AlgaePARC

Translating research into applications

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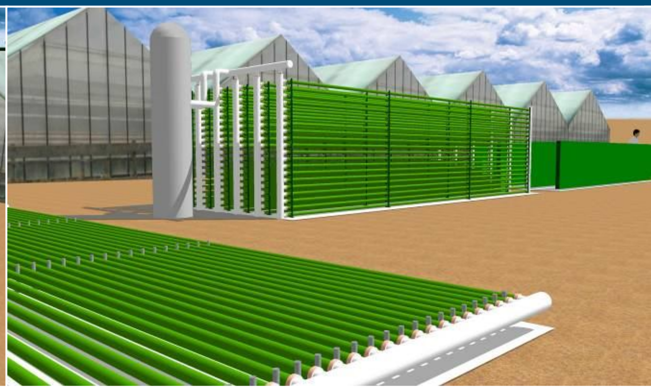
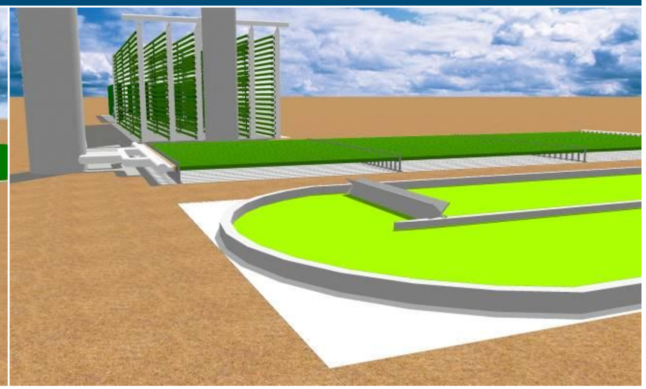

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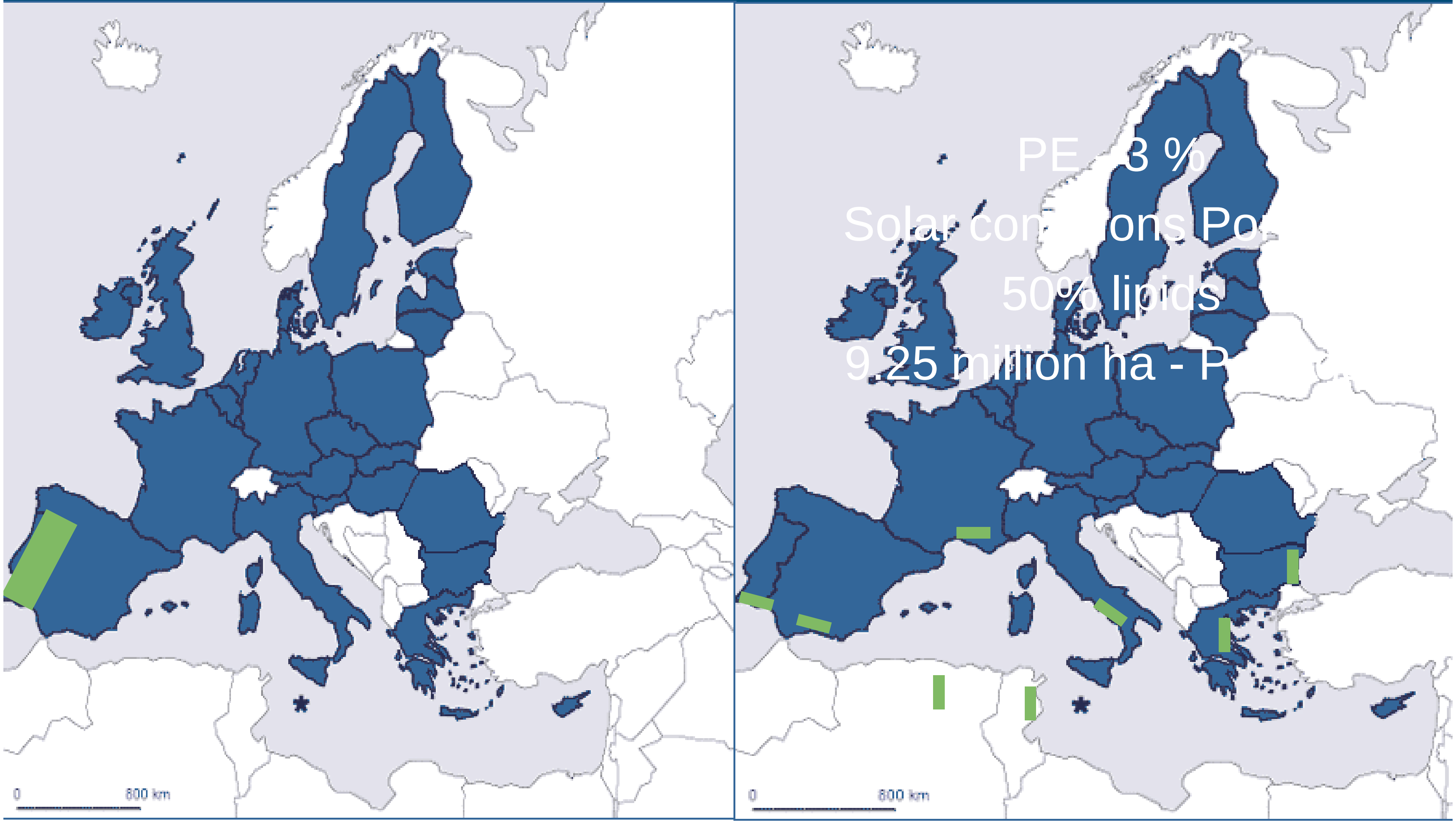
From a craft to an industrial process…

