# Developing supply chains from wheat as a feedstock

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***Wheat for Biofuels, Bioenergy and High Value Bioproducts***

***29 April 2008***

# Bio-based isn't new!

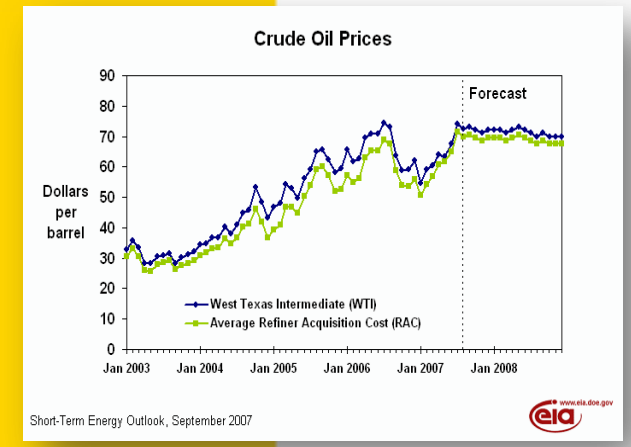
**Volumes of renewable materials**

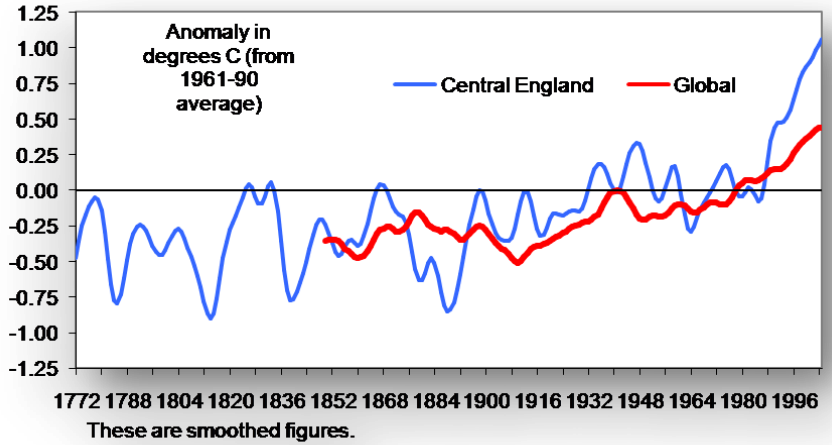
- Vegetable Oils - 19.8 million tonnes
- Starch - 22.5 million tonnes
- Fibres - 28.4 million tonnes
- Wood pulp - 42.5 million tonnes

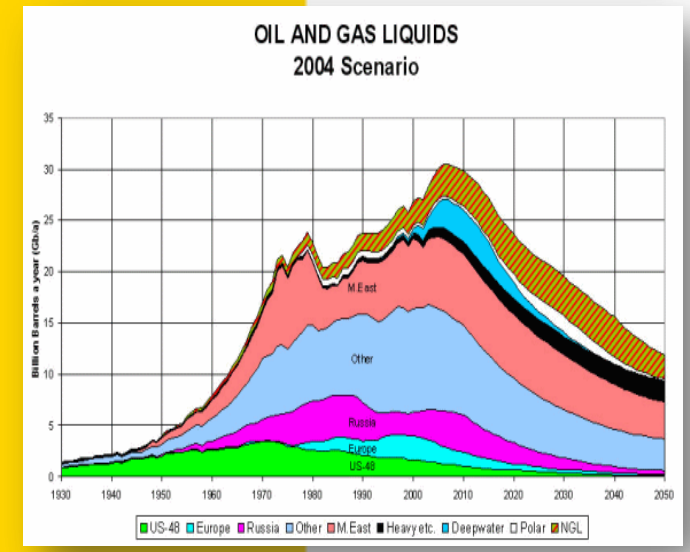
**Applications**

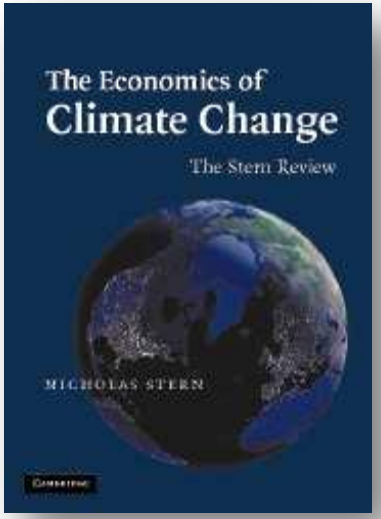
- Biolubricants
- Surfactants
- Starch Polymers
- Cellulose Polymers
- Natural Fibres & Biocomposites
- Fillers and adhesives

