

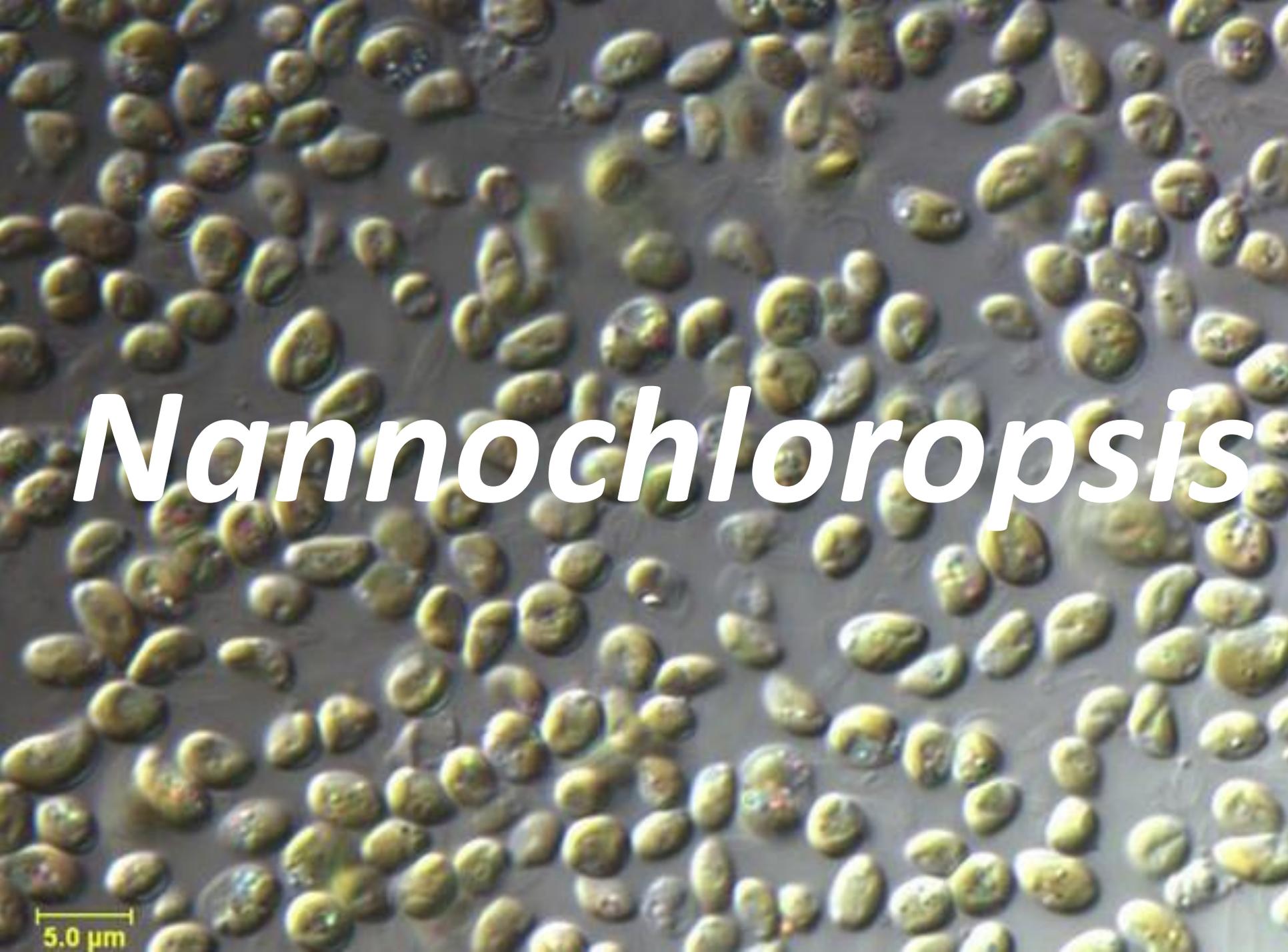
# (EMERGING) INDUSTRIAL PRODUCTION OF *NANNOCHLOROPSIS* MICROALGAE BIOMASS AROUND THE WORLD

# 2012



# *Nannochloropsis*

5.0  $\mu\text{m}$



# why ? This presentation ?

Necton **produces and sells** *Nannochloropsis* for Aquaculture since September **1997**... using photobioreactors

The company produces more than 12 different species with different autotrophic technologies and in the near future also mixotrophic

our *Dunaliella* research started in March **1989**... using raceways

**This presentation is only valid for the first semester 2013 – will be outdated further on.**

BIOFAT is a microalgae-to-biofuel **demonstration project** that integrates the whole value chain of algae process from its optimized growth, starch and oil accumulation, and finally to downstream biofuel production.

BIOFAT approach consists in **integrating complementary technologies** and skills from each different partner into a global multidisciplinary project.

Production area: **10 ha. *Nannochloropsis* + *Tetraselmis***

2 x 5.000 m<sup>2</sup> Pilot Plants in Italy and Portugal

Expected annual productivity: **100 ton/ha**

## Production stage

- ✓ PBRs for inoculum production
- ✓ Raceways for biomass production and induction of oil accumulation

Budget: **10.1 M€**



GIAVAP (Genetic Improvement of Algae for Value Added Product) is a large scale integrating project involving twelve partners from five European and one associated country participate in the project. Total funding for the whole consortium is 5.7 KEuro's.

*Phaeodactylum*

12% DHA

6% fucoxanthin

for lipids, carotenoids and proteins using model algae strains and suitable improved strains. Furthermore products will be tested for energy, pharmaceutical, nutritional or medical applications for economic evaluation of the production processes and their exploitation.

