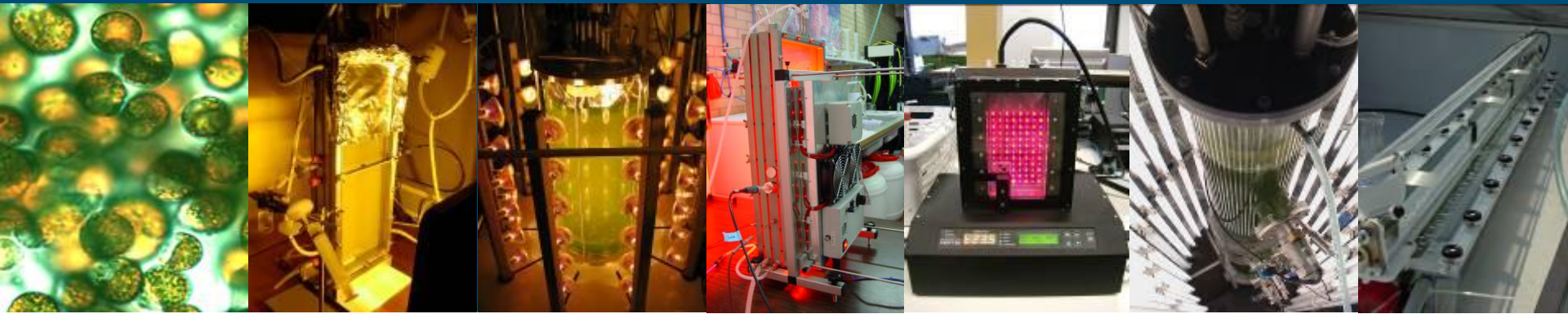


How can algae biology and biotechnology help to improve the efficiency of algae-to-biofuels production chains?

René Wijffels

www.algae.wur.nl

www.AlgaePARC.com



Cost estimation algae production*

- At 1 ha scale today:
10 €/kg
- At 100 ha scale today:
4 €/kg
- What will be possible:
0.40 €/kg
- Still too expensive for
biodiesel alone



To replace all transport fuels in Europe*

- 400 million m³ lipids needed
- 9.25 million ha surface area
- Equivalent to surface area of Portugal
- 400 million tons of proteins produced
- 40 times the amount of soy protein imported in Europe



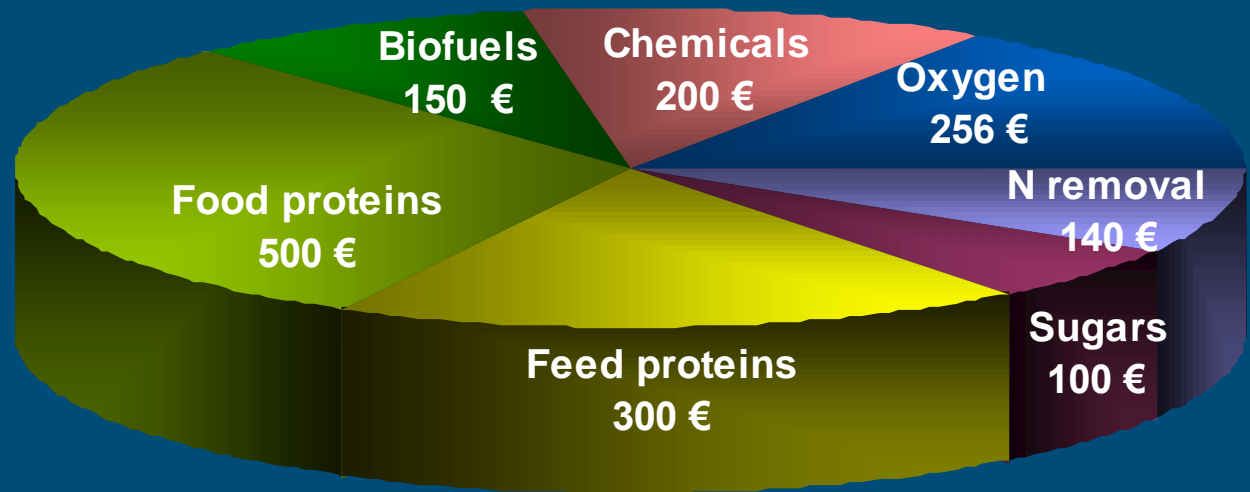
To replace all transport fuels in Europe*