- Current worldwide microalgal manufacturing infrastructure ~5000 tons of dry algal biomass
- High value products such as carotenoids and w-3 fatty acids used for food and feed ingredients.
- Total market volume is €1.25 billion (average market price of €250/kg dry biomass)
- World production of palm oil is nearly 40 million tons, with a market value of ~0.50 €/kg

Scale up | Production costs

Wijffels R.H., Barbosa M.J. (2010) An outlook on microalgal biofuels. ***Science*** 329: 796-799

Transport Fuels in Europe - 0.4 billion m3



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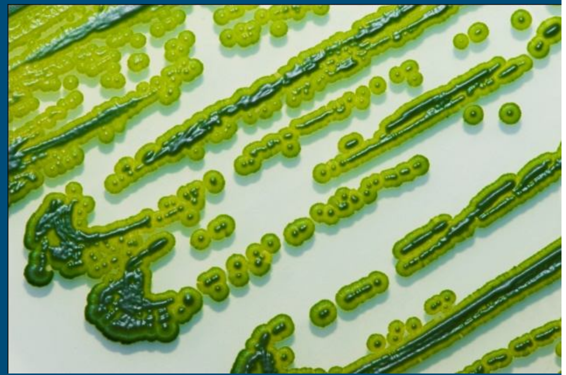
Wijffels R.H., Barbosa M.J. (2010) An outlook on microalgal biofuels. ***Science*** 329: 796-799

Production costs

- At 1 ha scale today: 10 €/kg
- At 100 ha scale today: 4 €/kg
- What will be possible: 0.40 €/kg

Norsker N-.H., et al (2010) Microalgal production – a close look at the economics. ***Biotechnology Advances***

