Green Biorefinery

Demonstration Plant
Havelland / Germany

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Germany

Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit

BIO POS
Forschungsinstitut
Bioaktive
Polymersysteme

Green Biorefinery Demonstration Plant Germany

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1. Introduction

Industrial Biorefineries are the key to build a new biomass-based industry.

Biorefining is the transfer of logic and efficiency of the fossil based chemical, chemical processing and material converting industry as well as energy production onto the biomass industry.

The product range of a biorefinery includes both, materials producible from crude oil and also products, which can’t be produced on crude oil basis.

Kamm, B.; Gruber, P.R.; Kamm, M.; Biorefineries, Industrial Processes and Products, ULLMANN’S, Wiley-VCH, 2007

1. Introduction

Depending on the physiology of plant material, two basic systems are considered according to refinery, cuttings, fractions and products.

- Ligno-cellulosic feedstocks (LCF) ‘nature dry’ biomass, cellulosic biomass and waste, wood, fast growing lumbers, straw and reed
  > processing in the LCF-Biorefinery

- Green ‘nature wet’ raw-materials, green grass, alfalfa, clover, immature cereals
  > processing in the Green-Biorefinery.

Kamm, B.; Kamm, M.; Principles of Biorefineries. Appl. Microbiol, Biotechnol., (AMB), 64 (2004) 137–145

2. Definition

Green Biorefineries (GBR's) are complex systems based on ecological technology for comprehensive (holistic), material and energy utilization of renewable resources and natural materials using green and waste biomass and focalising on sustainable regional land utilization.

GBR's orientate on the sustainability principles
(sustainable land utilization, gently technologies, self-sufficient
energy supply etc.).

📖 Kamm, B.; Kamm, M. Soyez, K.; In: Die Grüne Bioraffinerie – Ein ökologisches Technologiekonzept, Berlin 1998

3. Raw material

Green Biomass is for example

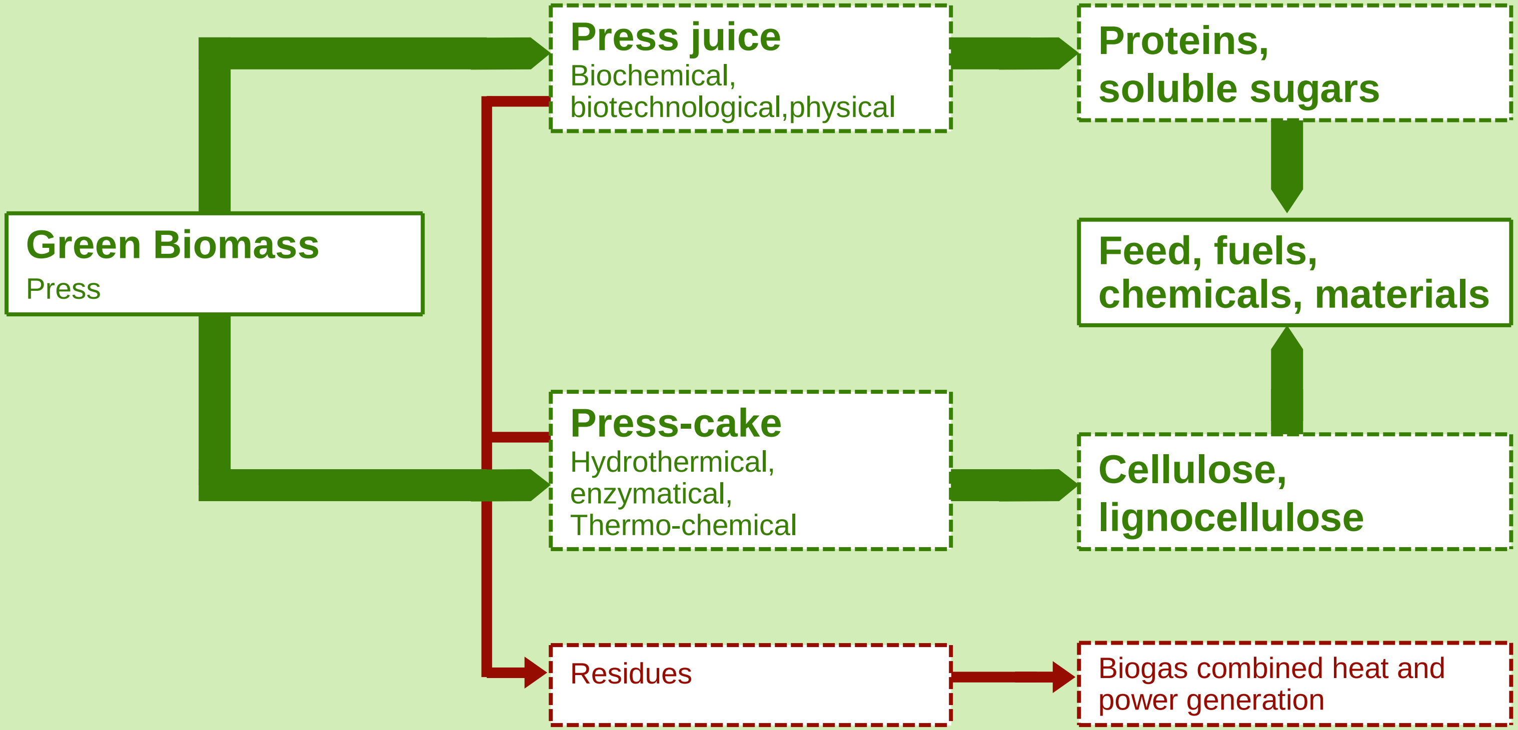
- Green grass from the cultivation of permanent grassland, set-aside agricultural land, nature conservation areas
- Green crops like alfalfa, clover, immature cereals from an extensive or modest intensive agriculture.