#	Participant	Country
01	Ben Gurion University	Israel
02	Rothamsted Research	UK
03	J.W. Goethe University, Frankfurt	Germany
04	Georg-August-University Göttingen	Germany
05	University College London	UK
<b>06</b>	<b>AlgaFuel, S.A.</b>	<b>Portugal</b>
07	Rosetta Genomics, Rehovot	Israel
08	University of Le Mans	France
09	CNRS / University Pierre et Marie Curie	France
10	Università degli Studi di Firenze	Italy
11	Algatechnologies	Israel

Coordinator: Prof. Sammy Boussiba | Objective KBBE.2010.3.2-03: Modification of Marine or Freshwater Algae to better suit Industrial Applications

Ben-Gurion University of the Negev | Type of funding scheme: CP-IP | large-scale integrating project



# conclusions ?

- Necton is selling *Nannochloropsis* on a commercial basis since 1997
- Reed Mariculture started in 1998 and is now the largest producer of Aquaculture
- Yantai Hairong Biology Technology Co. Ltd started in 2010 a 10 ha production
- Fitoplanton Marino started in 2002
  
- THREE PRODUCTS: **Algae paste** – **Dried algae** – **Algae extracts** (such as EPA oil)
  - > Each product with several formulations
  
- THREE TECHNOLOGIES: **Raceways** – **Photobioreactors** - **Plastic Bags**
  - > Each technology with several approaches

# 10 companies provide Product based solutions

- **EPA from Nannochloropsis (purified oil or algae extract)**

**Aurora – with A2EPA**

**Cellana – with ReNew Omega3**

**Qualitas Health – with EicoOil**

- **Nannochloropsis biomass with high EPA content (paste or dried)**

**Necton – with PhytoBloom**

**Reed Mariculture – with InstantAlgae**

**Fitoplanton Marino – with EasyAlgae**

**Yantai – with Hearol**

**Astaxa – with Astaxa Nanno**

**Proviron – with ProviFeed**

**Archimede – with MAC**

Wild / Selected /  
Genetically modified

What we grow

1

Microalgae

2

Where we grow

3

How we grow

Oceans  
Lakes  
Raceway  
Photobioreactor  
Fermenters

Autotrophic  
Heterotrophic  
Mixotrophic

# Lets see the details companies and ventures

2 types of companies:

- **Developers**

- **Users**

- > will focus here
- (some do both)
- > will overview only some of the most interesting

production using raceways

## **Aurora Algae, Pty**

Karratha, Australia & California, USA

Started: September 2006

Size: 9 ha - 100 ha expansion in 2014

Investment: 2 M A\$

[www.aurorainc.com](http://www.aurorainc.com)



# Aurora Algae in Karratha, Western Australia



Aurora Algae is a producer of algae-based products for the pharmaceutical, nutrition, aquaculture and fuels markets. The Company has developed the industry's first commercial-scale photosynthetic platform for sustainable, algae-based product development. Aurora Algae's proprietary algae strains and production process uses arid land, seawater and captured carbon pollution from industrial emitters, resulting in more capittally efficient and more environmentally sustainable algae farming.



# Aurora|algae™

Aurora Algae, Inc. was formerly known as Aurora Biofuels, Inc. and changed its name to Aurora Algae, Inc. in September 2010. The company was founded in **2006** and is based in Hayward, California with additional offices in West Perth and Karratha, Australia.

In 2011 the company received an initial A\$750,000 of a total Australian government LEED grant of up to A\$2 M for a demonstration plant. Overall, \$1.85M of the grant was related to the demo facility, and \$150K for the first commercial facility.

Image © 2013 DigitalGlobe

Aurora Algae Pty Ltd.. Level 3, 679 Murray Street. West Perth, WA 6005 Australia

[www.aurorainc.com](http://www.aurorainc.com)

Aurora Algae A2 EPA Pure™ is a fresh alternative to a growing problem. A2 EPA Pure oil delivers exponentially higher potency EPA; the purest, high quality ingredient for supplements and pharmaceuticals. While other forms of EPA are extracted from the middle-man (or fish), A2 EPA Pure comes straight from the 100% vegetarian source, is truly sustainable, and an ideal alternative to those avoiding fish or soy products.

### Benefits of an Algae Based EPA

- Unlimited scalability
- Year round fresh supply
- Allergen-free, vegetarian marketability
- Consumer palatability
- Eco-friendly and sustainably grown



Aurora Algae's 20-acre (nearly 9 ha) demonstration facility spans a nearly 1,000 acre (nearly 405 ha) property. Aurora's 38 individual microponds (~ 2 m<sup>2</sup>) provide a research tool for optimizing the growth parameters of patented strains prior to scaling up to larger ponds. Algae cultivation begins then in four 50 m<sup>2</sup> and four 400 m<sup>2</sup> inoculation ponds. The inoculation ponds provide intermediate steps to produce enough algae culture to inoculate six 1-acre ponds to produce approximately 15 ton/month of algal-biomass.

Aurora Algae has a patented air distribution system to optimize the conventional dissolved air flotation systems (DAF) for microalgae harvesting. A flocculant is added to the tank which conditions the algae for more efficient harvesting by promoting larger flocs and bubble-particle attachment. The alga is then moved into the DAF where the alga are separated from water, forming a thick wet paste. The paste is then placed in a dryer where it becomes algal powder, ready for extraction and conversion into the various A2 products.



Aurora|algae™



Aurora has combined traditional techniques with modern control systems technology to achieve maximum productivity in large-scale operations. All operations, from growing to harvesting biomass, are automatically controlled. The system measures variables such as temperature, pH levels, and turbidity and initiates adjustments as necessary. Information is instantly captured and available to the R&D team to allow further improvements and increased productivity.



Aurora Algae plans to break ground in Maitland in 2014 for an expanded commercial facility consisting of 100 hectares (250 acres) of algae ponds, capable of producing up to 600 metric tons of biomass per month, and scalable to **2,000 hectares** (5,000 acres). Maitland will be home to their first commercial scale facility. Located just meters from the demonstration site, will house fifty 5-acre ponds, producing an estimated 600 tonnes of biomass per month, consuming 40 ton/day of CO<sub>2</sub>.

