Biorefinery, the bridge between Agriculture and Chemistry

Utrecht 22 September 2005

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An Outlook & Questions to be answered

- Can energy production, transport fuels and base chemicals, based on plant breeding and processing, compete with production based on fossile materials?
- High volume chemicals or just bulk energy?
- Is there enough biomass? Where is the best place on earth? Netherlands, Poland, Developing World?
- Should there be one general intermediate or should we benefit from the synthesis opportunities in plants?
- Small scale or large scale operations?
- Who will take the lead?

There will be enough Biomass for 15% energy substitution (2050)

		% landarea WW	EJ/year
Non collected Straw	(50 %)	12*	75
Collected waste processing	(50 %)	12*	45
'Invisible' losses	(50 %)	15*	75
Forest / pastures	(10 %)	2*	150
Dedicated Crops land (sea)	(3 %)	3 (1 %)	300 (300)
Total		12 - 20 *	645 (945)

* More or less the same area

Total energy required (2050) 1000 EJ

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%
Rest			+/- 20%

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

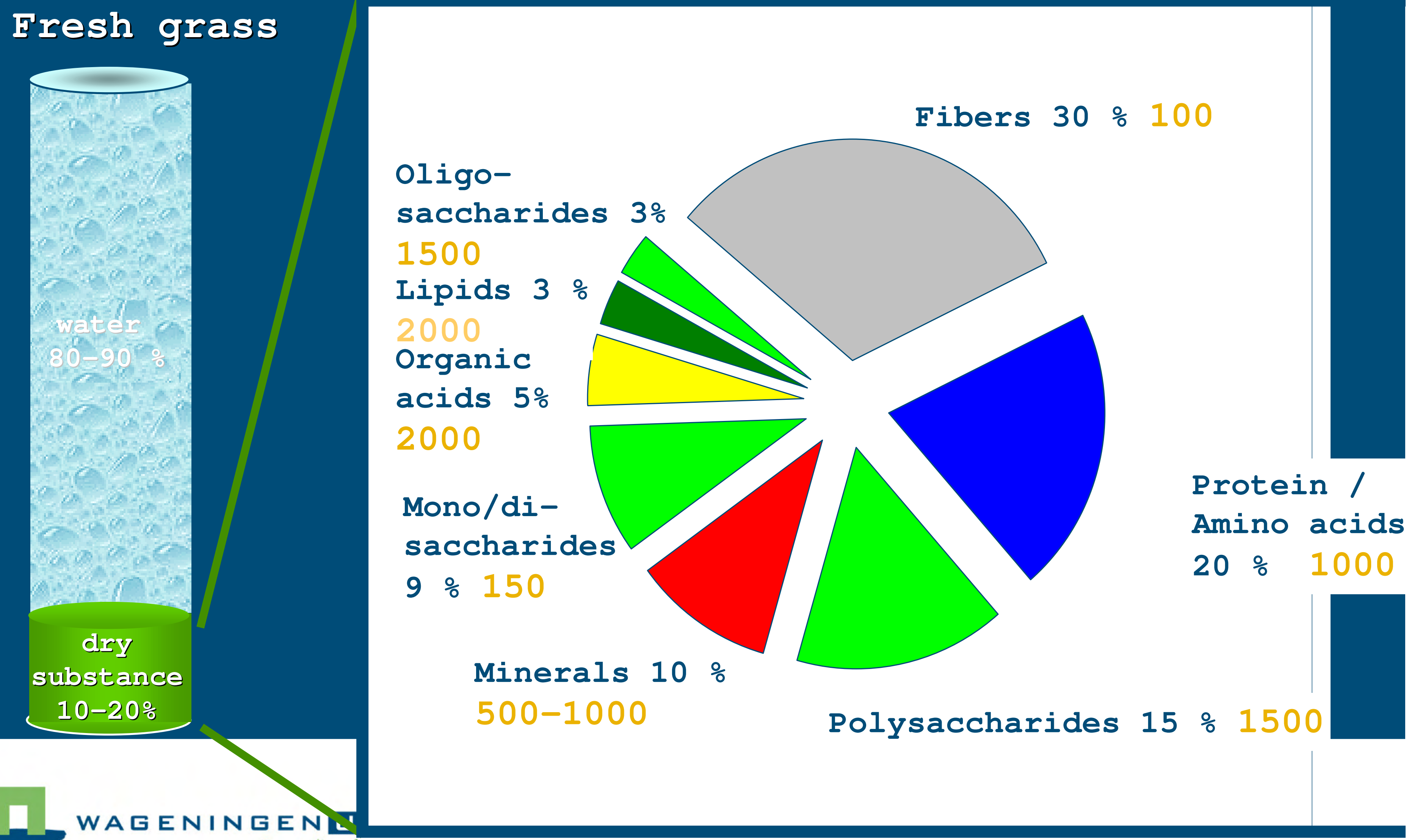
Assuming a yield of 10 tonnes dry weight per hectare, being 160 GJ,