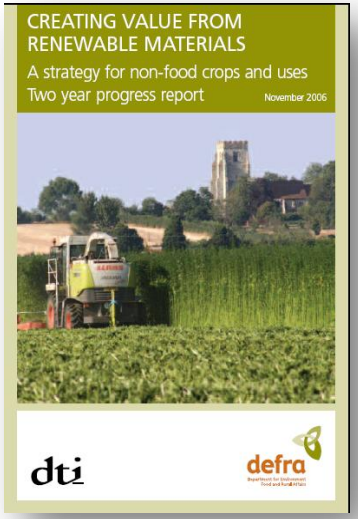
# A Changing Landscape



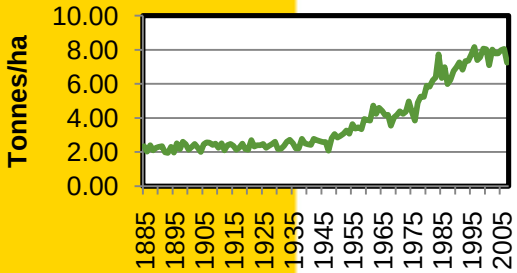



# Why Wheat?

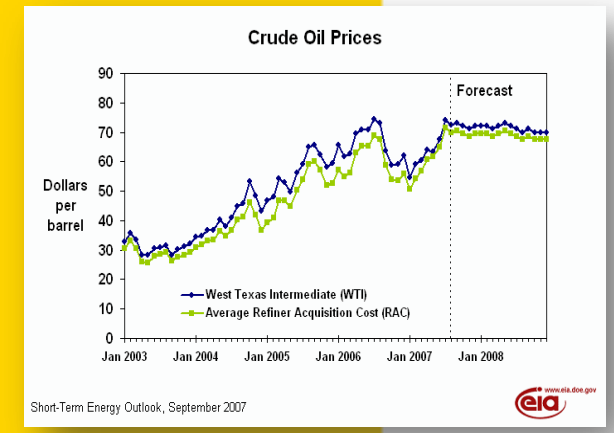
**UK Wheat Yields**




**Europe's dominant crop**

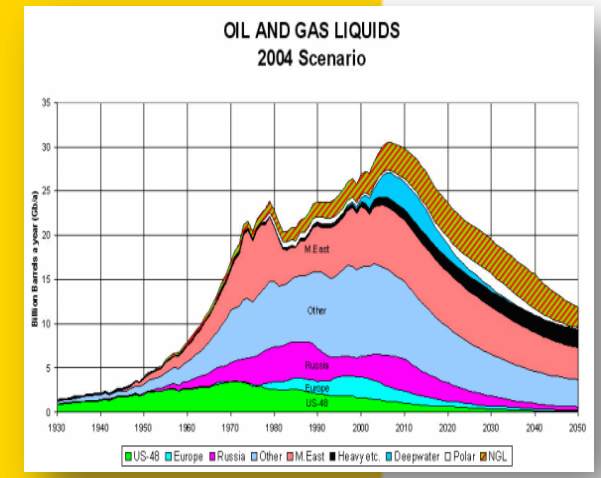
- UK production
  - ~1.8 million hectares
  - Yield ~8 tonnes/hectare (winter wheat)
  - 2007 harvest ~13 million tonnes
- European Potential
  - Large potential for increased yields in Eastern Europe
- Attractive cultivation costs per tonne of starch
- Source of starch, protein and lignocellulose

# Beyond starch




- Processed starch is fit for purpose in many applications - but is function limited
- Requirement to convert natural polymers to flexible monomeric building blocks
- Access polyesters, polyurethanes, co-polymers etc
- Potential building blocks are well known
  - Ethanol
  - Lactic acid
  - Fumaric Acid
  - Succinic Acid
  - 3-Hydroxypropionic acid
  - etc

