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The Biorefinery concept applied to microalgae

Olivier Lépine, Managing Director, AlgoSource

LIPINOV 23/11/2015

Outline

- AlgoSource : integrated on the whole value chain
- Biorefining : the way to put value into your biomass
- Algorefining technologies that work today
  - Generic methodology
  - Real Examples
- Biorefining for a sustainable microalgae development

AlgoSource
Saint-Nazaire, France

- More than 20 years of experience, with Alpha Biotech producing and transforming microalgae since 1993.
- 26 people (20 employees, 6 partners)
- Turnover ~ 1,6 M € in 2015, profitable
- Key development: Algo-refining
- 4 patents

- Key partnership, University of Nantes : GEPEA Lab
  Pr. Legrand & Jaouen & Pruvost (CNRS)
  www.gepea.fr 50 researchers on microalgae. Since 1985, 300 publications, 10 patents on Process engineering applied to microalgae

We produce and refine our microalgae biomass

CERTIFIED
ISO 9001/14001

Lloyd's Register LRQA

ENVIRONMENTAL MANAGEMENT SYSTEM ISO 14001

Antioxydant and immune system booster

AlgoSource Products (Alpha Biotech)

***Production of functional ingredients* for the cosmetic and nutraceutical industries since 1993**

We provide engineering services: feasibility studies, economic analysis, production systems

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Non-fully controlled systems

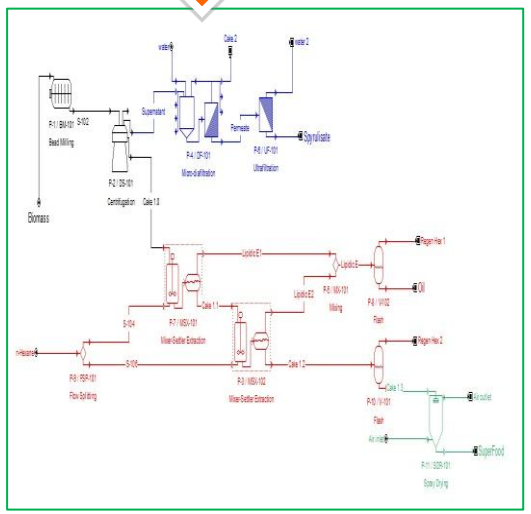
Automation

CERTIFIED
ISO 9001/14001

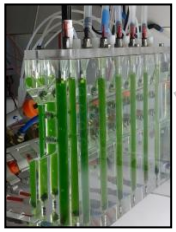
ISO 14001

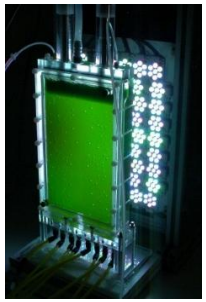
Lloyd's Register
LRQA

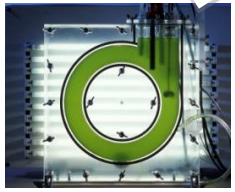
Pure inoculum
Production
50 to 200 litres