(or 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, 20% fuel, 60% Energy**	**:1940 - *3880***

Using *all crop* and good agricultural practices up to double values could be obtain

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



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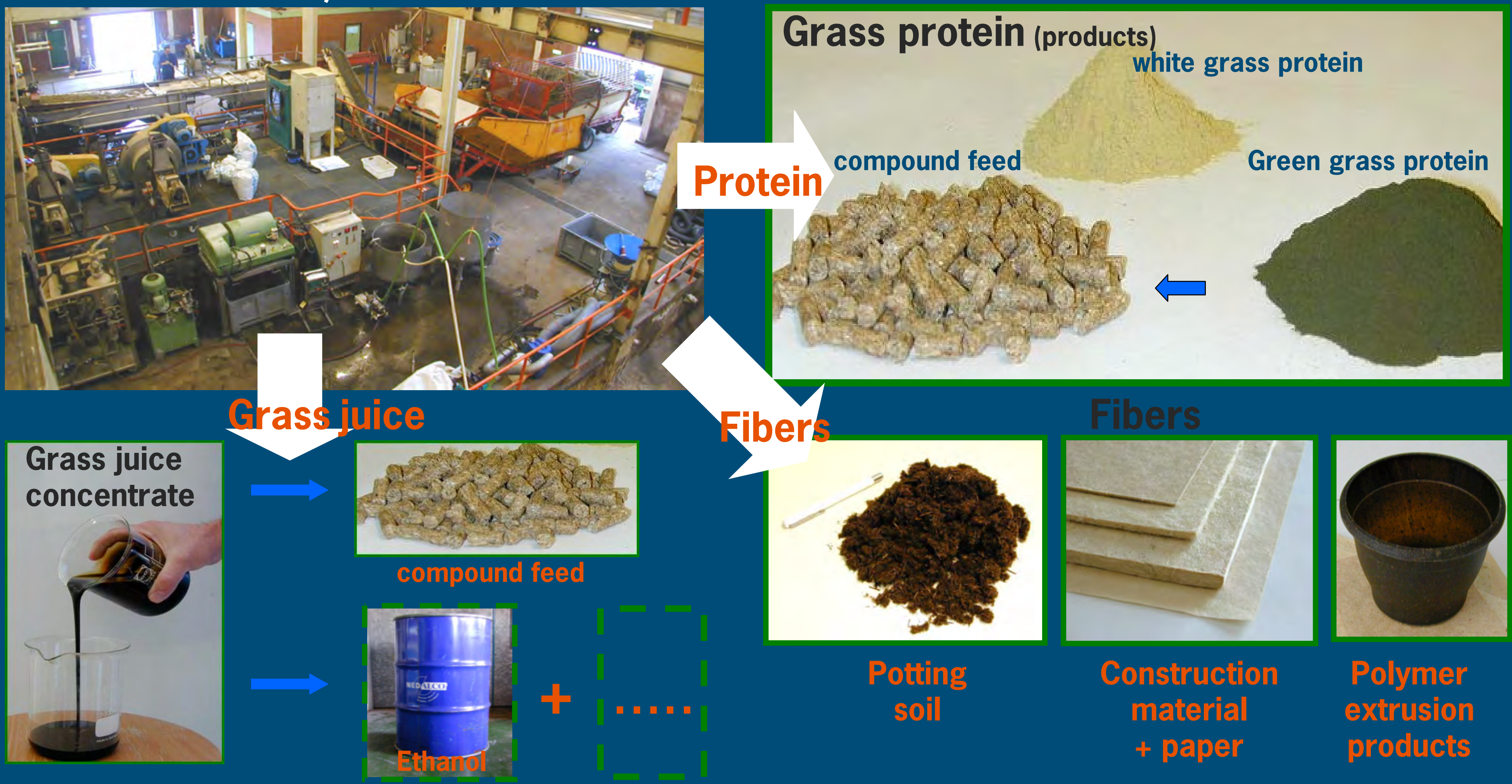
Pilot biorefinery line Foxhol (Groningen) (Prograss Consortium)



