Microalgae for production of biofuels and bulk chemicals

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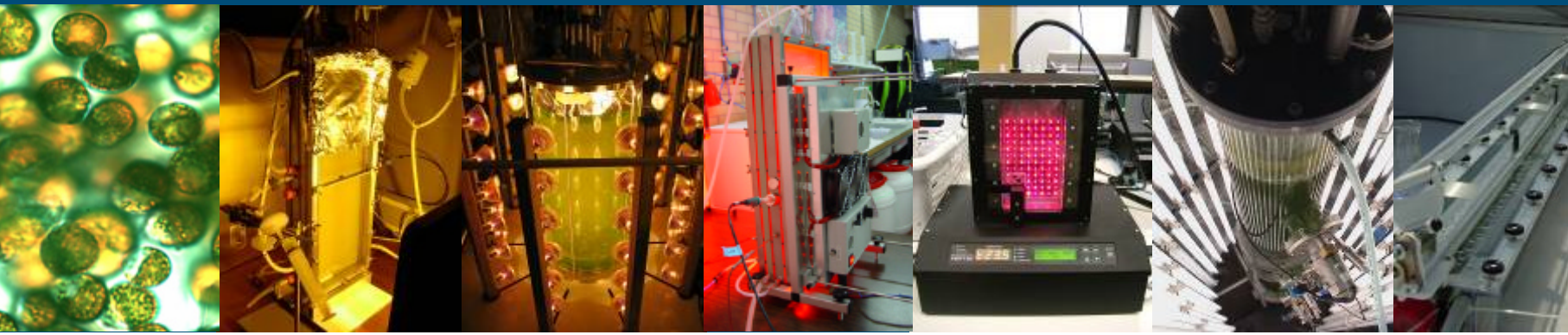
www.algae.wur.nl