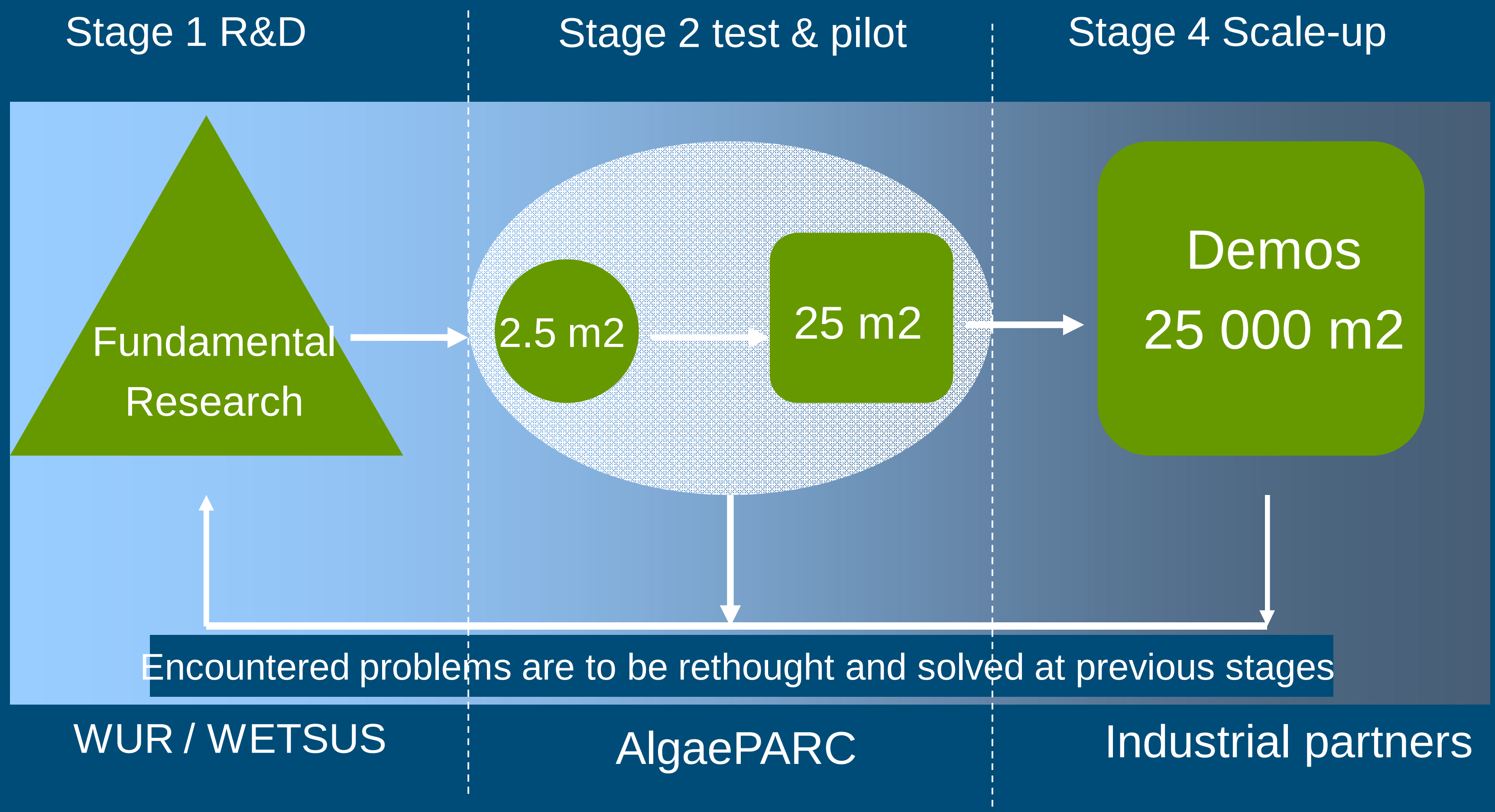
How ?



- Increasing photosynthetic efficiency
- Integrate processes (free nutrients)
- Decreasing mixing
- Developing cheaper and less energy consuming harvesting technologies
- Choosing locations with higher irradiations

Scale-up | Production costs | Energy requirement

Translate research towards applications



AlgaePARC

an international , open and independent centre for applied research on microalgae

The ultimate objective of AlgaePARC is to develop technology for sustainable production of feedstock for fuel , chemicals, food and feed

R&D at AlgaePARC is aimed to fill the gap between fundamental research on algae and full-scale algae production facilities

Production costs

Scale-up

Energy requirement

Production costs:

Increasing Photosynthetic Efficiency – what margin do we have?

PE 9.0 %

↓ reflection on PBR

8.6 %

↓ night biomass loss

7.8 %

↓ maintenance

What's left ?... 7.4%

ca 50% reduction in production cost

Light saturation?

Nutrient limitations? CO_2

Inhibition? O_2, light

Practice?... 3 - 4%

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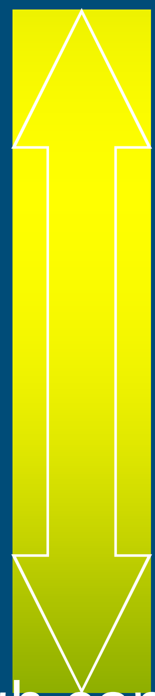
What's determining photosynthetic efficiency outdoors?

Measured / controlled parameters

- Light intensity
- Temperature
- O_2 partial pressure
- CO_2 partial pressure
- Gas flow rate / Liquid velocity
- Dilution rate
- pH
- Nutrients

