Biobased Chemistry & Industrial Biotech

Toward an Integrated Approach

Han de Winde

Netherlands Organisation for Scientific Research

About NWO

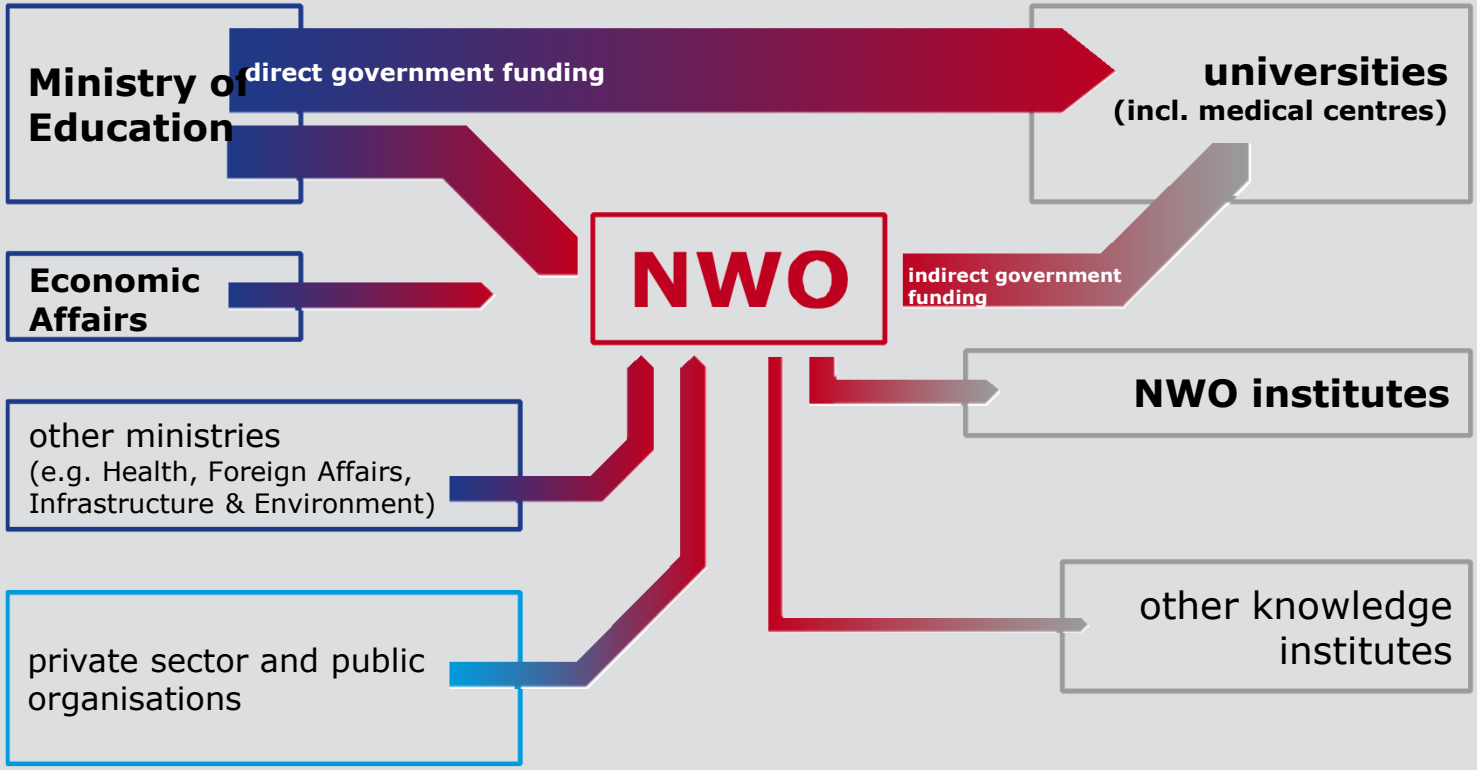
- **National research council** of The Netherlands
- Competitive research funding
- Enabling scientific **research to excel**
- Competition and selection via **peer review**
- Funds more than 5500 scientific researchers
- Knowledge utilisation

Funding 'fundamental' and application-oriented research

Budget 2012 (M€)

Talent and program research	294
Thematic research	145
Infrastructure and investments	59
NWO **institutes**	89
International cooperation	14
Other grants	70
Administrative costs	37
Total	**707**

NWO's role in research funding



New Dutch Government Policy

Ministry of Economic Affairs, Agriculture and Innovation

Top Sectors:

Agro-Food
Chemistry
Life Sciences
High Tech Systems
Water
Energy
Logistics
Horticulture
Creative industry
Headquarters

Topsector Chemistry

By 2050:

1. The Netherlands is the world leader in ***green chemistry***
2. The Netherlands is a global top 3 producer of ***smart materials***

➤ High-value, groundbreaking scientific research

Topconsortia on knowledge and innovation (TKIs)

- Process Technology
- Smart Polymeric Materials
- **Biobased Economy → cross sectoral!**
- "Nursery" for New Chemical Innovations <u>and</u> fundamental science

NWO International

International

Europe:

- Cooperation with other **national funding organisations**
- Jointly identifying **research themes**
- Jointly investing in **large research facilities**

Outside Europe:

- Advancing research cooperation with **China, India and Brazil**

Research cooperation NL-Brazil

- Bilateral program: NWO with CNPq and Fapesp on **Biobased Economy**
- Fundamental science and possibilities for PPP

Topics

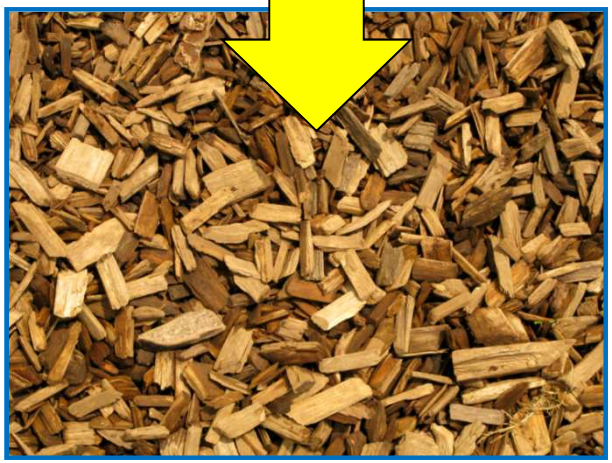
1. **Crop improvement**: More and better agricultural, horticultural and aquaculture products;
2. **Sustainable agriculture**: resilience of the production system;
3. **Biorefinery**; cascading and integrated processing
4. **Chemocatalytical, biocatalytical and thermochemical conversion** of biomass to chemicals and fuels

