Kombination von Biotreibstoffen der 1. und 2. Generation

Heike Frühwirth

4. Highlights der Bioenergie Forschung

02.12.2010, Wien

Our future. Clean energy.

Outline

- **BDI – BioEnergy International AG**
- **Algae Biorefinery**
- **BioDiesel from Algae**
- **BioGas from Algae Biomass**
- **Summary & Outlook**

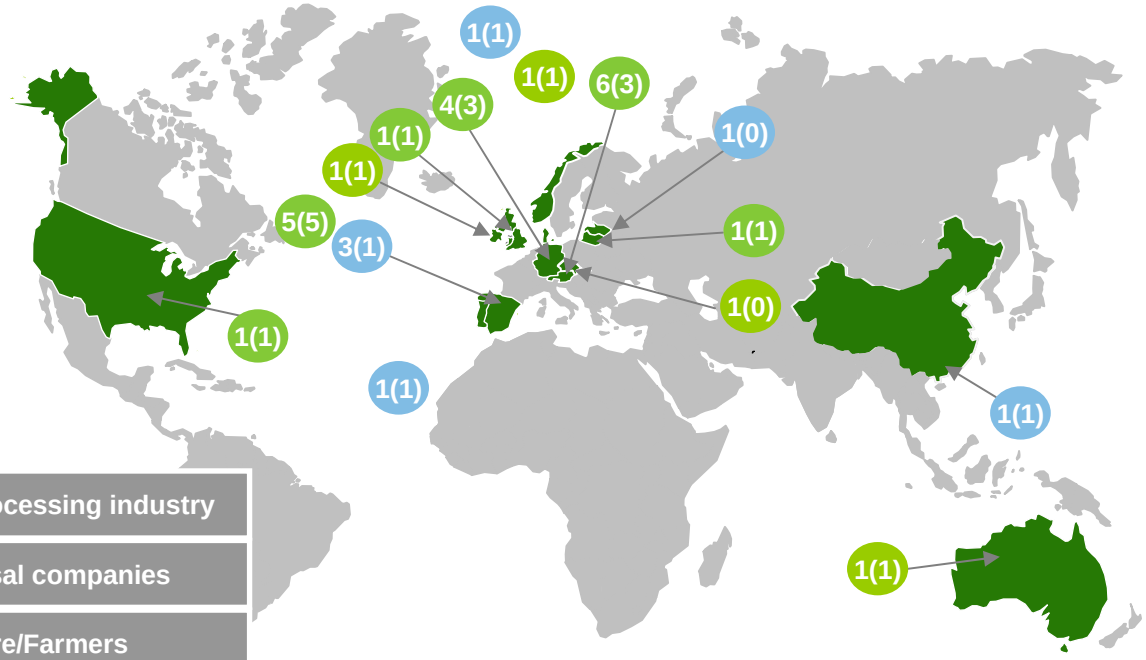
BDI – BioEnergy International AG

BDI Headquarters

BDI - BioEnergy International AG

Parkring 18
A-8074 Grambach/Graz
Austria / Europe
www.bdi-bioenergy.com

Diversified international Customer Base



Customers

- Fat- and meatprocessing industry
- Waste disposal companies
- Agriculture/Farmers
- Fresh Oil producers (Vegetable Oil)
- Fincancial investors
- Mineral Oil corporations

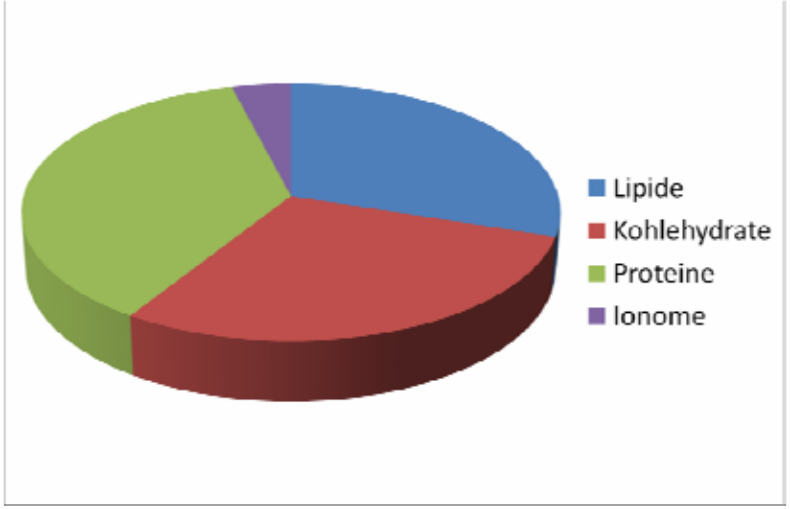
7(4) Number of plants ordered in the respective countries (figures in brackets denote number of Multi-Feedstock Plants)

22(17) Number of plants completed in the respective countries (figures in brackets denote number of Multi-Feedstock Plants)