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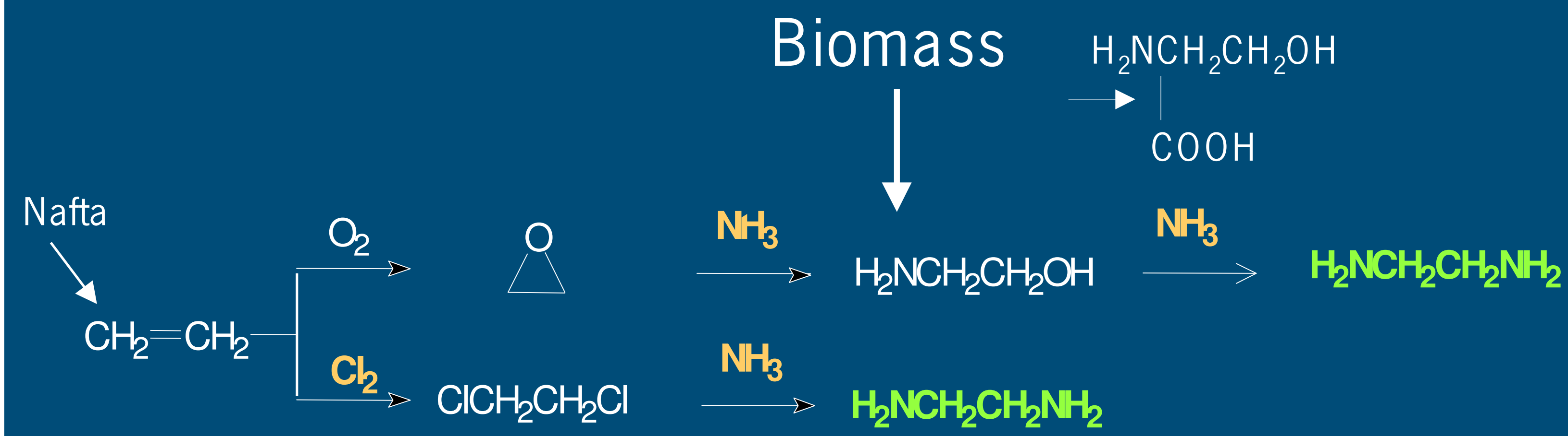
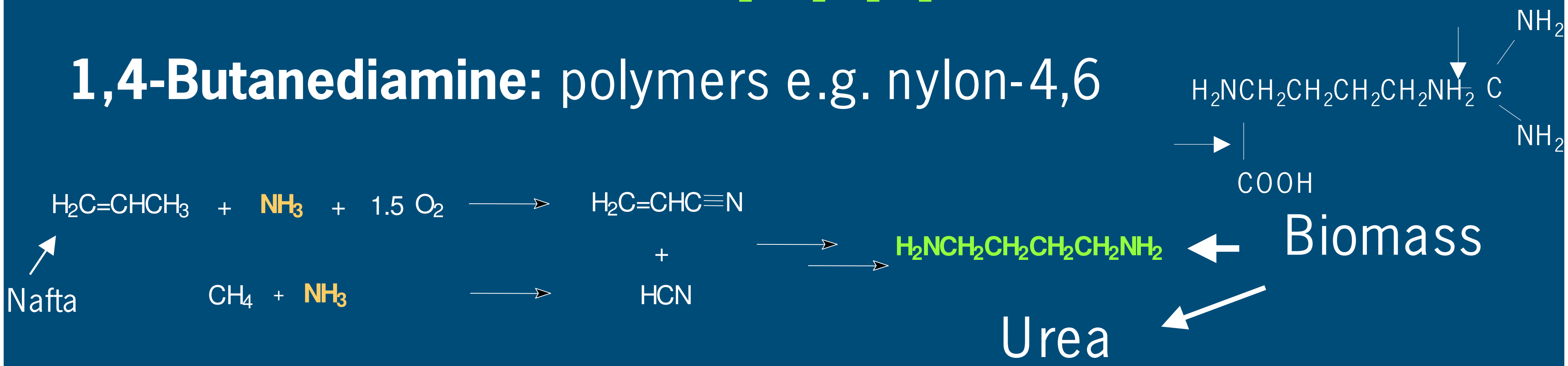
New routes to industrially important diamines