# Supply Chain Considerations



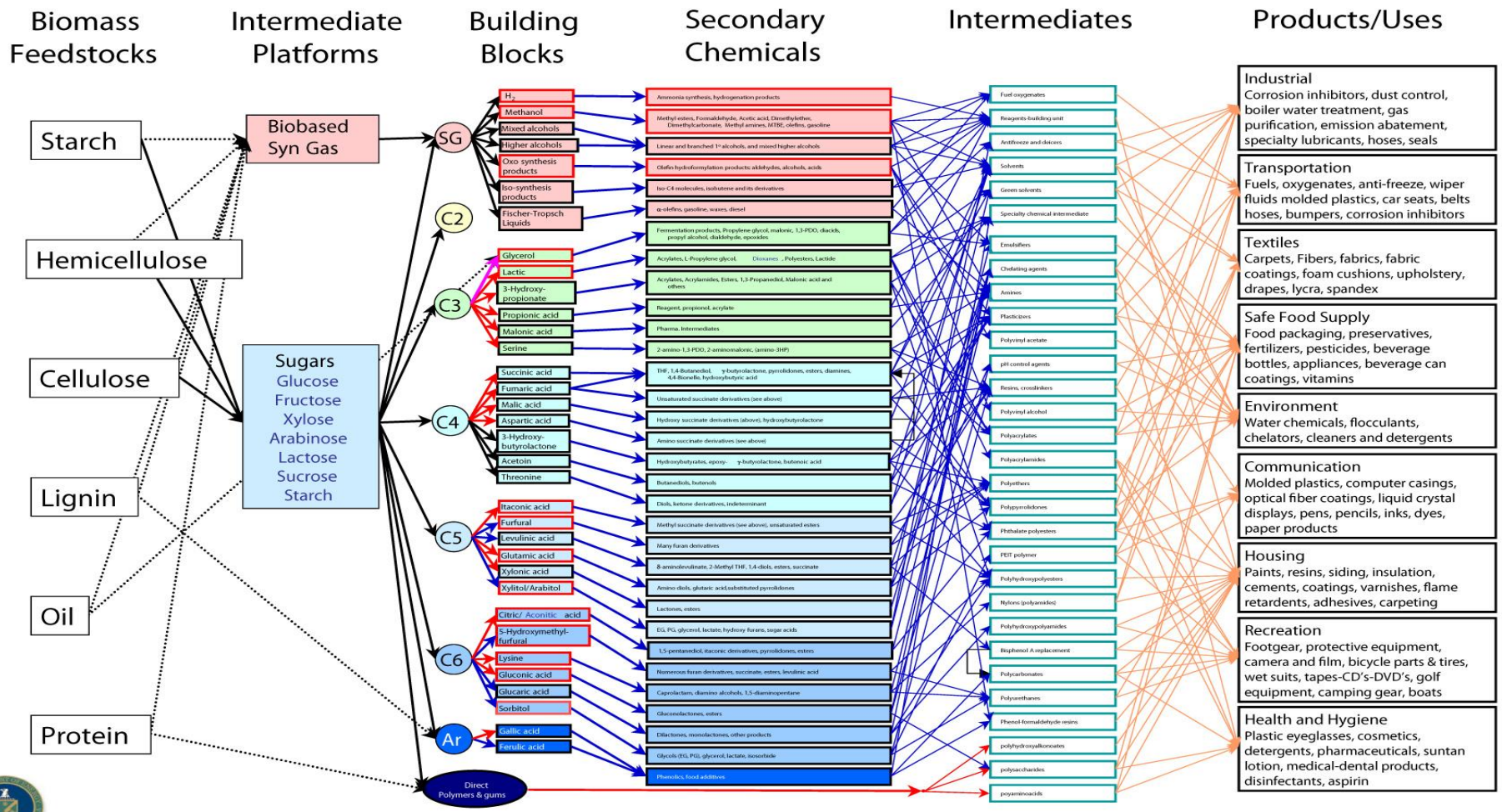

**Cultivation**
- Impact on current supply chains
- New crop, new supply chain, land impact

**Processing**
- Technology Status
- Competition from existing production

**Market Dynamics**
- Market location
- Green premium?

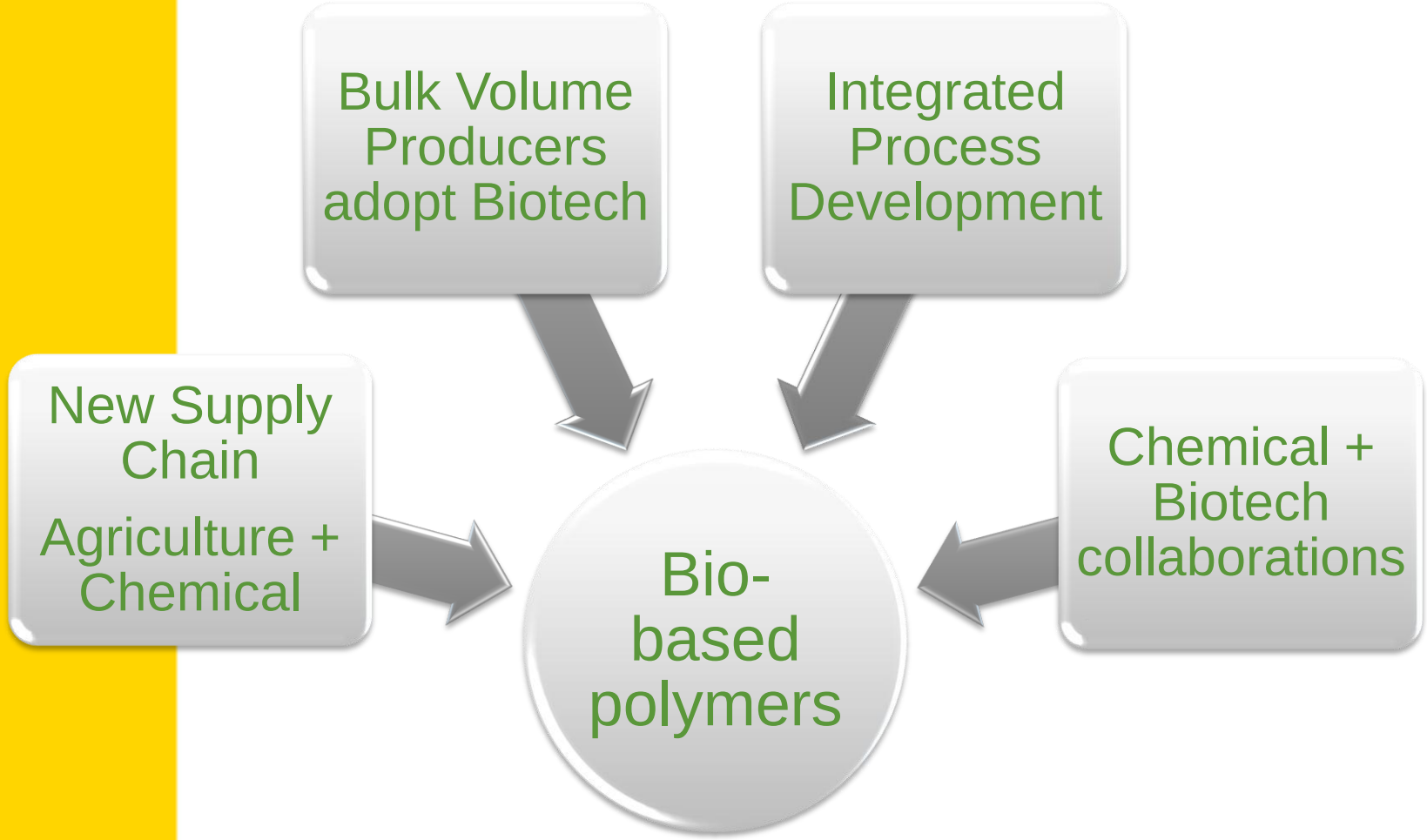
**End of life**
- Waste infrastructure
- Waste policies

