Low capital intensive biomass processing leads to increased employment

Produktion der Zukunft – Stakeholderdialog Biobased Industry, Witschaftszimmer Wien,

Johan Sanders, Em professor Biobased Commodity Chemicals, Innovation Manager Food and Biobased Research, Wageningen UR

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Biomass use today and in 2050 world wide

	Mton
Food incl. feed*	4 – 5000
Wood, paper, cotton	2000
Wood for cooking	4000
30% of 1000EJ in 2050=	20 000
All bulkchemicals in 2050	2 000

* Excluding grass and seafood

Design rules for a sustainable Bio-economy

People, Planet, Profit

- Improve efficiency of use of raw materials and energy
- Increase field yield but *keep components on the field that are required for soil fertility*
- Use all biomass components and *choose the right raw material*
- Use each component at its highest value:

  (molecular) structure is much better than caloric
- Reduce capital cost to speed up innovation and *to benefit from small scale without the disadvantages*

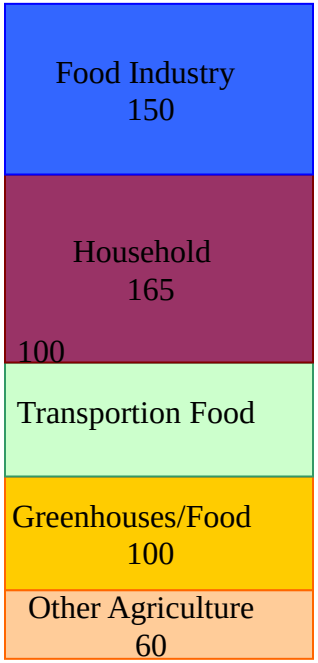
Our daily food needs a twenty fold higher energy input

Biomass
NL 635 PJ
EU 20.000 PJ

EU 1.800 PJ

2500 kcal/day = 55 PJ

Fossil
NL 575 PJ
EU 20.000 PJ



Total energy NL fossil 3.300 PJ
EU fossil 85.000 PJ

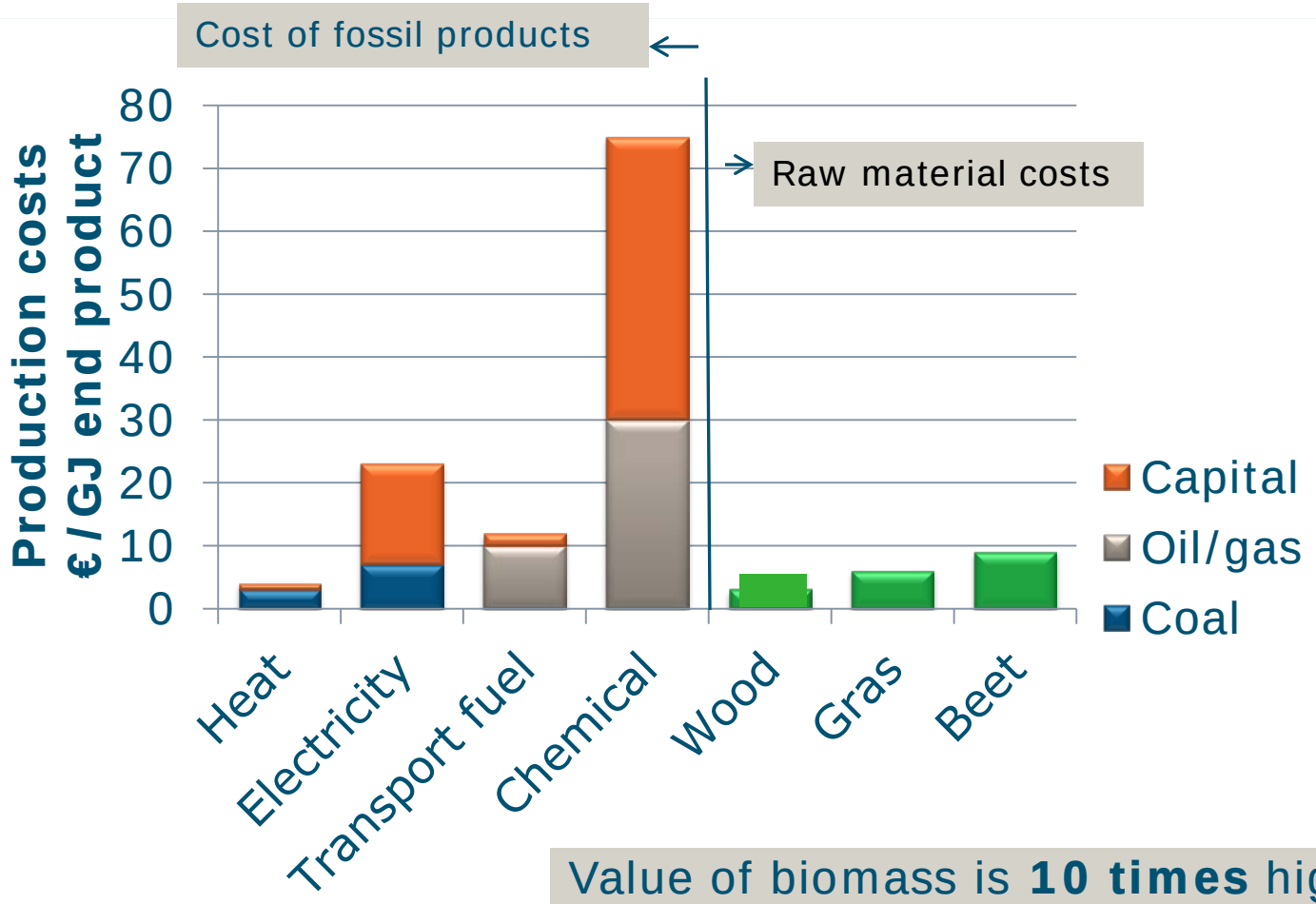
WAGENINGEN UNIVERSITY
WAGENINGEN UR

F - ladder

How to get the best value from biomass?

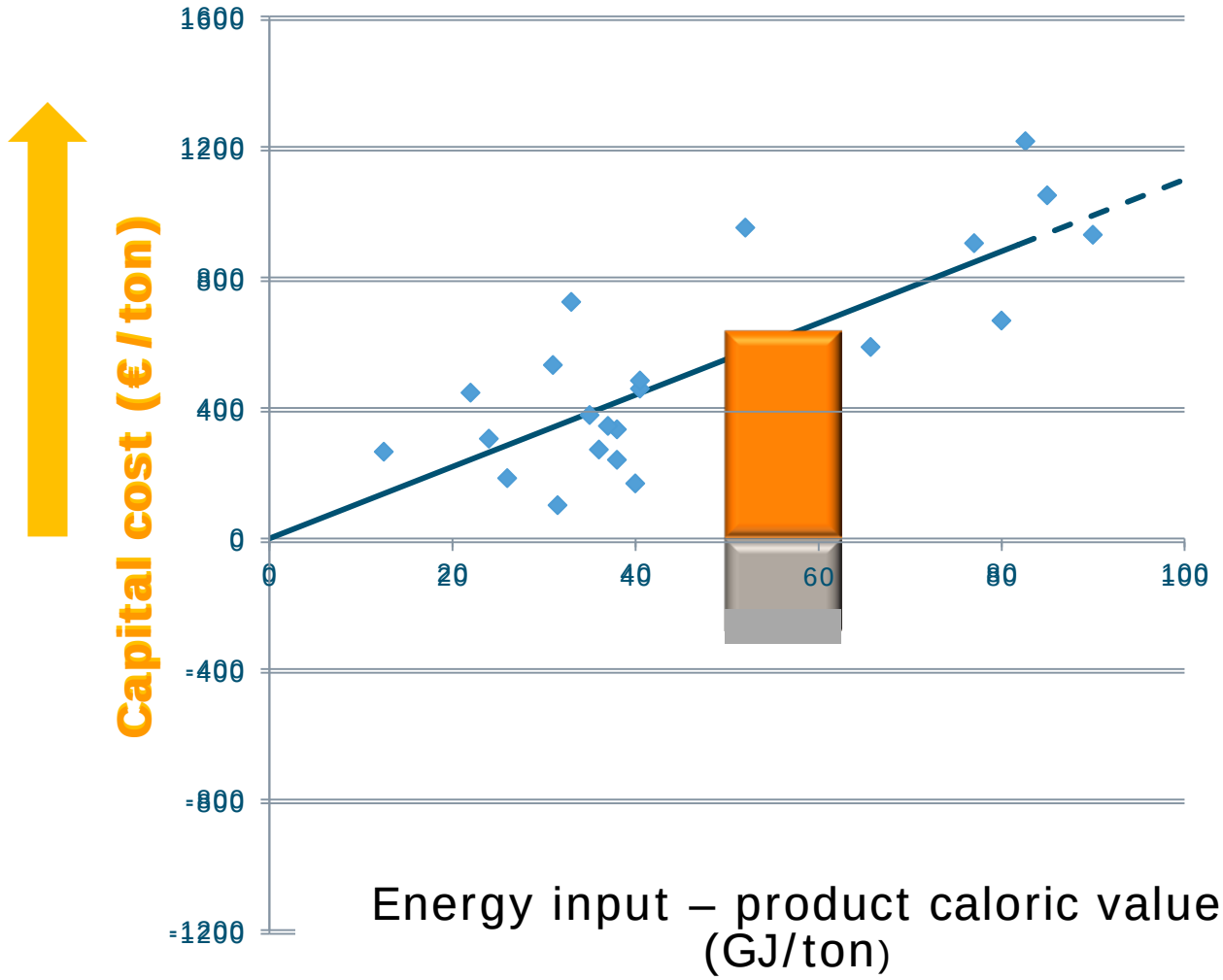
	€ / ton
Farma	High
Fun	High
Food ingredients	5 - 20000
Food nutritional	100-500
Feed/ Food **nutritional protein**	600-1000
Feed pigs	100-300
Feed cattle	50-250
Functional chemical	500-800
Fibre	500
Fermentation	150-400
Fermentation bulk	100-300
Fuel	100-300
Fertilizer	-/- 200-100
Fire	50-150
Flare	0
Fill	-/- 300

How biomass can best compete with fossil feedstocks



Value of biomass is **10 times** higher as chemical building block than to use it for biogas or bio-electricity

