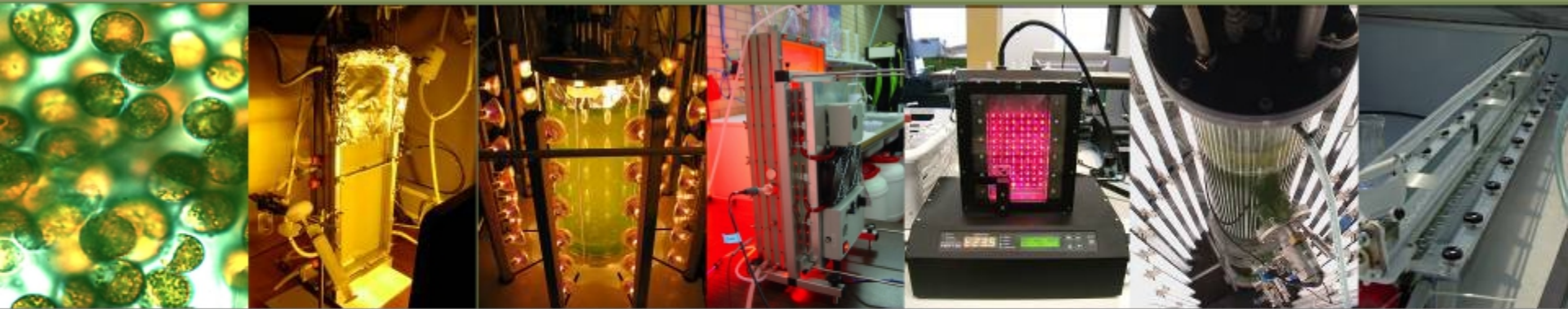


# bion Algae

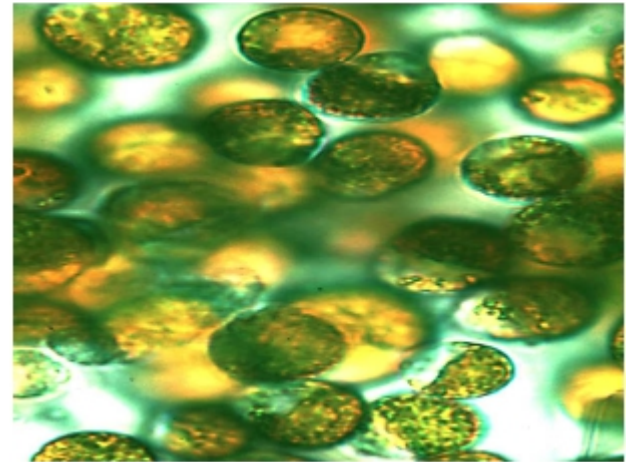
Project 2013

MICROALGAE FOR PRODUCTION OF BIOFUELS, FOOD  
AND CHEMICALS



# Contents

- ✓✓ Argentina: general, land and geographic information
- ✓✓ Biofuels Information
- ✓✓ York Argentina Group strategy
- ✓✓ Biodiesel from microalgae
- ✓✓ Feasibility study
- ✓✓ Biorefinery of microalgae
- ✓✓ Research agenda
- ✓✓ Plant prototypes
- ✓✓ Project design
- ✓✓ Algae markets
- ✓✓ Partnership
- ✓✓ Conclusions




bion Algae



# Argentina, general information





## ARGENTINA

Fact Sheet

Fact sheets are updated bi-annually, June and December

**General information:**

<b>Capital:</b> Buenos Aires	<b>Head of State and Head of Government:</b> President HE Cristina Fernández de Kirchner
<b>Surface area:</b> 2,780 thousand sq km	
<b>Official language:</b> Spanish	
<b>Population:</b> 40.9 million (2011)	
<b>Exchange rate:</b> A\$1 = 4.5721 Pesos (Mar 2012)	

**Recent economic indicators:**

	2007	2008	2009	2010	2011 (a)	2012 (b)
GD <sup>1</sup> (US\$bn) (current prices):	282.1	308.1	310.4	378.0	447.6	472.8
GD <sup>1</sup> PPP (US\$bn) (c):	524.7	572.6	583.5	644.3	710.4	758.2
GD <sup>1</sup> per capita PPP (US\$) (e):	13,331	14,485	14,539	15,901	17,516	18,319
Real GD <sup>1</sup> growth (% change yoy):	8.7	6.8	0.9	9.2	8.9	4.2
Current account balance (US\$bn):	4,104	5,113	6,389	2,109	-2,245	-3,312
Goods & services exports (% GD <sup>1</sup> ):	25.3	25.0	21.5	22.0	22.0	21.2
Inflation (% change yoy):	8.6	8.6	6.3	18.5	9.8	8.9

**Australia's merchandise trade with Argentina**

**Real GD<sup>1</sup> growth**

**Australia's merchandise exports to Argentina**

**Australia's trade and investment relationship with Argentina (d):**

Australian merchandise trade with Argentina, 2011:	Total share	Rank	Growth yoy <sup>1</sup>	
Exports to Argentina (A\$bn)	381	0.1%	41st	11.9%
Imports from Argentina (A\$bn)	550	0.2%	41st	32.0%
Total trade (exports + imports) (A\$bn)	931	0.2%	40th	49.5%

**Major Australian exports, 2011\* (A\$bn):**

Coal	178
Medicaments (incl veterinary)	38
Specialised machinery & parts	11
Crude vegetable matter	9
<small>*Excludes A\$100m of confidential items, 20% of total exports</small>	

**Major Australian imports, 2011 (A\$bn):**

Animal feed	282
Goods vehicles	161
Food vegetable oils & fats, soyl	52
Leather	33

**Australia's trade in services with Argentina, 2011:**

	Total share
Exports of services to Argentina (A\$bn)	na
Imports of services from Argentina (A\$bn)	na

**Australia's investment relationship with Argentina, 2011 (e):**

	Total	FDI
Australia's investment in Argentina (A\$bn)	935	914
Argentina's investment in Australia (A\$bn)	np	np

**Argentina's global merchandise trade relationships:**

Argentina's principal export destinations, 2011:		Argentina's principal import sources, 2011:	
Rank	Share	Rank	Share
1	Brazil 28.5%	1	Brazil 28.4%
2	China 8.0%	2	China 15.1%
3	Chile 5.7%	3	United States 10.7%
3F	Australia 0.7%	26	Australia 0.5%

Compiled by the Market Information and Research Section, DFAT, using the latest data from the ABS, the IMF and various international sources.  
 (a) All recent data subject to revision. (b) IMF SDI forecast. (c) PPP in purchasing power parity. (d) Total may not add due to rounding. (e) Data, as at 31 December.  
 Released annually by the ABS. na Data not available. np Data not published. \* Data not meaningful.



# bion Algae

(geographic location)



# bion Algae

(strategic land location)





# bion Algae

(Bahia de los vientos, Quequen. Argentina)



York Argentina Group  
Business Consulting  
& Investments Solutions

# Biofuel Generations



## ● First

- Bioalcohol
- Biodiesel
- Green Diesel
- Vegetable Oil
- Bioether
- Biogas
- Syngas
- Solid Biofuels

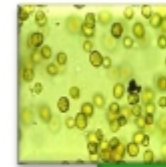
Oils, Starches  
And Sugars



## ● Second

- Biohydrogen
- Biomethanol
- Cellulosic Ethanol
- DMF
- BioDME
- Bioethanol

Sustainable Raw  
Material



## ● Third

- Algae Biodiesel

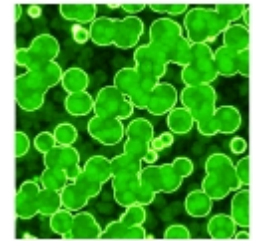
Sustainable Raw  
Material



York Argentina Group  
Business Consulting  
& Investments Solutions



# Biofuels, Economy and Society



## Social Aspects

- Food vs. Fuel debate
- Land use
- Poverty reduction
- Economic Flow



## Environmental Aspects

- Land erosion and deforestation
- Impact on water stock
- Biodiversity loss
- Pollution



