Microalgae for production of bulk chemicals and biofuels

René H. Wijffels

www.algae.wur.nl
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Microalgae sold in niche markets

- Natural β-carotene
- Astaxanthine
- Health shops
- Ingredient in feed
- Feed fish juveniles
- 1 billion €
- 4,000 tonnes of dry biomass
- Market price: 250 €/kg
Biodiesel from microalgae

- **Botryococcus**
  - Alkanes (C34)
  - High concentrations (40-70%)

- **Other algae**
  - 20-60% lipids

- **High productivity**
  - Palm oil: 6,000 l/ha/year
  - Algae: 20,000-80,000 l/ha/year
  - No competition with food
  - Salt water
Botryococcus

- Harvesting oil with hexane
Industrial demands

- High volumetric productivity and biomass concentration
  - Efficient photobioreactors
- High product concentration
  - Control secondary metabolism
- To be applied at industrial scale
Feasibility study

Delta nv

Horizontal tubes

Raceway ponds

Flat panels
Tubular reactor

Centrifuge

Harvest tank

Monitor and Control Unit

Degasser 25% Headspace

Nutrient Inlet

Biomass

Solar collector

Stack gas/CO2

Inlet

pH

T

DO

Pump

Monitor and Control

Unit

Stack gas/CO2

Nutrient

Inlet
Conclusions Delta report: economical viability

- Power input is the main constrain in photobioreactors
- Sensitivity analysis show that biomass production costs can be further decreased from 4 to 0.4 €/kg
- Parameters that need improvement
  - Mixing system / efficiency
  - Photosynthetic efficiency
    - reactor design
    - cultivation conditions
    - strain improvement / screening
  - Integrate processes
- Positive energy balance still needs to be reached
Economical Viability: Process integration and valorisation

Bulk chemicals and biofuels in 1,000 kg microalgae

- **400 kg lipids**
  - 100 kg as feedstock chemical industry (2 €/kg lipids)
  - 300 kg as transport fuel (0.50 €/kg lipids)
- **500 kg proteins**
  - 100 kg for food (5 €/kg protein)
  - 400 kg for feed (0.75 €/kg protein)
- **100 kg polysaccharides**
  - 1 €/kg polysaccharides
- **70 kg of N removed**
  - 2 €/kg nitrogen
- **1,600 kg oxygen produced**
  - 0.16 €/kg oxygen
- **Production costs**: 0.40 €/kg biomass
- **Value**: 1.65 €/kg biomass

![Pie chart showing the distribution of products and their values](image.png)
Research programs

- Photosynthetic Cell Factories (NWO)
- Solar-H and Solar-H2 (EU)
- Sealand Sole (Min. Agriculture, province Sealand, companies)
- IWT: collaboration with University of Ghent
- Proviron
- EOS-LT (Akzo, Ingrepro, Essent)
- Wetsus (17 companies)
- Pilot plant studies
Research agenda

- Maximization biomass productivity/ yield
- Reduction of energy input
- Maximization productivity metabolites
- New strains
- Biorefinery
- Design scenarios
- Pilot plant
Demonstration or pilot?

- Demand for demonstration
- Supply of lipids for biodiesel
- Systems are not good enough
- Why demonstrate something that is not good enough?
From fundamental research to pre-commercial development *

WUR/WETSUS Algae Pilot Production and Development Center BioFuel Venture

*Spring Associates/WUR
Algae Pilot Production and Development Center

- Development of a process chain
- Experience with systems
- Information for design of full scale plants
- Comparison of systems
- Comparison of strains
- Comparison of feeds (nutrients, CO$_2$, sunlight…)
- Supply of biomass for further processing
- Further processing
Microalgae and biorefinery

- Microalgae are promising
- Microalgae technology is immature
- Development of technology requires large research program
- Combination with biorefinery important
- Join forces
Discussion

- From the standpoint of an expert, is it really applicable this technology for biofuels, how much potential does it offer vs. costs involved?
- What are the main bottlenecks in the development of technology? What possible solutions could be raised?
- Which is the time horizon expected in the development of fuels and chemicals from microalgae?