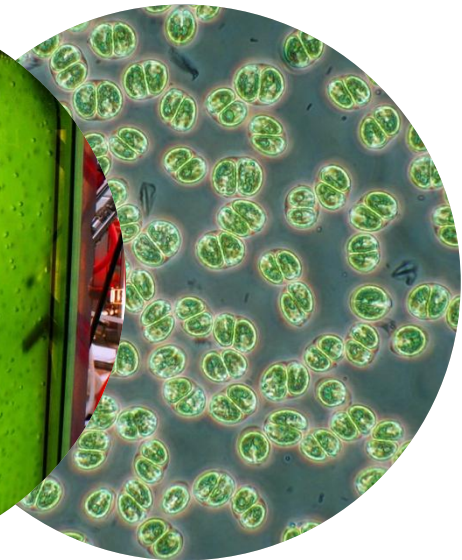
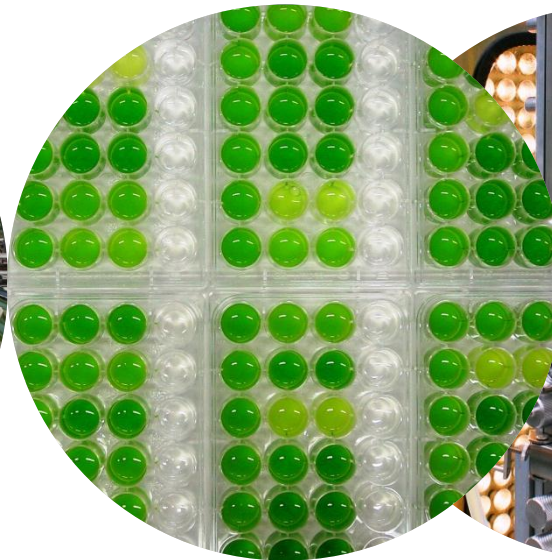


# AlgaePARC

## Algae Production and Research Centre

René Wijffels, Maria Barbosa



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# Contents

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- Research strategy and objectives
- Research programs
  - AlgaePARC pilot
  - AlgaePARC biorefinery
- Business cases
- Sustainability of production chains

# Can algae replace commodities of today?

## ■ European market:

- Fossil fuels: 400 Mtonnes/year
- Polymers and chemicals: 100 Mtonnes/year
- Palm oil: 7 Mtonnes/year
- Soy: 8 Mtonnes/year

## ■ Global microalgae market today:

- < 10,000 tonnes/year



# Research objectives

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

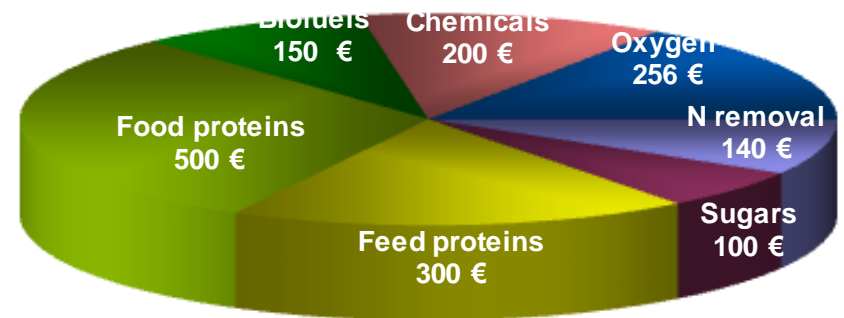


Research facility in Matalascañas, Spain

# Microalgae markets

- Present market volume: € 1 billion
- Present market segment: biomass value > € 50/ kg
- Objective market segment: biomass value <0.40 €/kg
- Value algae biomass: 1.65 €/kg
- Biorefinery essential

Applications	Value/Kg Biomass	Market volume
Nutraceuticals (human consumption)	€100	€60 million
Nutraceuticals (animal- and fish feed)	€ 5-20	€ 3-4 billion
Bulk chemicals	€1-5	>€ 50 billion
Biofuels	< €0.40	> €1 trillion



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

# An Outlook on...

René H. Wijffels<sup>1</sup> and...

Microalgae are considered as a step or two away from being a sustainable source for arable land. The technology needed to grow microalgae at a large scale, the methods to harvest and process them, and how to develop this process into a sustainable and economical way within the next 10 - 15 years.

**Develop this process is a sustainable and economical way within the next 10 - 15 years**

The concept was already proposed in the 1970s (1), but it was not until the oil crisis in the 1970s in Japan and the development of microalgal cultivation systems in 1978 to 1996, the Office of Fuels Development (2) to develop renewable transportation fuels (2). The main focus of the Japanese Aquatic Species Program (ASP) was the production of biodiesel from high-lipid microalgae grown in ponds, using waste CO<sub>2</sub> from power plants.

