
Green Biorefinery
Demonstration Plant
Havelland / Germany
Green
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Germany
Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit
BIO
POS
Forschungsinstitut
Bioaktive
Polymersysteme

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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

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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

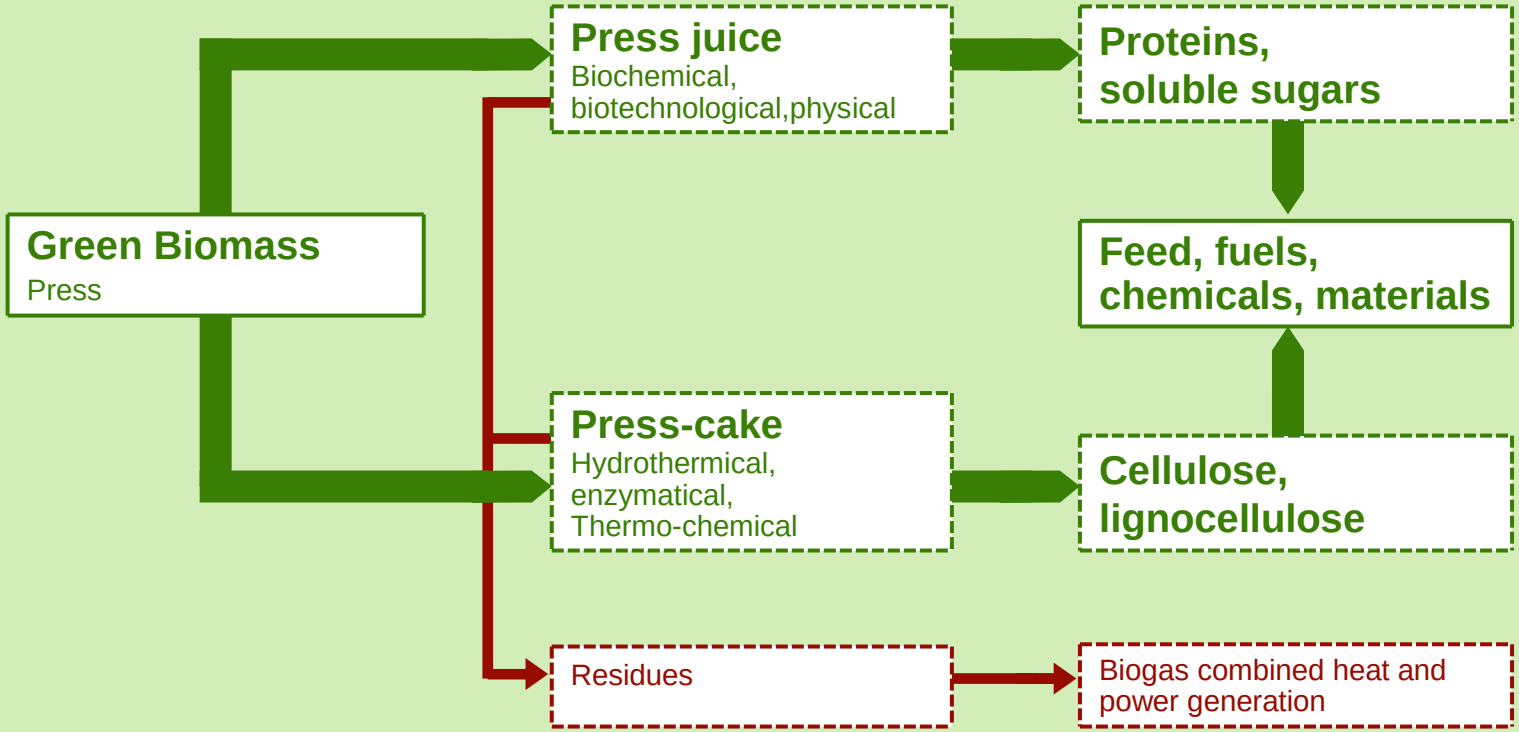
- Green grass from the cultivation of permanent grassland, set-aside agricultural land, nature conservation areas
- Green crops like alfalfa, clover, immature cereals from an extensive or modest intensive agriculture.

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

Grass, alfalfa, foliage, et al.

