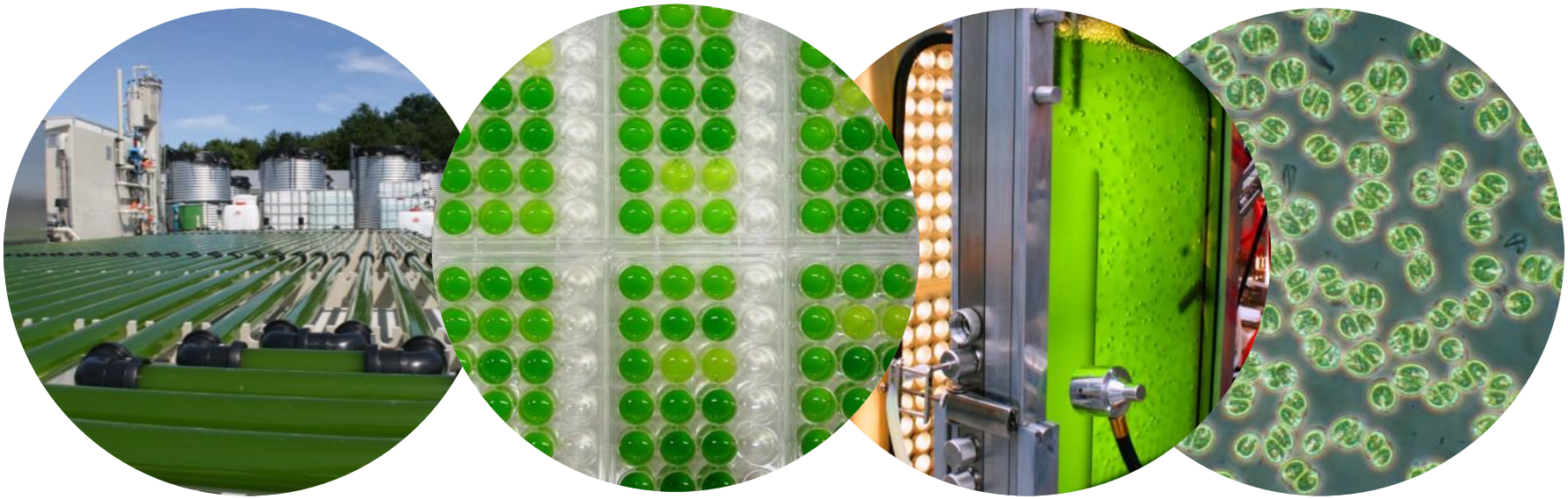
Outlook on microalgae production chains

Maria Barbosa & René Wijffels



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Process integration and Sustainability Assessment

Characterization of biomass components / functional properties

Harvesting → Cell disruption → Extraction → Separation / recovery

Cultivation

Biorefinery

Product development

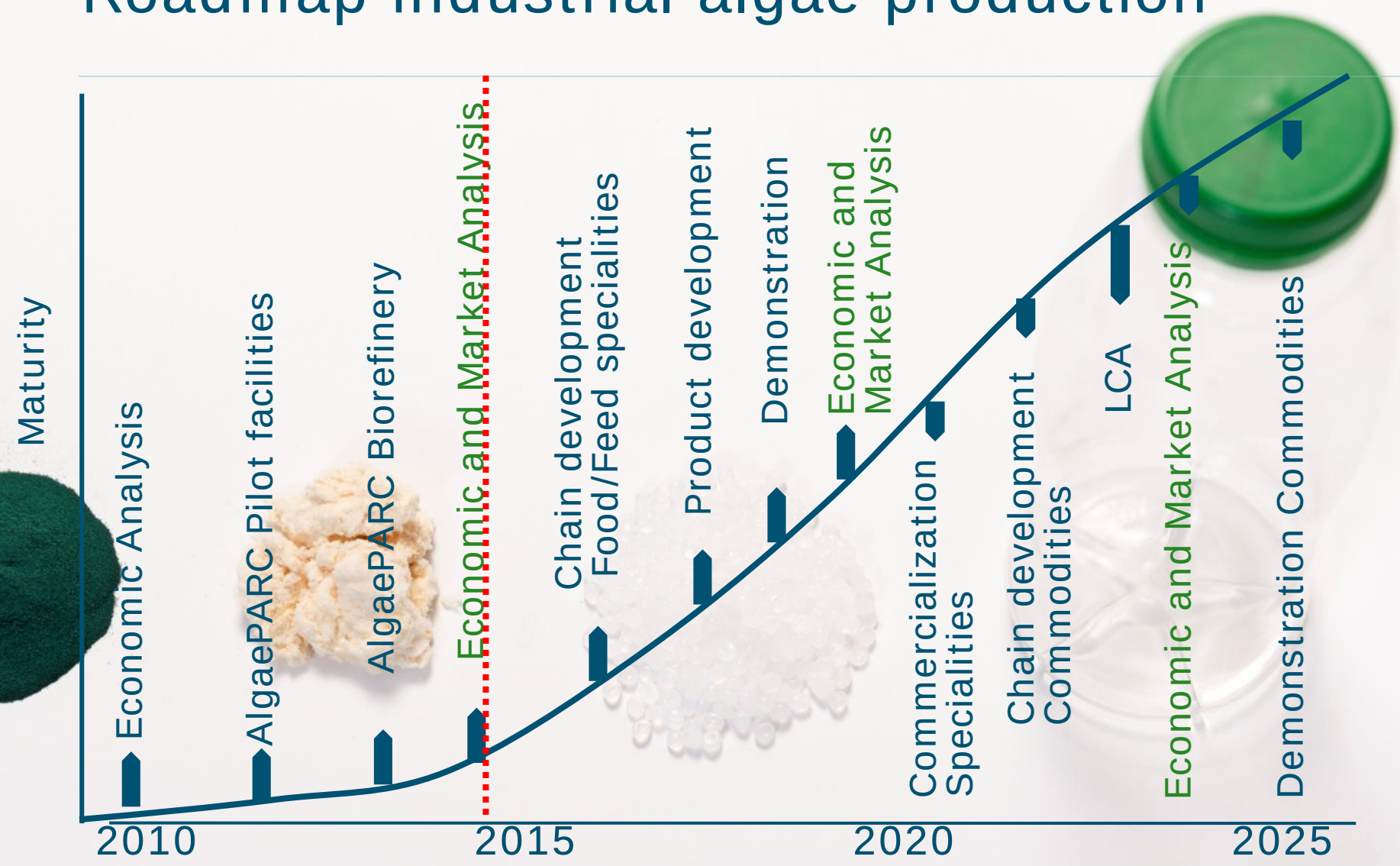
Socio-economic aspects of microalgae production chains