Utilizing green plants, proteins and carbohydrates are harvested at the place of syntheses, i.e. prior to translocation.
The loss of resources by translocation can be minimized, if the crops were harvested before flowering.

Green harvests generates more biomass and proteins per hectare and year than mature harvests or grain harvests.

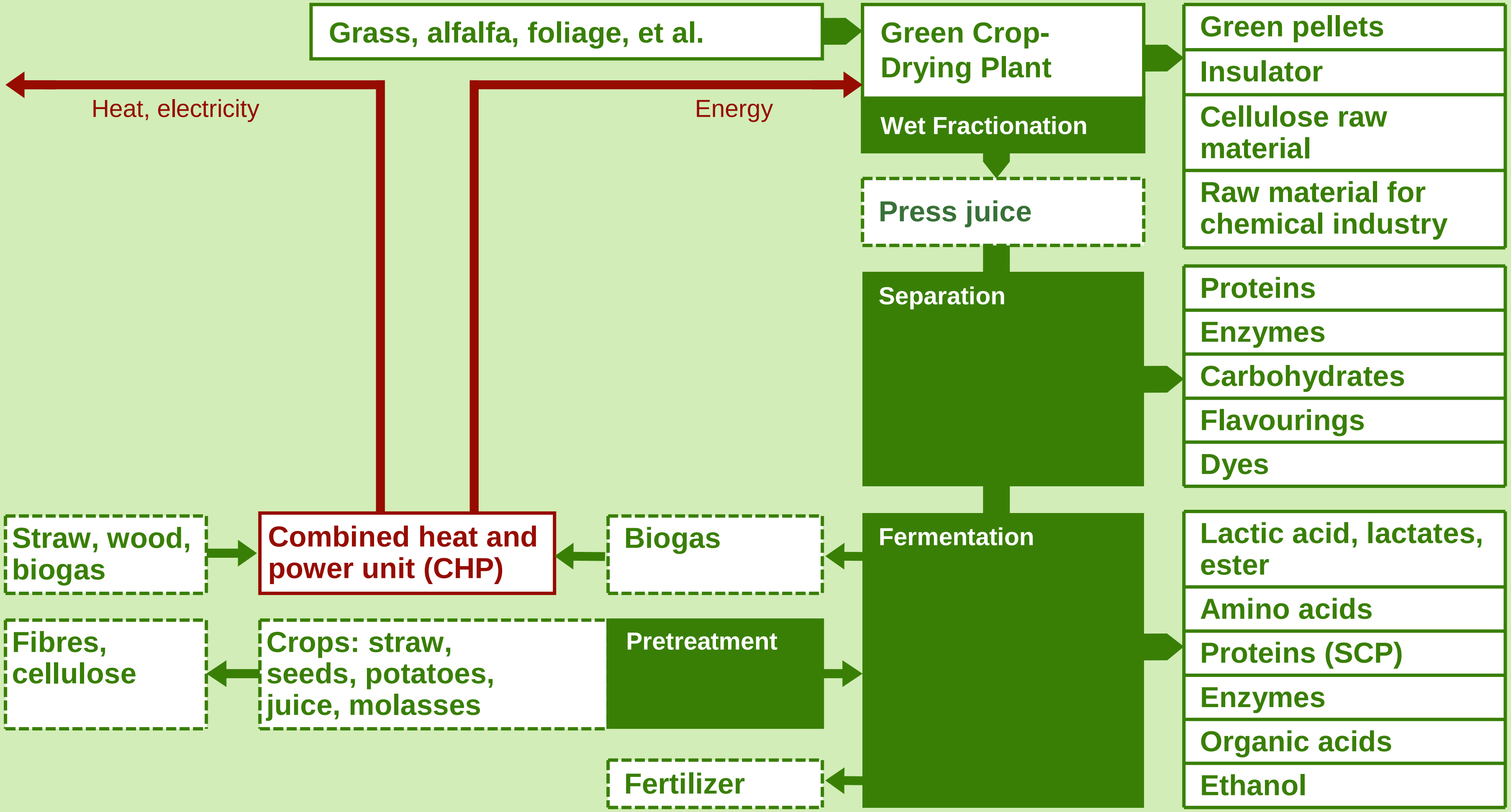
🕮 Carlssson, R., In: Die Grüne Bioraffinerie – Ein ökologisches Technologiekonzept, Berlin 1998

4. Biorefinery-System



🕮 Kamm, B.; Gruber, P.R.; Kamm, M.; Biorefineries, Industrial Processes and Products, Wiley-VCH, 2006