- 400 million m³ lipids needed
- 9.25 million ha surface area
- Equivalent to surface area of Portugal
- 400 million tons of proteins produced
- 40 times the amount of soy protein imported in Europe



Biorefinery of microalgae

- Production costs: 400 €/1,000 kg
- Value algae biomass: 1,650 €/1,000 kg



*Norsker et al. (2011) Microalgal production- a close look at economics, *Biotechnology Advances* **29**: 24-27

Wijffels et al. (2010) Microalgae for the production of bulk chemicals and biofuels, *Biofuels, Bioproducts & Biorefining*, **4**: 287-295.

WP3: Deliverable 3.1: Research Needs

- **Molecular level**
 - Sequencing and annotation of algae industrial candidate species
 - Identification and modelling of biofuel-related metabolic pathways
- **Ecosystem level**
 - Impact on the environment of large scale algae cultivation
 - Contamination with native species
 - Containment of GMO's
 - Logistics and infrastructure
- **Technological level**
 - Scale-up issues
 - Photobioreactor development
 - Biorefinery
- **Conversion to biofuels**
 - Combination of existing (petrochemical) and new technology
 - Issues related to the high water content of algae
 - New fuels (biohydrogen, pyrolysis products)



WP3: D3.2: Technological assessment

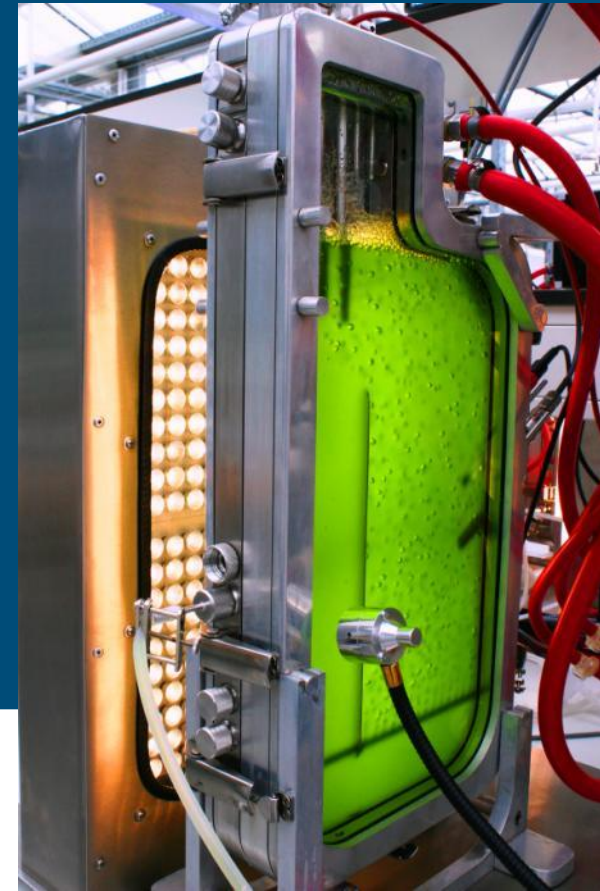
- Microalgae
 - Current large scale cultivation usually open ponds PBR's still require much research and engineering to exploit the inherent increased efficiency
 - Harvesting currently mainly energy-intensive centrifugation, bio- or auto-flocculation seems promising to reduce energy input
 - Extraction of biofuel building-blocks is a challenge because of the tough algal cell wall. New separation techniques are required to retain the functional properties of all biomass components
- Macroalgae
 - Large scale cultivation and harvest operational in Asia; new to Europe
 - Biofuels is new area of application, currently mostly for food purposes