Green Crop-Drying Plant

Wet Fractionation

Green pellets

Insulator

Cellulose raw material

Raw material for chemical industry

Heat, electricity

Energy

Press juice

Separation

Proteins

Enzymes

Carbohydrates

Flavourings

Dyes

Straw, wood, biogas

Combined heat and power unit (CHP)

Biogas

Fermentation

Lactic acid, lactates, ester

Amino acids

Proteins (SCP)

Enzymes

Organic acids

Ethanol

Fibres, cellulose

Crops: straw, seeds, potatoes, juice, molasses

Pretreatment

Fertilizer

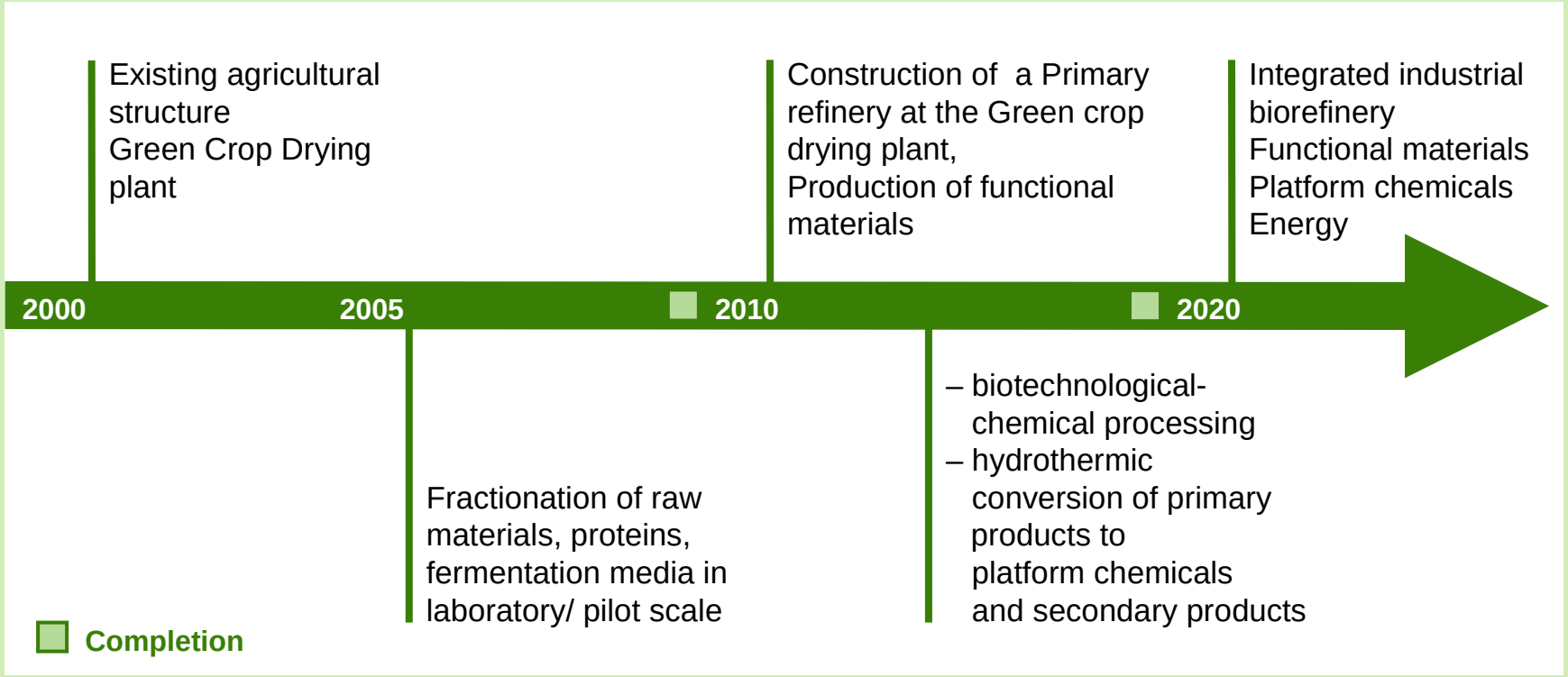
5. Technical aims

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

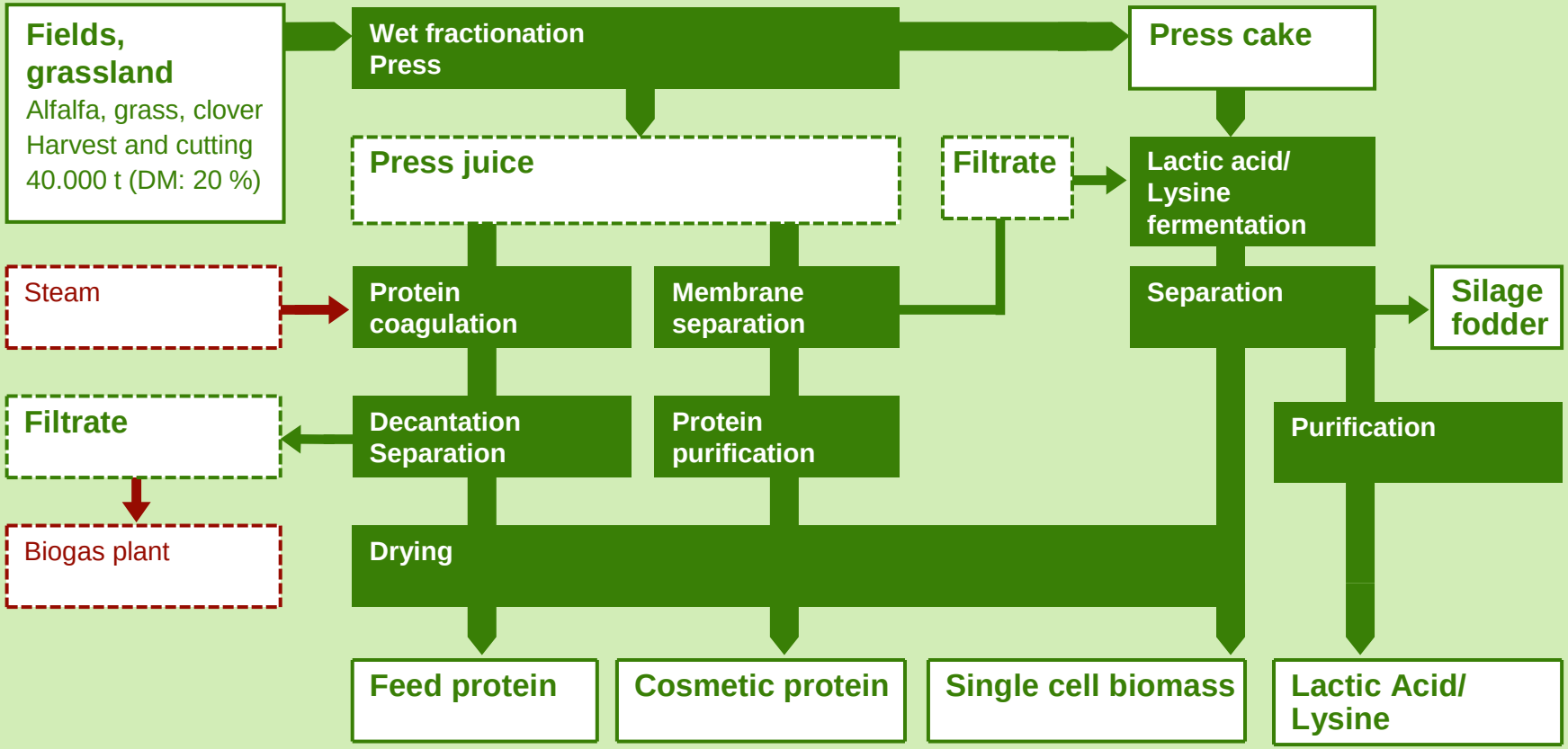
📖 Kamm, B.; Kamm, M.; Soyez, K., In: Die Grüne Bioraffinerie – Ein ökologisches Technologiekonzept, Berlin 1998

