ECO CONGRESS
innovations from biomass –
Öko-Innovationen mit Biomasse

ECO innovations from biomass 2015 –
17-18th of June, Papenburg, Germany

How to concretely access industrial sectors with microalgae production based on industrial ecology concept

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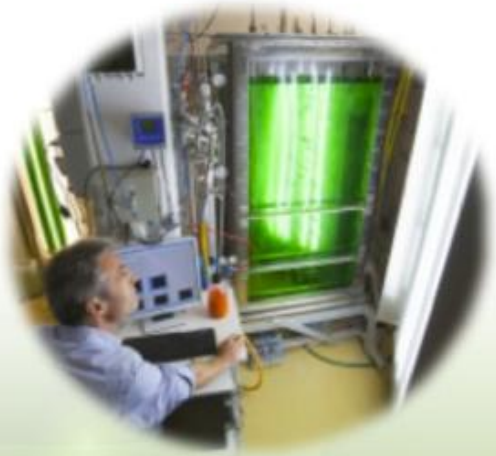
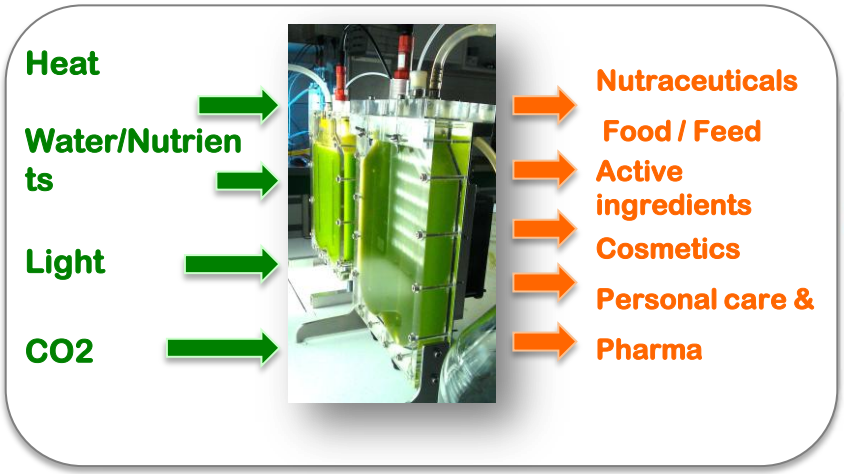


Who are we?

Our Expertises

MICROALGAE PRODUCTION ENGINEERING from LAB to INDUSTRY

WASTE MANAGEMENT VALORISATION



ALGO-REFINERIES MICRO-ALGAES' PRODUCTS

EQUIPMENT TRAINING & SALES

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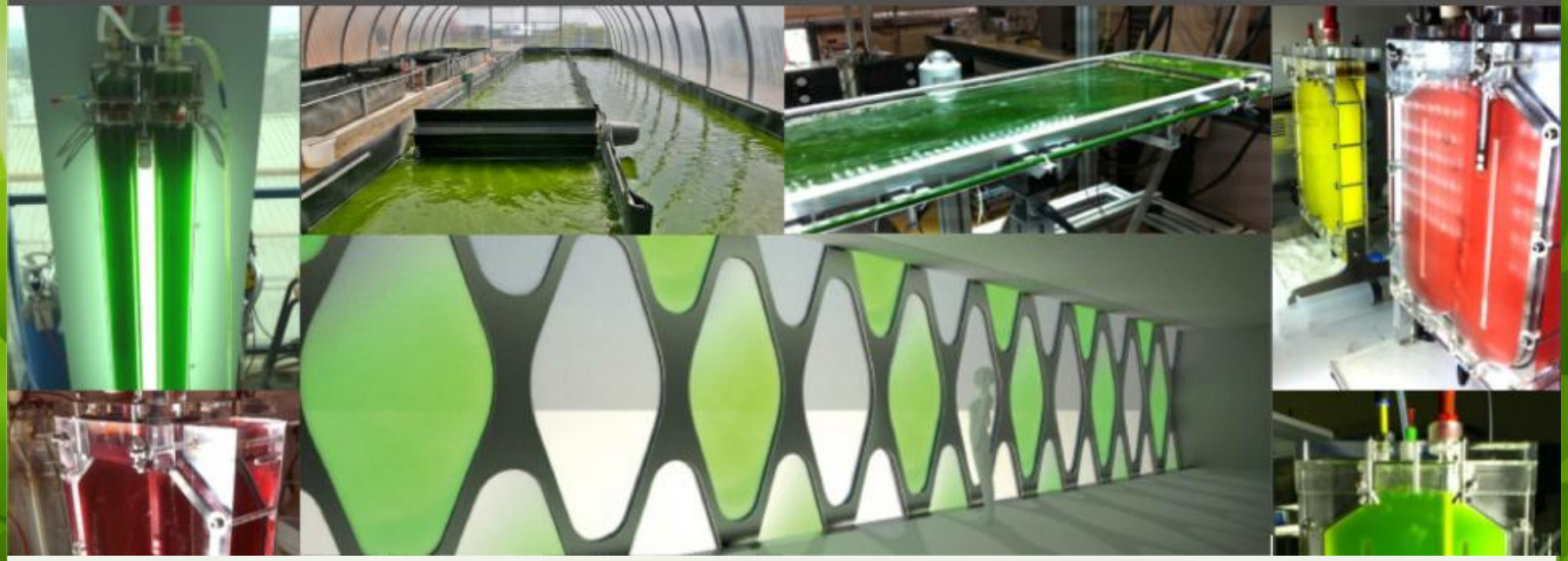
Who are we?