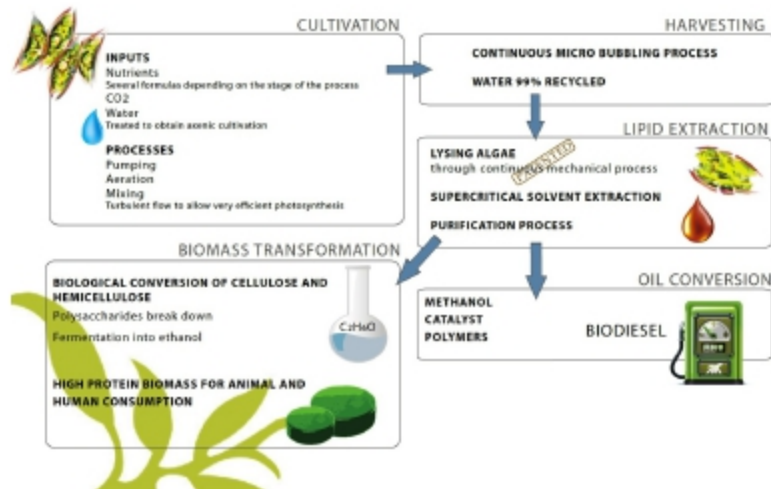
## Technical Aspects

- Energy efficiency
- Carbon emissions
- Sustainable production
- R&D

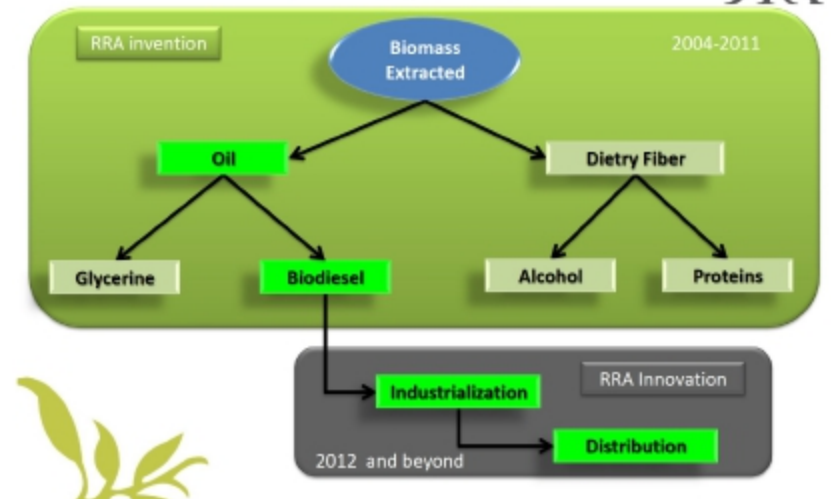


# York Argentina Group & RRA System strategy

## INDUSTRIAL PROCESS

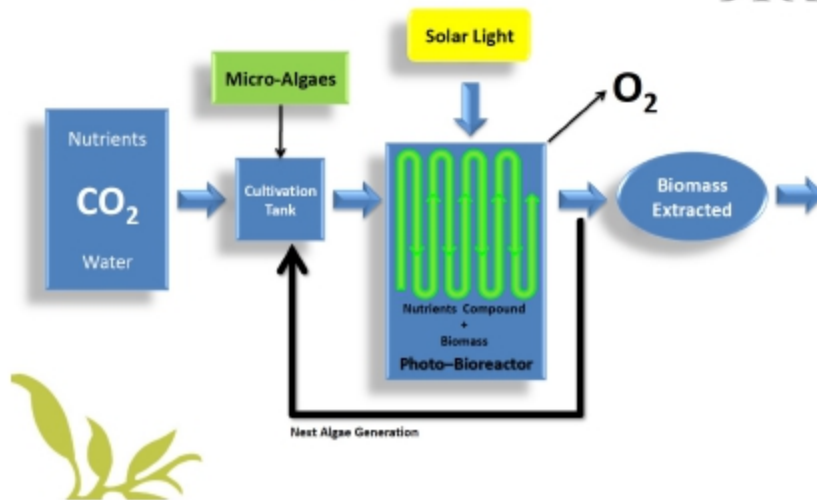


## Biodiesel B-100 production process and other products



# York Argentina Group & RRA System strategy

Biodiesel B-100 production process and other products



## RESEARCH AND DEVELOPMENT IN ALGAL PHYSIOLOGY

### NUTRITIONAL FACTORS

Formulas made for each metabolic route, species and on cultivation conditions.

Different compounds used in each formula.

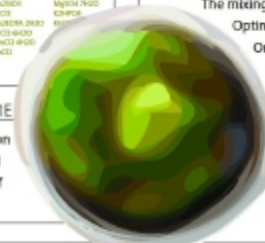
CAN001	CAN002
KUN004	MAL001(002)
ARG04 (001)	MAR01
MAR02	SAC0 2(00)
MAR03	MAR04 (000)
FIN01	GEN01
MAR04 (003)	MAR05
SAC01(002)	SAC01 (000)
SAC01 (003)	SAC01 (001)

### USE OF LIGHT

Effective use of strong light  
Light penetration depth

The mixing processes inside the photobioreactor  
Optimum light-dark cycle frequencies

Online monitoring of photosynthetic activity



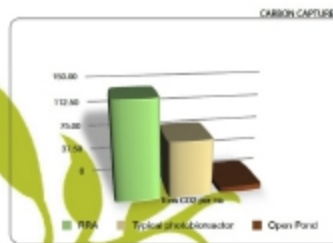
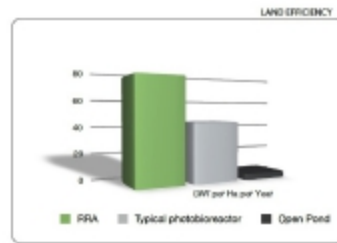
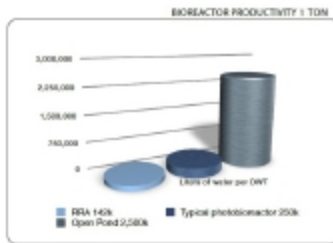
### PHYSIOLOGY IN MASS CULTURE

The key for the success of the production of micro-algae is the maintenance of all the cultures in the exponential phase of growth

Metabolic routes	Wild algal	High reproduction rate route	Stressful for lipid production route	Eutrophicities	Too Stressed
Stress level	+	0	++	0	+++
Nutrients & pH	Any formula	RRA's optimized formula	Depletion of certain nutrients and adjust specific pH values	+++	Any extreme conditions
Reproduction rate	+	+++	+	++	0
Increase in Biomass	+	+++	+++	++	0
Increase in Oil Content	+	+	++++	0	0

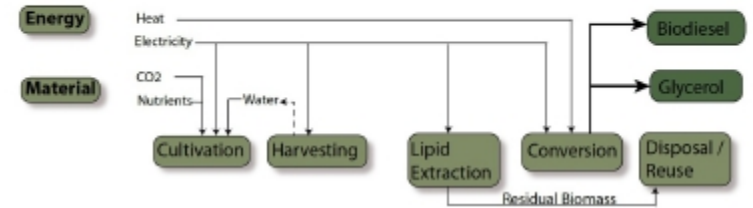
# York Argentina Group & RRA System strategy

## PROCESS EFFICIENCY



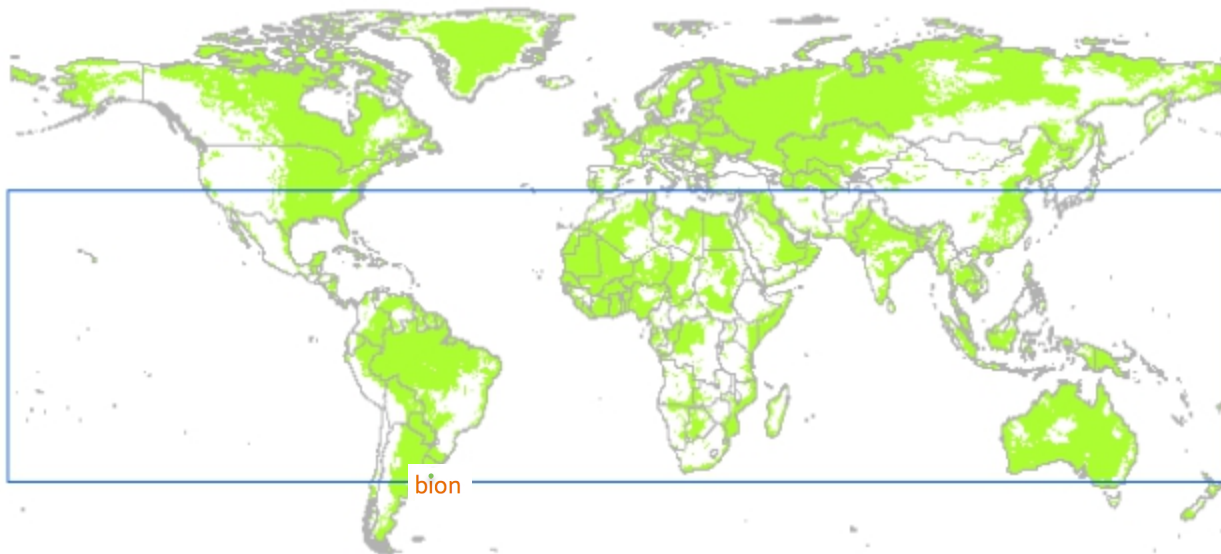
Parameter	Open Pond	Typical photobioreactor	RRA
Biomass concentration	0.41 kg m <sup>-3</sup>	4.0 kg m <sup>-3</sup>	7.2 kg m <sup>-3</sup>
Dilution Rate	0.20 d <sup>-1</sup>	0.004 d <sup>-1</sup>	0.02 d <sup>-1</sup>
Aerial Productivity	0.09 kg m <sup>-2</sup> d <sup>-1</sup>	0.04 kg m <sup>-2</sup> d <sup>-1</sup>	0.07 kg m <sup>-2</sup> d <sup>-1</sup>
Oil content	25%	25%	40%