WP3: D3.2: Value added products

■ Microalgae

- Biomass components need to be valorized in order to make biofuel production economically feasible
 - Specific fatty acids (i.e. omega-3 FA)
 - Pigments
 - Cosmetics
 - Isotopically labelled compounds
 - Bioactive compounds
 - Nano technology
 - Biomaterials
 - Pollution abatement (flue gas)
 - Proteins / enzymes



WP3: D3.2: Value added products (3)

■ Macroalgae

- Many applications already available
 - Food/feed
 - Health
 - Cosmetics
 - Agrochemicals (fertilizer)
 - Biotechnology
 - Biomedicine
 - Environmental (i.e. heavy metal chelation)



Objectives WUR

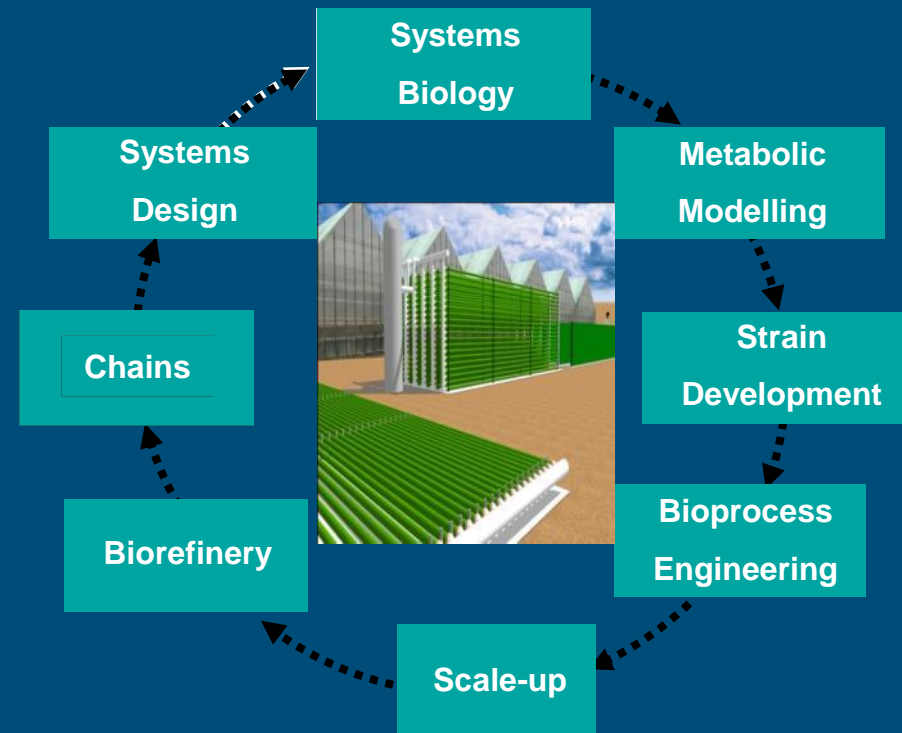
- Development of scalable technology
- Sustainable production of bulk products
 - Biofuels (biodiesel)
 - Food (protein, oil)
 - Feed (protein, oil)
 - Chemistry (amino acids, oil)
 - Materials (silica, polysaccharides)
- Biorefinery



Research facility in Matalascañas, Spain

Wageningen UR algae research

- Multidisciplinary approach
- Research topics
 - Efficient use of sunlight
 - Reduction of energy input
 - Maximization productivity metabolites
 - Biorefinery
 - Scale up
 - Design scenarios



AlgaePARC objectives

- International center of applied research
- Intermediate between basic research and applications
- Development of competitive technology (economics, sustainability)
- Acquire information for full scale plants
- Algal biomass for food, feed, chemicals and fuels



Research plan

- Comparison and optimization of photobioreactors (24 m²)
- Screening species on residual nutrients
- Development of production strategies
- Field tests of production strategies (2.4 m²)
- Long term tests at large scale (24 m²)
- Dynamic process control strategies
- Life Cycle Assessment