For the design and construction of its commercial facility in Maitland, Australia, Aurora Algae has given the initial engineering contract to MWH engineering firm, a global company in wet infrastructure, and John Holland (JH), the largest multidiscipline construction contracting business in Australia. The facility will be built on Aurora Algae's recently secured **1,500 acres** of land near its recently opened demonstration facility in Karratha. By this Aurora has taken a step forward towards the construction of the largest commercial scale algae facility in the world.

**Yantai Hairong Biology  
Technology Co. Ltd.**

China

Started: January 2010

Size: 12 ha

Investment: US\$ 20 M US\$

[www.hearol.com](http://www.hearol.com)



2011



Yantai Hairong Biology Technology Co., Ltd is the first company in China and also the largest enterprise in the world to culture and process *Nannochloropsis*. A joint venture registered in **January 2010** with the capital of **5 M US\$** mainly engages in the aquaculture process and development of marine microalgae.

The JV introduced the advanced flue-gas culture technology to produce *Nannochloropsis* with the exhaust gas from thermal power plant, and the first phase the culture area is about **100,000 m<sup>2</sup>** which can reach 10,000 ton/year of CO<sub>2</sub> reduction. The production capacity is 2 ton/week of biomass.



[www.hearol.com](http://www.hearol.com)

Yantai Hairong Biology Technology Co., Ltd aims to supply the market with various kinds of microalgae, like *Nannochloropsis* with high contents of EPA, and *Dunaliella* with high contents of  $\beta$ -carotene.

With the leading of Doctor Wang Yupeng, from China GuoDian Corporation, JV invited Professor AmiBen-Amotz, the famous microalgae expert from Israel as chief technical director.

Hearol from Yantai Hairong contains *Nannochloropsis oceanica* with 5% DW EPA and is available in several formulations. The products are sold as 'marine chlorella' for Aquaculture applications.





*Nannochloropsis oceanica* multiply fast and is rich in nutrition; therefore it is widely used in aquaculture, and is an ideal bath for breeding arcidae, shrimp, crab and rotifer. Average content is 20% carbohydrates, 40% proteins, and at least 30% lipids, of which most are unsaturated fatty acid, especially the content of EPA taking 30% of fatty acids and 5% of dry weight.

The company devotes to produce marine algae with high quality - *Nannochloropsis* with high contents of EPA, *Chlorella* with high contents of CGF, etc.



## Cellana, LLC

Kailua-Kona, Hawaii

Started: 2004

Size: 2.5 ha Demo - 88 ha in Maui in 2014

Investment: 70-90 MUS\$

[www.cellana.com](http://www.cellana.com)



# Cellana, LLC in Kona, Hawaii, USA



**Kona Demonstration Facility** a six-acre demonstration facility in Kailua-Kona enables Cellana to test different algae strains and produce product to accelerate development of a first commercial facility in Maui.



# Cellana, LLC in Kona, Hawaii, USA

[www.cellana.com](http://www.cellana.com)



Cellana, formerly **HR BioPetroleum, Inc.**, (HRBP), founded in Hawaii in 2004, uses marine microalgae to produce feedstocks for biofuels, skin and personal care products, nutritional oils, renewable chemicals and aquaculture and livestock feeds, while simultaneously reducing industrial emissions of CO2.

In 2007, HRBP and **Royal Dutch Shell PLC**, the international energy company, formed Cellana as a separate joint venture to build and operate a six-acre (2,5 ha) demonstration facility to grow marine algae and produce vegetable oil for conversion into biofuel.

HRBP became the sole owner of **Cellana LLC in January 2011**. Cellana intends to construct and operate commercial facilities to produce these products as integrated algae-based biorefineries. To date, **over \$100 million** has been invested in developing Cellana's algae strains, production technologies and its Kona demonstration facility.

**ALDUO™**  
Proprietary Process

**Closed System**    **Open System**

Grow in Photobioreactors    +    Grow in Open Ponds





## Cellana, LLC in Kona, Hawaii, USA



### Cellana's Marine Algae Produce Healthy Nutritional Oils That Contain an Abundance of Omega-3s

Cellana LLC has received a \$5.5 million U.S. Department of Agriculture grant to develop **affordable animal feed from marine algae** to facilitate the large-scale production of feedstocks for biofuels, aquaculture and other animal feeds. The project began May 1, 2011 and runs through April 30, 2014.

Cellana will receive \$5,521,173, which will be combined with \$1,643,661 provided by Cellana for the project, titled **“Developing a New Generation of Animal Feed Protein Supplements.”** Under this USDA grant, Cornell University will be conducting large-scale animal feeding trials using algae biomass provided by Cellana to identify the most economical and efficacious strains of algae.

