

# explor@re

**BDI – BioEnergy  
International GmbH**

# Herausforderungen bei der Verwendung von Algenöl als Rohstoff für BioDiesel

**BDI – BioEnergy International GmbH**

Robert Raudner

Netzwerk Algen 2018 Tulln



# *Business Data*

## **Business Activities**

- Consulting
- Engineering
- Construction
- Commissioning & Start-up
- After Sales Service

## **BioDiesel**

## **RetroFit**

## **Key Values**

- Longterm Experience
- Research & Development
- Turnkey Capability
- Financial Strength



# Historical Milestones

**1991 Austria**  
**1994 Austria**



1<sup>st</sup> Industrial-scale plant ever built world-wide for the production of BioDiesel from Rapeseed Oil

1<sup>st</sup> Multi-Feedstock Plant ever built world-wide for the production of BioDiesel from Used Cooking Oil

**1998 USA**



1<sup>st</sup> Multi-Feedstock Plant ever built world-wide for the production of BioDiesel from Animal Fat

**2005 UK-Scotland**



1<sup>st</sup> Multi-Feedstock Plant ever built world-wide for the production of BioDiesel from High Risk Fat

**2012 Hongkong**



1<sup>st</sup> Multi-Feedstock Plant ever built world-wide for the production of BioDiesel from Trap Grease



# References



**ALLGAS** (Spanish pronunciation for algae)

co-funded by the European Commission

**SEVENTH FRAMEWORK PROGRAM**

**ENERGY.2010.3.4-1**

**Biofuels from algae**

**Project Number: 268208**

**Total funds of the European Union: 7.1 M€**

**Project start 01.05.2011**



**Part of BDI's RetroFit program: prepare BioDiesel plants for the future**

**→ use of algae oil in an existing BioDiesel plant**

# Consortium

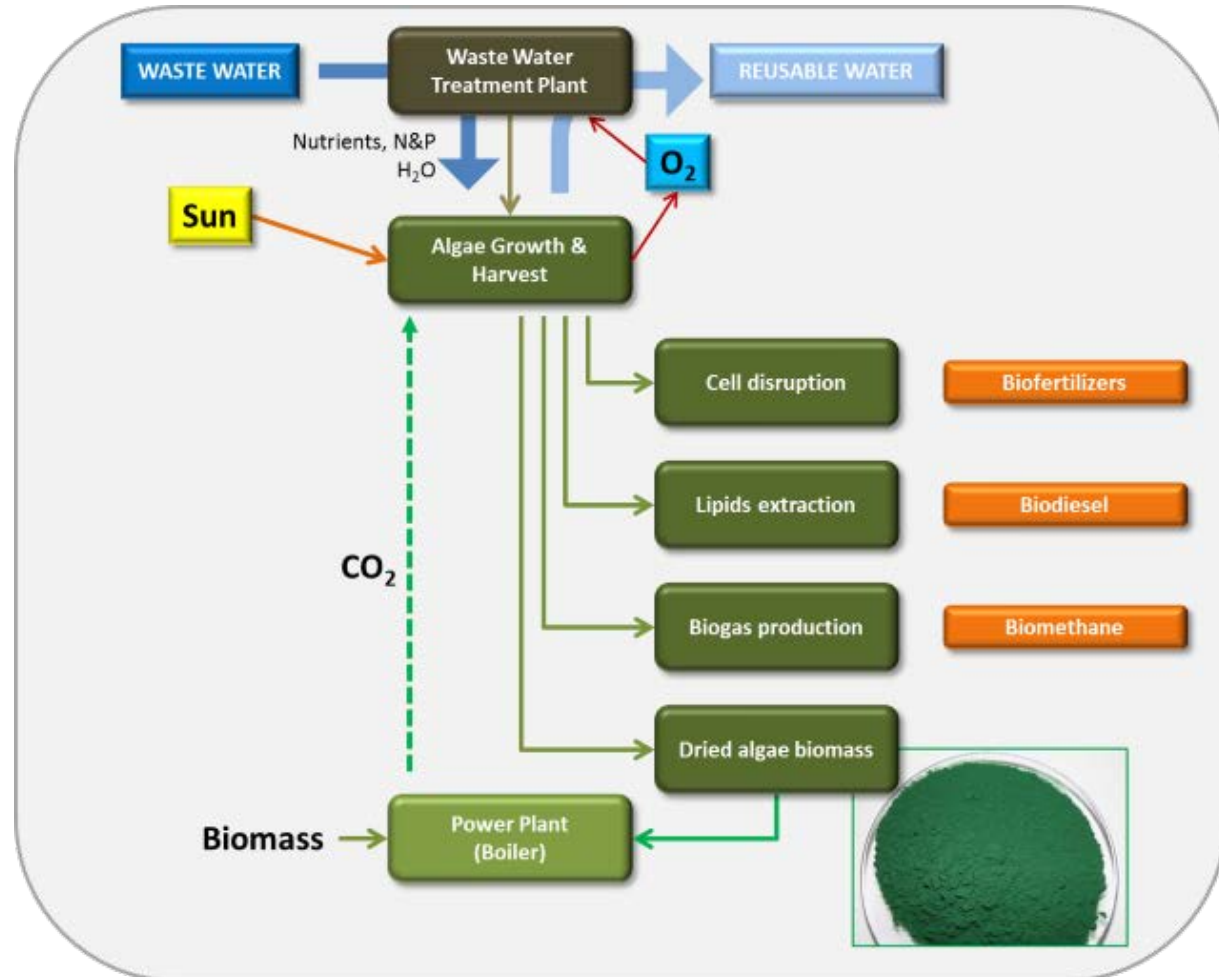
Participant organization name	Role	Country
<b>Aqualia Gestión Integral del Agua S.A.</b> Coordinator Frank Rogalla	Wastewater	<b>Spain</b>
<b>BDI - BioEnergy International GmbH</b>	Extraction Oil conversion	<b>Austria</b>
<b>Hygear B.V</b>	Biogas refinement	<b>Netherlands</b>
<b>University of Southampton</b>	Cultivation, Biogas	<b>UK</b>
<b>Fraunhofer Umsicht</b>	Analytics	<b>Germany</b>