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



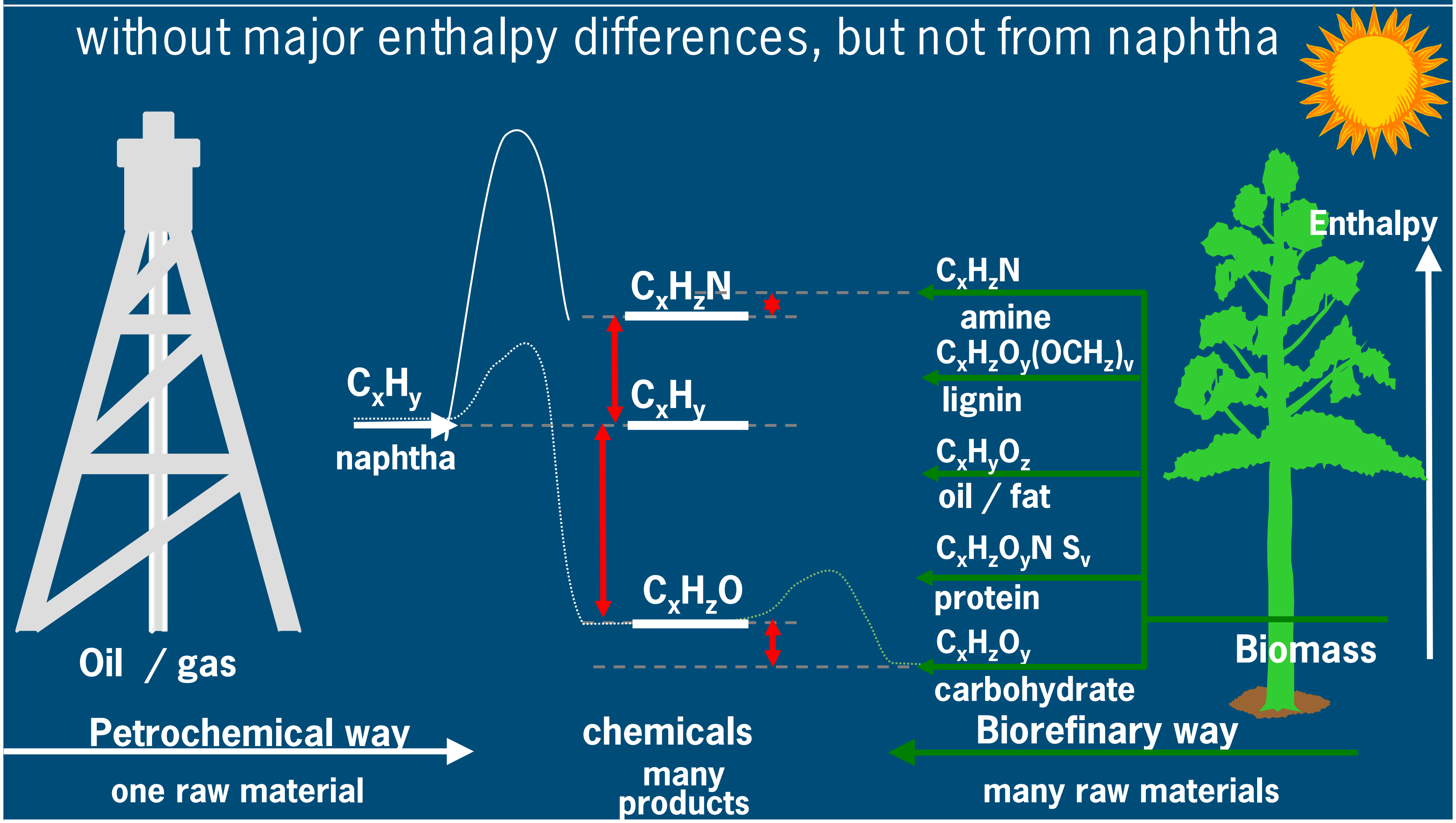
1,4-Butanediamine: polymers e.g. nylon-4,6



Costs breakdown of Bulkchemicals (**€/ton**) at 40$/bbl

	non-functionalised	functionalised
Raw materials	200	**650**
Capital	300-500	**400-650**
Operational	50	50
Recovery	50-100	50-100
Total	725	1300

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



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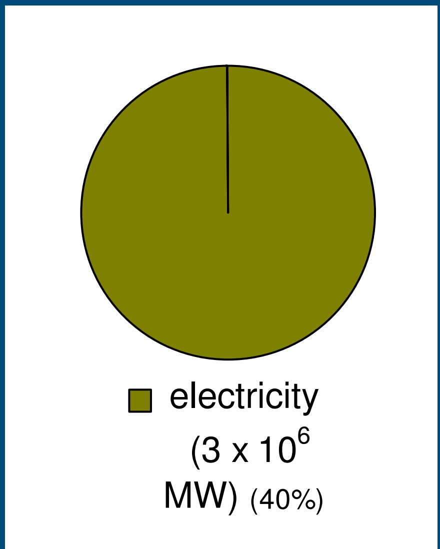
Biorefining will give Mitigation under Economic conditions

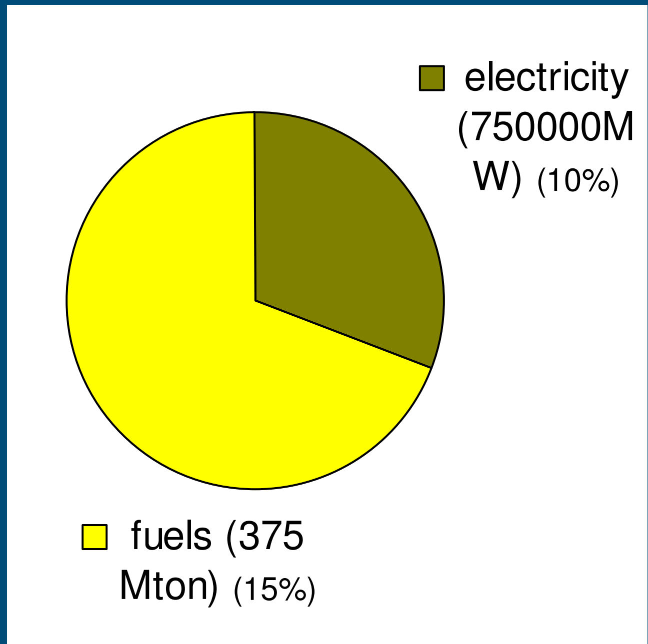
(125 M hectare = 0,8 % world land area)