Low controllability



High controllability

Production costs: Photosynthetic Efficiency

- At lab scale a photosynthetic efficiency of 6% seems to be within reach

Cuaresma et al., 2010

What about

- Pilot scale 10 – 100 m^2
- Extended time > 1 yr

Scale-up

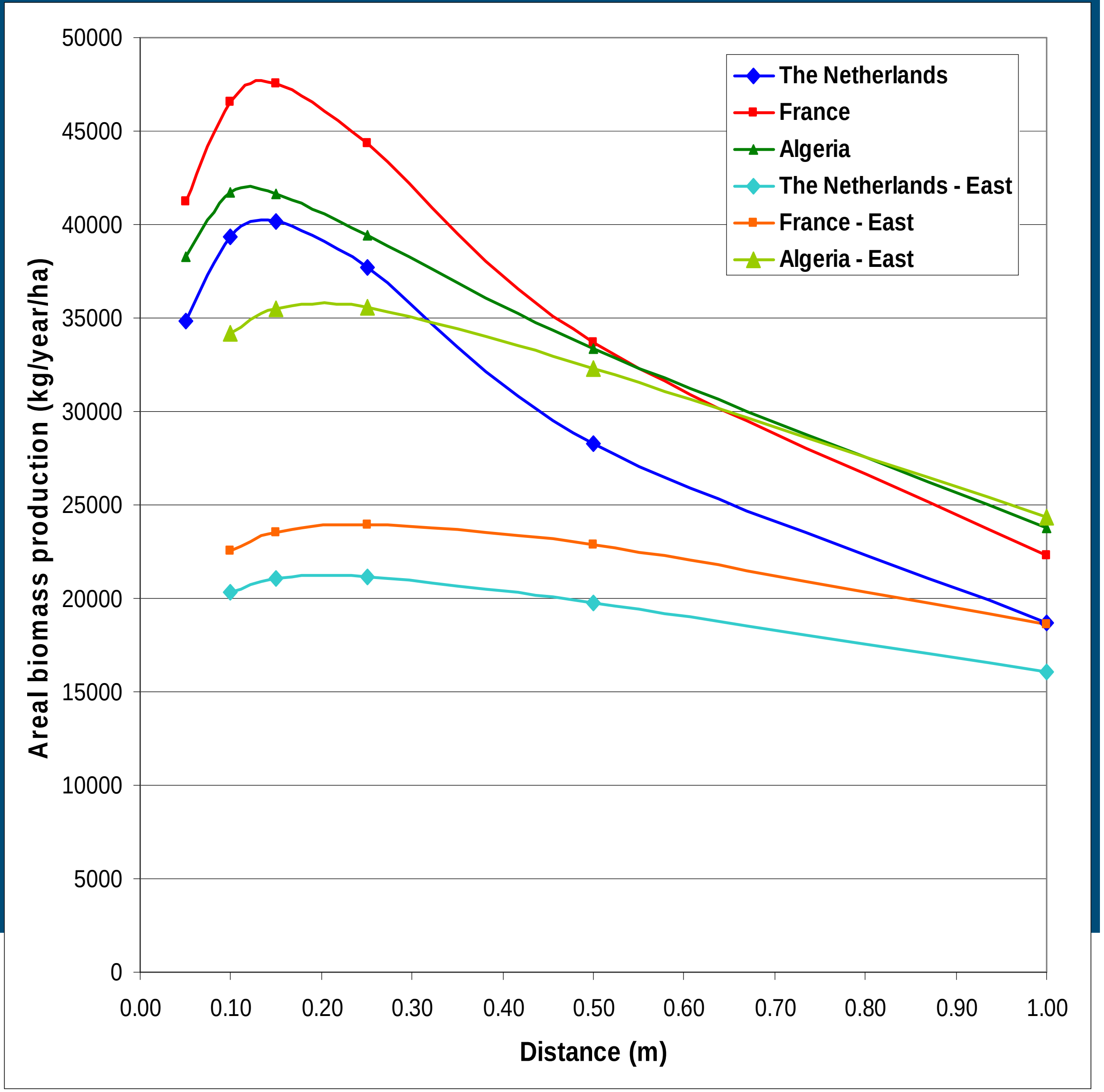
Information for design of full-scale plants

- Representative productivities
- Photobioreactor design
- Performance of different systems
- Operation strategies
- Plant layout