In Japan, the government financed a large research project entitled "Biological CO<sub>2</sub> Fixation and Utilization" from 1990 to 1999 (3). These programs yielded some successes—such as identifying lipid production strains, open production systems (raceway ponds), and principles for photobioreactor design (the use of fiber optics to bring light inside the systems)—that are still the focus of research today, but none has proven economically viable on a large scale. There have been several critical issues that have had a large influence on the stagnation of algal biofuels research. The high cost of energy, experienced record crude oil prices, increasing energy demand, and environmental concerns have pushed biofuels research in the past few years. In the narrower context of

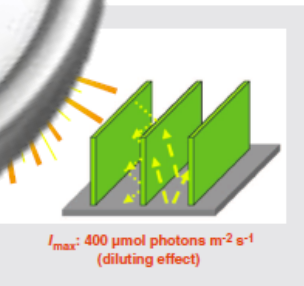


Fig. 1. The principle of light dilution. The light intensity (*I*) striking closely spaced vertical panels is much lower than the intensity striking a horizontal reactor on the same surface.

<sup>1</sup>Wageningen University, Bioprocess Engineering Center, Office Box 8129, 6700 EV Wageningen, The Netherlands; Wageningen University and Research Centre, Wageningen Bioenergy Research, Post Office Box 17, 6700 AA Wageningen, The Netherlands. E-mail: rene.wijffels@wur.nl (R.H.W.)

reason for this is that raceway ponds are used much more at larger scale and there is less room for improvement in these systems. Although generally assumed that production in photobioreactors is much more expensive than in a raceway system, we found that after optimization, cost prices in closed systems were actually lower than in a raceway pond.

### Biorefining of microalgae

The next question is whether it is economically feasible to produce biodiesel from microalgae if we are able to reduce

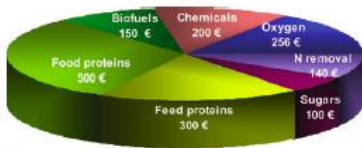


Figure 3. Value of algal biomass per 1000 kg after biorefining.

Downloaded from www.sciencemag.org

## Review



# Microalgae for the production of bulk chemicals and biofuels

René H Wijffels, Bioprocess Engineering Center, Wageningen University, The Netherlands  
 Maria J Barbosa, Food and Bioprocess Engineering Center, Wageningen University, The Netherlands  
 Michel H M Eppink, Bioprocess Engineering Center, Wageningen University, The Netherlands

Received January 19, 2010  
 Published online in Wiley InterScience  
 DOI: 10.1002/bbb

**Abstract:** The feasibility of producing bulk chemicals and biofuels from microalgae at large scale for industrial purposes is highly unlikely, however, the use of microalgae to develop a more sustainable and economical process to produce biofuels and bulk chemicals (such as carbohydrates) should be considered. The use of the functional components of the microalgal biomass (lipids for biodiesel and carbohydrates for fermentation and

**To develop a more sustainable and economical feasible process, all biomass components should be used**

Keywords: microalgae; bulk chemicals; biofuels; biorefining; integrated production chain; bioprocess engineering; Society of Chemical Industry and John Wiley & Sons, Ltd

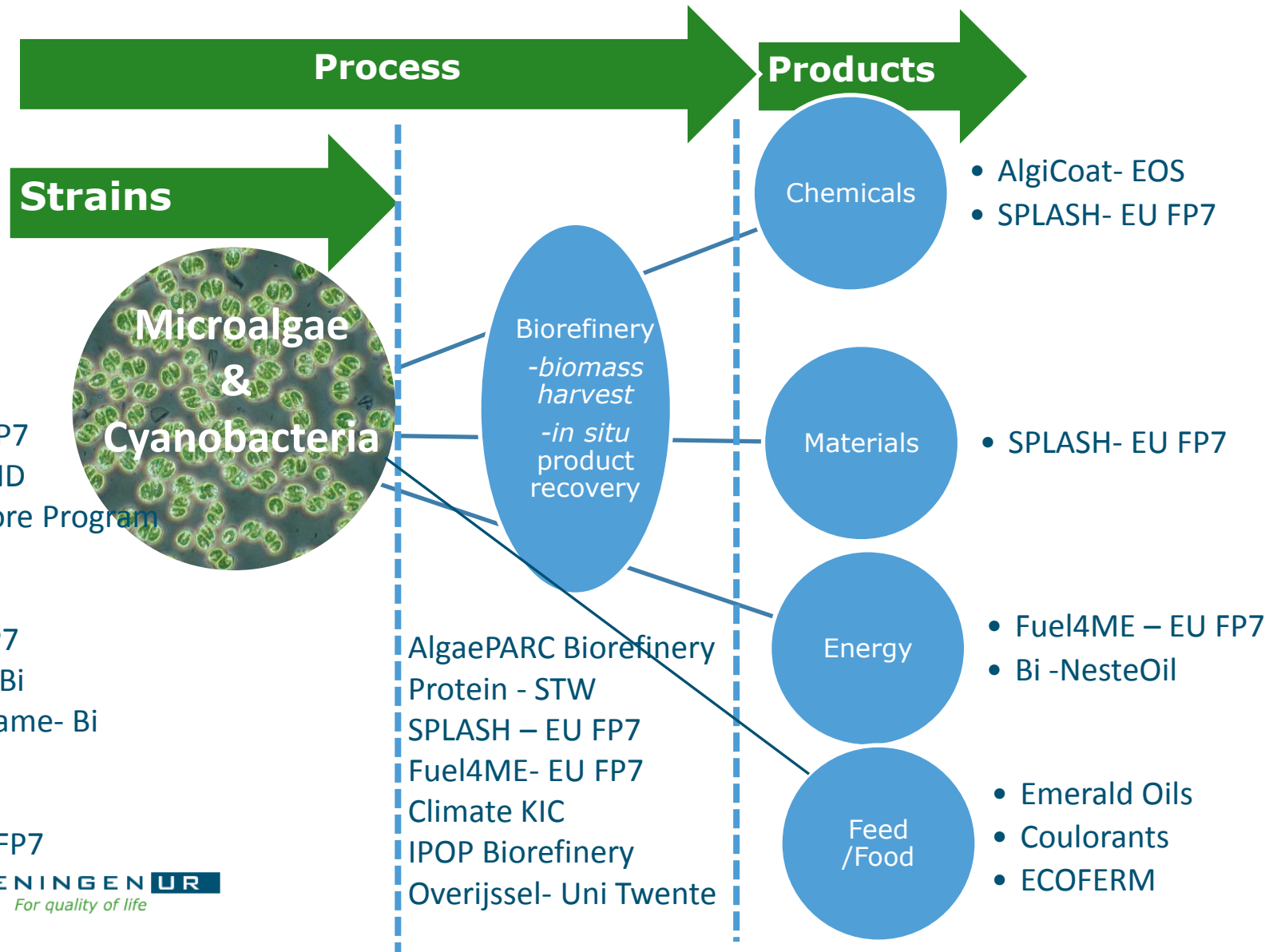
Keywords: microalgae; bulk chemicals...

