The biorefinery model

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Biomass use today and in 2050

	Mton
Food incl. feed*	5000
Wood, paper, cotton	2000
Wood for cooking	4000
30% of 1000EJ in 2050=	20 000
All bulk chemicals in 2050	600(= 2000 input!)

Only increasing field yields will not satisfy demands

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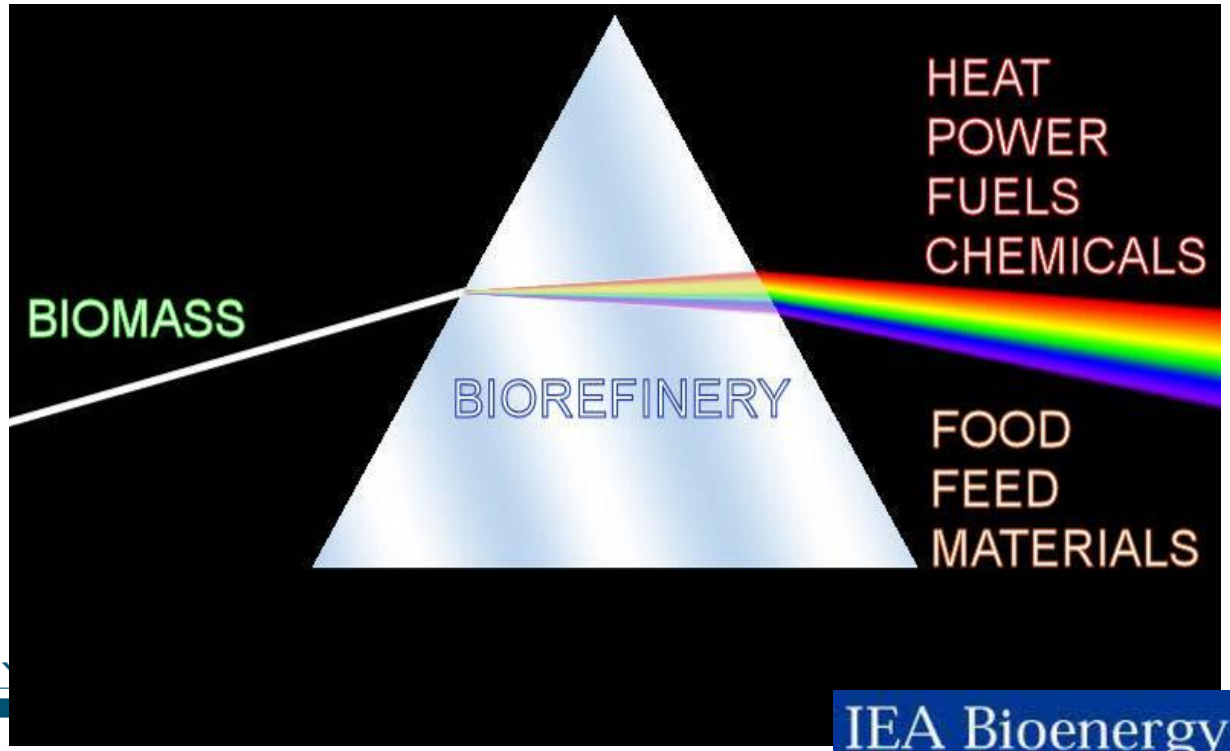
* Excluding grass and seafood

Biorefinery

- Biorefining: Sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, materials) and bioenergy (biofuels, power and/or heat).



How to compete with fossil under sustainable conditions?