- *Bilateral research funding: in total ~7 million euro*

Towards a sustainable bio-based economy





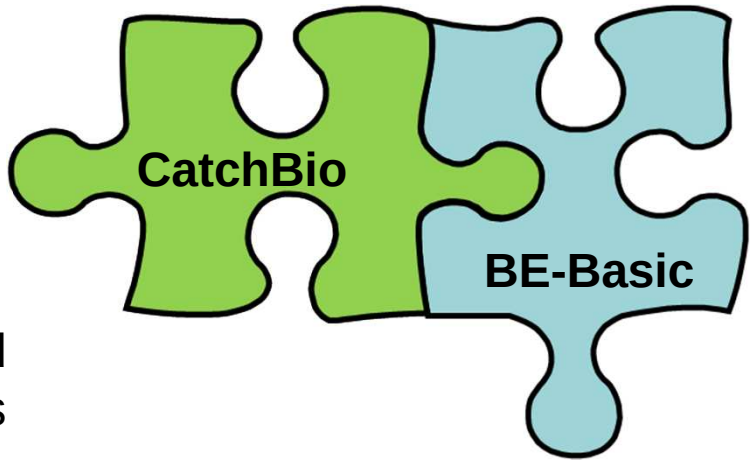



TU Delft

CatchBio

BE-Basic

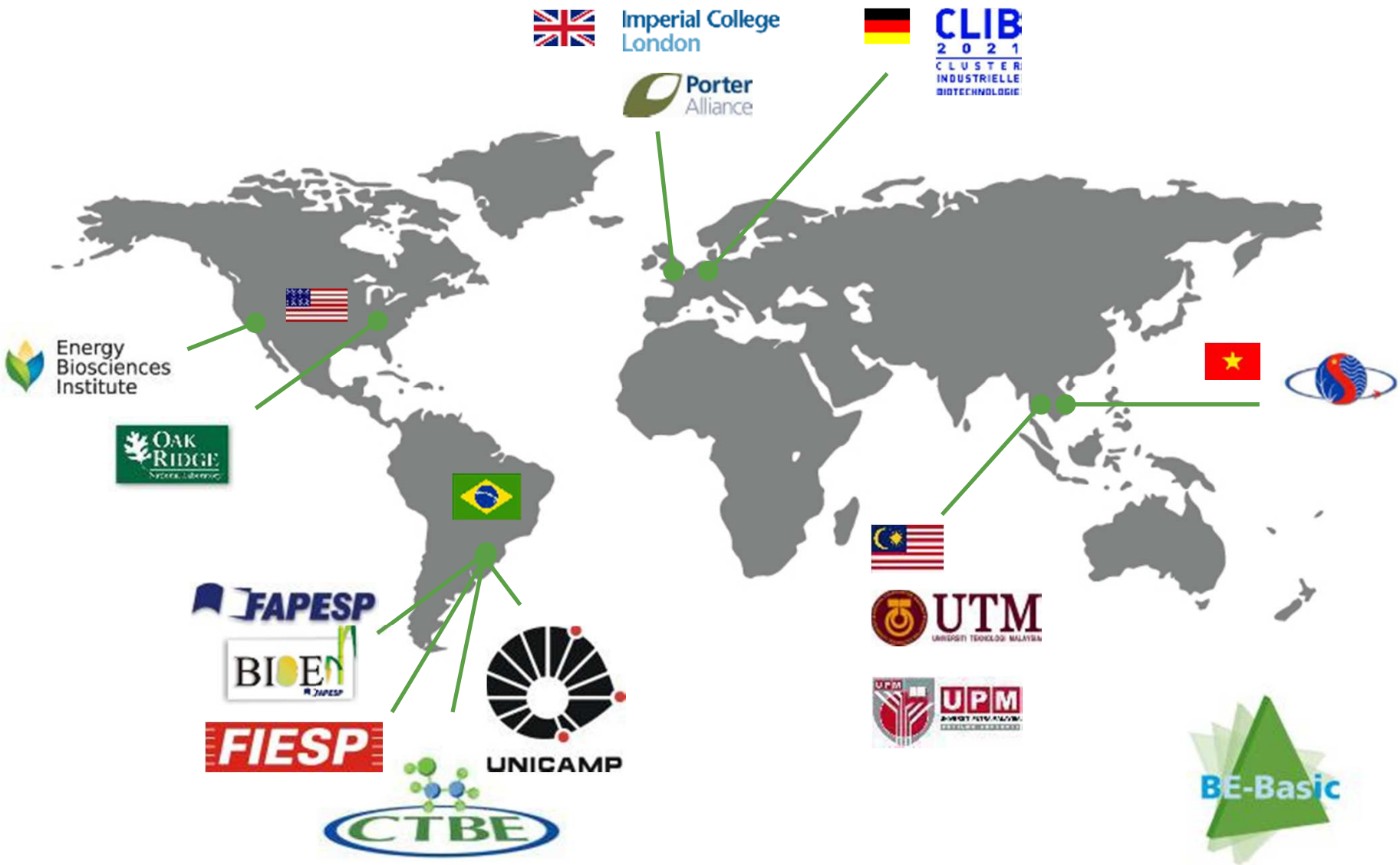
Fundament of TKI BioBased Economy



Chemocatalysis:
Use of organic and inorganic materials

Biocatalysis:
Use of enzymes and micro-organisms

International collaborations



Biobased Economy TODAY: efficient bio-mass utilization ?

"CO_2"

