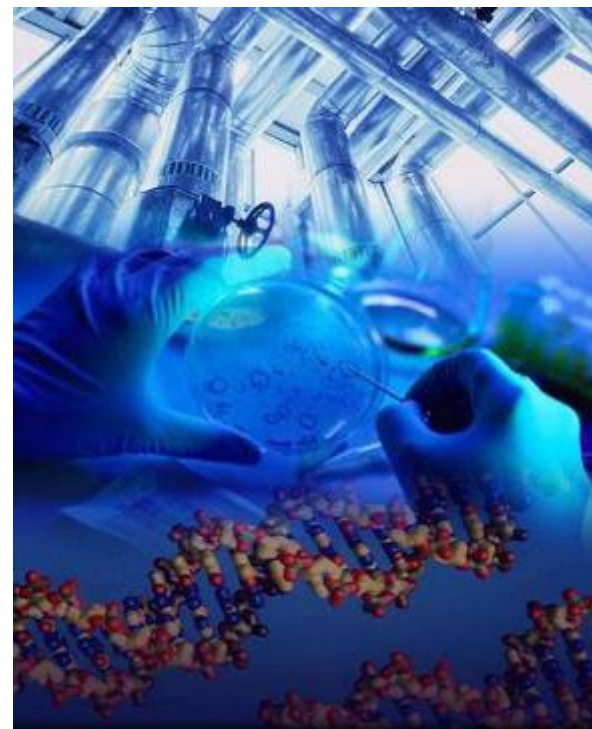


First Workshop on the Possibilities of Biorefinery Concepts

Workshop Session: Chemicals

**June 16, 2006
Wageningen**



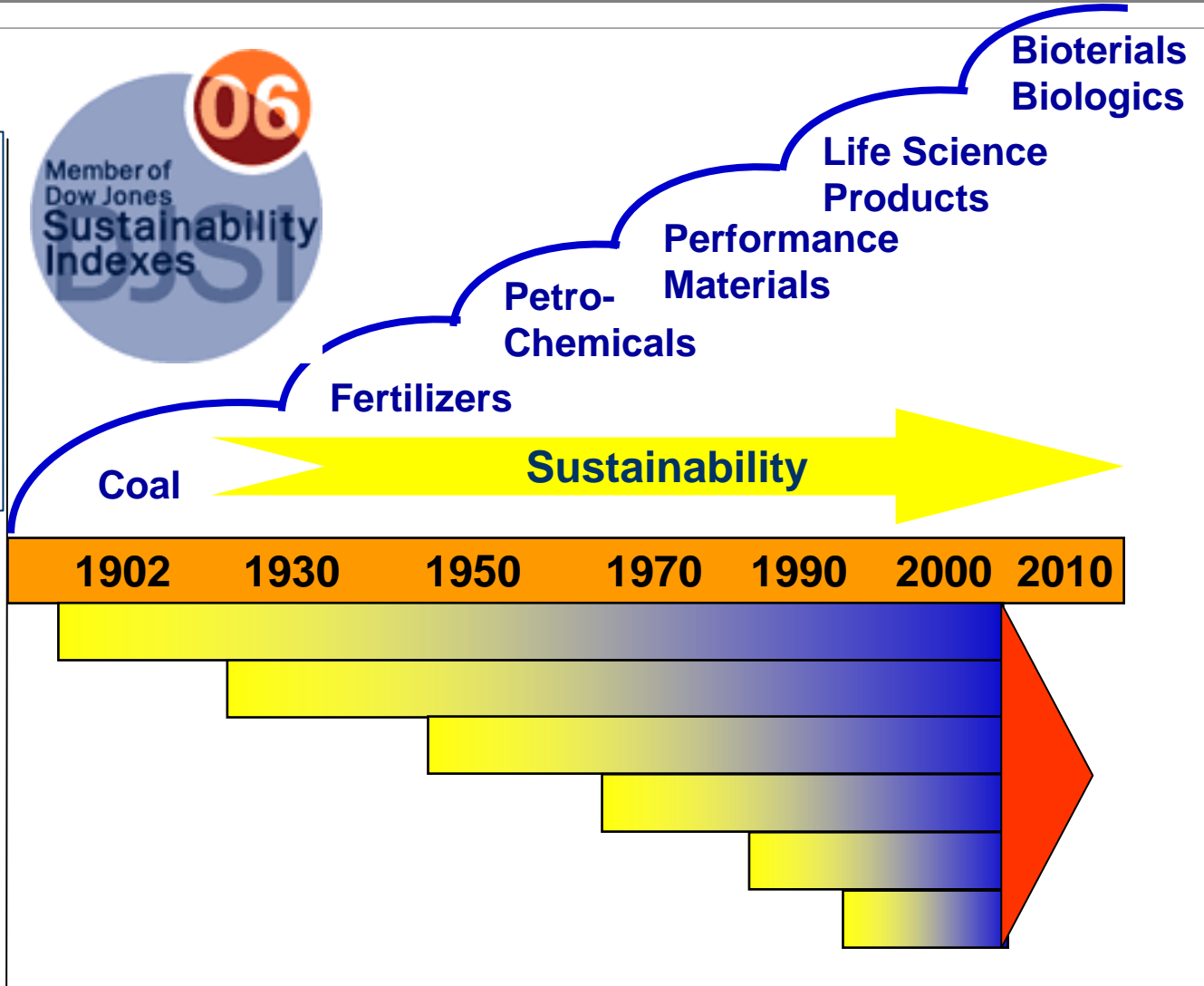
A century of transformations

Evolution



Technological Competences

- mechanical engineering
- chemical engineering
- polymer technology
- material science
- fine chemicals
- biotechnology

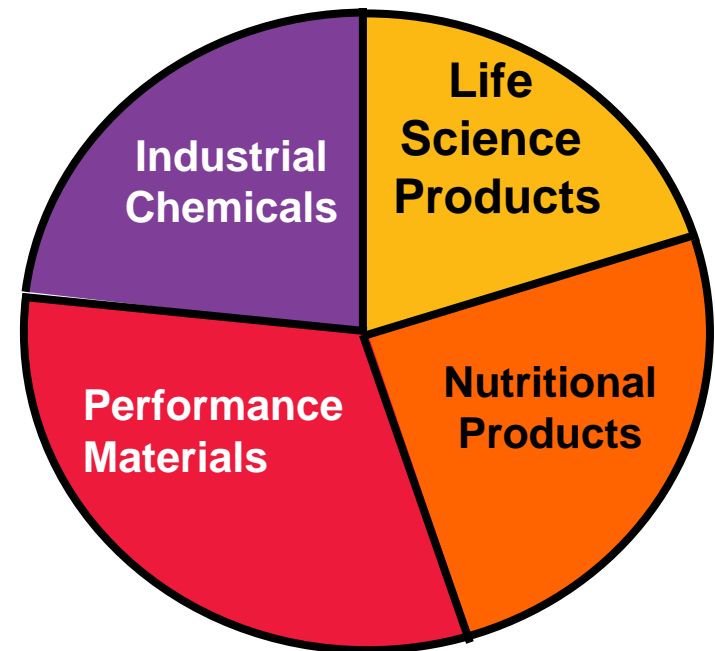


Globally active 'multi-specialty' chemical company

- Leadership positions in ~75% of product portfolio
- *Innovation driven*, R&D spend ~ € 300 million
- *Financially sound*, solid balance sheet