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) 40.000 t (DM: 20 %)	Milling Mechanical fractionation Protein separation (centrifugation, membrane techn.) Fermentation and separation (membrane techn.)	Heat 2200 GJ Electricity 500 MWh Hydrochloric acid (37 %) 167 t	Lysin-HCl (50 %) (DM 90 %) 620 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 %) 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

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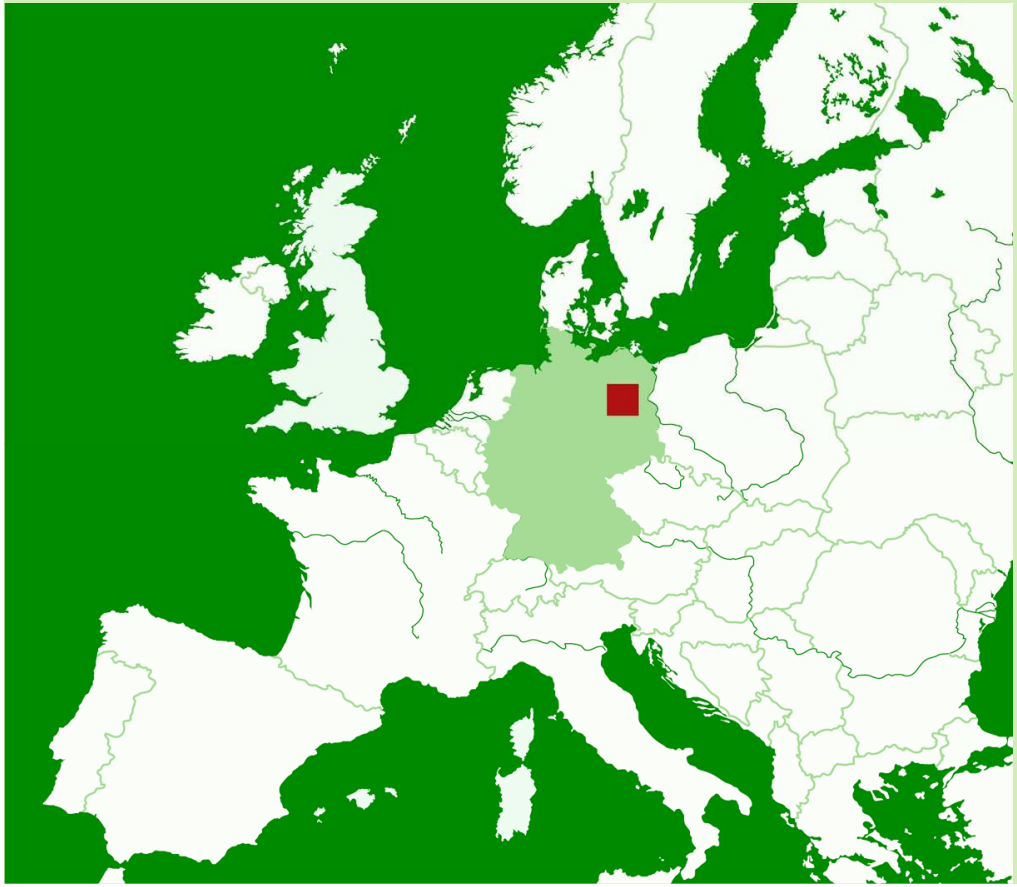
7.1 Site