- Choose the right raw material
- Use all biomass components
- Use each component at its highest value:

  (molecular) structure is much better than caloric value
- However, keep components on the field that are required for soil fertility

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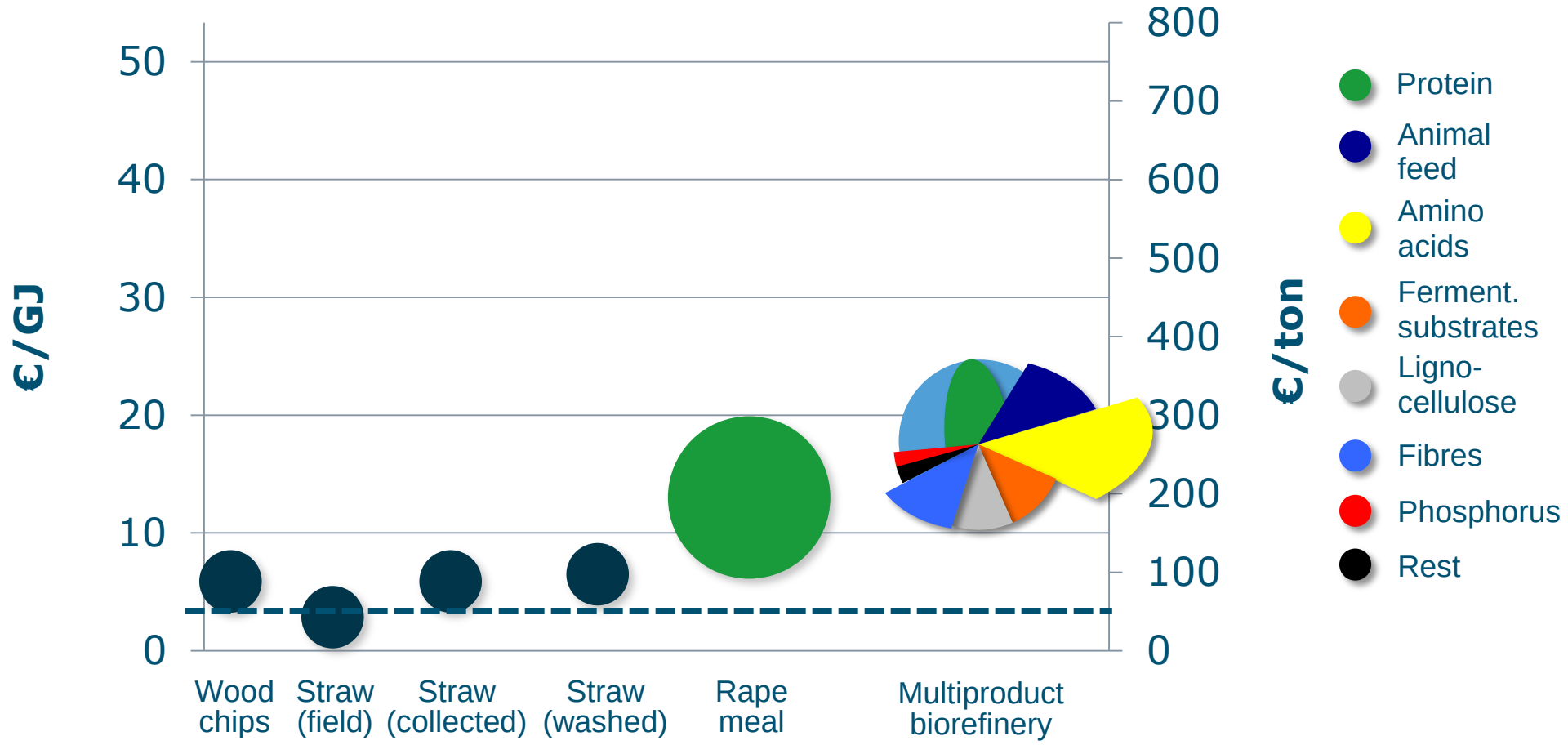
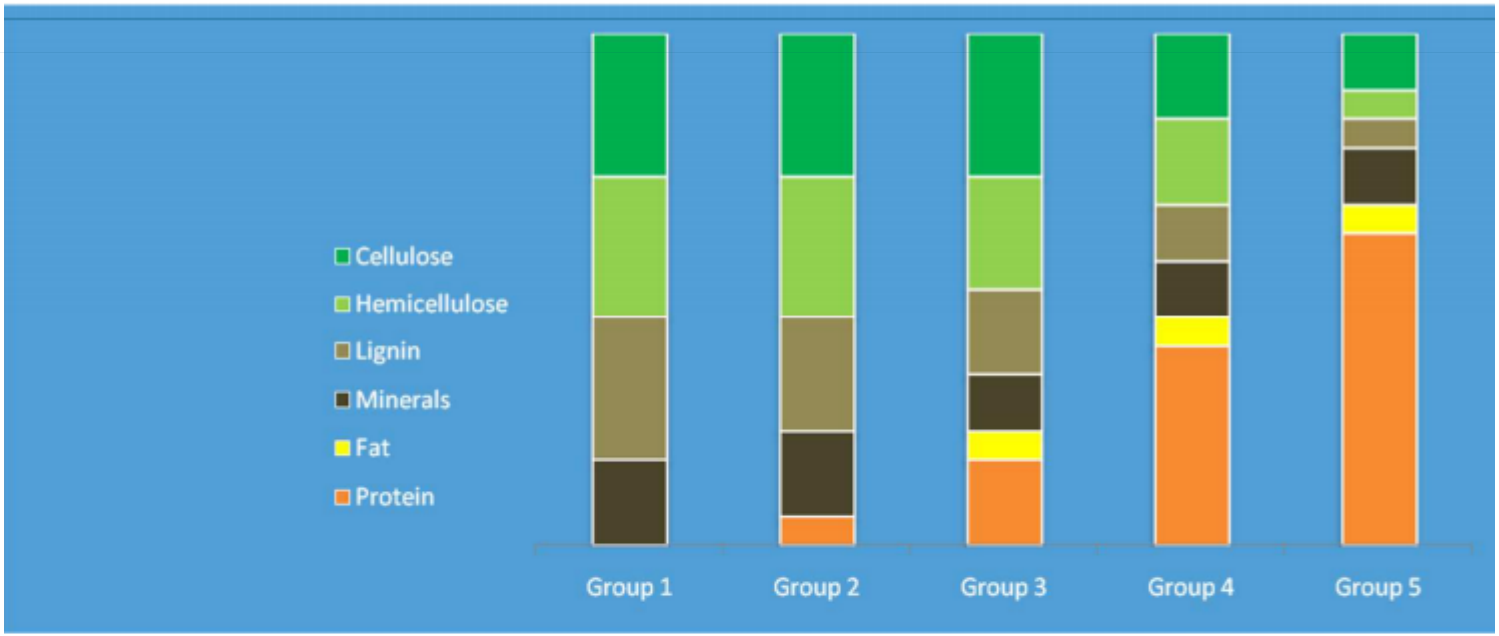
Biorefinery enables power generation at 45€/ton and high quality 2nd generation fermentation raw materials for 200€/ ton