Technical innovation & Diversity in production tools



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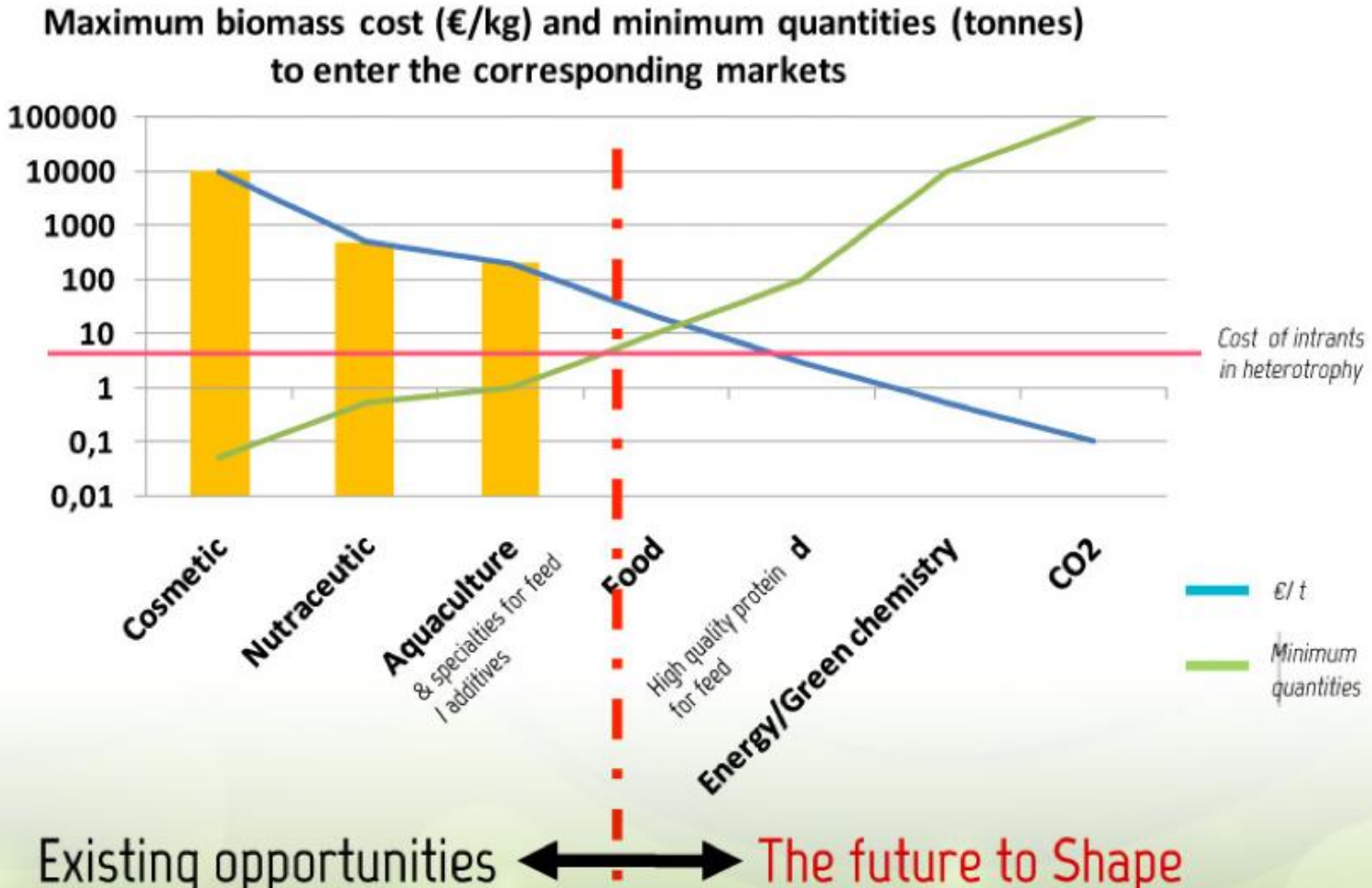
Our approach

Industrial ecology

Why thinking industrial ecology ?

