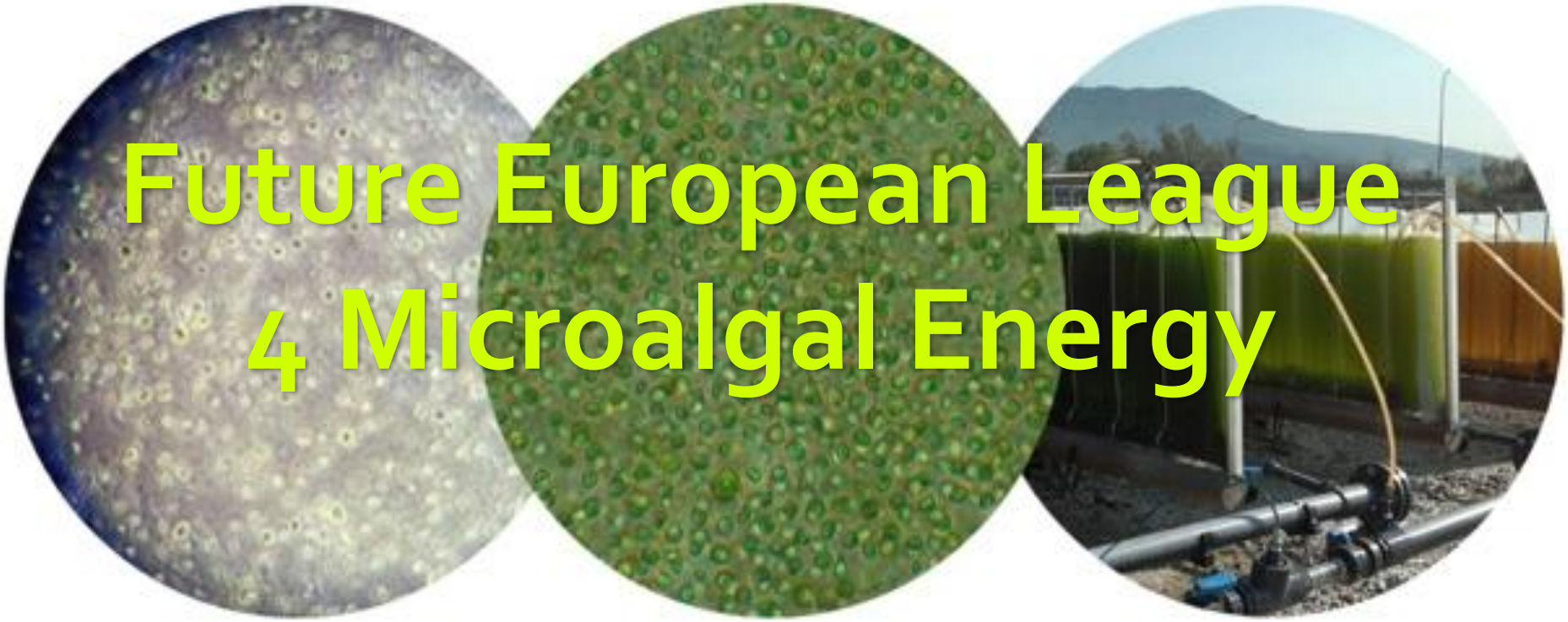
fuel4me



Future European League 4 Microalgal Energy

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Wageningen Food & Biobased Research, NL / Uni Research Bergen, Norway

General overview

FUEL4ME: **Fu**ture **E**uropean **L**eague **4** **M**icroalgal **E**nergy

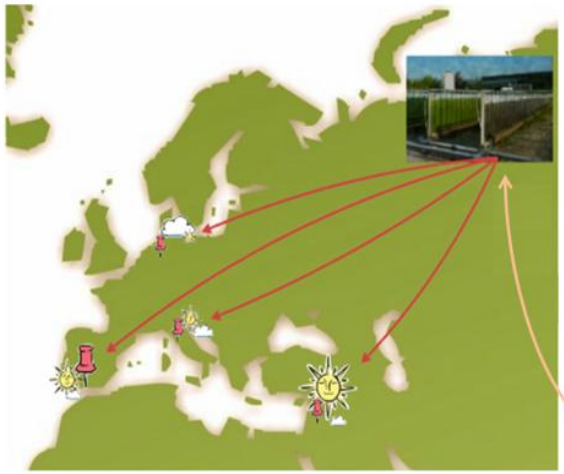
Main goal: to demonstrate a sustainable, scalable process for production of biofuels from microalgae and to valorize the by-products by 2017.

- **Budget:** 5.4 M€ from which 4M€ are supported by the European Commission through the 7th Framework Program under Grant Agreement No. 308983.
- **Duration:** 48 months: January 2013 to December 2016
- **Coordinator:** Wageningen Food & Biobased Research
- **Website:** http://fuel4me.eu/