Green Biorefinery



Protein content	0	5 %	15 %	35 %	50 %
Examples	Wheatsstraw	cocoahulls Corncobs Sugarcane leaf	Coffee pulp Rape straw Beet leaf	Rape meal	Soy meal
Cost (€/ton)	50-80	50-110	100-140	150-180	300-350

Teekens et al. (in preparation)

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Grass: few products or many ?

			€ / ton				€ / ton
Grass	100%	60	**60**	fibre	30%	100	**30**
				protein	15%	800	**120**
				juice	55%	100	**55**
Total value			**€ 60**				**€ 205**

Grass Biorefinery

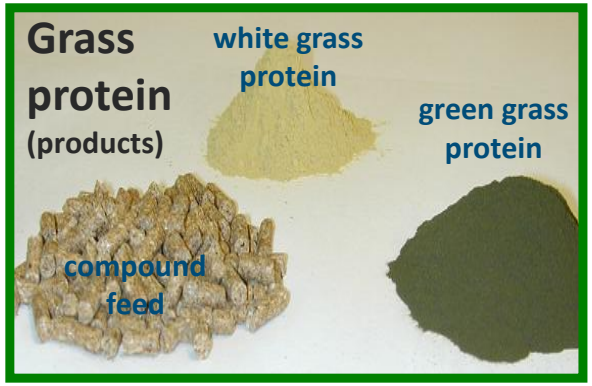
CULTURE → CUTTING → TRANSPORT → PRESERVATION → STORAGE

patent pending

REFINING → SEPARATION

JUICE FRACTION ← SEPARATION → FIBER FRACTION

PROTEIN RECOVERY → EVAPORATION → Grass juice concentrate → DOWN STREAM PROCESSING ⋯▶ 2°-generation products



DRYING → FRACTIONATION

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Grass Biorefinery

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Mobile pilot GRASSA! Oenkerk (2011)

Grass: few products or many ?