Microalgae and market access



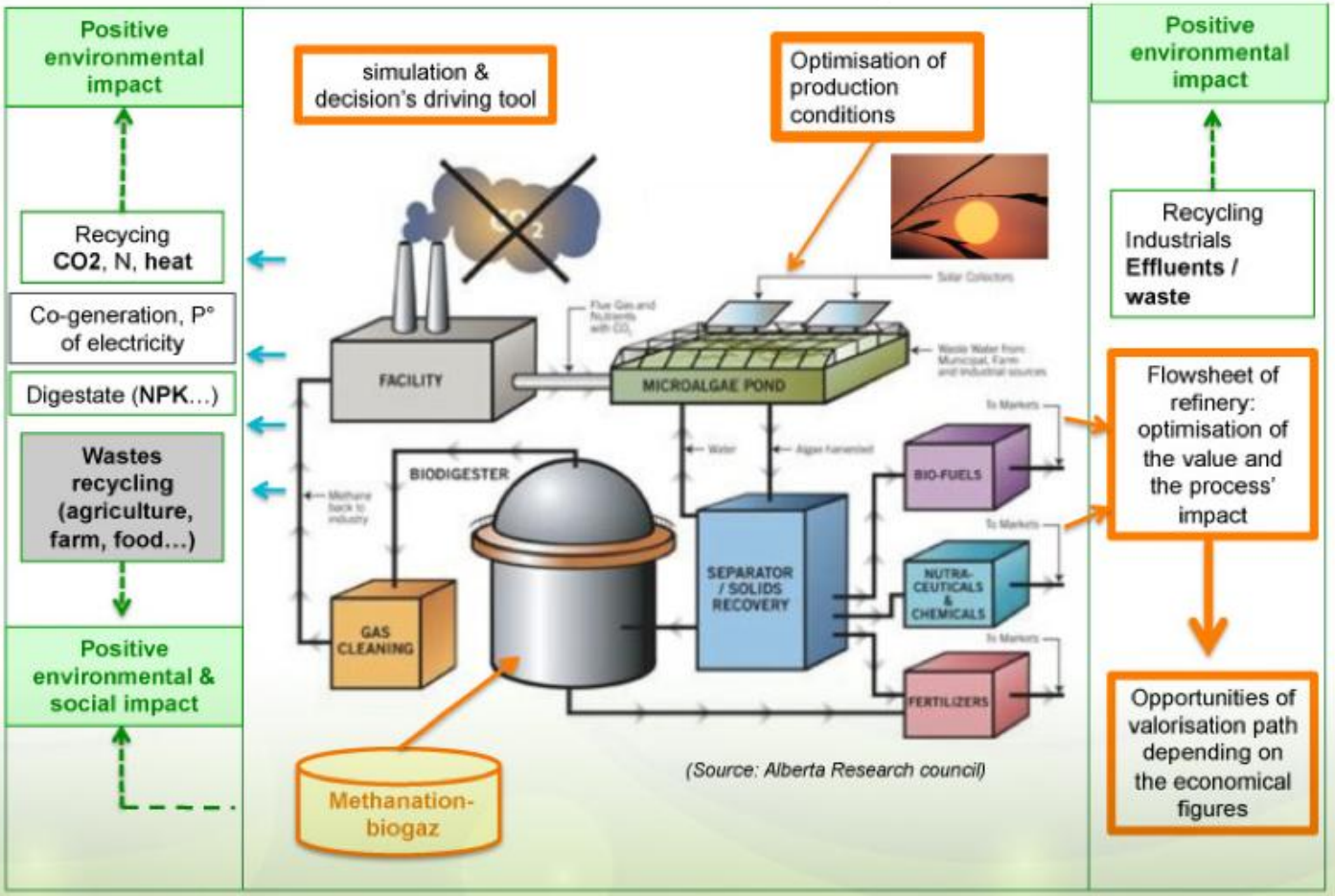
We are deeply engaged in a circular economy / sustainable development vision with our microalgae

4 concrete axis:

- **CO_2 capture**
- **Bio-asphalt**
- **Methanation**
- **Smart cities…**

Circular Economy

Autotrophy (or mixotrophy) and joint-economy required
a network of industrial activity interconnected



CO_2

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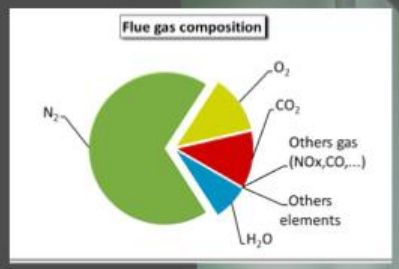
Capture of CO_2 and production of microalgae with the flue gas produced by a cement plant

Gargenville plant, France

❖ Flue gas sampling

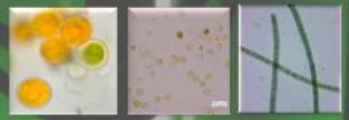
Sampling line



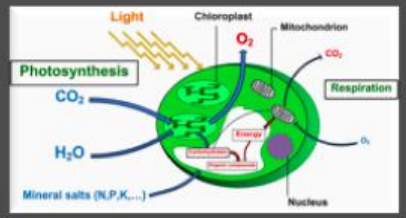
Flue gas composition

- A sophisticated sampling line is connected to the chimney in order to extract the flue gas. The control of gas flow rate is implemented by a electronic mass flowmeter (representative gas sample injected into the photobioreactor).
- The flue gas is composed mainly of dinitrogen , dioxygen, carbon dioxide and water with traces of different mineral compounds.

❖ Microalgae



Different strains of microalgae :
a) *Dunaliella Salina* b) *Chlorella vulgaris*
c) *Arthrospira platensis*



Mechanism of photosynthesis

Microalgae are micrometric unicellular organisms. Microalgae are autotrophic, they produce complex organic compounds from CO_2 and water using the energy of light (artificial or natural) by photosynthesis mechanism implementing chloroplasts which contain chlorophylls and other pigments. To obtain 1kg of dry algal biomass, about 1,8 kg of CO_2 is required.

The microalgae have many advantages:
- They can grow 5 to 10 times faster than food crops and with a high productivity
- Cultivate all the year and almost everywhere, even in non-arable land
- They produce numerous interesting products like protein, oil, pigment, …
- Capture and recycling of industrial carbon dioxide

Microalgae powder

Challenge / opportunity =>

CO_2 : coproduct of the cement industry

(≈ 700 kg CO_2 / t of cement) no valorization !!

CO_2

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Artificial light

Sunlight

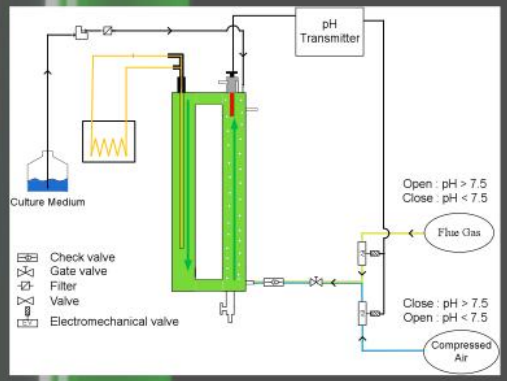
a) Plastic tubes airlift photobioreactors

b) Flat panel airlift photobioreactor

a) This pilot is composed of two identical tubular photobioreactors in order to compare the productivity. The first photobioreactor is supplied with pure CO_2 and the second with flue gas. Artificial light is used as energy source and the temperature of the system is of 25°C with a pH of 7,5

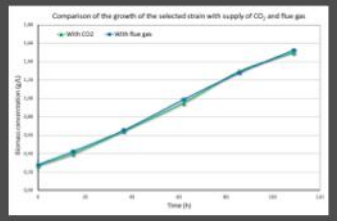
b) This PBR is flat, it has a rectangular shape with a thickness of 1.5 cm. The culture conditions are similar than the other photobioreactor, except the use sunlight as energy source. A luminometer is used to measure the quantity of sunlight in order to make a data model.