1e generation

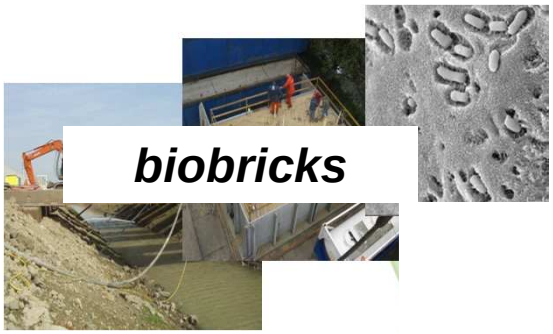
2e generation

biomaterials

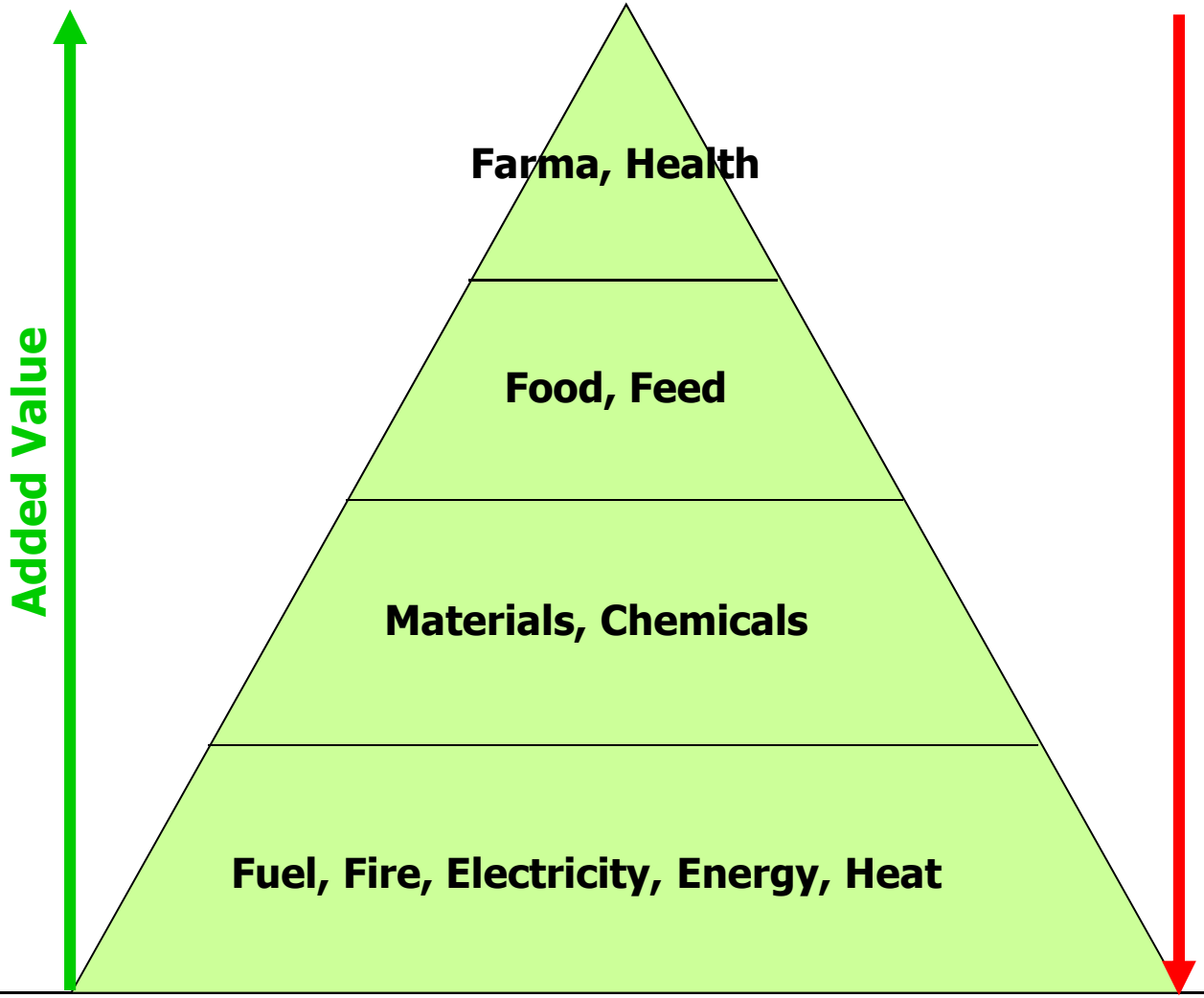
BE-Basic

agro-emissions
(run-offs, N_2O)

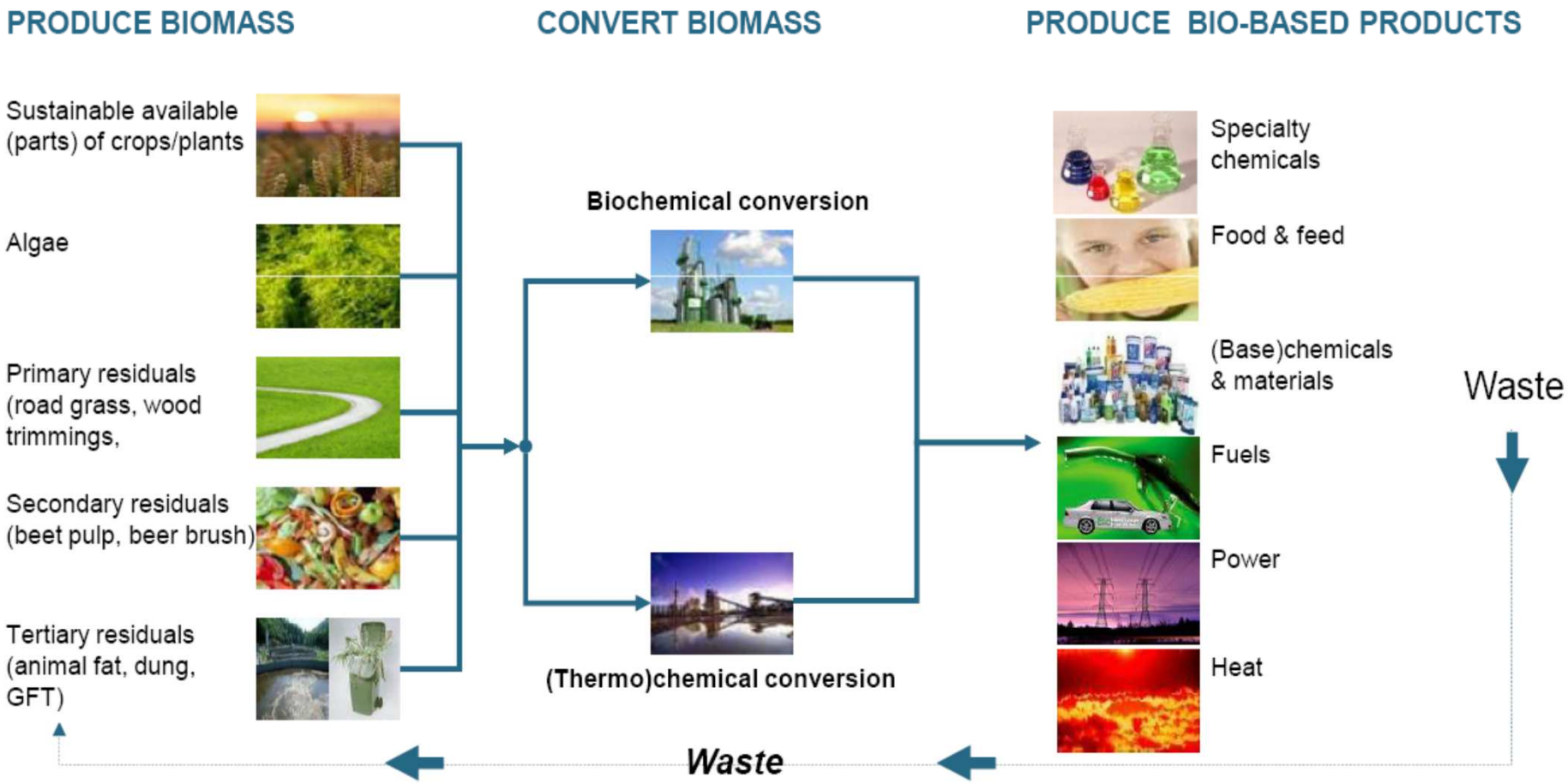
nutrients



Bioenergy paradox – cascading the pyramid !