Future European League 4 Microalgal Energy

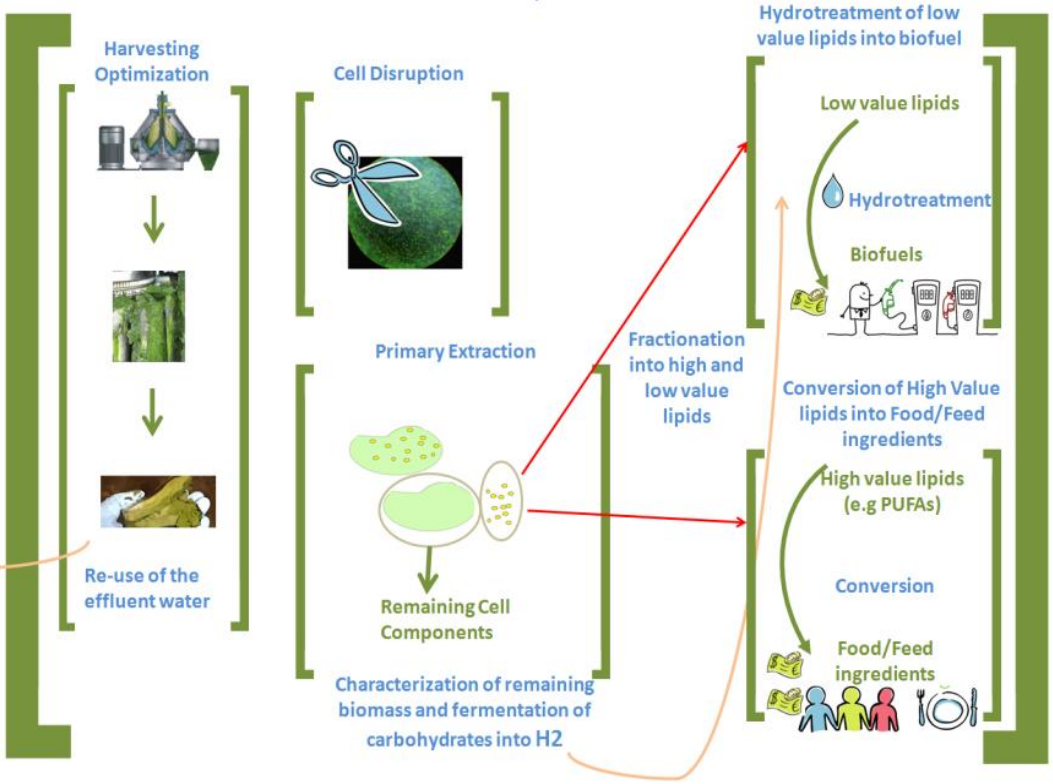
Optimization of Upstream processes

One step continuous biomass production

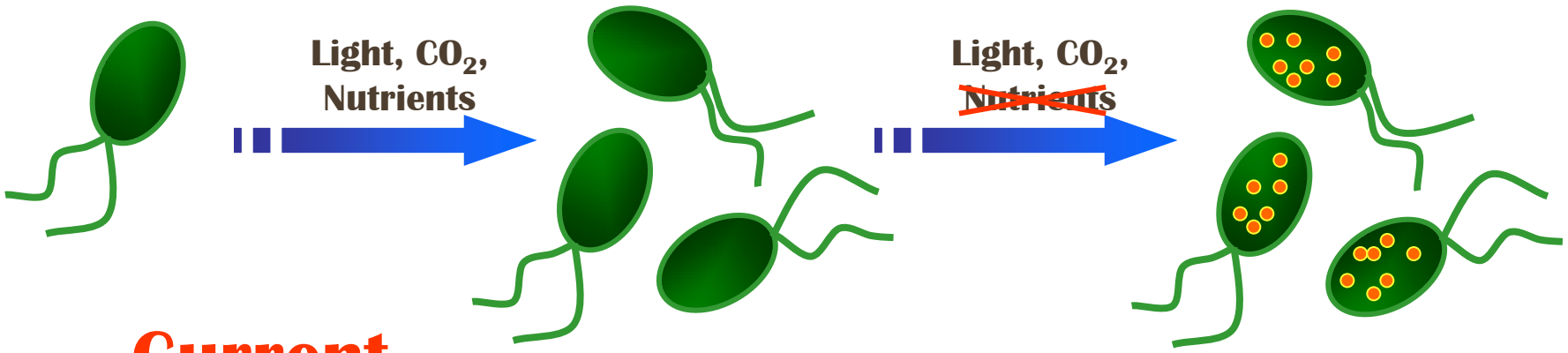


Optimization of Downstream processes

Continuous conversion process