# Strategy to collaborate with industry

- Demonstrate that biobased products have the quality to replace existing products
- Convince we can produce economically in the future
- Imagine we can reach the right market volumes
- Create awareness: it is not going to be easy
- Join forces
- Create a long term commitment



# Projects portfolio



FUEL4ME – EUFP7  
 Emerald Oils- FND  
 BioSolar Cells Core Program  
 AlgaePARC -PPP  
 SPLASH- EU FP7  
 InteSusAl- EU FP7  
 Petrochemical - Bi  
 StaatsOlie Suriname- Bi  
 Neste Oil - Bi  
 LG-SWITCH  
 AlgaeDISK – EU FP7



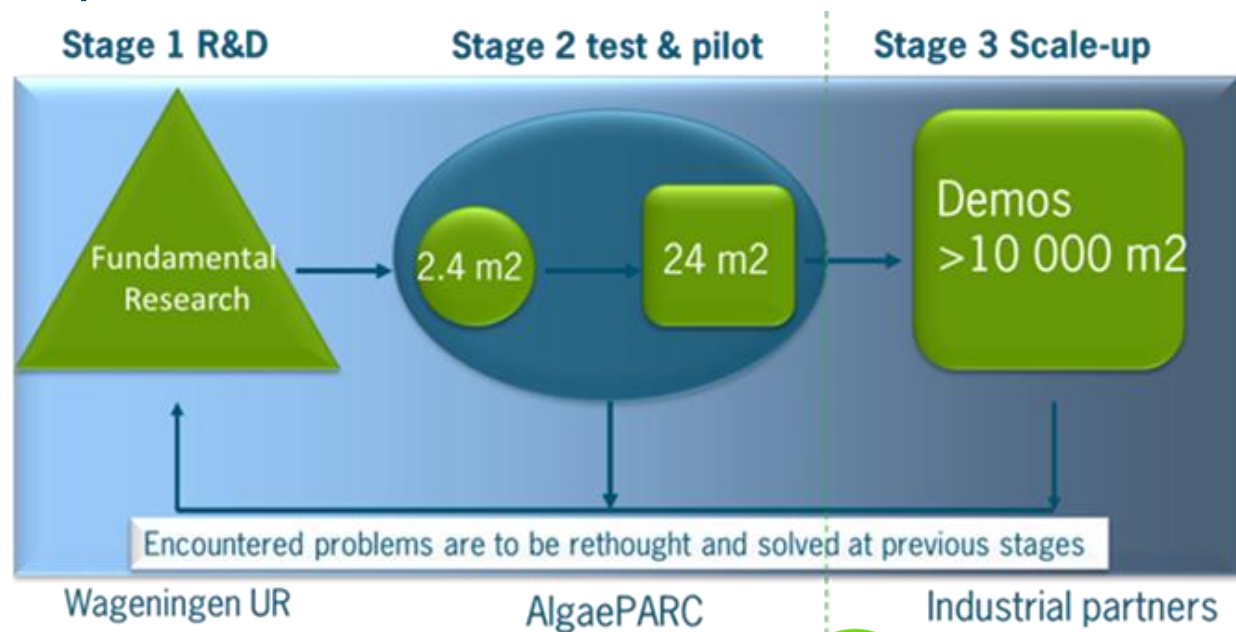
# AlgaePARC

- 8.8 M€
- Facility: 3.3 M€ subsidy
- Research program: 2.2 M€ subsidy, 2.8 M€ companies
- 19 companies



# Objectives

- Basic research is not sufficient
- Gap between basic research and commercial applications
- Continuous interaction between basic research and pilots
- Follow up in demonstrations
- Products
- Scale
- Production chain



