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## Joint Seminar of BMBF and Siemens "CO<sub>2</sub> Utilization Potential"

22/23 September 2009, Steigenberger Grandhotel Petersberg, Bonn

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### 22 September 2009

General introductory talk

Dr. Johannes Ewers, RWE Power AG

Keynote presentations on "CO<sub>2</sub> utilization on the basis of biological processes"

Dr. Ulrich Schurr, Forschungszentrum Jülich GmbH

▶ **Dr. Martin Kerner, SSC Strategic Science Consult GmbH**

Keynote presentations on "Inorganic CO<sub>2</sub> utilization, mineralization"

Prof. Hans Geerlings, TU Delft, DelftChemTech

Prof. Ron Zevenhoven, Åbo Akademi University

Keynote presentations on "Alternative fuels and energy sources for industry and transport"

Prof. Dr.-Ing. Kai Sundmacher, Max-Planck-Institut Dynamics of Complex Technical Systems

Prof. Dr. Eckhard Dinjus, Forschungszentrum Karlsruhe

# CO<sub>2</sub> utilisation on the basis of microalgae

Keynote presentation by  
Dr. habil. Martin Kerner

MD of Strategic Science Consult GmbH and  
Coordinator of the project TERM  
(Technologies for the Exploration of the Ressources Microalgae)



# Content

- Is it possible to develop feasible and economic microalgae technology for large scale biomass production and CO<sub>2</sub> utilisation by further research work
  - » General strategies
  - » Focus of research
  - » R&D potential
- What are the framework requirements to fortify microalgae R&D in Germany
  - » Interests within PPP structures
  - » Structural shortfalls
  - » Funding
  - » Suggestions for improvement