Funding AlgaePARC

■ Facility financed by

- Ministry EL&I
- Province Gelderland
- Wageningen UR

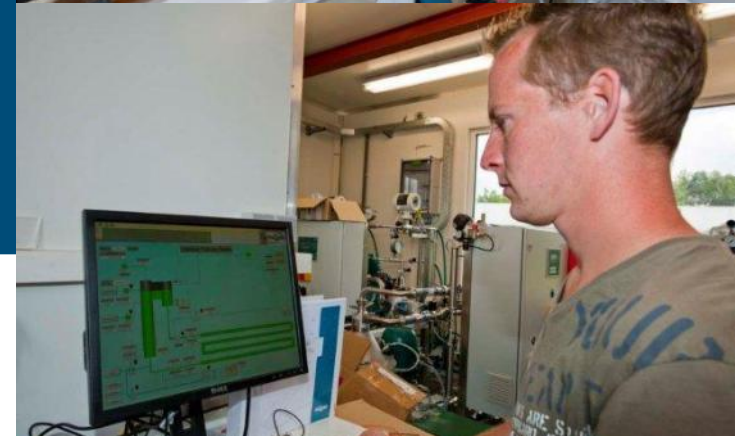
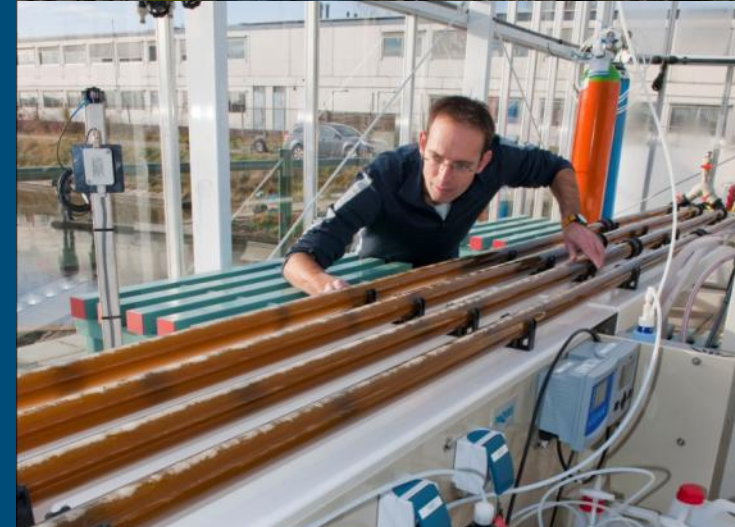