# AlgaePARC

- International centre 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



# AlgaePARC biorefinery

- 5.2 M€
- 3 M€ subsidy
- 12 companies



Characterization of biomass components / functional properties

Harvesting

Cell Disruption

Extraction

Separation

## AlgaePARC Biorefinery



# Business cases

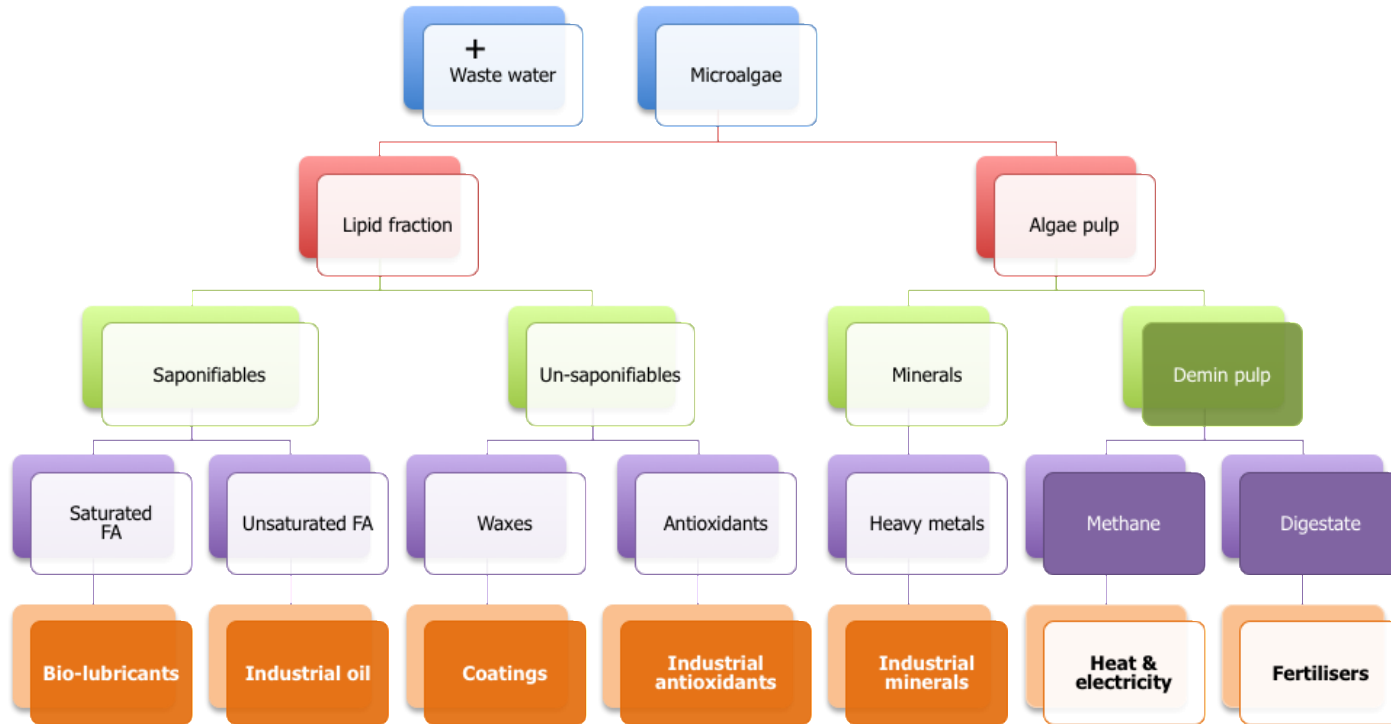
■ Future production costs: 400 €/Ton

■ Value?