Key data 2005 (based on 2*H1 '05)

Sales :	€ 8 b
EBITDA:	€ 1.2 b
EBIT:	€ 0.8 b
White Biotech:	€ 1.5 b
World wide:	€ 33 b

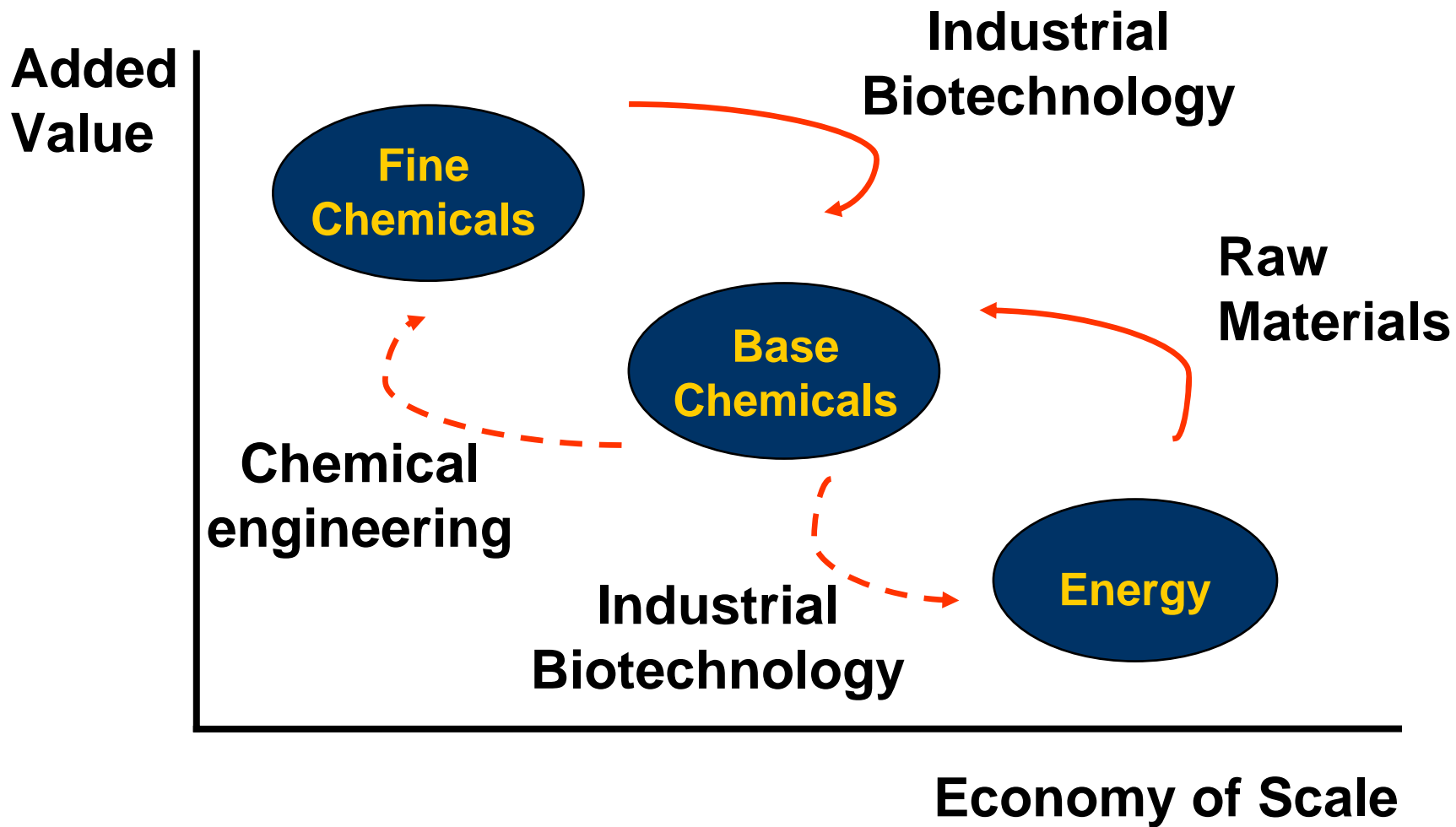


White Biotech enables drastic process improvements

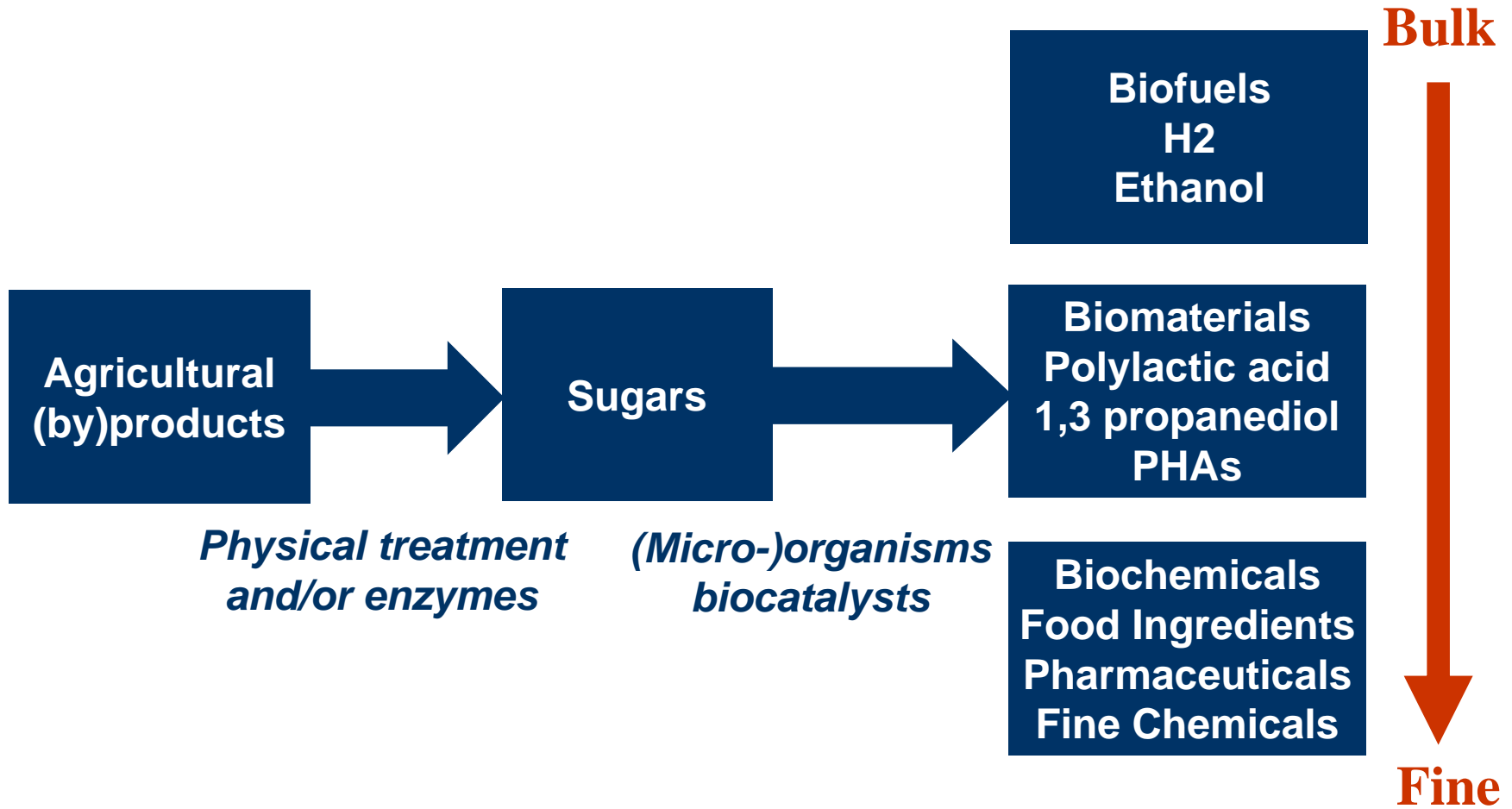
- ❖ **External drivers and rationale:**
 - **Increasing cost spread in hydrocarbons versus carbohydrates**
 - **Advances in science and technology**

