Biorefinery, the bridge between Agriculture and Chemistry

IEA Bioenergy workshop on Biorefineries

Ed de Jong, Johan Sanders
Wageningen University and Research center

WAGENINGEN UR
For quality of life

Many different drivers for one Biobased Economy

- Shortage of cheap oil
- High energy prices
- Security of energy supply
- Climate change by green house gasses
- Rural development
- Developing countries
- Geo-political conditions

Different countries/groups are confident however that a BbE can contribute to their goals.

WAGENINGEN UR
For quality of life

Dutch activities towards a Biobased Economy

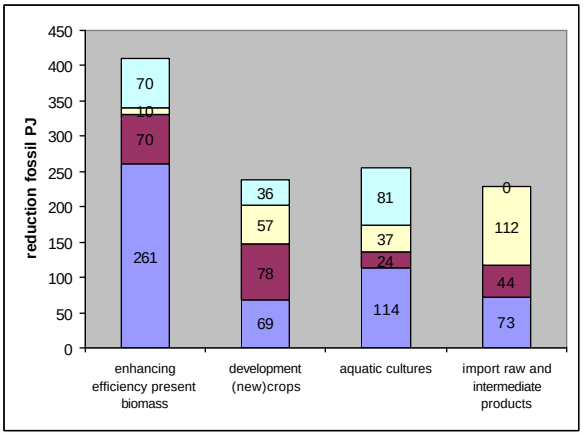
- Taskforce Energy Transition with 5 platforms formulating a.o. transition towards energy from Renewable Resourcesback-up research and Development programs:
  - EOS Biorefinery
- Governmental
- Platform Renewable Resources: 30% biomass energy in 2030:
  - 60% transportation fuels
  - 25% electricity
  - 17% heat
  - 25% chemical raw mateirals

WAGENINGEN UR
For quality of life

30% Dutch fossil substitution by biomass in 2030 = 900 PJ

Import (%)	**50***	**75**	**0**	**100**	**55/36 *** **
Land requirement (kha/PJ)	**0**	**9**	**(2)****	**5**	**3**
Absolute land requirement (kha)	**0**	**2300**	**(300)**	**1250**	**3550**

* No additional import
** no land required
*** additional import



WAGENINGEN UR
For quality of life

How to get there?

Transition paths

1. Sustainable development and production of biomass in the Netherlands as well as abroad
2. Realisation of the biomass import chain
3. Co-production of chemicals, transport fuels, electricity and heat
4. Production of synthetic natural gas (SNG) for the natural gas infrastructure
5. Innovative use of biobased raw materials for non-food and non-energy purposes and sustainable chemical products and processes.

WAGENINGEN UR
For quality of life

Biomass can have different applications and contributions..

	Integral cost prices (€ /GJ end product)	Raw material cost *fossile* (€ /GJ)	Netherlands energy is 3000PJ
Heat	4	3 (coal)	+/- 20%
Electricity	22	6 (coal)	+/- 20%
Transport fuel	10	8 (oil)	+/- 20%
Average bulk chemicals	75	30 (oil)	+/- 20%
Other industry			+/- 20%

WAGENINGEN UR
For quality of life

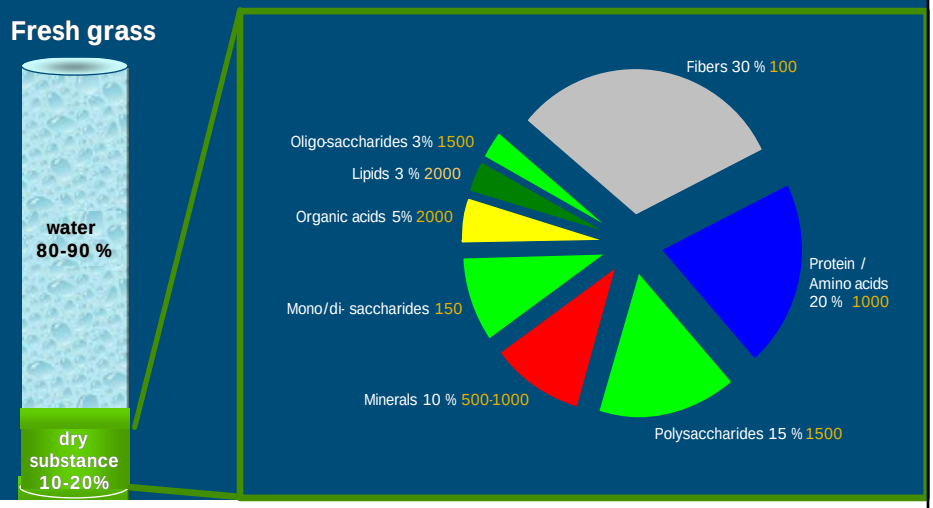
Biomass can bring different contributions to the farmer (€/ha)