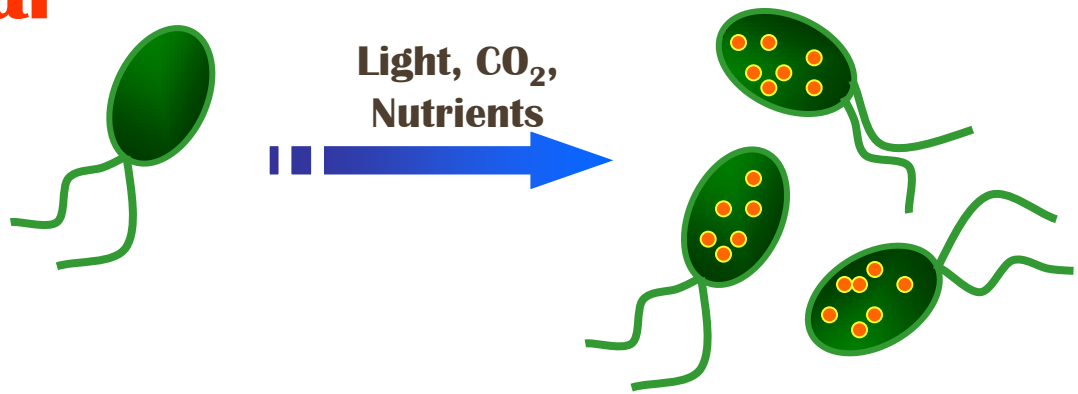


Lipid production



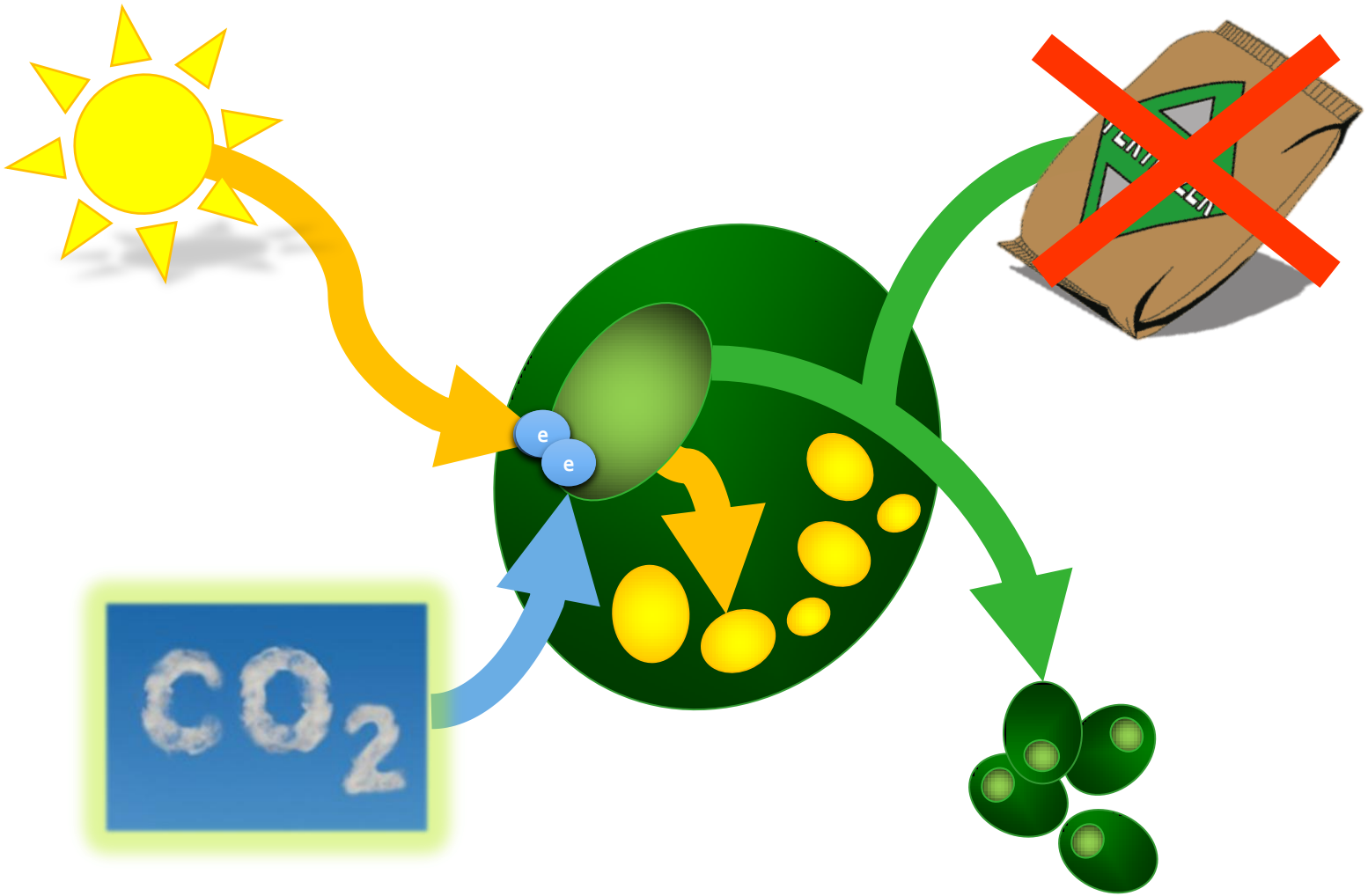
Current

Goal



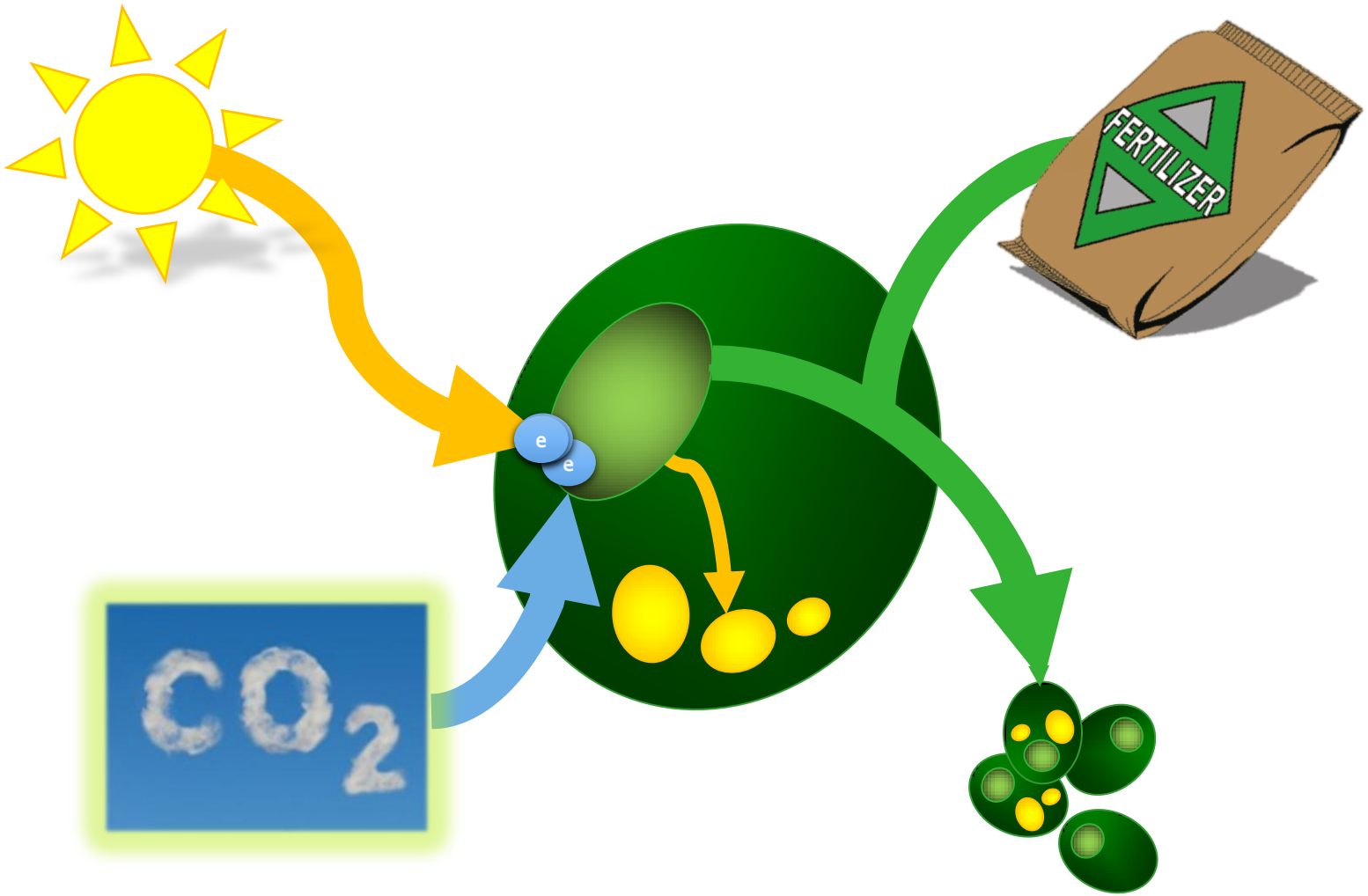
Hypothesis

TAG act as e^- sink



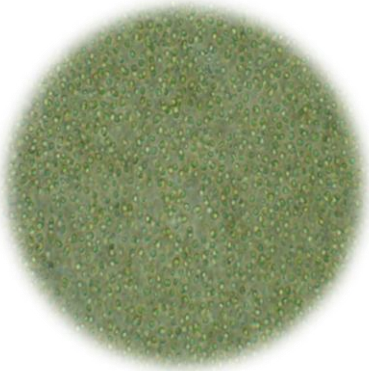
A new way of thinking

Growth and lipid production?