- ❖ **Target areas:**
 - **Build upon DSM strength and focus on:**
 - **Biotech-based production routes**
 - **New bio-based products**
 - **Enzymes beyond food and feed**

Trends in Chemical Industry



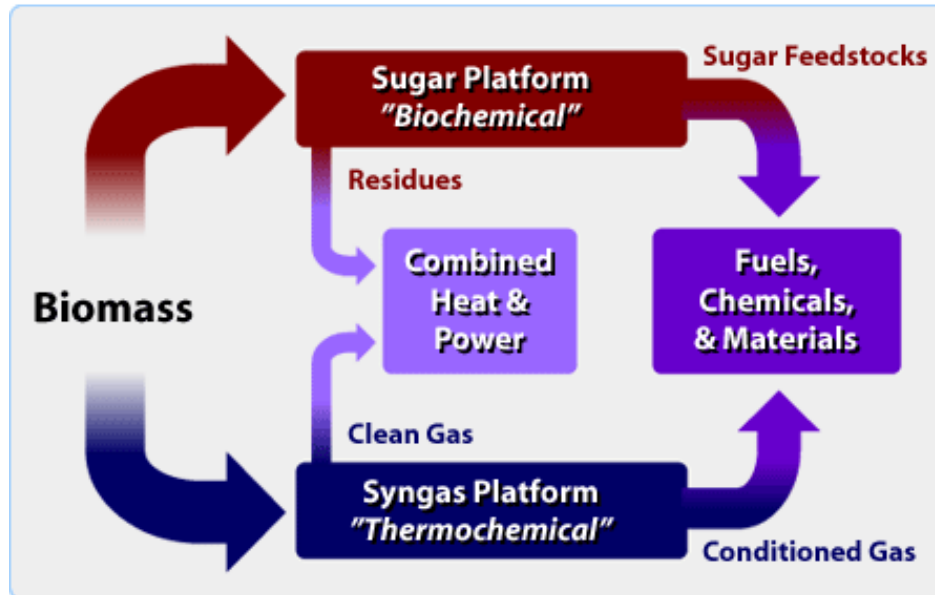
The White Biotech Value Chain



A BIOREFINERY CONCEPT IS SIMILAR TO PETROCHEMICAL REFINERIES, ONLY HAVING BIOMASS INSTEAD OF OIL AS INPUT

A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum. Industrial biorefineries have been identified as the most promising route to the creation of a new bio-based industry.

Biorefinery Concept



Bio-based product tree

The concept of a Biorefinery or an Oil refinery is value creation of by-products.

- Identical building blocks can be produced
- Bio-based = substitute for Petrol-based

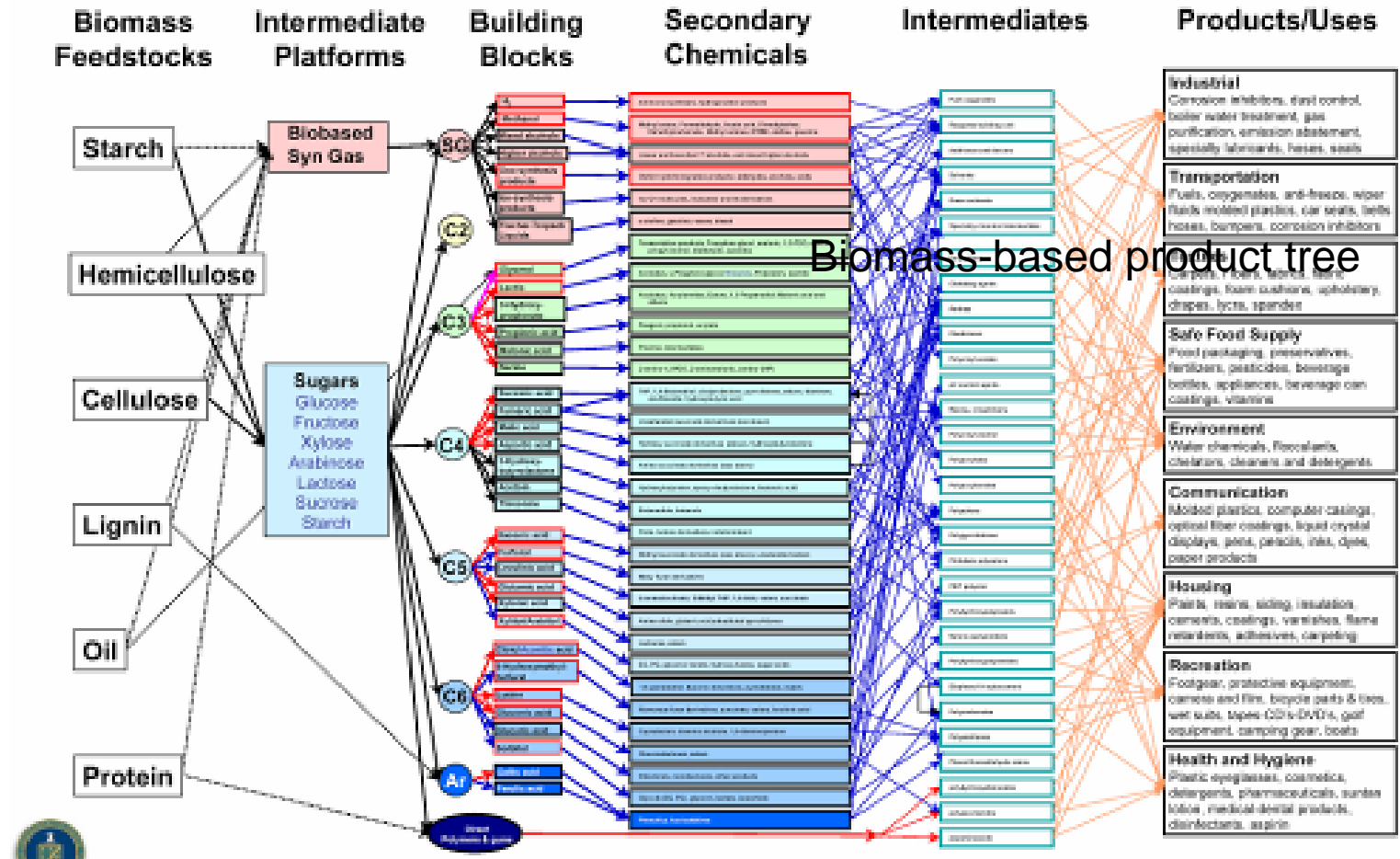


Figure 3 – Analogous Model of a Biobased Product Flow-chart for Biomass Feedstocks

