from research labs and the energy and chemical sectors.

David Price



Thank you!!