■ Research program financed by



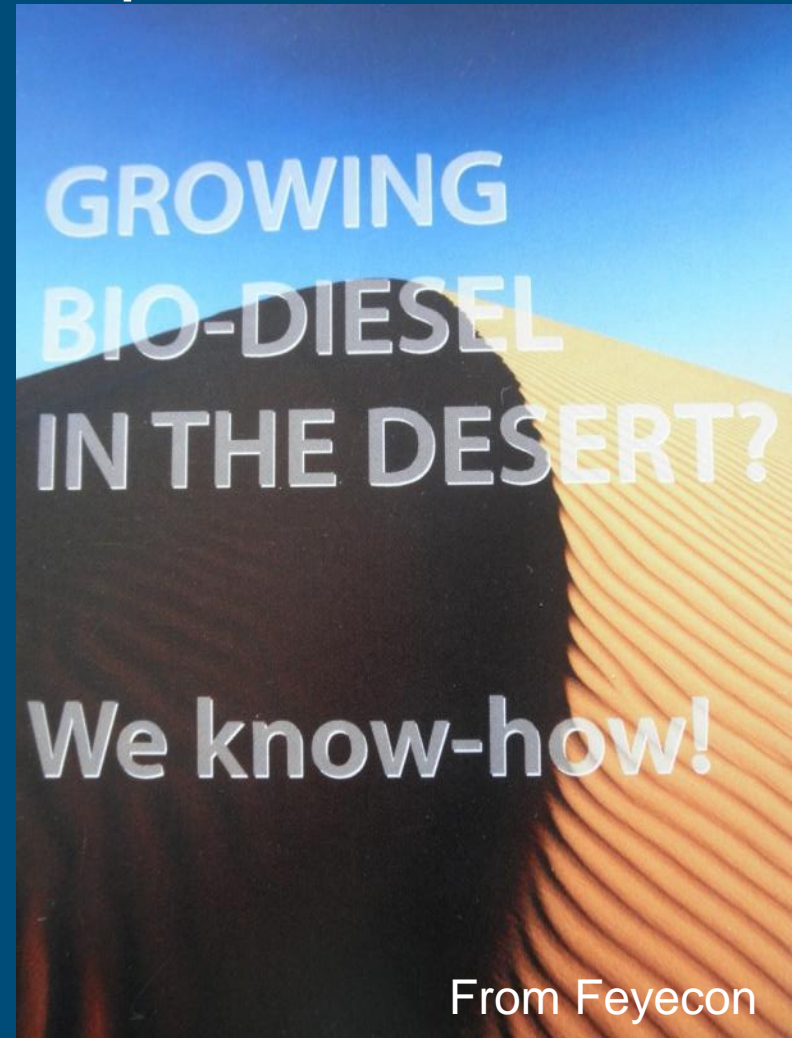
Complexity of biorefinery

- Business model in which different end users need to collaborate
- Market volumes must fit
- Highest value is obtained if functionality of molecules is maintained
- Biomass production and biorefinery depend on each other



Our dream: stand alone algae production*

- Algae production on seawater
 - Prevention of evaporation
- Phosphate/nitrogen
 - Make use of residual feedstocks
 - Do not use P/N at all: milking of microalgae**
- Growth on atmospheric CO₂



From fossil to biobased economy

- Need for professionals
 - 1,000 new professionals/year
 - 5% of students knows what biobased economy means
 - If explained 80% wants to change economy in a biobased economy
- Need for communication and education



Green generation with energy for the future

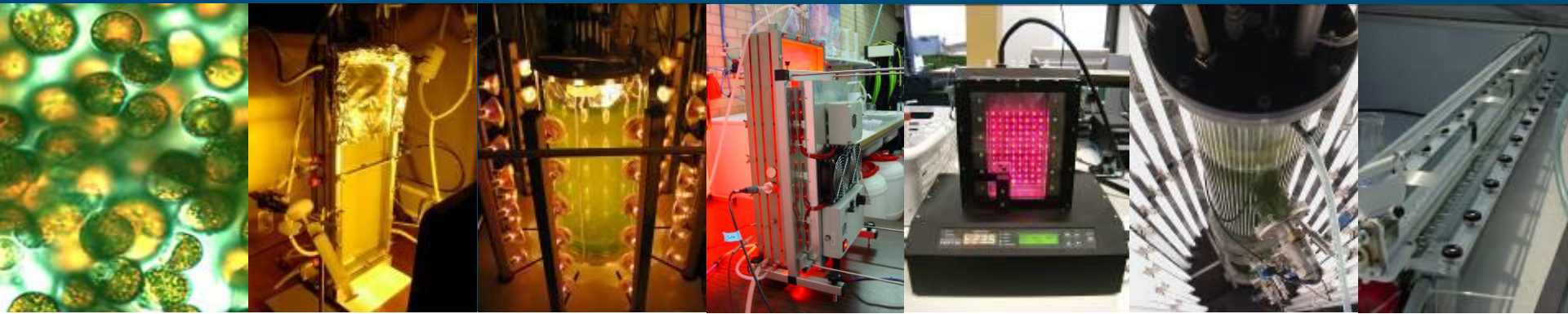
- Development education
 - High schools: learning modules
 - HBO/University: BSc/MSc
 - International graduate course algal metabolite production strategy and photobioreactor design



www.AlgaePARC.com

e-mail: Rene.Wijffels@wur.nl

twitter: @ReneWijffels



AGROTECHNOLOGY &
FOOD SCIENCES GROUP
WAGENINGEN UR