- Public acceptance and risks incl. GM algae
- Business models

Different products

- Biomass
  - Nutraceuticals
  - Fish feed
- Fine chemicals (DHA, EPA)
- Pigments
- Fertiliser
- Protein
- Oil

Roadmap industrial algae production



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Product costs

Scale

Production chain analysis

Market development

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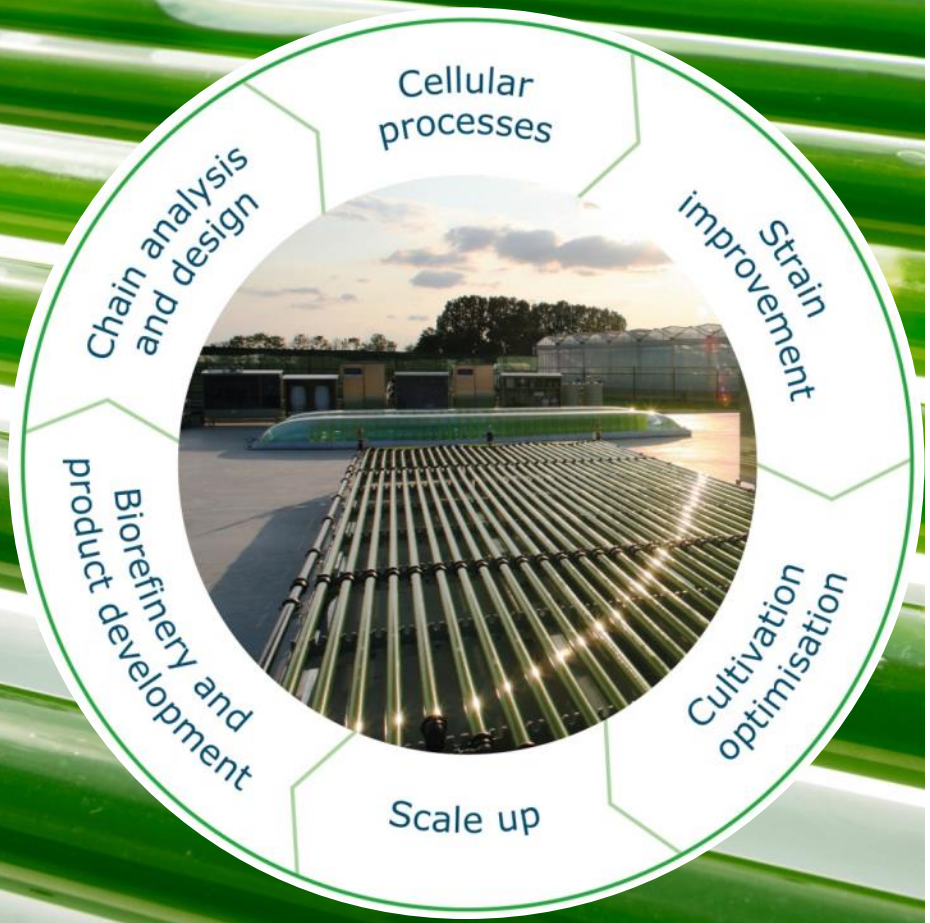
From basic to applied research



- Resources
  - Efficient use of sunlight
  - Reduction of energy input
  - Use of residual nutrients
- Strains
  - Robustness
  - Product accumulation
- Implementation
  - Scale-up
  - Biorefinery
  - Chain Analysis

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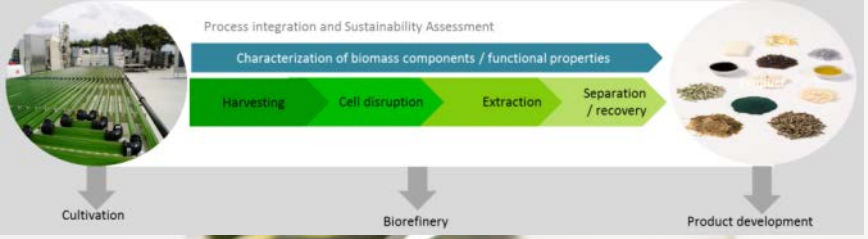

Economic Feasibility

Market value > production costs

Production costs

- Biomass production costs
- Biorefinery costs

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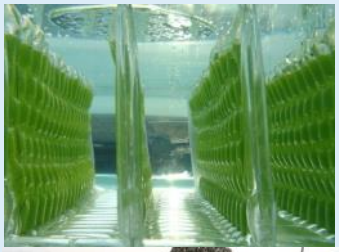
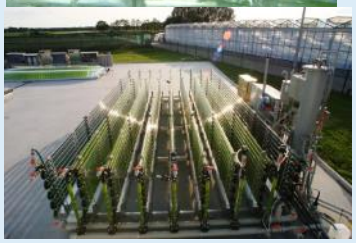
Biomass Production costs: Model

Input

- **Location**
  - Netherlands
  - Saudi Arabia
  - Canary Islands
  - Turkish Riviera
  - South Spain
  - Curacao
  - → Light Intensity, Electricity costs, Taxes, Labor
- **Cultivation System**



- **Empirical data**
- **Specific parameters**
  - Culture temperature
  - Daily Dilution
  - Mixing day/night)
  - Operation days per year
  - …