## COMBINATORIAL PROCESSES OF ALGAL BIODIESEL SUMMARY



Case	Cultivation	Harvesting	Lipid Extraction	Conversion	Disposal / Reuse
<b>Base Case</b>	Raceway Pond	Centrifugation	Drying + Press + Hexane	Esterification	Landfillin
<b>Other Cases</b>	Annular	Filtration	Supercritical		Anaerobic Digestion
	Tubular	Floc. Chitosan			
	Flat Plate	Floc. pH Adjust			
<b>RRA Case</b>	Tubular PBR	Micro Bubbling (continuous)	Mechanical lysing	Supercritical Esterification	Human & Animal consumption

# World Map (moderate slopes)



**Figure 4.9: Land areas (green) located at altitudes lower than 500 m (1500 ft), assumed to encompass most areas with moderate slopes (Harmelen and Oonk, 2006).**



# World Map (optimal solar radiation)

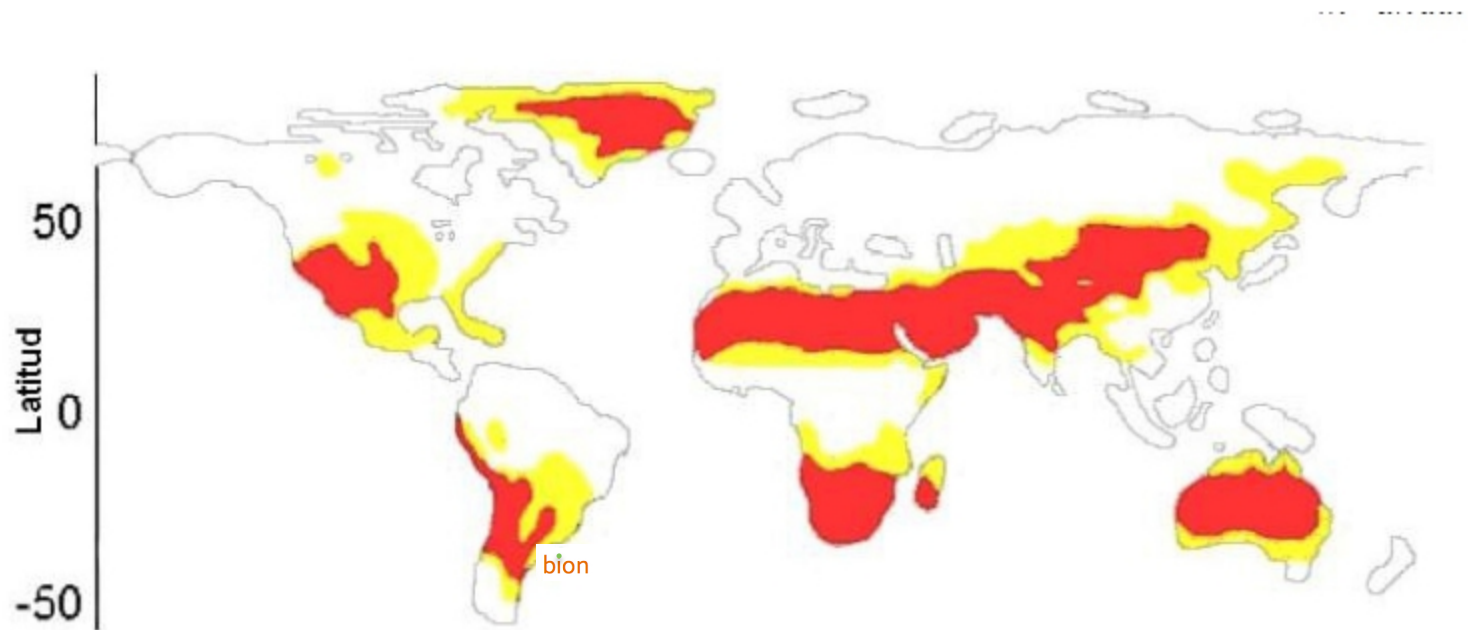


Figura 5.7: Distribución geográfica de la radiación solar óptima [CHIS07]

# Biodiesel from microalgae

## ✓✓ Botryococcus

✓✓ Alkanes (C34)

✓✓ High concentrations (40-70%)

## ✓✓ Other algae

✓✓ 20-60% lipids

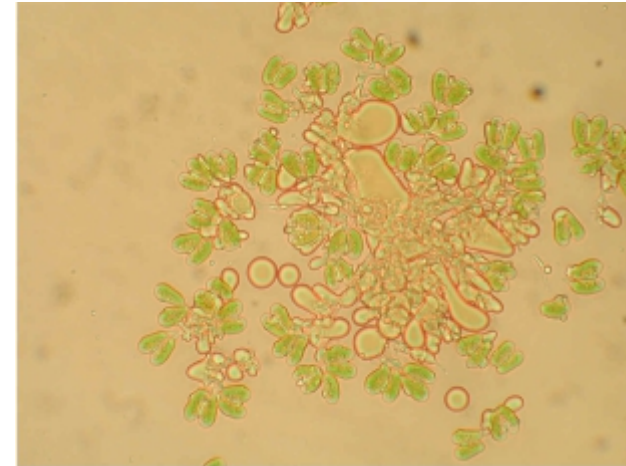
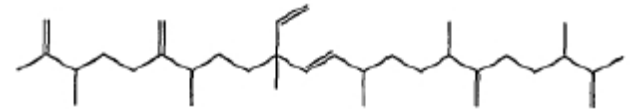
## ✓✓ High productivity

✓✓ Palm oil: 6,000 l/ha/year

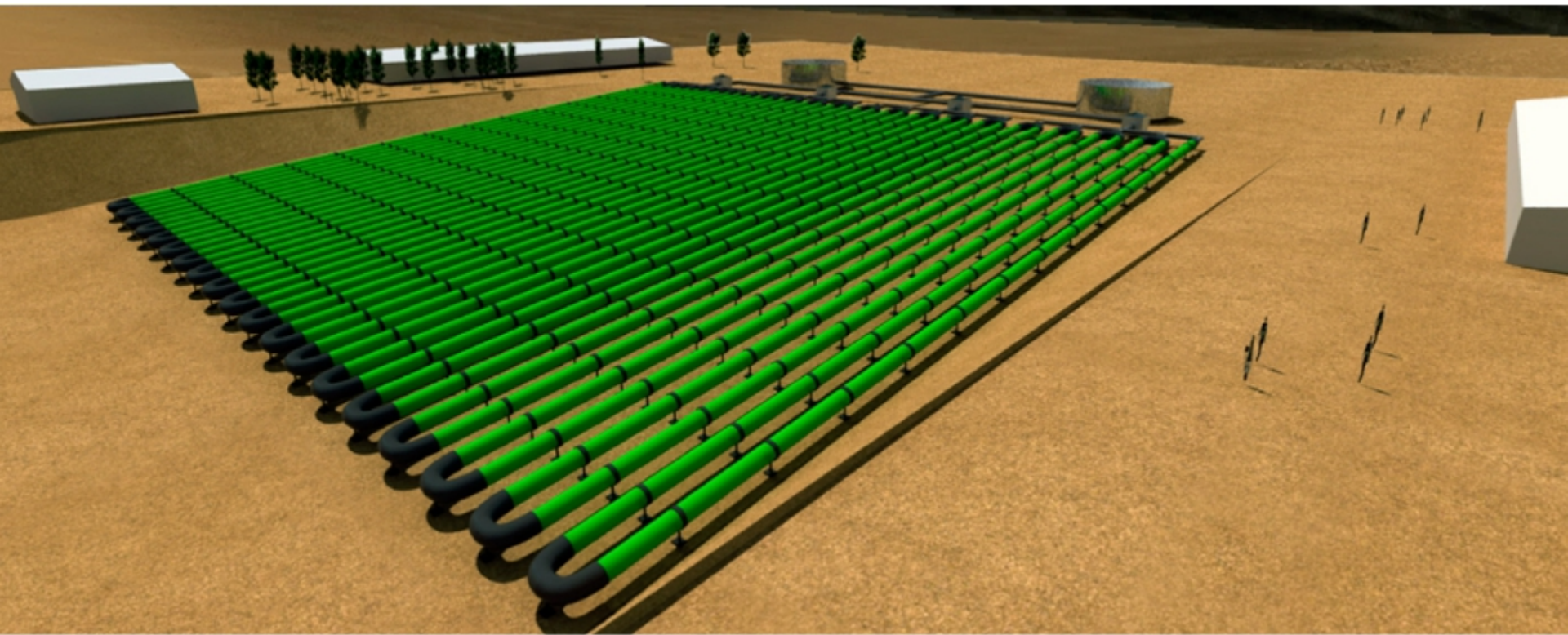
✓✓ Algae: 20,000-80,000 l/ha/year

✓✓ No competition with food

✓✓ Salt water/River water

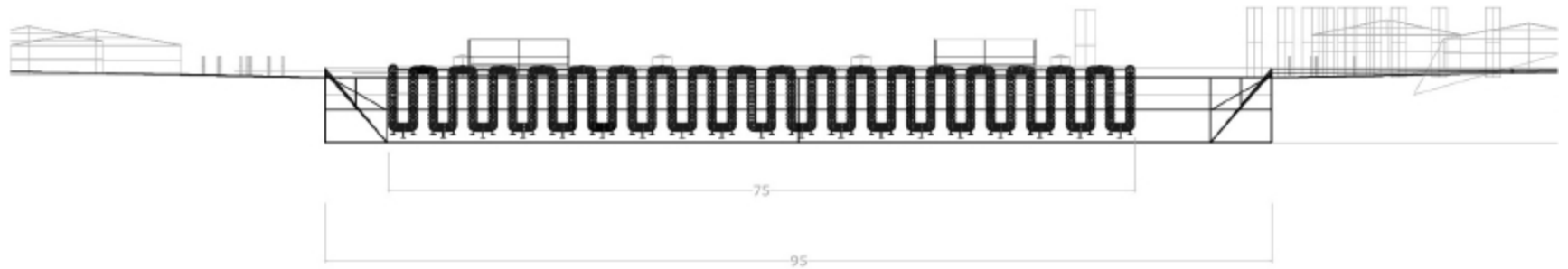


# Plant prototype: design (1)





# Plant (1)



PLANTA DE CULTIVO

PLANO:

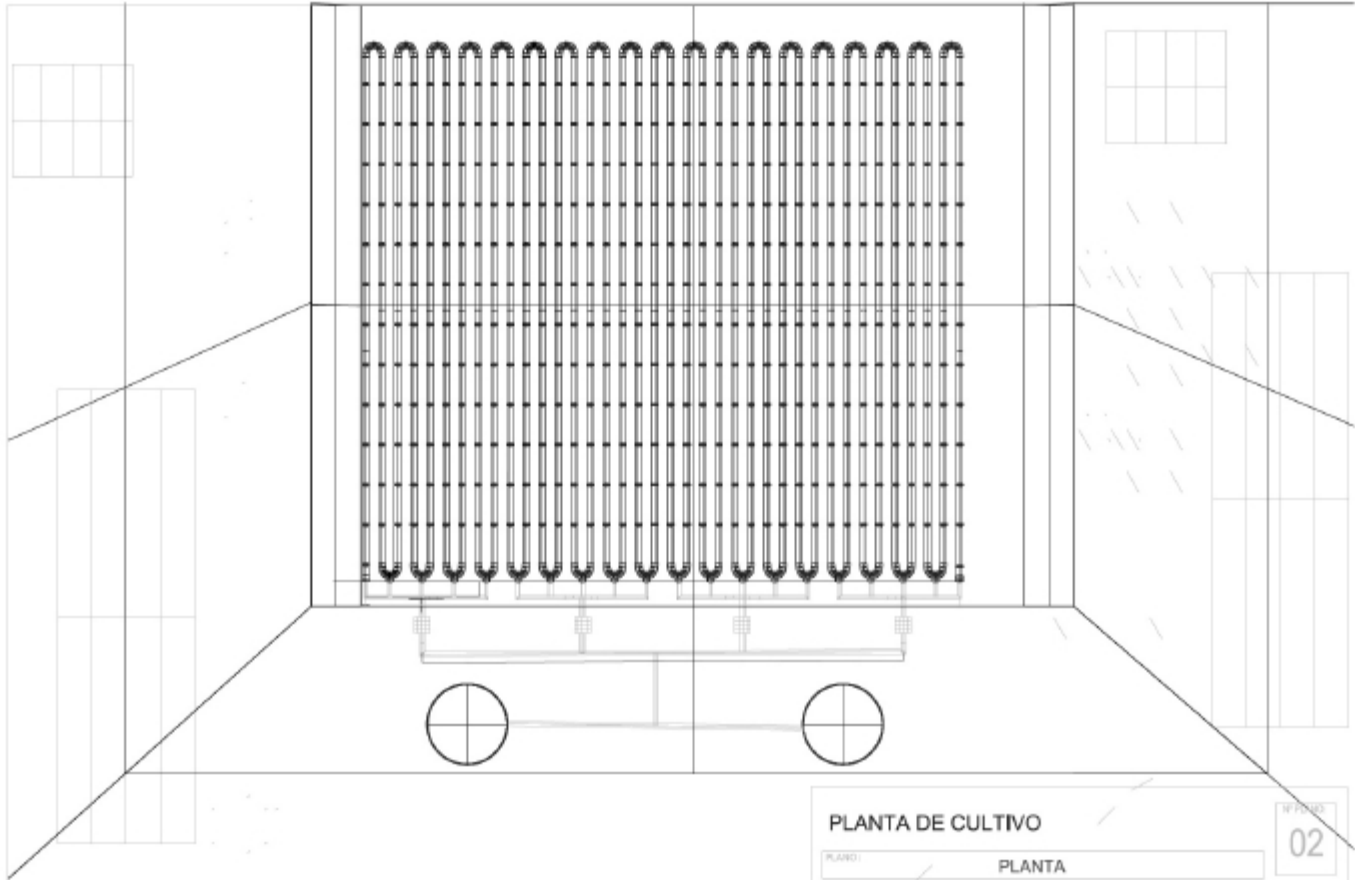
ALZADO PRINCIPAL

Nº PL

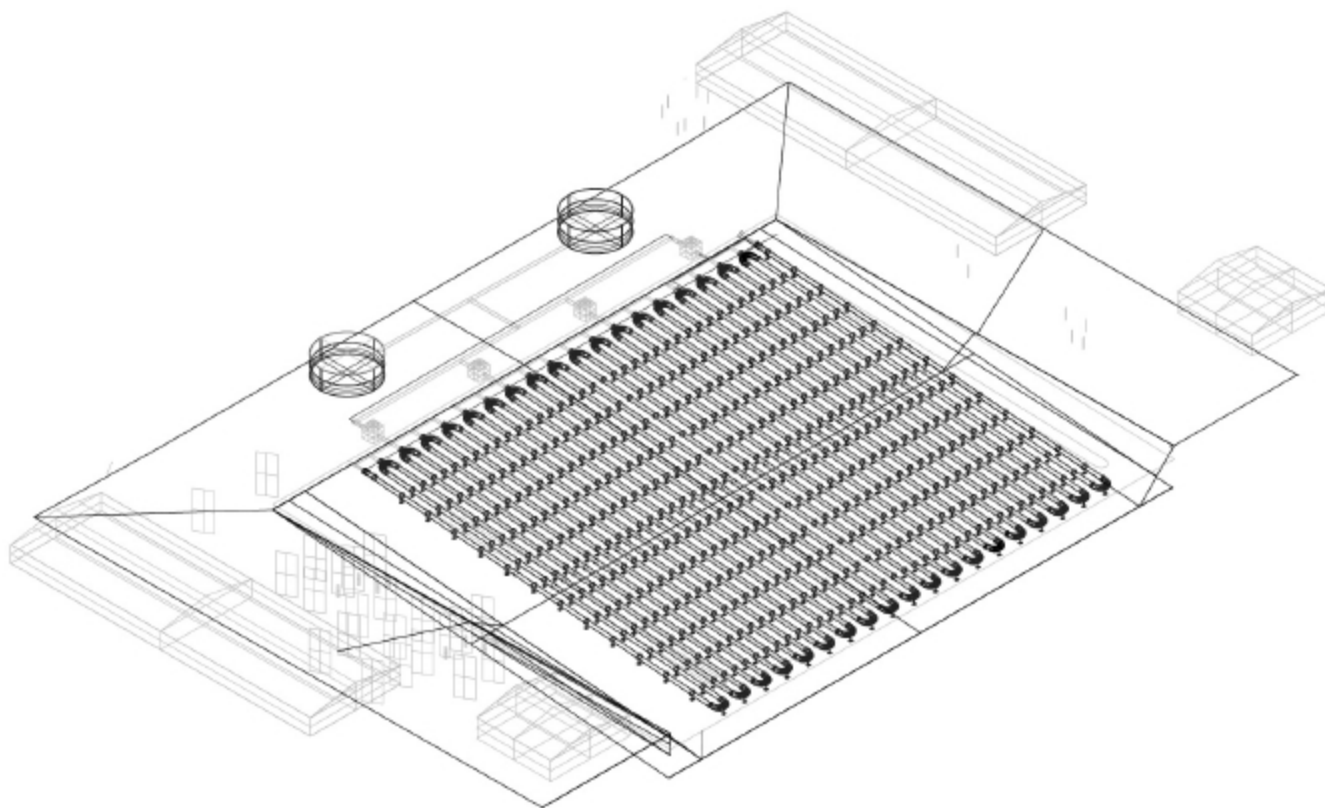
0



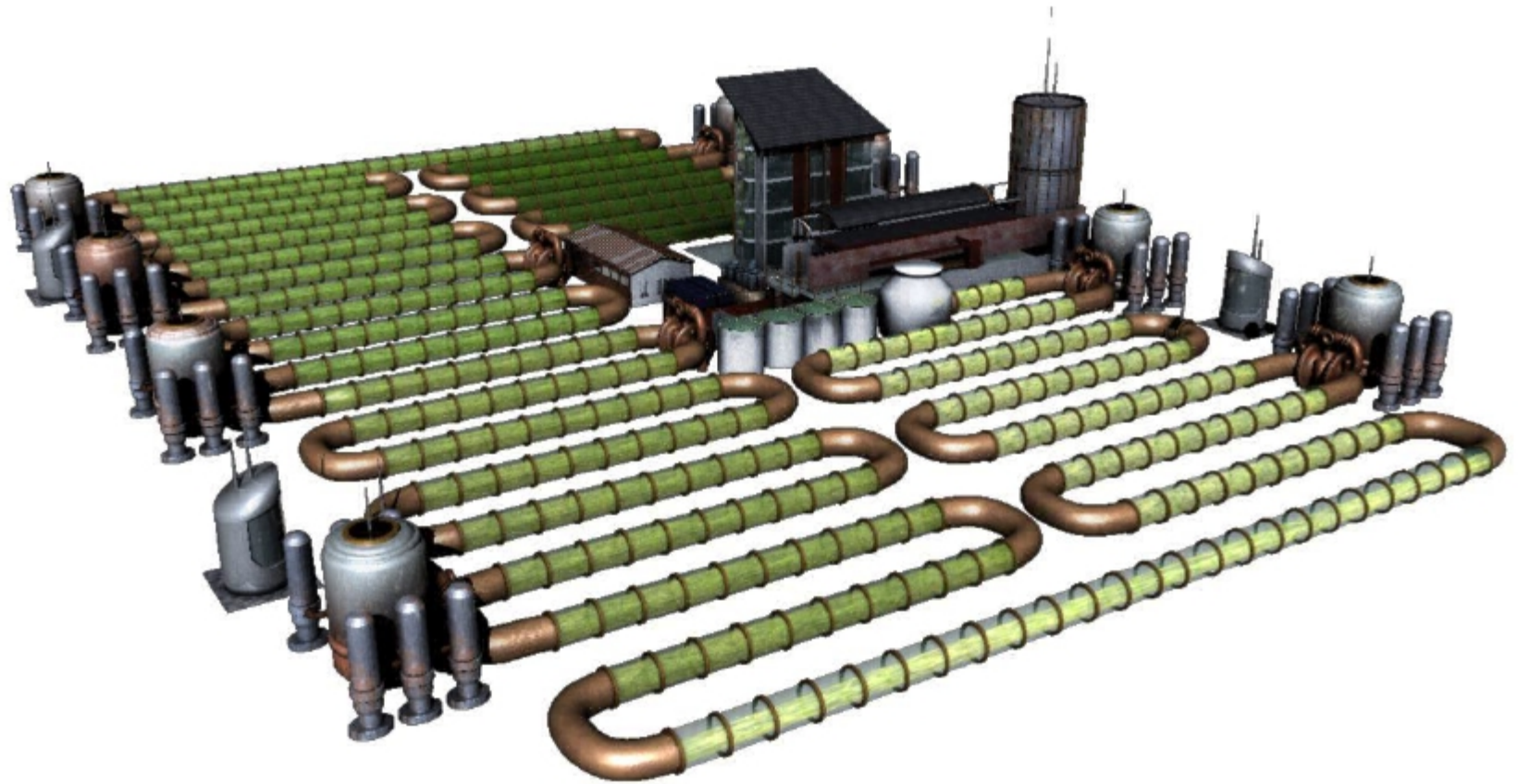
# Plant (1)



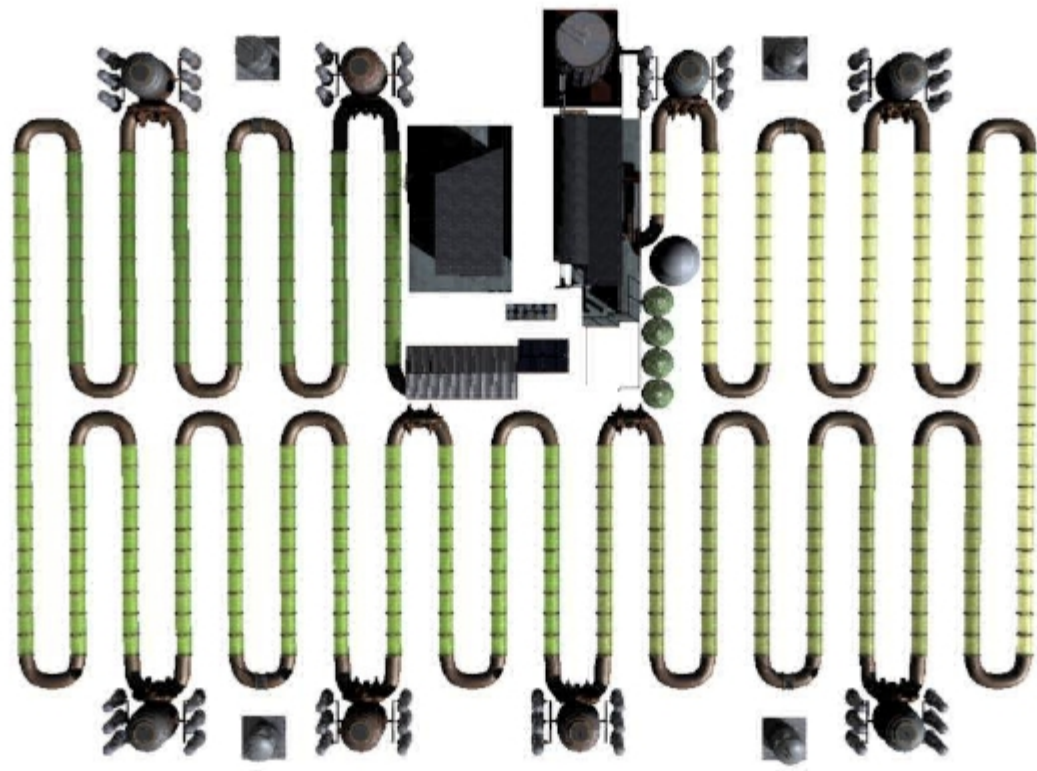
# Plant (3D)(1)



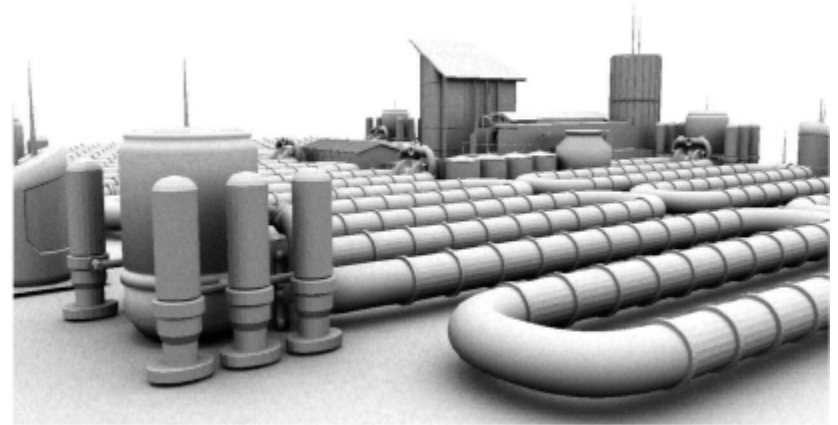
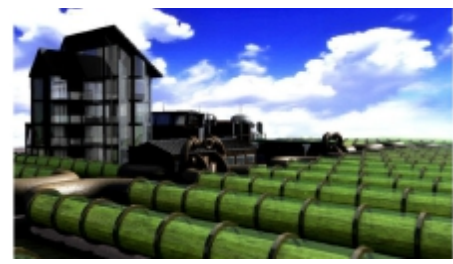
# Plant prototype: design (2)



# Plant (2)



# Plant design (2)



# Economical Viability: biorefinery of microalgae

## Bulk chemicals and biofuels in 1,000 kg microalgae

### 400 kg lipids

- ✓✓ 100 kg as feedstock chemical industry (2.66 usd/kg lipids)