Scale-up

Layout

e.g Effect panel distance and orientation



Slegers et al, submitted

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Energy requirements

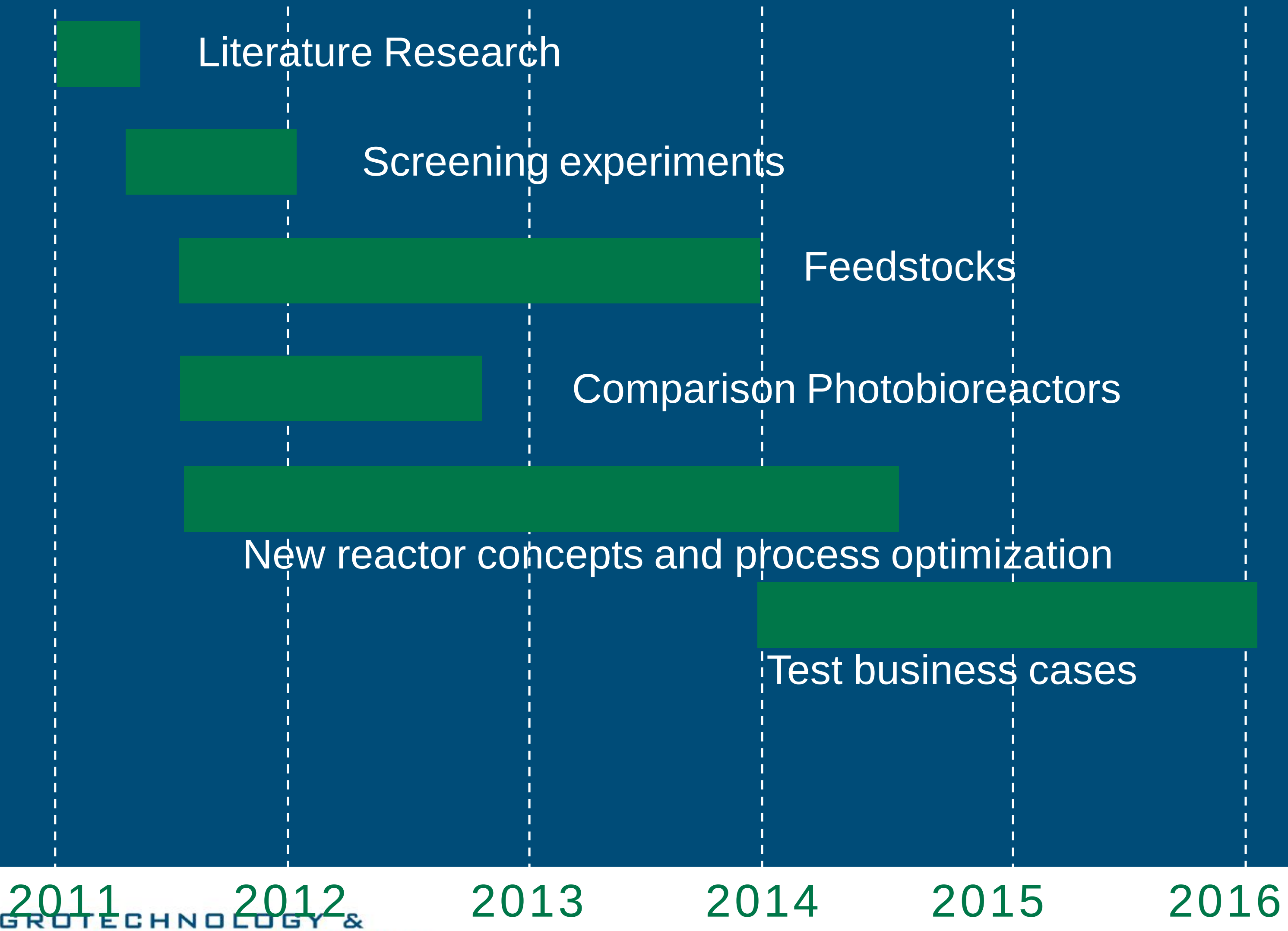
- Gassing
  - Supply CO_2
  - Remove O_2
- Mixing
  - Prevent sedimentation
  - Distribute nutrients and light
- Harvesting

Challenge:

- Enhance transfer rates

- Process control to exploit external conditions

Time Plan and R&D Activities



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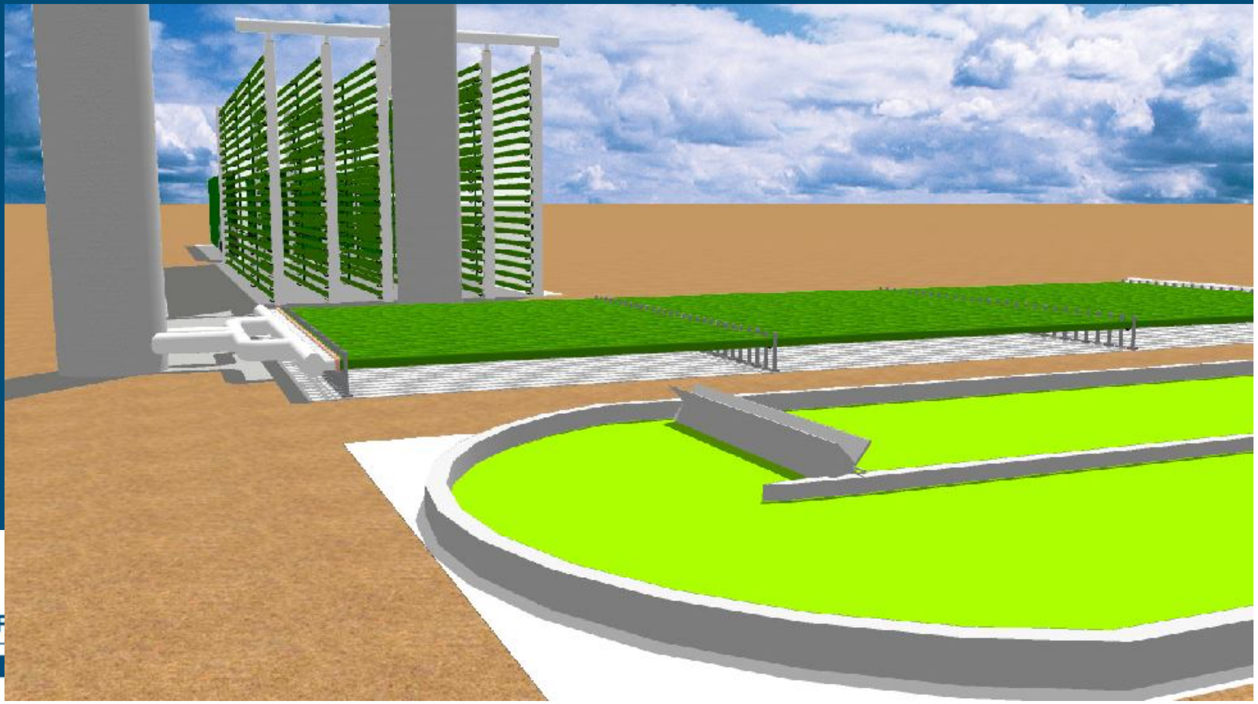
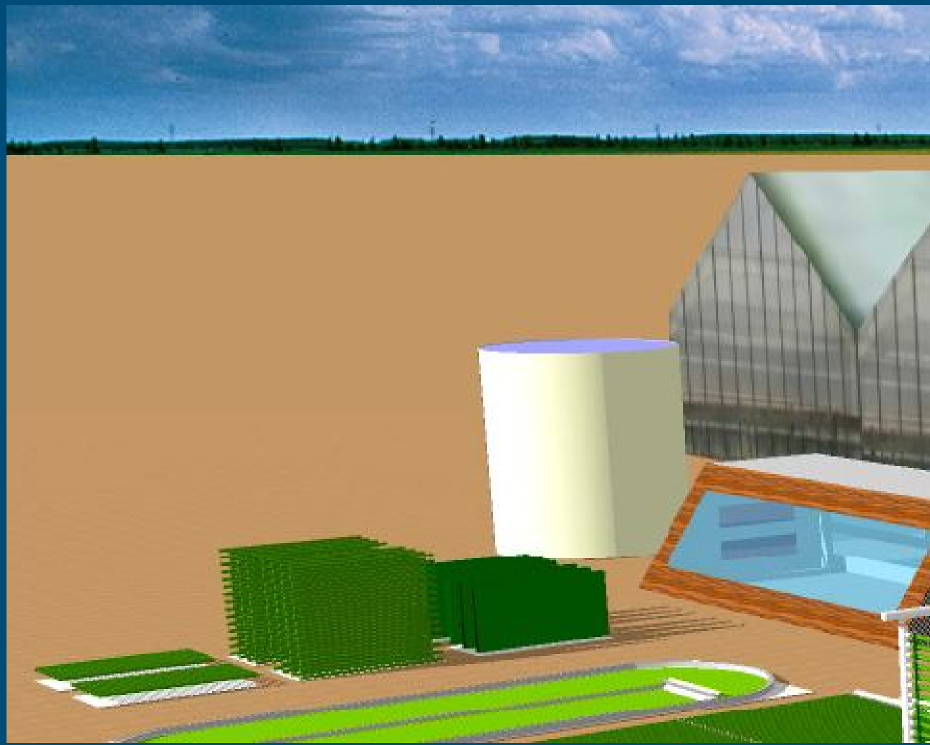
24 m^2 systems