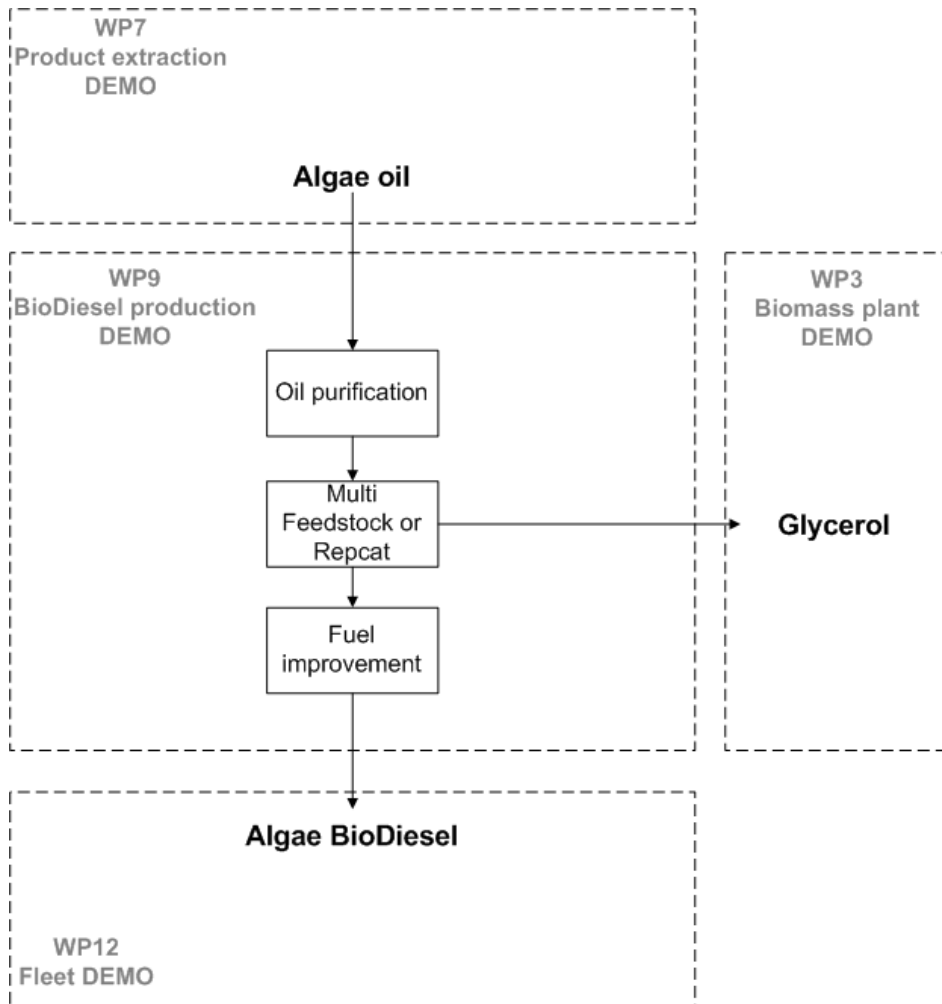
# AllGas Project

- Integrated in waste water treatment
- Open pond-raceway
- Extraction of lipids
- Lipids in BioDiesel
- Residues and Algae in Biogas
- Fleet test of Algae Biogas
- Feasibility Study Algae BioDiesel
- DEMO-Scale 2 ha in Spain





# BDI's part





# *Project Delay*

Prototyp (2014)



Industrial scale demonstration (2017)





## QUALITY OF FEEDSTOCK

**1<sup>st</sup> question: what can be obtained from Algae ?**

**→ Lipids**

**Definition of “lipids” according IUPAC:**

*“A loosely defined term for substances of biological origin that are soluble in nonpolar solvents. They consist of saponifiable lipids, such as glycerides (fats and oils) and phospholipids, as well as nonsaponifiable lipids, principally steroids.”*

[<http://www.chem.qmul.ac.uk/iupac/class/lipid.htm>]