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

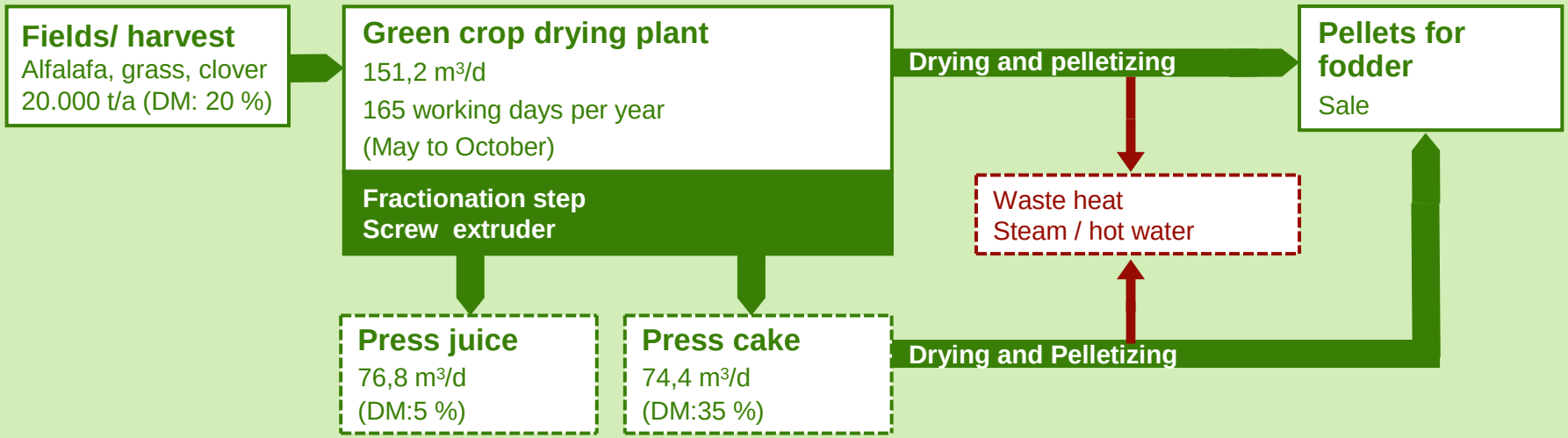
Product line press juice Production of proteins and fermentation juices

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

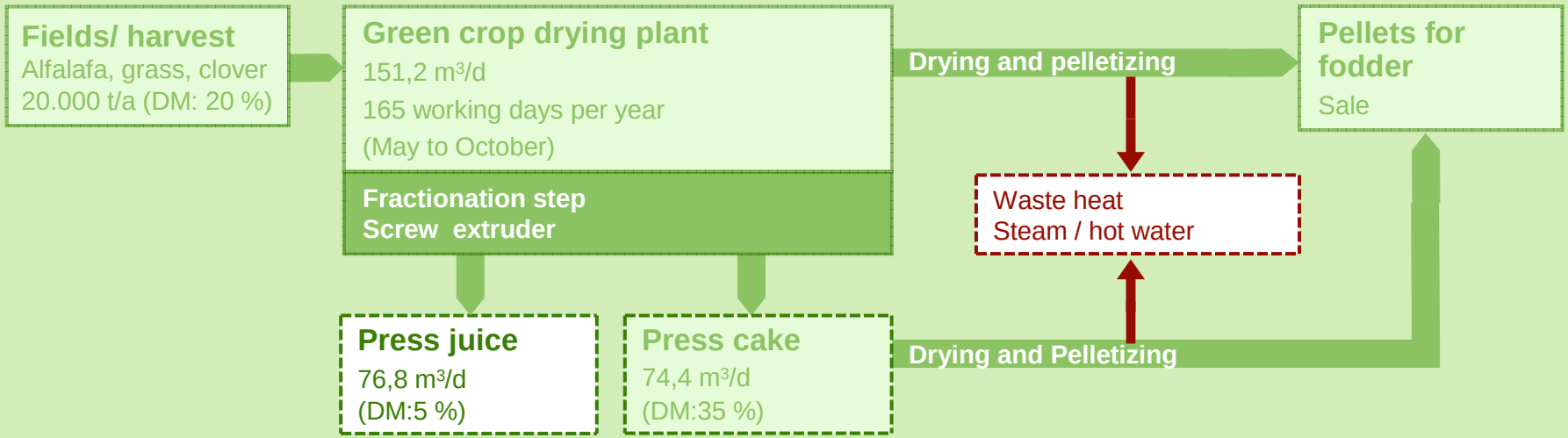
Product line press juice Scale-up and engineering of the press-juice line

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

Press juice
76,8 m³/d (DM 5 %)

Waste heat / steam
hot water

75,8 m³/d (DM 5 %)

1 m³/d (DM 5 %)

Heat exchanger

Fermentation reactor
74,7 m³/d (DM 3 %)

Protein
coagulation (60°C)

Waste heat, hot water

Waste heat steam

Protein
coagulation (75°C)

Fermentation
media

Decantation
Phase separation

Protein phase
(Green protein)
200 kg / d (DS 15 %)