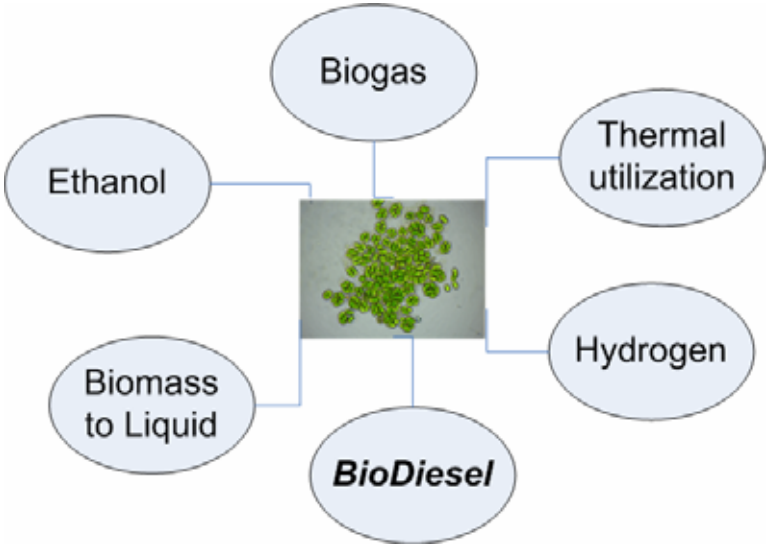
Biorefinery Concept

Products

Algae composition



Possible energy products



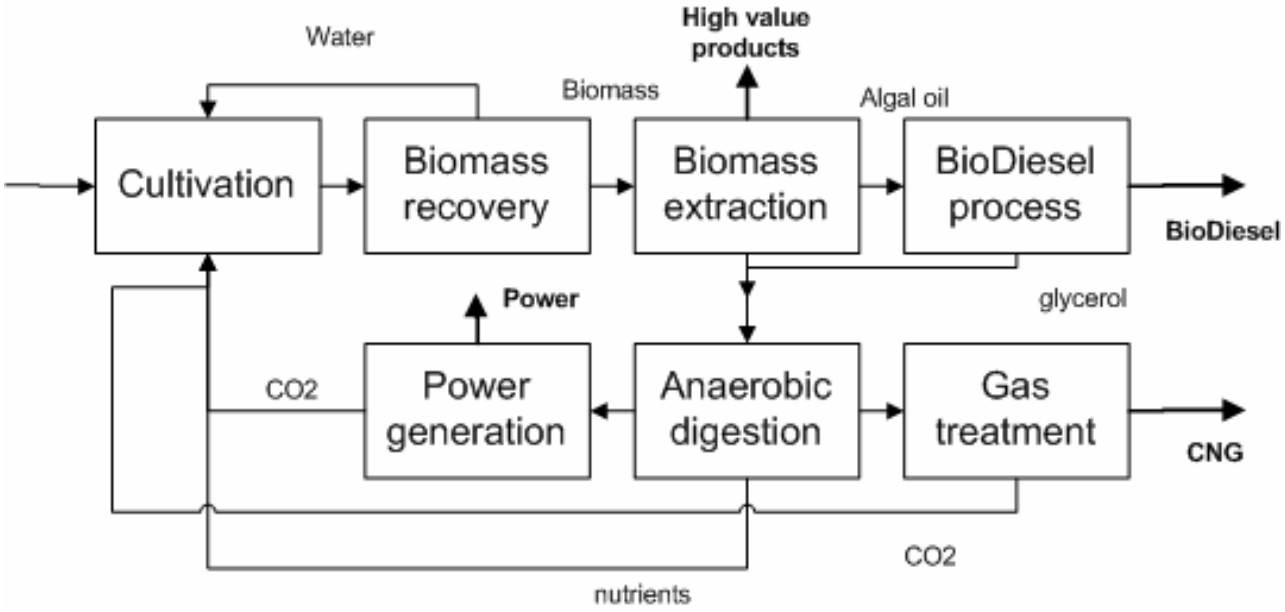
Overall Process

Biorefinery:

waste water
municipal waste
CO_2

→

BioDiesel
PUFA
Biogas



Overall Process

Algae cultivation

Biomass extraction

BioDiesel process

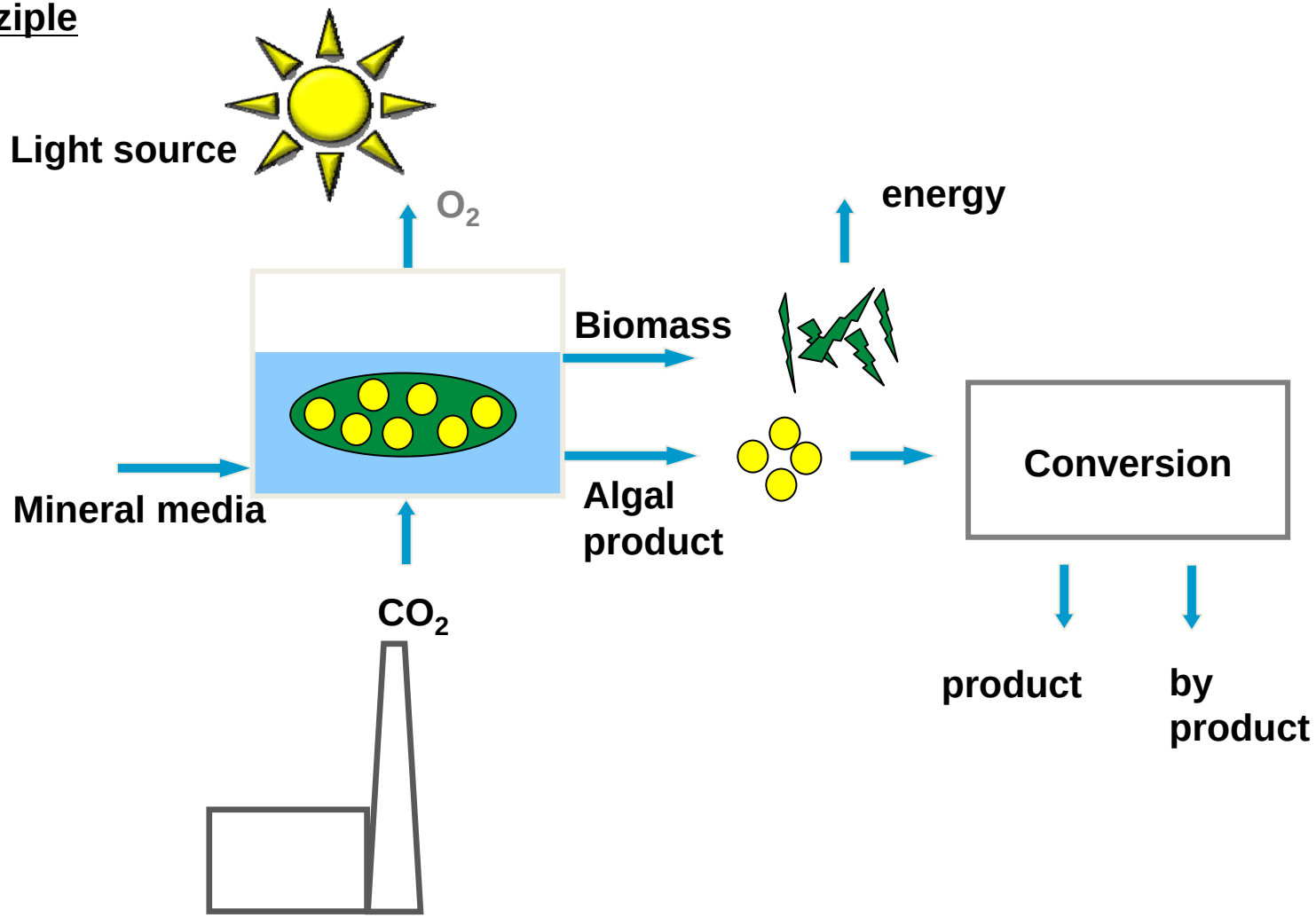
Anaerobic Digestion

Gas Treatment

Algae Cultivation

Algae cultivation

Prinziple



Algae cultivation

Open cultivation

Open ponds

Sapphire Energy, San Diego

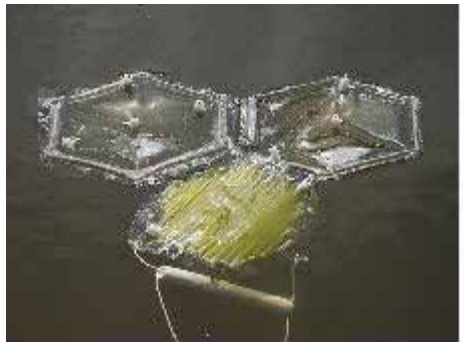
Closed cultivation

Horizontal tubes

Airlift reactors

Klötze, Subitec, Germany

Novel concepts



NASA, US

Algae Cultivation

Energy balance

		Open Ponds	Flat Panel PBR	Tubular PBR
Volumetric Productivity	[kg/m3.d]	0,035	0,27	0,56
Biomass Concentration	[kg/m3]	0,35	2,7	1,02
Energy Consumption	[W/m3]	3,72	53	2500

$$Net\_energy\_ratio = \frac{\Sigma energy\_produced}{\Sigma energy\_requirements}$$

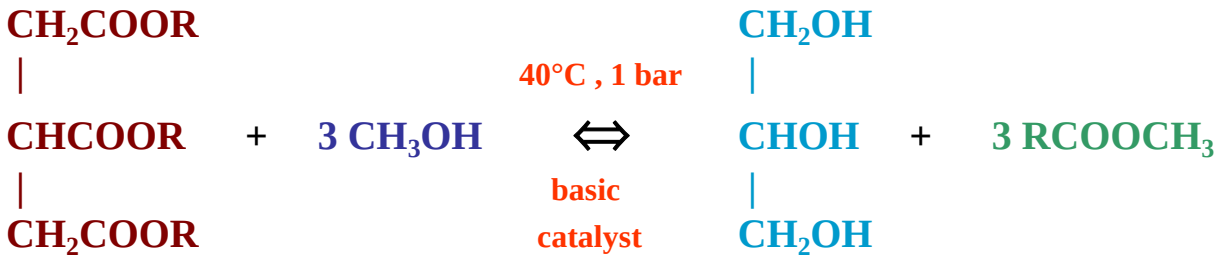
		Open Ponds	Flat Panel PBR	Tubular PBR
NER for Oil	[-]	3,05	1,65	0,07
NER for Biomass	[-]	8,34	4,51	0,2