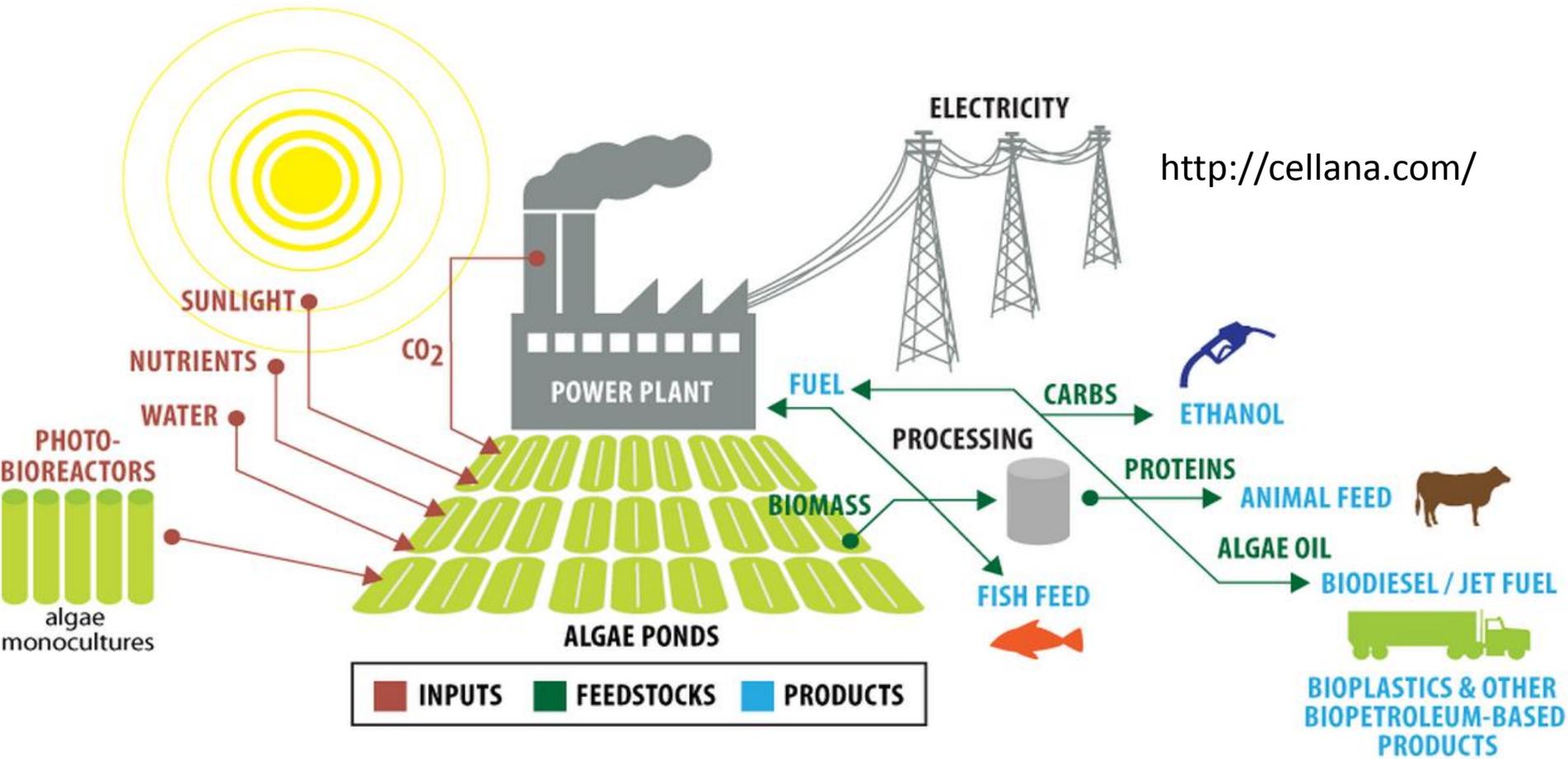
Cellana has established world-class strategic partnerships, collaborations and alliances to utilize the best information and technology available to produce algae and related products at economic scale.



Maui 88 ha site plan: 8 modules x 11 ha = 88 ha. Production: 12,000+ MT/year.



# BIOREFINERY MODEL



<http://cellana.com/>

Cellana, LLC, Alexander & Baldwin, Inc. Hawaiian Electric Company and Maui Electric Company, subsidiaries of Hawaiian Electric Industries, Inc. signed in 2008 a memoranda of understanding to pursue the joint development of a commercial-scale microalgae facility on Maui to produce lipid oil for valuable products, such as aquaculture and animal feeds. [www.cellana.com](http://www.cellana.com)



# Clean Algae, SL

Gran Canaria, Spain

Started: 2008

Size: 0.25 ha – 1 ha new in 2013

Investment:

[www.cleanalgae.es](http://www.cleanalgae.es)



## CleanAlgae, SL in Las Palmas, Spain



CleanAlgae is a SME founded in 2008 with head-office & operations located on the island of Gran Canaria.

The business was initially developed around the idea of obtaining PUFA oils rich in omega-3 fatty acids taken directly from a microalgae source, rather than the current source which comes from fish origin. This business idea comes from two companies that combine their experience in scientific and product development, along with product to market expertise (Feyecon and AlgaeBiotech). Together they created the CleanAlgae business and, after evaluation, decided to settle in the most ideal geographical location to maximize the production and cultivation of microalgae in Europe, the Canary Islands.

CleanAlgae took its first steps to develop pilot-scale processes at the **Center of Marine Biotechnology of Taliarte (Gran Canaria)** where the microalgae specie *Nannochloropsis gaditana* was selected, due to its high content in omega-3.

Clean Algae has developed a specific device, the Light Enhancement Factor (LEF), to enhance the light penetration in ponds and at least double their productivity. Algae harvesting and processing are provided by AlgaeBiotech, a sister-SME also located in Gran Canaria, and dedicated to creating new innovative products and processes in the field of **product extraction from algae**.





# Clean Algae, SL in Las Palmas, Gran Canaria, Spain



300 m<sup>2</sup> raceway

CleanAlgae with 3 x 300 m<sup>2</sup> 1000 m<sup>2</sup> raceway algae ponds in Las Palmas, Gran Canaria, Spain



## AlgaeBiotech SL in Den Bosch, The Netherlands



With operations in Spain and The Netherlands, Algae-Biotech SL is a technology-oriented enterprise focused on providing the most advanced systems for microalgae cultivation. These systems include all phases of the process, from food-grade water pre-treatment and nutrient composition to photobioreactor and outdoor raceway cultivation, through to harvesting, dewatering, drying and packaging.