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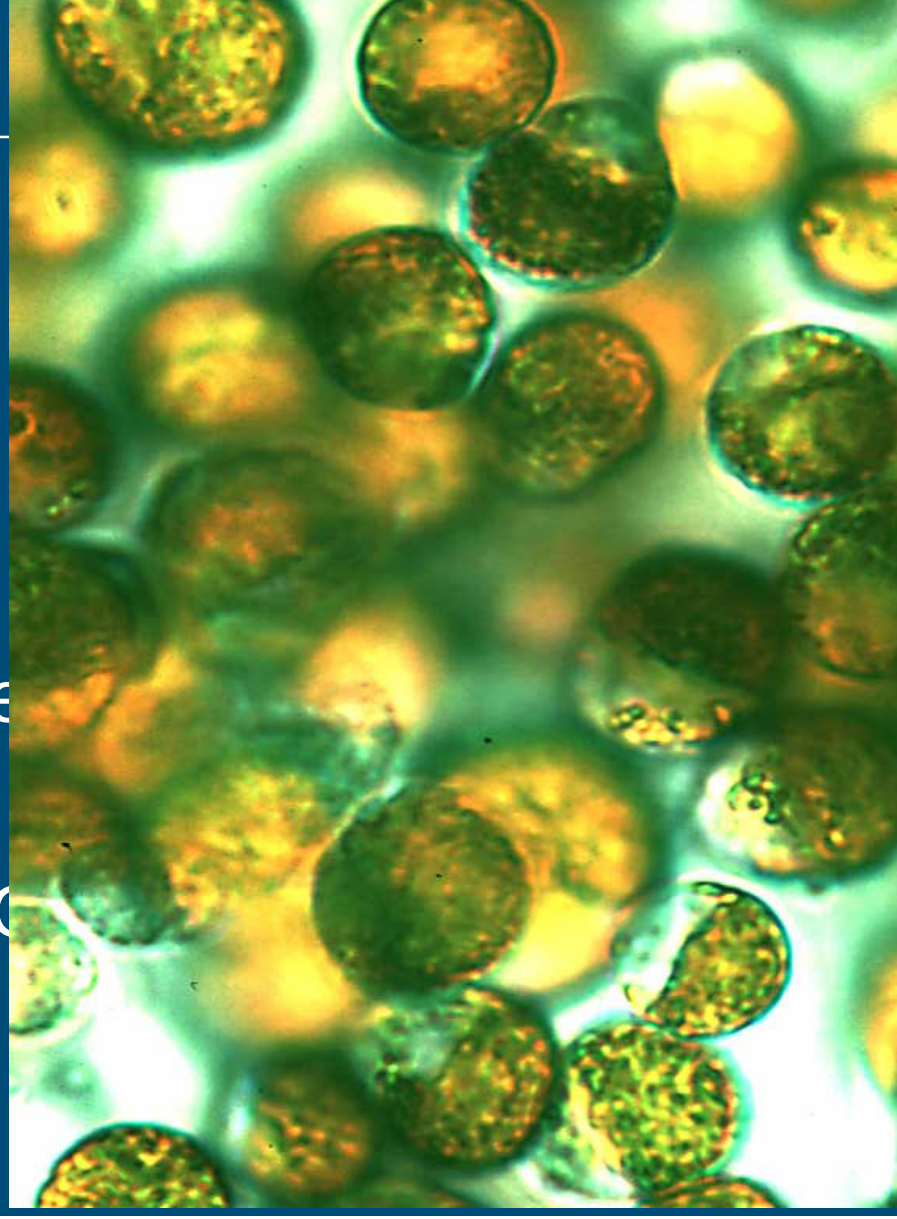
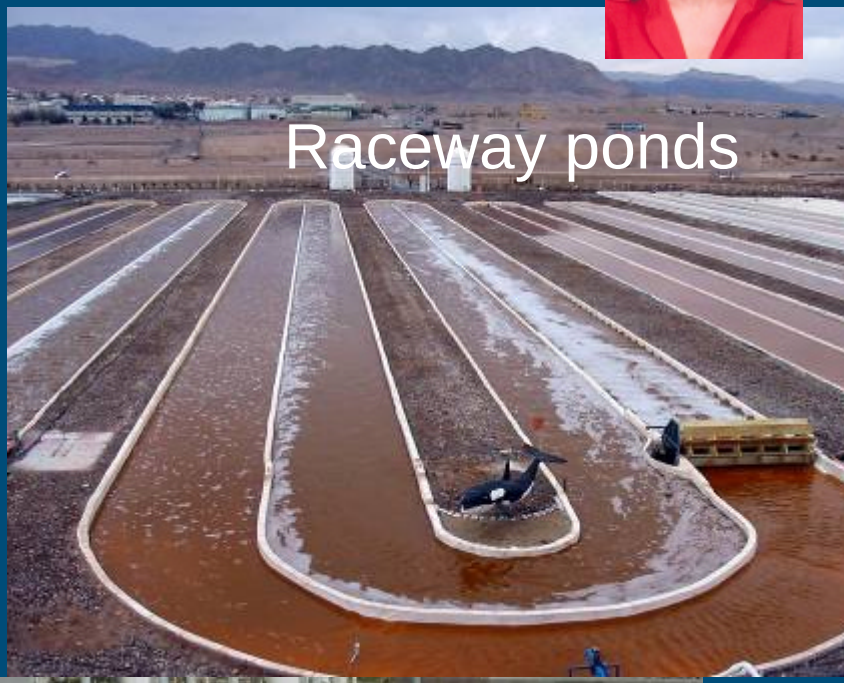