# Potential Supply Chains




Analogous Model of a Biobased Product Flow-chart for Biomass Feedstocks

# New Industry Dynamics



# Bio-Based Polymers

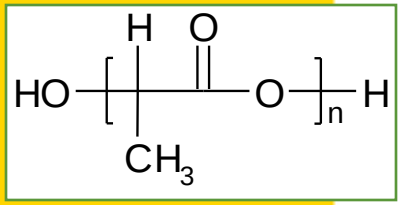
**European Market growth**

- Biodegradables are expected to grow from 25kt in 1998 to 2-4 million tonnes in 2020
- By 2020 durables could account for 50% of renewable polymers

Most growth scenarios are based on crude oil prices <$50 bbl

Difficult to assess the impact of >$100 bbl oil and volatile agricultural markets

# Commercial Activity





- Polylactic acid – PLA
- Developed by Dow Chemical and Cargill
- NatureWorks facility in Nebraska capacity 140 kt
- Good process and polymer properties vs conventional plastics
- One of only a small number of synthetic polymers that are fully biodegradable and **compostable**
- Claim - From cradle to resin, 68 percent less fossil fuel resources than traditional plastics (PET)

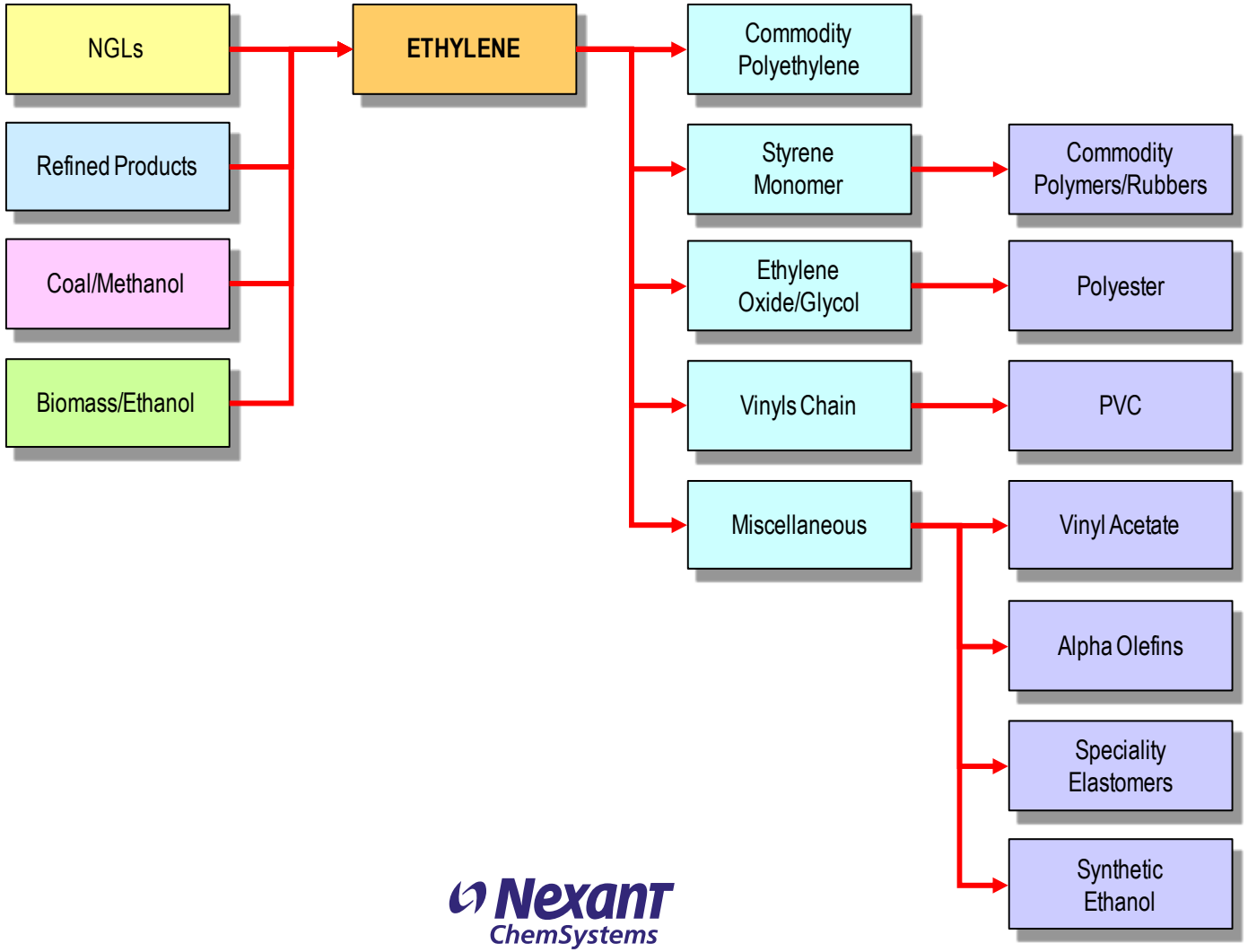
# Commercial Activity

Courtesy of DuPont

- Susterra™ 1,3-Propanediol
  - Produced in a collaboration between DuPont and Tate & Lyle
  - Processing site in Tennessee - capacity 40,000 tonnes per year of PDO
  - Applications
    - Sorona® Clothing, Carpets, Plastics
    - Zemea™ PDO for personal care
- Energy & GHG emissions
  - Energy – 63.9MJ/kg cf 111.0
  - GHG's – 2.18kg$CO_2$eq cf 5.0

NNFCC

# Durable Polymers




Nexant ChemSystems

# Near Term Commercial Activity

- No technical hurdles for the production ethylene from biomass

- Braskem (Brazil)
  - Planned HDPE production Q4 2009
  - Capacity 200,000 tonnes/year
- Dow/Crystalsev (Brazil)
  - Planned PE production 2011
  - Capacity 350,000 tonnes/year

- Same economic considerations as fossil based production, feedstock cost and availability, construction and operating costs, access to market etc

- Can Europe reduce feedstock costs or leverage a technology advantage?