Capital costs per ton of bulkchemical product vs heat dissipation



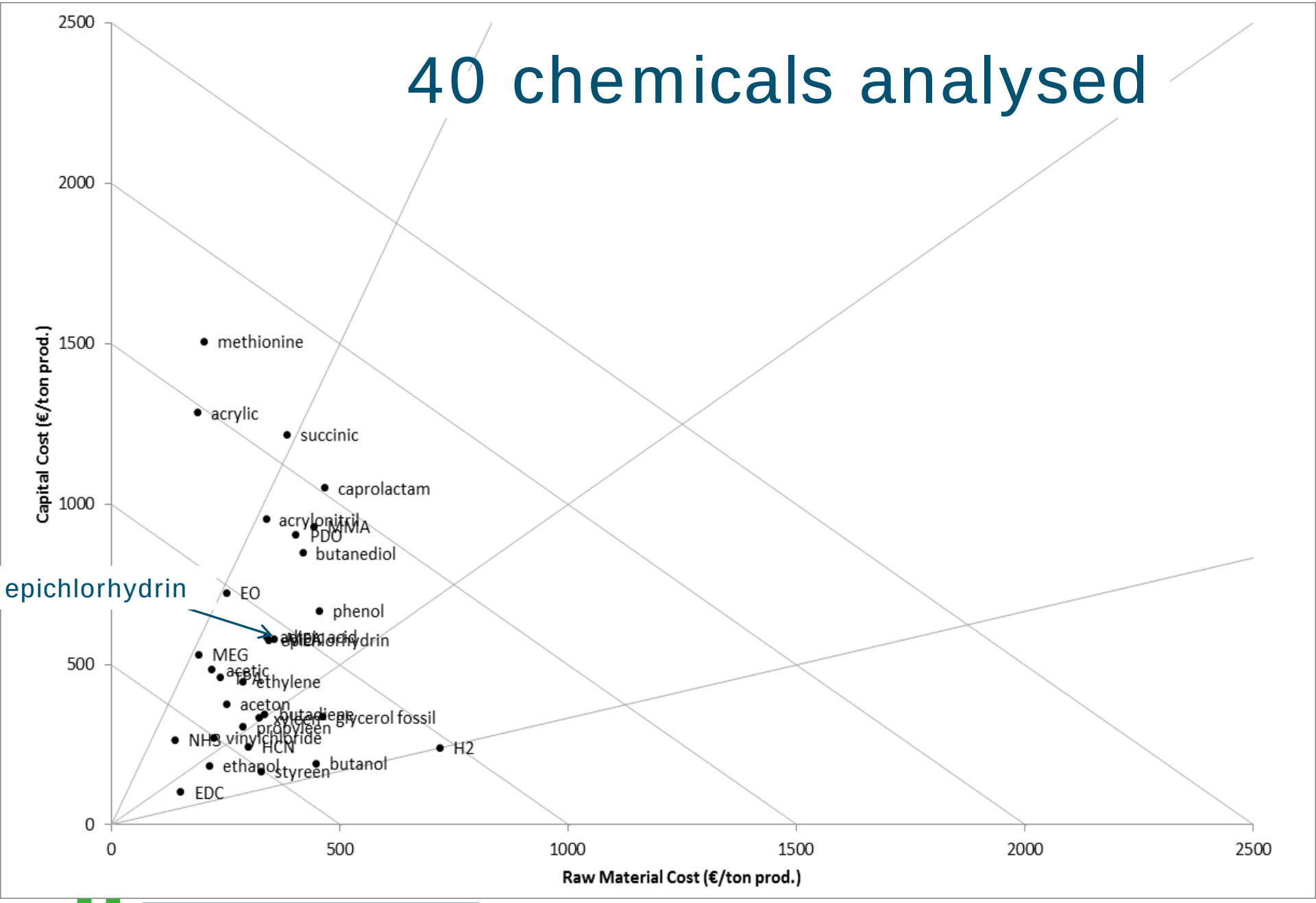
heat-exchange leads to high capital cost

- In the (petrochemical) industry this leads to Economies of scale as the major competitive factor
- Reducing capital cost for heat exchange will however offer :

1. more economic room for raw material costs and cost of labour
2. More opportunities to operate on smaller scales *even for (bulk) chemical products!*

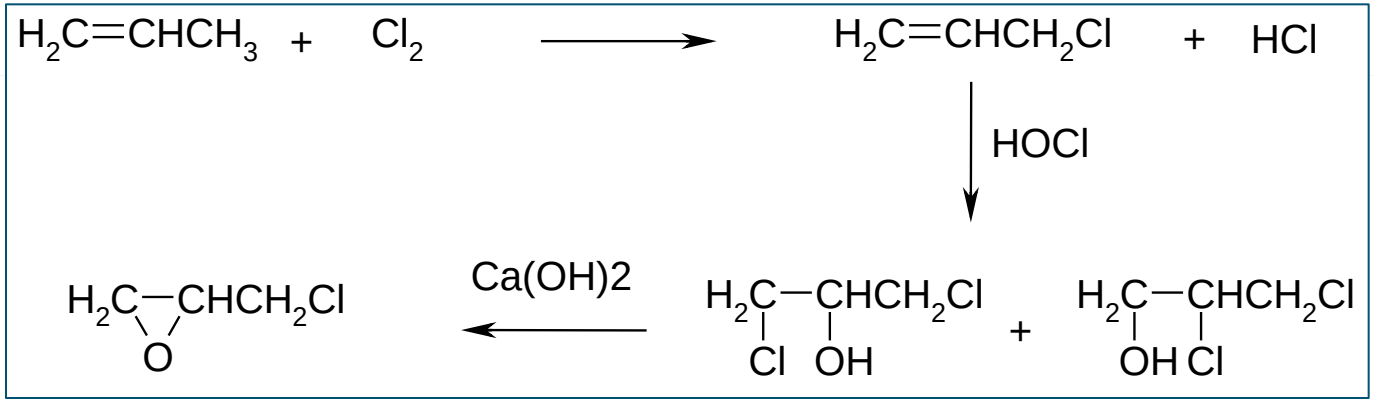
- Safe chemical production at lower cost
- Less dependent on infrastructure of large chemical sites

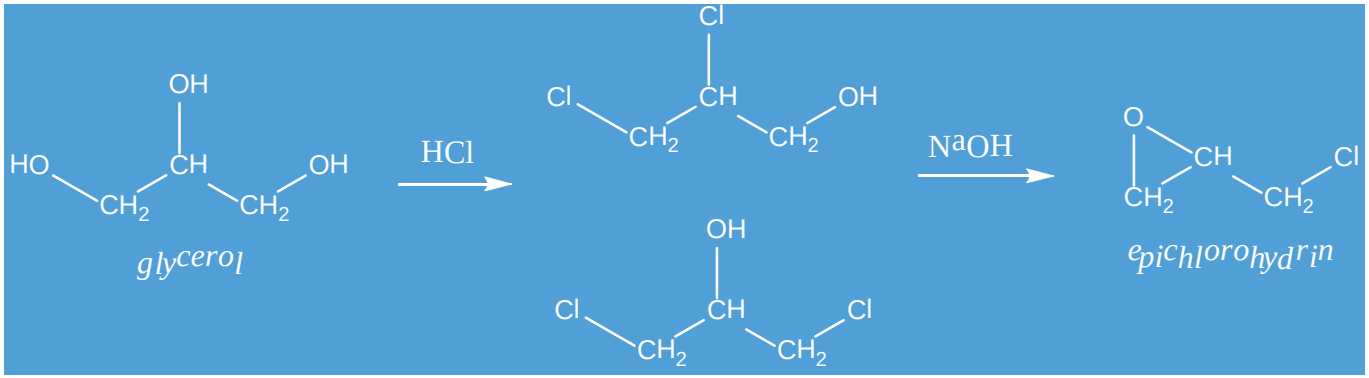
40 chemicals analysed



epichlorhydrin

Epichlorohydrin from glycerol leads to *little heat exchange and valuable product*





- Solvay 'Epicerol' process: glycerol to epichlorohydrin

- Price:

  € 1300 - 1500 per tonne

- Volume:

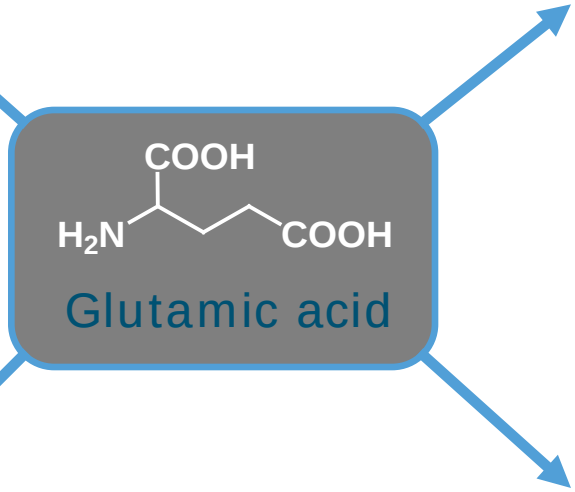
  0.5 mln tonnes per annum

At glycerol prices of 350€/ ton the margins are 40- 50%

Use of plant molecular structures leads to *little heat exchange and valuable product*