Assuming a yield of 10 tonnes dry weight per hectare, being 160 GJ, using *all crop* and good agricultural practices up to double values could be obtained: 20 tonnes whole crop yield, 320 GJ/ha

	€/hectare
• All Energy at coal value	: 640 ---
• All transportfuel	: 1360 ---
• All bulkchemical	: 6400 ---
• **20% bulkchemical, 80% Energy**	**: 1800 – *3600***
• **20% bulkchemical, 40% fuel, 40% Energy**	**: 2080 - *4160***

WAGENINGEN UR
For quality of life

The separated components of grass value 700 - 800€/ton as compared to 50 – 70 €/ton raw materials



WAGENINGEN UR
For quality of life

Pilot biorefinery line Foxhol (Groningen) (Prograss Consortium)

Grass protein (products)

white grass protein

Protein

compound feed

Green grass protein

Grass juice

Fibers

Grass juice concentrate

compound feed

Ethanol

HTU-Biofuel

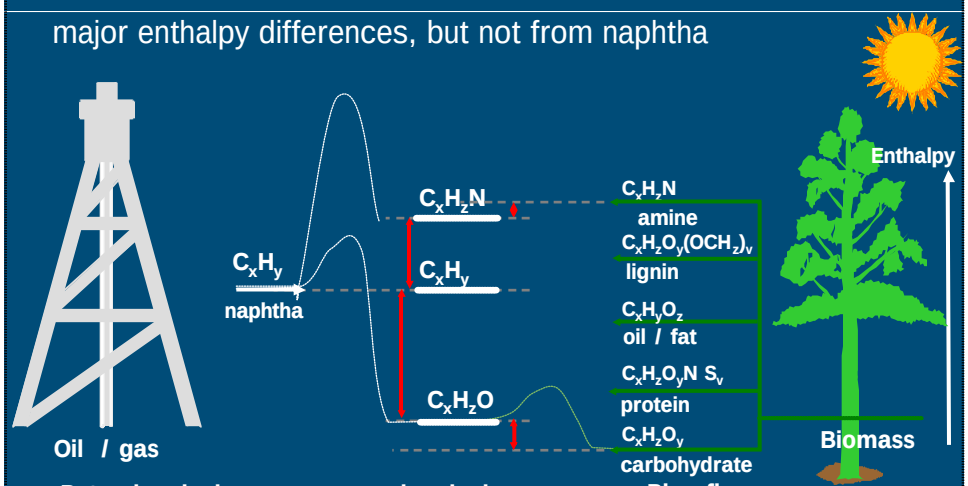
Construction material + paper

Polymer extrusion products

WAGENINGEN UR

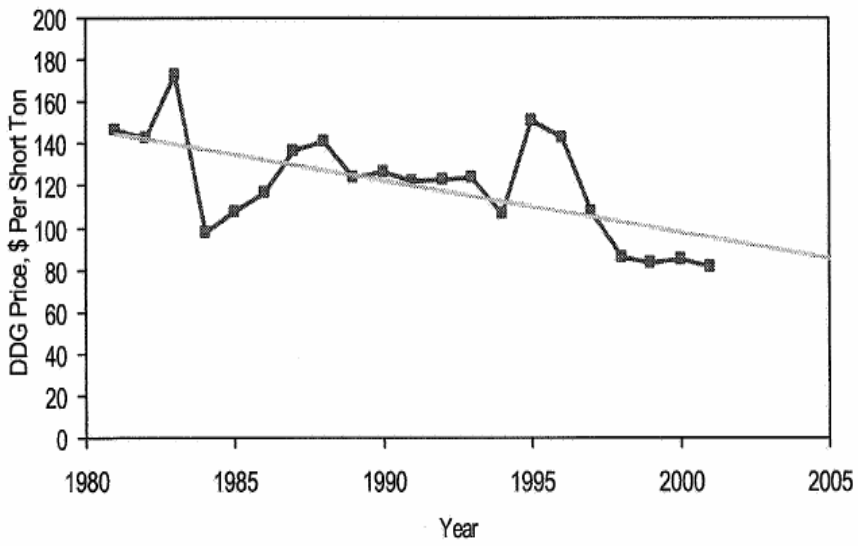
For quality of life

Functionalised chemicals can be made from Biomass without major enthalpy differences, but not from naphtha



WAGENINGEN UR

For quality of life



Source: PERP Report Ethanol 04/05-8

From gluten to bulkchemicals

2005: USA 5,5 Mtonnes DDGS à 60-110 $/ton; (90€/ha)

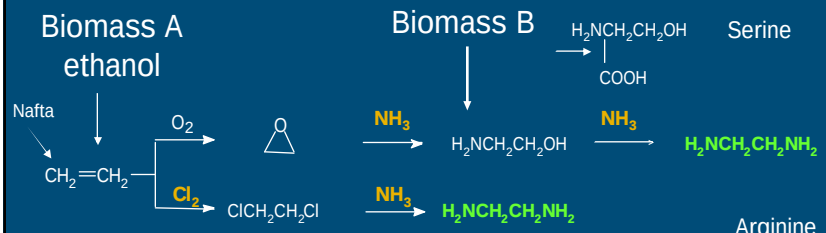
2012: 15 M tonnes (only from ethanol)

Byproduct value almost equal to ethanol value:

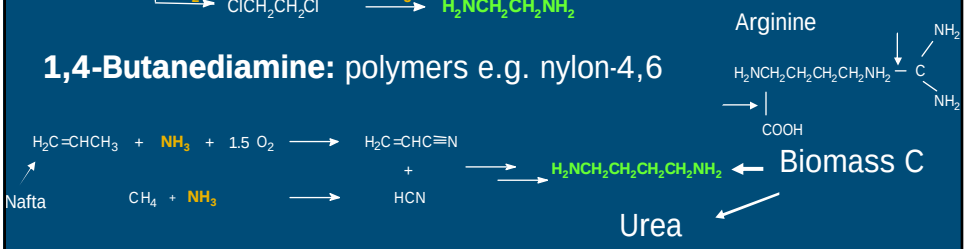
380 kg	glutamic	à 400/tonne	=	155
70 kg	serine	à 700/tonne	=	50
70 kg	leucine	?	=	
150 kg	essential aa's	à 1000/tonne	=	150
300 kg	other aa's	à 500/tonne	=	150
	Gluten products:		**total**	**500+ €/ha**
3.5 m3	**ethanol**	**à 250/m3**	**=**	**875 €/ha**