# Assessing UK options

Market Attractiveness

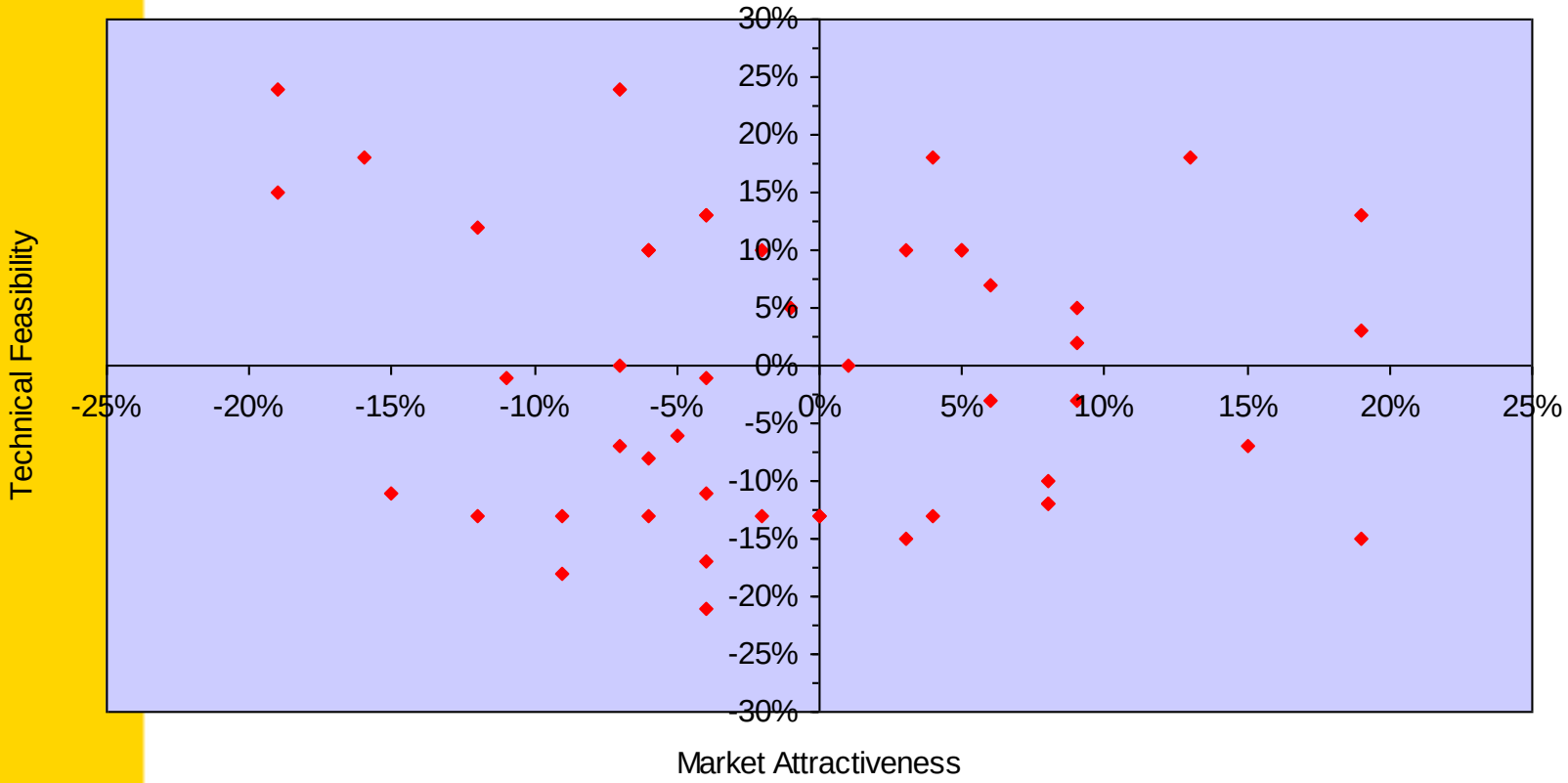
- Local/European/Global Markets
- Profitability
- Competitive Intensity
- Partnering requirements
- Downstream development opportunities