- Nannochloropsis
- Scenedesmus

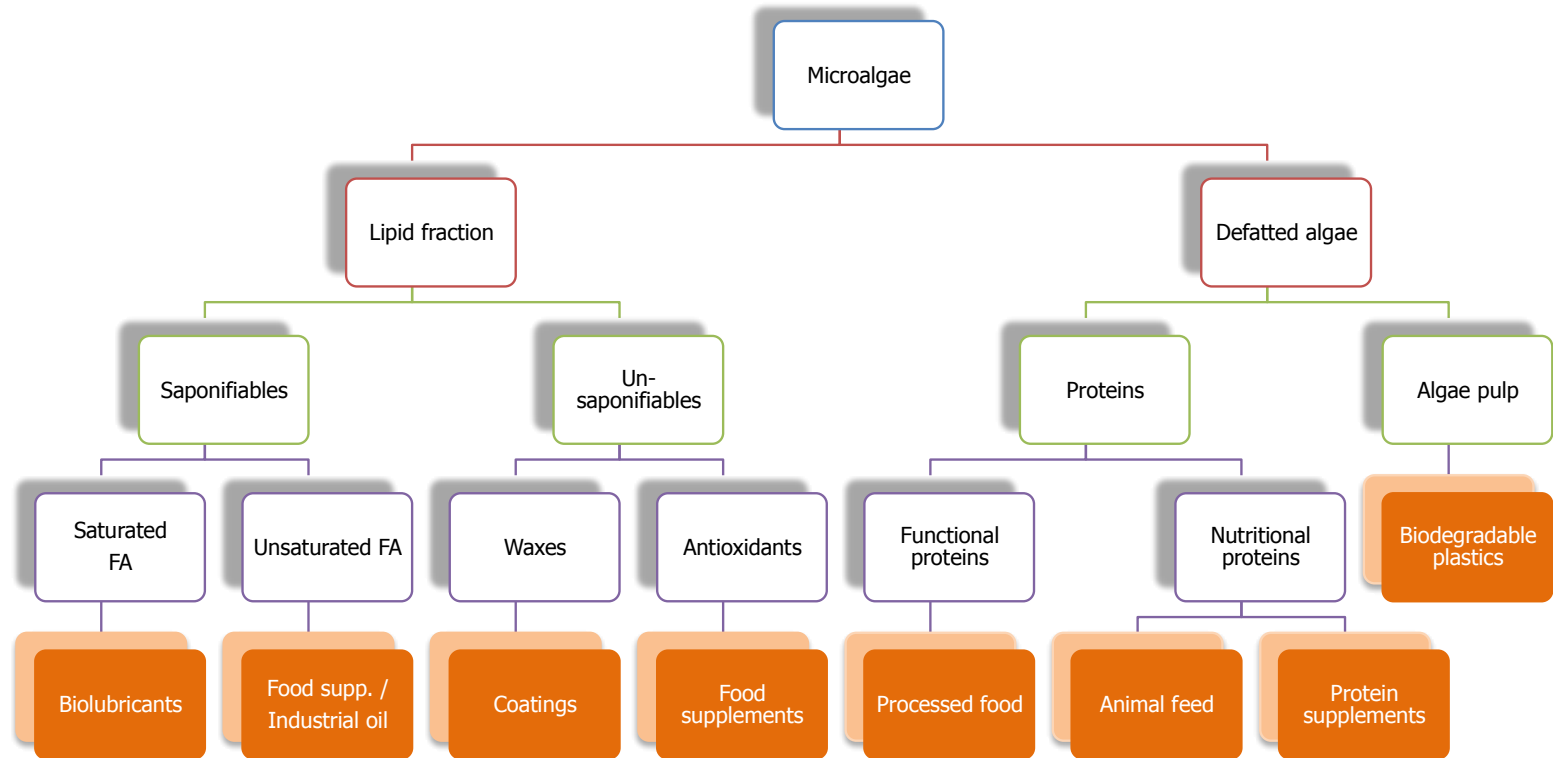
	Nannochloropsis	Scenedesmus
<b>Lipids</b>	20-50%	15-40%
Saturated FA	4-9%	1-2%
Monounsaturated	5-11%	6-17%
Polyunsaturated	6-14%	5-15%
Omega-3 (EPA)	4-10%	
Unsaponifiables	3-7%	1-3%
Waxes (algaenan)	2-4%	<1%
Terpenes (lutein)		0,2-0,5%
<b>Carbohydrates</b>	15-30%	10-20%
<b>Proteins</b>	30-50%	30-50%
<b>Phenolics</b>	2%	<2%
<b>Other organics</b>	4-5%	5%
Vitamins	0,2-0,5%	
Chlorophyll	0,1-0,7%	
Nucleic acids	2-4%	2-4%
<b>Minerals</b>	7-10%	10-12%