Output

- € / Kg biomass
- CAPEX & OPEX
- NER
- Sensitivity Analysis
- Areas to focus

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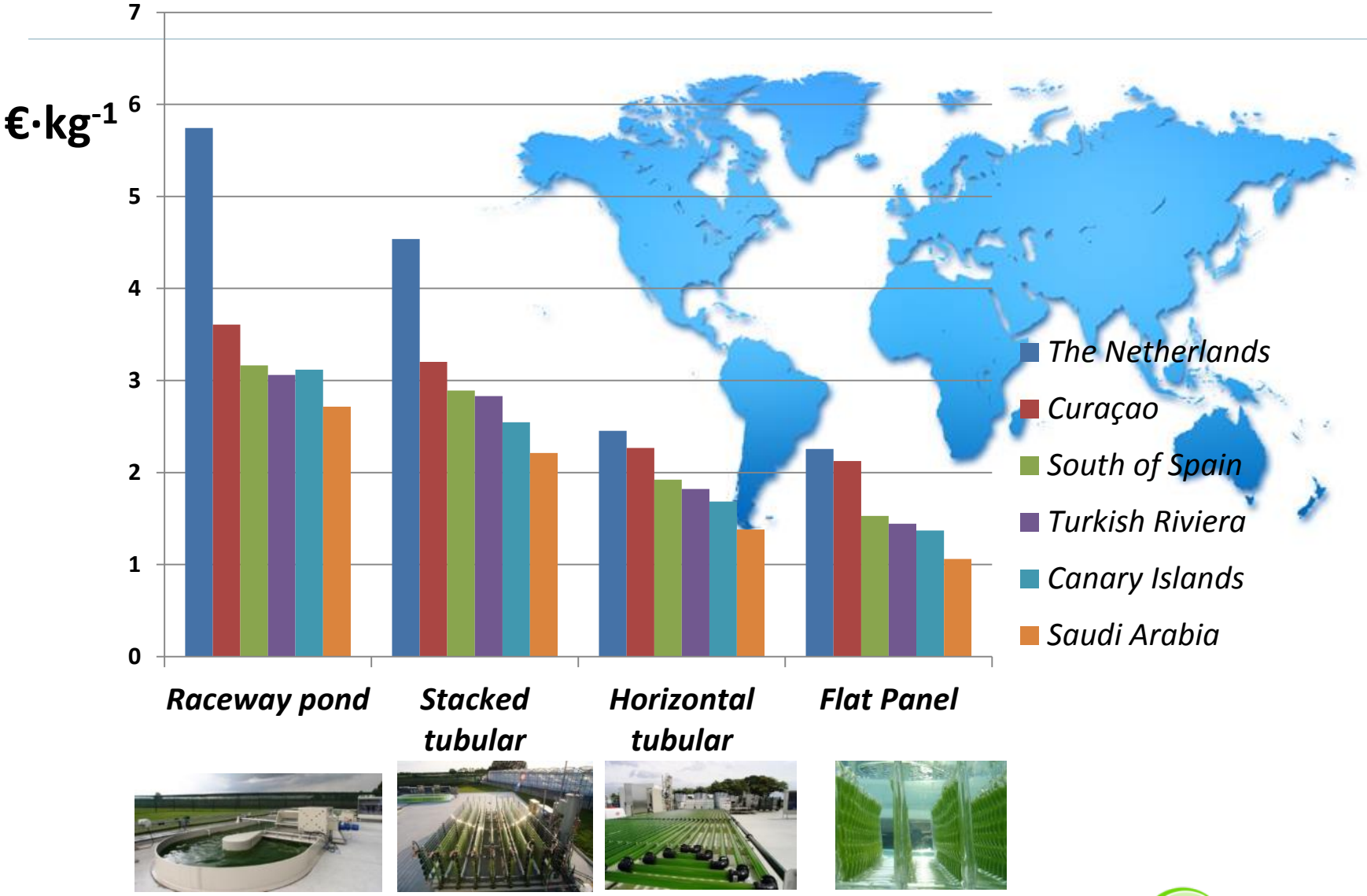
Projections with AlgaePARC pilot facility data:

- Photosynthetic Efficiency
- Operational strategy: Chemostat & Turbidostat
- Biomass concentration
- Dilution rate
- Gas flow rates (flat panels and degasser in tubulars)


Results: Projections 100 ha



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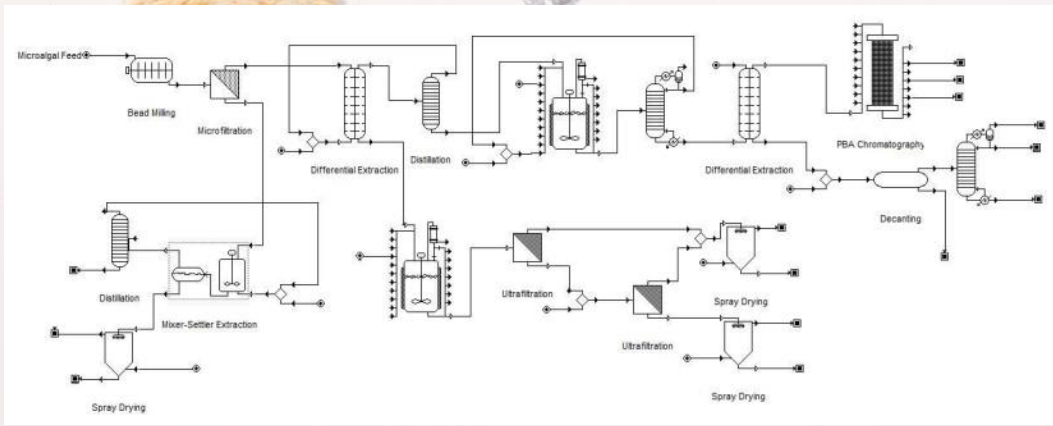
Biorefinery

- Biorefinery costs

1 – 1.5 €/kg biomass



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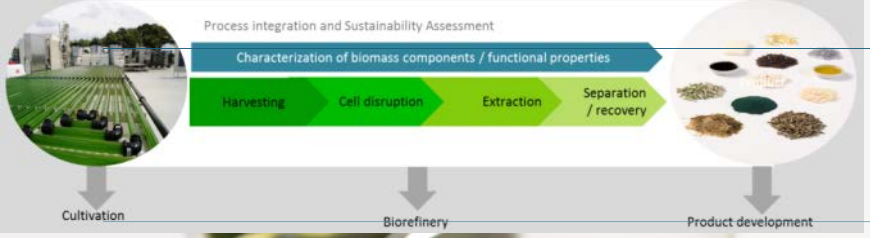

