Presentation 2.4: Forest biorefining and implications for future wood energy scenarios

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Abstract
The diversification of the forest products industry to include bioenergy may be characterized by evolution of a number of co products. The biorefinery concept, which considers energy, fuels, and chemical or material production within a single facility or cluster of facilities, may be the route forward for the forest industry that provides optimal revenues and environmental benefits. Forest-based biorefining platforms may use traditional or innovative platforms. A review of biorefineries in other sectors is followed by an examination of potential co products. A number of existing pilot or demonstration facilities exist around the world today, and many of these are described. The growth of biorefining in developed regions creates a technology transfer opportunity that could be facilitated through an FAO-led network similar to IEA Implementing Agreements or Tasks.

Forest biorefining and implications for future wood energy scenarios

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Outline

1. **Defining biorefining in the global context**
2. Forest-based biorefining platforms
3. Potential coproducts from the forest-based biorefinery
4. Examples of pilot and demonstration sites
5. Summary & Recommendations

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Definitions

- Lignocellulose-based biorefinery:
  Combination of bioenergy, 2nd-gen biofuel, bioproducts
- 1st-generation biofuels
  Commercial, based on food or foodstuff waste
- 2nd-generation biofuels
  Non-commercial, based on non-food
  (including forest biomass)
- Can be used in conventional infrastructure
- 3rd-generation biofuels
  Non-commercial, non-conventional

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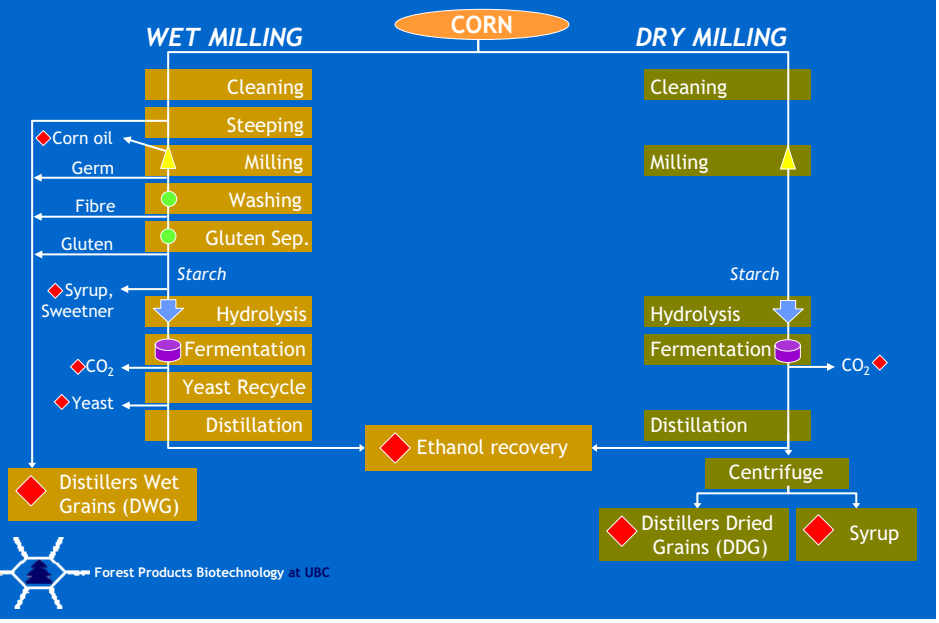
Agricultural biorefinery