# Scenario: Lipids + Biogas energy



**Scenedesmus: €600/T**  
**Cost of production: €400/T**

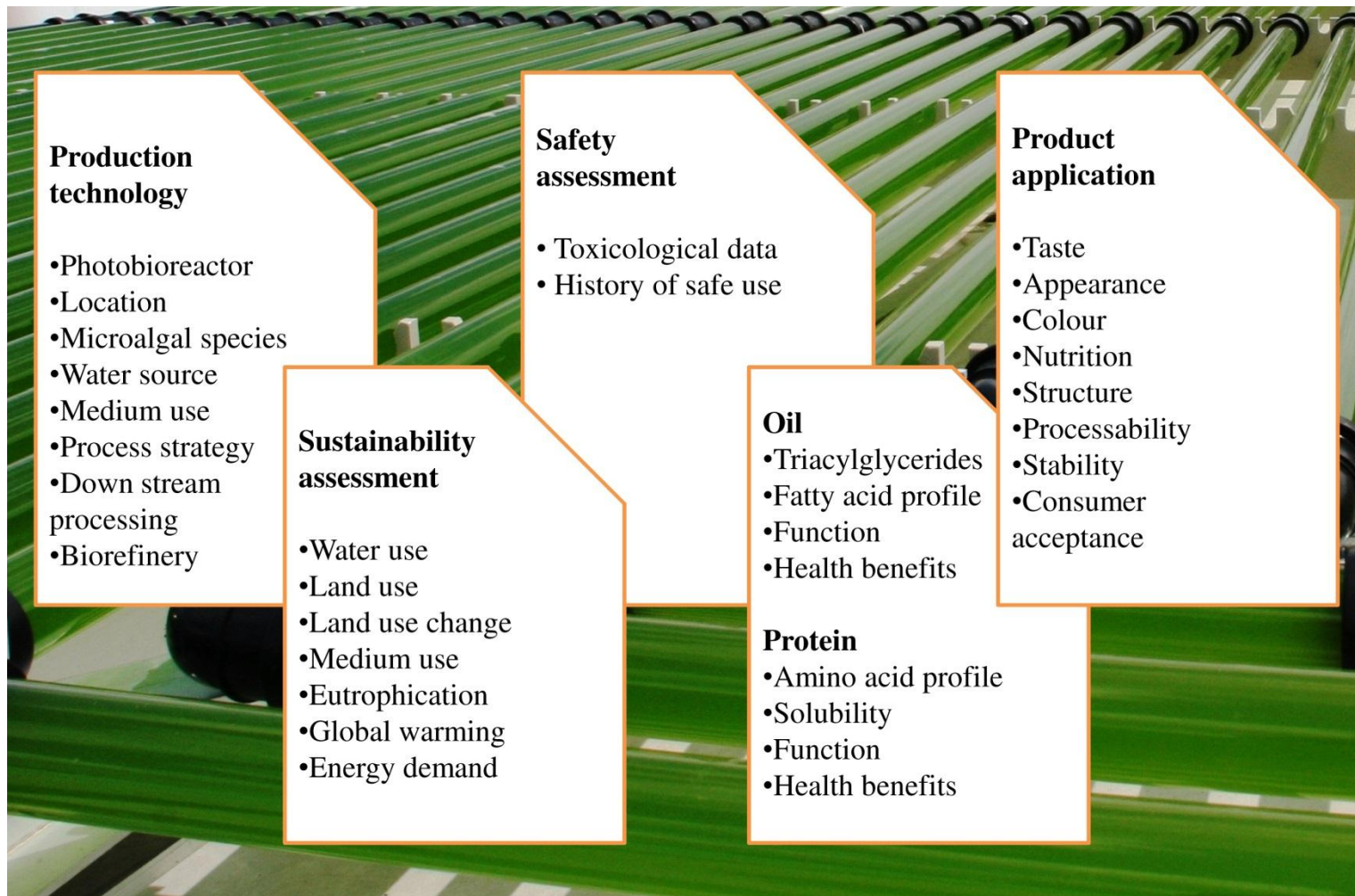
# Scenario: Lipid & protein biorefinery



**Nannochloropsis: €8,000/T**

**Cost of production: €400/T**

# Sustainability of production chains



Draaisma B.B., Wijffels R.H., Slegers P.M., Brentner L.B., Roy A., Barbosa M.J. (2013) Food commodities from microalgae. *Current Opinion in Biotechnology* 24: 169-177



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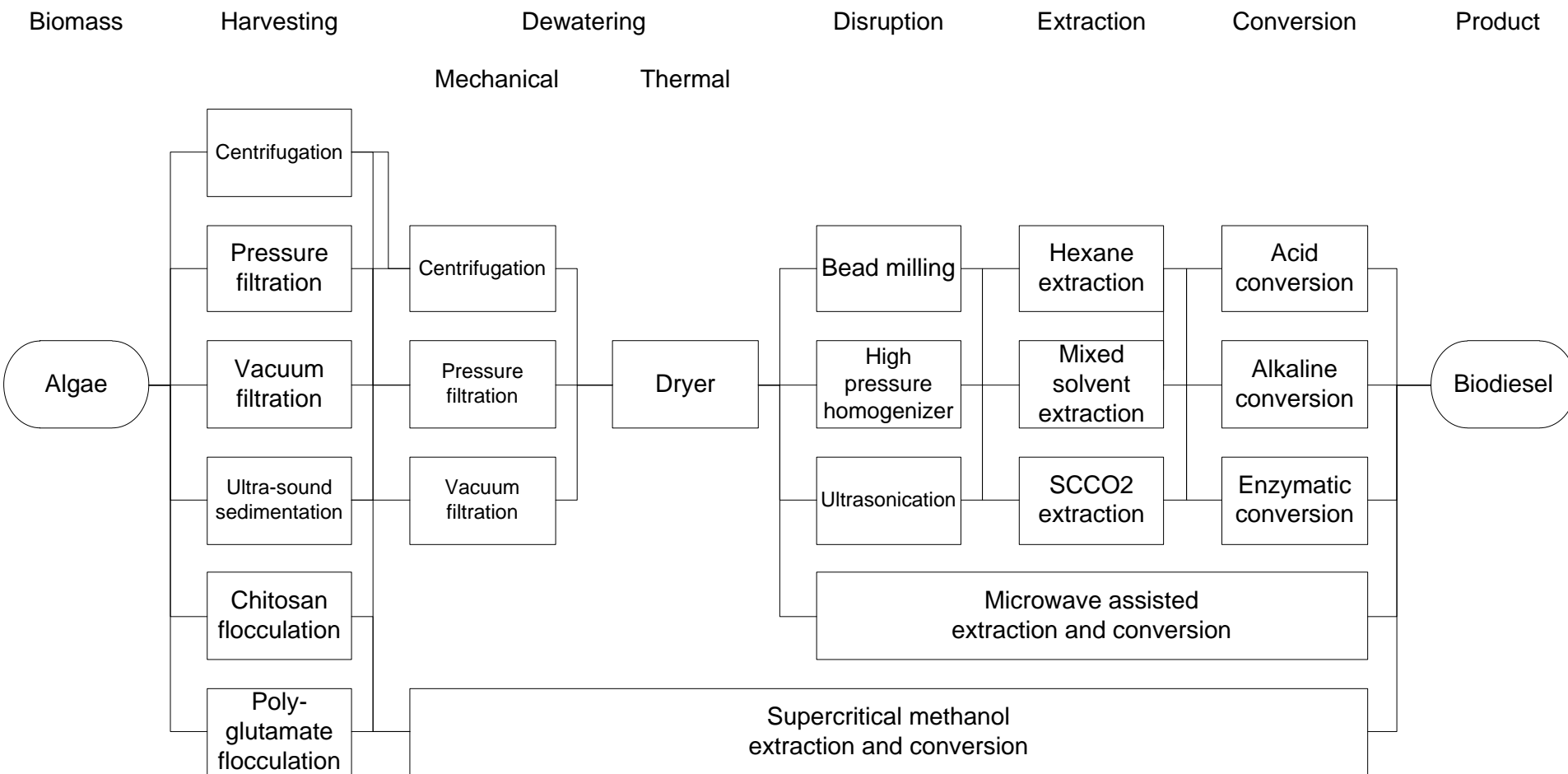
# Sustainability of production chains