Feasibility study Delta nv



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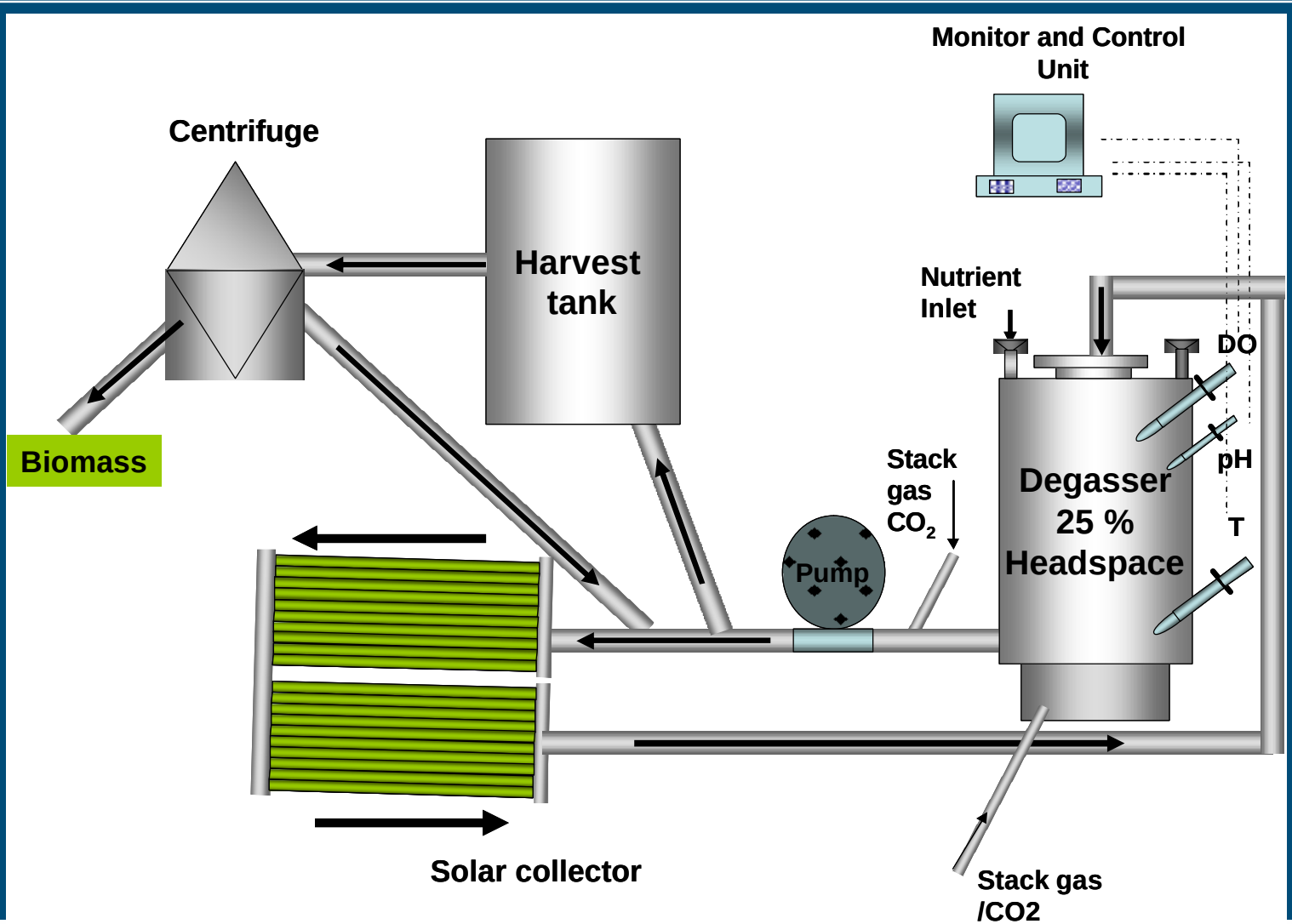
Tubular reactor