Petrol-based product tree

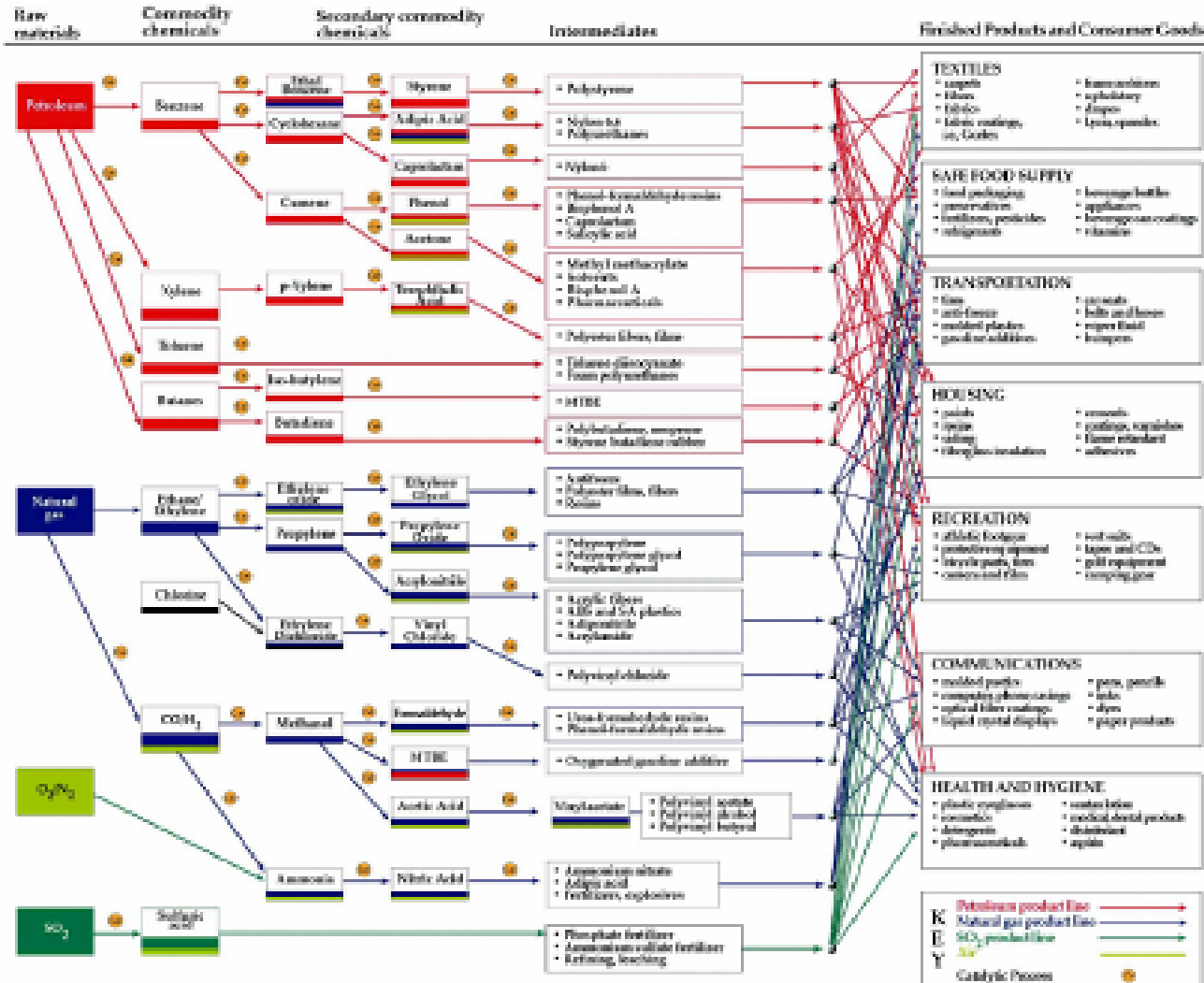
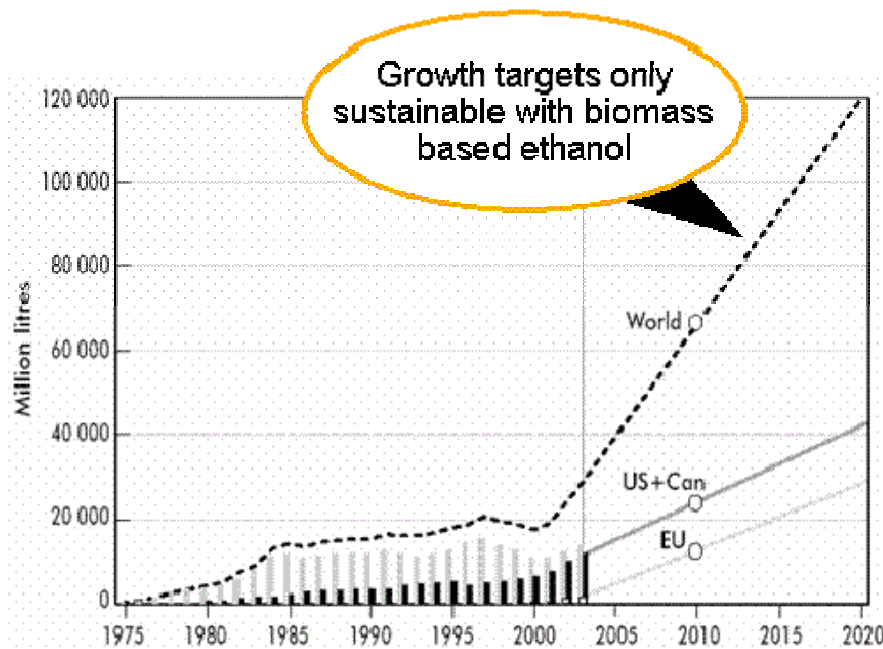