O. Jorquera, A. Kiperstock Comparative energy LCA of microalgal biomass production in open ponds and PBR, Bioresource Technology, 2009

BioDiesel from Algae

BioDiesel Process

Transesterification



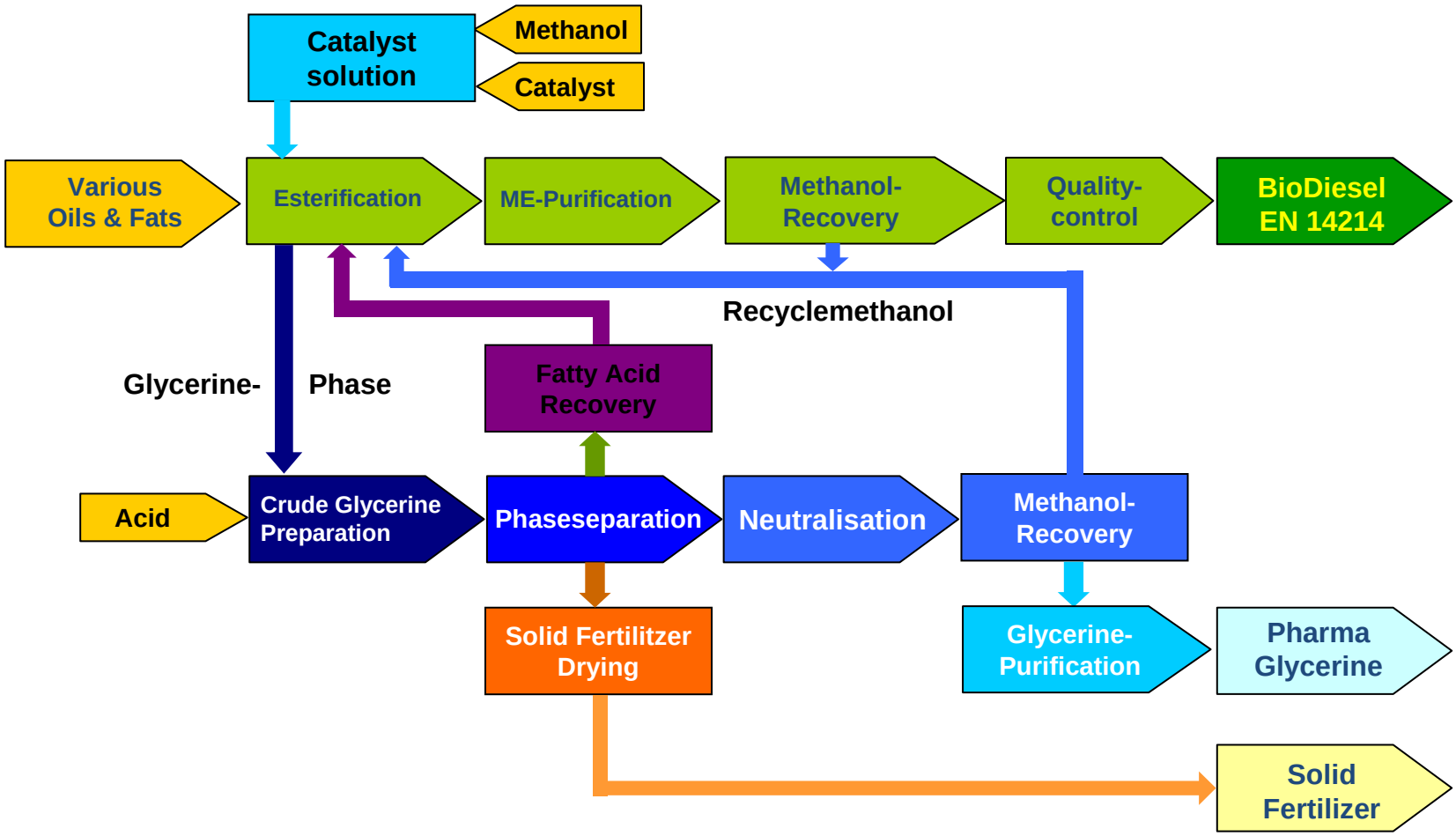
triglycerid (fat) + 3 methanol ⇔ glycerine + 3 fatty acid methyl ester