4. Biorefinery-Systems



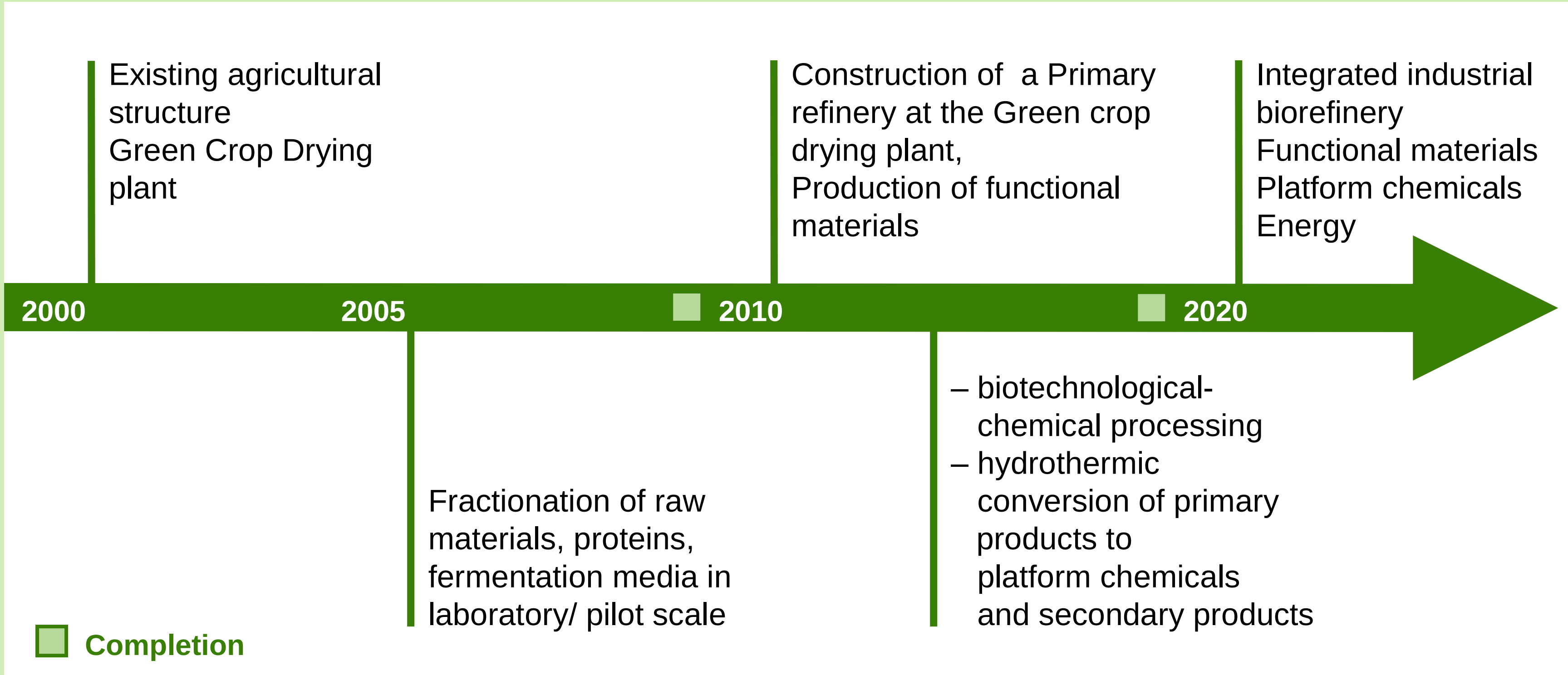
5. Technical aims

Combination of

- Technologies for the fractionation of green plant material
- Leaf-protein extraction technologies
- Biotechnological processes
- Extraction processes (chlorophyll, carotenoides)
- Technologies for the combination of biotechnological and chemical processing
- Technologies for biogas generation

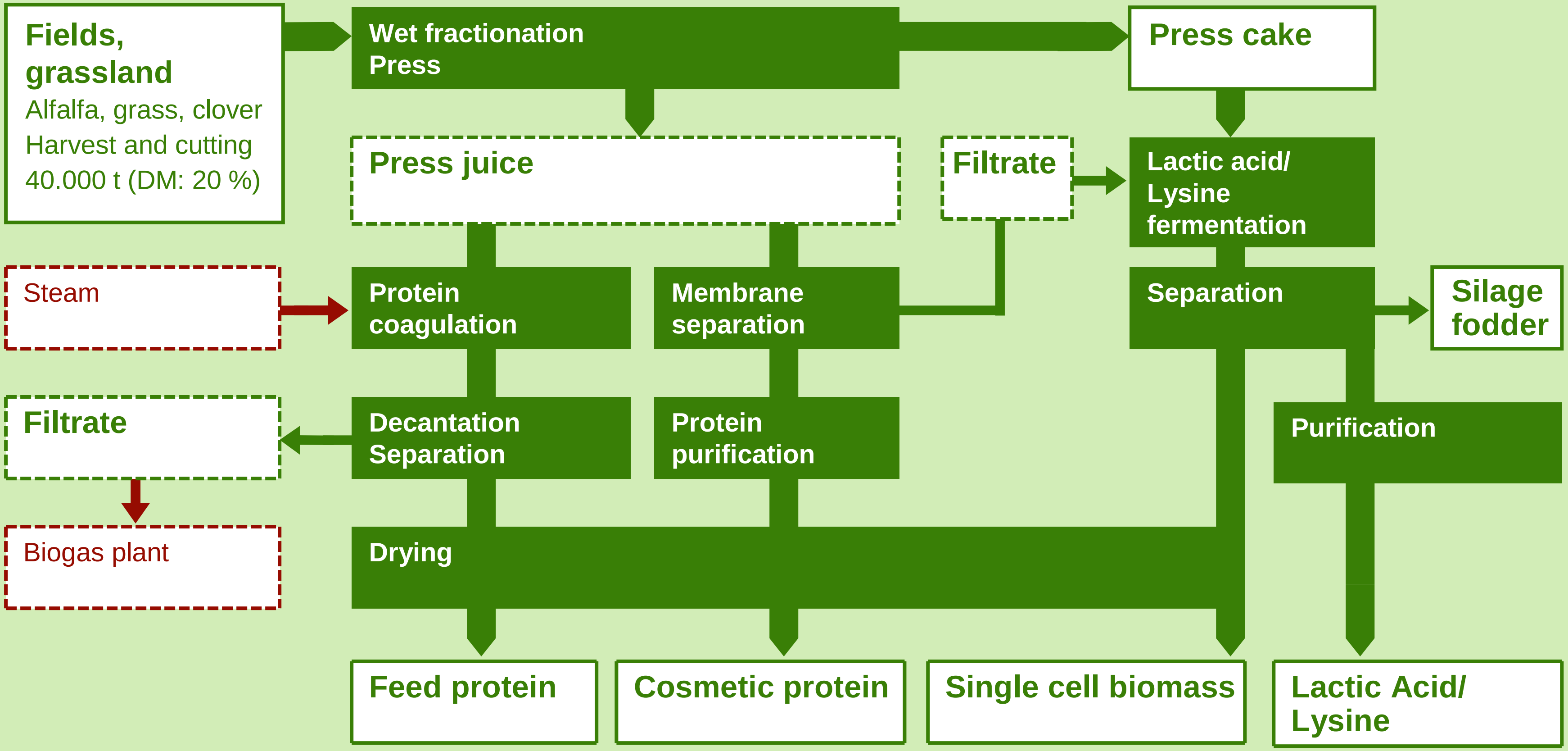
📖 Kamm, B.; Kamm, M.; Soyez, K., In: Die Grüne Bioraffinerie – Ein ökologisches Technologiekonzept, Berlin 1998