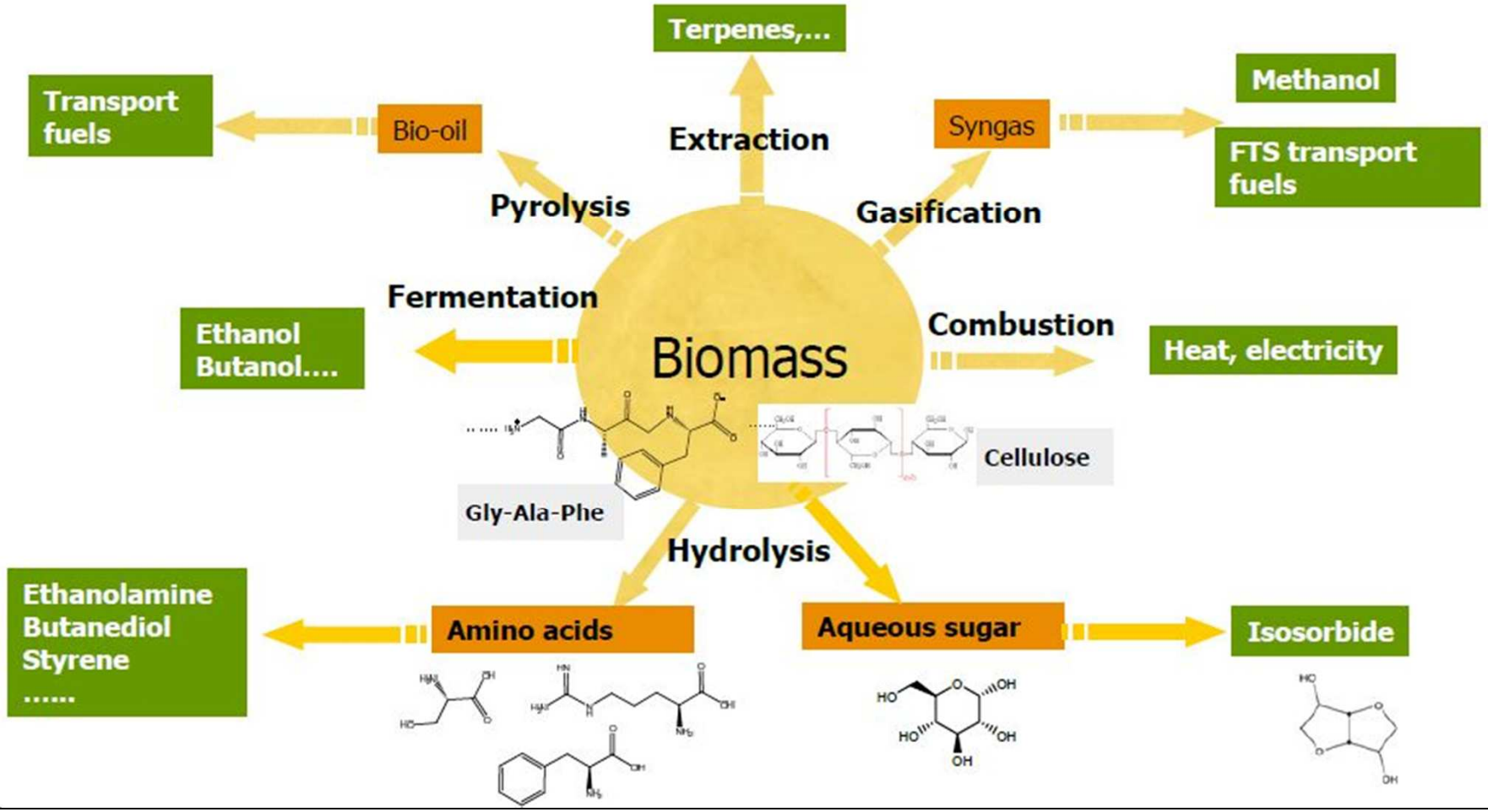


Biorefinery is the sustainable conversion of biomass into a plethora of products en energy



Broad technology portfolio required …

Biomass Conversion, potential routes & products



Ethanol from Ag-waste: 2nd generation biotech

Hemi-cellulosic plant material

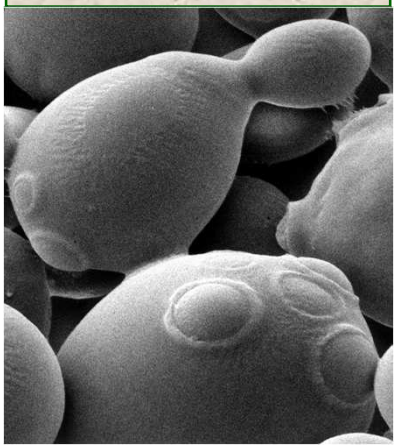
Ethanol

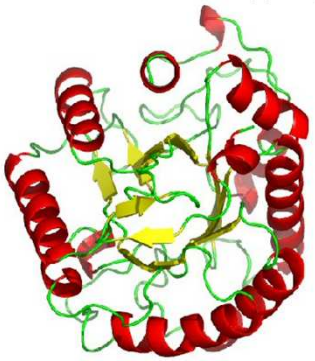
Pretreatment → Cellulose Hydrolysis → Sugar Mixture → Fermentation