- ✓✓ 300 kg as transport fuel (0.66 usd/kg lipids)

### 500 kg proteins

- ✓✓ 100 kg for food (6.65 usd/kg protein)
- ✓✓ 400 kg for feed (1 usd/kg protein)

### 100 kg polysaccharides

- ✓✓ 1.33 usd/kg polysaccharides

### 70 kg of N removed

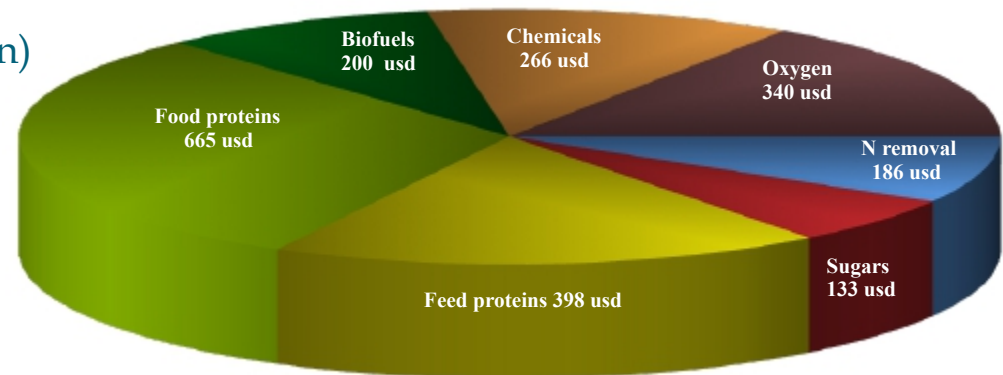
- ✓✓ 2.66 usd/kg nitrogen

### 1,600 kg oxygen produced

- ✓✓ 0.21 usd/kg oxygen

Production costs: 0.53 usd/kg biomass

Value: 2.19 usd/kg biomass



# York Argentina Group research agenda

Photobioreactor design

O<sub>2</sub> removal and CO<sub>2</sub> supply  
Biofilms for post-treatment  
wastewater