5. Technical aims



6. Mass balance and energy input

Examples: Green Biorefinery / selected and simplified view of Green Biorefinery processes



6. Mass balance and energy input

Scenario 1: Lactic acid

Biomass

Green 'nature wet' raw materials (Green grass, alfalfa, clover)

40.000 t
(DM: 20 %)

Technologies

Milling

Mechanical fractionation

Protein separation (centrifugation, membrane techn.)

Fermentation and separation (membrane techn.)

Process energy

Heat
2200 GJ

Electricity
1005 MWh

Product-Mix

Lactic acid (90 %) (DM: 90 %) 660 t

White protein (DM: 90 %) 38 t

Green protein (DM: 90 %) 550 t

Silage fodder (DM: 40 %) 13.000 t

Single cell biomass (DM: 90 %) 33 t

Residues for biogas (DM: 2 %)
17.690 t

Kamm, B.; Schönicke, P.; Kamm, M.; CLEAN 2009, 37 (1), 27-30

6. Mass balances and energy input

Scenario 2: Lysin

Biomass	Technologies	Process Energy	Product mix
Green 'nature wet' raw materials (Green grass, alfalfa, clover)	Milling	Heat 2200 GJ	Lysin-HCl (50 %) (DM 90 %) 620 t
40.000 t (DM: 20 %)	Mechanical fractionation	Electricity 500 MWh	White protein (DM 90 %) 38 t
	Protein separation (centrifugation, membrane techn.)	Hydrochloric acid (37 %) 167 t	Green protein (DM 90 %) 550 t
	Fermentation and separation (membrane techn.)		Silage fodder (DM: 40 %) 13.000 t
			Single cell biomass (DM: 90 %) 31 t
			Residues for biomass (DM: 2 %) 17.770 t

📖 Kamm, B.; Schönicke, P.; Kamm, M.; CLEAN 2009, 37 (1), 27-30

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7. Demonstration plant

Green Biorefinery – Havelland type

Region Havelland:

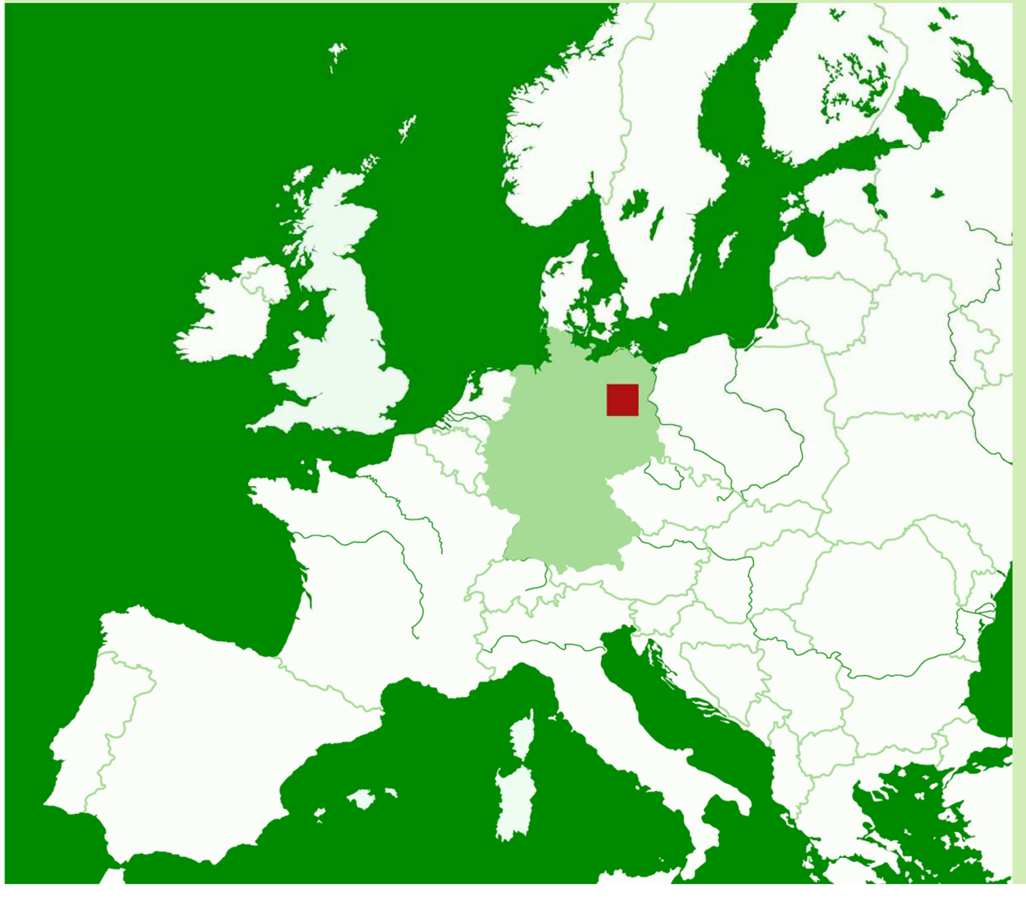
State of Brandenburg, to the west of Berlin
53 % of the area is under agricultural cultivation
62.000 ha cropland
29.000 ha grassland