R = fatty acid chain

Esterification

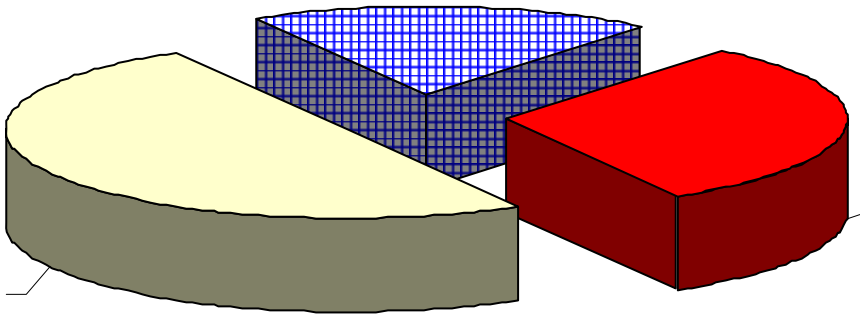
free fatty acid + methanol ↔ fatty acid methyl ester + water

BDI-Process – Flow chart



EN14214 – BioDiesel-Quality Standard

Esterification
5 parameters; 19%

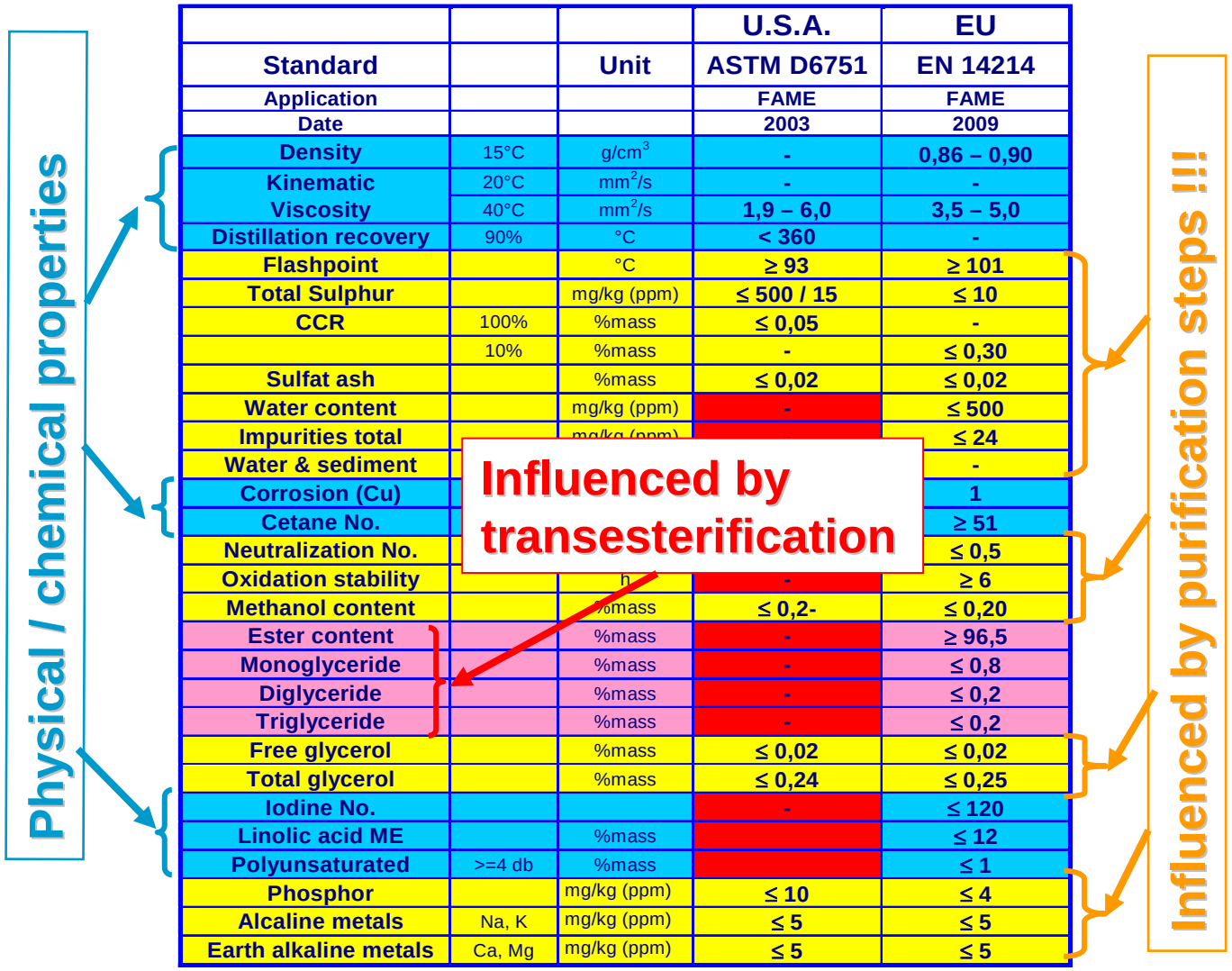


Raw material
8 parameters; 31%

Purification steps
13 parameters; 50%

BioDiesel quality parameters influenced by raw material and process

EN14214 – BioDiesel-Quality Standard



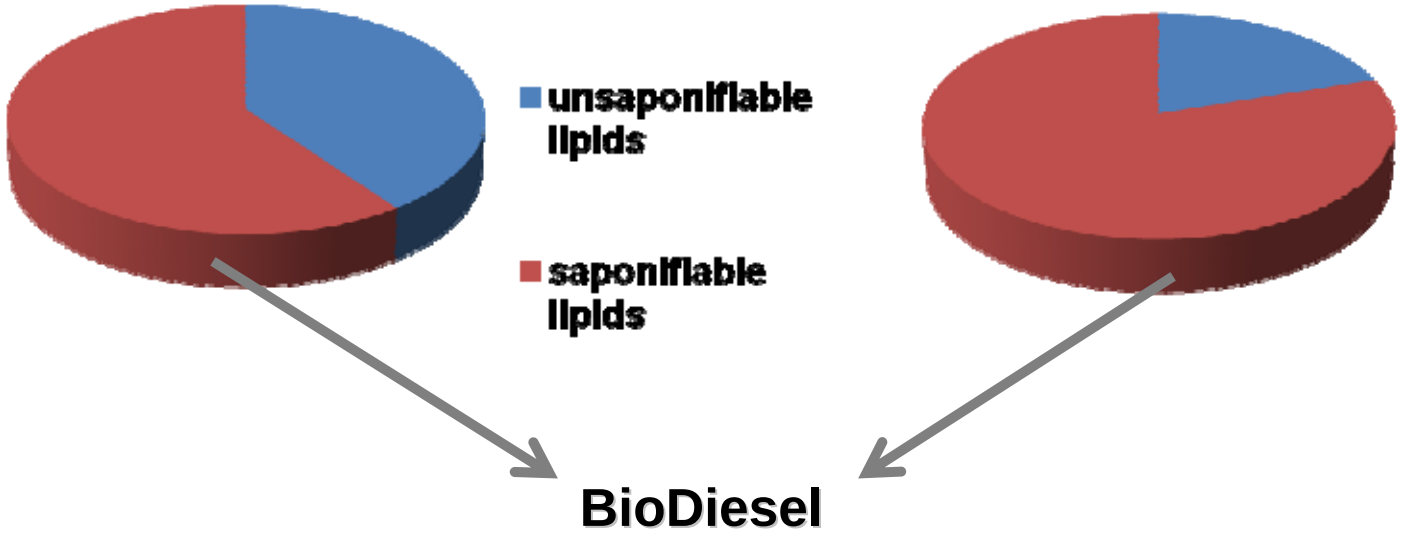
Standard		Unit	U.S.A. ASTM D6751	EU EN 14214
Application			FAME	FAME
Date			2003	2009
Density	15°C	g/cm³	-	0,86 – 0,90
Kinematic Viscosity	20°C	mm²/s	-	-
	40°C	mm²/s	1,9 – 6,0	3,5 – 5,0
Distillation recovery	90%	°C	< 360	-
Flashpoint		°C	≥ 93	≥ 101
Total Sulphur		mg/kg (ppm)	≤ 500 / 15	≤ 10
CCR	100%	%mass	≤ 0,05	-
	10%	%mass	-	≤ 0,30
Sulfat ash		%mass	≤ 0,02	≤ 0,02