(Energy) efficient routes to industrially important diamines

1,2-Ethanediamine : rubber chemicals, pharma, lubricants,detergents



1,4-Butanediamine: polymers e.g. nylon-4,6



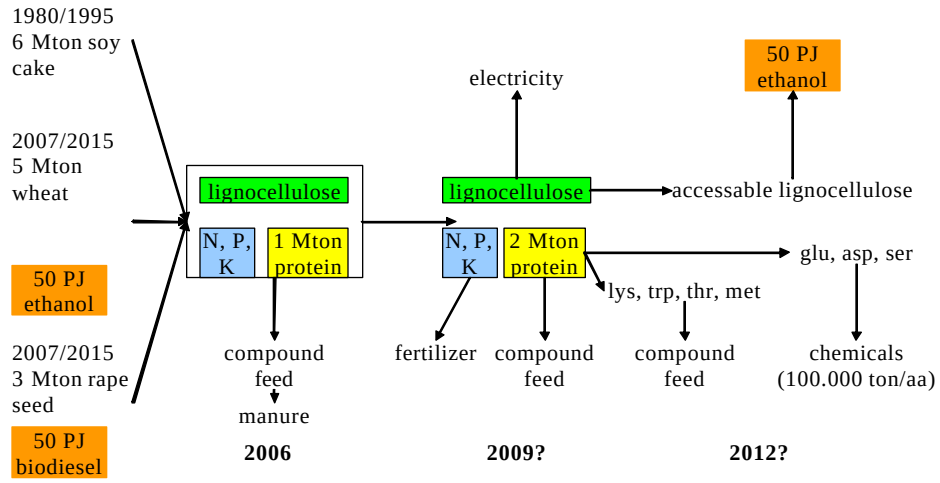
WAGENINGEN UR
For quality of life

Other co-products as a consequence of biofuel production

- if 10% of the WW transportation fuels are produced from corn, wheat, rape, palm, sunflower, cane this will supply 100 million tonnes of proteins
- Several bulkchemicals might be produced from amino acids
- Enzyme and/or fermentation technology will enable efficient processes

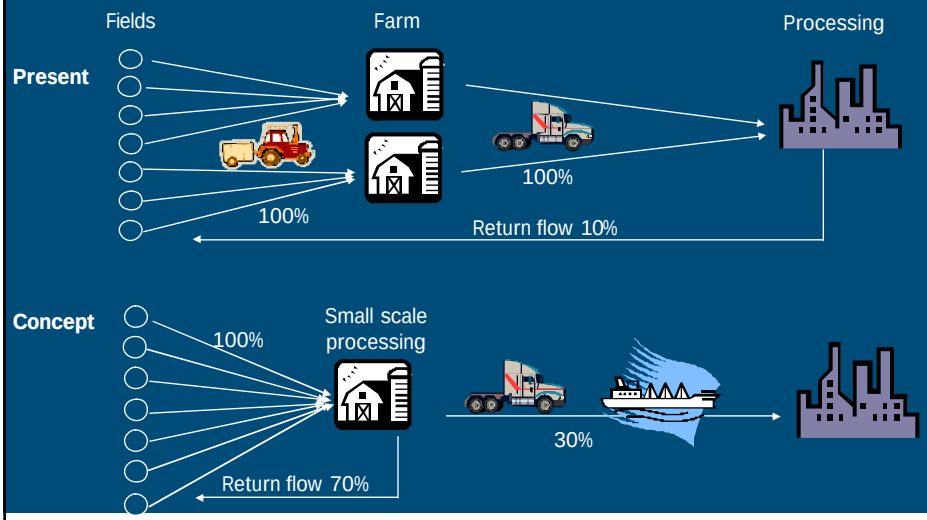
WAGENINGEN UR
For quality of life

Development of Dutch BbE can be build on Dutch pilars: Agriculture, Chemistry, Ports.



Advantages of small scale processing

Forward integration and small scale operation reduces tranport cost and seasonality and will give more income to the farmer



WAGENINGEN UR
For quality of life

Beethanol: small scale ethanol and sugar production from sugar beets, beet residues, leaf and wheat

Farm process enables 2500 – 3000 €/ha gross income by:

- low transport costs
- lower Lang factor (relates equipment costs to installed factory costs)
- By-product valorization:
  - Supply greenhouse or houses with heat < 1 km
  - Supply greenhouse with CO_2 < 3 km
  - Return abundant compound K_2O in fertilizer back to land < 5 km
  - Use of waste products for biogas for subsidized electricity

WAGENINGEN UR
For quality of life

Mobile Cassava starch refinery in Africa

Source: Duteso

WAGENINGEN UR
For quality of life

Advantages of Small scale (pre) processing

Advantages

- Less transport
- Short recycle streams
- New integrations (energy, organisation, labour, product chains..)

Disadvantages:

- Economy of scale? Not for biological processes!