**Algae Biotech SL** has a demonstration facility in Den Bosch, NL for trials and experimentation- this initial pilot algae growing facility has an area of 2500 m<sup>2</sup>. The facility boasts (9) raceway ponds from 6 m<sup>2</sup> to 300 m<sup>2</sup>, with a total raceway surface area of 1500 m<sup>2</sup>. These are inoculated from the on-site laboratory, which can scale up cultures from petri dish colony to **(6) 120 liter photobioreactors**.

Algae-Biotech's earlier work began in Gran Canaria, Spain where small-scale production continues. has a sister company, **CleanAlgae SL**, which focuses on the growing of algae. At this moment, CleanAlgae SL is developing its main growing operations in Gran Canaria, with the knowledge gained at these two locations will be put into practice at the large-scale production facility, which is currently being developed in Cádiz, Spain under the framework of the FP7 European Project All-Gas.





# Algae Biotech, SL in Den Bosch, The Netherlands



Algae Biotech SL, is a Spanish-based company dedicated to create an algae processing platform to address the growing demand for biomass and its derived products, such as oils and proteins in global food, cosmetic, feed, pharmaceutical and energy markets. Algae Biotech's intellectual proprietary technology covers supercritical carbon dioxide drying, extraction and purification technology to create the cleanest food grade oils in the market. These scalable technological systems enable commercial-scale production of a wide range of algae products.



## Aquaviridis

Mexicali, Mexico

Started:

Size: 0.5 ha – 100 m<sup>3</sup>

Investment:

[www.aquaviridisinc.com](http://www.aquaviridisinc.com)



## Aquaviridis in Mexicali, Mexico



[aquaviridisinc.com](http://aquaviridisinc.com)

Aquaviridis, Inc. has developed a facility to operate known technologies on a pilot scale south of Mexicali in Ejido Nuevo Leon, Baja California Norte, Mexico.

The technologies to be used at the company facilities are open ponds, close loop photobioreactors and heterotrophic systems.

Aquaviridis will test and modify technologies to develop techniques and equipments to produce the most commercial viable alga cultivar and production methods utilizing local resources in the environmental conditions at the Mexicali Valley location. Additional to the advantages of being located in the Mexicali region.

Aquaviridis has the most experienced personnel in commercial **algae farming worldwide (gained in Earthrise and Algenol)**. The technical and commercial development staff has decades of real experience in production, harvesting, biomass processing, product development and commercialization of products based in algae.

Aquaviridis has rented a 5,000 m<sup>2</sup> site in the middle of Ejido Nuevo Leon, a small town 20 miles south of Mexicali, Mexico. The initial phase of the project is completed. The site has a fully equipped algae strain management and characterization lab, open pond, automated close loop photo bioreactors and heterotrophic algae production research and scale up facilities, cutting edge algae harvesting and product processing equipment.

The facility counts with:

- several strain validation micro-ponds, each one with a volume capacity of 400 liters, and currently are in construction 7 more ponds,
- two of 25 m<sup>2</sup> each one with capacity of 5,000 liters,
- two of 54 m<sup>2</sup> each one with capacity of 10,800 liters and the last set of three 100 m<sup>2</sup> with capacity of 20,000 liters each,

The total facility volume of culture capacity is around **100,000 liters**.

The facility will also have fully automated

- 1 bench scale close loop photo bioreactors with 500 liter capacity,
- 2 medium sized fully automated close loop **photobioreactors** with 10,000 liter capacity and
- 3 **heterotrophic** reactors of 1000 liter capacity.

The site will also have state of the art harvesting facilities, biomass processing units and a mini-refinery for extraction of valuable products. Since the first week of January of 2012, six micro-ponds have been in operation culturing four different algae species.



QUALITAS  
Health

**Qualitas**

Israel

Started: 10 year experience

Size:

Investment:

[www.qualitas-health.com](http://www.qualitas-health.com)



## Qualitas Health in Jerusalem, Israel



Qualitas Health is a privately-held company developing high-value vegetarian food supplements and pharmaceutical ingredients based on Omega-3 oils from a sustainable algae source. Building on over 10 years' experience in microalgae cultivation and extraction from the biofuel sector, the company's team has developed a unique and proprietary technology for strain selection, sustainable microalgae farming and harvesting, oil extraction and concentration. The technology allows for the effective production of proprietary premium Omega-3 supplements for a wide range of applications.

**Qualitas Health** and **Valicor Renewables** announced February, 11, 2013 a strategic partnership that will accelerate the launch of high-EPA Omega-3 oil from algae. Headquartered in Dexter, Michigan, Valicor operates three business groups, Environmental Services, Separation Technologies and Renewables, concentrating on the advancement of its technologies in processes and fluid management to meet client needs. Since beginning the **Algae Extraction Program in 2007**, Valicor Renewables has established transformative new techniques for the extraction and fractionation of algae oil. The development of the patent pending **Valicor Algafrac™ technologies** has provided for commercially scalable processes which efficiently and cost-effectively extract both polar and non-polar lipids.



# Qualitas Health in Jerusalem, Israel



## Rich in EPA

*EicoOil™* is rich in the omega-3 LC-PUFA eicosapentaenoic acid (EPA) and contains no DHA. Extensive clinical research has shown that oil with a high EPA:DHA ratio has a significant positive effect on cardiovascular health, inflammation and on mental health and function.



### Applications:

soft-gel capsules, two-piece hard shell capsules, functional foods



## Highly Bioavailable

In *EicoOil™*, the majority of the omega-3 fatty acids are conjugated with polar-lipids (phospholipids and glycolipids). The chemical structure of polar-lipids allows them to be more effectively absorbed into the body and easily digested. Both *EicoOil™* and krill oil naturally contain polar-lipids.



## Vegetarian

*EicoOil™* is extracted from non-GMO strains of microalgae *Nannochloropsis oculata*. This source answers a clear need for LC-PUFA's from a vegetarian source which can be used in vegan and kosher products.