Diagram pH control and supply of carbon dioxide



The regulation of pH is a very important parameter to maintain a optimum pH. During the photoautotrophic growth, cells take up the dissolved CO_2 and the pH increases. When the pH is above the setpoint value (it's 7,5 for our experiment), the flue gas or the pure CO_2 are injected into the photobioreactor. When the pH is below the setpoint value, the injection is stopped.

Growth with flue gas or pure CO_2



- Microalgae can grow with the flue gas
- The growth between the culture with pure CO_2 is almost identical to the culture with flue gas

Outlook

❖ Industrial applications of microalgae

Short-term		Mid- and long-term	
Nutrition	Cosmetic & Health	Environment	Energy
• Human • Animal	• Antioxidant • Carotenoid • Phycobiliprotein • Omega 3 & 6	•Water treatment	• Biofuel • Biomethane • Bioethanol

CTG Italcementi Group

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Methanation

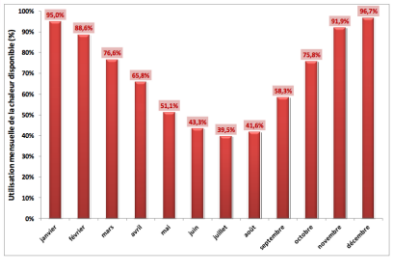


Figure 4 : Taux mensuel d'utilisation de la chaleur pour une surface de production de 5 hectares

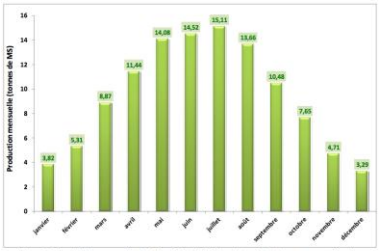
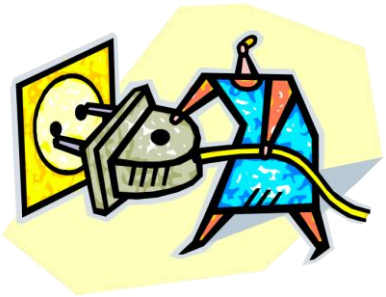


Figure 6 : Production mensuelle (matière sèche) d'*Arthrospira platensis* pour une surface de production de 5 hectares

Methanation

1



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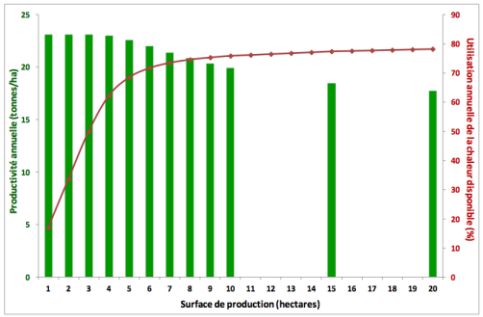


Figure 3 : Evolutions du taux annuel d'utilisation de la chaleur et de la productivité annuelle en fonction de la surface de production

Study on industrials' effluents capture and their valorization with microalgae production

↔ **Revenue 1**

Biomass' P° + bonus energy

Revenue 2 + 3

Smart cities

☑ **Issues**: climate change, ecological footprint of the city, global food challenge, end of resources and fossil energy

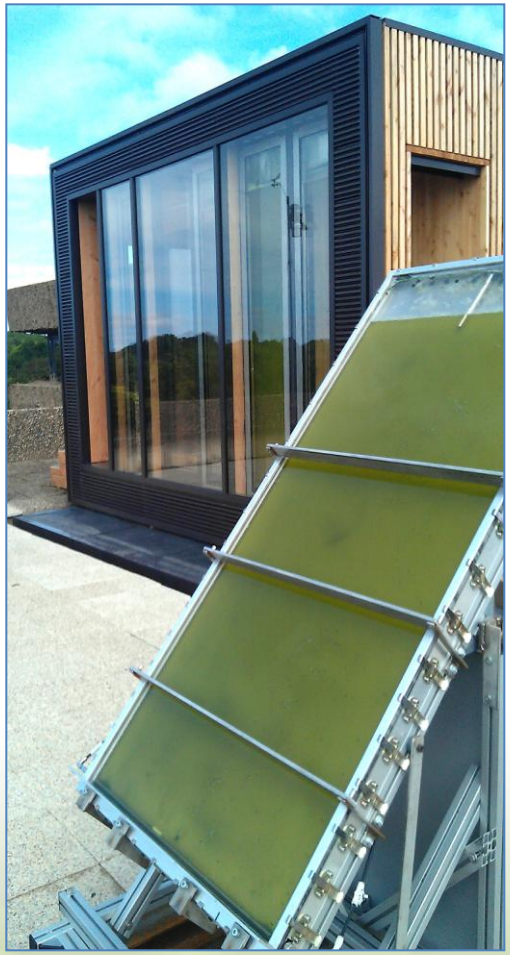
☑**Solution**: associate microalgae cultures to the building

☑ **Why**: it exists a complementarity between microalgae cultures and building functioning