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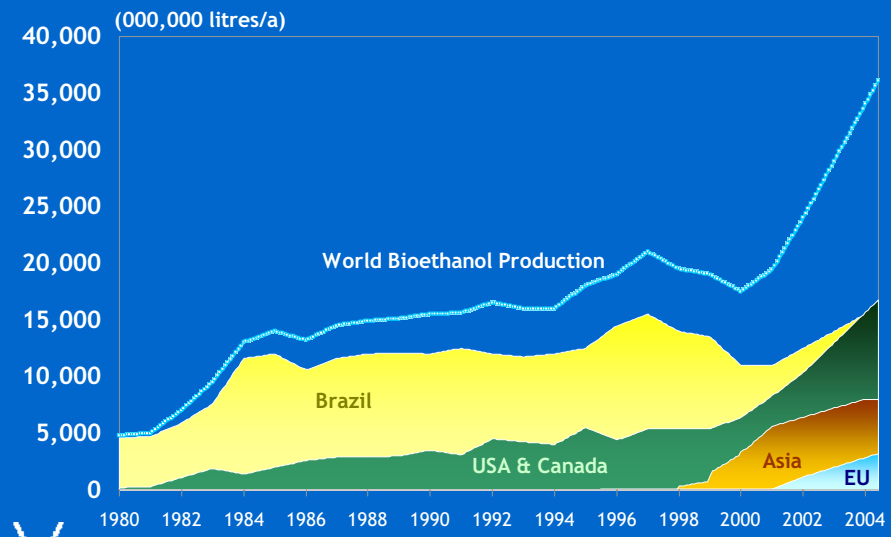
Bioethanol Production



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Sources: (1) FO Licht. 2005.
(2) Fulton, L. 2004. International Energy Agency, Paris.