## Sustainable

The algae that produce *EicoOil™* are grown in ponds using brackish water. This growing process is renewable and does not utilize resources that could be used to grow food/forage and does not exploit natural ocean resources.

### Technical information:

Appearance .....	Dark green viscous oil
EPA content .....	25-30%
Polar-lipid content.....	>15%



# Qualitas Health in Jerusalem, Israel



Qualitas Health team is highly experienced in large-scale algae cultivation, having designed, built, and operated large-scale commercial integrated algae-aquaculture farms for over a decade.

The team is led by Dr. Isaac Berzin, a renowned pioneer in algal large-scale production who has been engaged in the development of large-scale algae cultivation systems for many years.

(GREEN FUELS)

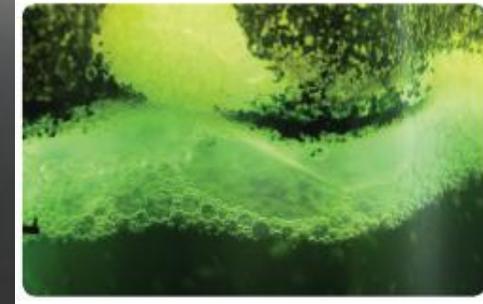


## Qualitas Health Ltd.

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Jerusalem ISRAEL

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Fax +972-2-591-6087  
info@qualitas-health.com

[www.qualitas-health.com](http://www.qualitas-health.com)



Through years of multidisciplinary scientific research, they have optimized the biology of the natural salt-water algae strain, *Nannochloropsis oculata*, to enhance its ability to produce high content Omega-3 oil and to deliver optimal yields in a variety of climates and conditions. They have pioneered sustainable and cost-effective salt-water culturing and harvesting processes for large-scale commercial production that minimize energy and water demands and maximize production performance. **Their farm-grown microalgae are cultivated in shallow open or closed ponds using a proprietary growth medium that is based on saline water to conserve resources.** Pure CO<sub>2</sub> from local emitters is supplied on-demand, and enables over 90% carbon utilization, thereby minimizing emissions and keeping a very low carbon footprint. The algae are harvested daily, without using toxic chemicals and output water is recycled back into farm operations.

# Seambiotic



Israel

Started: 2003

Size: 0.1 ha

Investment:

[www.sembiotic.com](http://www.sembiotic.com)



## Seambiotic in Askelon, Israel

Seambiotic



Seambiotic was founded in 2003 to grow and process marine microalgae using a revolutionizing ecologically based environmental system. For the last five years, Seambiotic has carried out R&D pilot study comprising about a 1,000 meter square of ponds at the power plant of the Israeli Electric Corporation in Ashkelon.

Throughout the study, new and advanced research methods have been developed for cultivation of various species of marine micro algae using the power station's carbon dioxide emissions released directly from their smokestacks and which pass through pipelines directly to Seambiotic's open ponds.



Seambiotic 2008



24/03/2009



# Seambiotic in Askelon, Israel

## Major Achievements (2005-2008):

1. Direct use of electric power plant coal burning flue gas
2. Direct use of electric power plant turbine cooling sea water
3. Continuous production of microalgae, ~7 tons/1,000m<sup>2</sup>/year
4. Production of high lipid *Nannochloropsis* to 50%/AFDW
5. Processing the algal mass to bio-diesel, bio-ethanol and protein
6. Supply of mass of algae to many algae companies
7. Reducing CAPEX and APEX of algal biotechnology





Seambiotic possesses unique technology for gas transfer and cleaning, command and control of its concentration in cultivation ponds and its absorption within the algae for energy rich products.

Algae can grow preferably in open ponds over closed bioreactors. Algal ponds are generally shallow to ensure the penetration of light into the culture; they are kept continuously mixed by gentle stirring. The algae "feed" comes from the supply of carbon dioxide. Feed of carbon dioxide is the biggest cost item in the long run of algal cultivation.

Seambiotic cultivates a few selected species of marine autotrophic microalgae with high content of lipids and carbohydrates as equivalent to the production of bio-diesel and bio-ethanol.

Seambiotic grows the following algae species: *Nannochloropsis sp.*, *Phaeodactylum tricornutum*, *Amphora sp.*, *Navicula sp.*, *Dunaliella sp.*, *Chlorococcum sp.*, *Tetraselmis sp.*, *Nannochloris sp.*

# Kibbutz Maagan Michael

Israel

Started:

Size:

Investment:

WWW.



מעגן מיכאל  
MAAGAN MICHAEL



## Kibbutz Maagan Michael in Coastal Plains, Israel

Production of *Nannochloropsis* for Aquaculture in Maagan Michael, a kibbutz in Israel. It is the largest kibbutz in the country, with a population of over 1,400 residents (not including external workers), located 30 km south of Haifa and 70 km north of Tel Aviv and lies near the edge of the Mediterranean Sea west of Mount Carmel, south of bordering kibbutz Maayan Zvi, and north of the Taninim Stream.

## **Sales Monzón, S.A.**

Barcelona, Spain

Started:

Size:

Investment:

<http://salesmonzon.com>



Sales Monzón S.A. extracts the salt from the deposits formed by karsts millions of years ago stemming from marine formations that were present in Aragon, Navarra and Catalonia. The deposits of greater quality of the salt are located in the extraction sites of Castejón del Puente. These deposits lie at a depth of between 500 - 1,200 meters. The salt is extracted from the cavities dissolved in water which makes up the saturated brine. That brine reaches the surface by being channeled through tubes and assisted by the pressure of the water entering into the same cavity. The salt crystallizes in the decanting pools. That crystallization process is being achieved by aid of heat exchangers that considerably increase the production of the plant. 99.8% purity is the quality of the salt that is obtained due to its purification process of dissolution in the cavity, and the following crystallization achieved in the decanting pools.