Economic Feasibility

Market value > production costs

Production costs

- Biomass production costs
- Biorefinery costs

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Market Analysis

	Product	Selling price € /ton
Biofuel	Biokerosene	500
	Biochar	150
Biochemical	Biopolymer	2,500
	Biolubricant	2,000
	Biopolymer additivies	3,000
	Coating	5,000
	Paint	10,000
	Bulk Chemical	1,000
Food/Feed	Protein	1,000
	Lipids	950
	Carbohydrates	750
Food aditives	Poly-unsaturated fatty acids	75,000
	Functional Protein	3,000
	Pigments	1,100,000
Cosmetics	Antioxidants	30,000
	Glycolipids, Phospholipids	6,000

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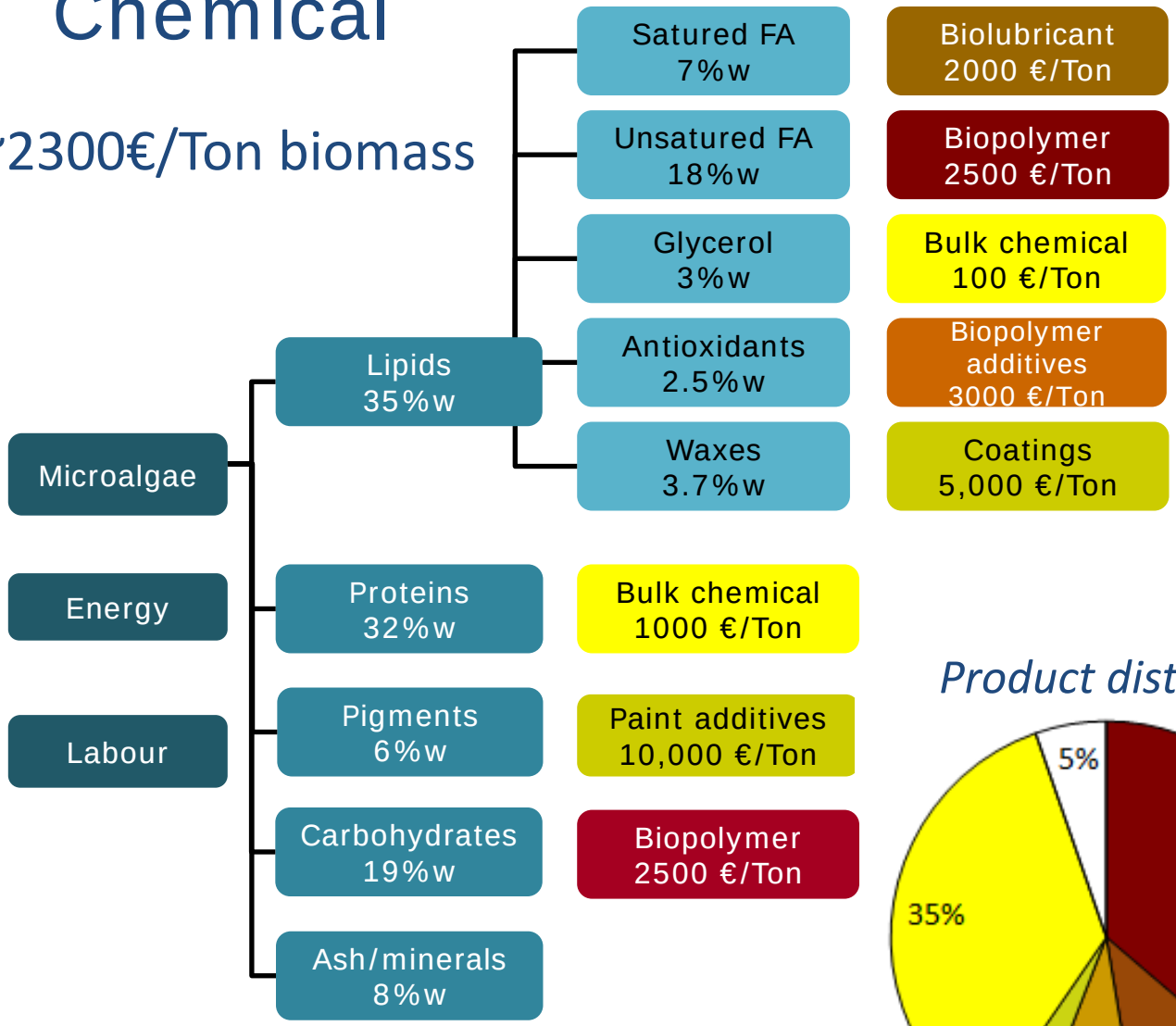
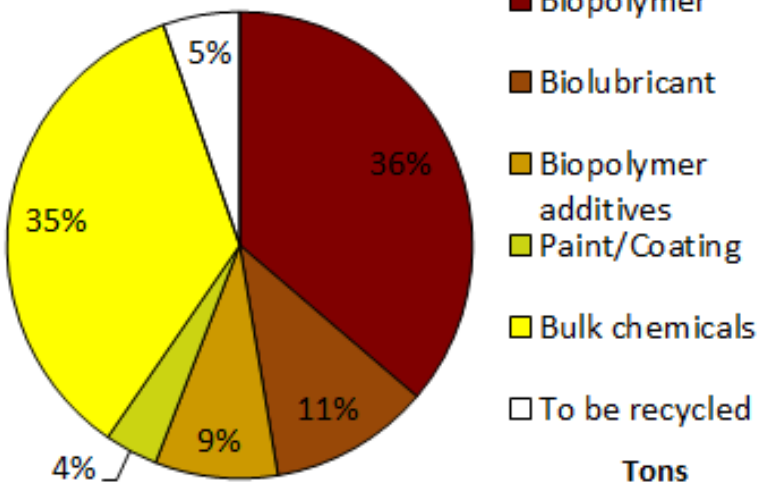
Chemical