			€ / ton				€ / ton
Fiber	30%	100	**30**				**30**
Protein	15%	800	**120**	Rubisco	5%	8000	**400**
				Protein	10%	800	**80**
Oligo/ monosaccharide	12%	100	**12**	Fos	3%	3000	**90**
				Saccharide	9%	100	**9**
Minerals	10%	500 - 1000	**75**				**75**
Aminoacids	5%	1500	**75**	Arg	0.25%	7000	**17**
				Phe	0.25%	8000	**20**
				Trp	0.25%	30000	**75**
				Thr	0.25%	4000	**10**
				Aa's	4%	1500	**60**
Polysaccharide	15%	1500	**225**				**225**
Lipids	3%	2000	**60**				**60**
Organic acids	6%	1000	**60**	Fumaric	1%	4000	**40**
				Malic	1%	3000	**30**
				Citric	2%	1000	**20**
				O.A.	3%	1000	**30**
Total value			**€ 657**				**€ 1271**

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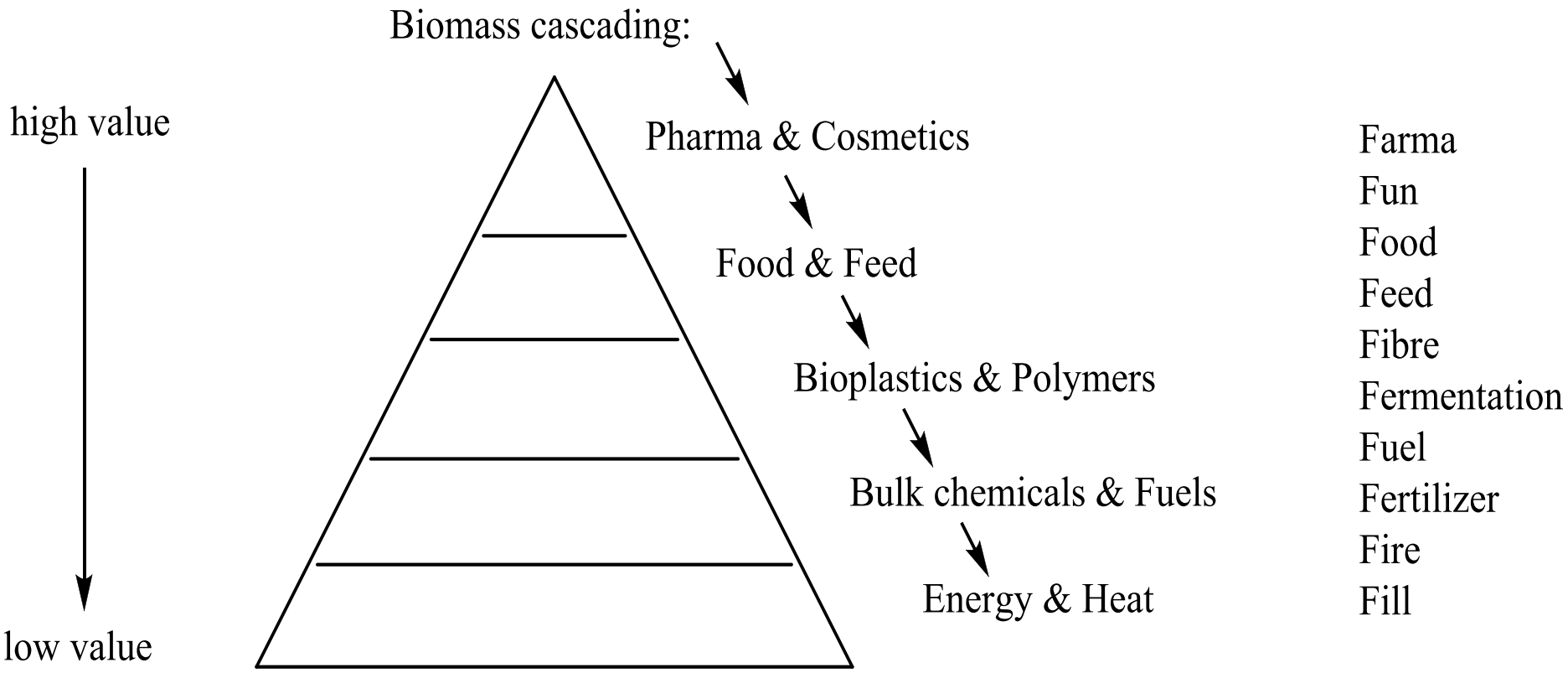
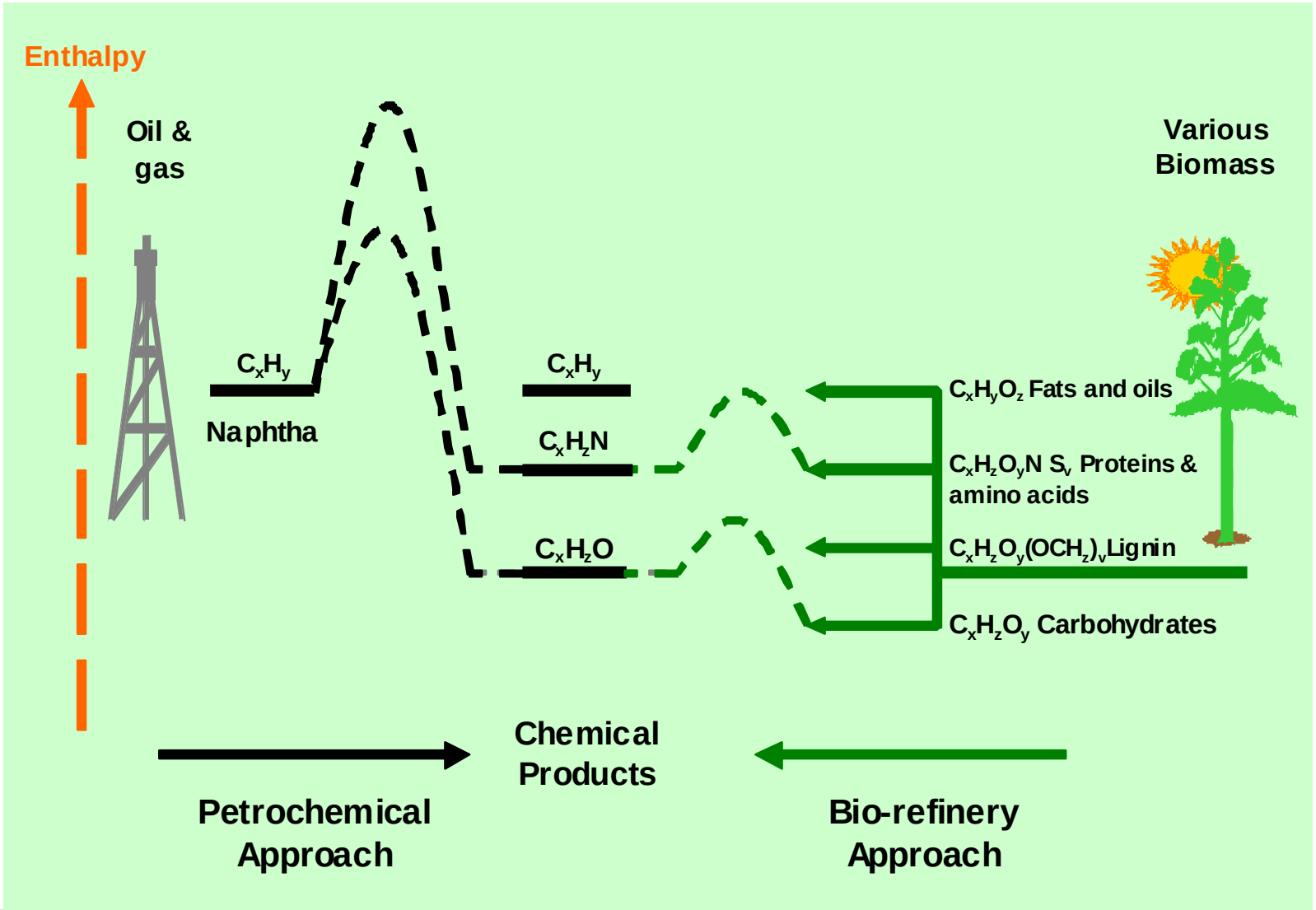
Eco-pyramid for biomass utilization