# General strategies

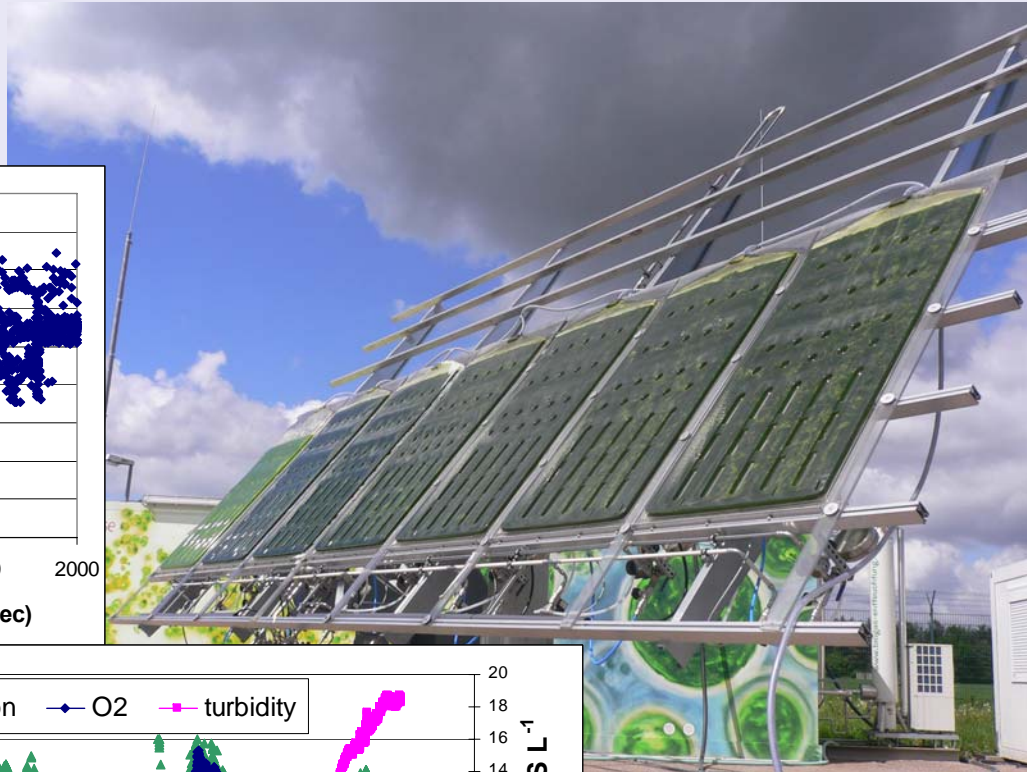
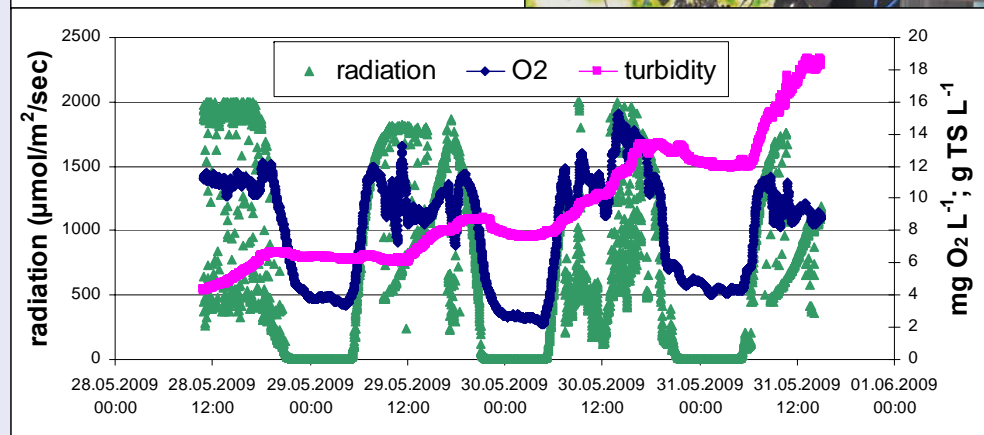
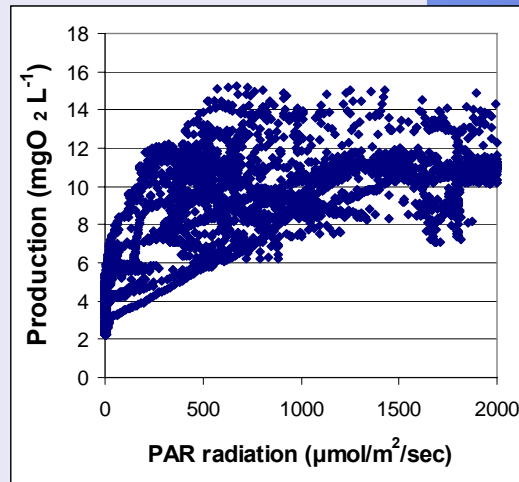
## Improving the production

- Increase the efficiency of light conversion (< 12%)
- Increase the use of radiation (200-300  $\mu\text{mol}/\text{m}^2/\text{sec}$ )
- Increase the amount of biomass produced (>15 g dw/ $\text{m}^2/\text{a}$ )
- Control the composition of the biomass (energy content, high value biochemicals etc.)

## Improving the added value

- Develop different products from biomass
- Develop large scale technology (automation and drives)
- Couple microalgae technology with the cycling of wastes ( $\text{CO}_2$ ,  $\text{NO}_x$ , nutrients, organic substances, heat)

# Focus of research : Reactor technology



TERM Technologies for the Exploration of  
the Ressource Microalgae

# Focus of research: Reactor technology

- Problems solved
  - Biofouling
  - Efficient use of radiation
  - Supply with flue gas
- Unsolved problems
  - Efficient use of flue gas
  - Temperature control (overheating)
  - Product engineering