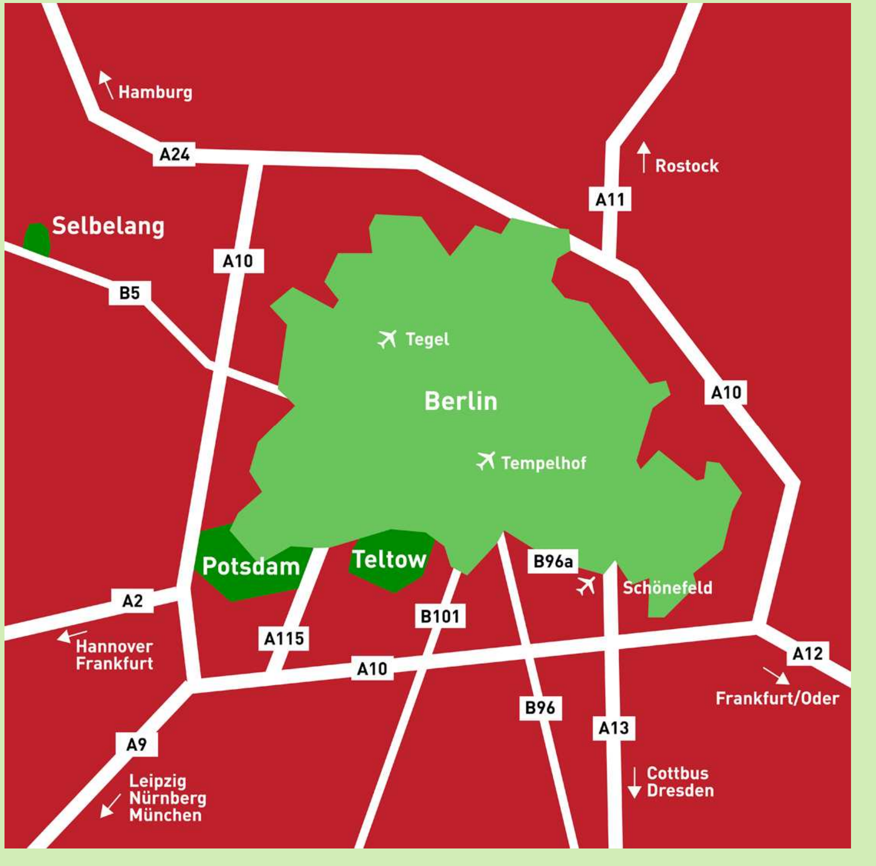
Havelländisches Luch with the Green crop drying plant Selbelang as a central object

- Chemistry Park Premnitz
- High state of knowledge of the agro-industrial research- and educational institutions

Agrarbericht, Land Brandenburg, 2008

7.1 Site




Hamburg
A24
Rostock
A11
Selbelang
A10
B5
Tegel
Berlin
A10
Tempelhof
Potsdam
Teltow
B96a
Schönefeld
A2
B101
Hannover
Frankfurt
A115
A10
A12
Frankfurt/Oder
B96
A13
A9
Leipzig
Nürnberg
München
Cottbus
Dresden

7.2 Partner

Coordination and experimental work
for basic material recovery of grass/ alfalfa

biopos e.V.
Research Institute Bioaktive Polymer Systems
Research location Teltow-Seehof
www.biopos.de
Representative: Mrs. Prof. Dr. Birgit Kamm

Primary refinery
Fractionation and storage
Production side

Drying Plant Selbelang
FMS-Futtermittel GmbH
Representative: Mr. Dipl.-Ing.
Bernd Müller