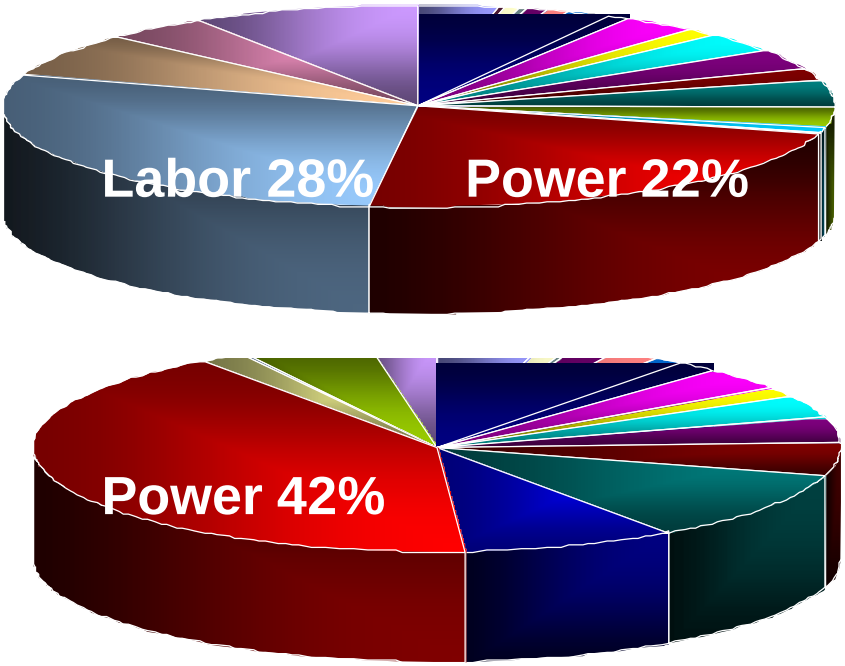


Biomass production cost

ha

00 ha

otential



10.62 € / kg biomas

4.02 € / kg biomas

89% decreas

0.4 € / kg biomass
15 €/GJ

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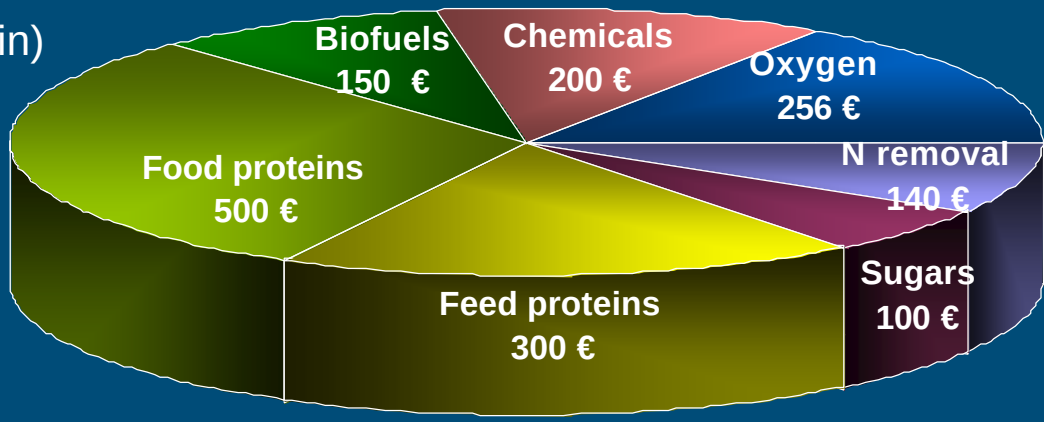
Economical Viability: biorefinery of microalgae

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