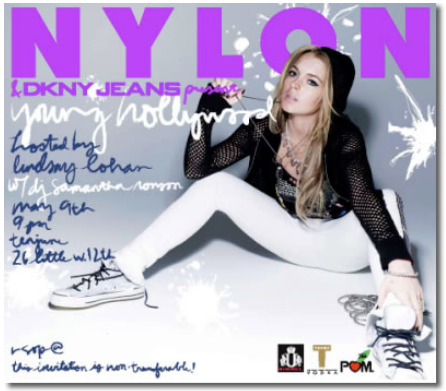
N-Vinylpyrrolidone

Acrylonitrile



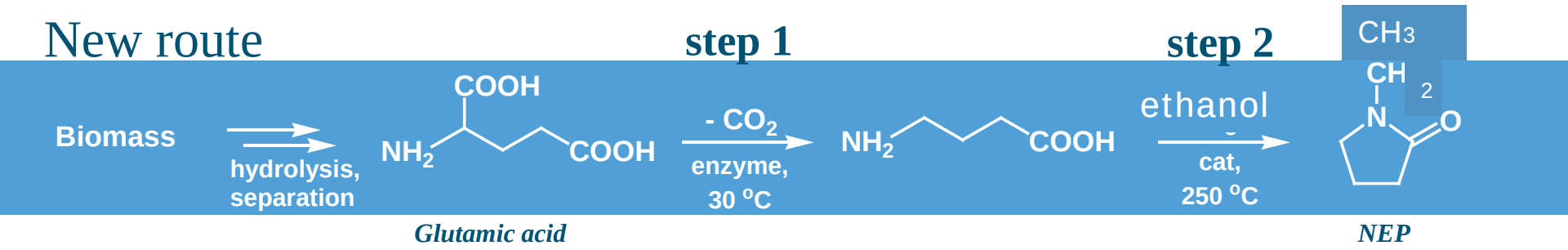
N-Methylpyrrolidone

Diaminobutane



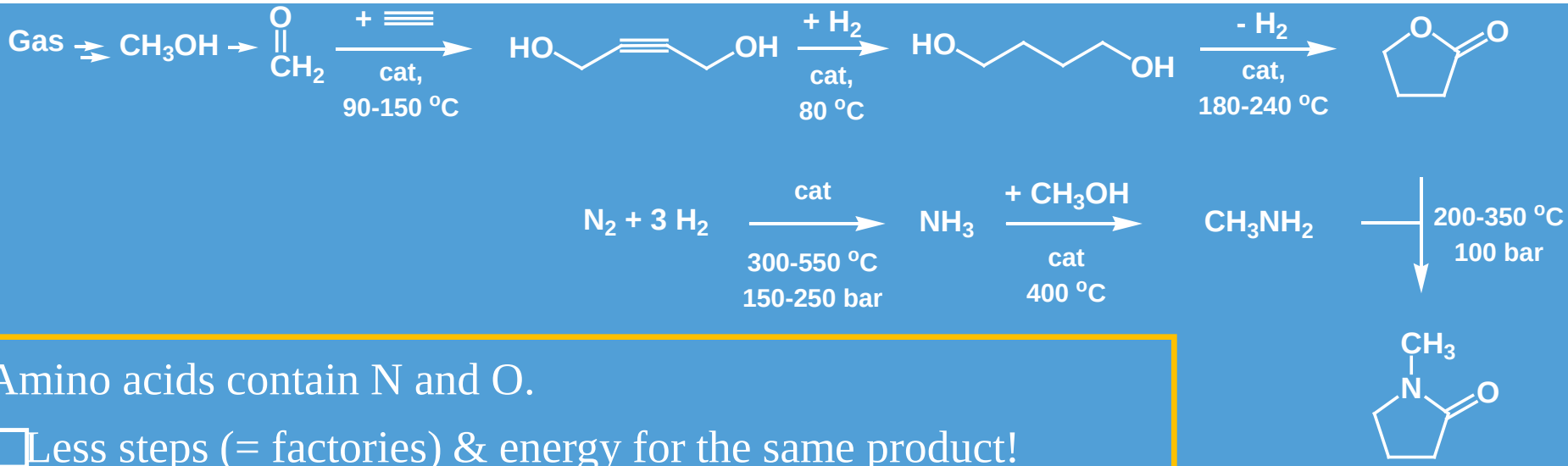
The route to NEP, new vs conventional NMP

New route



Glutamic acid *NEP*

Conventional route



Amino acids contain N and O.

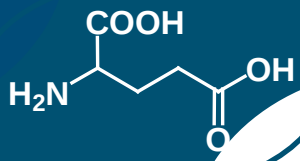
☐Less steps (= factories) & energy for the same product!

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

Second generation ethanol costs a lot of capital and energy and will not give much value! **False hope?**

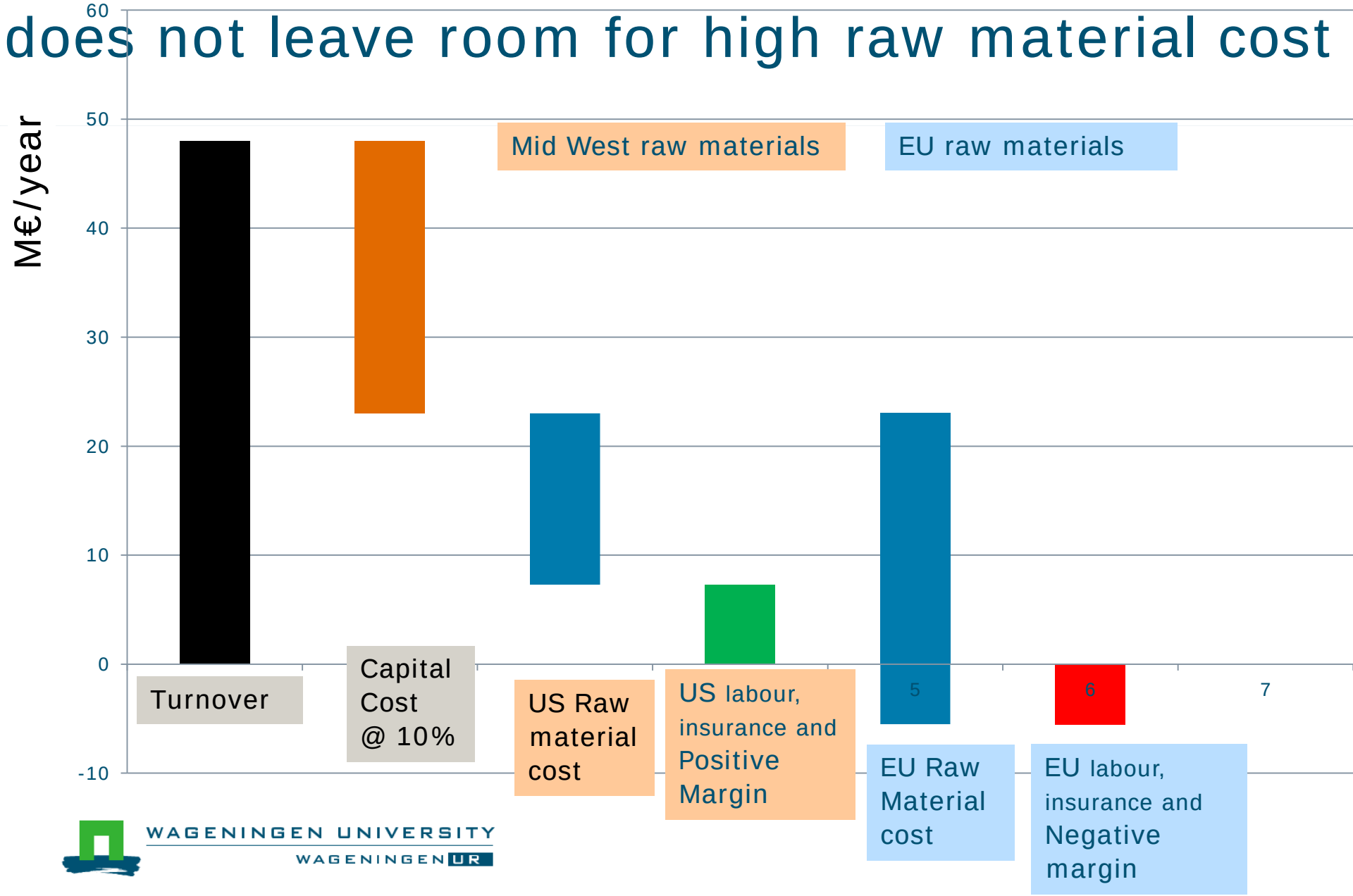
Wheat straw

pretreated

and Enzymatic treatment

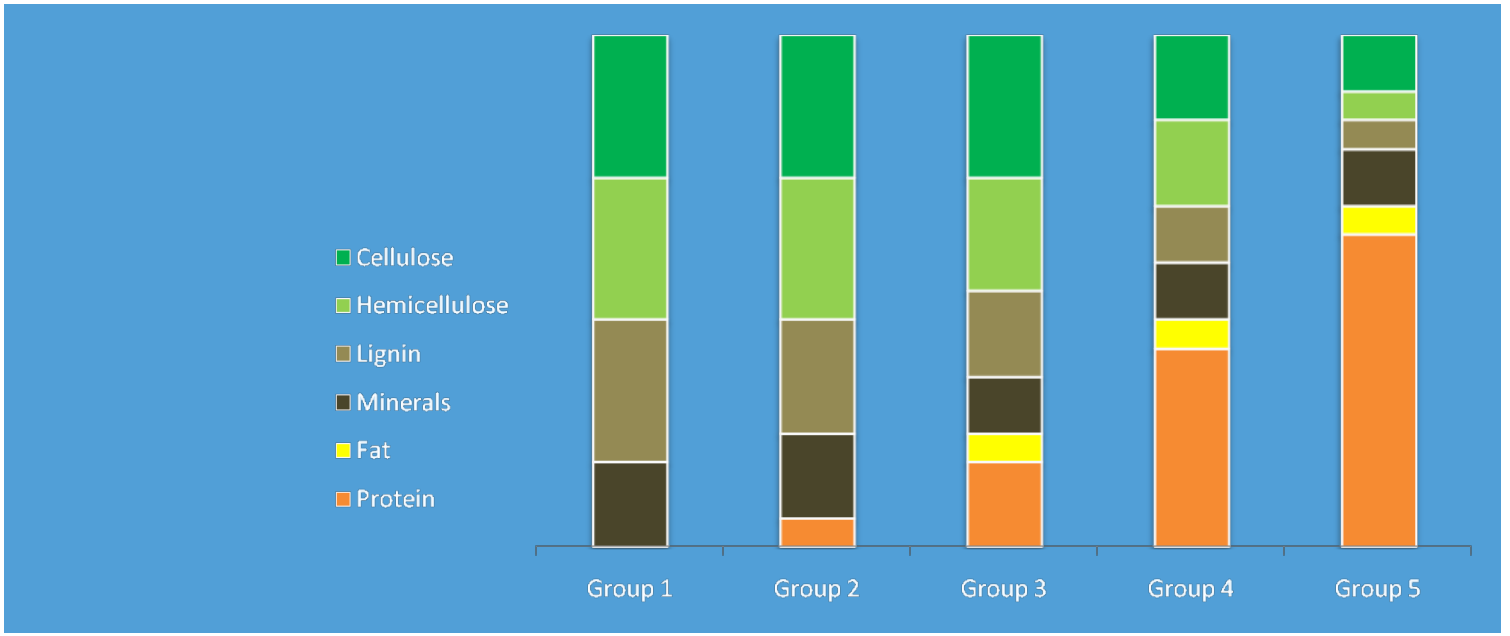
WAGENINGEN UNIVERSITY
WAGENINGEN UR

Heat exchange requires high capital cost and does not leave room for high raw material cost