~2300€/Ton biomass



Product distribution



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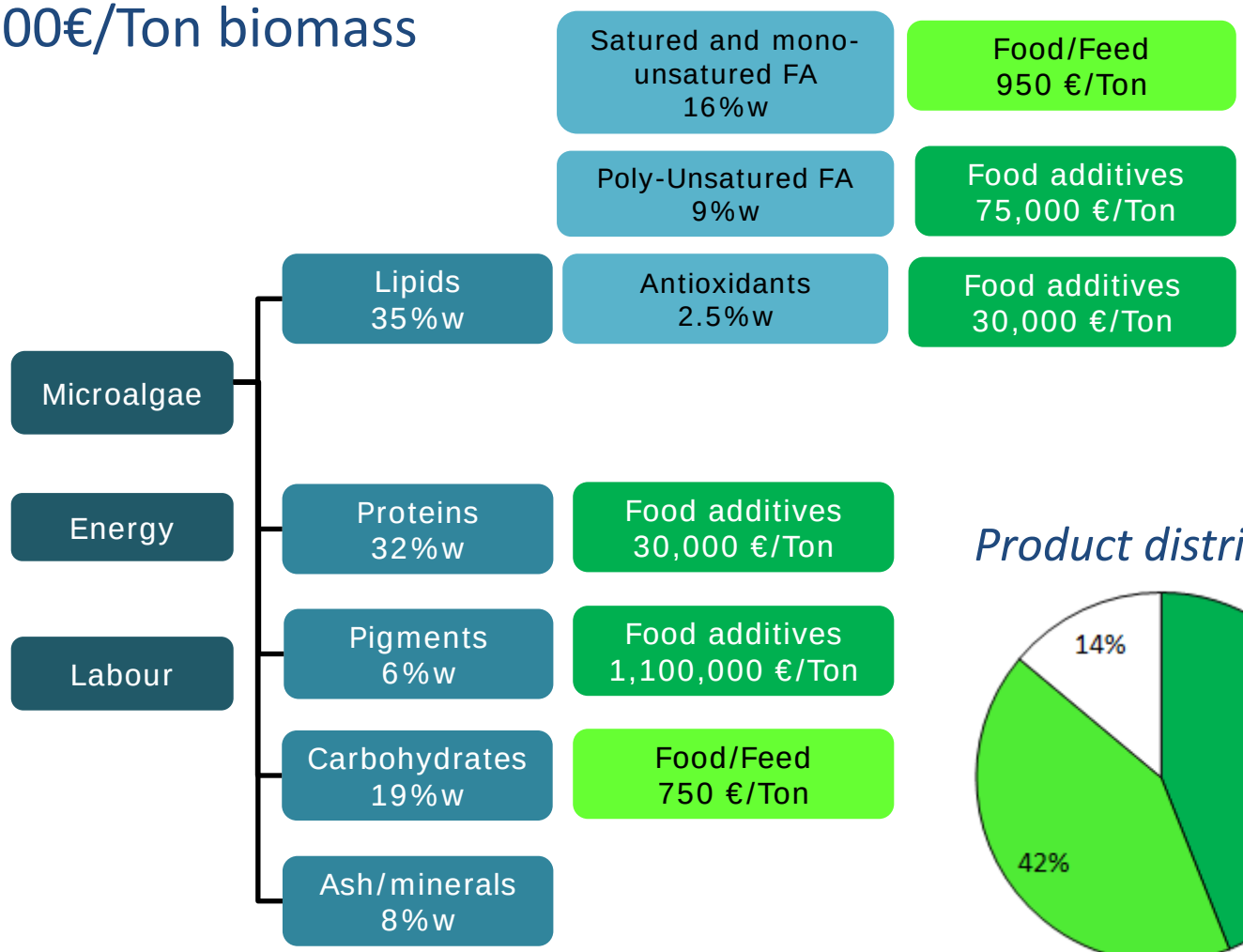
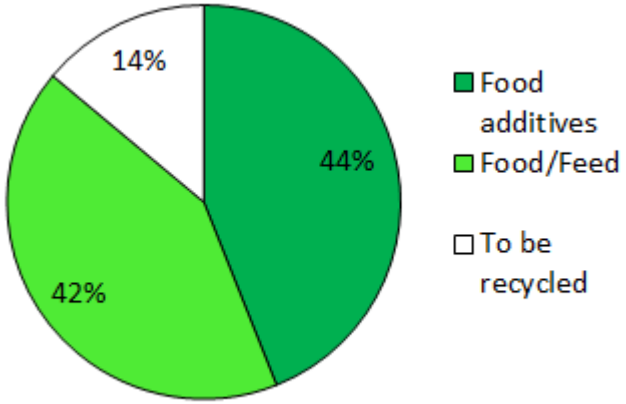
Food/feed production