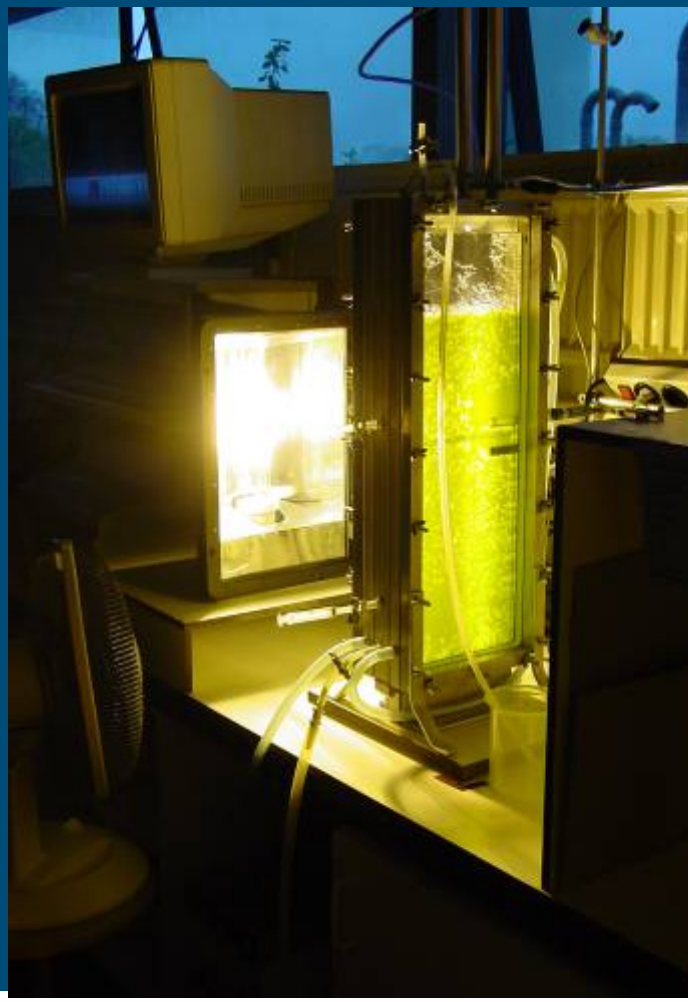


Research programs

- Photosynthetic Cell Factories (NWO)
- Solar-H and Solar-H2, SUNBIOPATH (EU)
- Sealand Sole (Min. Agriculture, province Sealand, companies)
- SUNLIGHT (University of Ghent)
- CO_2 fixation (TNO)
- Reactor design (Proviron, University Huelva, Wetsus)
- AlgiCoat (Akzo, Ingrepro, Essent)
- Wetsus (15 companies)
- AlgaePARC (15 companies)