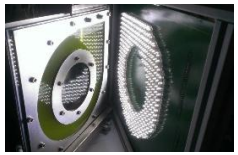


Screening tool









Autoclavable
Control
supervisory
software

High-
power
LEDs

autoclavable

MultiCells
PBR

Flat panel &Torus
PBRs

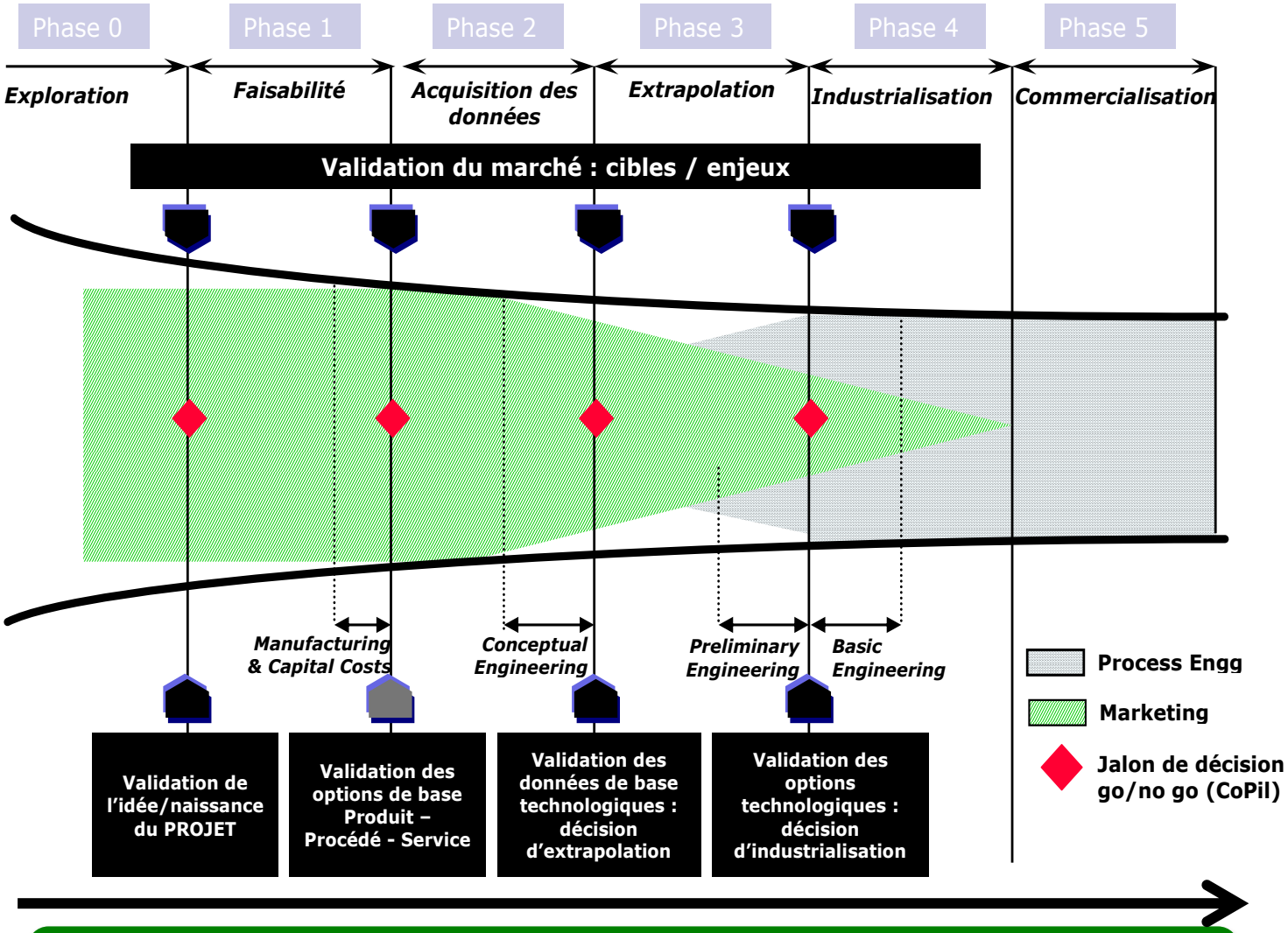
Airlift flat
panel PBR

Refining

Experimental throughput

Industrial production

Industrial innovation development methodology



Early Techno-Economic Analysis

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Companies and final consumers are interested in functions, not micro-algae

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Anti-cancer

Skin Protection

Strengthen your Natural Defenses

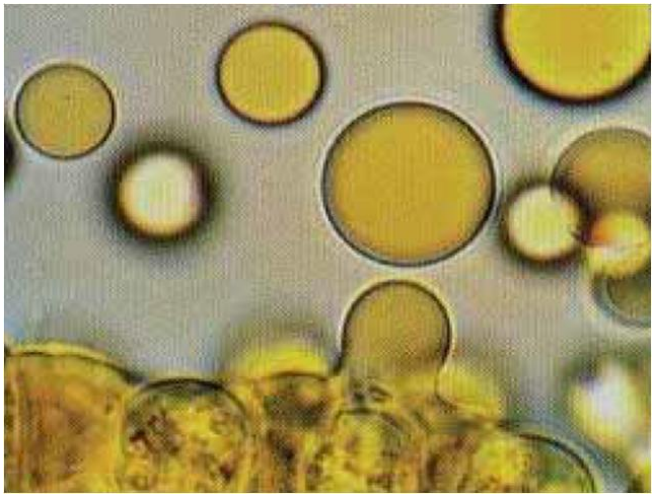
Algorefining is the way to optimize the production of those products and the value of your biomass