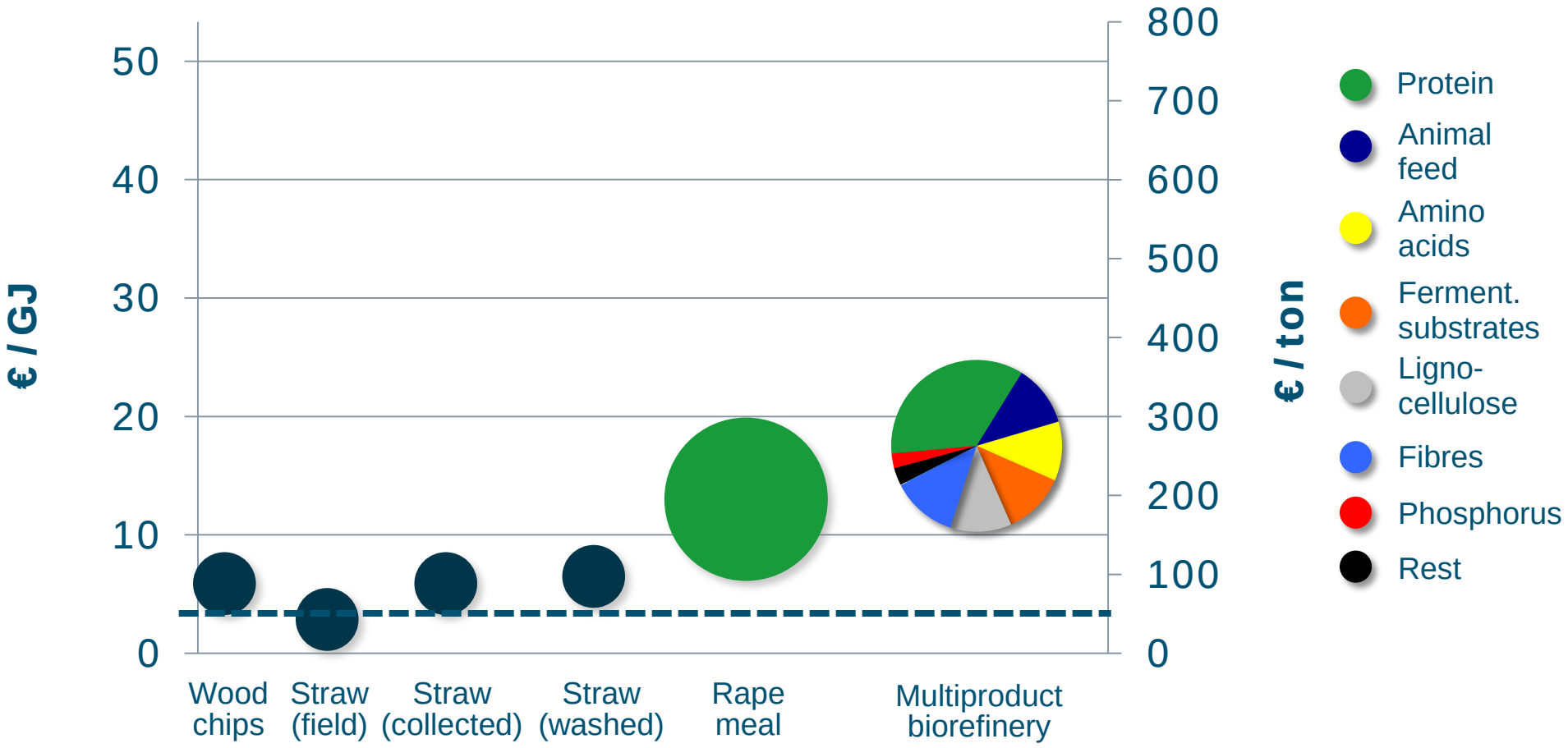
WAGENINGEN UNIVERSITY
WAGENINGEN UR

Biorefining of agricultural residues ..



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

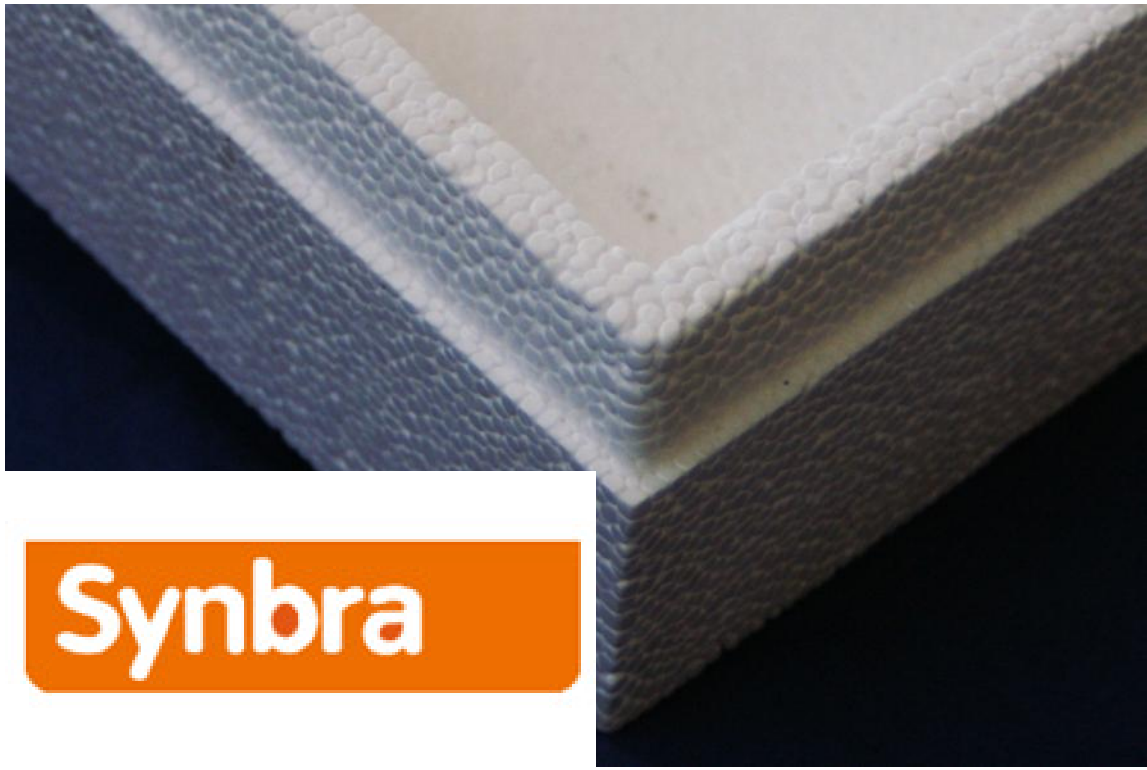
Biorefinery enables power generation at 45€/ton and high quality 2nd generation fermentation raw materials for 200€/ ton ***at small scale***

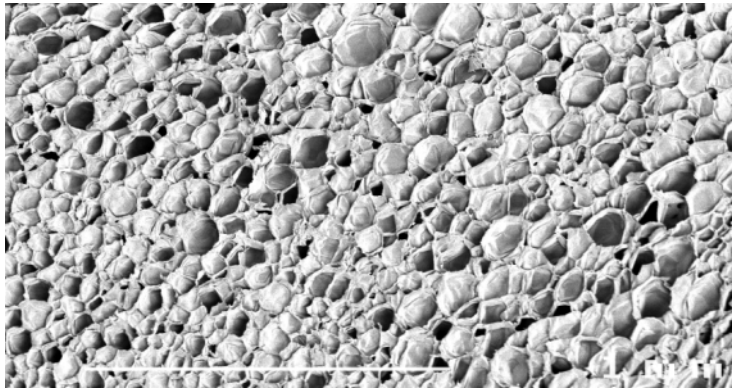


WAGENINGEN UNIVERSITY
WAGENINGEN UR

3D-foamed polylactic structures (Wageningen UR)