Wageningen research agenda

- Photobioreactor design
- O_2 removal and CO_2 supply
- Biofilms for post-treatment wastewater
- Control of primary metabolism
- Harvesting and Oil extraction
- Biorefinery
- Design scenarios



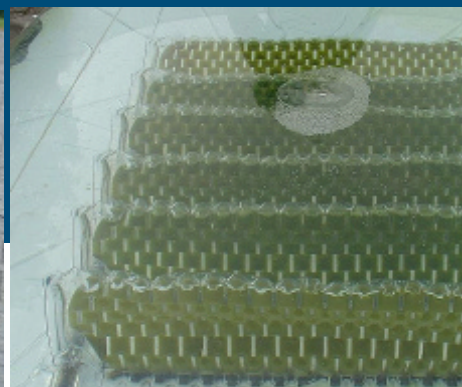
Photobioreactor design





- Closed photobioreactors
- Maximization of photosynthetic efficiency/productivity
  - High light intensity/shading
  - High biomass density
  - Energy input
  - Shear effects
  - Growth inhibition
  - Light guides
  - Flashing light effect
  - Variations in light intensity

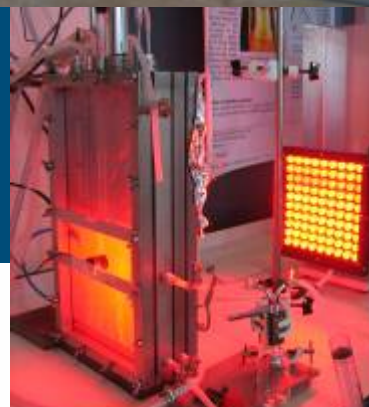




O_2 removal and CO_2 supply




- High Oxygen partial pressure inhibits photosynthesis
  - Maximal tolerable O_2 partial pressure
  - Strains more resistant to O_2
  - Develop new technology to remove O_2
- Energy efficient CO_2 supply
  - Conditions: high pH, high salt
  - Use of $_{CO2}$ absorbers
  - Selection of lipid accumulating strains

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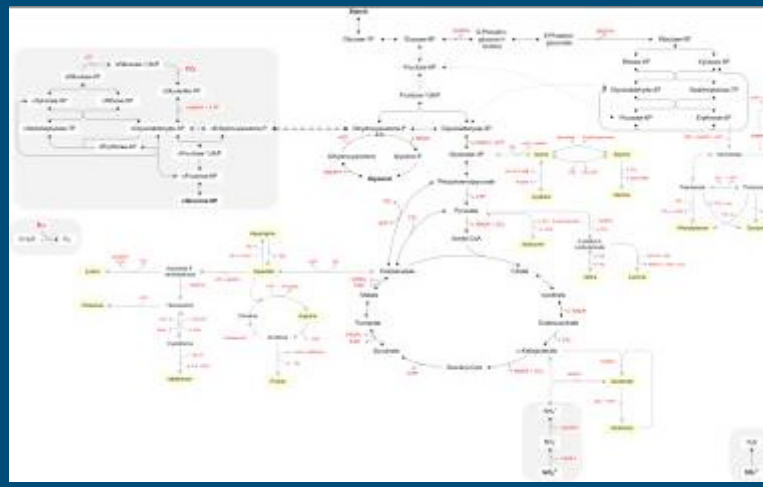
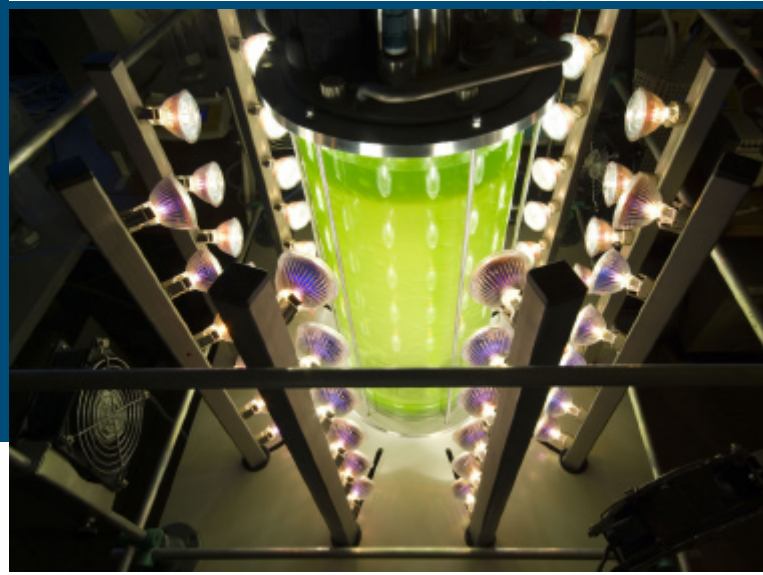
Control primary metabolism