- → CO_2 capture from boilers
- → treatment of local effluents
- → valorization of fatal heat and building heat loss
- → production of algae biomass for the health, cosmetic and food sectors
- → renewable energy

Smart cities

Prototype demonstrator on the roofs of the University in Saint-Nazaire => First result of interest:



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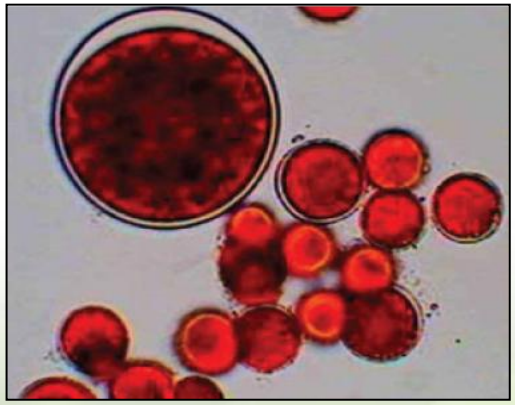
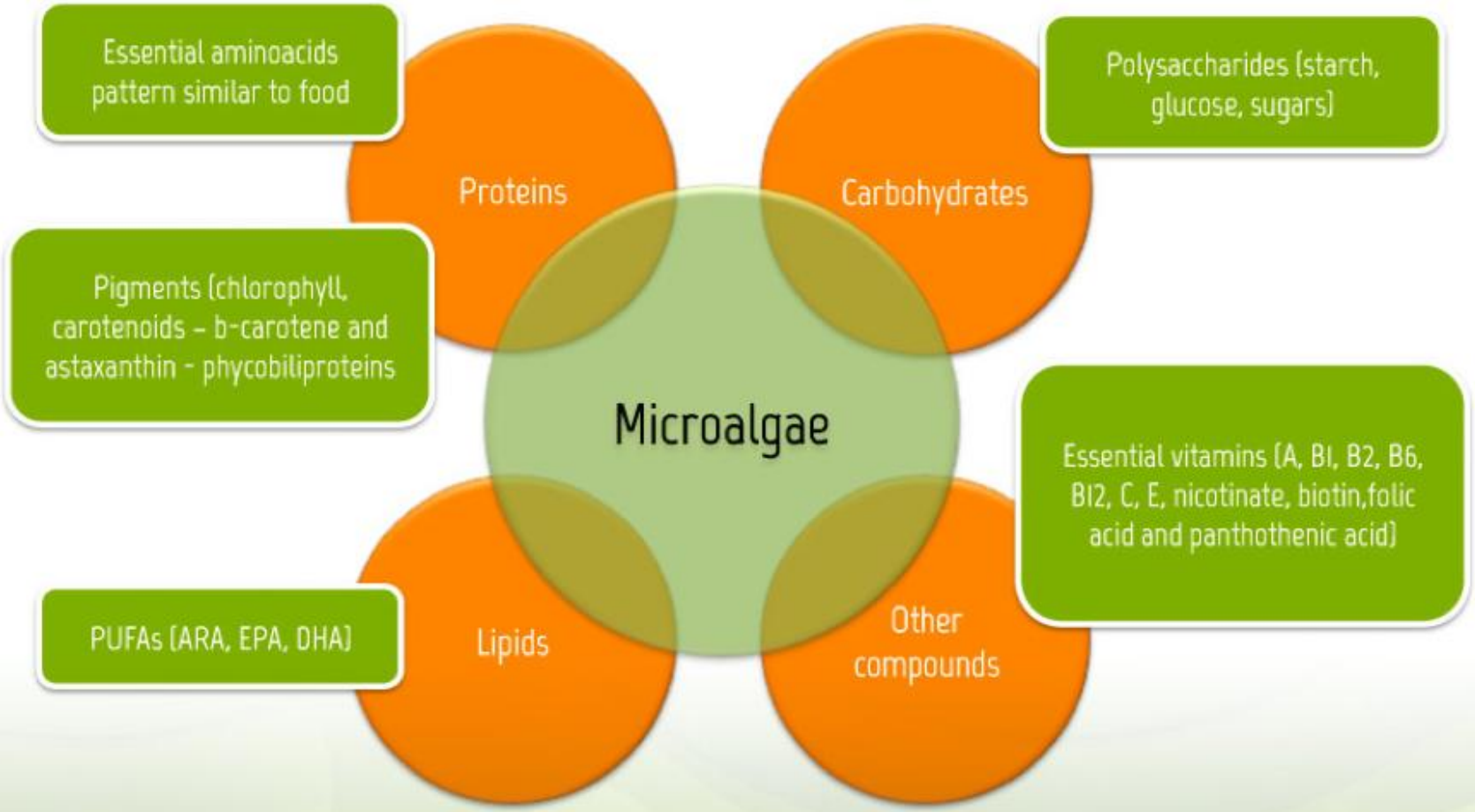
- Reducing the use of air conditioning