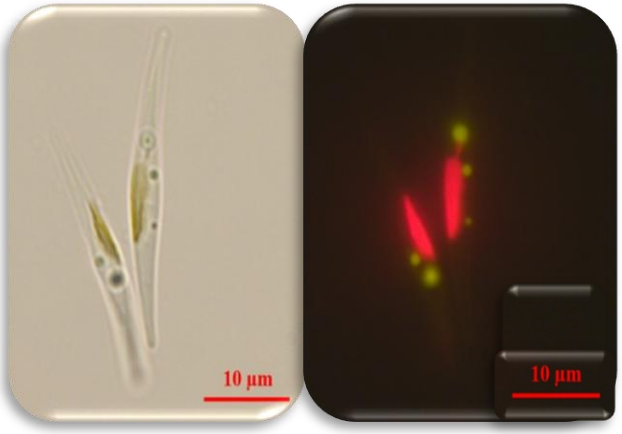


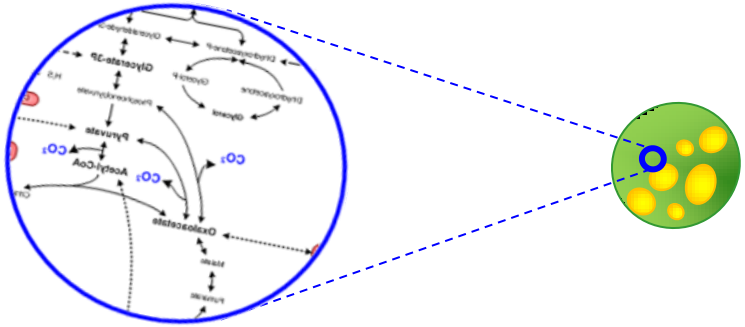
Work package 1

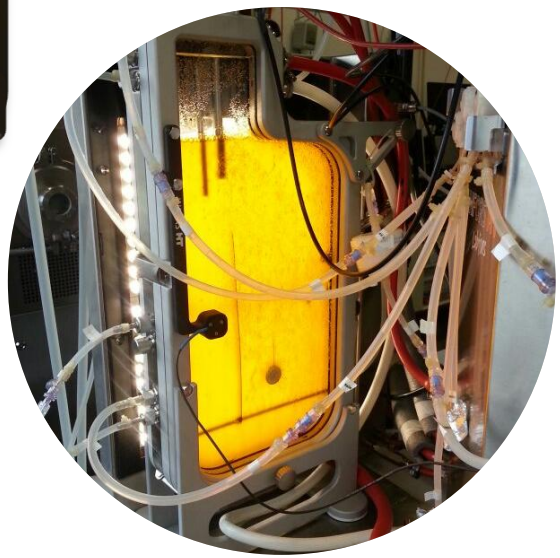
Develop a continuous one-step process with maximal lipid productivity:
genes, metabolism, biochemical aspects and bioprocess engineering.