- Expandable bead technique
  - Good cell structure
  - Density <30 g/l





Synbra

Sheet: Karin Molenveld

Anaerobic fermentation of bulkchemicals

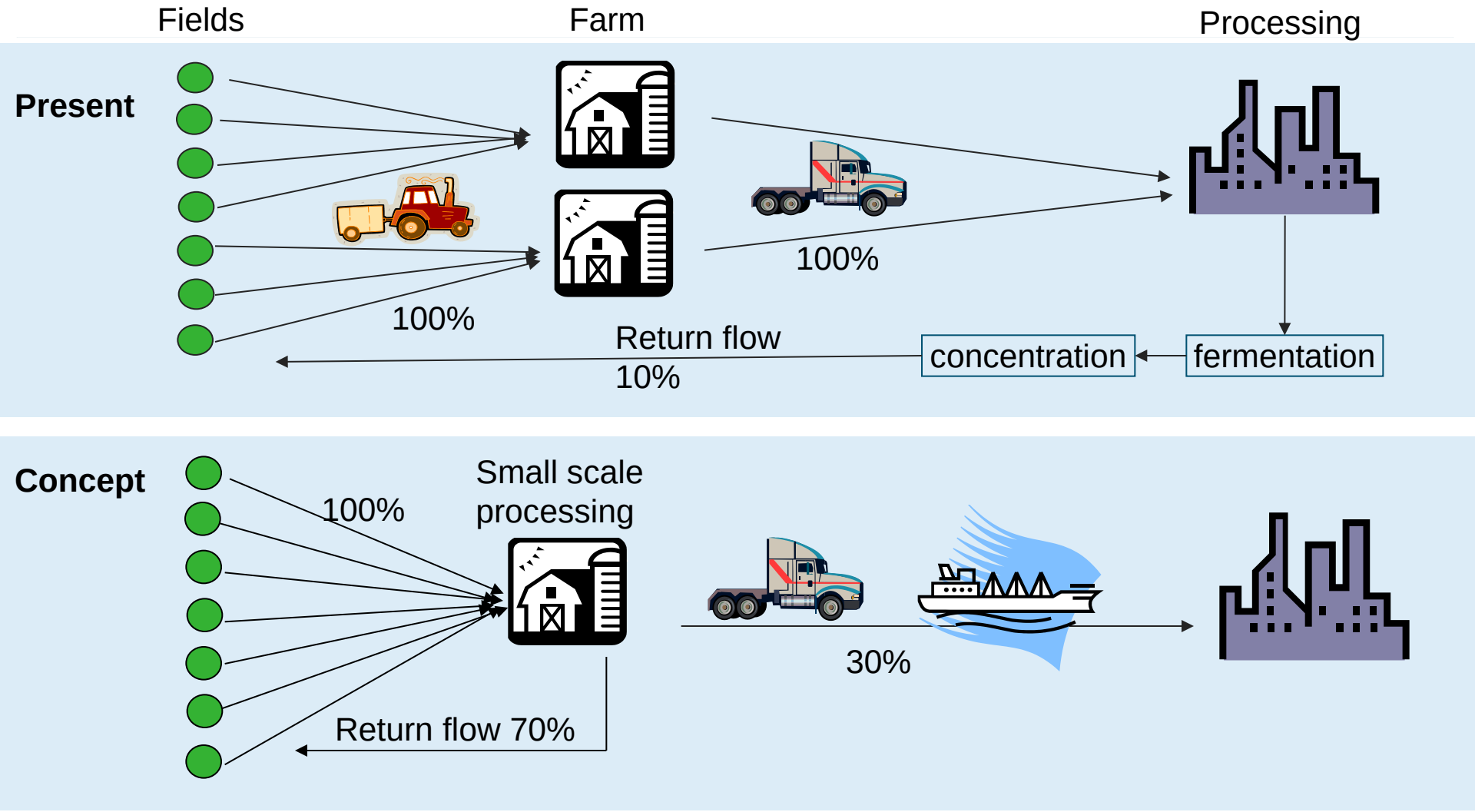
Yield: 0.95 g/g or J/J

Productivity: up to 5 times higher →

lower capital requirements

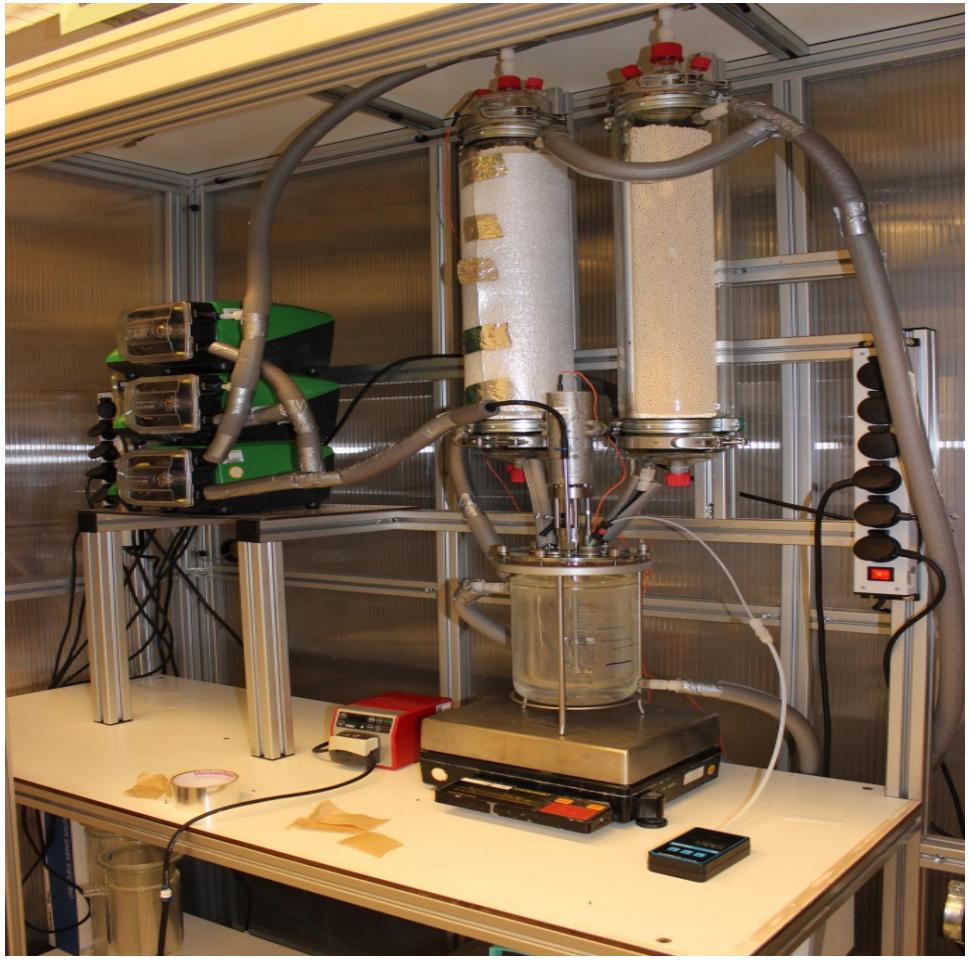
4 projects running

Small scale biorefinery reduces transport cost and seasonality

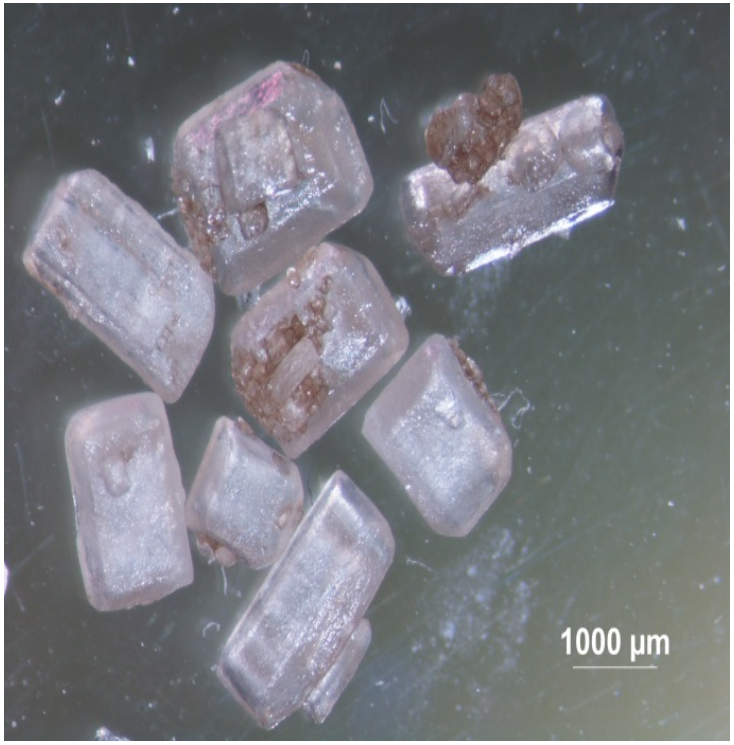


small scale beet sugar production(2-500ha)

can beet large scale factories !



Less energy
Less transport
Minerals recycled to field



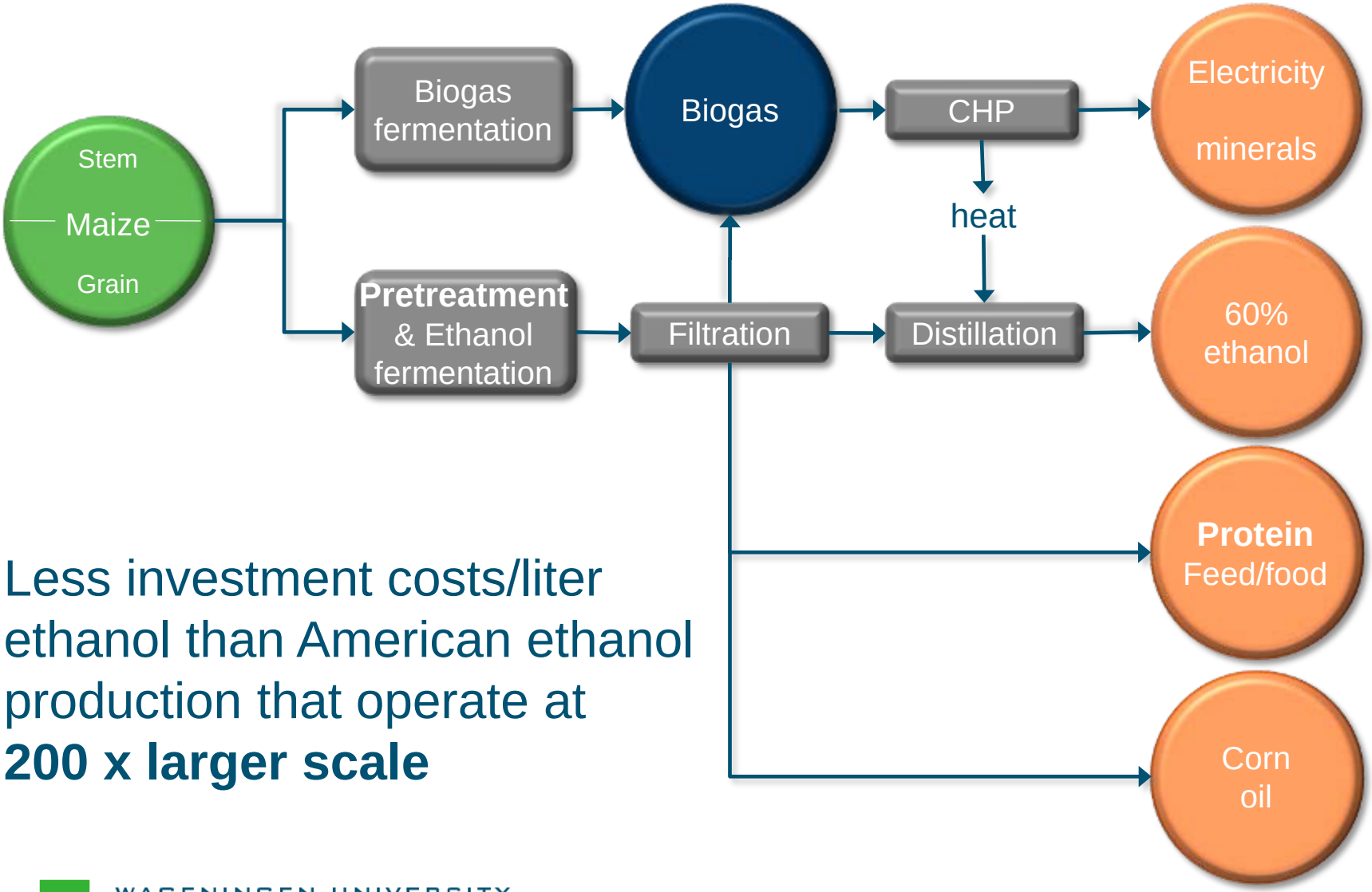
WAGENINGEN UNIVERSITY
WAGENINGEN UR

Kolfschoten et al

Small scale biorefinery

- Lower costs for transportation towards factory **and back!**
- Year around for the precious unit operations
- Water and minerals stay on site
- Less waste treatment on factory
- More income to farmers
- Gradual development of market as well as sourcing raw materials

protein/oil/ethanol/biogas from small scale corn-biorefinery



Less investment costs/liter ethanol than American ethanol production that operate at **200 x larger scale**

Byosis/Zeafuels (Lelystad, Netherlands)






3 generations Grassa!refining

1st Generation (2011)
(Friesland)

2nd Generation (2015)
(Uganda)

3rd Generation (2016)
(Netherlands)