Water content		mg/kg (ppm)	-	≤ 500
Impurities total		mg/kg (ppm)		≤ 24
Water & sediment				-
Corrosion (Cu)				1
Cetane No.				≥ 51
Neutralization No.				≤ 0,5
Oxidation stability		h	-	≥ 6
Methanol content		%mass	≤ 0,2-	≤ 0,20
Ester content		%mass	-	≥ 96,5
Monoglyceride		%mass	-	≤ 0,8
Diglyceride		%mass	-	≤ 0,2
Triglyceride		%mass	-	≤ 0,2
Free glycerol		%mass	≤ 0,02	≤ 0,02
Total glycerol		%mass	≤ 0,24	≤ 0,25
Iodine No.			-	≤ 120
Linolic acid ME		%mass		≤ 12
Polyunsaturated	>=4 db	%mass		≤ 1
Phosphor		mg/kg (ppm)	≤ 10	≤ 4
Alcaline metals	Na, K	mg/kg (ppm)	≤ 5	≤ 5
Earth alkaline metals	Ca, Mg	mg/kg (ppm)	≤ 5	≤ 5

Algae Oil

Possible raw material for BioDiesel production:

Monoglycerides
Diglycerides
Triglycerides
Fatty acids

Possible composition of algae oil:



Content of saponifiable fraction within algae oil varies for different species and process conditions