- Objective: control metabolism
  - High yield on light
  - Production of lipids
  - Production of colourants
- Metabolic network model and flux calculations to predict rates in primary metabolism
- Research reactor to apply wide range of cultivation conditions
- On-line monitoring of production and consumption rates (CO_2, O_2, N, biomass)

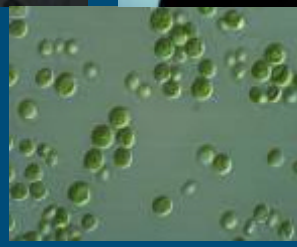


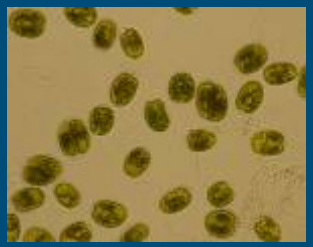


Harvesting and oil extraction

- Reduction of cost & energy demands
  - No additional chemicals
  - Ensure medium reuse
- Bio- & auto-flocculation
  - Microalgae with high lipid content
  - Characterization of algae
  - Mechanistic study
  - Kinetics of harvesting
- Milking of microalgae

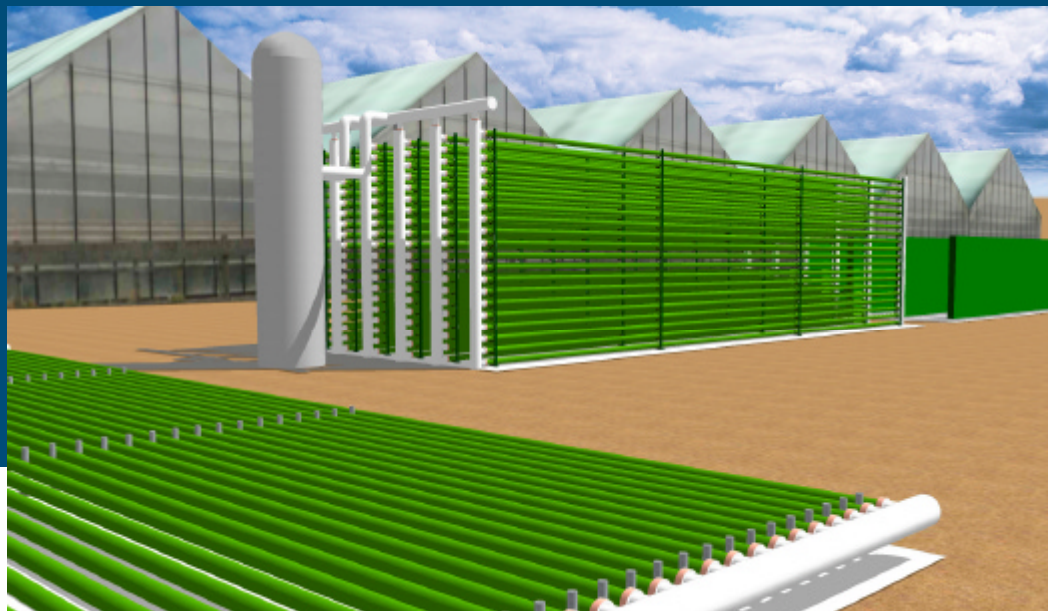



AlgaePARC: Algae Production and Research Center

- 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



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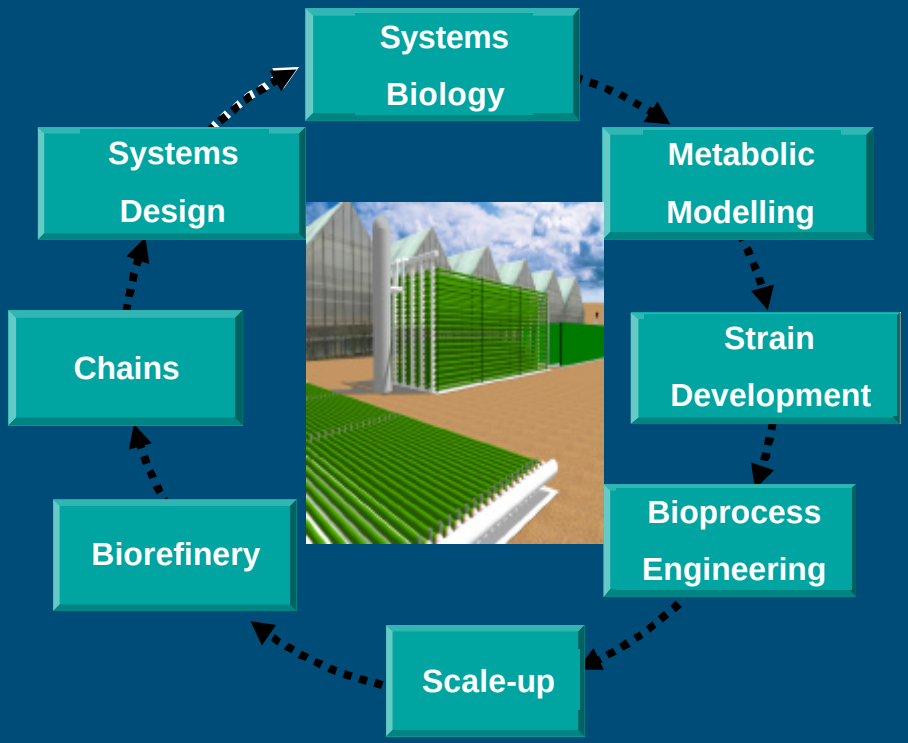
AlgaePARC

- Research plan
- 4 outdoor systems of 25 m^2 each
  - Open pond: reference
  - Horizontal tubular system: high light intensity, oxygen accumulation
  - Vertical tubular system: low light intensity, oxygen accumulation
  - Flat panel system: low light intensity, no oxygen accumulation
- 4-8 systems of 2.5 m^2
- Specific requirements: extra systems