~8100€/Ton biomass



Product distribution



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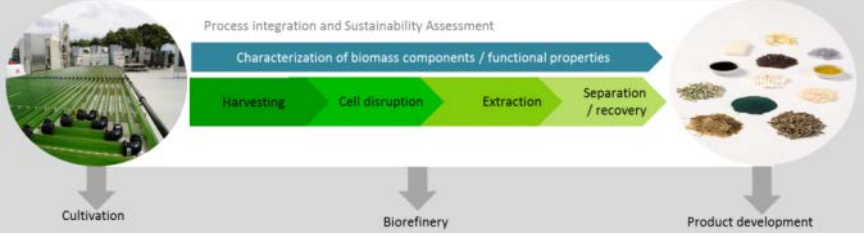
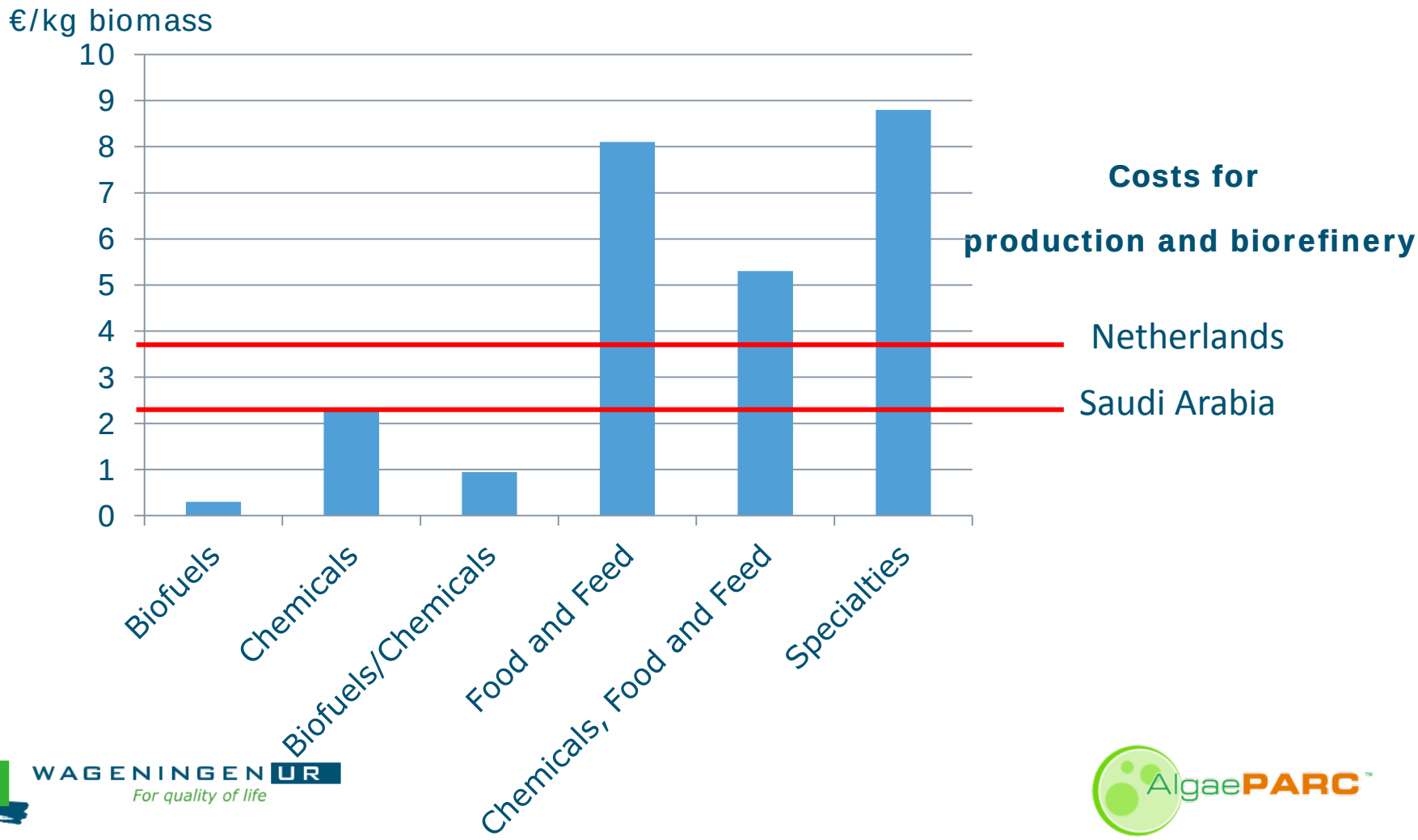


Market combinations vs costs



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Conclusions

- Business cases within reach on basis of projected costs of biomass production and biorefinery
  - Increase product range and volume
  - Reliability : quality and quantity
- Scale up still needs to be realized
- Further reduction in cost is required for commodities

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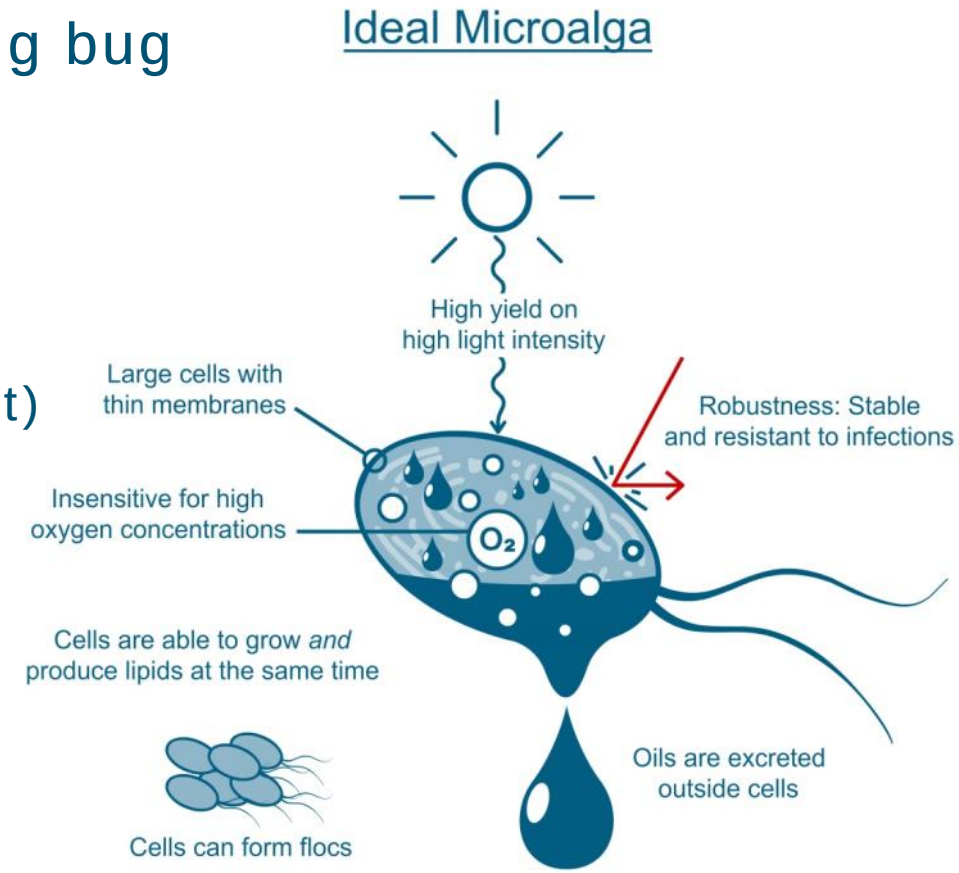
Further reduction in cost

- Few industrial strains: Plug bug
  - Productivity
  - Down time
  - Energy (temperature, cell disruption, location of product)



*Wijffels & Barbosa (2010) . **Science**. 379: 796-799.