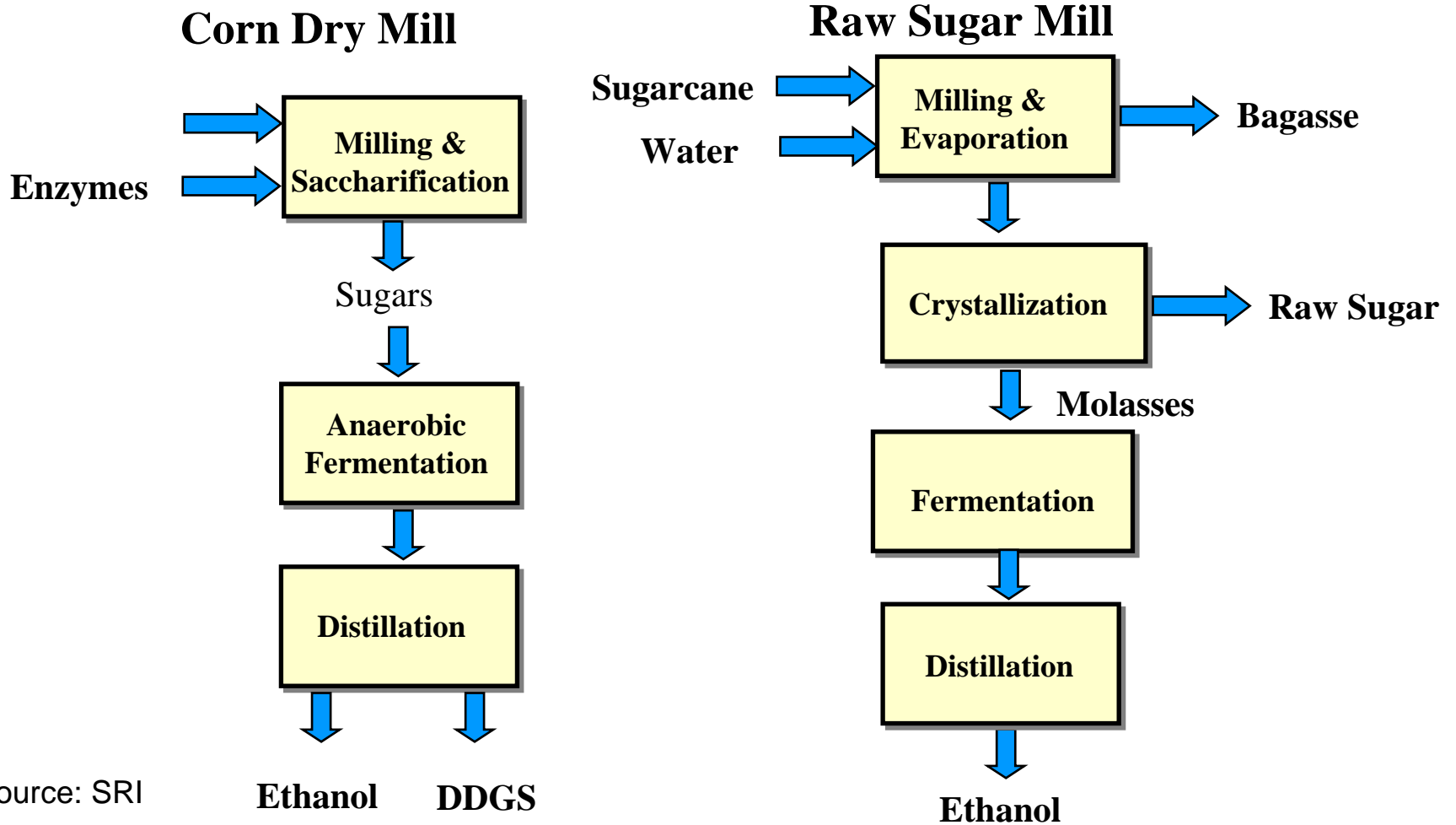
Figure 2 – An Example of a Flow-Chart for Products from Petroleum-based Feedstocks

Driving forces

- **Reduced dependency on foreign energy resources for homeland security**
- **Support for domestic farmers (big lobby group)**
- **Decrease environmental pressure (Kyoto)**

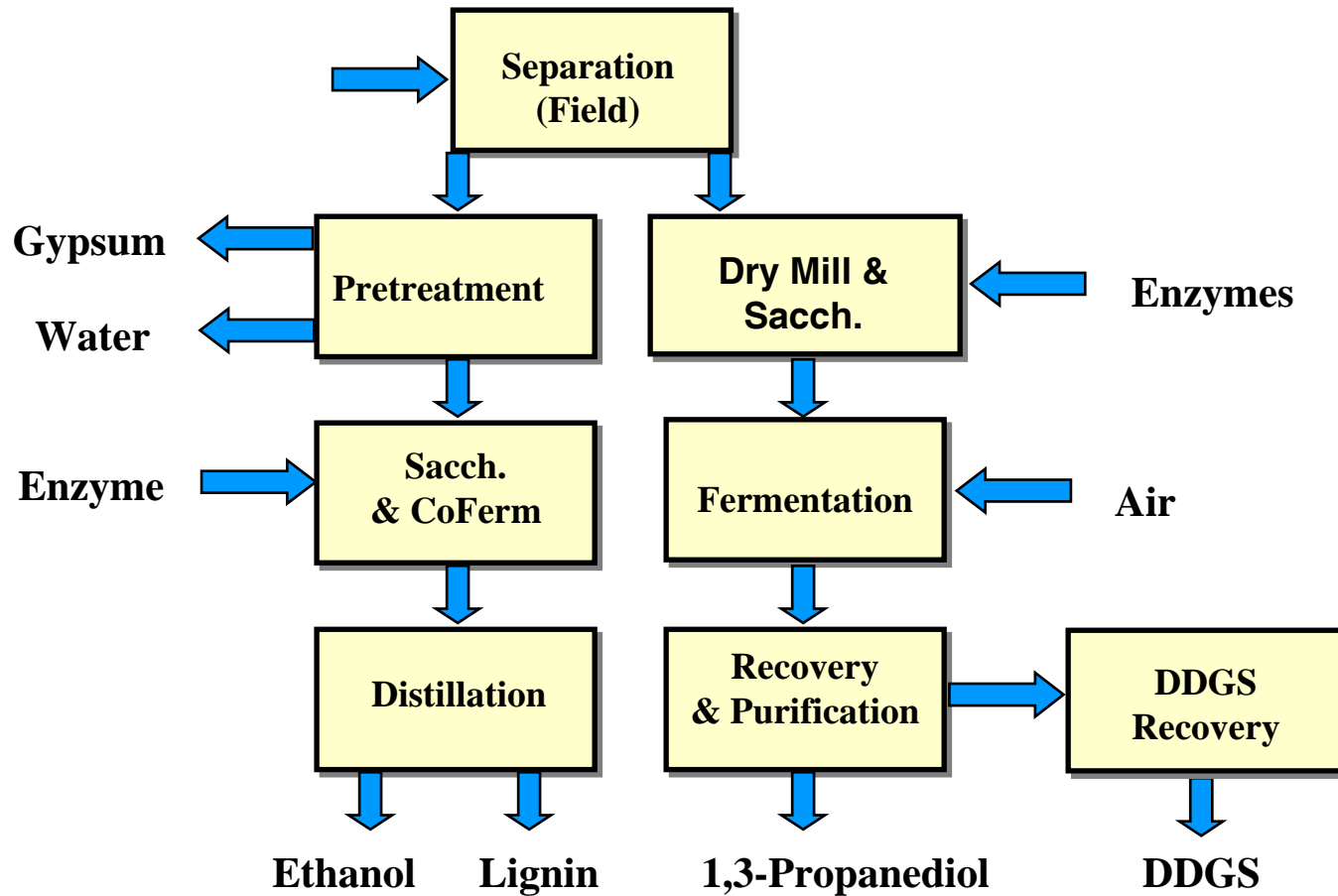


US – 30 bln l. by 2012
EU – 12 bln l. by 2010
China – 15 bln l. by 2020
Brazil – 15 bln l. TODAY