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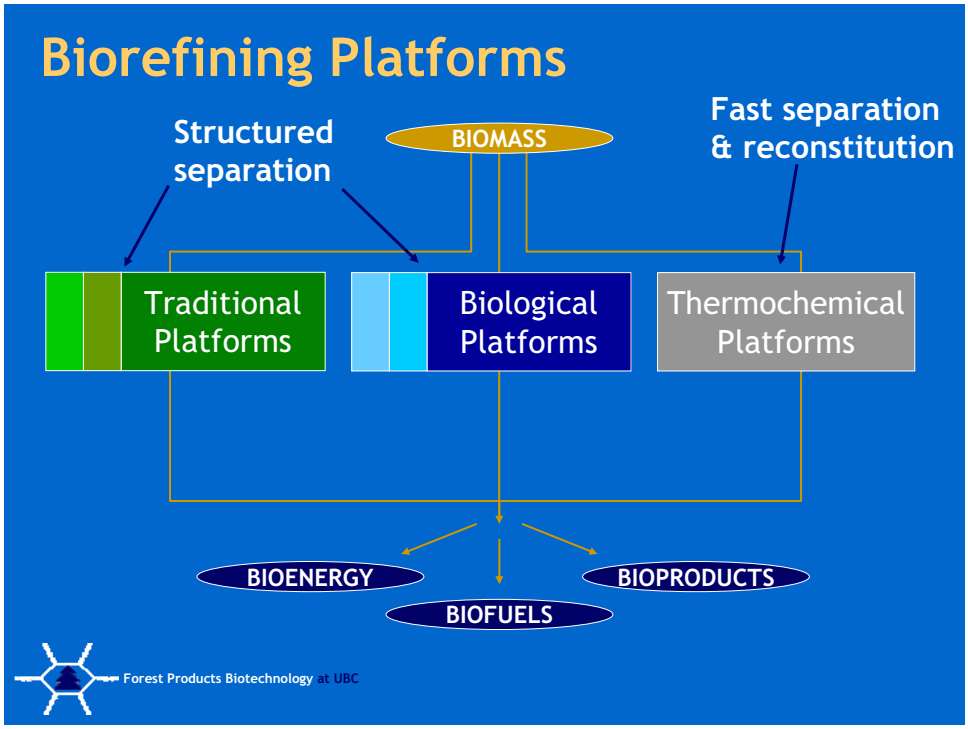
Biorefining Platforms
Structured separation
BIOMASS
Fast separation & reconstitution
Traditional Platforms
Biological Platforms
Thermochemical Platforms
BIOENERGY
BIOPRODUCTS
BIOFUELS
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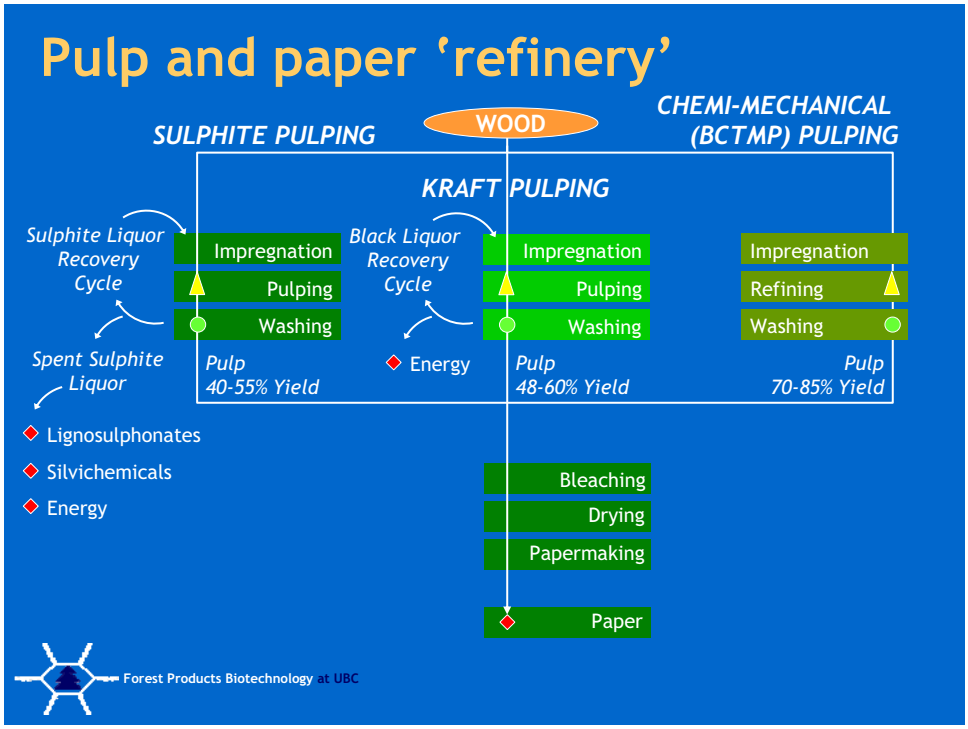
Pulp and paper 'refinery'
WOOD
SULPHITE PULPING
CHEMI-MECHANICAL (BCTMP) PULPING
KRAFT PULPING
Sulphite Liquor Recovery Cycle
Impregnation
Pulping
Washing
Spent Sulphite Liquor
Pulp 40-55% Yield
Black Liquor Recovery Cycle
Energy
Pulp 48-60% Yield
Refining
Pulp 70-85% Yield
Lignosulphonates
Silvichemicals
Energy
Bleaching
Drying
Papermaking
Paper
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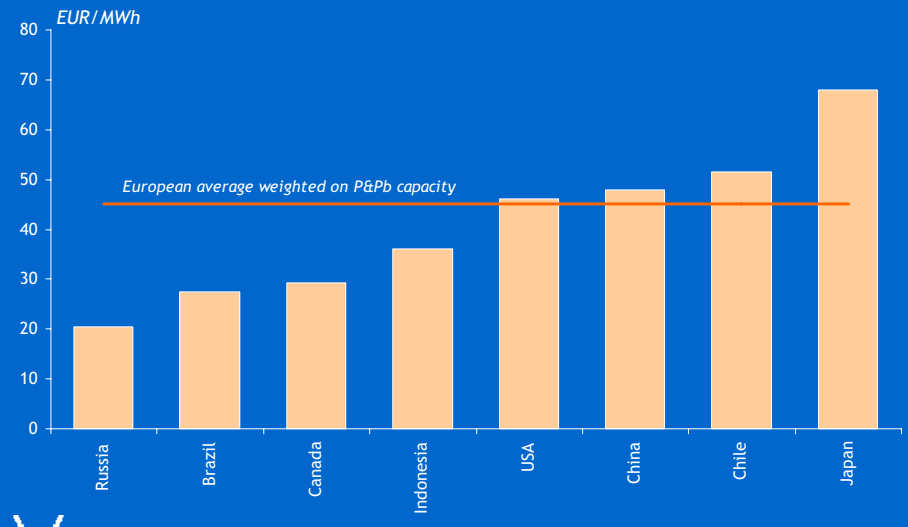
Price of Purchased Power