75 billion €

60 €/ton biomass

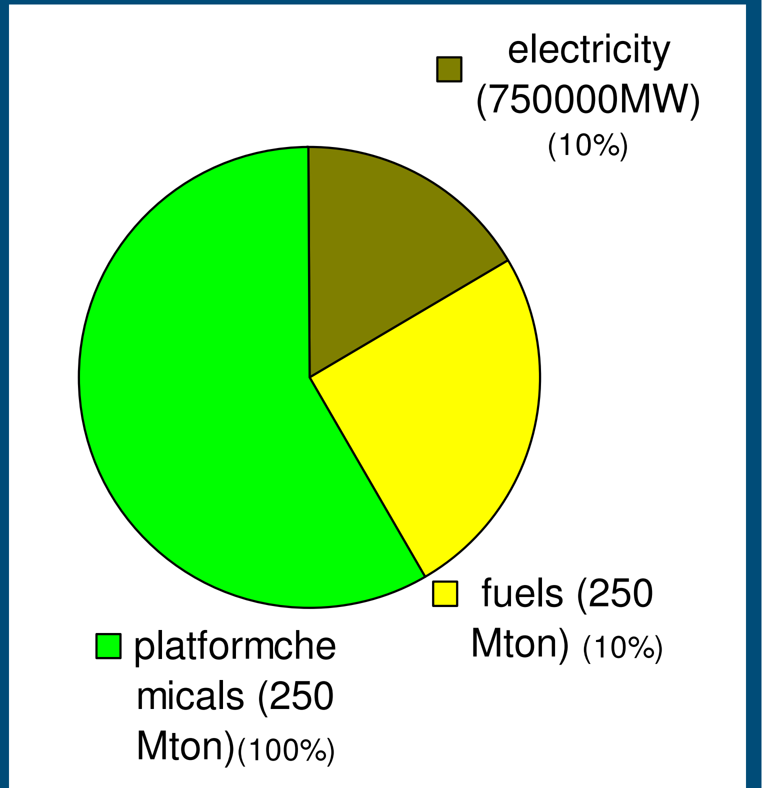
minus 1200 Mton CO_2



97 billion €

80 €/ton biomass

minus 1200 Mton CO_2



180 billion €

140 €/ton biomass