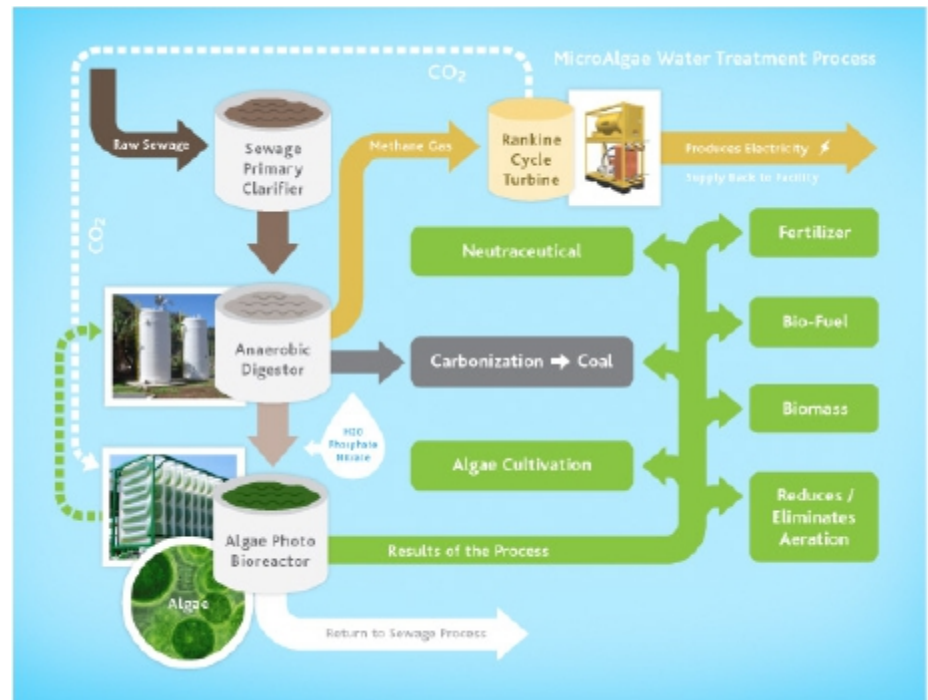
Control of primary  
metabolism

Harvesting and Oil  
extraction

Biorefinery

Design scenarios

ALPARC





# Control primary metabolism

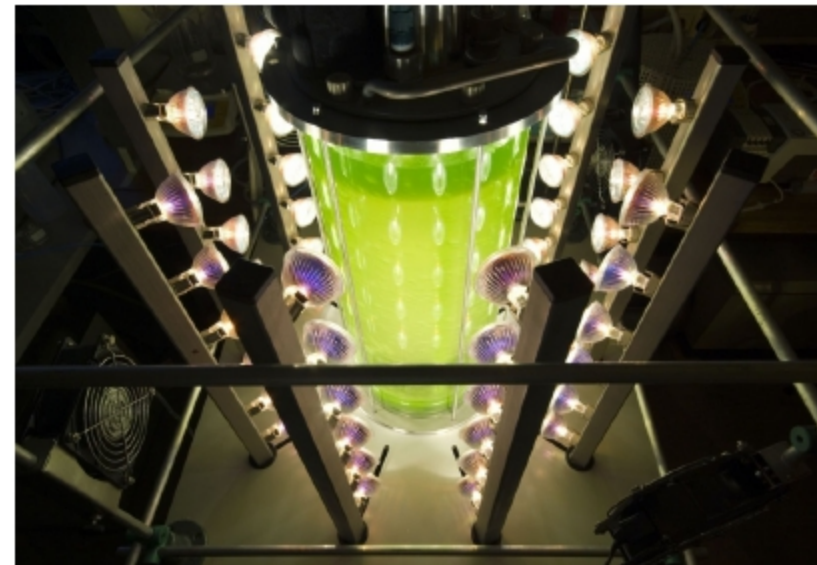
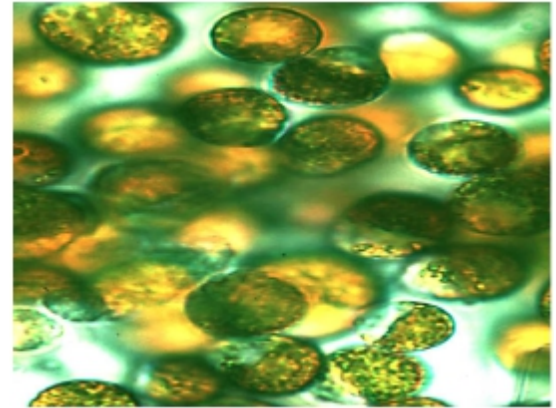
Objective: control metabolism

- ✓✓ High yield on light
- ✓✓ Production of lipids
- ✓✓ Production of colorants

Metabolic network model and flux calculations to predict rates in primary metabolism

Research reactor to apply wide range of cultivation conditions

On-line monitoring of production and consumption rates ( $\text{CO}_2$ ,  $\text{O}_2$ , N, biomass)



# Building a metabolic model

Model organism: *Chlamydomonas reinhardtii*

Ametabolic model was built

- ✓✓ About 300 enzymatic reactions were modeled
- ✓✓ Lumping linear pathways
- ✓✓ 159 reactions and 161 metabolites

35 enzymes were not annotated

- ✓✓ 28 were retrieved in the *C. reinhardtii* genome with sequences of related organisms
- ✓✓ 7 remain missing

Checked by comparing Photosynthetic Quotient ( $O_2$  production rate/ $CO_2$  uptake rate, Quantum Requirement (mol light quanta needed per mol  $O_2$  produced) and Biomass yield (g biomass/mol photons)



# Projects

Genome based metabolic flux model for Chlamydomonas

Metabolic flux models and lipid accumulation in green algae

Metabolic flux models and lipid accumulation in diatoms

Metabolic flux models and colorant production

Metabolic flux models and alkane accumulation in Botryococcus (contract negotiation)



# Design scenarios

## Objective

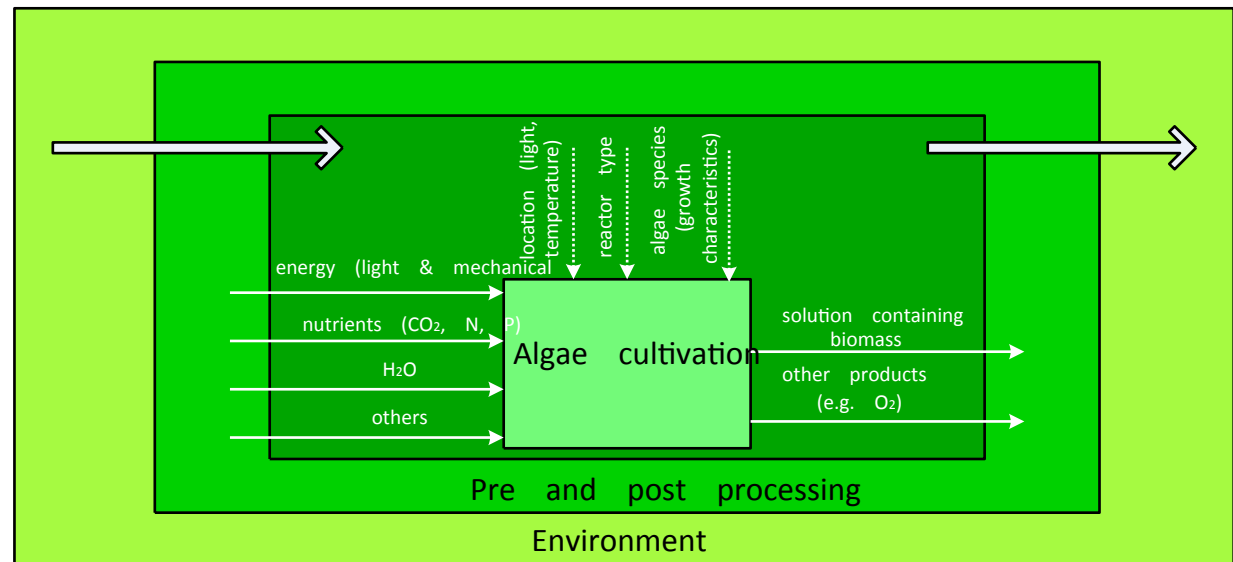
- ✓✓ Develop scenarios for production of energy carriers at very large scale