Microalgae Main commercial products

- **Beta-carotene: BASF, Nikken Sohonsha (Nature-Beta Technologies)**
- **DHA : DSM**
- **Astaxanthin : Algatechnologies, Cyanotech, Fugi, Parry…**
- **Superfood: Spirulina, Chlorella, AFA, Odontella, Euglena**
- **Special food for Aquaculture: EPA-DHA**
  - ***Nannochloropsis, Phaeodactilum, Skeletonema, T-iso, Pavlova, Tetraselmis, Chaetoceros …***
- **Cosmetic Ingredients**
  - ***Porphyridium, Thalassossiera, …***
- **Phycocyanin**

LIPIDS from microalgae that are not commercial

- Biofuels : C14-C18 saturated
- Zeaxantin, and other Carotenoids
- EPA
- Phyto-Sterols
- Squalene : C30
- Alcan
- C34-C48 (Botryococcene)
- C90 sporopollenin
- And many others to be discovered



BIO-BITUMEN

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- Replace fossil-based bitumen
- 50% biomass conversion
- Standard visco-elactic properties

Patented process

Algoroute

Région PAYS DE LA LOIRE

IFSTTAR

ALPHA BIOTECH

Chimie Et Interdisciplinarité Synthèse, Analyse, Modélisation
UMR CNRS 6230
UNIVERSITÉ DE NANTES

algosource technologies

GEPEA

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Algorefining: a core activity for AlgoSource

- **2011-2014- ANR AlgoRaffinerie: formalization of a methodology, and concept development on Porphyridium and Chlorella.**

- **2012-2015- FP7 BIOFAT application of the concept on Nannochloropsis and Tetraselmis in the scope of energy production. Development of wet extraction**

- **2013-2016- ADEME AlgoRaff: : development of a Spirulina Algorefinery; optimization of the refining process as a function of physiological induction: impact on the process and economics**

- **2013-2016-Private projects towards industrial production units: products/process optimization, engineering, marketing, upscaling**

Algorefining Methodology

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Step 1 : Identification of the value

Step 2 : Physiological/Topological analyses

Step 3 : Conceptual process design and modelling

Step 4 : Experimental model validation, Upscaling

Step 5 : Techno-Economic optimization, LCA analysis

Algorefining in the BIOFAT project

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SEVENTH FRAMEWORK PROGRAMME

A European project supported through the
7th Framework Programme for R&T Development

BIOFAT
BIOfuels From Algae Technologies

Project BIOFAT, FP7, E.U.

Demonstration at industrial scale (1 ha) of the feasibility of biofuels and bioproducts' production.

Coordinated by ALGAFUEL (P)

A FOUR-YEAR PROJECT

- **2 academics**
- **6 SMEs**
- **1 large entreprise**
- **Portugal (1), Italy (3), Spain (1), Israel (1), The Netherlands (1), France (1), USA (1).**

Step 1 : Identification of the value

-***Strain 1***:

-TAG (0.6$/kg)

-PUFAs (100$/kg)

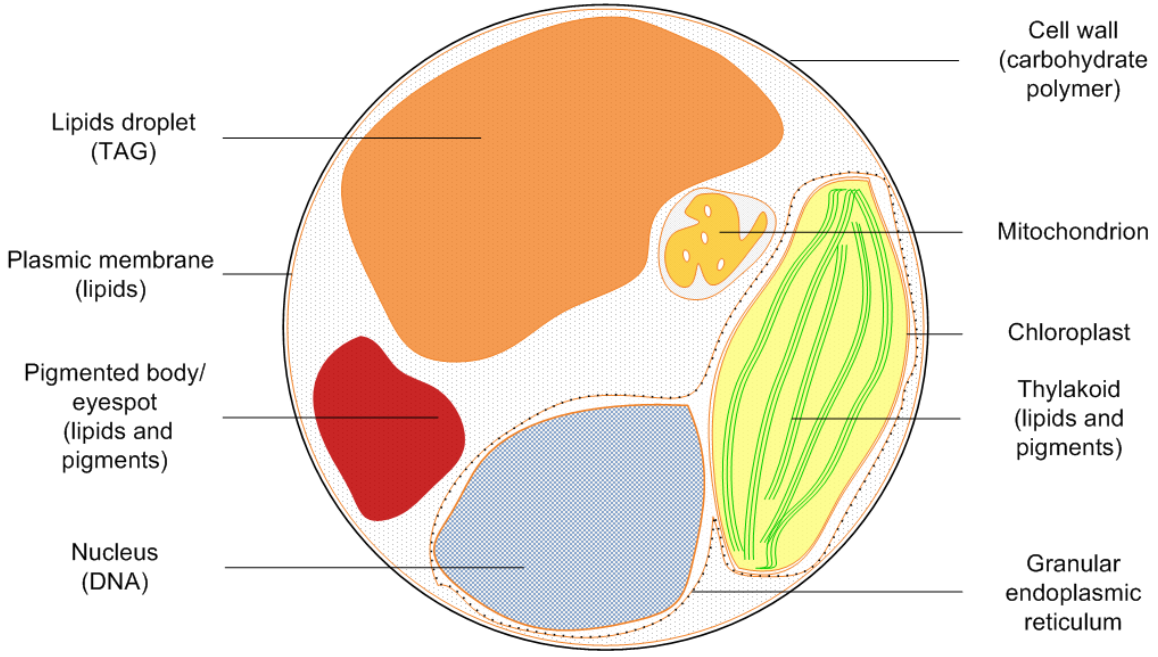
-Pigments:

(100-1000$/kg)

-violaxanthin,

-vaucheriaxanthin

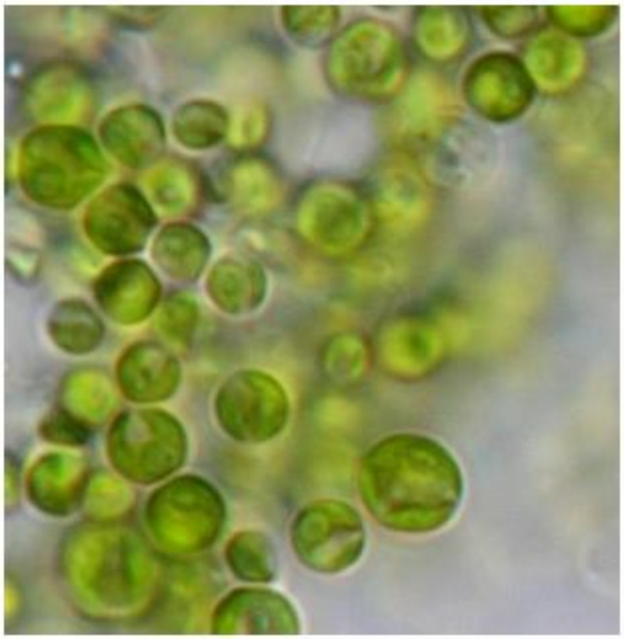
-Vitamins: E>100$/kg)



Step 2 : Physiological/Topological analyses

Step 3 : Conceptual process design and modelling

C. vulgaris : CO_2 capture, food grade



➔ around 50 % proteins

➔ around 6 % of TFA

➔ around 4 % of pigments

Additional value implementation possible with :

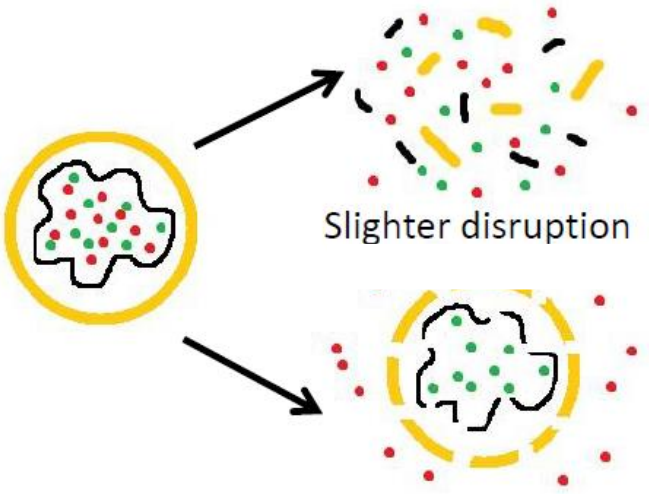
➔ Pigment / protein / lipid fractionation (no purification here)