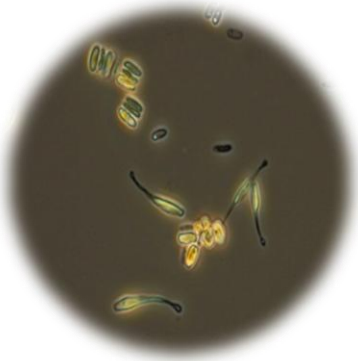


Nannochloropsis









Phaeodactylum

Ben-Gurion University of the Negev

WAGENINGEN UR
For quality of life

Work package 2

Pilot plants: ~10 m²

AlgaePARC

F&M

Ben-Gurion University of the Negev

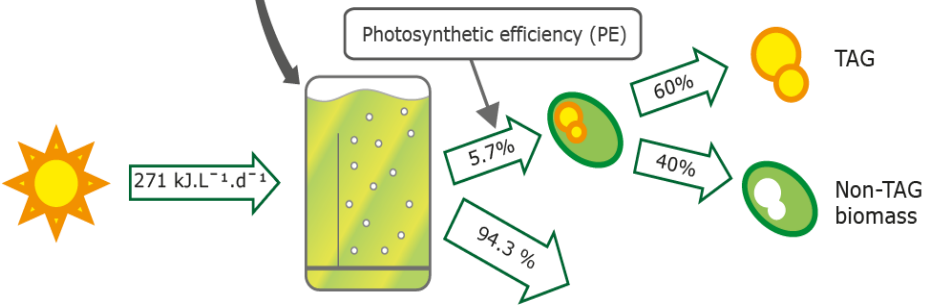
One step continuous biomass production

Demonstration plant: ~200 m²

Proviron

Conclusions batch vs. continuous

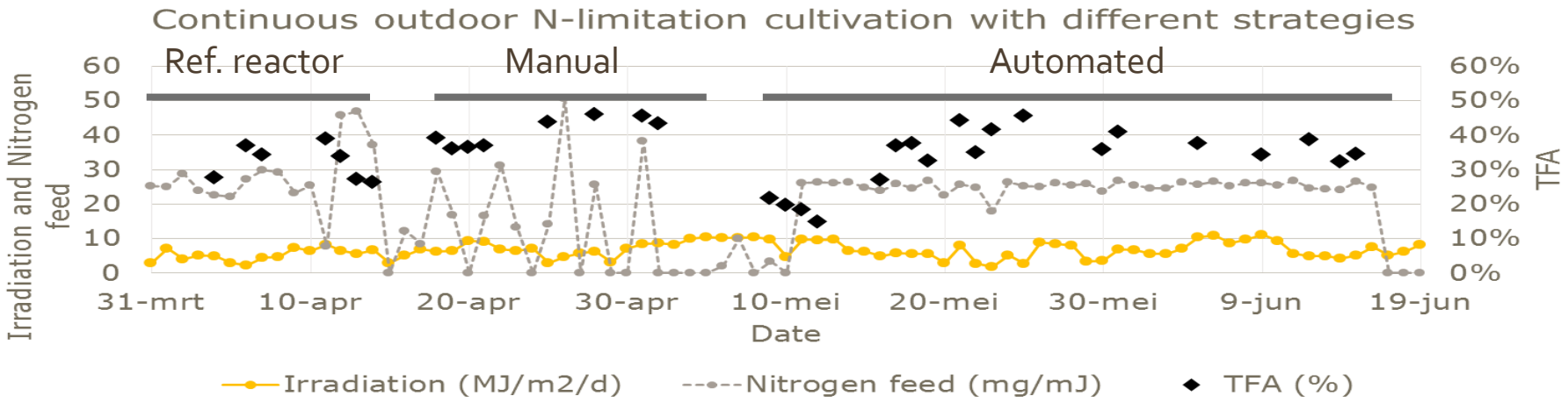
D	N-feed	PE	Flux towards TAG
0.50	100%	5.4 %	14 %
0.50	24%	4.1 %	47 %
0.25	100%	6.4 %	6 %
0.25	35%	5.6 %	41 %
0.25	23%	5.7 %	60 %
0.25	12%	2.7%	57 %



Lipid productivity:
Batch and continuous mode on average in same range / both in lab and outdoor

Lipid content:
generally higher in batch mode

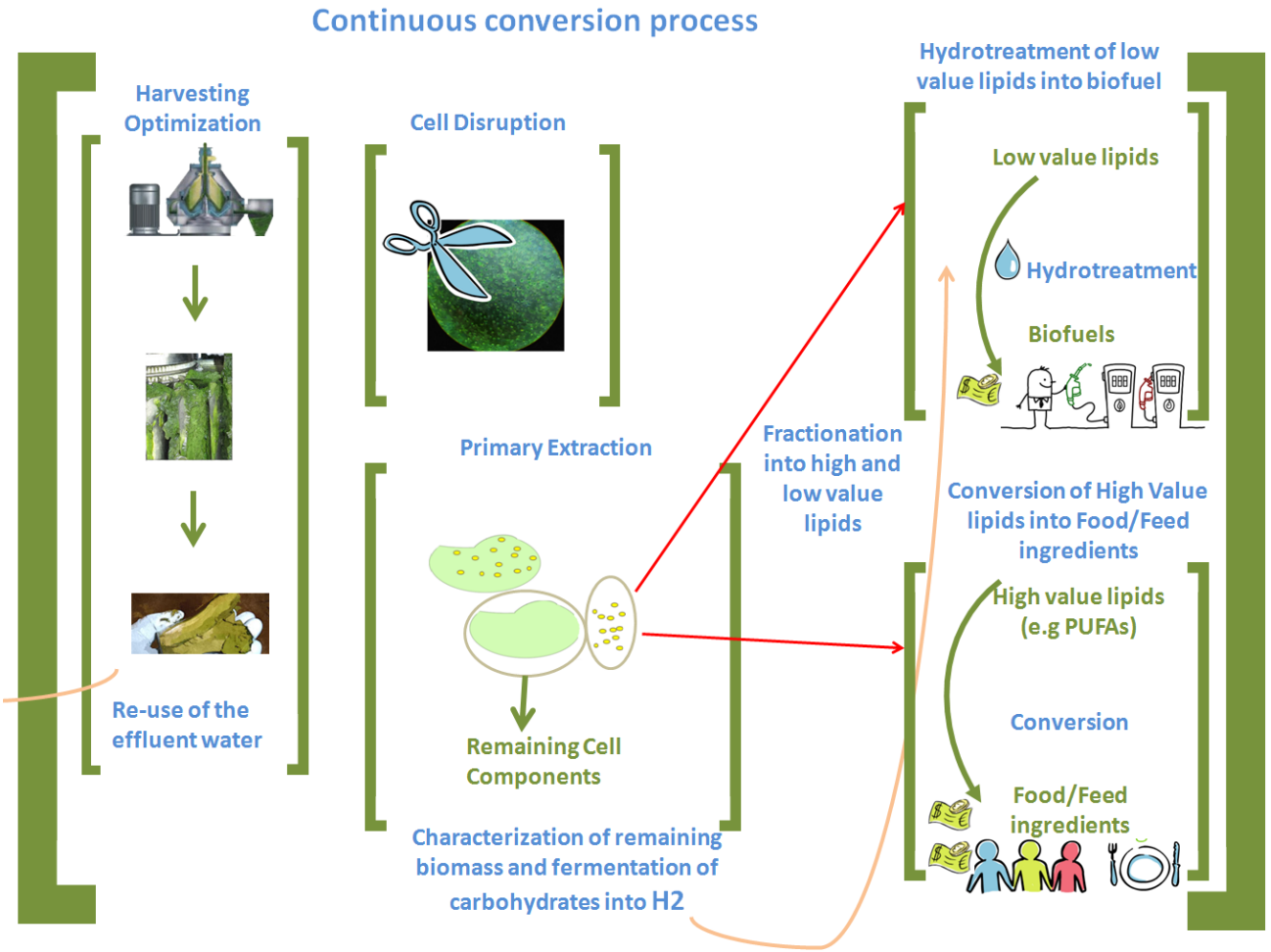
Process robustness:
varying results for both
(i.e. sometimes batch more robust, sometimes continuous more robust).