# Focus of Research: Gene technology

Prozess	Aim	Potential	Research status (BR = Basic Research)
CO <sub>2</sub> Fixation	Increase of biomass production	??	BR: enzymatic regulation
Photosynthesis	Light efficiency & ETR	10-?? %	BR: Antenna pigments, Regulation PS I & II
Photorespiration	Minimize loss of ATP	30 % biomass	pat. method validated at higher plants
Metabolism	Production of spez. substances	100 %	BR
Biomass-composition	Increase of energy content	100 -?? %	Nutrient limitation/ addition of organics
H <sub>2</sub> -Formation	Increase of production	6 -?? fold	BR: 6 fold proved for <i>C. reinhardtii</i> CC406

Prof. Dr. Kruse, Uni Bielefeld  
Prof. Dr. Nickelsen, Uni München

# Focus of Research: Gene technology

- Pilot plants need security status 1

## **S1 demands for**

- a closed production system (to ensure escape of large quantities)
- Auxotrophie (no survival in nature)
- Specific treatment of waste water (UV radiation)

- Public opinion is against products from transgenic organisms

- Legislation necessary for using transgenic microalgae on the industrial scale

- + Products do not have to be declared from transgenic algae if they are from outside the organisms (milking technology)

# Focus of Research: Harvesting

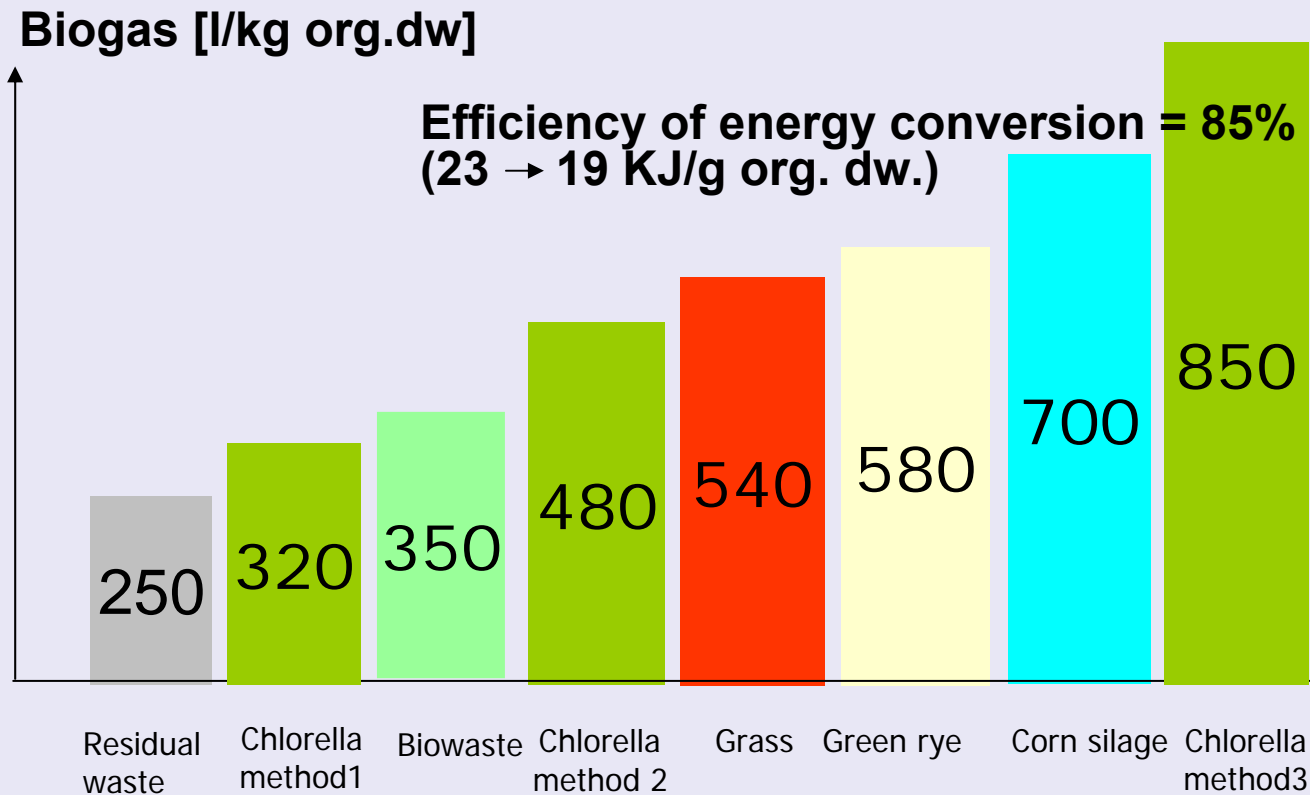
General aim: harvesting at zero energy



Example of an enhancement of flocculation and sedimentation of *Chlorella vulgaris* by adding the condensate from flue gas

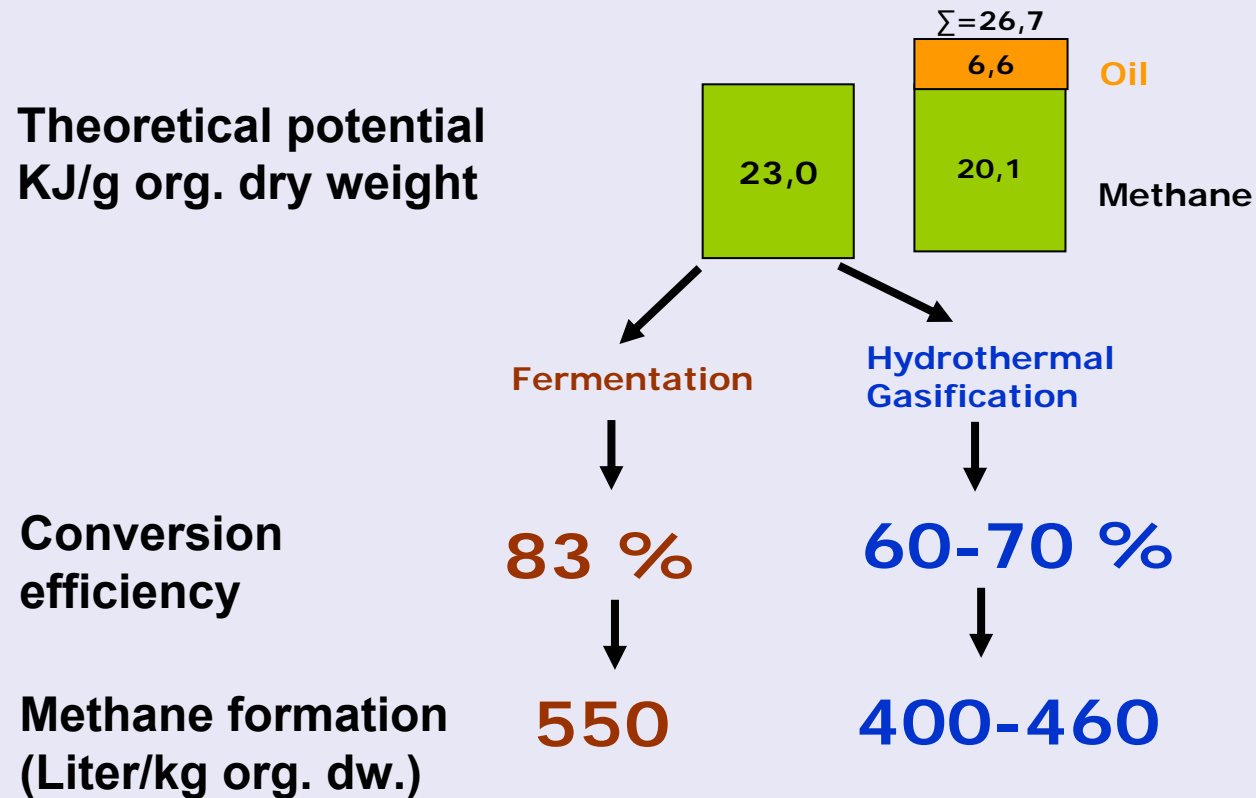
TERM Technologies for the Exploration of  
the Resource Microalgae