➔ No drying

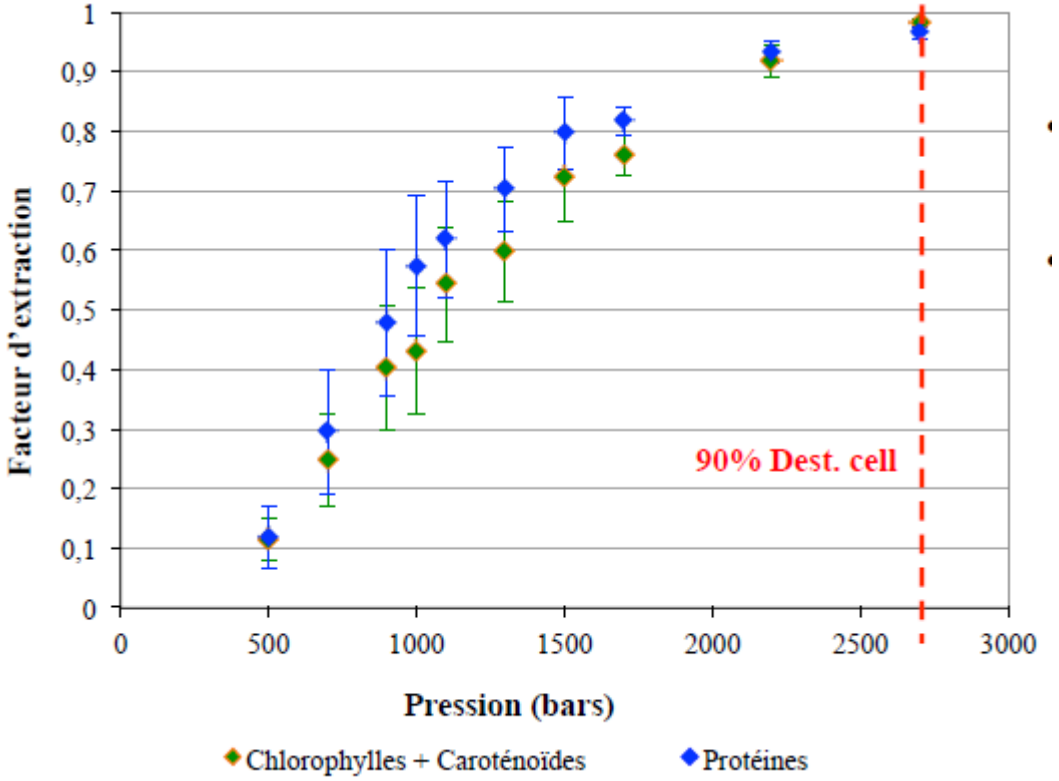
➔ Continuous and intensified processes (scalable ones)