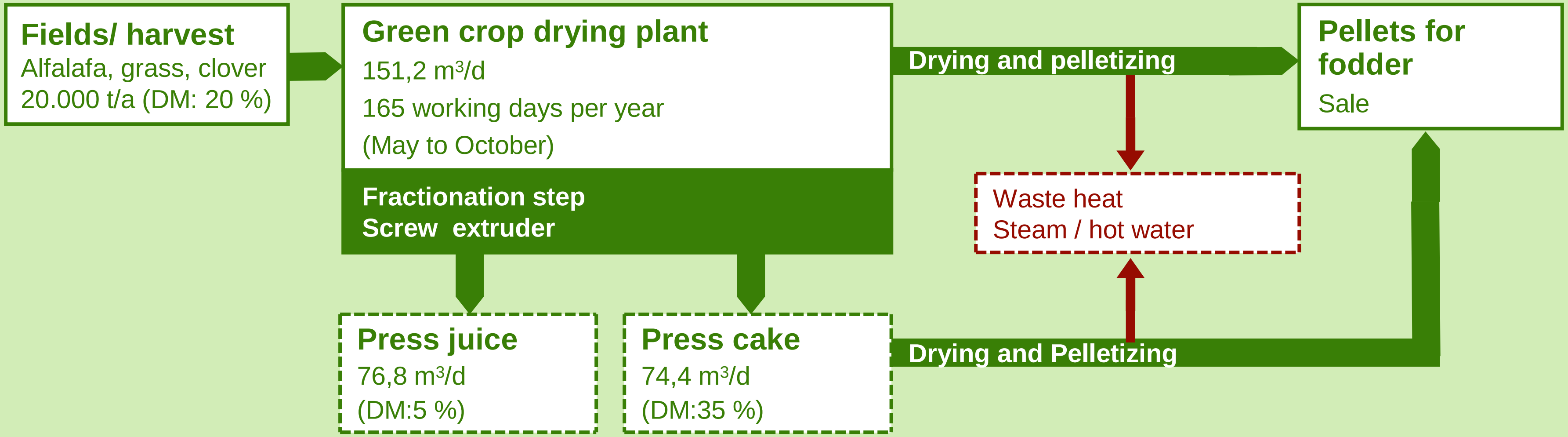
Product line press juice
Production of proteins and
fermentation juices

biorefinery.de gmbh
laboratories Teltow-Seehof
www.biorefinery.de
Representative: Mr. Dr. Jörg Beckmann

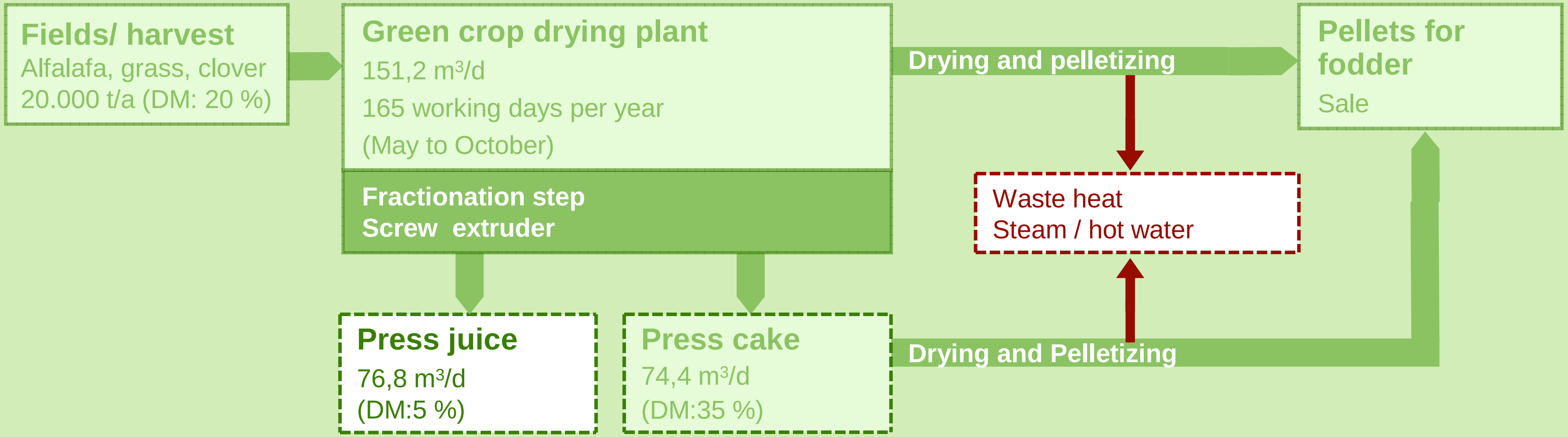
Product line press juice
Scale-up and engineering
of the press-juice line

LINDE-KCA-DRESDEN GMBH
www.linde-kca.com
Representative: Mrs. Dr. habil.
Karin Bronnenmeier