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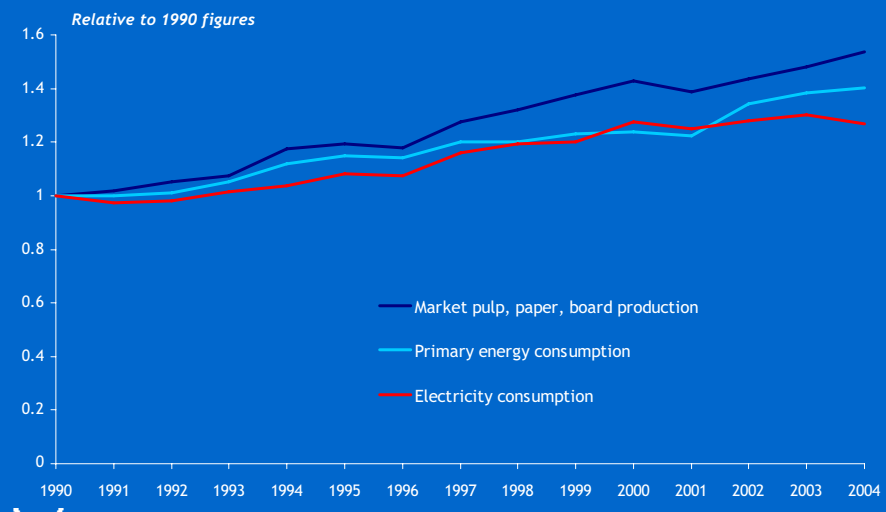
Paper production growth vs. power



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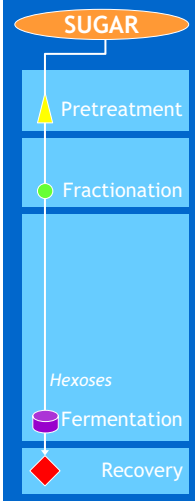
Brazil - Sugar



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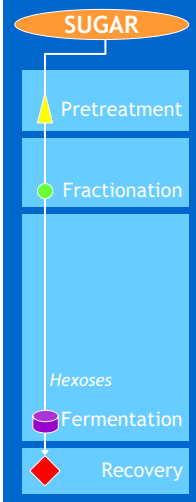
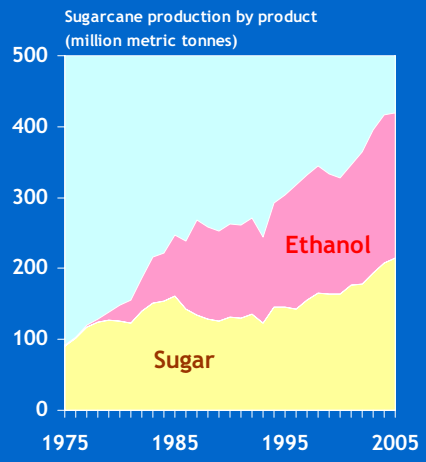
Sources: (1) FAOStat 2006; www.fao.org
(2) Bolling, C. and Suarez, N.R. (2001). USDA/ERS - SSS-232.

Brazil - Sugar





Sources: (1) FAOStat 2006; www.fao.org
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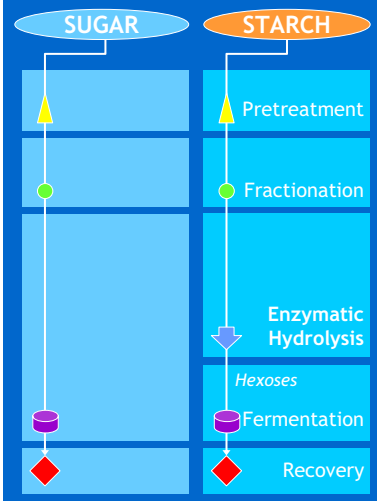
United States - Starch



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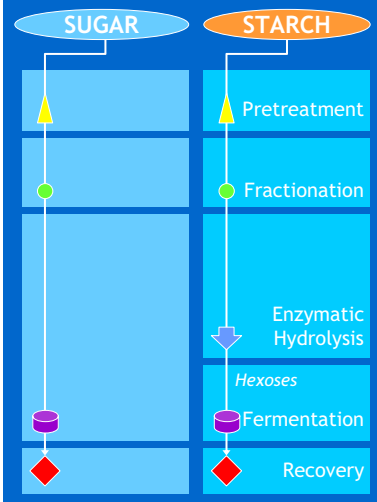