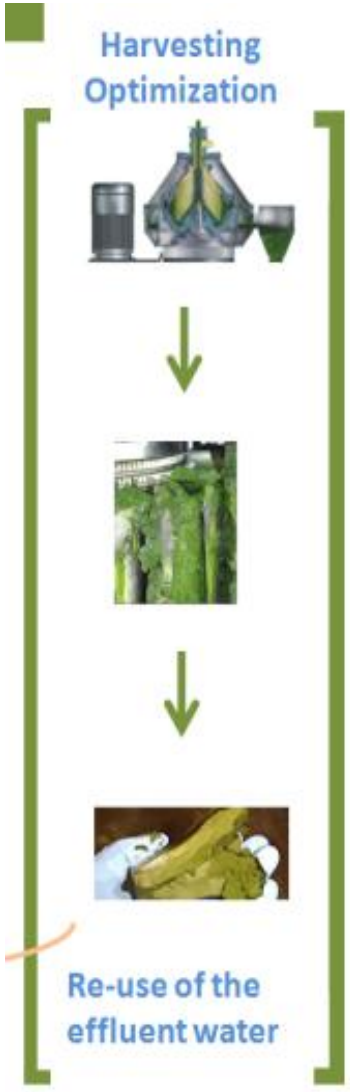
Workpackage 3 + 4

Optimization + Demonstration

Downstream processes



Harvesting

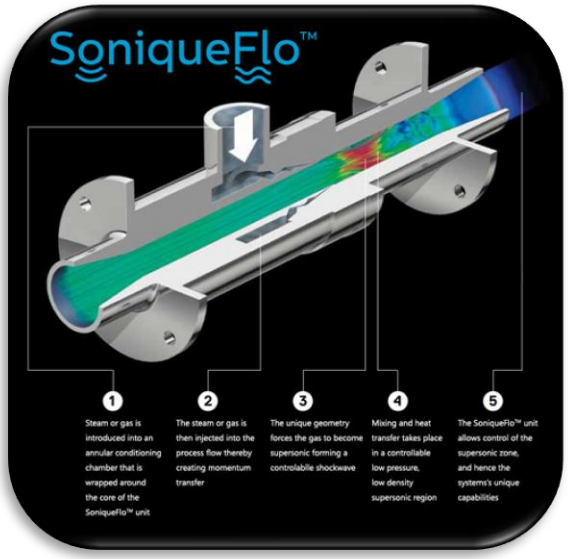


evodos
Separation Excellence

Key findings:

- Improved design → easier harvesting, minimize paste losses
- separation efficiency > 90%
- harvesting capacity > 6m^3/day for the selected microalgae

Cell disruption

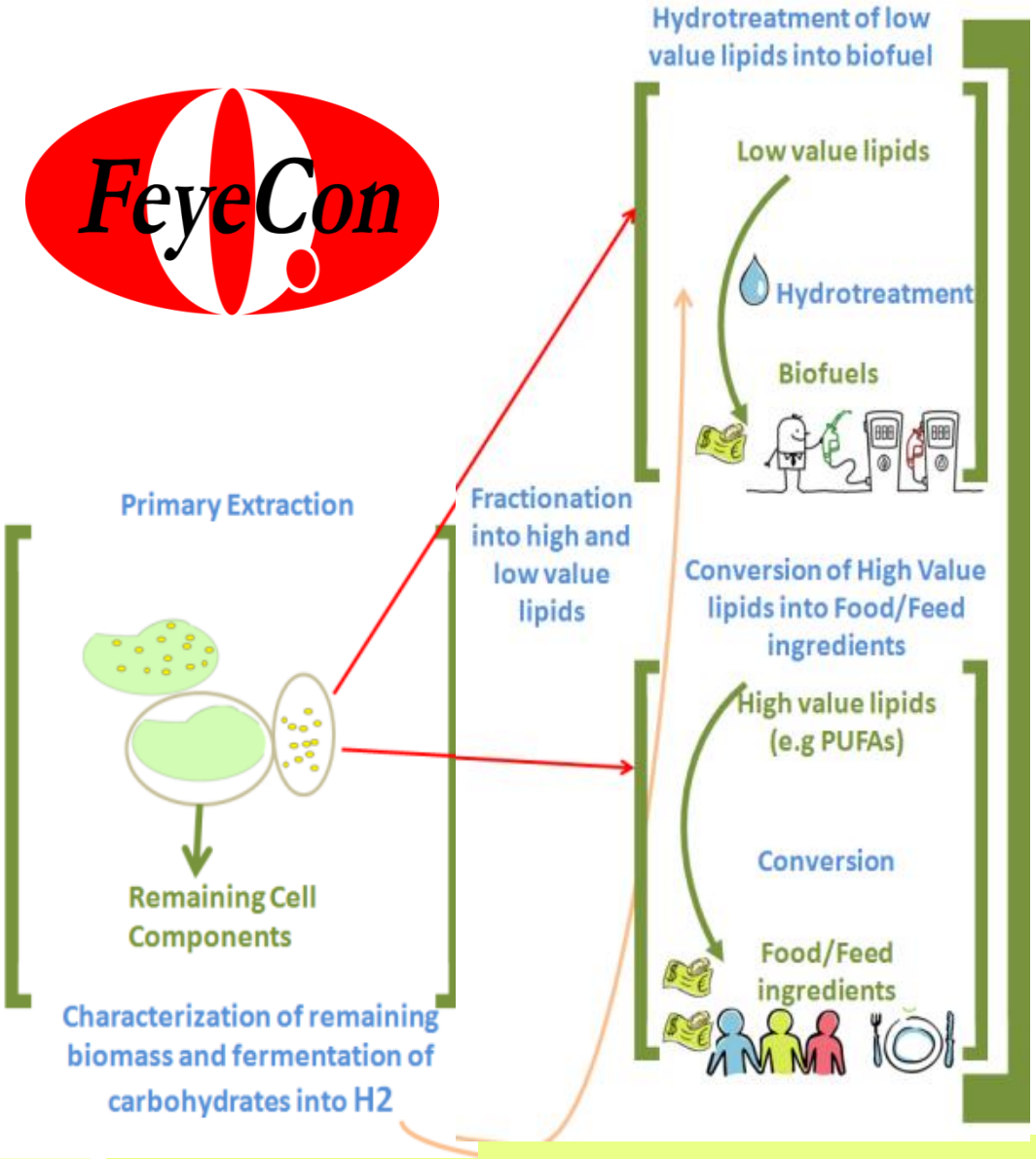


Key findings:

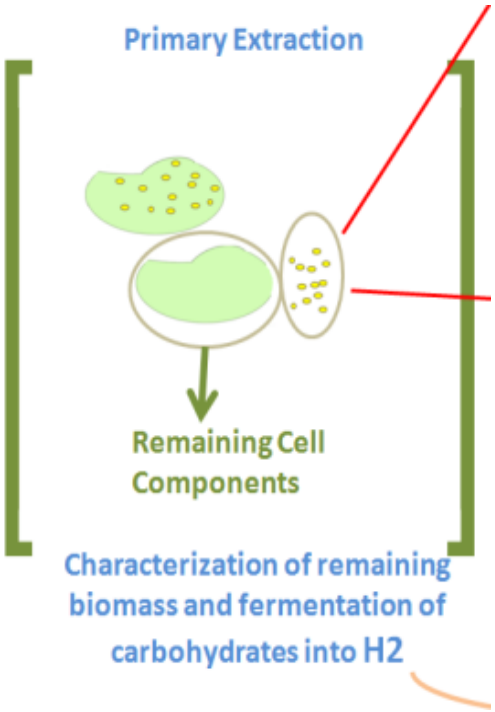
technology ready to be commercialized for cell disruption

- 25% of operational costs saved
- Less capital expenditure.
- High energy efficiency during the process
- It is a solvent free solution
- It has a very small carbon footprint.