Raw Material

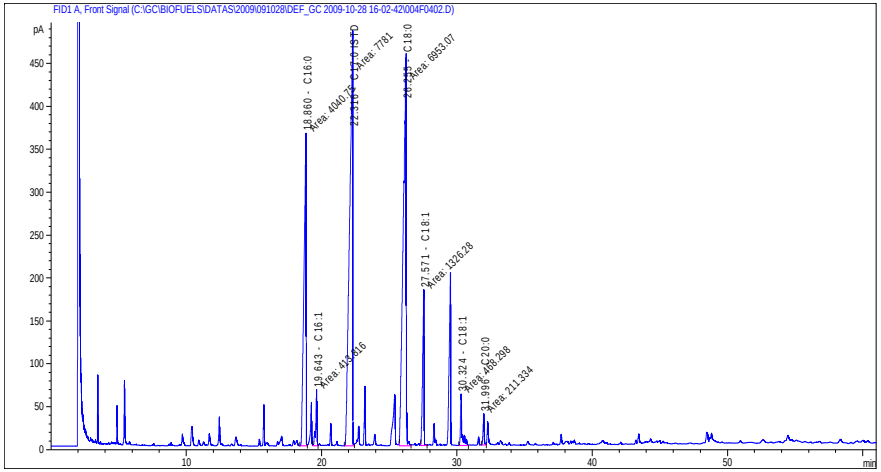
Specification for raw material entering the BDI BioDiesel process

Unsaponifiable
Total fatty acids
Free fatty acid
Water
Insoluble substances
Phosphorous
Sulphur
Polymerised triglycerides
Polyethylene type plastics
Iodine number
Linolenic acid
Polyunsaturated fatty acid (≥ 4 double bonds)

Crude algae oils are off spec in various parameters

Algae Oil

Comparison of fatty acid profile of algae oil with different raw materials



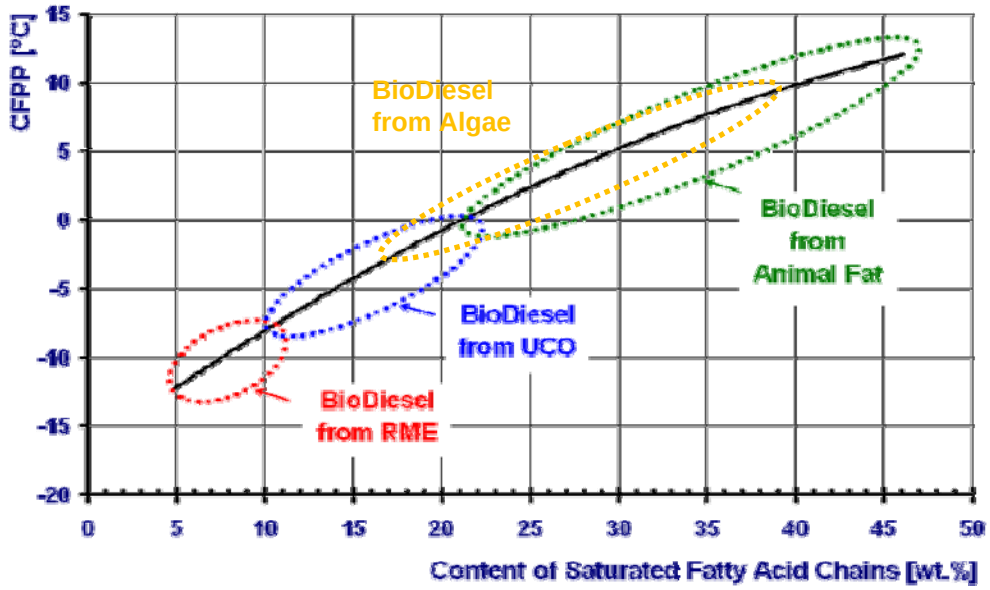
	Rapeseed	Animal fat	Algae oil
C14:0		4%	
C16:0	5%	27%	36%
C16:n		4%	8%
C18:0	1%	20%	9%
C18:1	55%	41%	38%
C18:2	34%	3%	7%
C18:3	4%	1%	3%

Algae BioDiesel CFPP Value

⇨ **Cold Filter Plugging Point (CFPP) [°C]**

Measure for cold behaviour, between cloud point and pour point.
CFPP = highest temperature a defined BioDiesel-volume is no longer able to pass a standardised filter in a certain time.

EN14214 mentions different limits for climate and saison



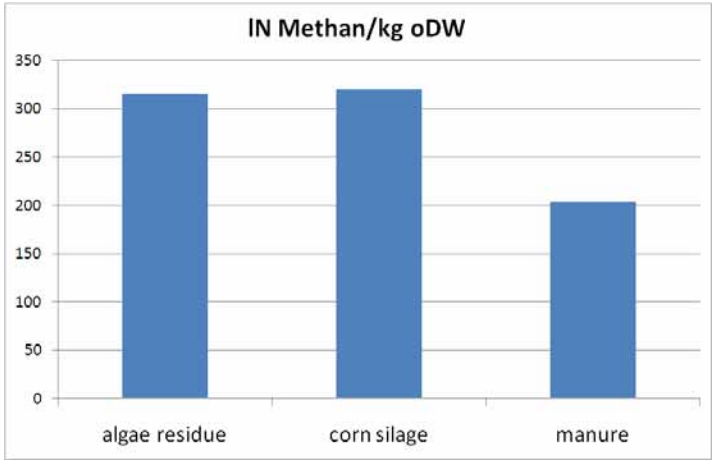
CFPP can be influenced by additives blending

Digestion of Algae Biomass

Biogas

- fermentation of algae paste - solid/liquid separation affects overall energy balance

- fermentation of biomass residues after extraction of oils or high value products



Average biogas rates 500 lN/kg_{oTS}

Relatively high Methane ratios 63% compared to corn silage: 53%

Algae Cultivation with CO_2 from Biogas

CO_2 source

fossil sources: incineration, power plants, cement industry…..