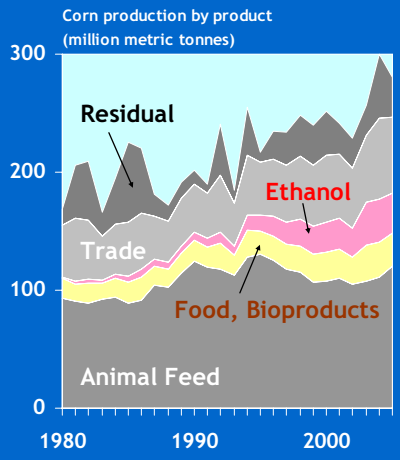

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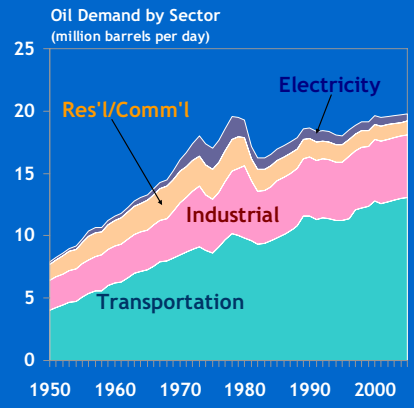
Oil refinery



Traditional oil refining:

- ~68-70% transportation sector (i.e. gasoline, diesel)
- ~21% industrial processing
- ~5% ind. plastics, chemicals (over 2,000 refinery products)
- ~4% residential/ commercial heating
- <3% electricity generation

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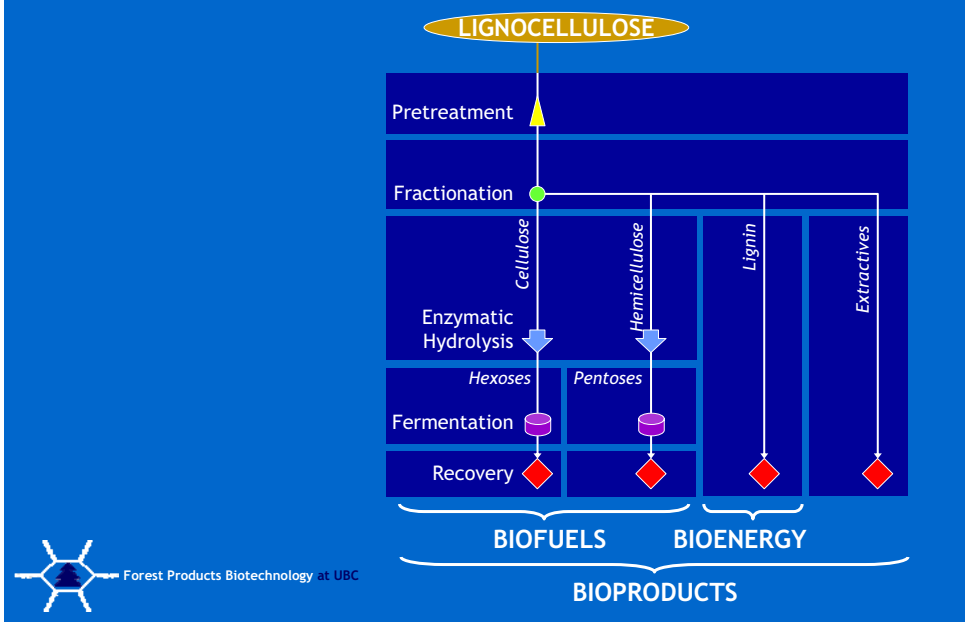
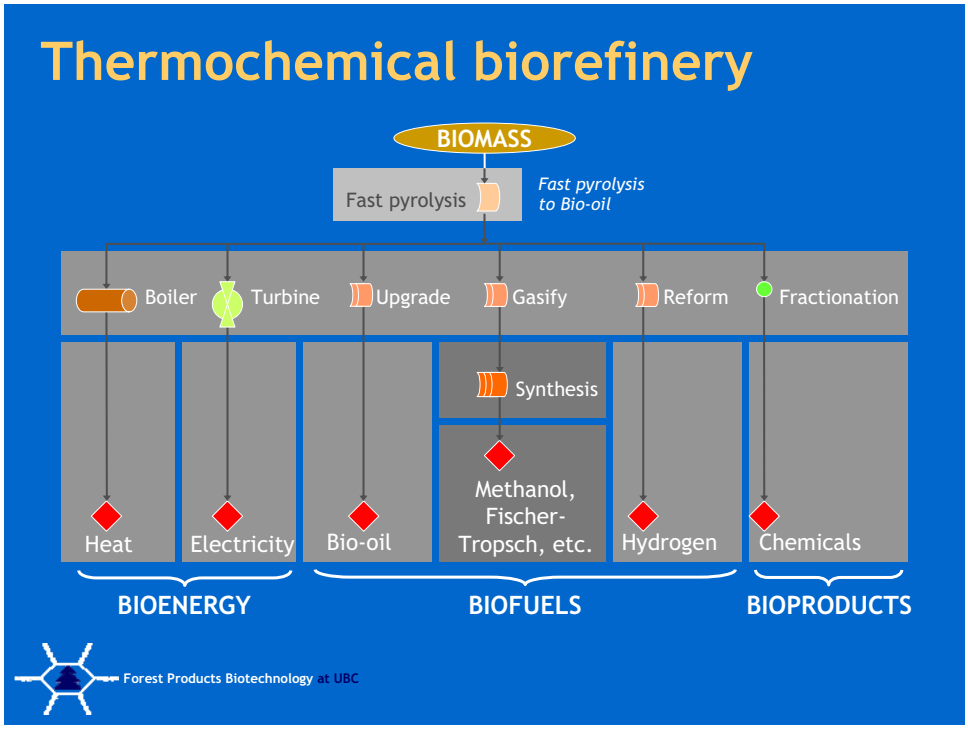
Source: (1) EIA. 2005. *Annual Energy Review*. US oil demand by end-use sector. http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/oil_market_basics/Dem_image_US_cons_sector.htm