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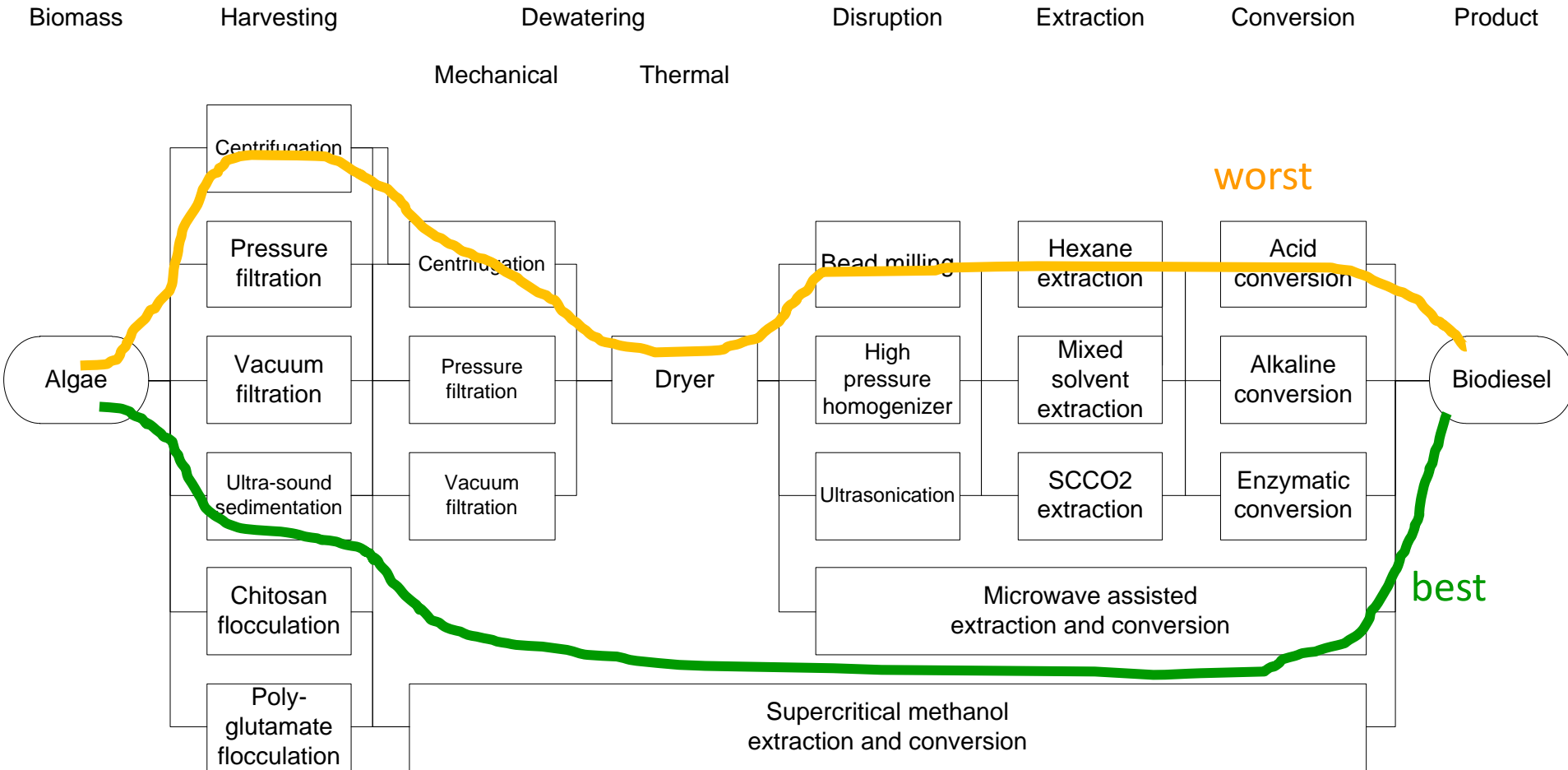
- Scenario analysis
- Life cycle assessment driven biorefinery design
  - Processing conditions
  - Product routing and resource recovery
- Integration of algae biorefinery with supply chain