- Long time performance (1 year)
- 4 systems running in parallel
- Problems: solve in lab
- Representative productivities for full scale
- Information for design of full scale plants (layout, distance between tubes or plates, light path, orientation)



2.4 m² systems

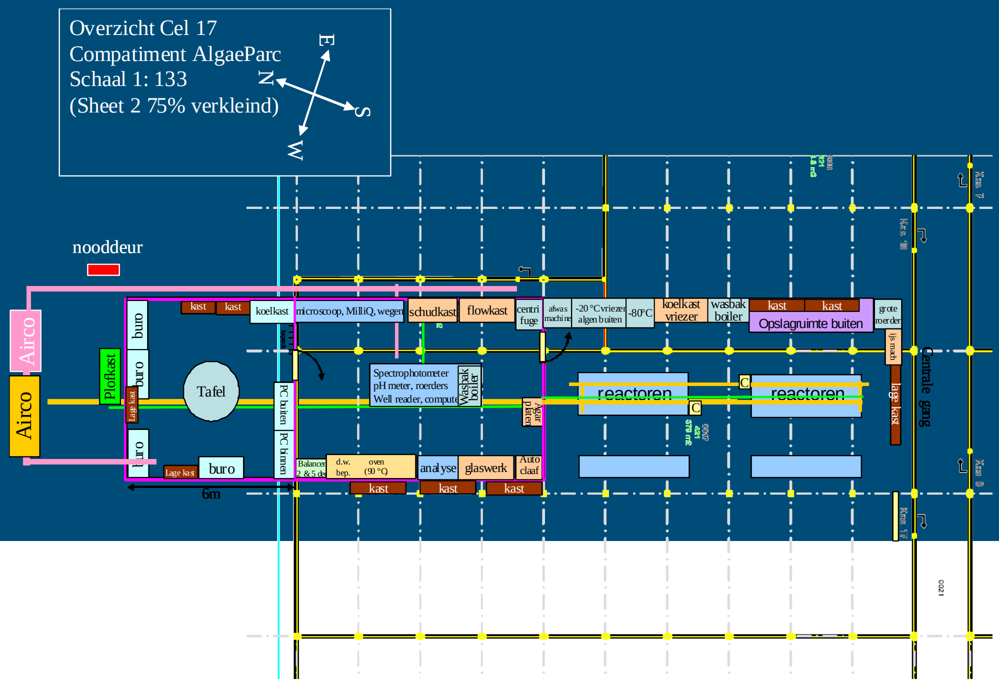
- Phase between lab and pilot
- Test things where you are not sure of
- Different strains
- Different feed stocks
- Adaptations in design
- New systems
- If successful
  - To 25 m^2 scale
- If not successful
  - More experiments
  - Reject



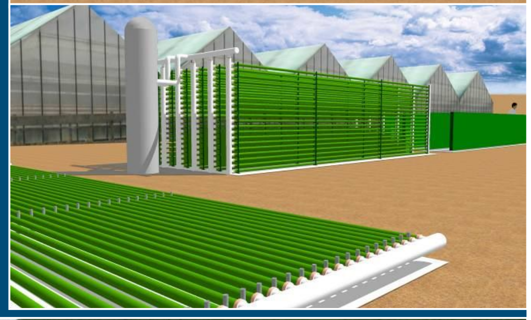
…and a Lab

- Storage of strains
- Medium optimisation
- Initial test of feedstocks
- Screening
- Analytics
- Support for outdoors

mL –> m3 *in situ*



Cultivations systems (24 m^2)



Open pond

- Reference

Horizontal tubes

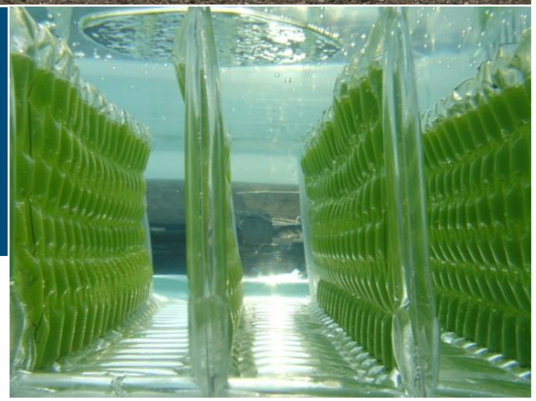
- high light intensity
- oxygen accumulation

Vertical stacked hor. tubes

- light dilution
- oxygen accumulation

Vertical plastic films (ProviApt)