WAGENINGEN UNIVERSITY
WAGENINGEN UR

www.grassa.nl

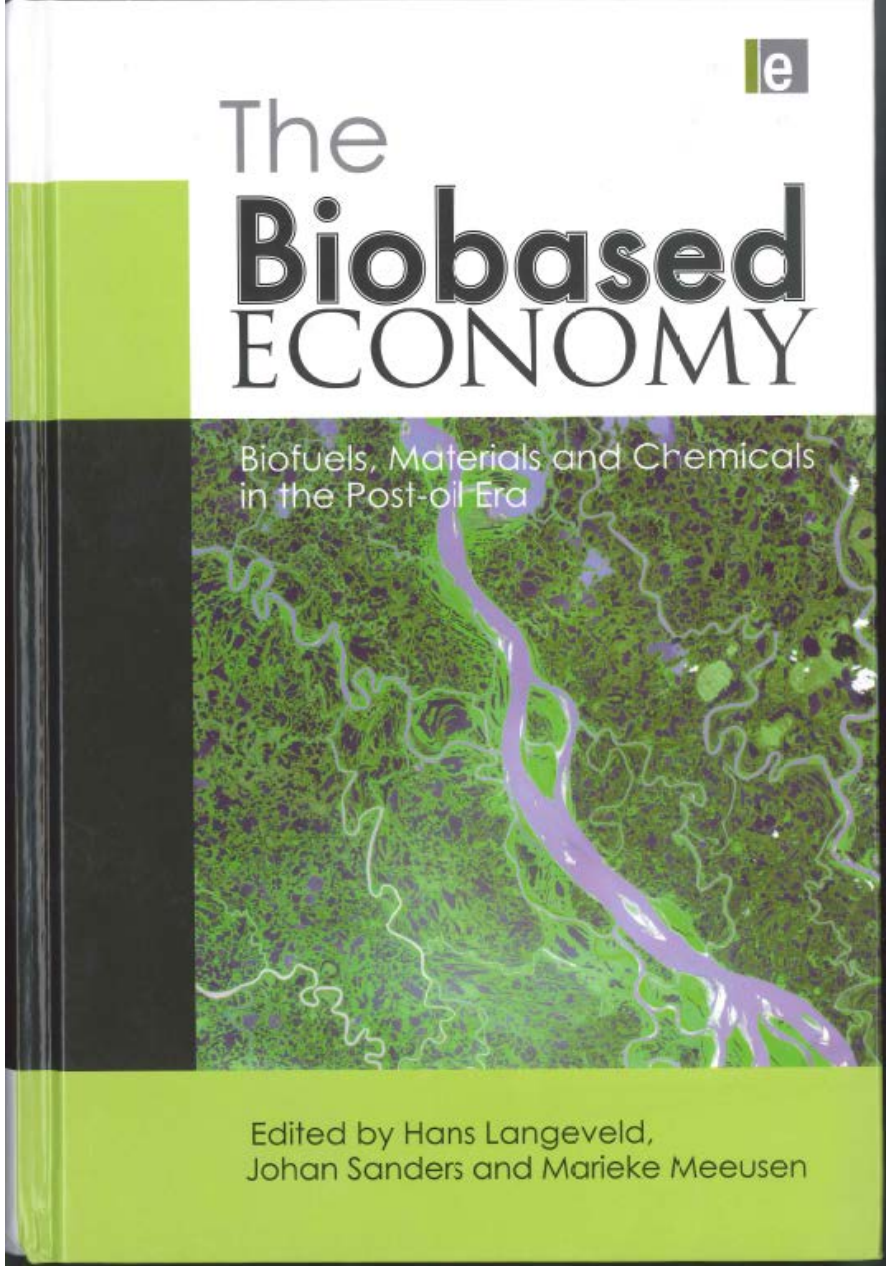
Grassa DEMO draait sinds
november 2016

Just protein is not sufficient to cover the costs

bioraffinery	3 products		8 products	
	income	costs	income	costs
Grass costs		60		60
Process costs		120		440
protein	120		120	
fibers	30		30	
Juice components	55			
minerals			75	
Organ. acids			60	
Amino acids			75	
sugars			12	
FOS			225	
Vitamines A, E			50	
Unsat fatty acids			60	
totaal	**205**	**180**	**707**	**500**

Conclusions

- Biorefinery for feed, materials and chemicals will create good income for agriculture and enables even to compete with coal, natural gas and Brazilian biomass!
- Avoiding heat exchange and small scale processing reduces capital as well as costs for energy and transportation and
- will lead to higher employment



WAGENINGEN UNIVERSITY
WAGENINGEN UR

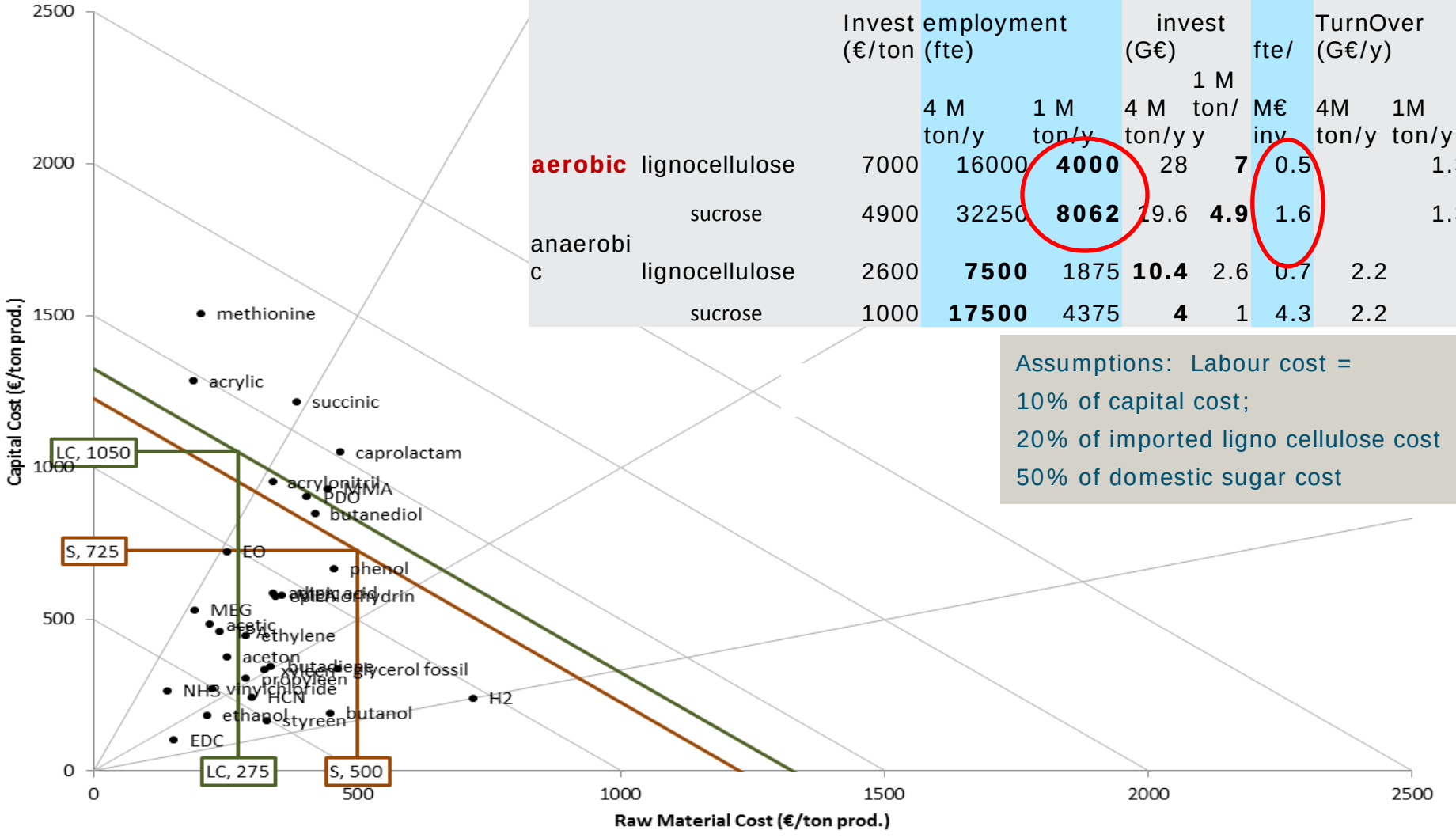
Earthscan, ISBN 978-1-84407-770-0

Aerobic Sugar processes → 1250€/ tonne

LC processes→ 1350€/ton

		Invest (€/ton	employment (fte)		invest (G€)		fte/	TurnOver (G€/y)	
			4 M ton/y	1 M ton/y	4 M ton/y	1 M ton/y	M€ inv	4M ton/y	1M ton/y
aerobic	lignocellulose	7000	16000	**4000**	28	**7**	0.5		1.3
	sucrose	4900	32250	**8062**	19.6	**4.9**	1.6		1.3
anaerobic	lignocellulose	2600	**7500**	1875	**10.4**	2.6	0.7	2.2	
	sucrose	1000	**17500**	4375	**4**	1	4.3	2.2	

Assumptions: Labour cost =
10% of capital cost;
20% of imported ligno cellulose cost
50% of domestic sugar cost



WAGENINGEN UR

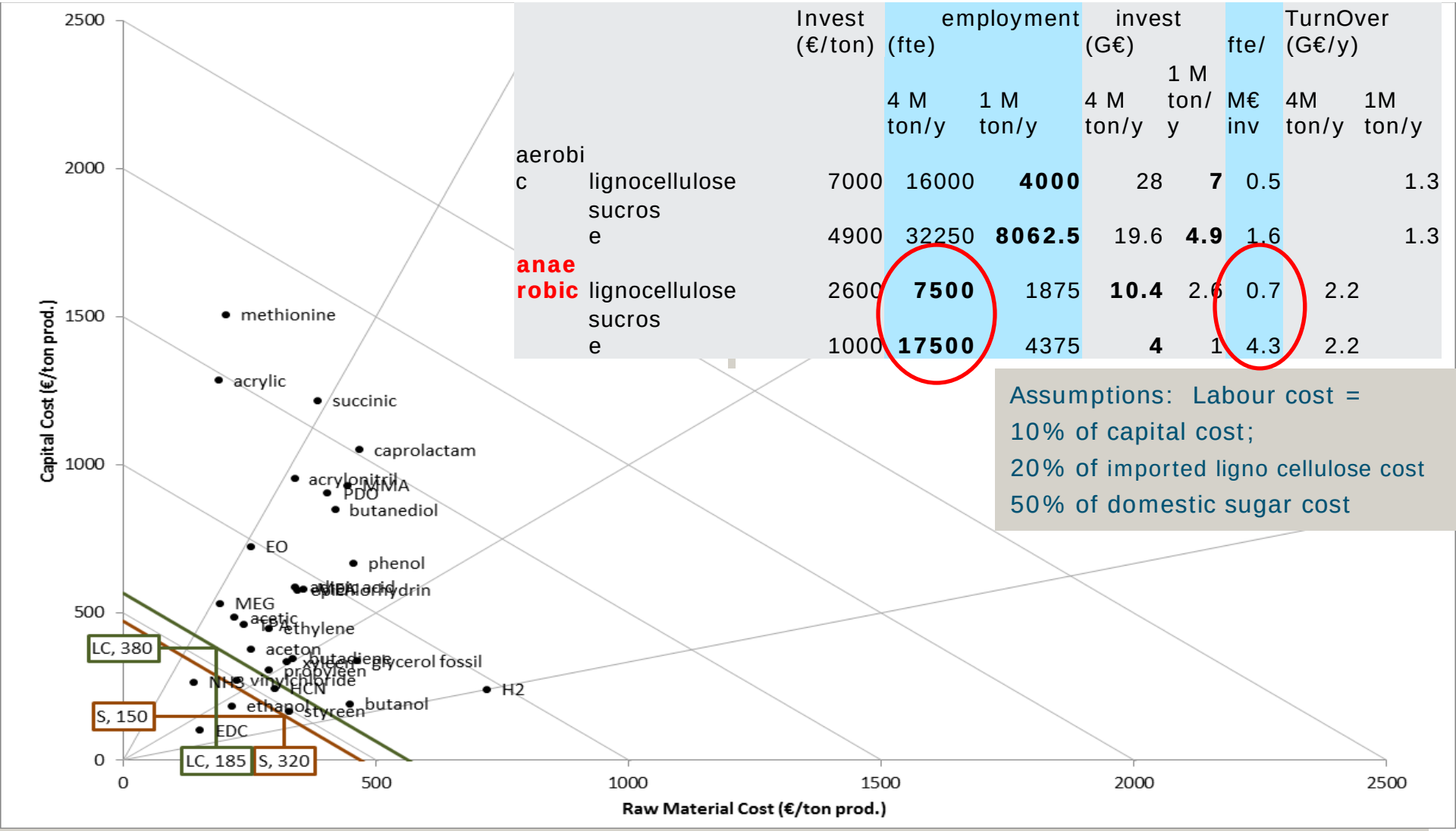
http://www.biobasedeconomy.nl/wp-content/uploads/2011/08/Can-production-of-bulk-chemicals-on-a-small-scale-be-competative-formated-20131126FINAL.pdf