Biological platform



Thermochemical biorefinery



Bioproducts

			Company
Bulk polymers: Polylactide (PLA), 3-hydroxypropionic acid, 1,3-propanediol, etc.	THERMOCHEMICAL	BIOLOGICAL	NatureWorks, DuPont, Cargill
Nutraceuticals: xylitol, arabitol, etc.			Codexis, etc.
Platform chemicals: Glycerol, furfural, levulinic acid, succinic acid, etc.			DuPont, etc.
Biofuels: ethanol, bio-hydrogen, etc.			Iogen, Abengoa, etc.
Biofuels: bio-oil, methanol, ethanol, Fischer-Tropsch, BTL, etc.			Choren, etc.
Bioenergy: electricity, steam, combined heat & power (cogen), district heating, wood pellets, etc.			Williams Lake Bioenergy Facility, etc.

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Iogen Corporation

- Bioconversion commercial development facility in Ottawa
- **$29 million** in collaboration with Royal Dutch Shell (2003)
- **$30 million** investment by Goldman Sachs (2006)
- 40 ton/day of straw, grasses and corn stalks
- Preparation for $300-400 million full-scale facilities

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Lignol Innovations

- Organosolv pulping originally developed by G. E. and Repap ($200 million)
- Products include (1) unique, pure lignin with developed markets, (2) furfural, and (3) cellulose-to-ethanol
- Benefits of focus:
  - 3 key products can minimize risk
  - Resources devoted to primary goals
  - Further co-products will strengthen business later

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SunOpta Bioprocess Group

- Focus on steam-explosion pretreatment, including a continuous digestor
- Owns/operates 3 biomass conversion facilities producing dietary fibre
- Partnered with Abengoa Bioenergy in developing 2 pilot biomass-to-ethanol facilities (Spain, USA)