Technical Feasibility

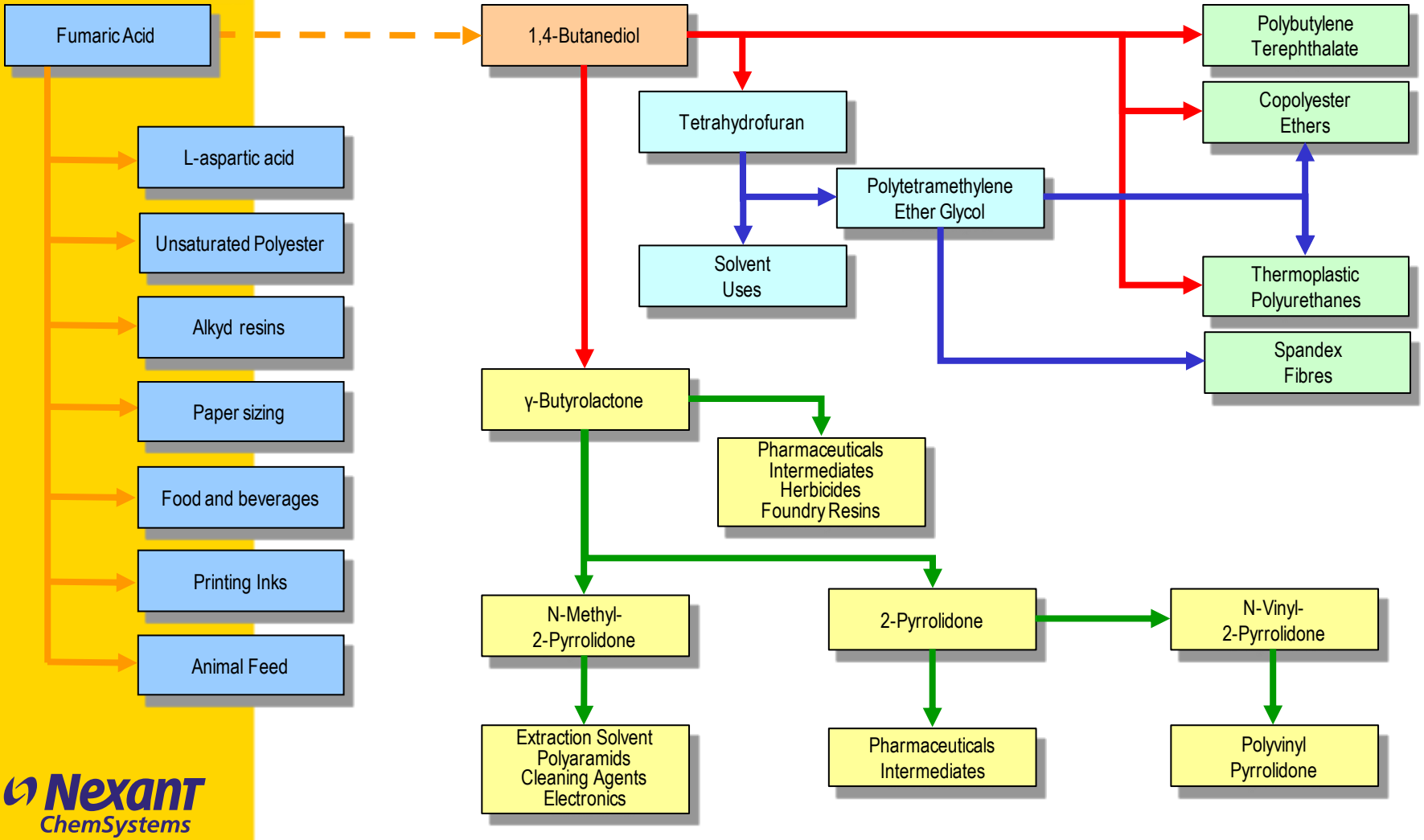
- Commercial development
- Capital Investment
- Ability to operate at world scale
- Technical Complexity
- Technology Access
- Environmental factors