**→ In discussion in CEN/TN 454: algae oil vs. total lipids**

“nonpolar solvents”: Influence of solvent’s polarity on quality and quantity

Solvent	H <sub>2</sub> O	Methanol	Diethyl ether	Petroleum ether	n-Hexane
Max. Water content	-	soluble	1,05% w/w	0,08% w/w	0,02% w/w
$\epsilon_r$ [1]	80,1	33,0	4,27		1,88
$\epsilon_r$ [2]	high	0,73	0,29		0
$\epsilon$ [3]	78,5	32,6	3,4	2,0	1,9

[1] David R. Lide, ed., CRC Handbook of Chemistry and Physics, 87th Edition, Internet Version 2007

[2] Meyer, V.R. (2009): Praxis der Hochleistungsflüssigchromatographie (10. Auflage), WILEY-VCH

[3] <http://infohost.nmt.edu/~jaltig/TLC.pdf> download 17.09.2014

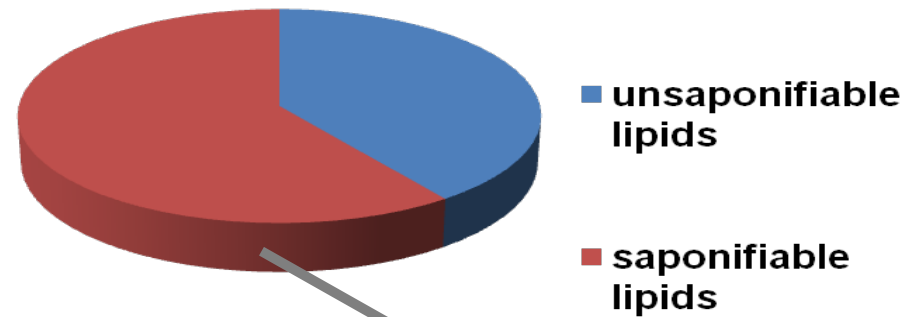
# Lipid Quality

## Polar Lipids

- Phosphoglycerides
- Glycosylglycerides

## Unpolar Lipids

- Acylglycerols
- Free fatty acids
- Unsaponifiables



→ BioDiesel (?)

Possible influence of unsaponifiables on yield, ester content (distillation required?)