# Algae biorefinery: possible process units

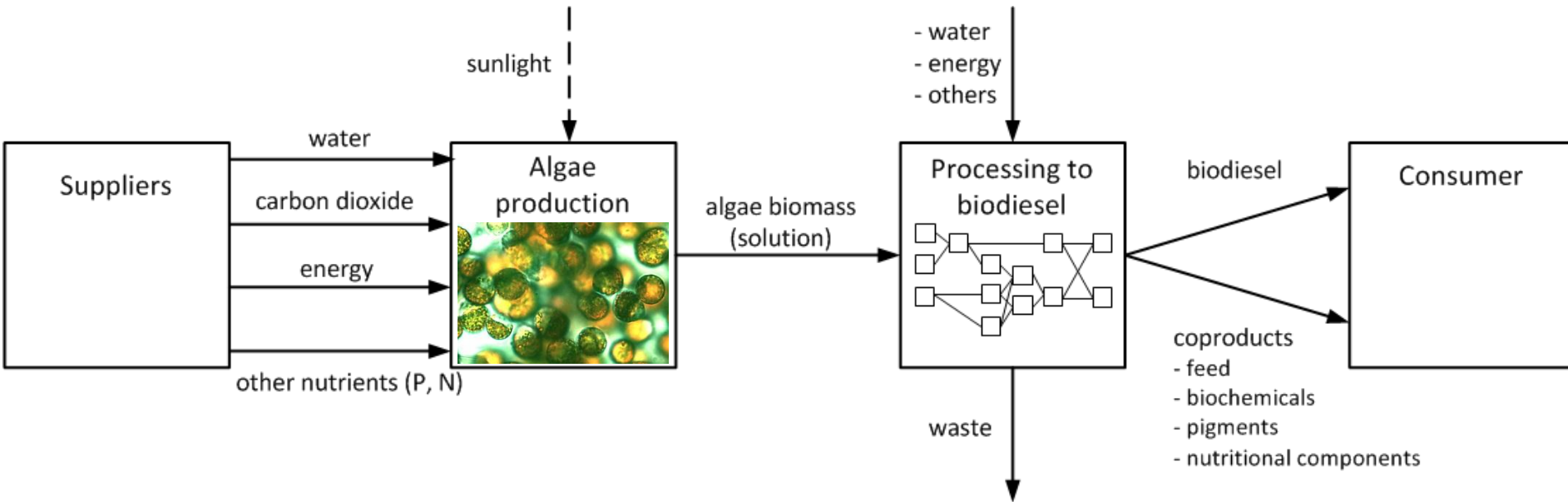
## ■ Example: biodiesel



# Energy consumption: worst/best≈10/1

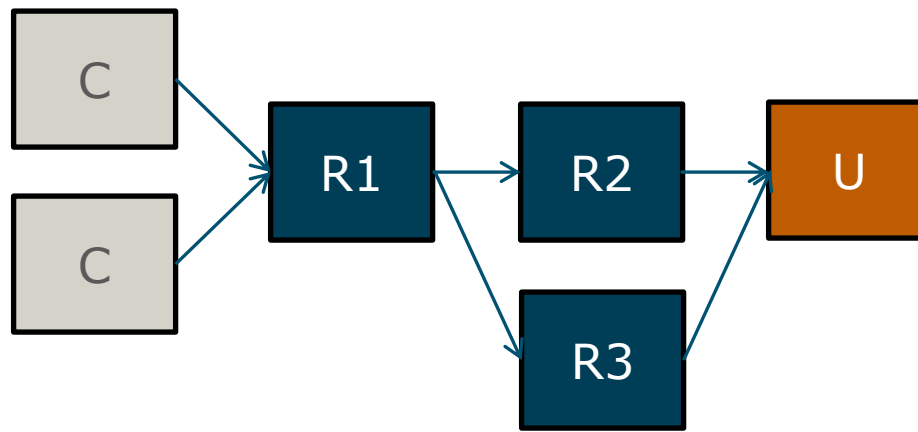


# Algae cultivation and supply chain



# Algae biorefinery and supply chain

- How to organize the cultivation-refinery-user chain?
- Transport of large volumes has impact on sustainability and economy
- Specialization in processing
- Economy of scale?
- Seasonal variation in cultivation request for operational flexibility or storage
- What is the effect of storage on quality/yield?
- What is the effect on the processing methods?



# Algae for commodities

- Demonstrate that biobased products have the quality to replace existing products
- Convince we can produce economically in the future
- Imagine we can reach the right market volumes
- Create awareness: it is not going to be easy
- Join forces
- Create a long term commitment



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[www.AlgaePARC.com](http://www.AlgaePARC.com)

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[Vacancy: tenure track assistant professor algal biorefinery](#)

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