- Development of algal models with extraction of high added-value molecules

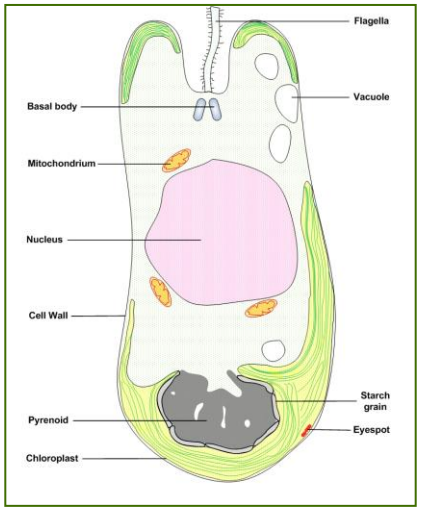


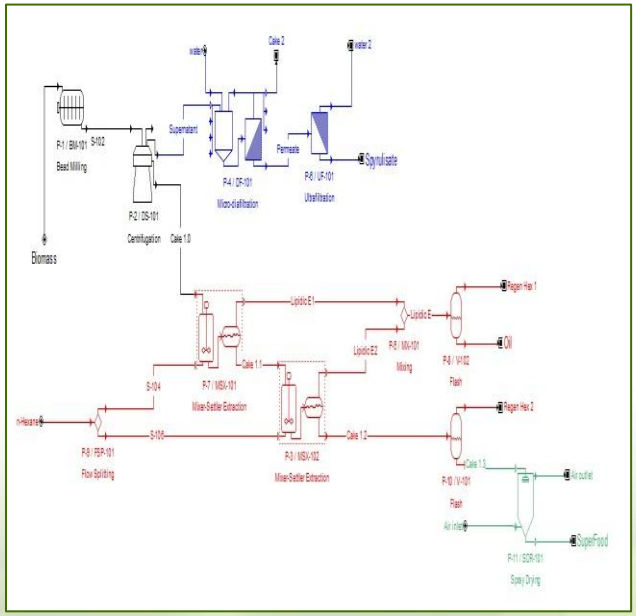
Microalgae biomass value



Our methodology

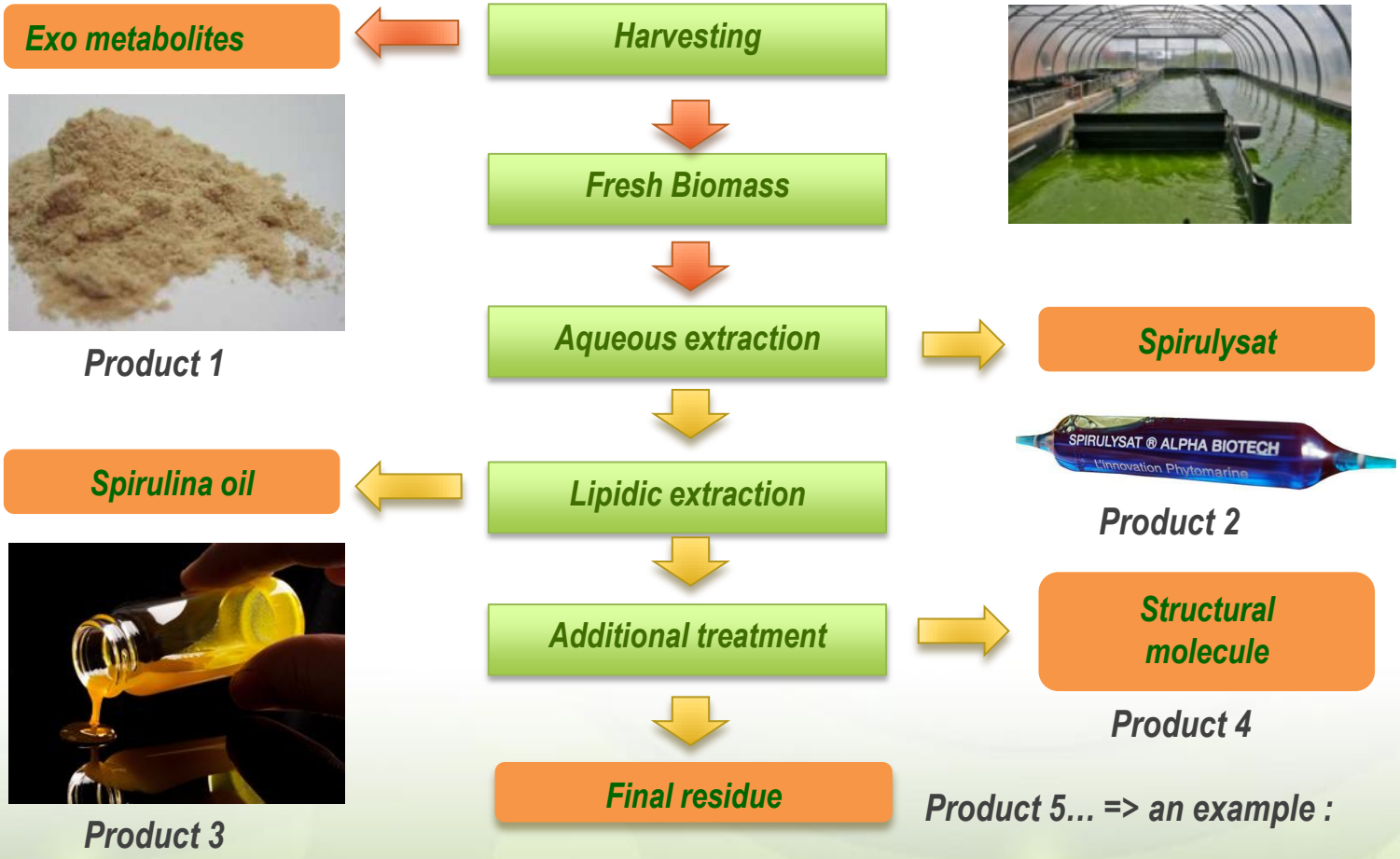
- *Step 1 : Identification of the value (market study)*
- *Step 2 : Topological analysis*
- *Step 3 : Conceptual process and flow sheet design*
- *Step 4 : Economic pre-validation*
- *Step 5 : Experimental validation*
- *Step 6 : Techno-economic analysis*





Example

Spirulina biorefinery



Nutraceuticals

Example of market development

Spirulina extract valorization

Bloo tonic,
the spiruline-based tonic water!