minus 1500 Mton CO_2

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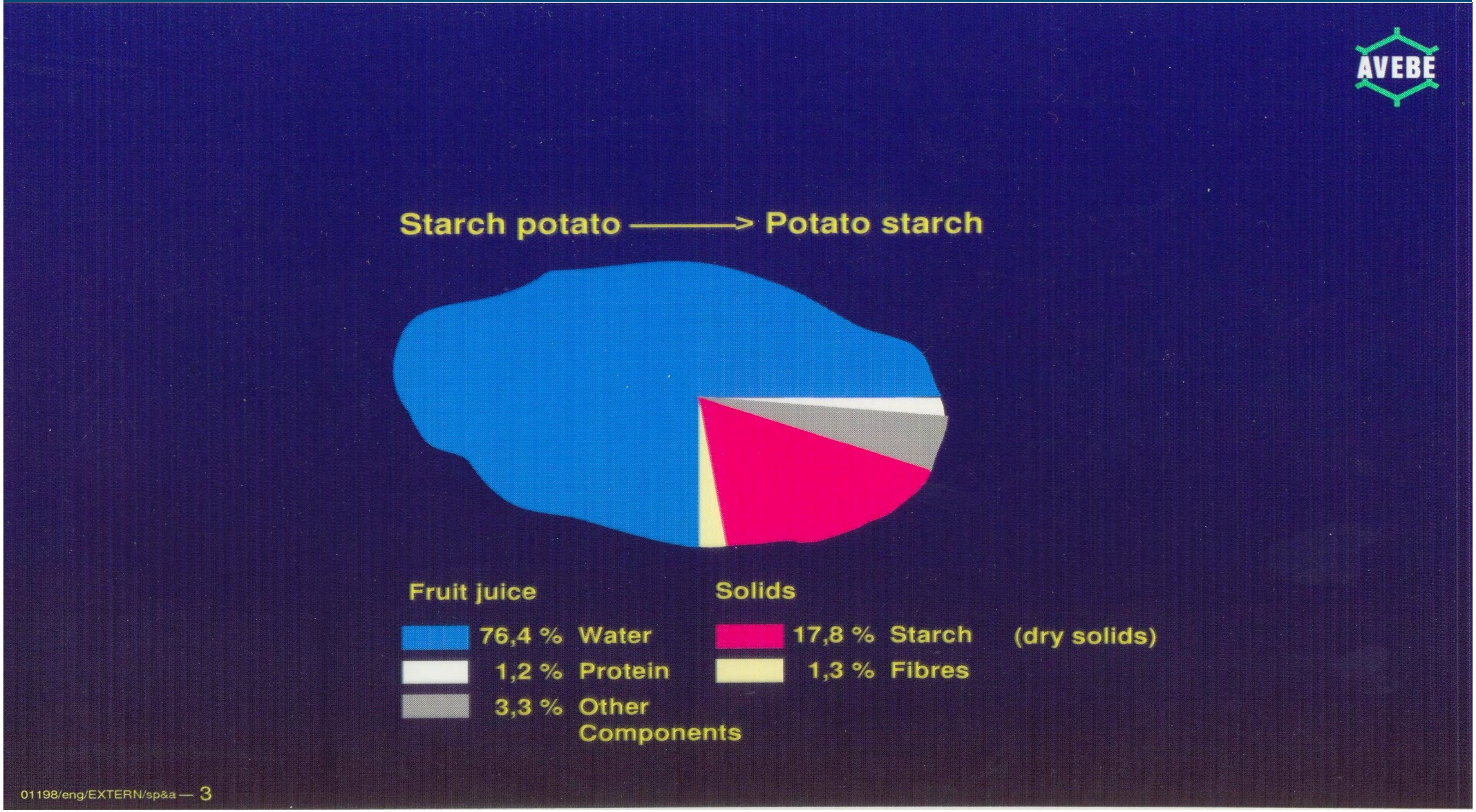
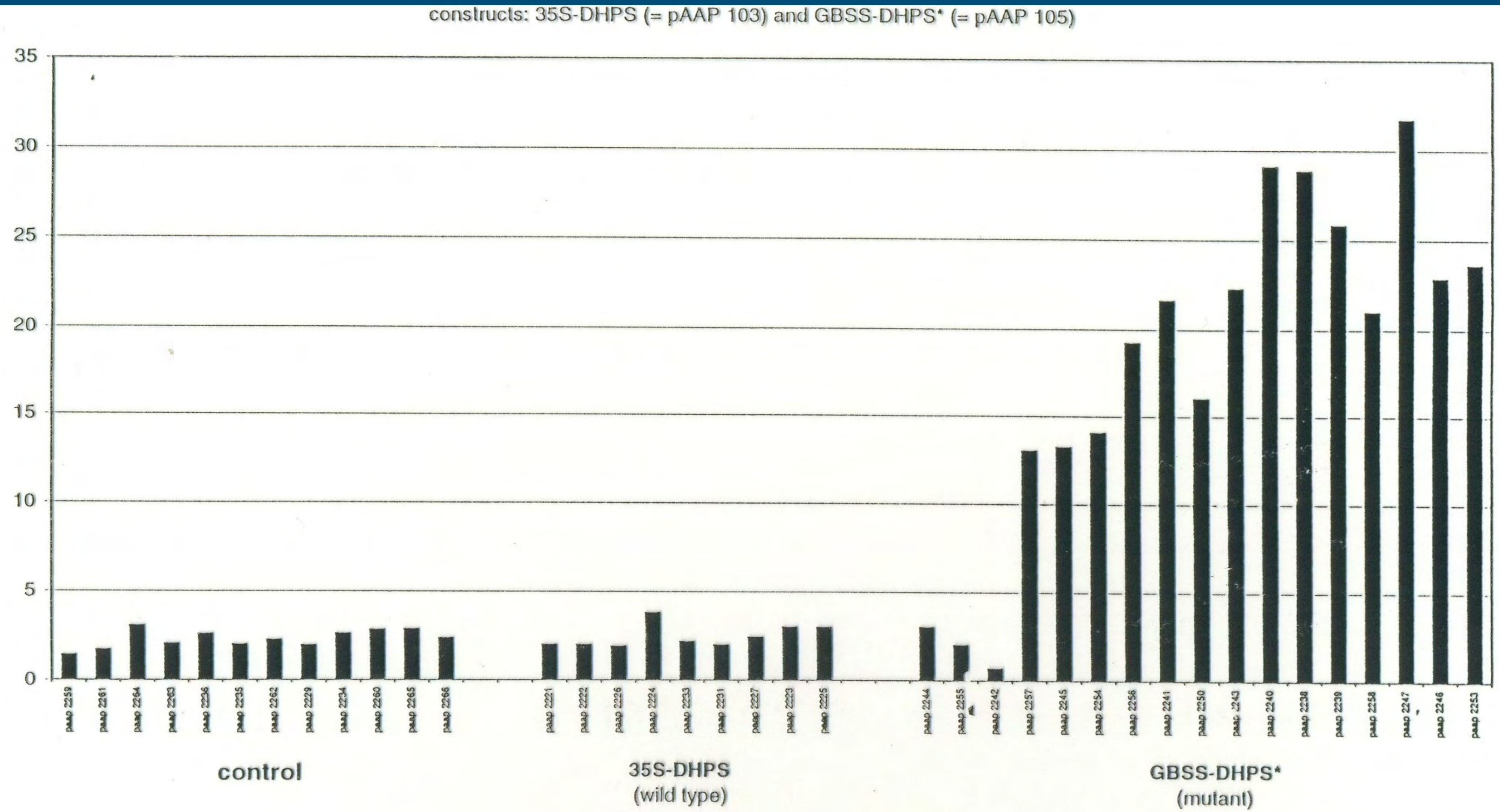
Developments that will improve the biomass route