## Why

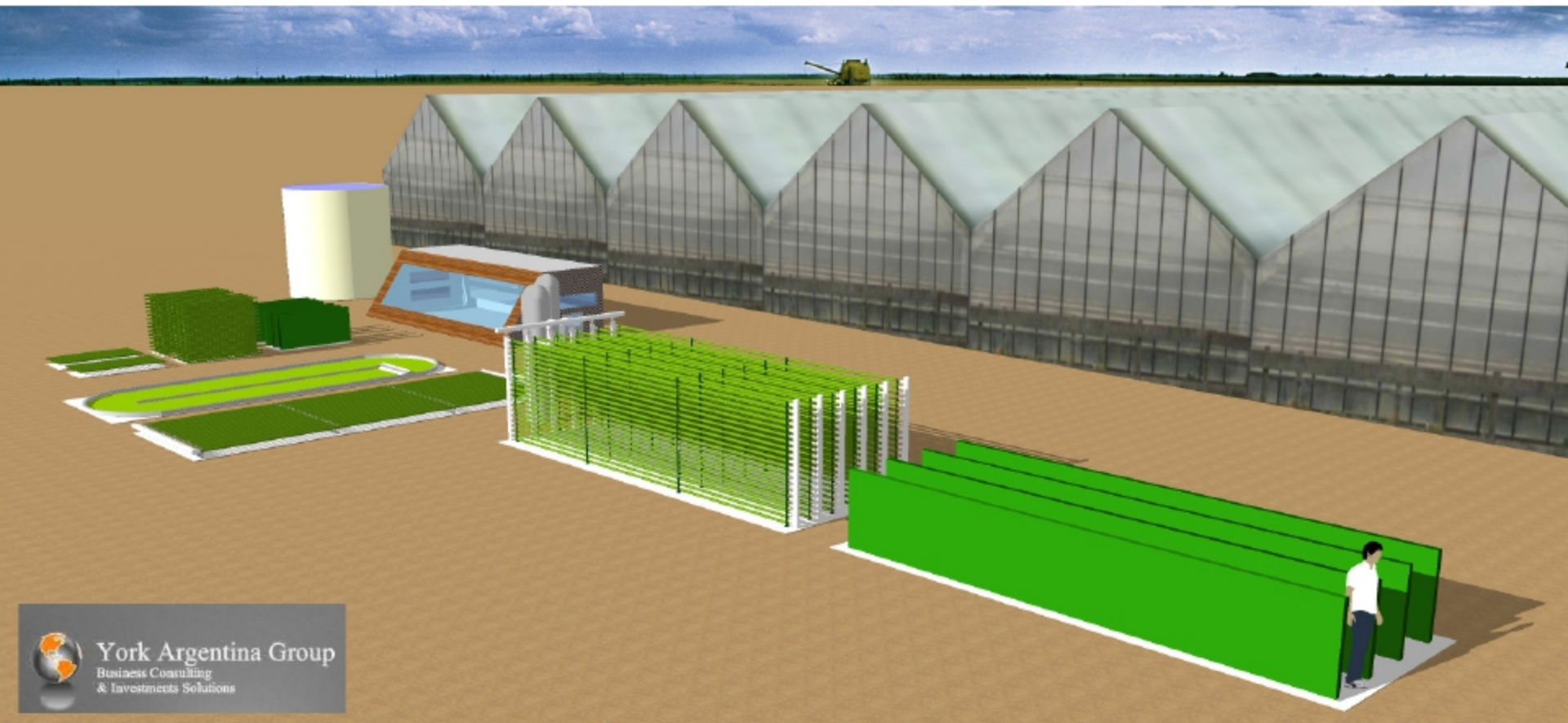
- ✓✓ Logistics: complexity and energy use of supply of materials

## Research issues

- ✓✓ Sustainability
- ✓✓ Scale
- ✓✓ Location



# bion Algae



Build up an international , open and independent center for applied research

Translate research towards applications

Acquire Information for design of full scale plants

Develop competitive technology (economic viability and positive energy balance)

Cradle to Cradle: Closing material loops - CO<sub>2</sub>, N, P

To be applied in and outside the Netherlands

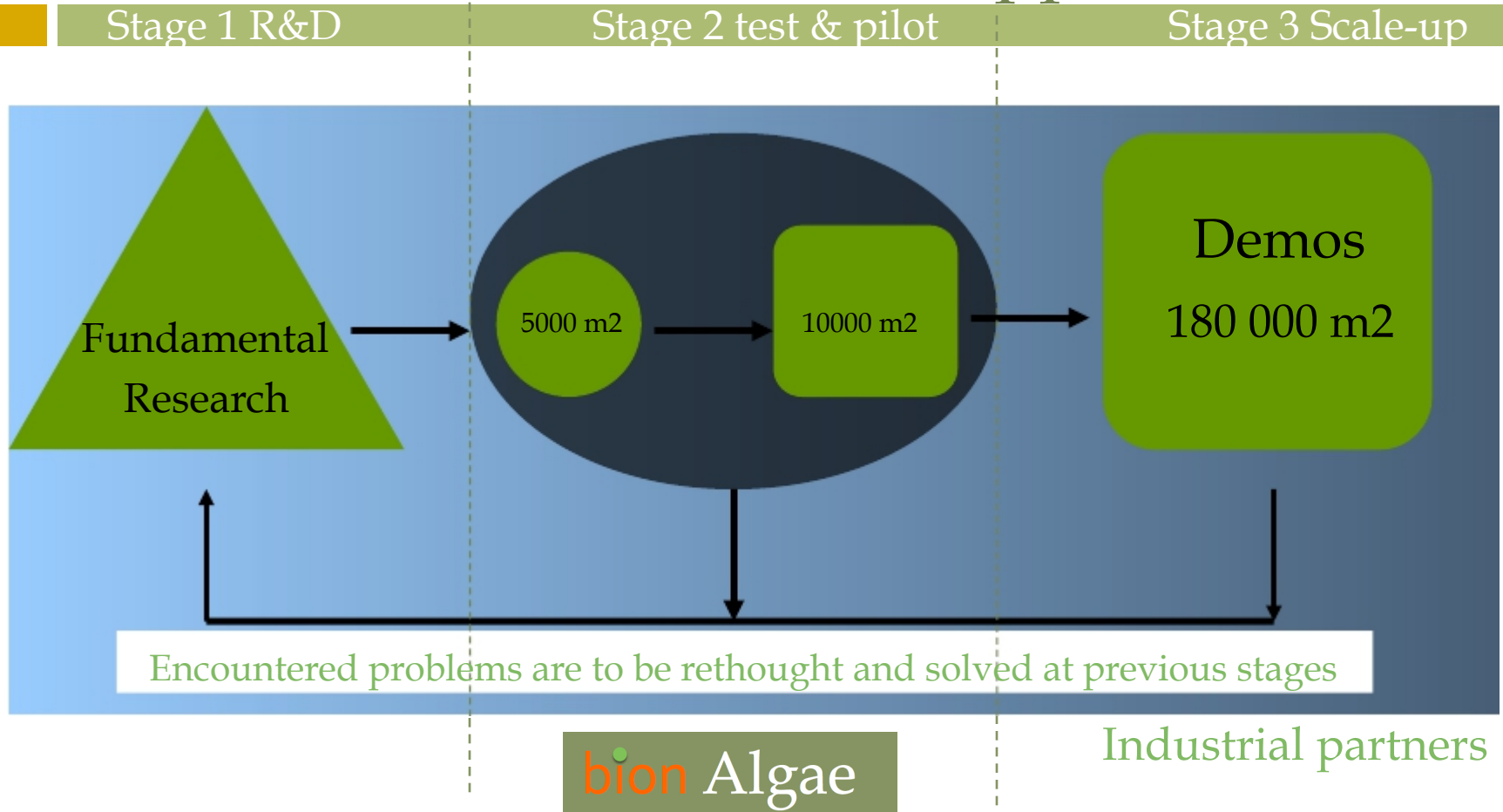
Defined Research Program (5 years) & Contract research

Production of algal biomass for bulk chemicals, food and feed ingredients and biofuels

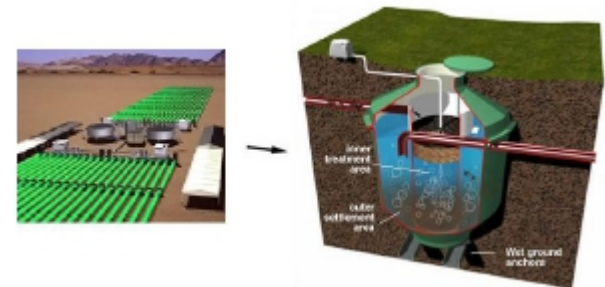
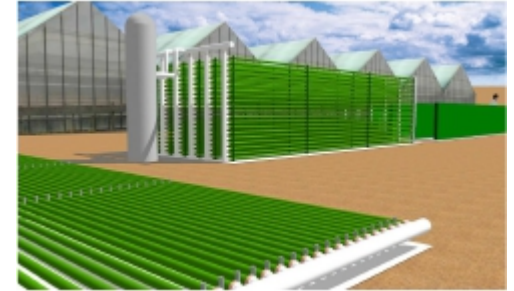
Pilot as intermediate between lab and demo