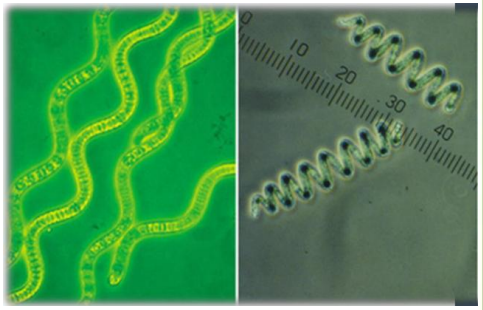
Beverages,
Functional drink
etc.

bio-asphalt

algoroute

Spirulina residue valorization

Hydrothermal liquefaction as a route to transform microalgae residues in bio-asphalt



bio-asphalt

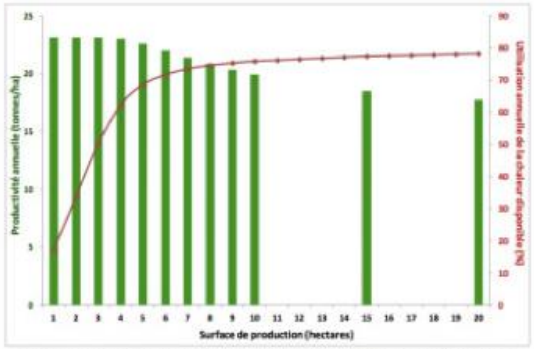
algoroute

- **Results**
  - Feasibility is shown
  - A process has been identified
    - Viscoelastic properties can be tuned
  - A Patent has been filed

- **Outook:**
  - To work on durability
  - To optimize the process
    - Understand more deeply HL
  - Collaboration with industry

R&D tools

Simulation study to predict the plant size and evaluate its rentability



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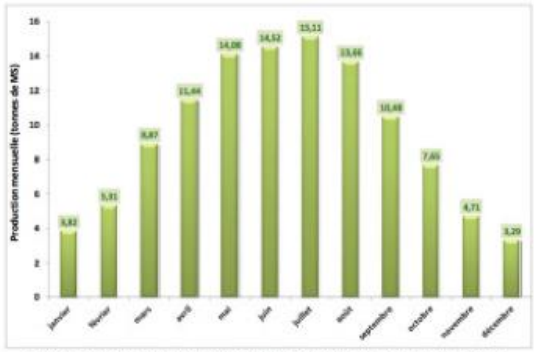

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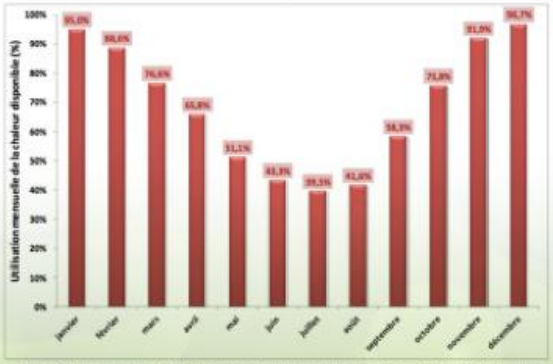

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R&D tools

Microalgae: culture in greenhouses

Example of Spirulina production plant after realization of a simulation study on the basis of the effluent available to define the appropriate size...