Oil must be pumpable for industrial scale conversion



Parameter	Expectations	Value
Algae oil content in DW	20% w/w acc. EU-goal	2-5% w/w *
Esterifiables	100% w/w	50 – 70% w/w *
Unsaponifiables	< 2% lt. BDI spec	10-50% w/w *
Sulphur	<100 mg/kg acc. BDI spec	200-300 mg/kg *
Phosphorous	<100 mg/kg acc. BDI spec	> 6000 mg/kg*
Magnesium	ppm-Area	> 2000 mg/kg*

\* Depending on extraction process

- 1. Sophisticated BioDiesel process required**
- 2. Key-parameters differ significantly from vegetable oil**
- 3. To achieve BioDiesel standard, most likely blending with other feedstock required**

## Phosphorous

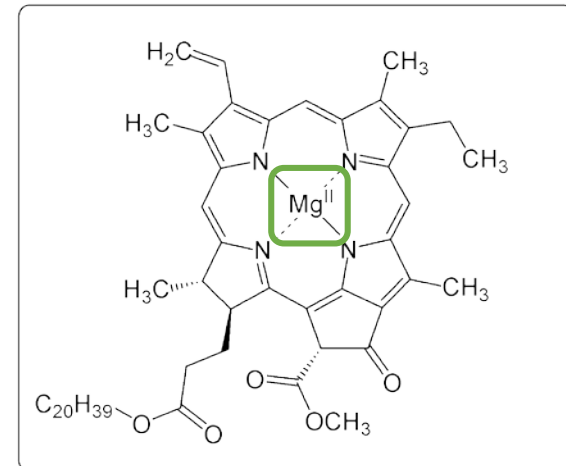
Phospholipides (membrane lipids) – very much depending on extraction process, degumming possible?

→ Phase separations ?

## Metals II

Magnesium part of chlorophyll

Sulphur content?



Chlorophyll a

## Fatty acid distribution

→ Iodine number

→ C18:3

→ PUFA (i.e. acc. EN 14214: C20:4, C20:5, C22:5 & C22:6), (but C16:3?, C16:4?, C18:4?)

Fatty acid profile and the lipid composition may change in one species depending on

- Temperature Effects<sup>1</sup>
- Different Lights<sup>1</sup>
- Salinity Effects<sup>1</sup>
- pH Effects<sup>1</sup>
- Nutrient Effects<sup>1</sup>

<sup>1</sup> e.g. M. T. Arts, M. T. Brett, M. J. Kainz (eds): Lipids in Aquatic Ecosystems, 2009, Springer



# Alge BioDiesel Quality

## Quality of biodiesel depending on algae oil

Property	Unit	min.	max.
Ester content	% w/w	96,5	-
Density at 15°C	kg/m <sup>3</sup>	860	900
Viscosity at 40°C	mm <sup>2</sup> /s	3,50	5,00
Flashpoint	°C	101	-
Sulphur content	mg/kg	-	10,0
Cetan number		51,0	-
Ash content	% w/w	-	0,02
Water content	mg/kg	-	500
Total contamination	mg/kg	-	24
Copper corrosion (3h at 50°C)	-	1	
Oxidation stability at 110°C	hours	8,0	-
Acid value	mg KOH/g	-	0,50
Iodine number	g <sub>I<sub>2</sub></sub> /100g	-	120

# Alge BioDiesel Quality

## Quality of biodiesel depending on algae oil

Property	Unit	min.	max.
Linolenic acid methyl ester (C18:3)	% w/w	-	12,0
Poly unsaturated FAME ( $\geq 4$ db)	% w/w	-	1
Methanol content	% w/w	-	0,20
Monoglycerides	% w/w	-	0,70
Diglycerides	% w/w	-	0,20
Triglycerides	% w/w	-	0,20
Free glycerol	% w/w	-	0,02
Total glycerides	% w/w	-	0,25
Metals I (Na + K)	mg/kg	-	5,0
Metals II (Ca + Mg)	mg/kg	-	5,0
Phosphorous	mg/kg	-	4,0
CFPP	°C		

# Challenges

- Availability of algae oil
- Reasonable price
- Algae oil must be pumpable
- Algae oil is not comparable to vegetable oil
- Quality of the oil → lipid content ≠ esterifiable oil
- Standard BioDiesel process cannot handle algae oil as no phase separation occur → special process required e.g. BDI RepCat Technology
- Quality of final product depending on quality of algae oil



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