Sales Monzón is formed in 1992 initially focusing on the drilling of wells for the extraction of the brine, followed by the building of the first evaporation pools. In 1993 the first three motors are being put into operation with a capacity of generating 1,980 settle Kwh of electricity. The same motors are recovering their residual heat in order to warm up the brine and to increase the crystallization process of the salt.



### **Offices**

Balmes 354 3º 1ª B 08006 Barcelona (Spain)

Tel: 93 232 94 55 [margarita@salesmonzon.com](mailto:margarita@salesmonzon.com)

### **Factory**

Camino del Vedao s/n. 22310 Castejon del Puente

Tel: 974 40 07 53 [jgomez@salesmonzon.com](mailto:jgomez@salesmonzon.com)

<http://salesmonzon.com>



# Photobioreactors



## See Algae Technology

Vienna, Austria

Started: August 2011

Size: 0.2 ha in Viena – 1 ha in Brazil

Investment: 10 M €

[www.seealgae.com](http://www.seealgae.com)

# SAT in Vienna, Austria and in Recife, Brazil



SAT – See Algae Technology, GmbH was founded in August 2011 and acquired another company which had been active in the algae space since 2008. This acquisition included all personnel, the IP rights and the pilot plant operated by this company (CO<sub>2</sub>).

SAT is headquartered in Vienna, Austria, operates a pilot plant in cooperation with a local power utility and has subsidiaries in the US, Brazil and South Africa. SEE ALGAE Technology (SAT) designs, engineers and builds production plants for algae based compounds. SAT algae plants are able to provide those products at currently prevailing market prices.

The SAT team has been active in algae project development since early 2008. SAT has developed proprietary processes which ensure an outstanding level of productivity. SAT supplies both natural and genetically modified algae strains which are optimized to grow in SAT algae plants.

**2.500 ton / ha / year !**



*Fuels*

*Chemicals*



*Nutrients*

*Animal & Fish-Feed*



## SAT in Vienna, Austria and in Recife, Brazil

Under the **€8 million agreement**, SEE ALGAE will design an algae farm and provide its algae cultivation technology to JB, oversee the farm's installation, and ensure the farm's initial productivity.

SEE ALGAE Technology, GmbH, signed an agreement to supply and install a 1 hectare “dual-use” algae production plant for Recife, Brazil-based Group JB (“JB”), one of the leading bioethanol producers in Brazil. Once operational, this farm will primarily be utilized to produce algae biomass and bioethanol from both natural and genetically modified algae strains. Algae biomass is used as a replacement for soybean meal in feed for livestock and fish. This production process will also yield algae lipids which can be used to make biodiesel and certain biochemicals, among other compounds.

The JV, “ALGAS DO BRASIL,” will make use of JB's extensive commercial contact network to enhance SEE ALGAE marketing efforts. ALGAS DO BRASIL will be 63% owned by SEE ALGAE and 37% owned by GRUPO JB.



## SAT in Vienna, Austria and in Recife, Brazil

Algae can change their metabolism rather quickly from autotrophic to heterotrophic growth. The changeover can be made easier and faster by going through a transition stage which sharply reduces light and CO<sub>2</sub> supply and at the same time offers high quantities of an alternative carbon carrier – MIXOTROPHIC GROWTH

Scientific research has shown that this conversion stage results in a 3 to 10 times increased growth rate compared to normal autotrophic growth. SAT keeps the algae in this stage only for a very short period. This enables SAT to harvest the growth boost of this phase without becoming entangled into the contamination problems from the increasingly heterotrophic nature of this process. SAT algae density at end of growth stage is approx. >15 grams/ liter.

SAT together with KEMIRA has developed a special flocculation process to pre-concentrate the algae at a density of up to 80 grams/liter.

**necton**

**Necton, S.A.**

Olhão, Portugal

Started: 1997

Size: 0.25 ha / 20 m<sup>3</sup>

Investment: 300 K€

[www.necton.pt](http://www.necton.pt)



# Necton in Belamandil, Olhão, Portugal



Necton, Companhia Portuguesa de Culturas Marinhas, S.A., was established in 1997 and develops its activities in the marine biotechnology field - having specialized in the production and marketing of traditional sea salt and microalgae. Its headquarters and production units are located in Belamandil in the Natural Park of Ria Formosa, in Olhão, Portugal. In the business area of salt the company currently counts on a production area of over 23 ha of salt evaporation pond. In the microalgae business area, several production photobioreactors are studied and developed at the site. Necton has also in its facilities laboratories that provide technical support to the activities developed. Necton's team currently has around 30 employees.

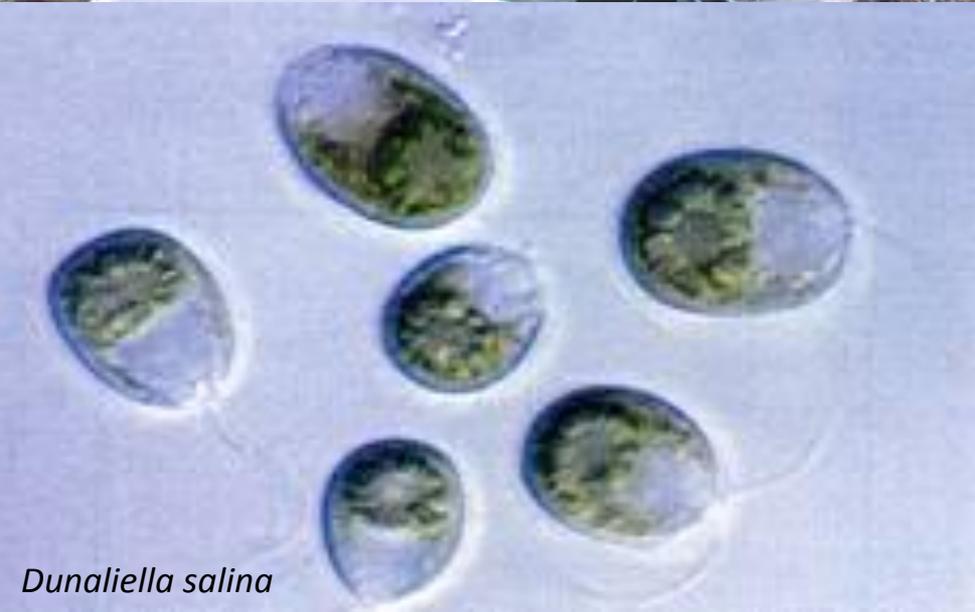


## Necton in Belamandil, Olhão, Portugal

necton



Raceways (1992 to 1997)