Step 3 : Conceptual process design and modelling

High Pressure destruction



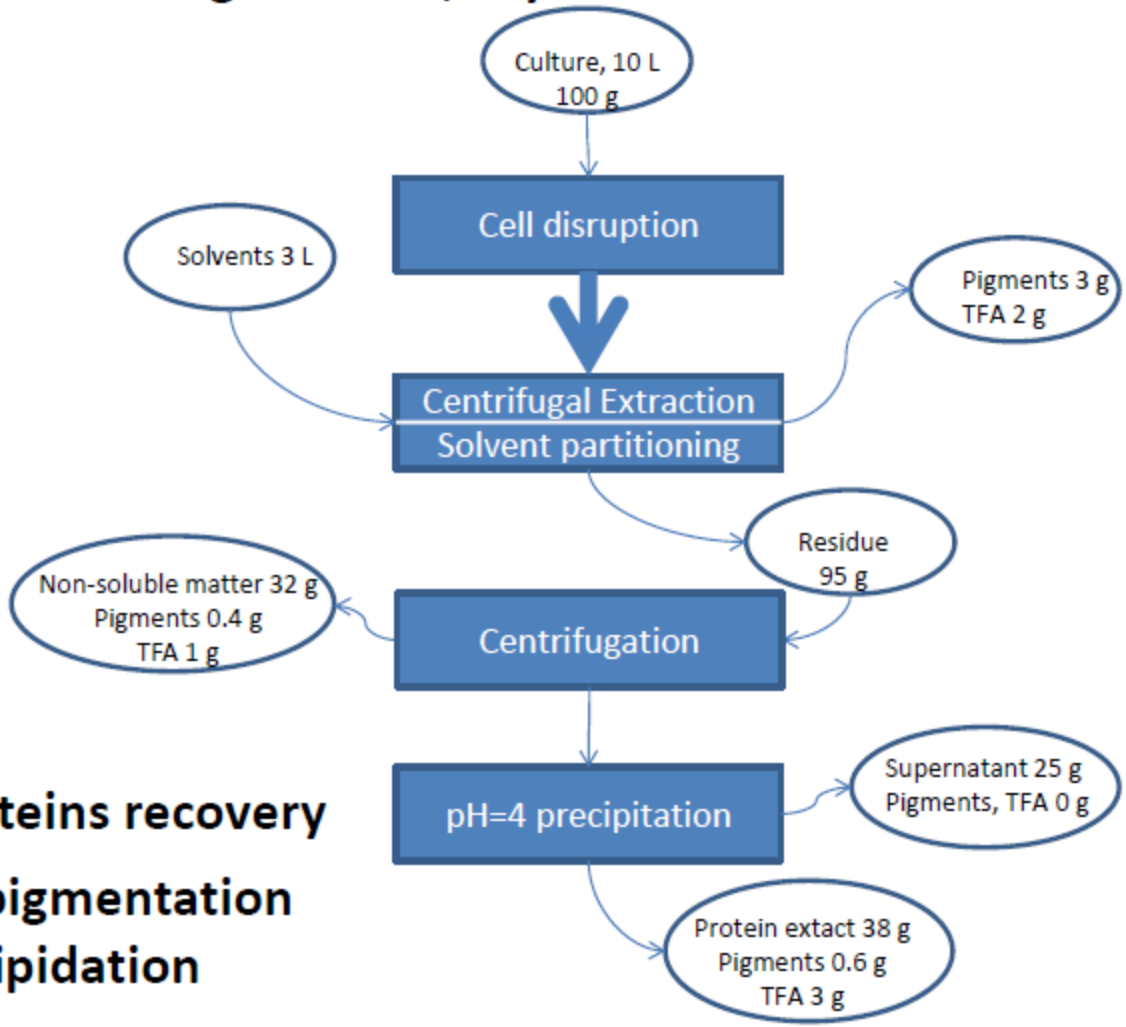
De-structuration



Cell destruction does not allow for a selective extraction, leading to emulsion, increase energy consumption and costs.