Anaerobic sugar processes →500€/ tonne

LC based processes → 550€/ tonne

		Invest (€/ton)	employment (fte)		invest (G€)		fte/	TurnOver (G€/y)	
			4 M ton/y	1 M ton/y	4 M ton/y	1 M ton/y	M€ inv	4M ton/y	1M ton/y
aerobic	lignocellulose	7000	16000	**4000**	28	**7**	0.5		1.3
	sucrose	4900	32250	**8062.5**	19.6	**4.9**	1.6		1.3
anaerobic	lignocellulose	2600	**7500**	1875	**10.4**	2.6	0.7	2.2	
	sucrose	1000	**17500**	4375	**4**	1	4.3	2.2	

Assumptions: Labour cost =
10% of capital cost;
20% of imported ligno cellulose cost
50% of domestic sugar cost



http://www.biobasedeconomy.nl/wp-content/uploads/2011/08/Can-production-of-bulk-chemicals-on-a-small-scale-be-competative-formated-20131126FINAL.pdf

Design rules for small scale in biorefinery

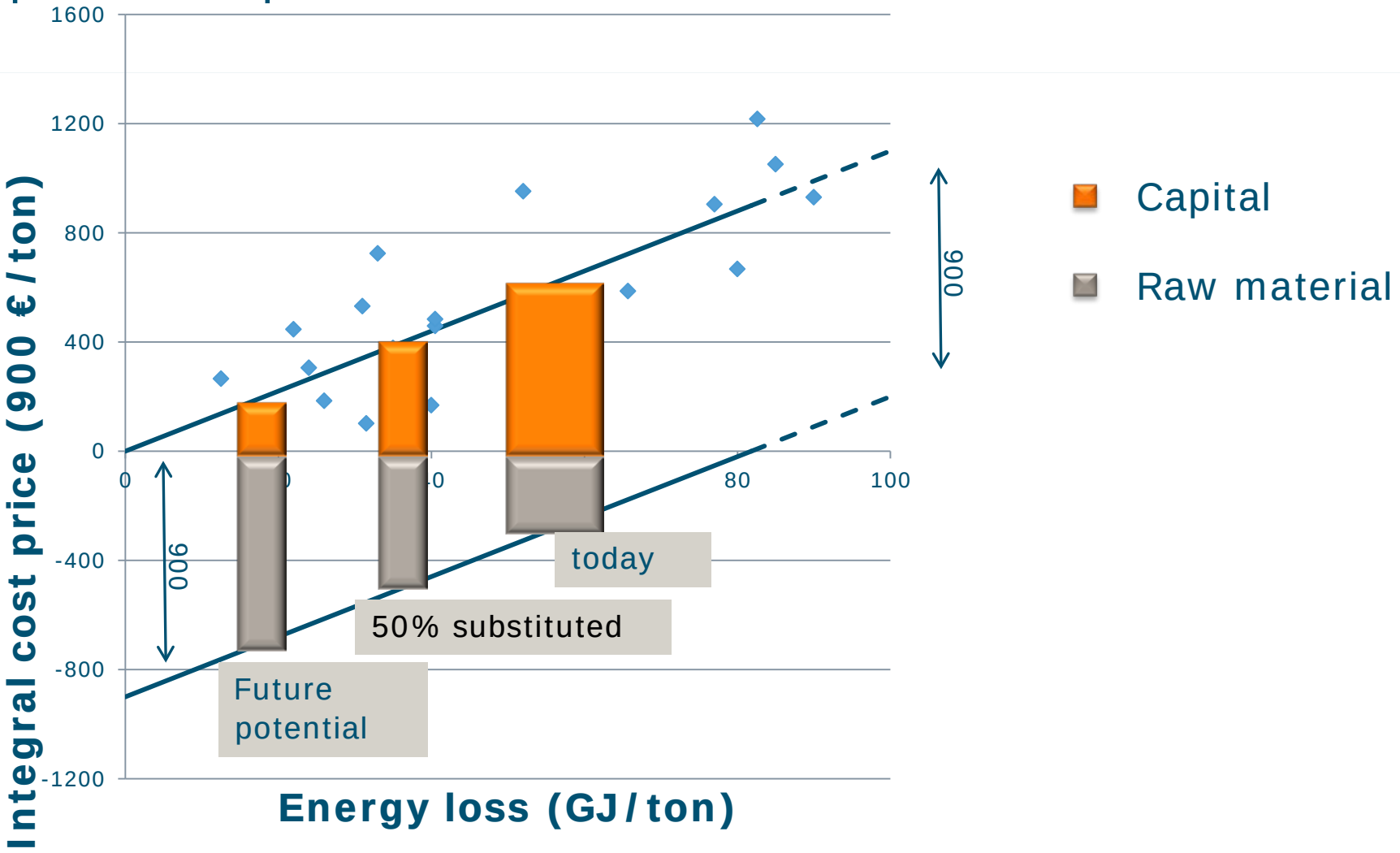
Advantages of small scale without the disadvantages

- Splitting the process in two parts
- Decrease investment cost by:

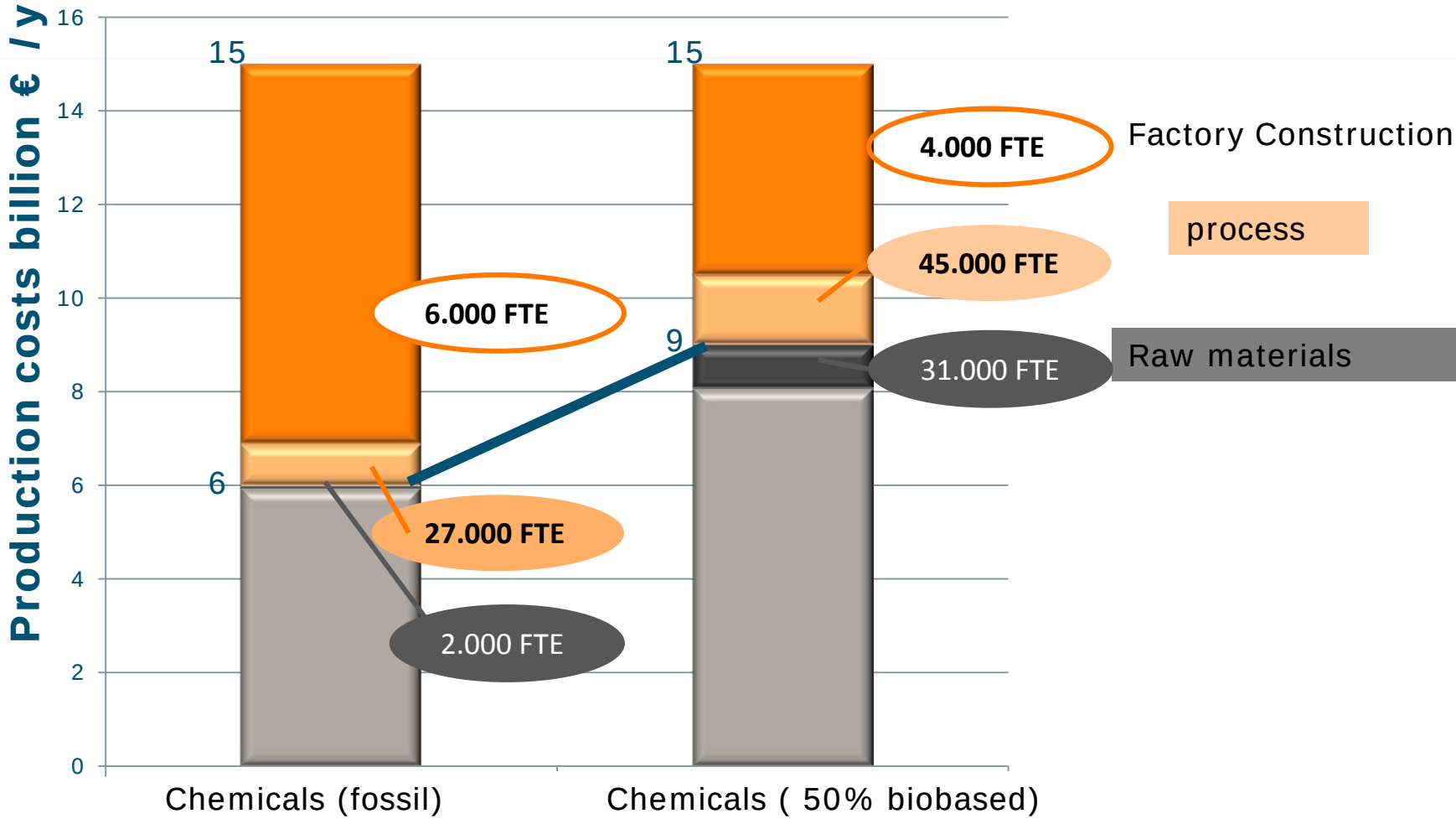
1. Minimize heat exchange and/or avoid heat exchange by clever solutions (Lange, J. P. (2001). Cattech 5(2): 82-95.)
2. Using unit operations with little economy of scale

- (Waste) energy use and the combination with biogas and CHP
- Developments start bottom-up: from 500 ha →100times 500ha

Processes with lower need for heat exchange, have lower capital costs per ton of product and can be economical at smaller scale.