Lignin

Combustion

Heat, electricity





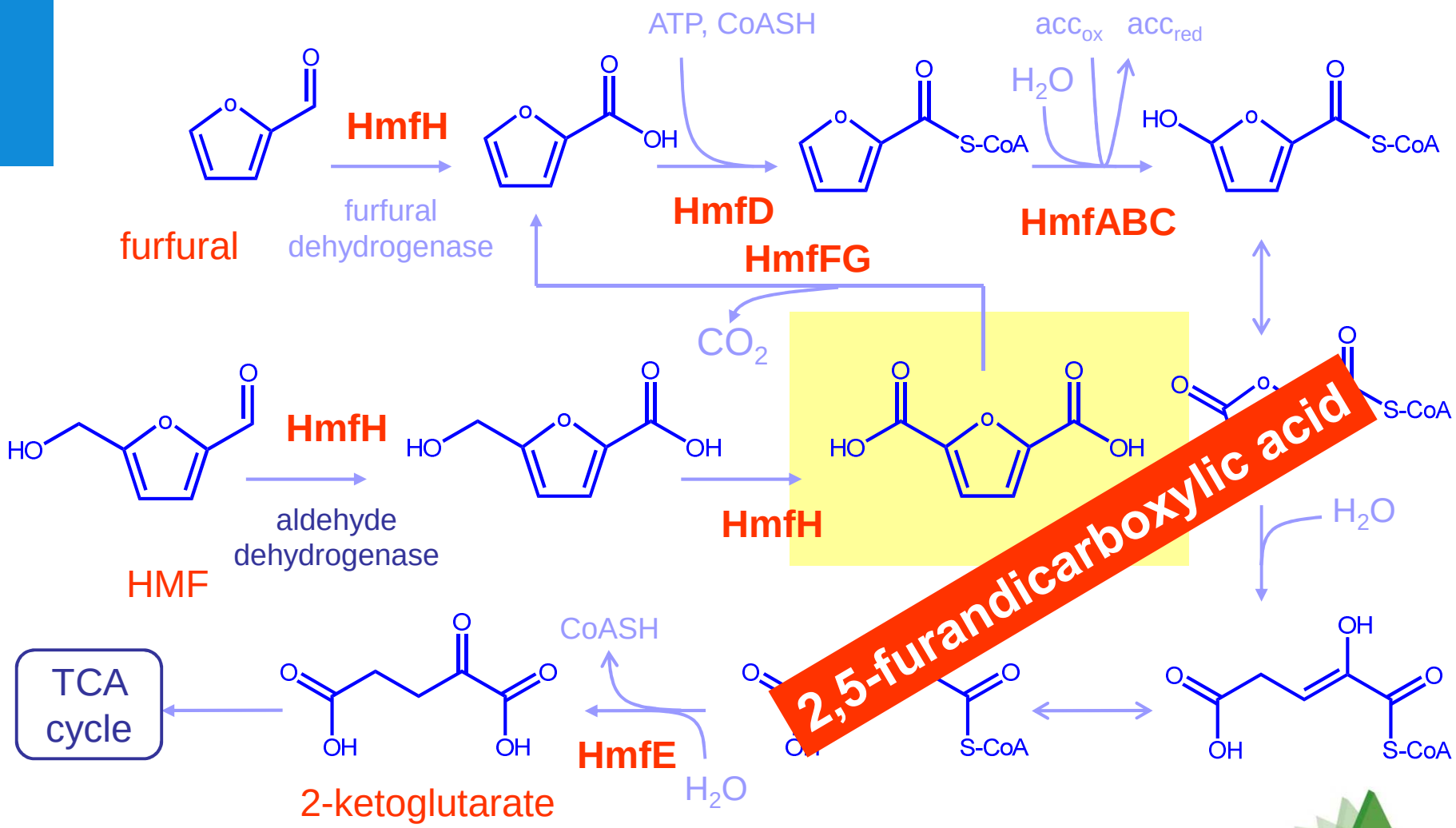
Cellulase

BE-Basic

Sugars in Crop Residues: the Pentose Challenge

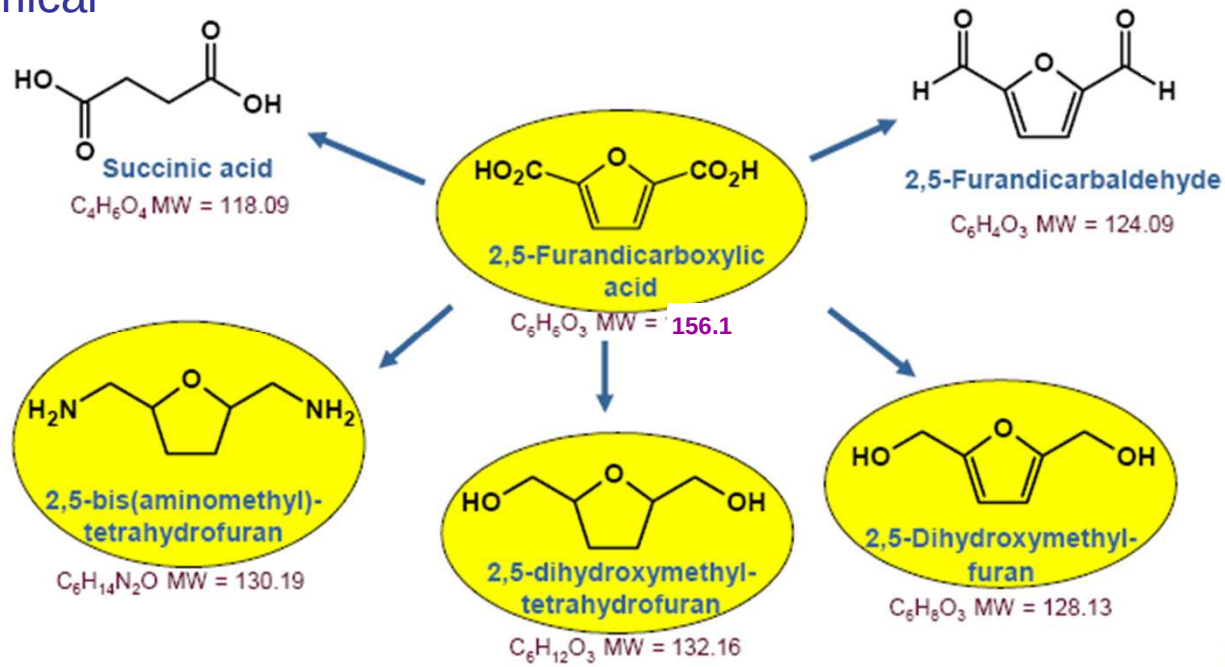
	Corn stover	Wheat straw	Bagasse
Sugars (%)			
glucose	34.6	32.6	39.0
mannose	0.4	0.3	0.4