Lipid extraction, fractionation & conversion



Lipid extraction, fractionation & conversion

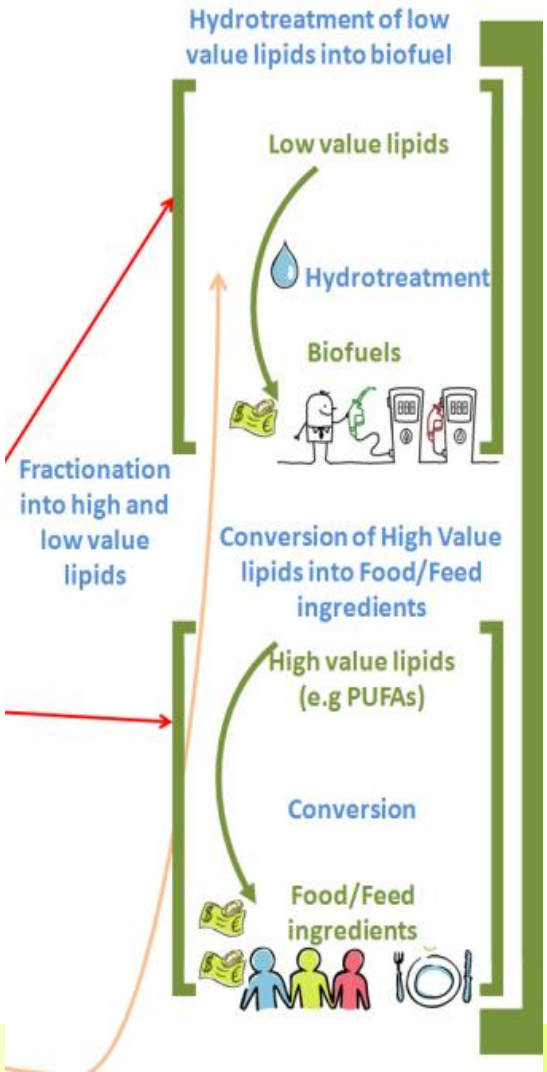


Primary extraction of lipids with supercritical fluid:

- Extraction of TAG with very high efficiencies (>95%)
- The biomass after extraction looks stable and has high value

Remaining protein rich fraction after lipid extraction could be fermented for hydrogen production.

Lipid extraction, fractionation & conversion



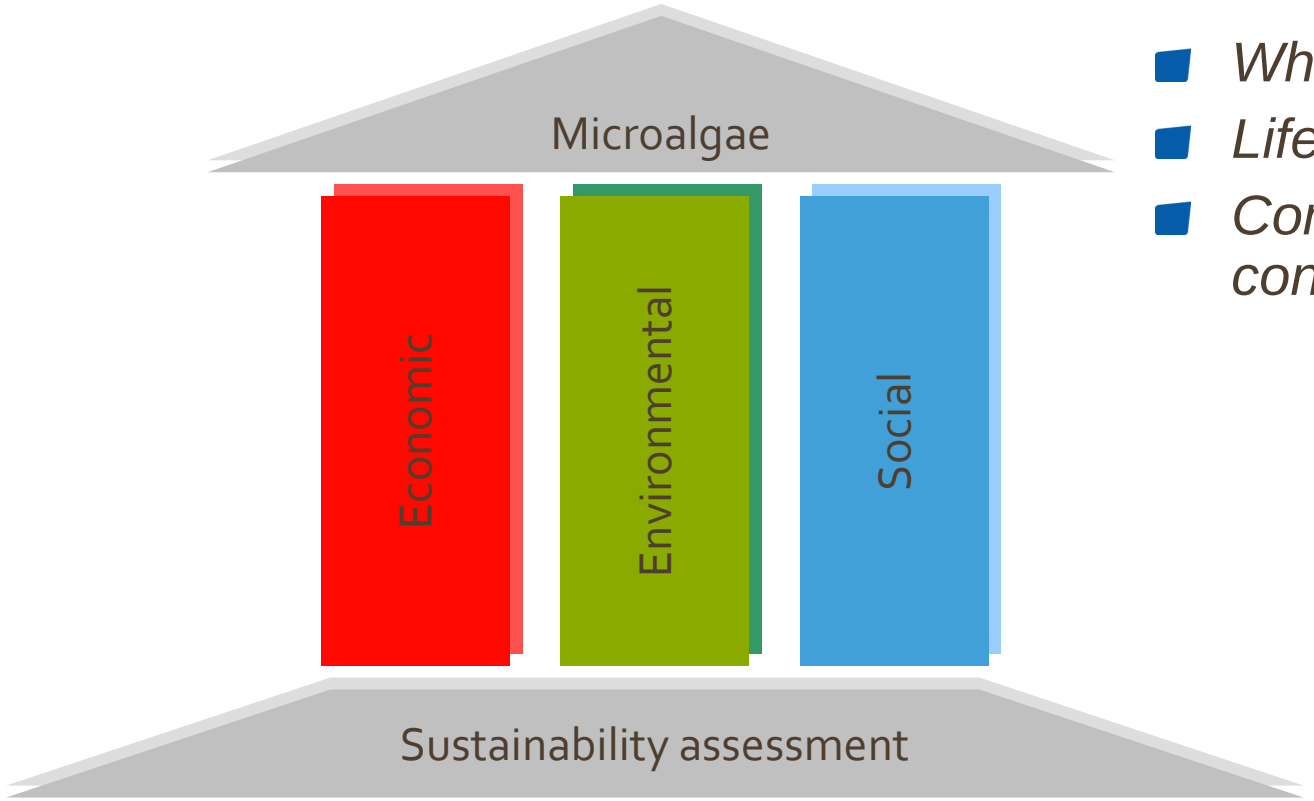
Novel reactive extraction and separation protocols based on advanced supercritical fluid technology:

- PUFAs were purified >81% which is higher than other technologies
- Concentration of PUFAs was stable and robust during 60 hours (in continuous running).
- FFAs content of oil was reduced from 23% to 1% at 50C (promising for today's vegetable oil main challenge).