# Assessing UK options

**Screening Matrix results indicate ten products in the desired attractiveness regime**



# Chemical Opportunities



# The End Game?

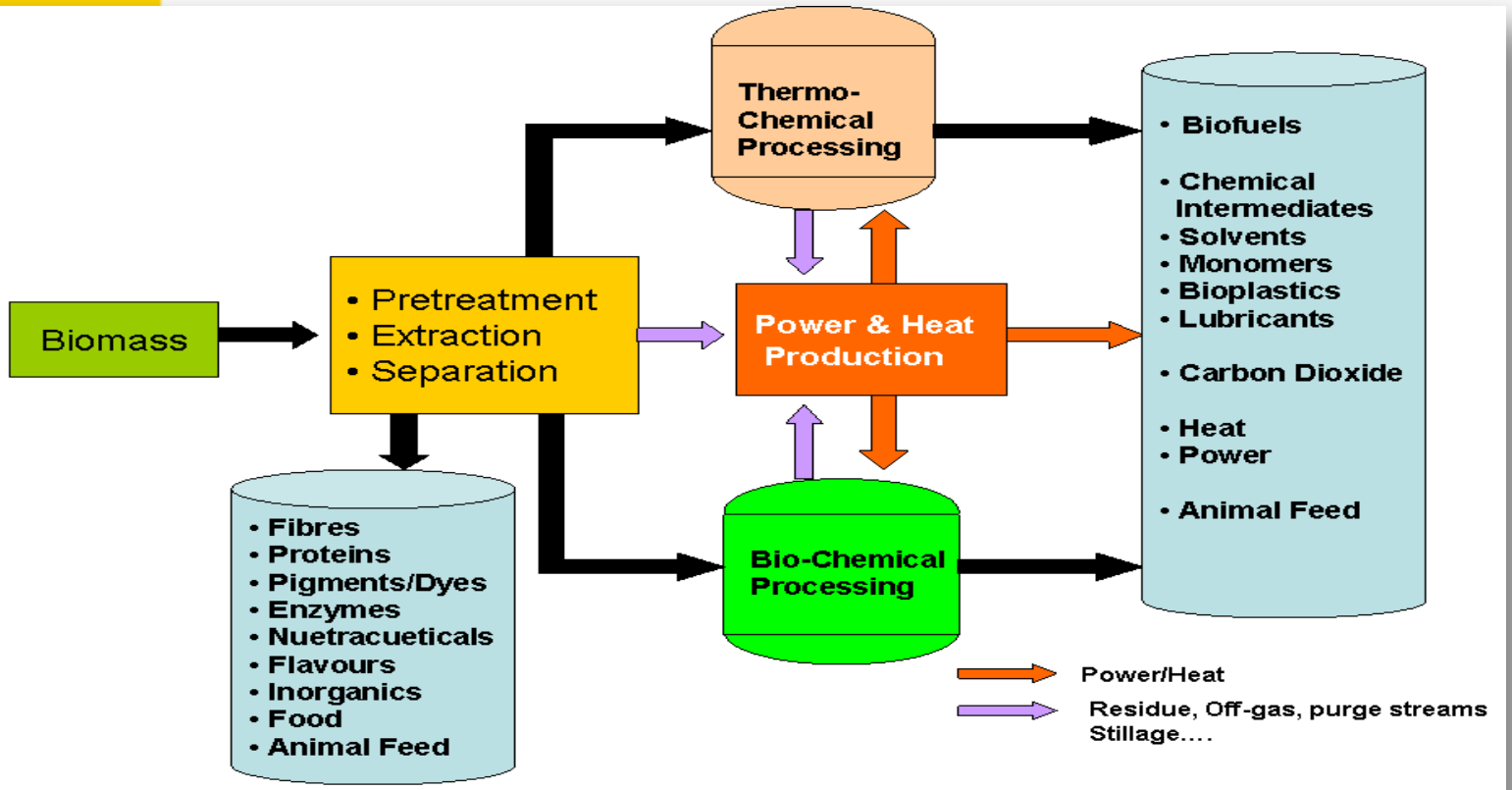



Figure 17 Generic Biorefinery Complex

Source: Mapping the Develop of UK biorefinery complexes (Tamutech Consultancy)