Step 4 : Experimental model validation, Upscaling

➔ for 100g biomass, dry matter basis

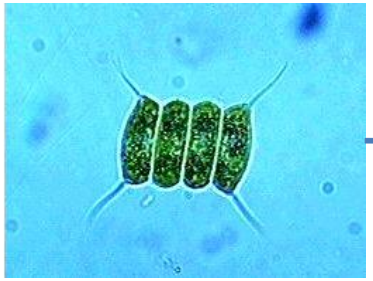


➔ 70% proteins recovery

➔ 85% depigmentation

➔ 50% delipidation

Step 5 : Techno-Economic optimization, LCA analysis



Wet Extraction

Valorization of a high value compound

Residues

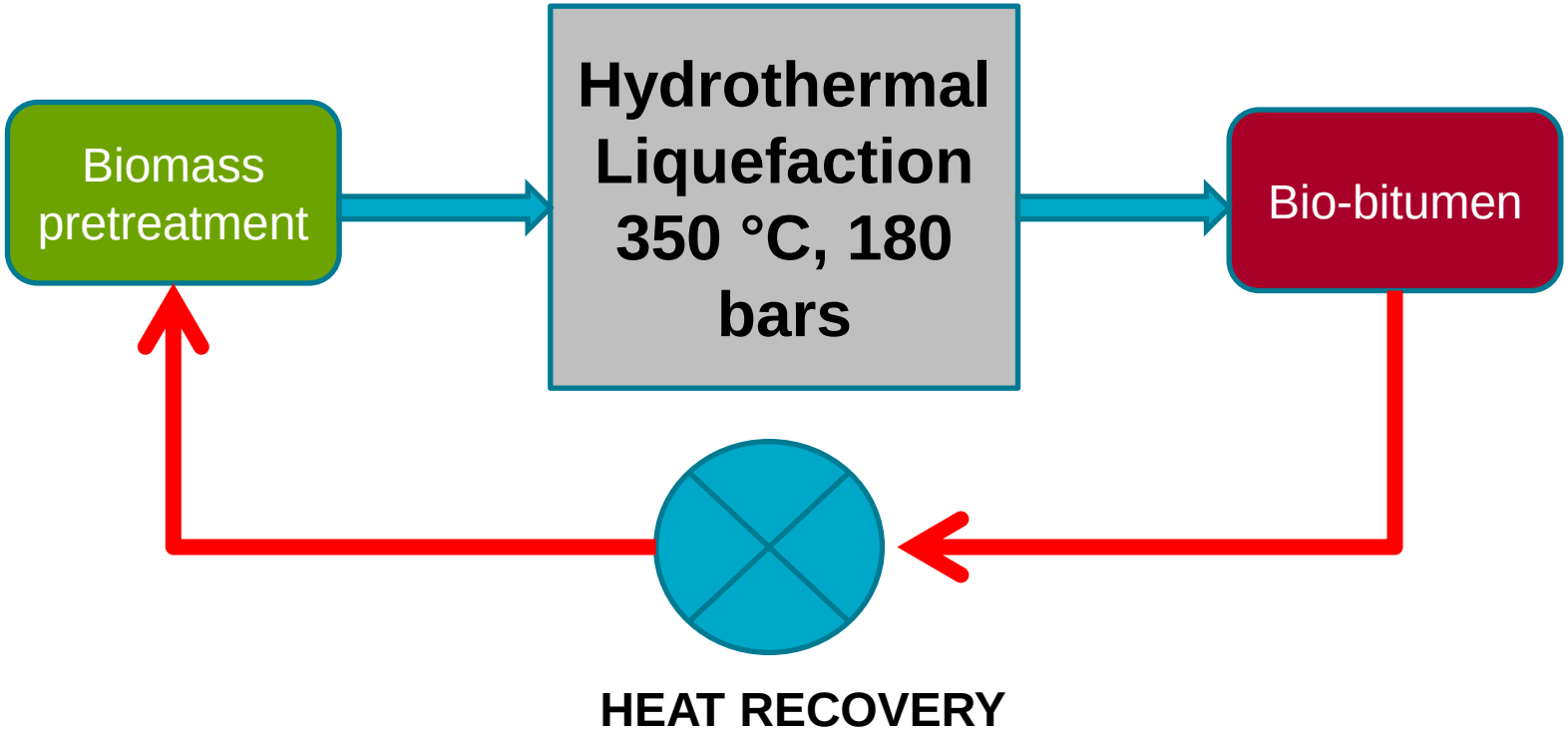
Hydrothermal Liquefaction

Bio Bitumem

Bio Road

AlgoRoute Project

Step 5 : Techno-Economic optimization, LCA analysis



Step 5 : Techno-Economic optimization, LCA analysis

- **1000 ton/year bio-bitumen process capacity**
- **CAPEX < 1000 k€**
- **OPEX 0.7 k€/ton excluding biomass cost and cost of capital**
- **price compatible with current commercial bio-bitumen markets**
- **Project feasibility demonstrated, project phase 2 has been submitted to funding scheme with a large industrial company in France**

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Algorefining generic process

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Harvesting

Exo metabolites

Product 1

Fresh Biomass

Extraction 1

Product 2

Extraction 2

Microalgal oil

Product 3

Additional treatment

Product 4

Structural molecule

Final residue

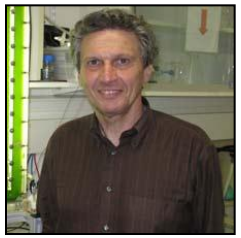
Product 5

Conclusion

- Biorefining can unlock your microalgae potential value
- We provide Process design and early economic evaluation to identify solutions that works
- We use Process modeling and standard engineering tools for a comprehensive economic, environmental and risk analysis for a sustainable development
- We use and develop Algorefining in our daily operation since 2008

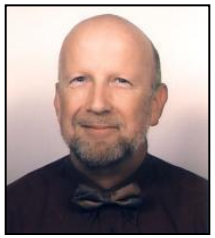
Our team gathers expertise on the whole value chain

Contact: olivier.lepine@algosource.com



Pr. Jack Legrand

Mr. Philippe Dréno



Dr. Jean Jenck

Mr. Olivier Lépine

Pr. Jérémy Pruvost

Pr. Pascal Jaouen

Deloitte Technologies Fast 50 WEST AWARD 2013

Thank you for your attention

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