# Translate research towards applications

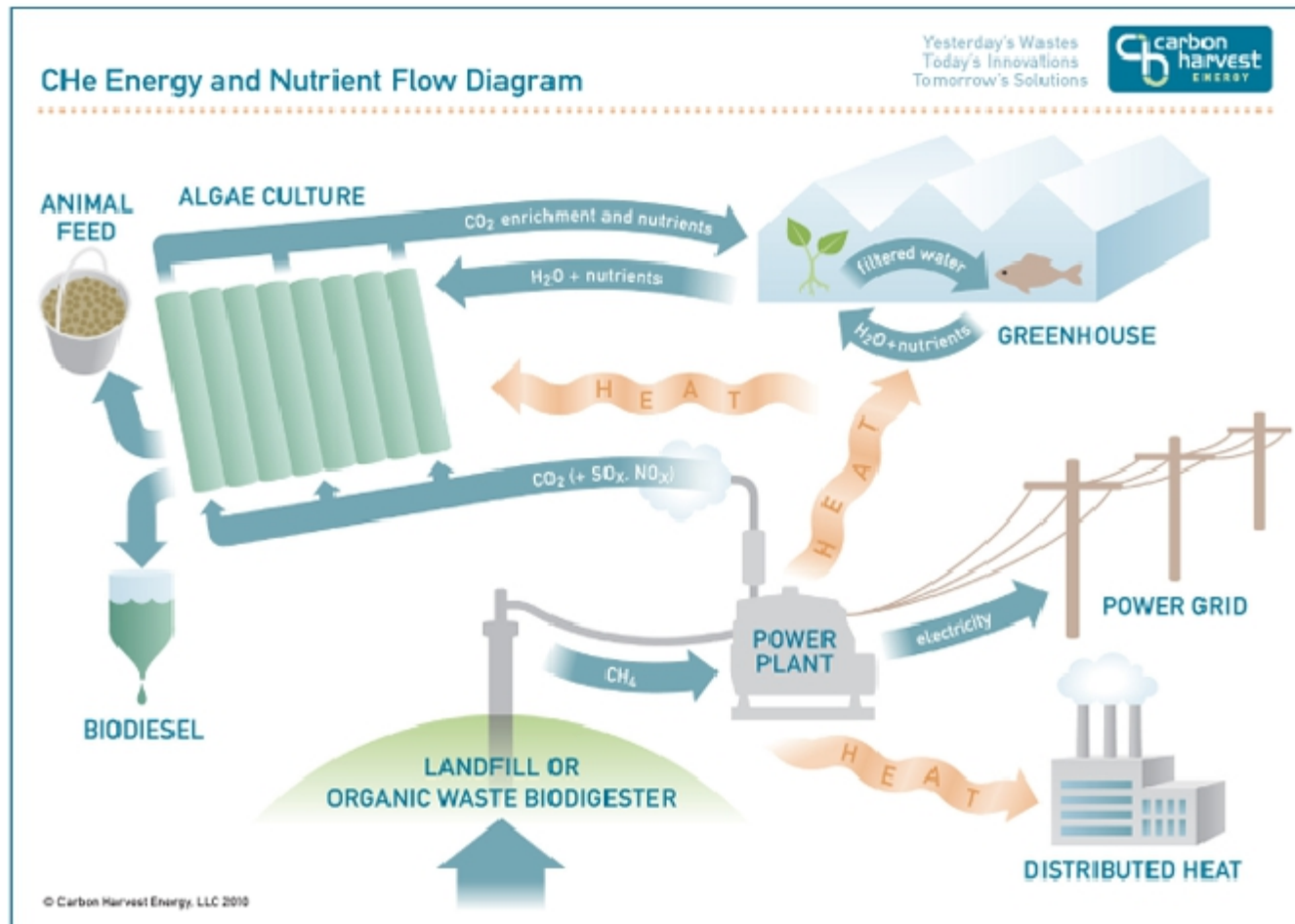


- Development of a process chain
- Experience with systems
- Information for design of full scale plants
- Comparison of systems
- Comparison of strains
- Comparison of feeds (nutrients, CO<sub>2</sub>, sunlight...)
- Supply of biomass for further processing
- Further processing





# CHe Energy and nutrient flow diagram



## Main Features

Uniqueness - 4 different systems that can run in parallel (minimum)

Fundamental aspects for successful operation and scale up of photobioreactors to commercial plants

Control Units: accurate online measurements and control of a wide range of metabolic and environmental parameters

Flexibility: The reactors should be easily changeable to allow fast testing of different systems

## Markets

At Heliae, we've unlocked the full value of algae. Heliae's Volaris™ production platform overcomes the technical and economic hurdles that have traditionally plagued algae operations and offers our commercial partners the ability to convert this dynamic, sustainable feedstock into market-ready products that meet the needs of society. The Volaris™ platform makes algae a realistic ingredient for a range of industry sectors that were not feasible – until now.



# Chlorella & Spirulina



## • Spirulina & Chlorella

These premium **organic** algae are high in protein and easily absorbable by the body and **certified low lead** and **non-irradiated**.

### • Benefits of Spirulina

- Is a protein powerhouse and contains up to 70% complete protein!
- Is rich in chlorophyll which oxygenates and alkalis the blood.
- Is a source of omega fatty acids which lowers bad cholesterol.
- Contains vitamin B12.
- Promotes beneficial bacteria.
- Has immune boosting properties.

### • Benefits of Chlorella

- Is alkalisng.
- Decreases inflammation.
- Binds with with toxic chemicals and heavy metals and moves them out of the body.
- Promotes the production of healthy flora throughout the digestive system.
- Boosts energy and vitality.
- Boosts immunity and has cancer fighting properties.



# CO<sub>2</sub> & cosmetics



## CO<sub>2</sub> ABATEMENT

Throughout the last century there has been an alarming increase in the level of carbon dioxide gas found in the Earth's atmosphere. Man and his massive use of fossil fuels is to blame. This results in an overheating of the Earth's surface (greenhouse effect), with consequent alteration of the climate (climate change).

Marine phytoplankton is the main CO<sub>2</sub> fixation system on our planet. Consisting basically of microalgae and cyanobacteria, it captures inorganic carbon whilst releasing oxygen via photosynthesis. Living beings therefore depend on this momentous biological process in order to obtain oxygen, as well as the food we need for subsistence.



## COSMETICS

Several species of microalgae, particularly *Spirulina* and *Chlorella*, are used in cosmetics and body care. Renowned international brands are already including extracts of these unicellular microorganisms in their formulae.

The afore-mentioned extracts can mostly be found in facial and body care products, including anti-ageing, refreshing, regenerative and anti-irritant creams. They can also be found in sunscreens, hair care or as makeup pigments and hygiene products.



# Biofuels, aquaculture & nutrition



Aquaculture

## AQUACULTURE

Intensive use of extractive fishing is threatening important species and forces governments to impose temporary stoppages whilst the profitability of fishing fleets is decreasing and ship-owners are seeing their livelihoods threatened.

As a result of this and in order to satisfy the continually growing demand for fish to feed the world's population, it has been necessary to breed different types of fish, crustaceans and molluscs in fish farms.

Fish larvae feed on multicellular microorganisms -Rotifera and Artemia-, which in turn require a balanced and natural feeding on microalgae. This is the only way to achieve healthy farmed fish which compare favourably with those found in the wild.



Biofuels

## BIOFUELS

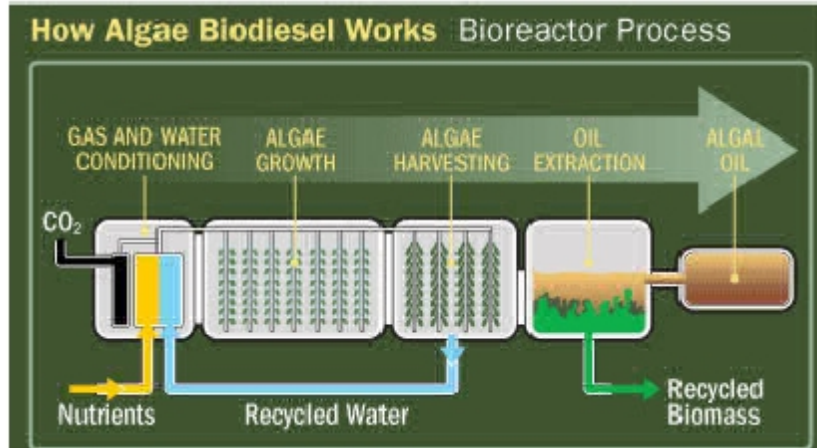
Production of biofuels from certain microalgae and cyanobacteria would appear to be the most promising alternative to current methods, since its yield is very high, sustainable, uses either wastewater, brackish or seawater, does not require the use of agricultural land, does not compete with human food and the cultivation process consumes the CO<sub>2</sub> noxious gas.



Nutrition



# Algae Biodiesel



# WWW.YORKARGENTINA.COM

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