Examples:

- Cassave
- Grass/beet

WAGENINGEN UR
For quality of life

Developments that should improve the biomass route

- Lower raw material price
- better refinery/ separation technologies/downstream processes
- More efficient fermentations
- Plant GMO to tailor make products
- new material-properties
- small scale technology and integrations that can give more income to the farmer

WAGENINGEN UR
For quality of life

Conclusions: Biorefinery, the bridge between Agriculture and Chemistry

- Biorefinery increases the value of the individual biomass components
- (platform) chemicals can be derived from biomass under economic conditions. For the moment functionalized chemicals offer the best chances to compete with petrochemical processes
- Although our harbours can also export biomass components, our big harbours can benefit from the abundant agriculture abroad.
- Small scale (pre)processing offers economic advantages and potential forward integration to the farmer

WAGENINGEN UR
For quality of life

IEA Bioenergy

IEA Task 42 Biorefineries

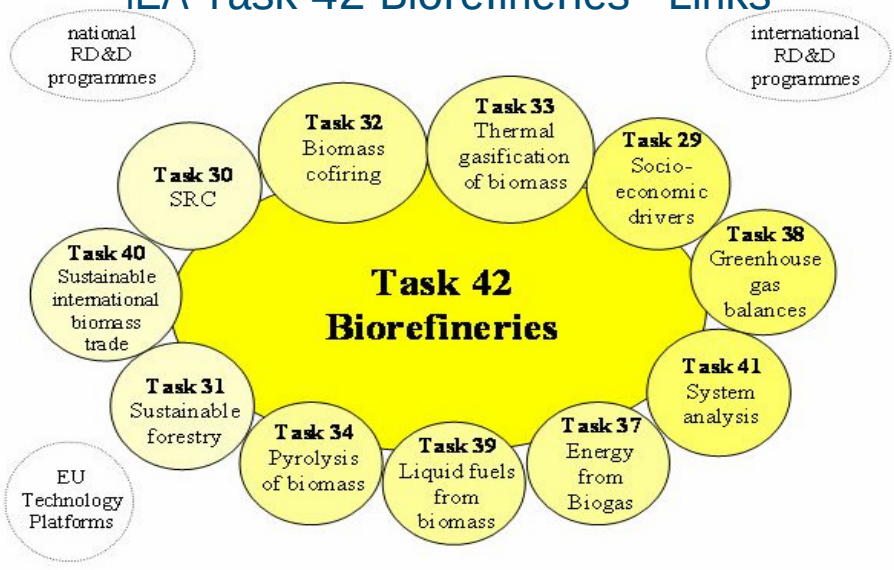
Integrated biorefinery concepts convert a variety of feedstocks, including residues, into a portfolio of products with improved energetic chain efficiency, economy and environmental effects, compared to stand-alone processes often producing only one or two products.

The methodology of integrated system approach – optimising the overall added-value of the portfolio of biomass-derived products, within an acceptable overall ecological framework – is one of the major aspects in which this Task distinguishes from the other IEA Bioenergy Tasks.

WAGENINGEN UR
For quality of life

IEA Bioenergy

IEA Task 42 Biorefineries - Links



IEA Bioenergy — Task 42 - Tasks

1. Task web-site
2. Common definition and classification system on Biorefineries
3. Mapping of existing biorefineries in participating countries
4. Identification of biorefinery (related) RD&D programmes in participating countries
5. Financial-economic and ecological advantages and disadvantages of biorefinery-based co-production over single product processes

WAGENINGEN UR
For quality of life

IEA Bioenergy — Task 42 - Tasks

6. Fostering multi-disciplinary partnerships of key stakeholders (platform function)
7. Co-production of chemicals and secondary energy carriers, addressing a.o. favourable functionalised and platform chemicals (building blocks) to be co-produced, incl. market compatibility aspects
8. Co-operation with ongoing international activities, a.o. other IEA Bioenergy Tasks and EU Technology Platforms
9. Dissemination of knowledge, including teaching

WAGENINGEN UR
For quality of life

Thank you for your attention!!

WAGENINGEN UR
For quality of life