Decantation
Phase separation

Ultrafiltration

Fermentation media
720 kg/d (DM 1,4 %)

Fermentation reactor

Waste heat hot water

Protein Phase
(Green protein)

Protein phase
(White protein)

Fluidized bed drying

Spray drying

Green proteins
1704 kg/d (DM 90 %)

White proteins
11 kg/d (DM 90 %)

Press juice-line I
(Thermo-section)

Press juice-line II
(Membrane-section)

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

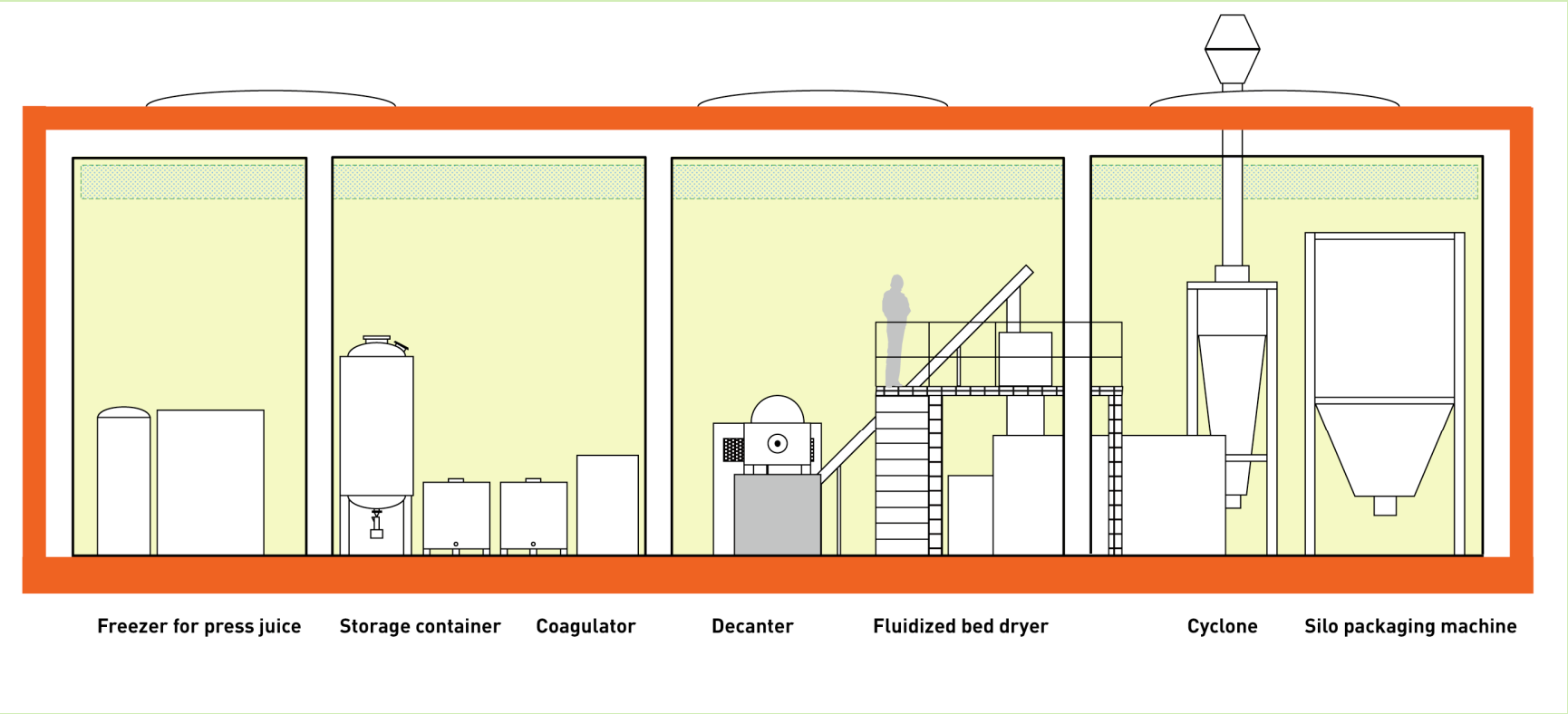
Operation costs per year

Specific product costs	K €/a	€/kg product
Raw material	54	0.22
Fuels	10	0.04
Other raw materials and supplies	68	0.28
Personnel	80	0.32
Spare parts	10	0.04
Utilities	10	0.04
Sub-total	**232**	**0.94**