Molecular structure is better than caloric value



Protein recovery from biomass

Biorefinery is not just producing biofuels

For economic feasibility

protein recovery and use

is an essential part of

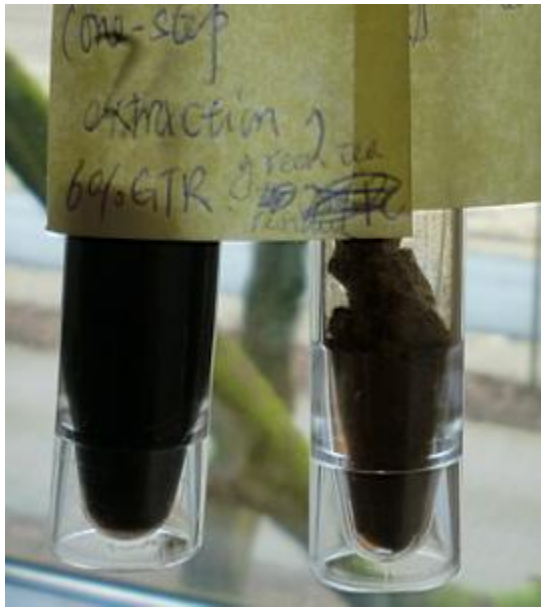
the overall biorefinery

- Research
  - Several biomass sources, preferably “waste”
  - Protein hydrolysis to amino acids
  - Selective recovery through e.g. crystallization or electrodialysis
  - Always in a bigger picture: with the other components

Protein from Tea residue

- Also other components
- General mechanisms for leaves

One-step extraction for LP



Extract **Powder (freezing dry)**

Multiple-extraction for multiple products:

Raw material

Pigment **Polyphenol**

Pectin **Protein**

Final residue

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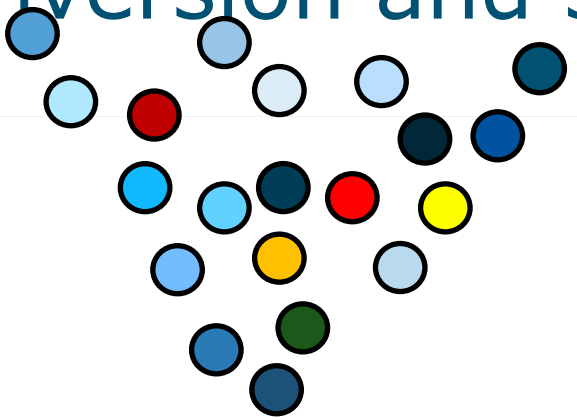
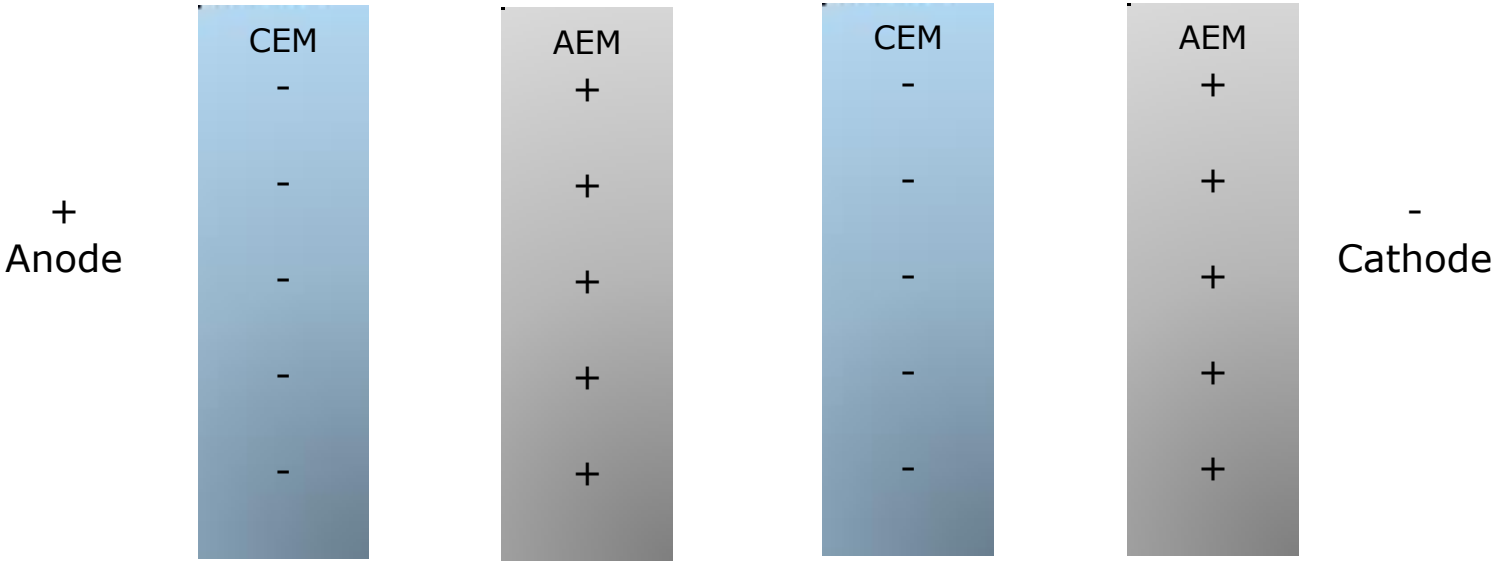
Integrated conversion and separation





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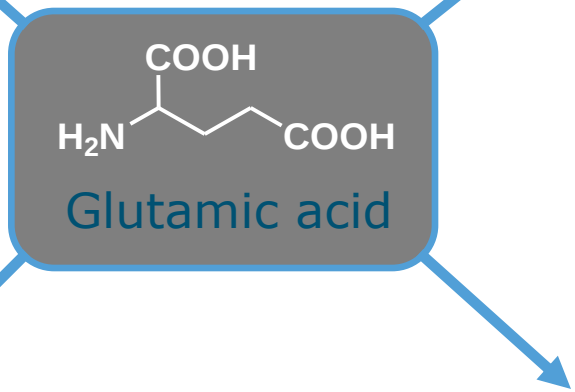
Use of plant molecular structures