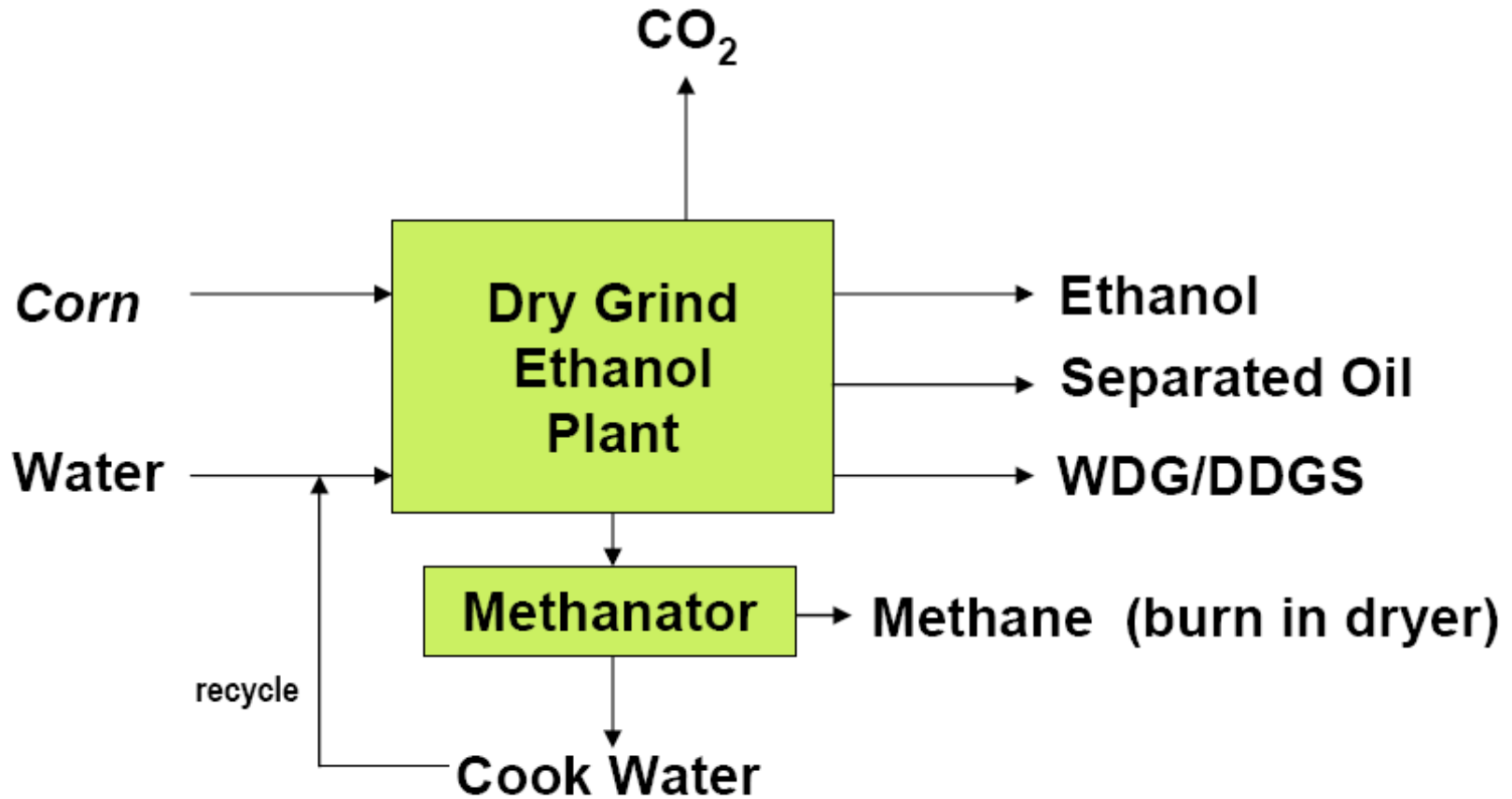


Source: SRI

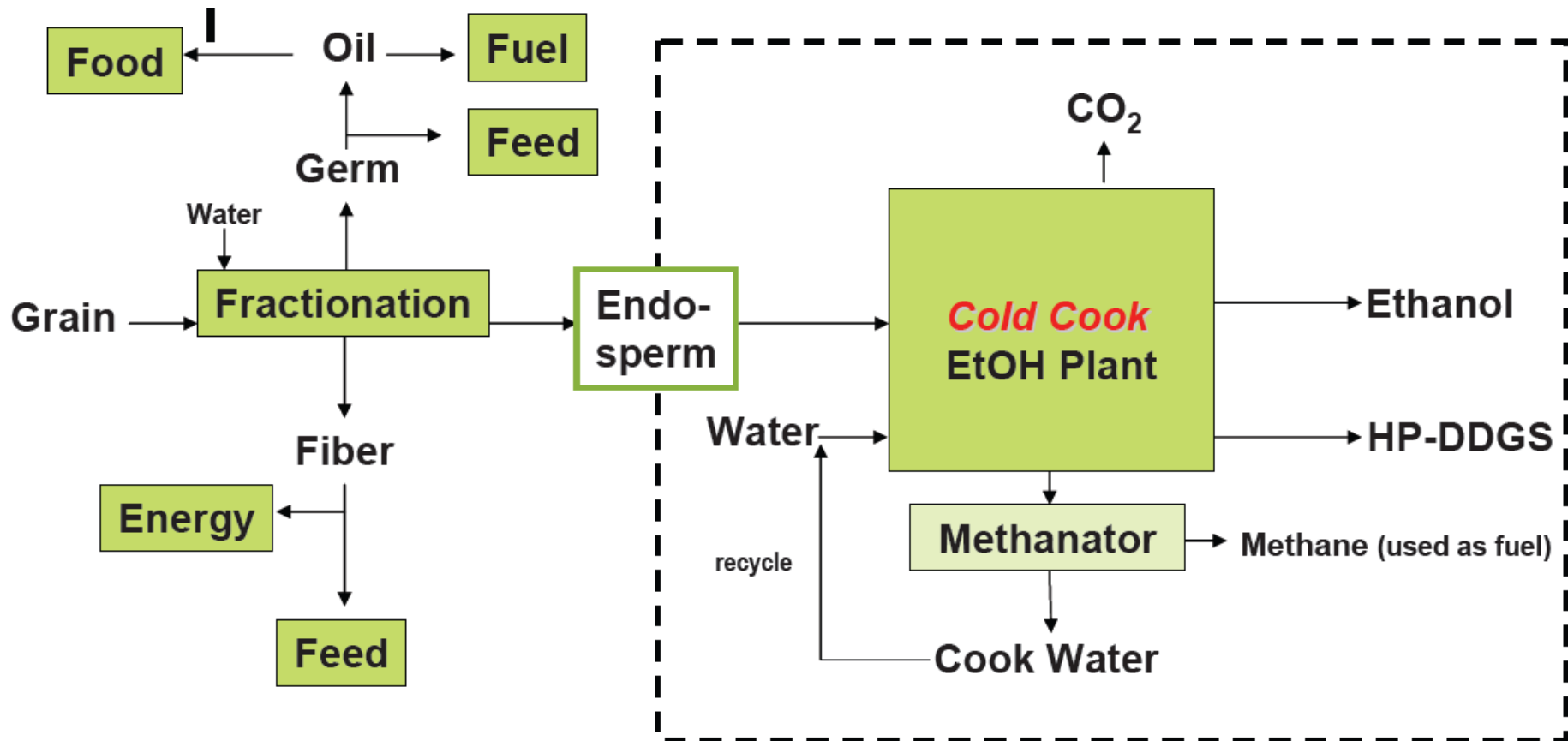
Whole Corn Biorefinery



Source: SRI

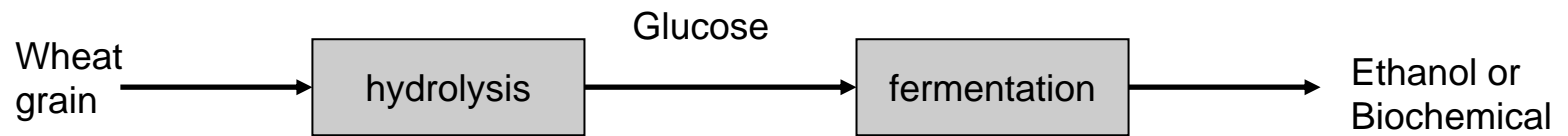


Source: ICM

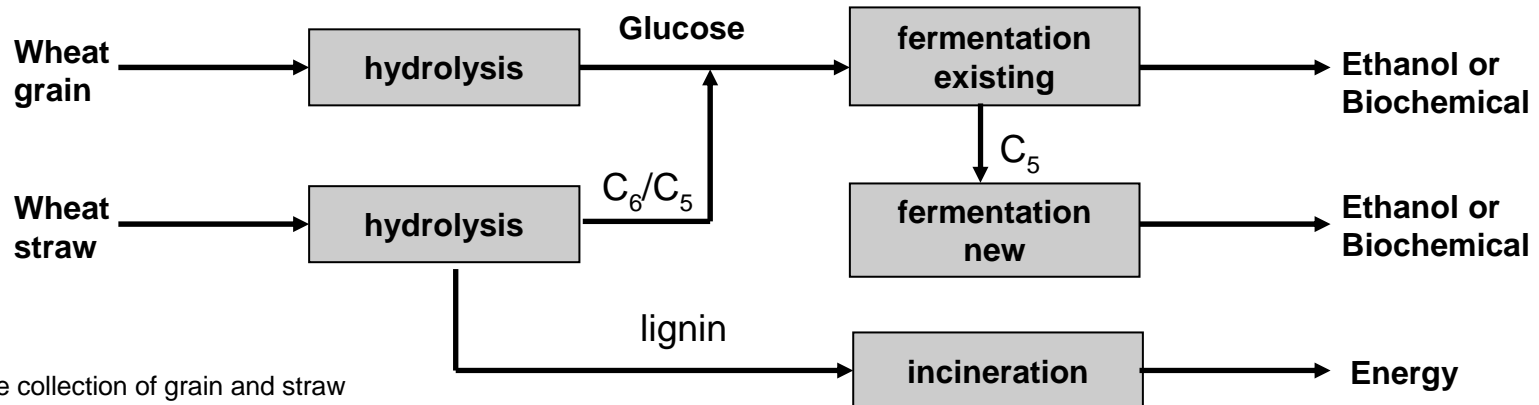


Source: ICM