# The Bigger Picture

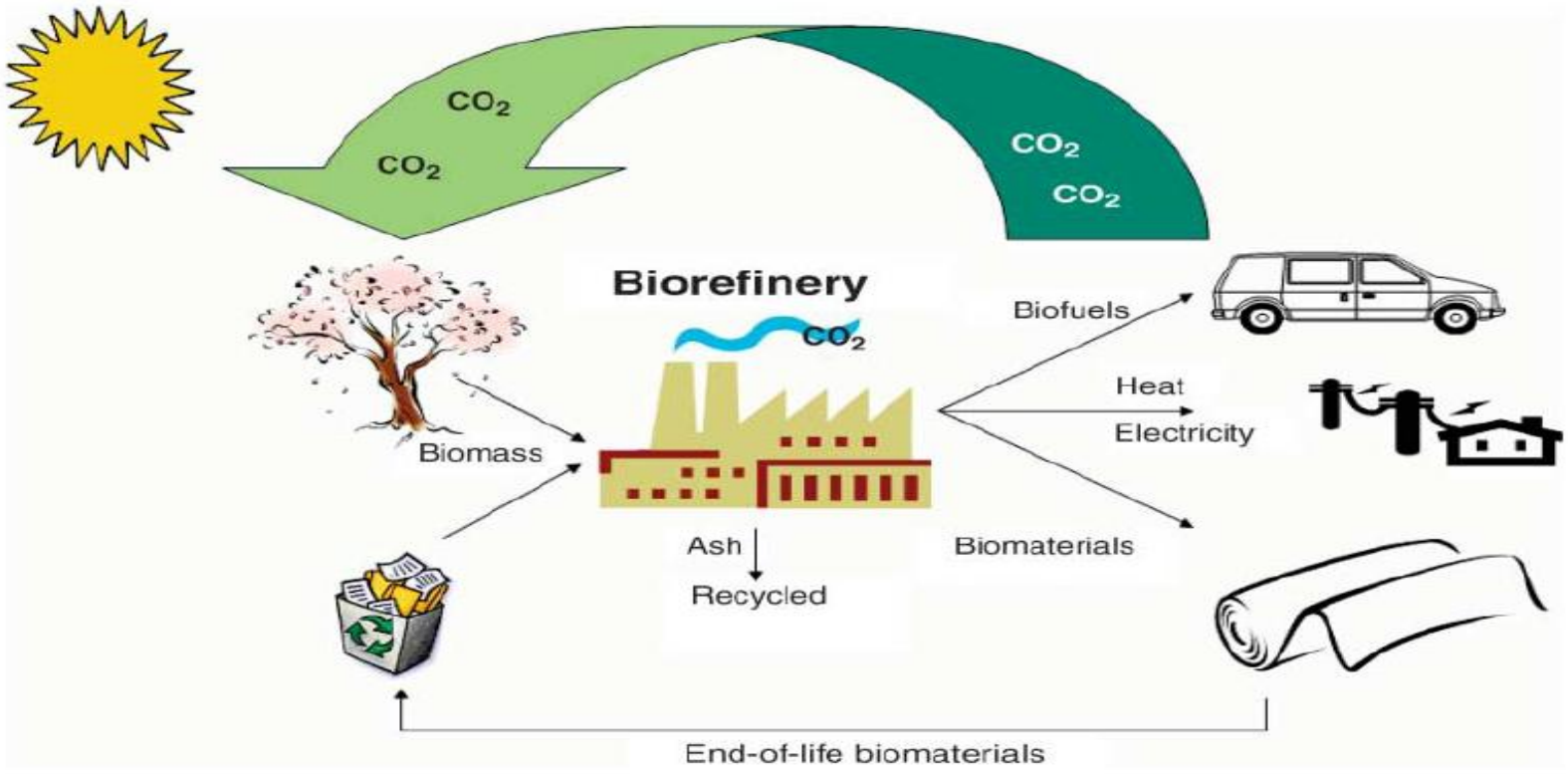



**Fig. 1.** The fully integrated agro-biofuel-biomaterial-biopower cycle for sustainable technologies.

**Figure from Ragauskas *et al,* (2006)**
**The Path Forward for Biofuels and Biomaterials. Science 311: 484-489**