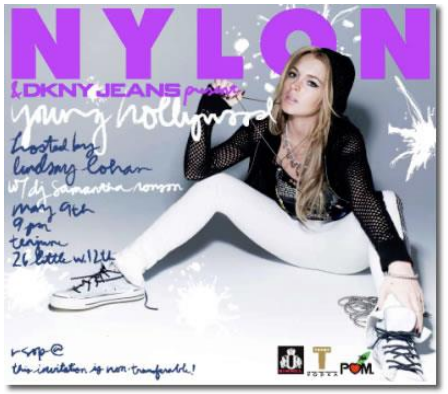
N-Vinylpyrrolidone

Acrylonitrile



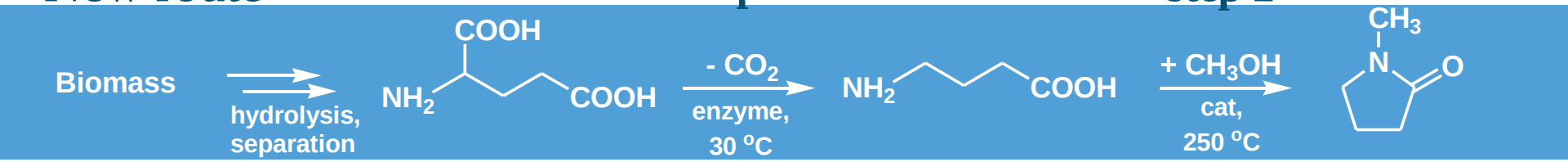
N-Methylpyrrolidone

Diaminobutane



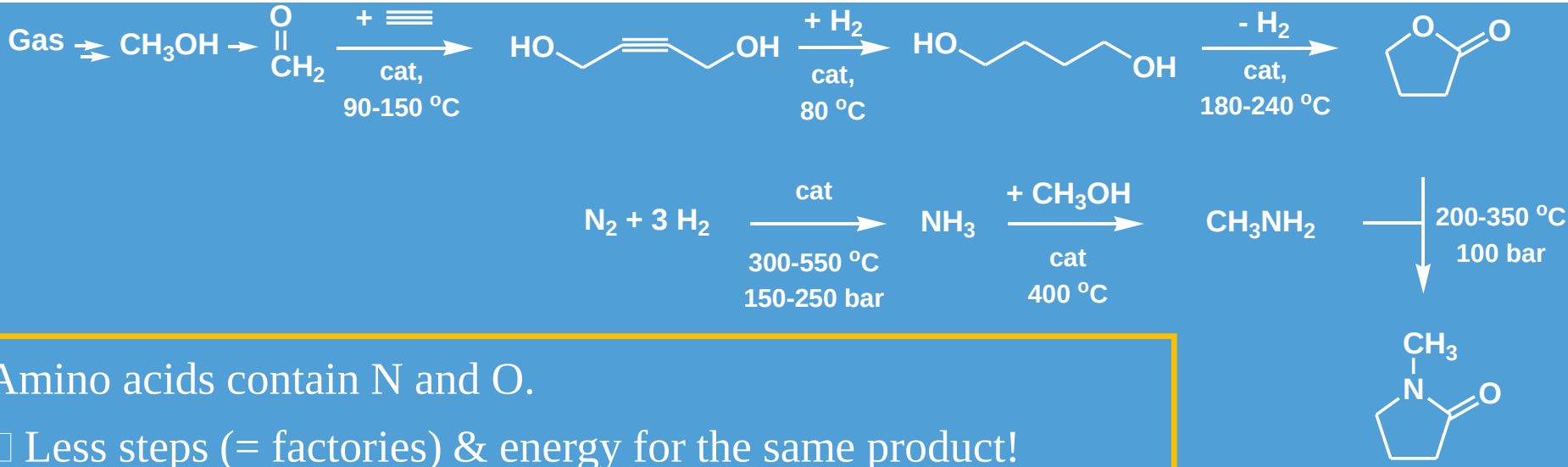
The route to NMP, new vs conventional

New route



Glutamic acid *NMP*

Conventional route



Amino acids contain N and O.

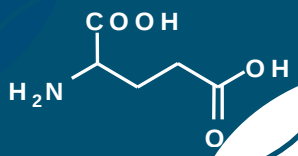
- Less steps (= factories) & energy for the same product!

Biobased NMP, makes an ethanol plant profitable

500 Million liters bioethanol

(~ 400 kton) =200M€

360 kton DDGS (~130 € / ton) =46M€



23 kton NMP

(~2500 € / ton)

=58 M€/y

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Do not transport what you do not need

Small scale biorefinery

Solving the problem of low functional density of biomass

- Advantages
  - Lower transportation costs
  - Water and minerals stay on site
  - Less waste treatment on (central) factory
  - Increased storage times
  - More income to farmers
  - Faster innovations
- Disadvantage
  - Economy of scale

Starch from Cassava in Nigeria

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Design rules for scaling in biorefinery

Advantages of small scale without the disadvantages

- Splitting the process in two parts
- Low investment cost
- Minimize heat exchange
- Energy use and the combination with biogas and CHP
- Developments start bottom-up

Bruins & Sanders (2012) BioFPR 6(2):135-145

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