- light dilution
- no oxygen accumulation



Screening Experiments

- Axenic strains
- Storage of strains (cryopreserved or freeze dried)
- Strain selection on growth rate, lipid content and extractability (well plate experiments).
- Optimisation of cultivations conditions (temperature, pH, macronutrients)
- Testing promising strains in experimental units outdoors (2.5 m^2 photobioreactors)

Deliverables

- Strains with high biomass and oil productivities

- Database with strains, growth rates and lipid content

Feedstocks

- Comparison industrial grade nutrients vs. analytical grade nutrients
- Selection of the most promising waste streams as feedstocks
- Determination of growth rate and lipid content of microalgae grown on selected waste streams\waste gas (different sources of CO_2, N and P)
- Extension of database from literature research

Deliverables

- Selection of best strains for different feedstock combinations

- Algae uptake capacity of nutrients from different waste streams

Comparison of Photobioreactors

- Areal and volumetric biomass and lipid productivity
- Energy balance
- Nutrient requirements
- Carbon dioxide consumption and oxygen production
- Operational costs
- Cleanability
- Culture stability (assessment of infections and algae population)
- Robustness of the system

Deliverables

-Long time performance

- Biomass and lipid productivity

-Metabolic performance under different conditions

-Determination of culture stability

- Information for improvement of operation strategies

New reactor concepts and process optimization

- Test new concepts and variations on reactor design / layout
- Optimize photobioreactors geometrically
- Develop operation strategies
  - Dilution rate /harvesting time
  - Media recycling
  - Heating/cooling vs. operation costs and energy requirements

- Optimise productivity and decrease energy requirements by dynamic process control to exploit external conditions:
  - adjusting biomass concentration, circulation velocity or gas flow rate

Deliverables

- Fast assessment of performance of new concepts and variations

- Development of operational strategies

- Optimization of lipid and biomass productivity

Test Business cases

- Reorganisation of initial systems and performance of new runs with different waste streams
- Translation of data from pilot plant photobioreactor to industrial scale. The following parameters will be evaluated: productivity, costs, energy, and technical feasibility

Deliverables

- Proof of concept of different business cases

- Knowledge of the costs, energy requirements and technical feasibility based on experimental data (that can be used in the design of demonstration plants)

Financial structure AlgaePARC 7 M€

- AlgaePARC facility:
  Ministry of Agriculture
  - Province of Gelderland
  - Wageningen UR + industry
- AlgaePARC research program (2011-2015):
  Part of Towards Biosolar Cells
  - in cash contribution companies
  - in cash matching TBSC
- Ambition to become international independent center of applied algae research
  - Additional projects photobioreactor technology, processes and biorefinery
  - Contract research

Time Plan

- Indoors facilities, December, 2010
- Outdoor reactors + facilities, March 2010
- Grand Opening - Mid May 2011

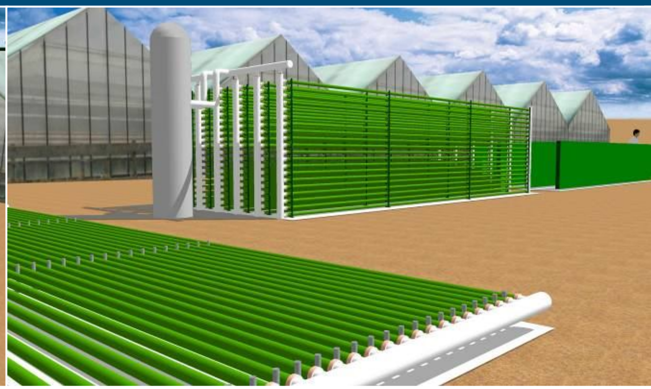
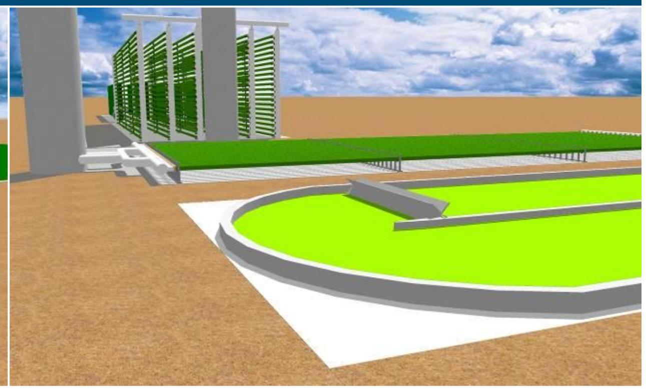
26-06-10

15-09-10

12-10-10

www.algae.wur.nl

www.AlgaePARC.com

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