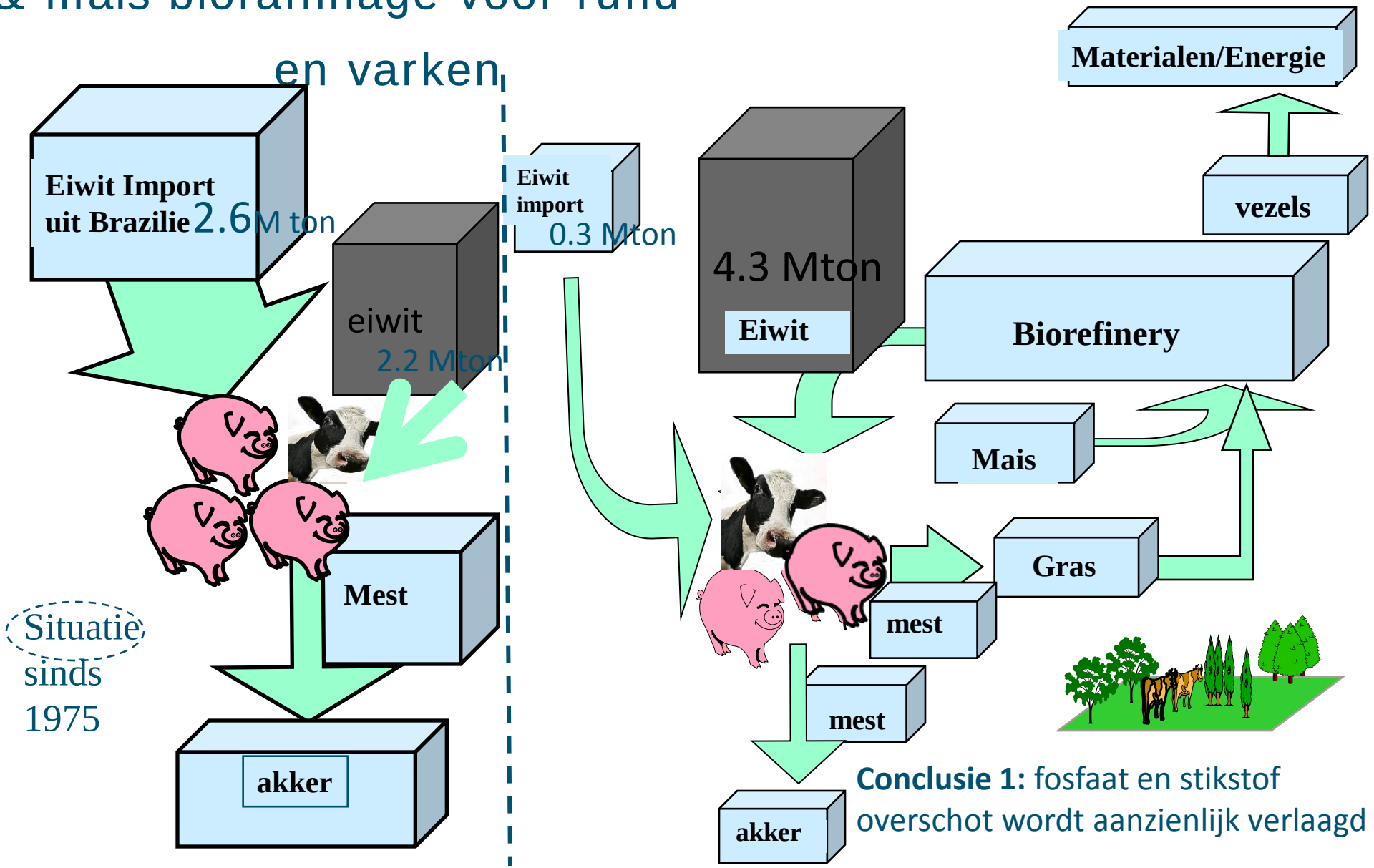


Employability can grow with 40 000 jobs to supply the dutch chemical industry with 50% of biomass raw materials (now being ca 80 000 fte)



WAGENINGEN UNIVERSITY
WAGENINGEN UR

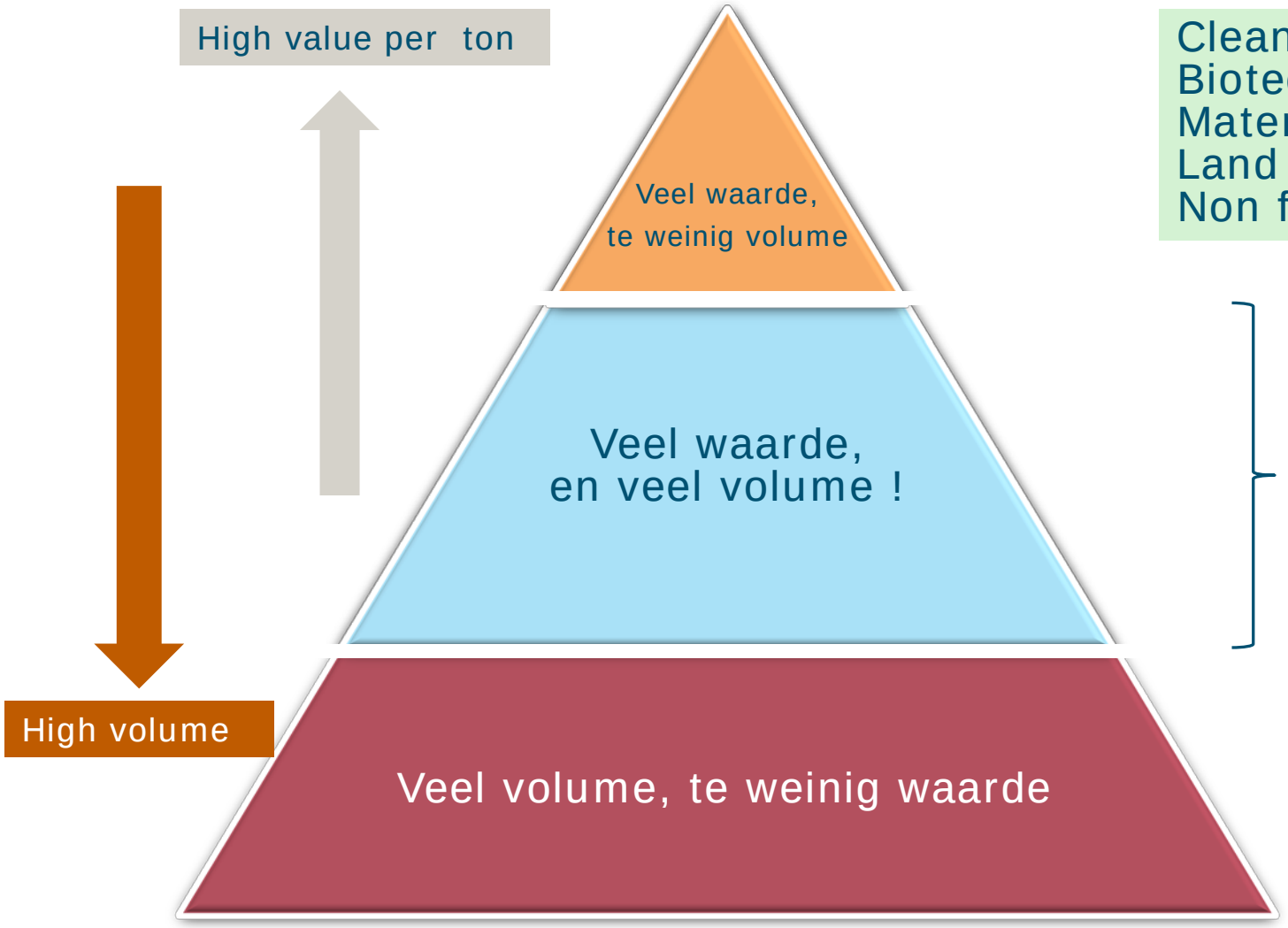
& mais bioraffinage voor rund en varken



Conclusie 1: fosfaat en stikstof overschot wordt aanzienlijk verlaagd

Conclusie 2: bioraffinage van locale grondstoffen leidt tot hoogwaardig veevoeder eiwit een lagere footprint en is economisch nu restproducten afgezet kunnen worden in de Biobased

Economische dragers in de BioEconomy



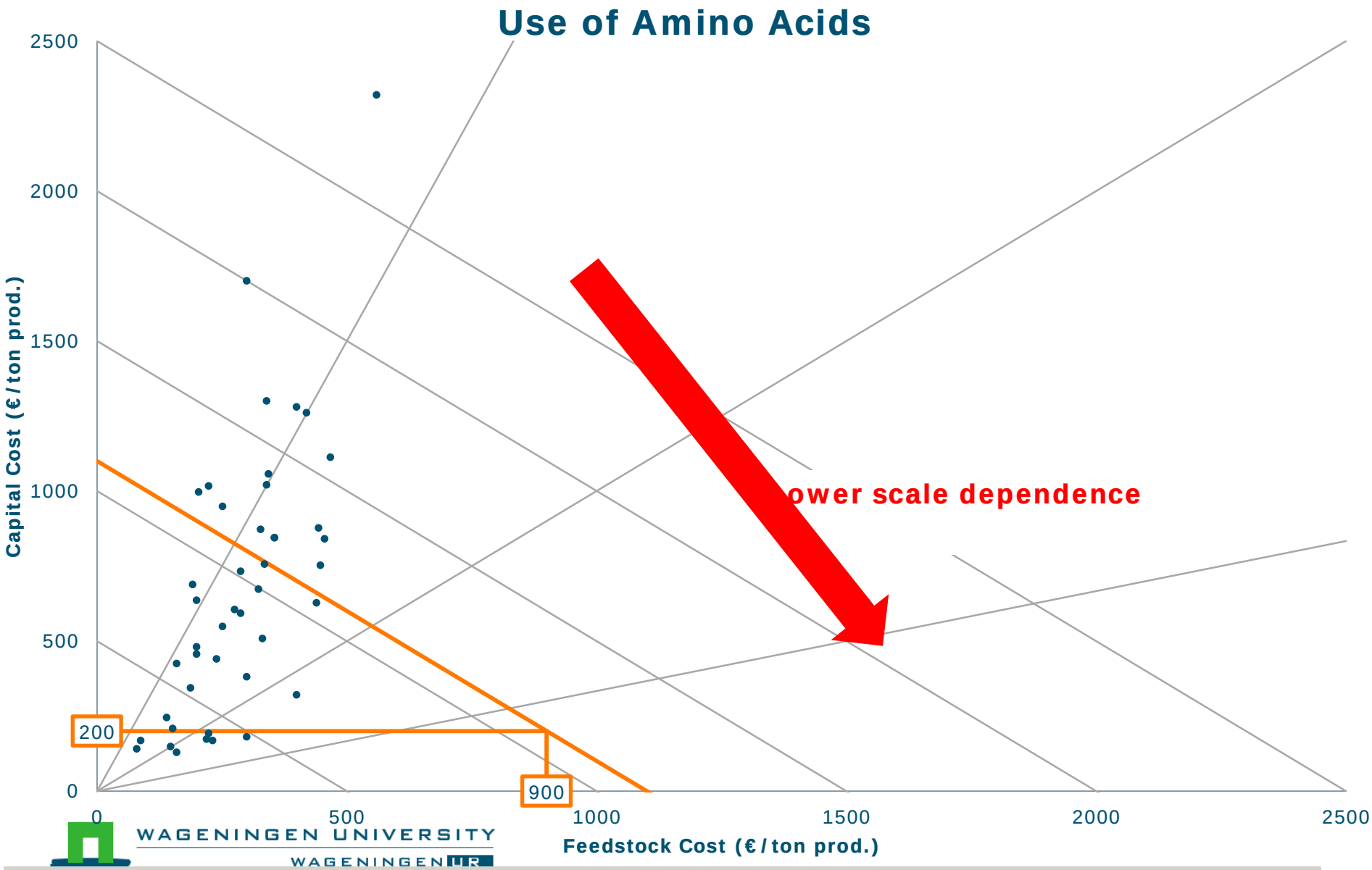
Cleantech
Biotechnologie
Materialen/ Chemie
Land & Tuinbouw
Non food

Eiwitten
Chemicaliën
Materialen

Increase of labour using biomass in chemical industry

- If half of the Dutch chemical industry (15 billion € added value (6G€ raw material cost + 9G€ capital cost) would run on biomass, this will require about 20 000 jobs in agriculture and 20 000 jobs in biorefinery;
- Cf half of Dutch chemical industry runs on fossile resources that require about 2000 fte.
- 40 000fte is equivalent to about 2 billion € and can be commercially feasible at lower capital requirements

Low scale dependency when capital costs are relatively low



WAGENINGEN UNIVERSITY
WAGENINGEN UR

http://www.biobasedeconomy.nl/wp-content/uploads/2011/08/Can-production-of-bulk-chemicals-on-a-small-scale-be-competative-formated-20131126FINAL.pdf