- *Lower raw material prize*
- *better refinery technologies*
- GMO to tailor make products
- new material-properties
- small scale technology and integrations that can give more income to the farmer

Using the potential components of Potato



Lysine (%) in mature transgenic potato tubers



Project: BIOFOAM (EU KP5, QLK-1999-01298)

Goal: Development of new polymers (poly(ester)amide) based on renewable feedstocks for industrial foam applications

Results

- Successful integrated synthetic route(s) from a biobased origin:
- 1,2-ethanediamine, 1,4-butanediamine, 1,2-ethanediol, 1,4-butanediol, adipic acid, ε-caprolactone.
- Monomer quality (purity) acceptable for polymer applications
- Successful polymer formation for foam applications.

Small scale (pre) processing technology

Advantages

- less transport
- short recycle streams
- new integrations (energy, organisation, labour,..)
- product and chain innovations

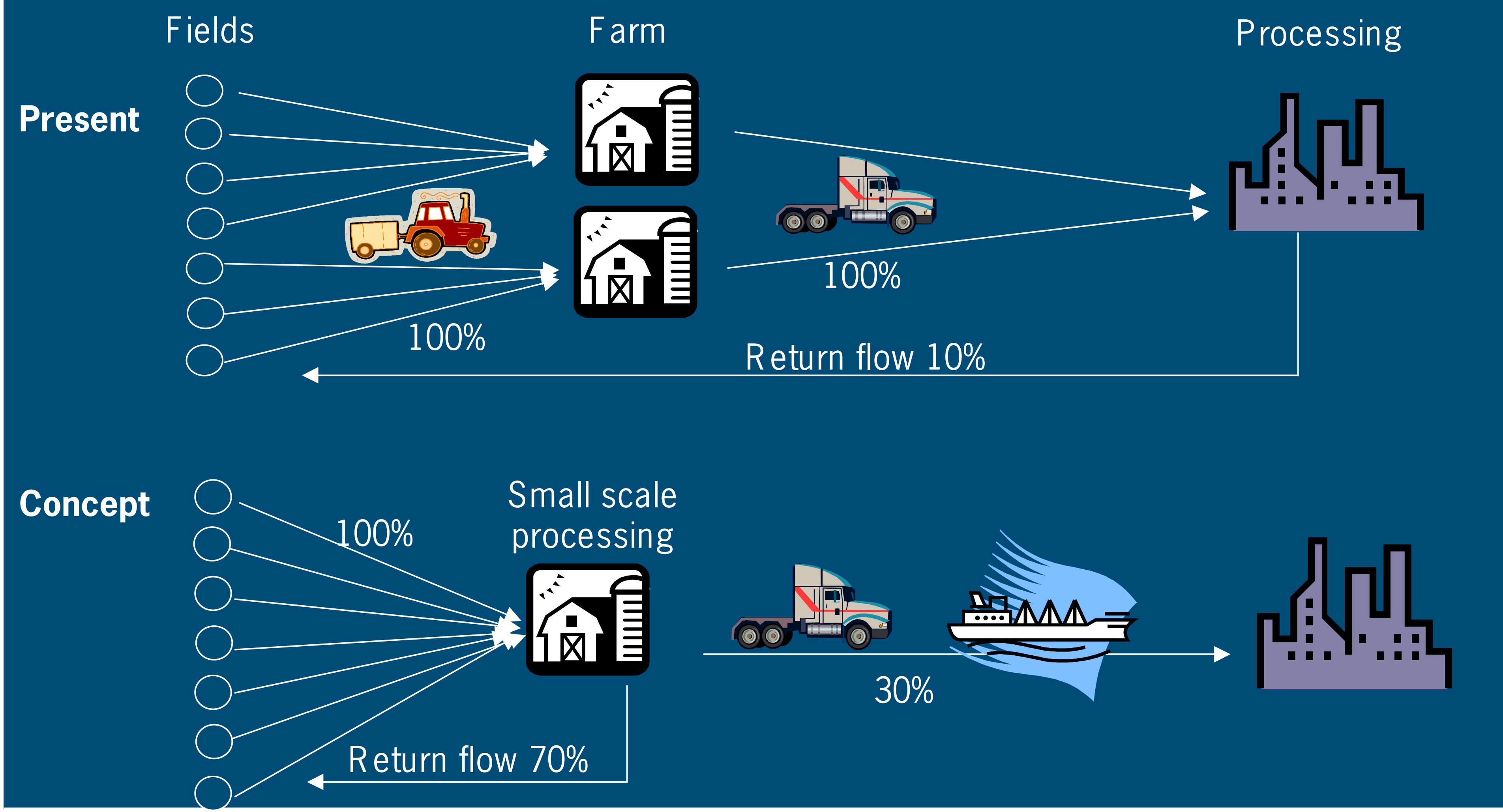
Disadvantages:

- Economy of scale?