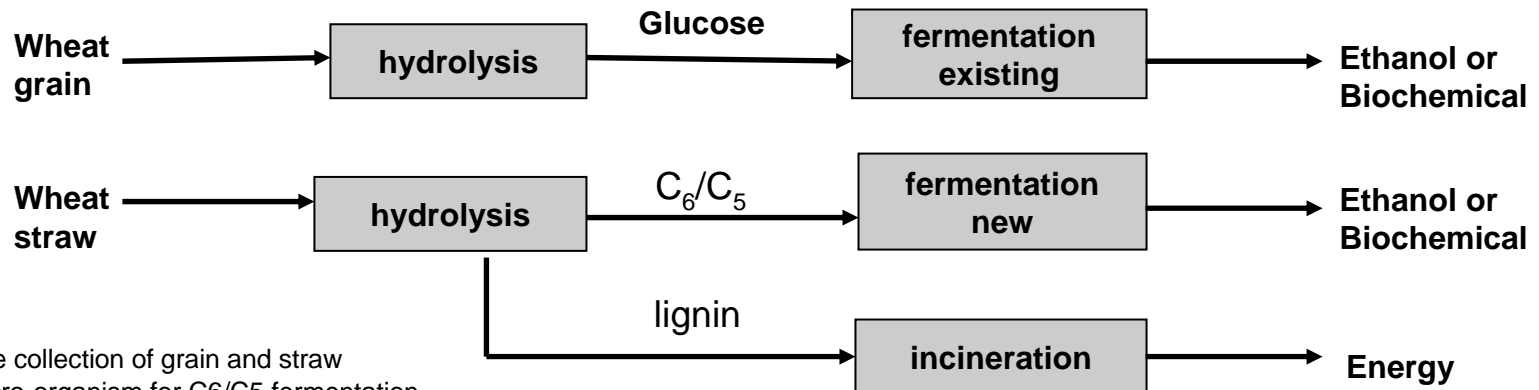
EU Today



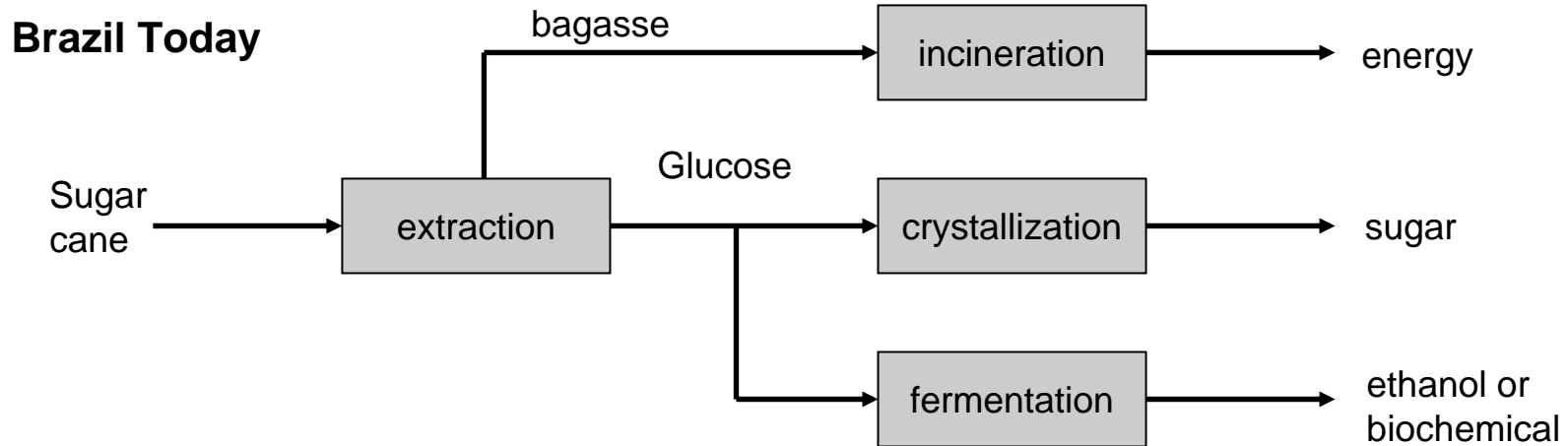
Fermentation in EU - Future



- Separate collection of grain and straw
- No change in micro-organism in existing fermentation
- New micro-organism for C5-conversion