... and after training people to microalgae culture and quality management

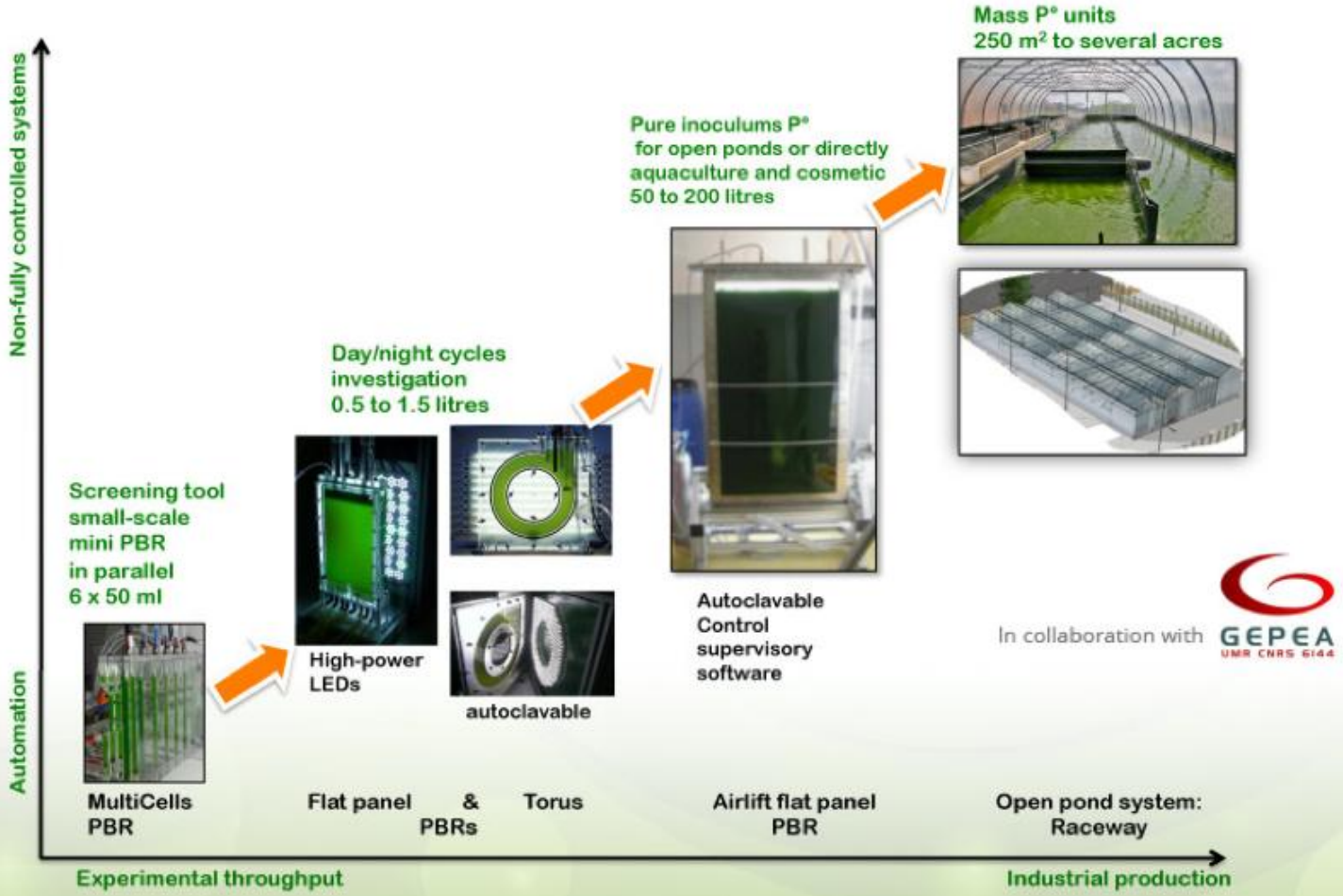
New plant March 2013

First production July 2013

Easy to built + low price + low biomass output over-comes by the rooftop / greenhouse and the waste recycling (heat, CO2...) process.

R&D tools

AlgoSource provides tools for any stage of your project: from lab scale study to mass production



R&D tools

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R&D tools

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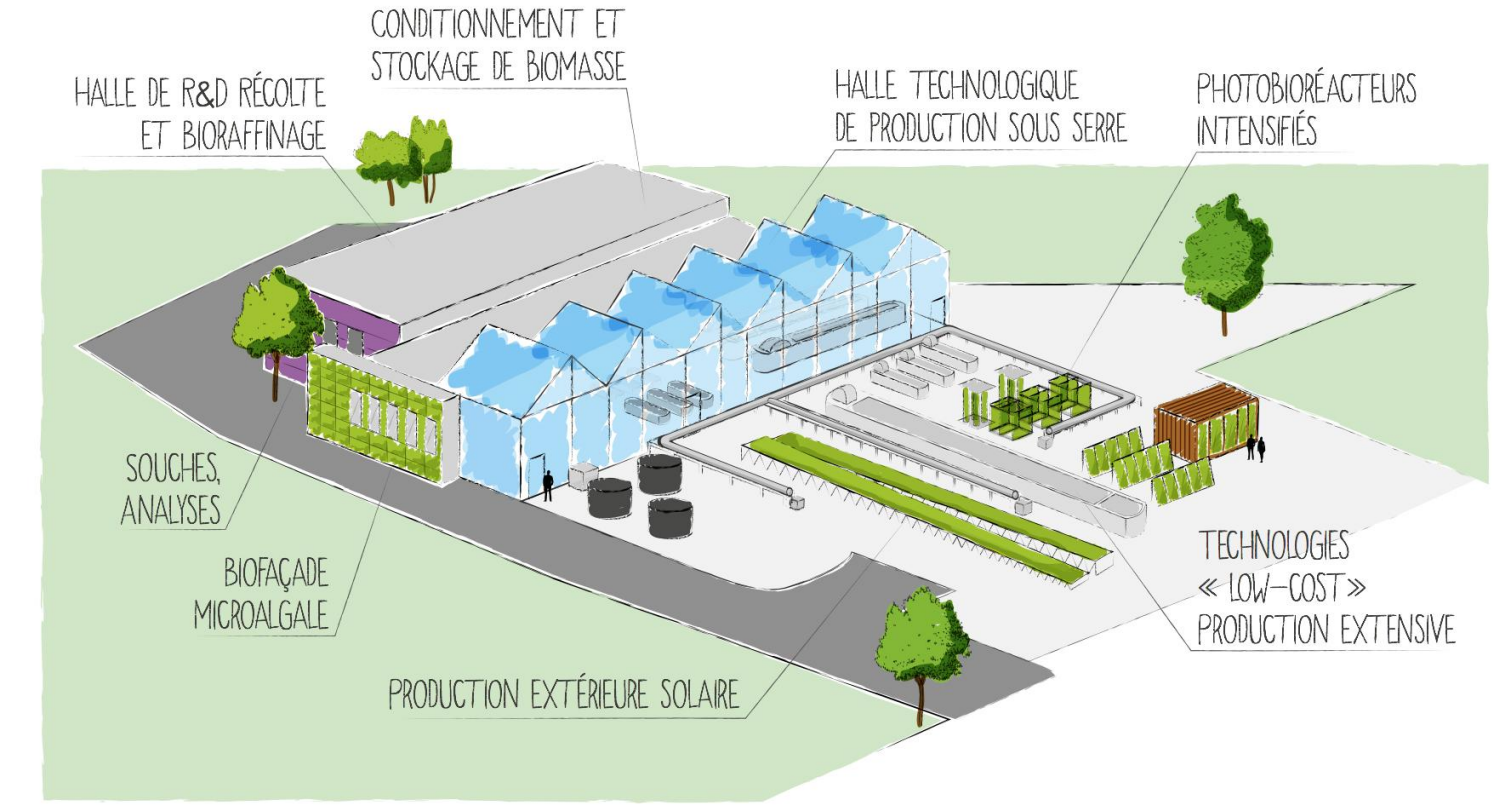

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Thank you for your attention

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