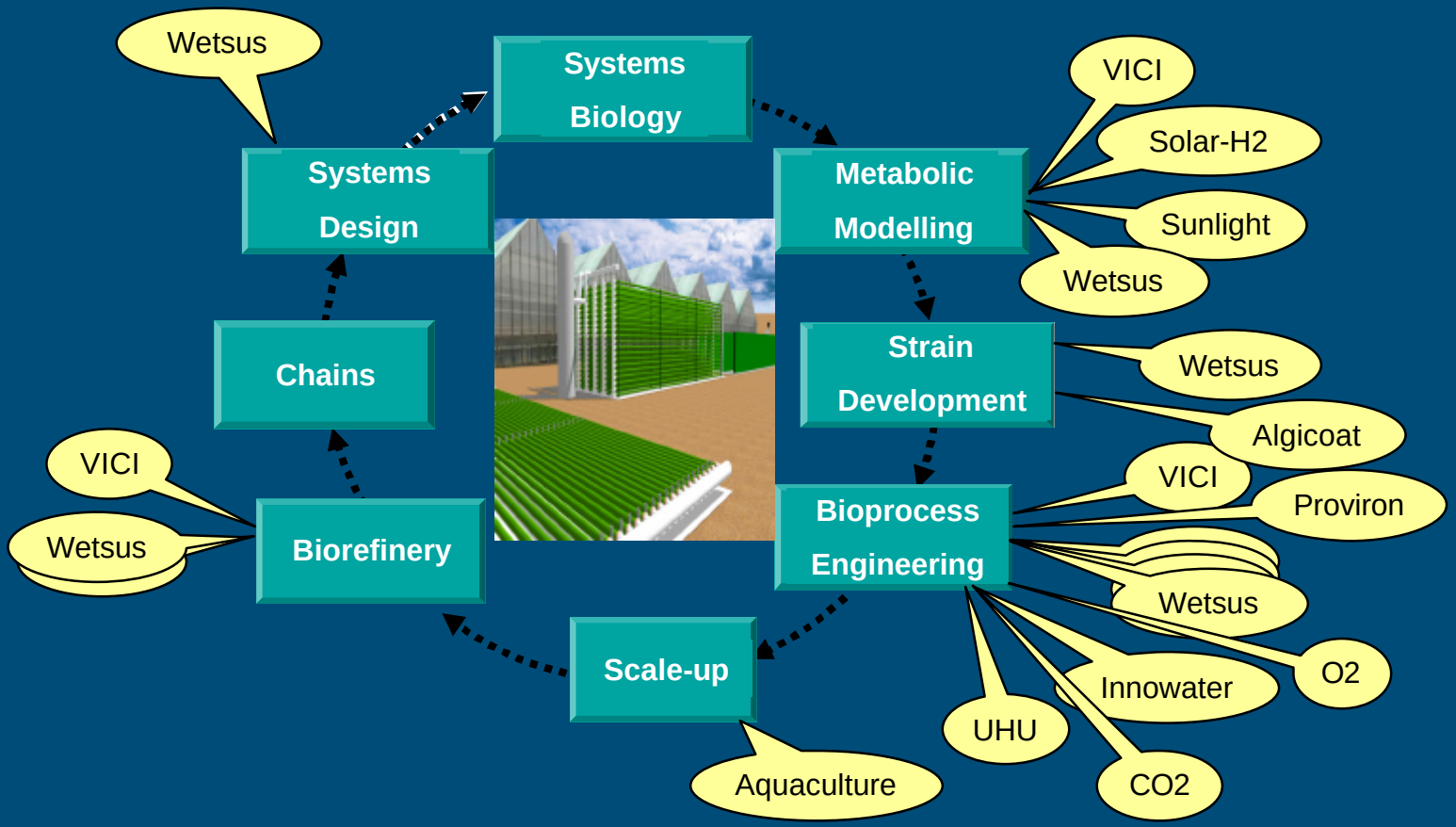
2.5 m^2 systems

- Phase between lab and pilot
- Test things where you are not sure of
- Different strains
- Different feed stocks
- Adaptations in design
- New systems
- If successful
  - To 25 m^2 scale
- If not successful
  - More experiments
  - Reject

Development of a technology



Present research projects



What we aim at

Conclusions

- Microalgae are promising for production of bulk chemicals and biofuels
- Microalgae technology is immature
- Development of technology requires large research programs
- Combination with biorefinery important
- Join forces

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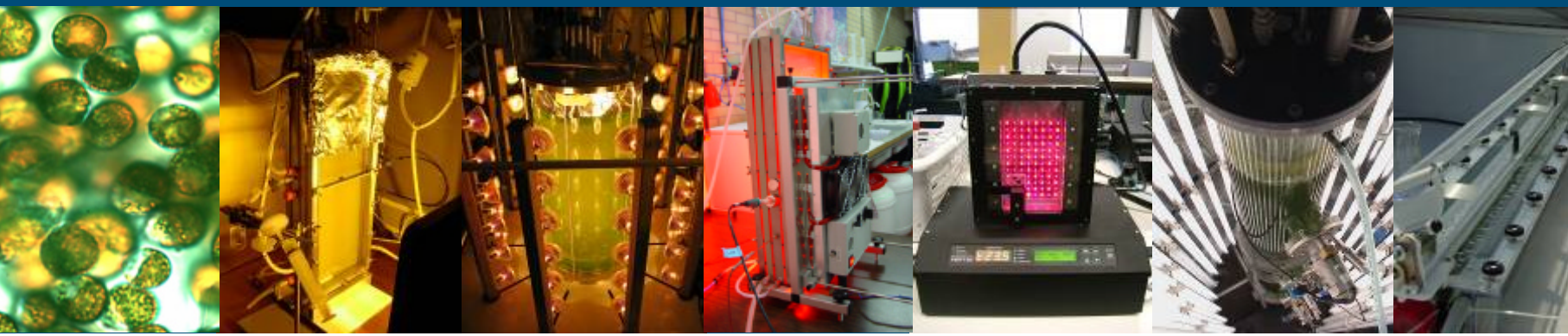

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