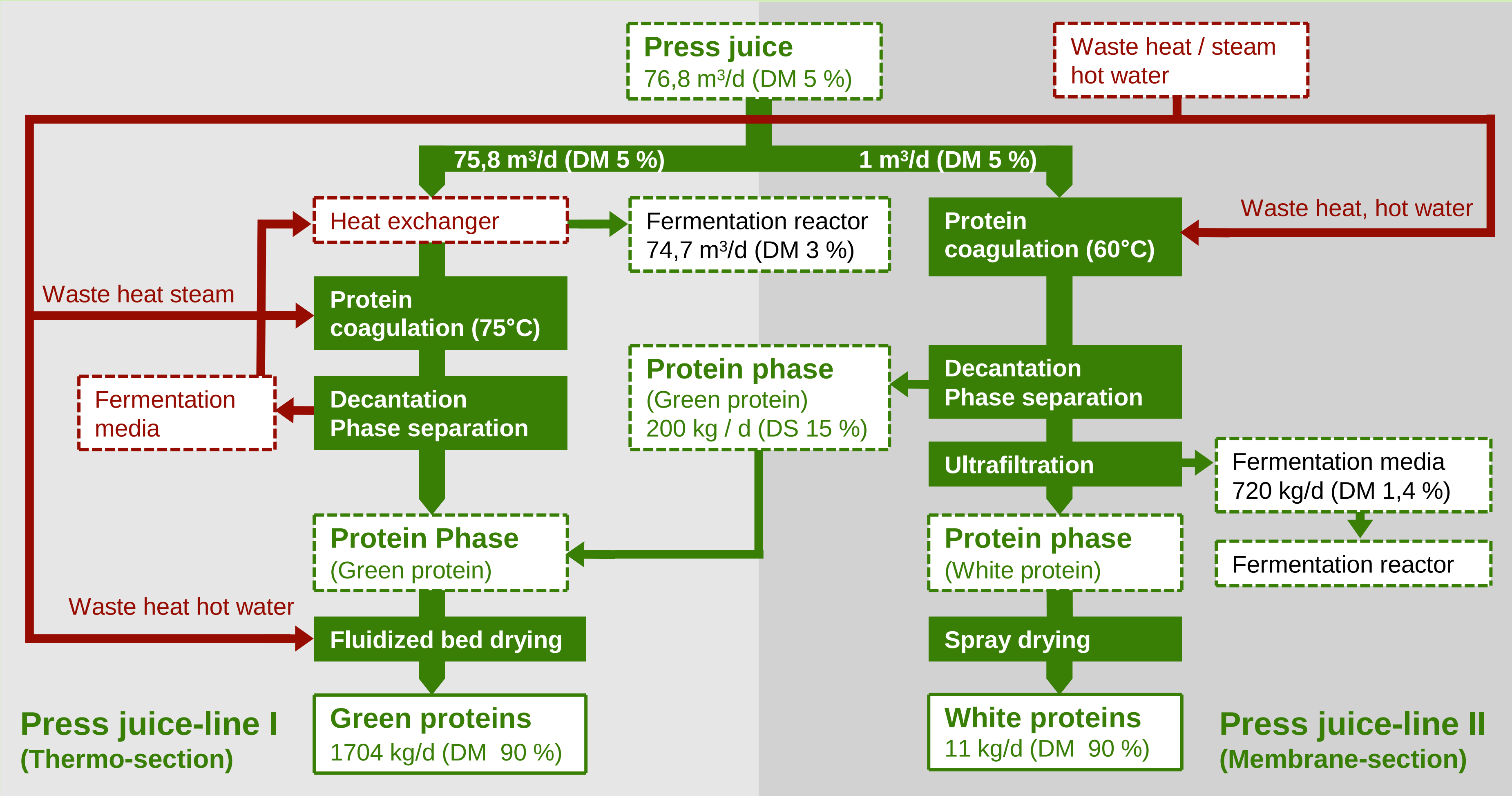
7.3 Primary refining process and products



7.3 Primary refining process and products



7.4 Process, functional proteins and fermentation media



7.4 Functional proteins and fermentation media

White proteins

High functional potential

- for foams, foam stabililizer, films (cosmetic)

Green proteins (for high-quality feed)

- Amino acids (Asp, Glu, Ser, His, Gly, Thre, Arg, Ala, Tyr, Val, Phe, Ile, Leu, Lys, Pro, Hydroxypro, Met, Cys, Trp)
- Carotene
- Xantophyll
- Fat

Fermentation media (for biotechnological processes)

- Glucose
- Proteins, amino acids
- Fats
- Minerals (Na^+, K^+, Ca^{2+}, Mg^{2+}, P, NO_3^-, SO_4^{2-}, Cl^-)

7.5 Estimation of investment costs

Technology costs Project specific subsystems	K €
Package unit costs	1.438
Equipments costs inclusive bulk and assembly costs	1.390
PLS costs	263
Sub-total	**3.136**

Building occupancy expenses	K €
Open up	63
Exterior	102
Building	817
Sub-total	982

Engineering costs	K €
Package unit	180
Equipments	382
PLS	95
Sub-total	**657**

Engineering costs	K €
Open up	18
Exterior	25
Building	75
Sub-total	**118**

Total investment costs incl. escalation (+/- 20 %) and management **6,2 Mio €**

7.6 Efficiency calculation

Operation costs per year

Specific product costs	K €/a	€/kg product
Raw material	16.5	0.07
Fuels	10.5	0.04
Other raw materials and supplies	68	0.28
Personnel	60	0.24
Spare parts	10	0.04
Utilities	10	0.04
Sub-total	**175**	**0.71**

Reduction of costs Drying Plant	K €/a	€/kg product
Heating energy costs	**104**	**0.42**