# Research focus: Energy recovery

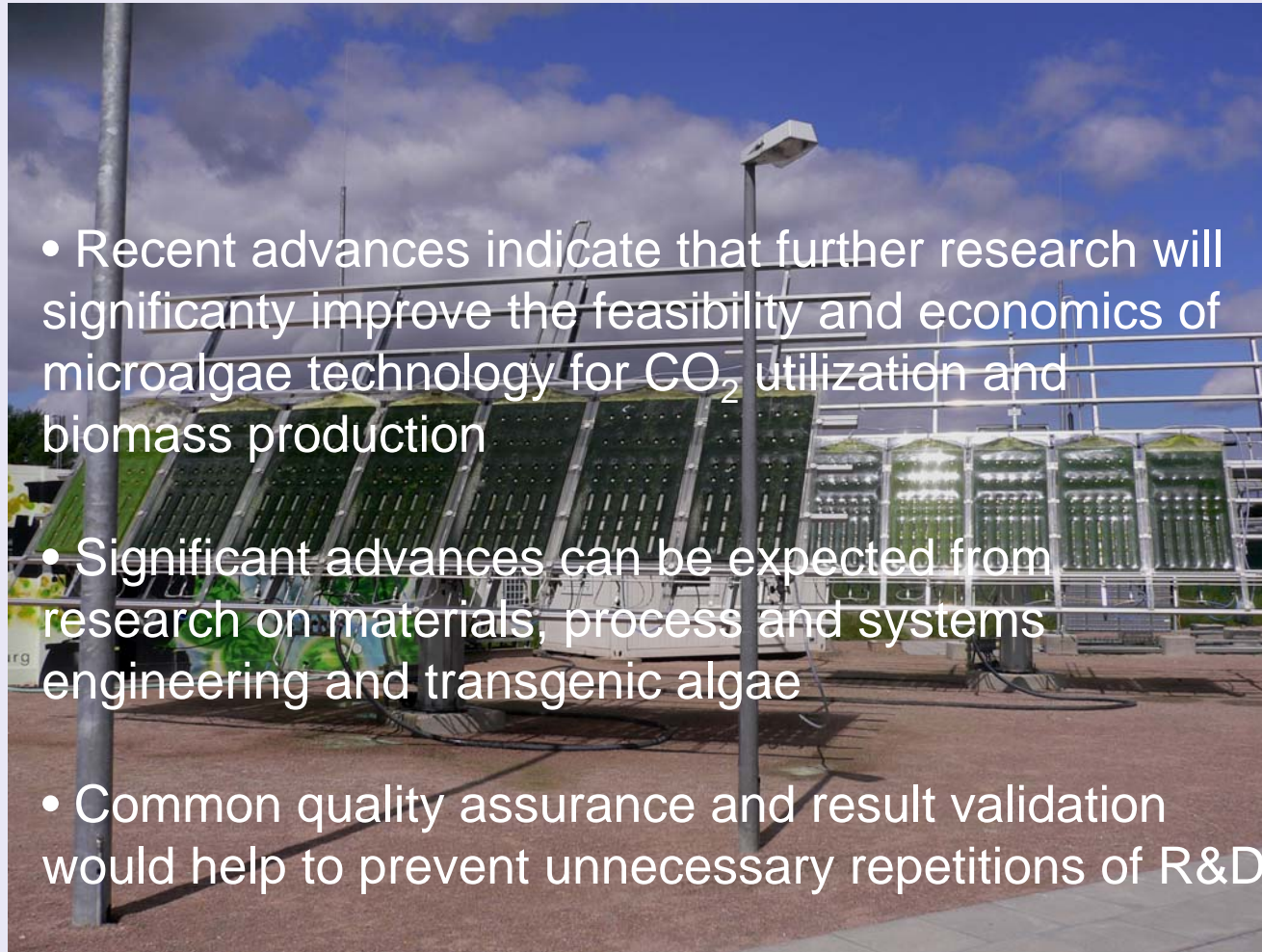


J. Heerenklage, I. Körner, TUHH  
Institut für Umwelttechnik und  
Energiewirtschaft

# Research focus: Energy recovery

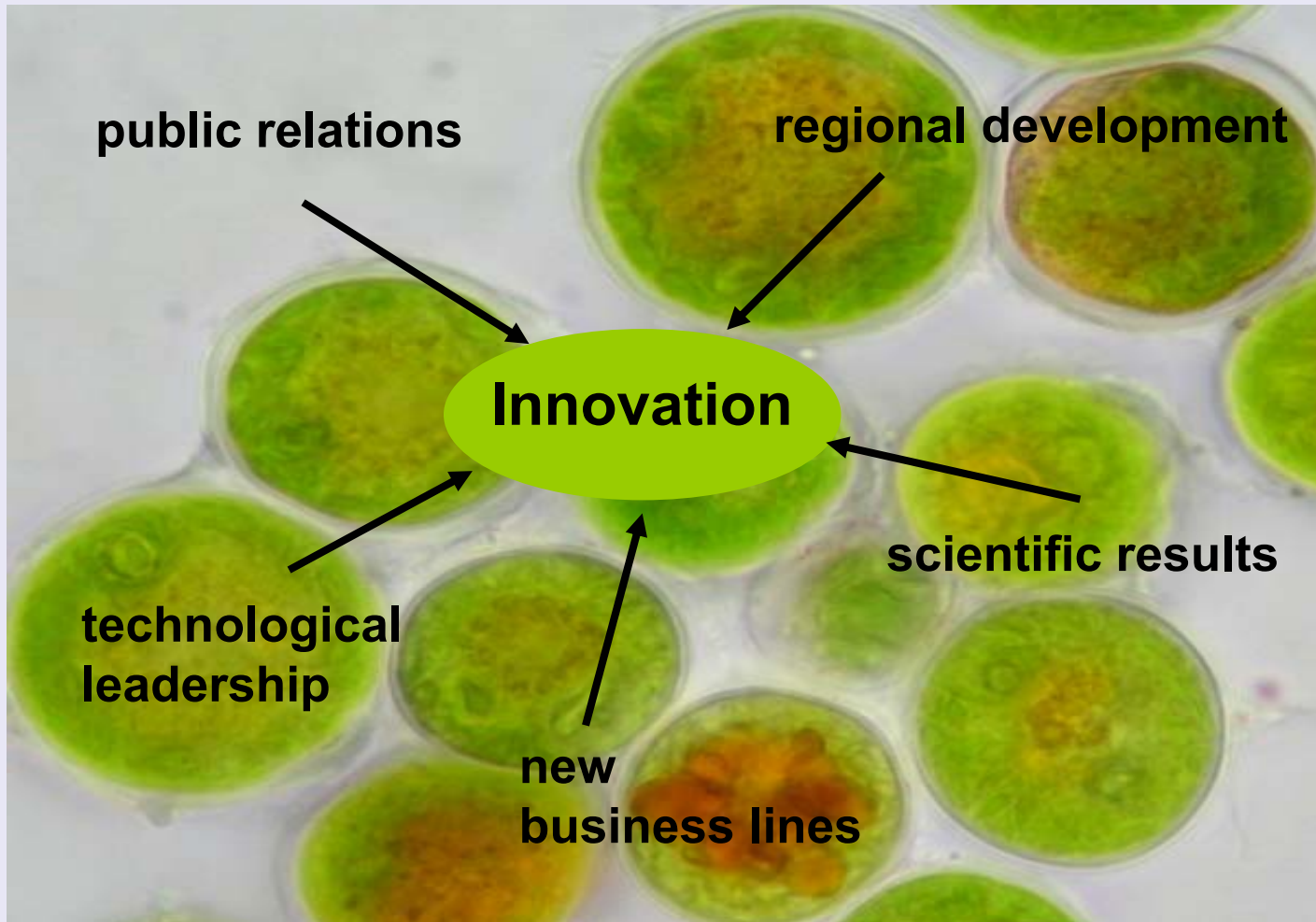


# R&D Potential

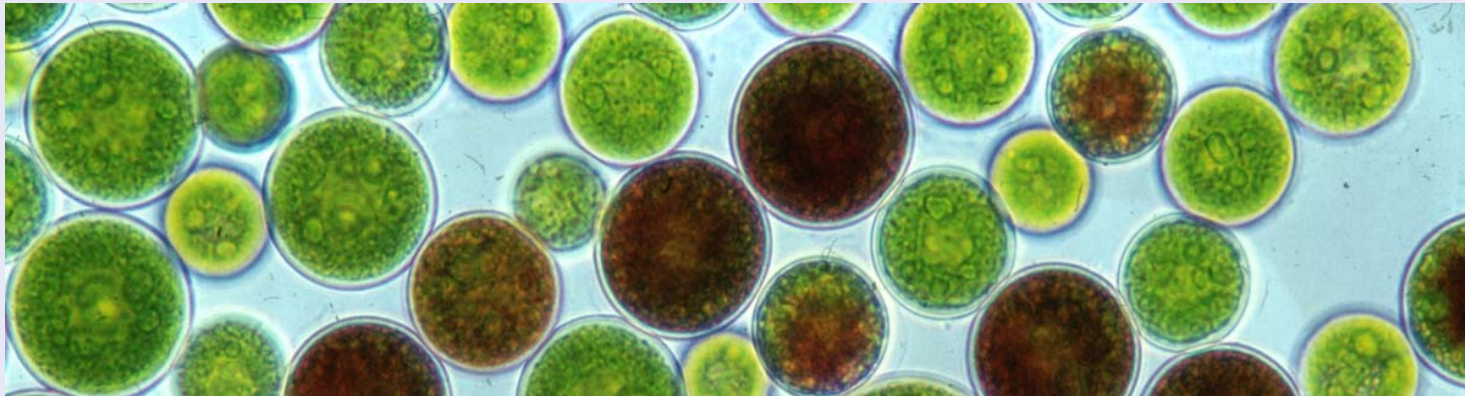


- Recent advances indicate that further research will significantly improve the feasibility and economics of microalgae technology for CO<sub>2</sub> utilization and biomass production
- Significant advances can be expected from research on materials, process and systems engineering and transgenic algae
- Common quality assurance and result validation would help to prevent unnecessary repetitions of R&D

# Interests of different players of PPP structures in microalgae technology



# Structural shortfalls



1. Technological leadership and new business lines are driving forces for innovation development and are mainly located at SME`s which need a specific funding to reduce R&D risks
2. A singular interest in PR without the willingness to bear the risks of new approaches of R&D is contraproductive for innovation development
3. Scientific results are a strong interest for research institutions if funding rate is 100%
4. Regional development interests are very efficient to direct funding properly. It limits, however, the participation of partners from another region

# Funding shortfalls

## **EC-FP7 Work Programmes 2010**

Calls in Energy programme

- Biofuels from microalgae (3.4.1)

Calls in KBBE programme

- Algae for high added value products(3.2.1)
- Biomass from micro- and macro-algae for industrial applications (3.2.2)
- Modification of algae for industrial application(3.2.3)

**Apparent gap**

## **National programmes**

- None for microalgae (BMW, BMBF, BMU)
- Funding of industrial research and prototype development possible by ZIM- and regional- programmes (reserved for SME`s)

# Suggestions for improvements

- Public support programmes should close the apparent gap between national and EC funding
- A research and development fund financed by large industries could help to direct the flow of private funding towards new and innovative research
- Politics should improve the conditions for private investments into microalgae research