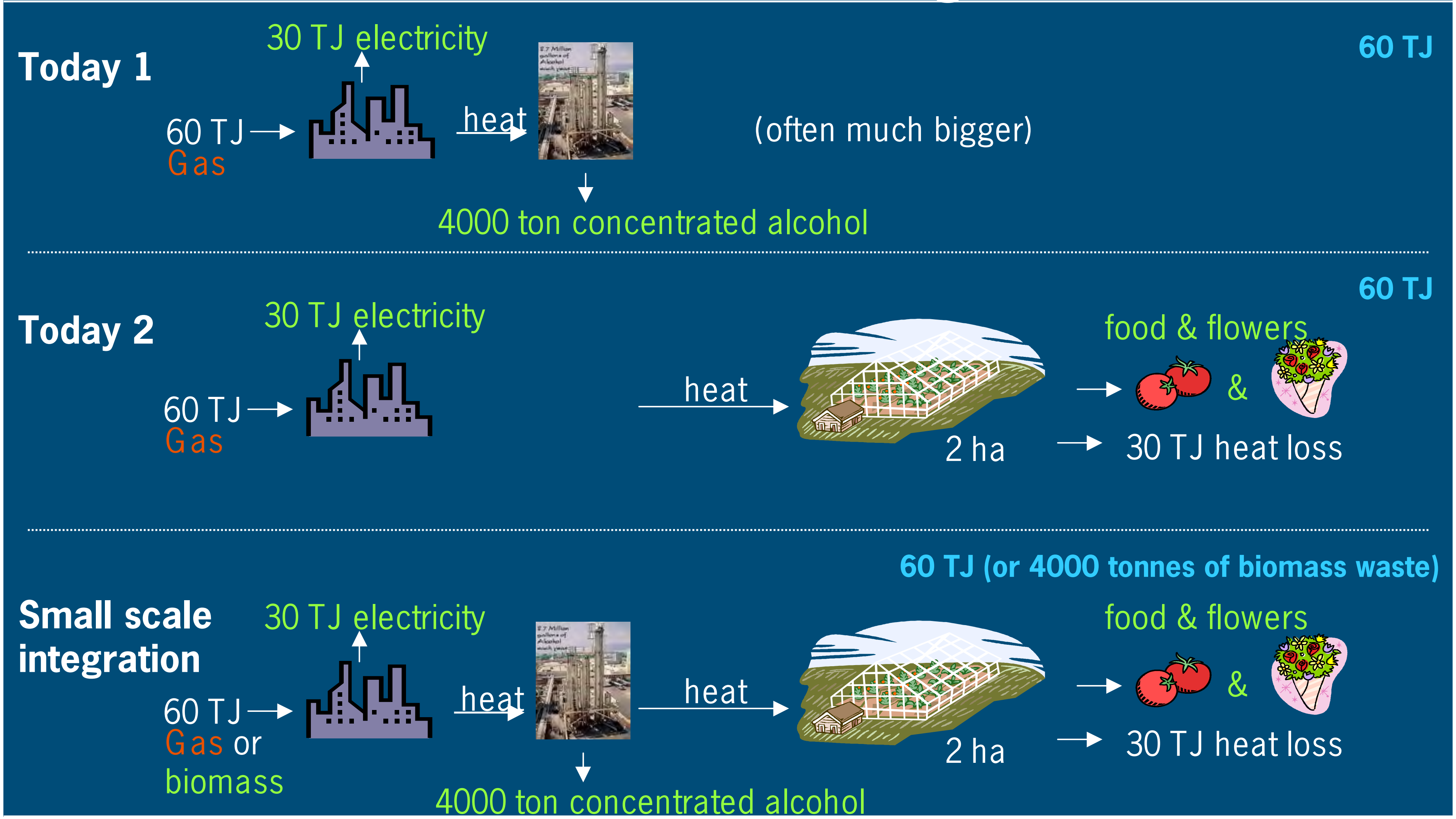
Examples:

- cassave
- grass
- multifold application of energy?

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



Small scale offers innovative heat generation



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Mobile Cassava starch refinery in Africa

Source: Duteso

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Conclusions

- Biorefinery increases the value of the individual biomass components (cf Pigs are not converted all to meatballs!)
- (platform) chemicals can be derived from biomass under economic conditions. For the moment functionalized chemicals offer the best chances to compete with petrochemical processes
- Small scale (pre)processing offers economic advantages and potential forward integration to the farmer
- Energy production can optimalise the biorefining of biomass to chemicals and fuels

Afsluiting

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Benutting van bulkchemicaliënwaarde verhoogt grondstofwaarde van biomassa van 60 naar 140 €/ton

	Eindwaarde (G€)	(fossiel) grondstof waarde	Fossiel €J/y input	Mtonnen biomassa input	€/ton biomassa
Bulkchemicaliën	375	90-120	15-20	250	360-480
Ethanol	75	45	7.5	500	90
Elektriciteit	80	30	7.5	500	60
Totaal	525	65-195	30-35	1250	130-150

6 €/GJ = 50 $/bbl

4 €/GJ = kolen

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