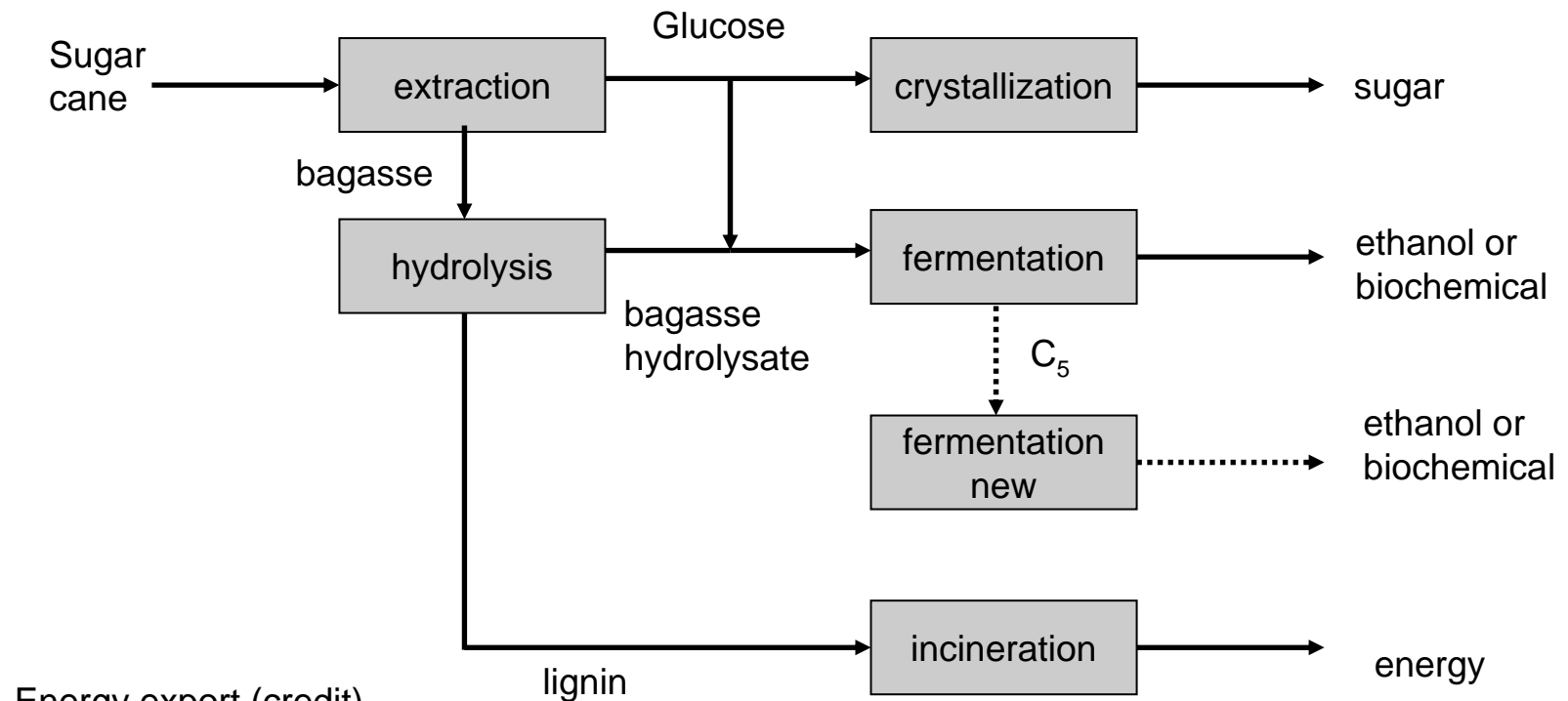


- Separate collection of grain and straw
- New micro-organism for C6/C5 fermentation
- Corn grain and corn stover: identical scenario as wheat grain and wheat straw



- Energy export (credit)
- Whole crop collection
- Self supporting in energy

Brazil Future



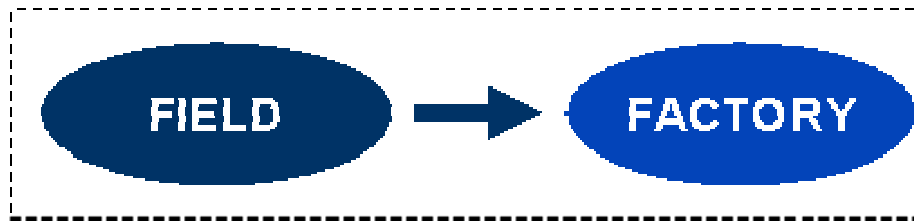
Energy export (credit)
Whole crop collection
Self supporting in energy

- Zero waste streams
- Valorization of by-products (> energy value)
- Full integration and closed loops of heat – C/N source (e.g. cell mass, CO₂)
- Chemical industry solution: Pipe-to-Pipe
 - Security of supply
 - No transport of sugar
 - Availability of low cost sugar
- Several stakeholders → future (new) business models

Various location factors
impact feedstock prices

- Economical**
- Wages
 - Land prices
 - Interest rates
 - Unit costs

Feedstock production



- Natural**
- Sugar yield
 - Needs for irrigation
 - Mechanization
 - Crushing campaign

- Political**
- Subsidized crop prices
 - Taxes on income, property and energy
 - Non wage labor costs
 - Factor prices
 - Subsidized product prices

- In the long run (2015 and later) the conventional renewable feedstocks will be complemented by fermentable sugars from (ligno)cellulose sources (agricultural waste, energy crops).
- Main usage for (ligno)cellulose based sugars will be for **bio-fuel production** (ethanol) in large-scale **bio-refineries**
- Low cost fermentable sugars together with cheap electricity are expected to become available adjacent to bio-refineries
- The introduction of the biofuels will be mainly driven by **national government's legislation** aimed at achieving various political goals
- The emergence of (ligno)cellulosic feedstock is subject to a great number of uncertainties

- 1 Bioraffinage is onontkoombaar om op een economisch en ecologisch verantwoorde wijze in de lange-termijn vraag naar biomassa-gerelateerde producten te voorzien.
- 2 Bioraffinage begint bij het opwerken van restproducten uit bestaande industrieën
- 3 Bioraffinage is noodzakelijk voor marktconforme productie van bio-energie
- 4 Bioraffinage dient aan te sluiten op bestaande infrastructuur om zodoende implementatie te bespoedigen
- 5 Thermochemische versus biochemische bioraffinage is als economische versus energetische efficiency

- 6 Grootschaligheid is een vereiste bij het toepassen van bioraffinage
- 7 De verschillende producten (verkregen via bioraffinage) mogen niet te veel verschillen qua financiële opbrengst
- 8 Bioraffinage is geen deelproces, maar moet de hele keten van oorspronkelijke grondstof tot uiteindelijke producten omsluiten. Daarom is samenwerking tussen de verschillende marktpartijen van groot belang
- 9 De drijfveren voor raffinage van biomassa zijn reductie van depletie van de ruwe olievoorraden en diversificatie van de grond- en brandstofvoorziening, i.t.t. het veelgebruikte argument van reductie van broeikasgasemissies.
- 10 Implementatie van bioraffinageconcepten in de Nederlandse economie op de langere termijn vereist een gemeenschappelijk gedragen visie en RD&D Roadmap.