Reduction of costs Drying Plant	K €/a	€/kg product
Heating energy costs	**103**	**0.42**

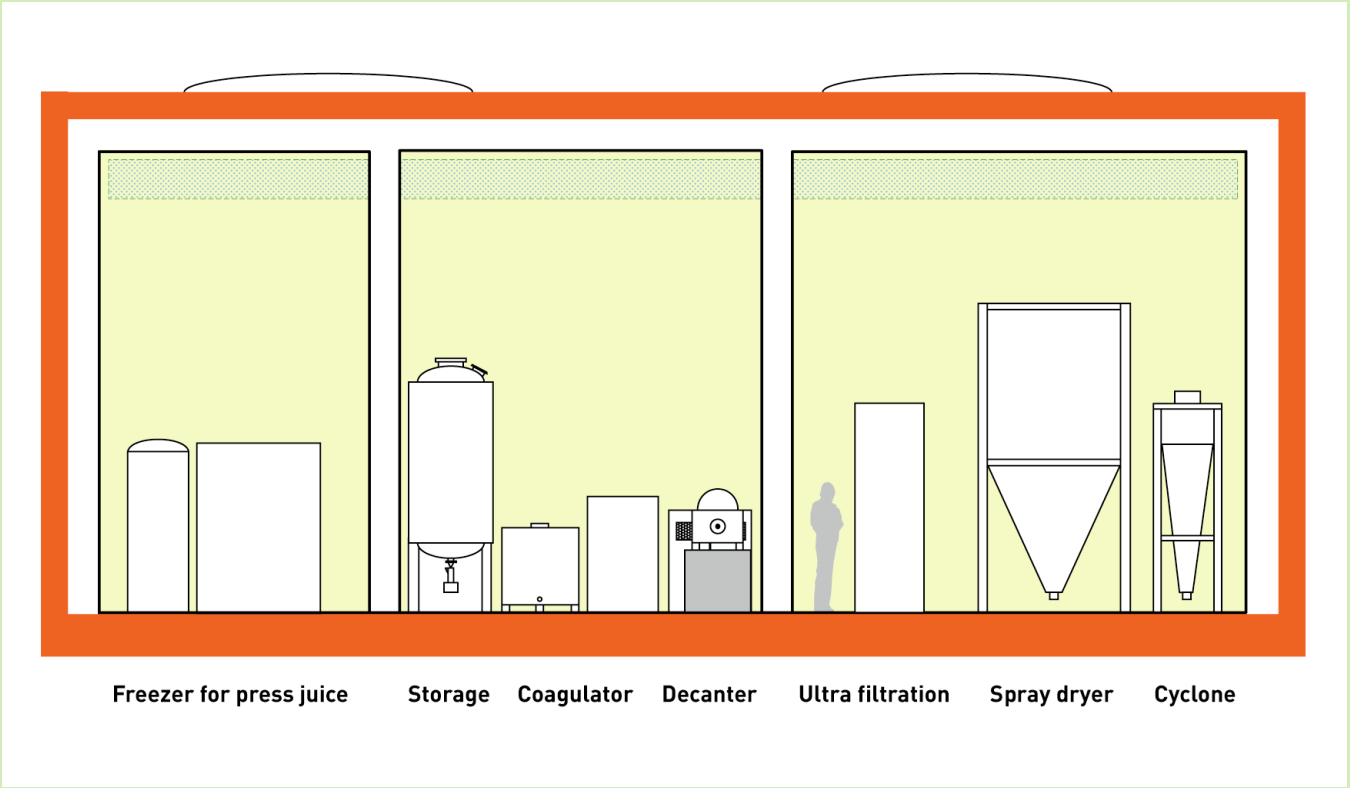
Operating costs considering the heating energy savings in the drying plant	**129 K €/a**	**0.52 €/kg product**

7.7 Layout production facility



📖 Project planning, LINDE KCA, 2009

7.8 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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