galactose	1.0	0.8	0.5
xylose	19.3	19.2	22.1
arabinose	2.5	2.4	2.1
uronic acids	3.2	2.2	2.2
Other (%)			
lignin	17.7	16.9	23.1

Furaldehyde metabolic pathways of *C. basilensis* HMF14



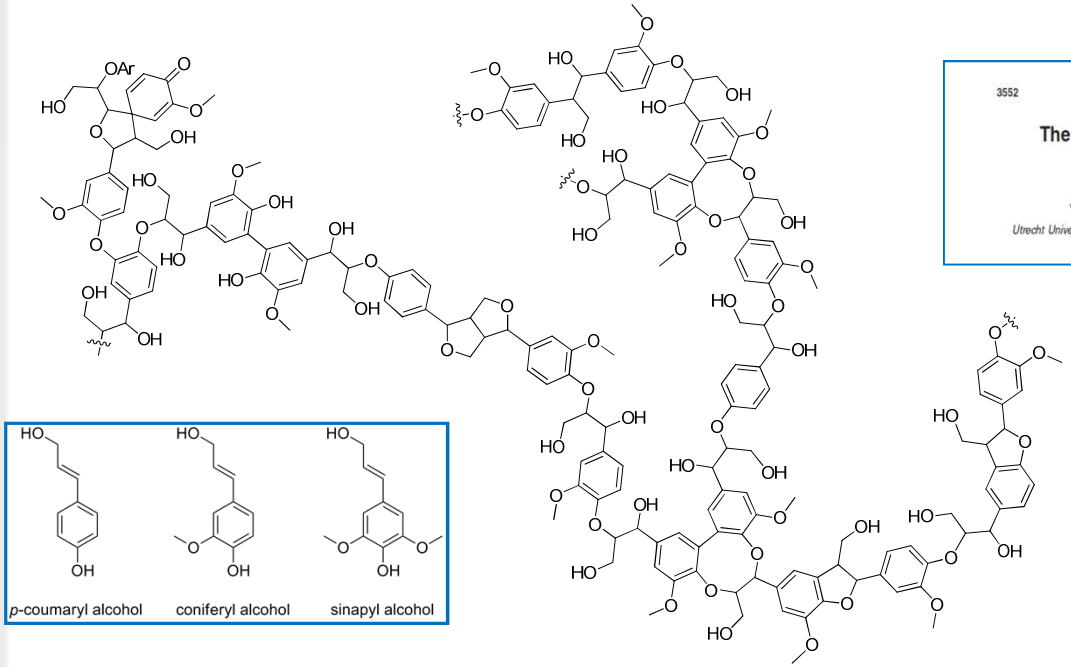
2,5-Furandicarboxylic acid (FDCA, FDA)