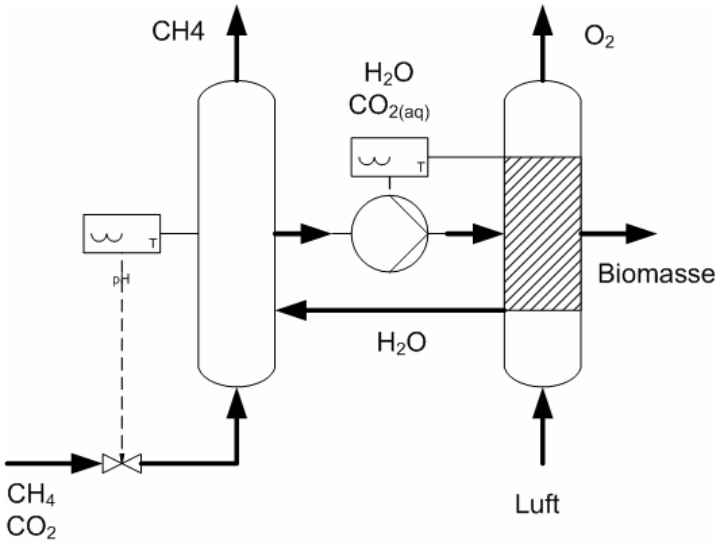
biogenic sources

CO_2 removal from gas mixtures => valorization of gas quality

Biogas **(CH_4)**

→ Biomass

Biogas **(CH_4, CO_2)**



Outlook

Demonstration project AllGasOil:

Industrial scale demonstration of sustainable algae cultures for biofuel production
2011-2016

European consortium:
algae cultivation in 10 ha algae facility in Spain

use of waste water, CO2 from Biogas
production of BioDiesel, Biogas, PUFA, power

BioDiesel conversion in existing BDI plant




Summary

- **Microalgae high potential for added value and future energy products**
- **Algae oil is a challenging raw material for BioDiesel production: fatty acid profile, impurities**
- **Algae oil composition claims mature conversion technology for reaction & purification**
- **algae biorefinery reasonable comibination of suitable processes**

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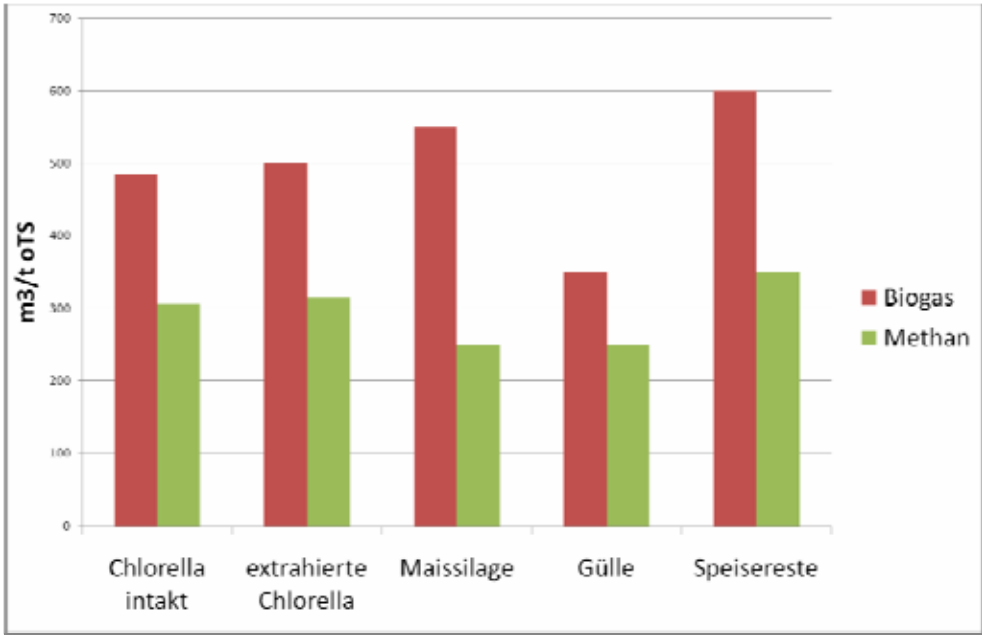
Our future. Clean energy.

Vergärungsversuche Algenbiomasse

Untersuchung von AlgenBiomasse als Biogassubstrat

über Enbasys (Fa. ATRES)

- **Intakte Biomasse**
- **aufgeschlossene Biomasse**
- **Vergleich mit Lit.-Werten**



Relativ hohe Methananteile 63% (Vgl.: 53% Maissilage)

Umrechnung auf TS von Maissilage (35%) und Marktwert von 40€/t
=> überschlägig 120€/t Algenbiomasse erwirtschaftbar

Interessante Option für <u>Extraktionsreste</u>