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Tembec Chemical Group

- Part of Tembec's sulphite pulp mill on the Ottawa River
- Mix of hardwood and softwood feedstocks for pulping
- Produces lignosulfonates, resins, and ethanol from spent sulphite liquor
- Produces about 17 million litres EtOH annually, sold primarily in the food sector

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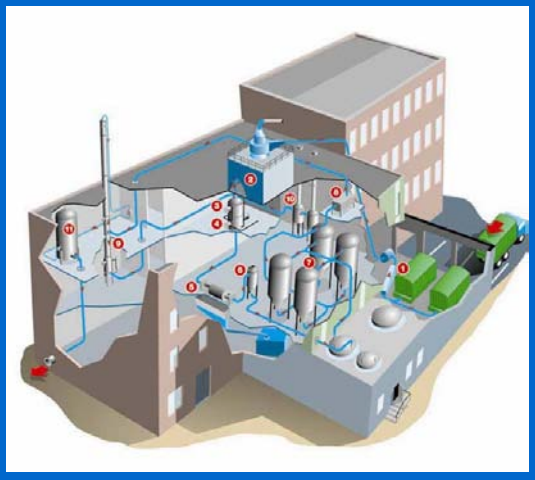
Etek Etanolteknik AB (Sweden)

- Bioconversion pilot facility in Örnsköldsvik
- $15 million investment by four primary shareholders
- 500 l per 24 hours (equivalent to 2 tonnes input material)
- Research and development centre



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Abengoa (Spain, USA)

- Castilla y Leon (start 2004)
  - 200 million litres/a EtOH;
  - 2.5% lignocellulosic-based
  - Co-products: Dried Distillers Grains, CO_2 for food
- York, Nebraska 2
  - Starch pilot plant (2004)
  - Biomass pilot plant (2005) (corn stover)
  - $36.1 million ($US) project with DOE
- Partnership with SunOpta

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NREL (USA)

- National Renewable Energy Laboratory, DOE
- Bioconversion pilot facility in Golden, CO
- 1 tonne per day capacity
- National centre for R&D activities

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Conclusions

- The biorefinery concept can maximize returns and improve the economic performance of bioenergy technologies
- Greatest historical increases in energy demand are for transportation fuels
- Most advances have been made in 'developed' regions; we need a network to transfer technologies to 'developing' partners

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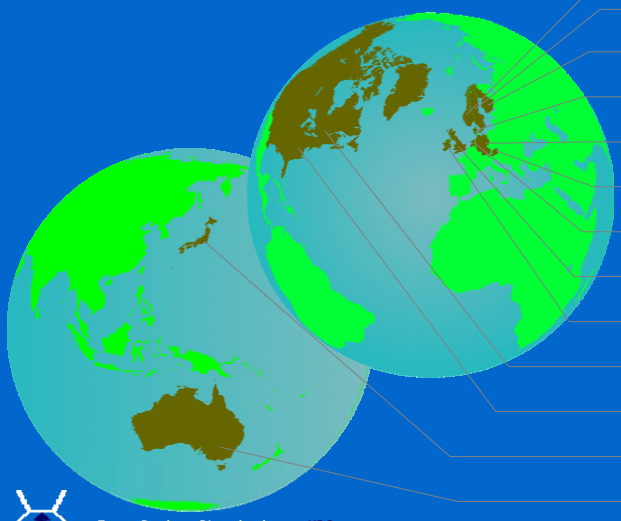
IEA Bioenergy Task 39



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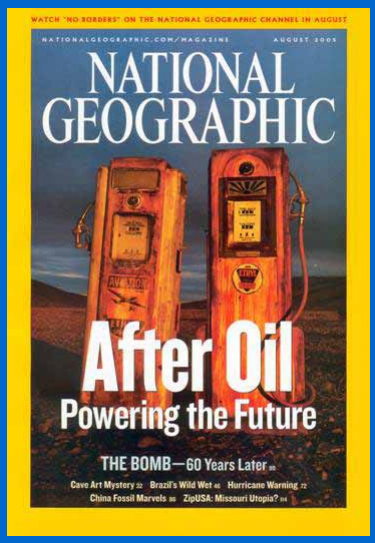

Questions?

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