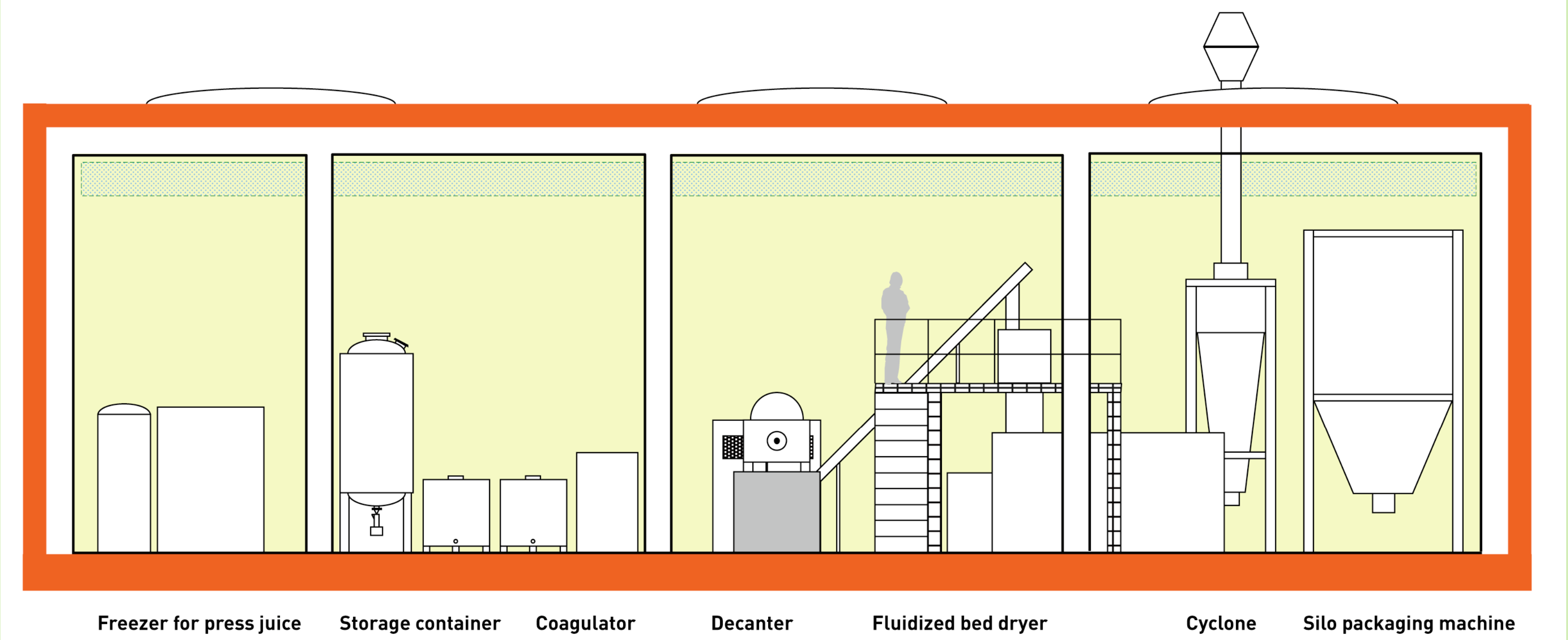
Operating costs considering the heating energy savings in the drying plant	**71 K €/a**	**0.29 €/kg product**

7.7 Effect on climate protection
Processing of 20.000 t biomass (1st step of construction)

Savings potential by connecting the facility to the existing drying plant	
Coal **CO_2**	**2.073 t/a** 4.172 t/a

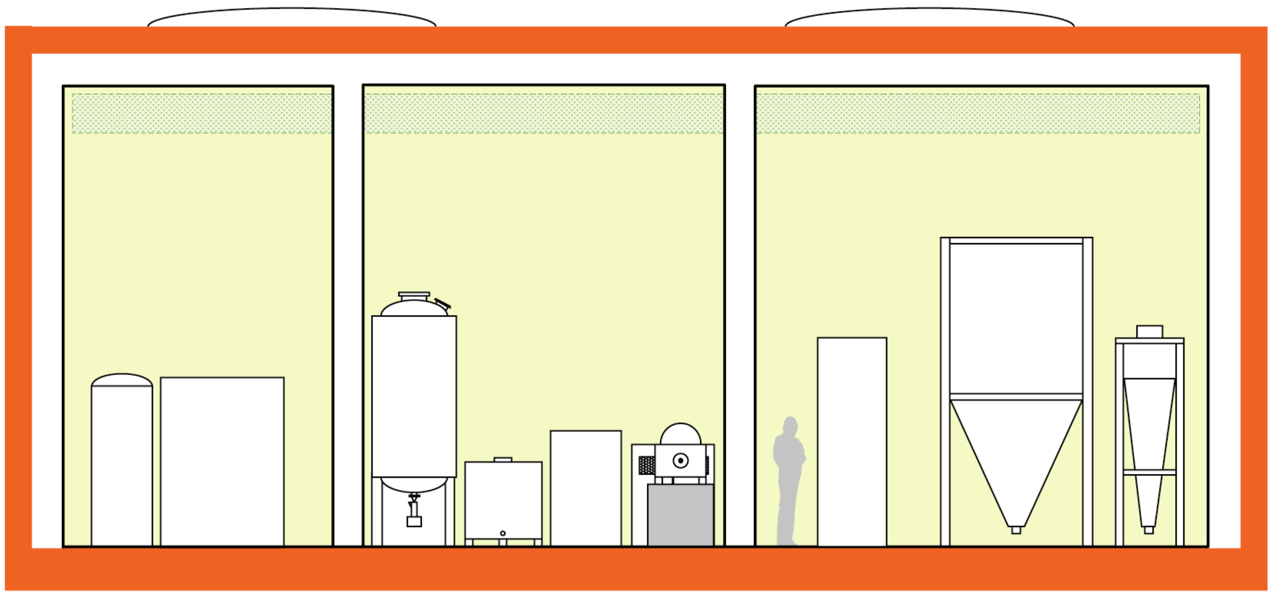
GHG reduction per € investment funds	37,18 € charges / t CO_2
Facility operating time: 40 years Data according to Basic Engineering, variation (+/- 20%)	

7.8 Layout production facility



📖 Project planning, LINDE KCA, 2009

7.9 Layout pilot plant



📖 Project planning, biorefinery.de GmbH, 2009

8. Outlook

- Upgrading of the Primary refinery in a 40.000 t scale (year-round operation)
- Addition of fermentation units to the production of platform chemicals
- Addition of technologies for press cake processing outside of the fodder sector (chemical raw material, carbohydrate source for platform chemicals)
- Addition of the product line synthesis gas

9. Contact

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