Process chain: impact of species

Process integration and Sustainability Assessment

Characterization of biomass components / functional properties

Harvesting → Cell disruption → Extraction → Separation / recovery

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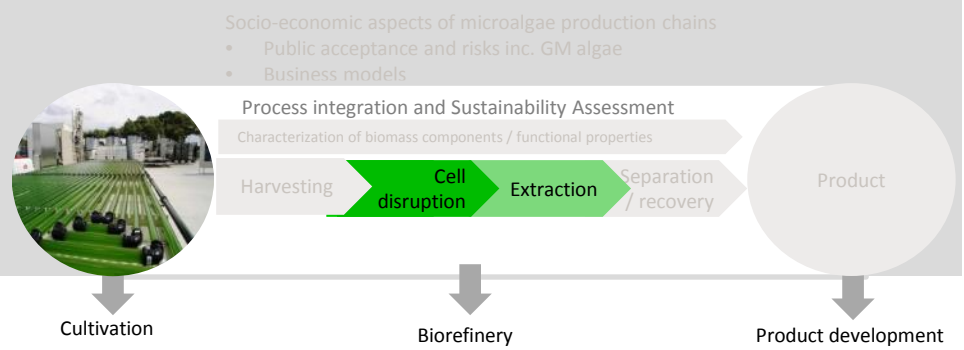
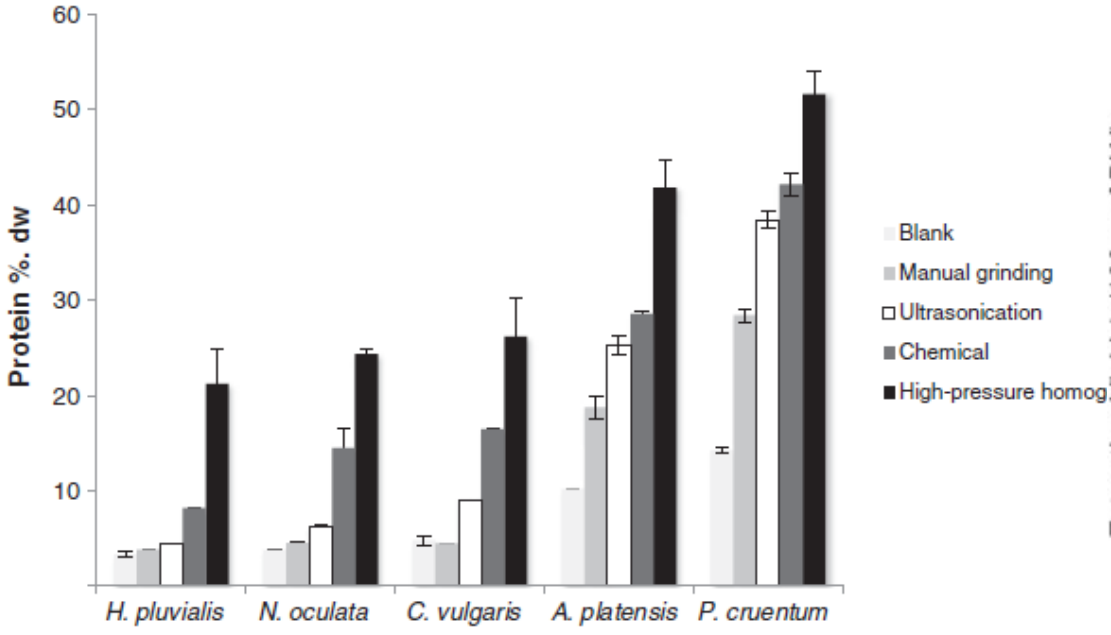
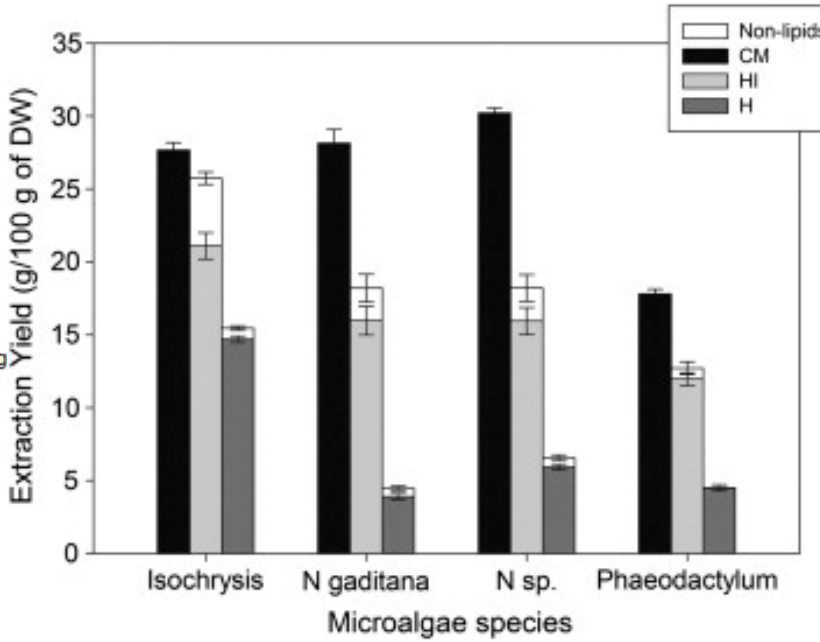


Species

CM: chloroform/methanol
HI: hexane/isopropanol
H: Hexane



Safi et al., 2014, Algal Res



Rykebosch et al.2013. Algal res.