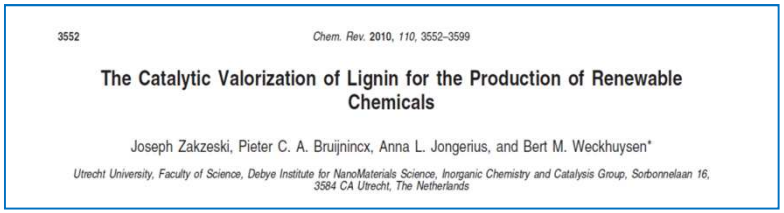
- Top-12 value-added chemicals from biomass
  (2004 DOE-NREL report Todd Werpy)
- Estimated market size 4-12·10^9 \$/yr
- Replacement for terephthalate in polymers
- Platform chemical



Koopman *et al*. (2010) Biores. Technol.
doi:10.1016/j.biortech.2010.03.050

Catalytic depolymerization of lignin to chemicals





3552 Chem. Rev. 2010, 110, 3552–3599

The Catalytic Valorization of Lignin for the Production of Renewable Chemicals

Joseph Zakzeski, Pieter C. A. Bruijnincx, Anna L. Jongerius, and Bert M. Weckhuysen*

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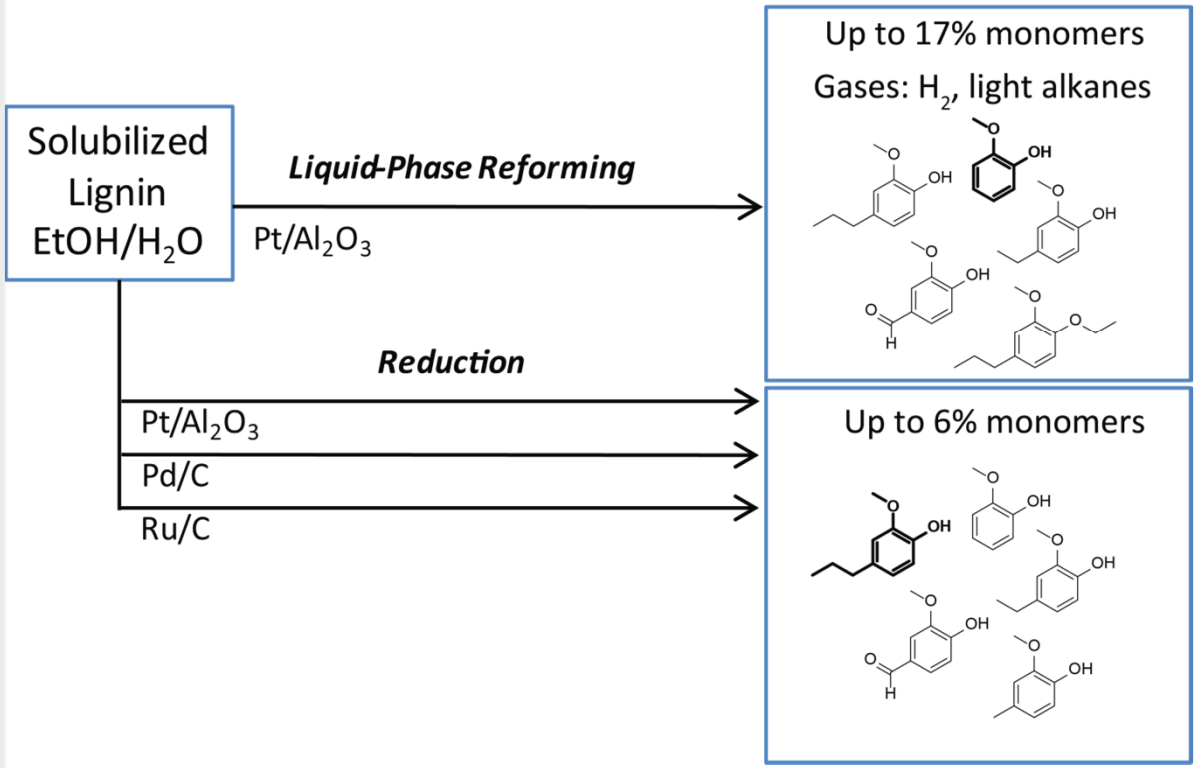
- **Large lignin streams** generated by pulp- and paper industry, future streams available from biorefinery operations

- **Current use**: 98%: low value heating fuel
  2%: chemicals and materials

- **Chemocatalytic lignin valorization** reviewed in *Chem. Rev.* **2010**, *110*, 3552

Catalytic depolymerization of lignin to chemicals



Typical conditions:

498K, 90 min, 59 bar He
1/1 v/v EtOH/H_2O

473K, 4h, 30 bar H_2
1/1 v/v EtOH/H_2O

- **Integrated approach** to the valorization of lignin
- Various catalytic processes tested to convert solubilized lignin feed
- Product yield and composition depends on the **process/catalyst combination**

J. Zakzeski, A.L. Jongerius, B.M. Weckhuysen et al. *ChemSusChem*, **2012**, 5, 1602 – 1609

NWO International

Thank you for your attention