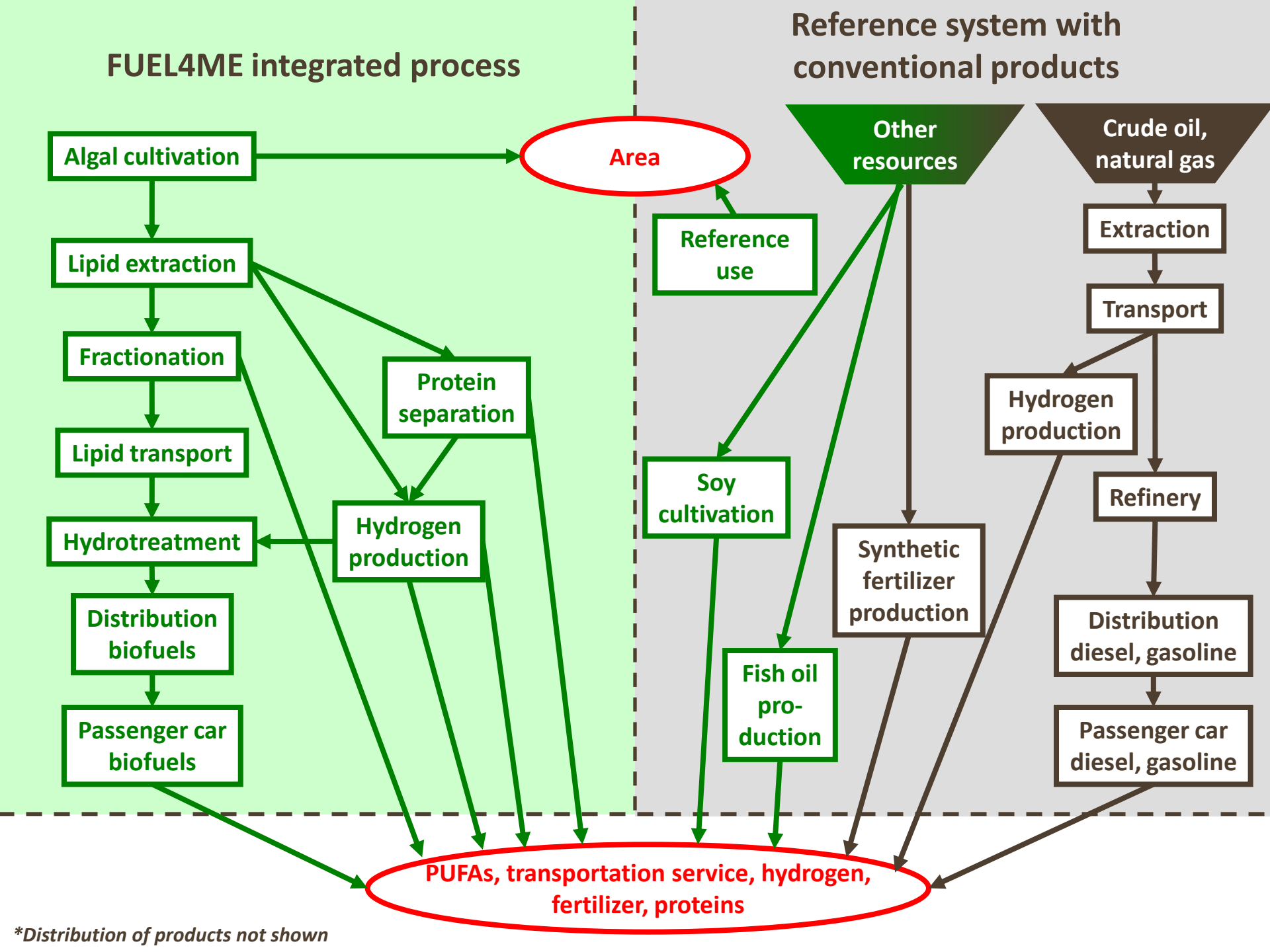
Neste sucessfully hydrotreated algae oil in micro-reactor to Neste renewable diesel.
Neste renewable diesel is a premium-quality drop in fuel compatible with all diesel engines and it is already commercially available.

Work package 5

To assess the environmental, social and economic sustainability of the continuous production and conversion process developed by FUEL4ME consortium.



- *Whole value chain*
- *Life cycle consideration*
- *Comparison with conventional system*


FUEL4ME integrated process
Reference system with conventional products
Algal cultivation
Area
Other resources
Crude oil, natural gas
Reference use
Extraction
Lipid extraction
Transport
Fractionation
Protein separation
Hydrogen production
Lipid transport
Soy cultivation
Refinery
Hydrotreatment
Hydrogen production
Synthetic fertilizer production
Distribution biofuels
Fish oil pro-duction
Distribution diesel, gasoline
Passenger car biofuels
Passenger car diesel, gasoline
PUFAs, transportation service, hydrogen, fertilizer, proteins
*Distribution of products not shown

Sustainability assessment

Main conclusions from the sustainability assessment

Main influences on the sustainability in the whole production chain:

- Cultivation & Harvesting
  - Electricity demand
  - Source of CO_2
  - Source of water
  - Suitable land

Main conclusions

Due to the **current state of the art** and the **big amounts** needed for biofuels it seems that microalgae cultivation for biofuels appears **less feasible** than for high value products, e.g. PUFA. **and a promising biorefinery approach was shown to have a strongly improved economic balance**

The FUEL4ME integrated process **can become economic viable and environmental sustainable** because of the current immature TRL level of the FUEL4ME integrated process, and the future possible technology improvements in a long-term perspective. We have shown the first steps in improvement of the chain and decreasing production costs along the chain. Yet, it still will need much more time and effort to make biofuel from microalgae economically feasible.

A **long term innovation strategy**, first with stronger **focus on higher value products**, will result in economically feasible and environmentally sustainable microalgae-based products.

Thanks for your attention!

Questions?