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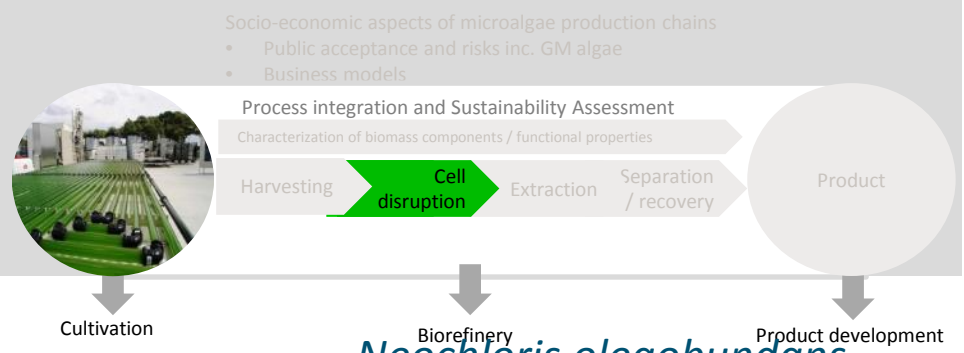
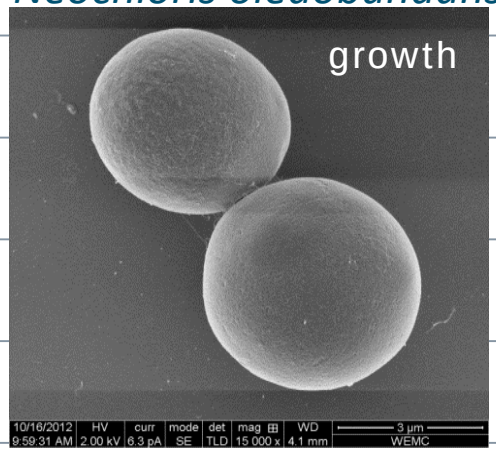


Growth phase

Neochloris oleaobundans



Neochloris oleaobundans

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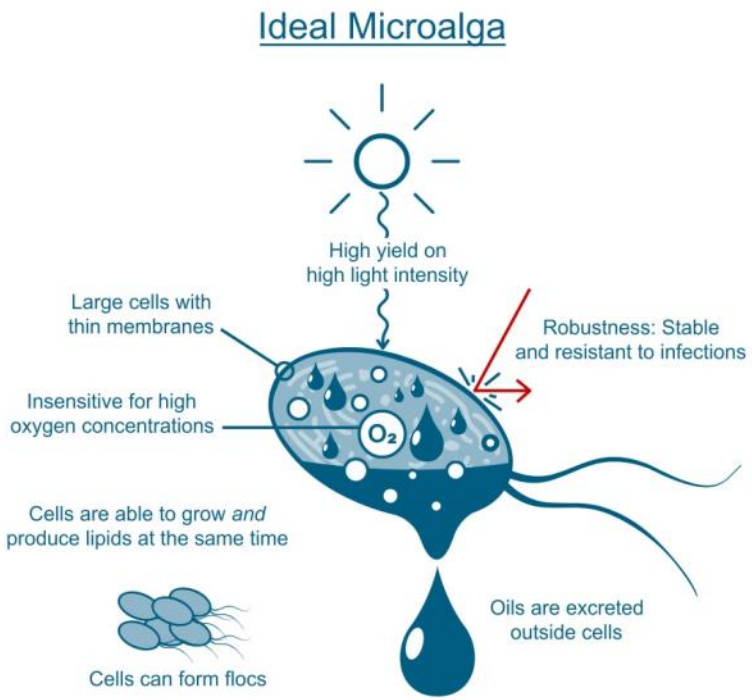
Further reduction in cost

- Few industrial strains: Plug bug
  - Productivity
  - Downtime
  - Energy (temperature, cell disruption, location of product)
- Cultivation process strategies
  - Mass transfer
  - Night vs day
  - Operational strategy
- Biorefinery
  - Validation of first cost estimations
  - Identification of major cost factors



*Wijffels & Barbosa (2010) . ***Science***. 379: 796-799.

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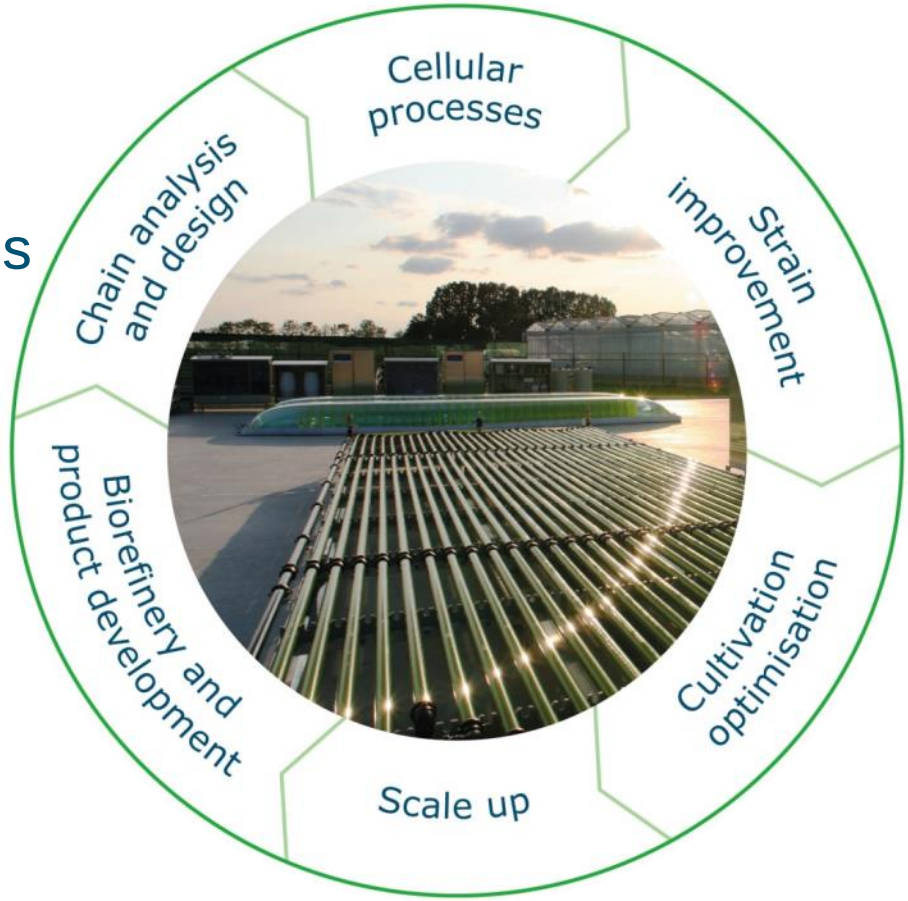
Where is the breakthrough ?

From economical analysis

- Combination of improvements
- Multidisciplinair approach



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AlgaePARC Production & Research Centre

AlgaePARC Biorefinery

European Projects

Dutch Research Council

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Academic partners

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