*Dunaliella salina*

The company started with a research programme initiated in the College of Biotechnology, Portuguese Catholic **University** in Porto in March **1989**. The initial objective was the scale-up for beta-carotene production using *Dunaliella* microalgae with large-scale production using raceways.

A pilot plant was established in **Belamandil**, Algarve, south of Portugal in 1992 to test the knowledge developed in lab and prototype scale.

The business activity with production and sales started in **September 1997**. The phytobloom range of products was developed and sold at the European level for cod, seabream and other aquaculture hatcheries.

The microalgae production facility is located in a 14 ha salt marsh.



Necton in Belamandil,  
Olhão, Portugal

necto



*Porphyridium*



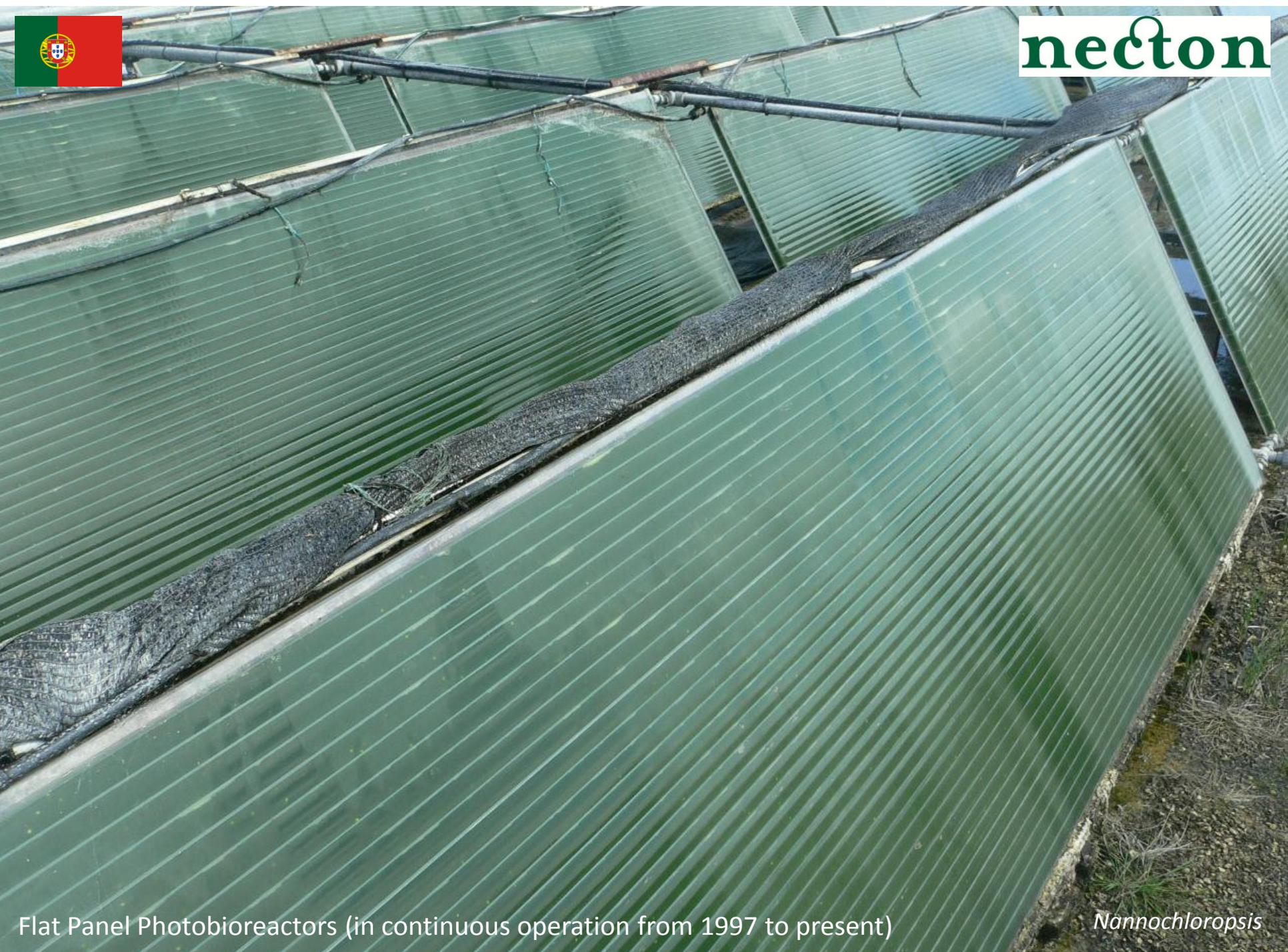
*Nannochloropsis*



*Phaeodactylum*



*Haematococcus*



Flat Panel Photobioreactors (in continuous operation from 1997 to present)

*Nannochloropsis*



## Necton in Belamandil - Olhão, Portugal



*Nannochloropsis*

Tubular photobioreactors designed and built by Necton are in continuous operation everyday, every year since **2005** to present. Several microalgae are grown in this PBR and harvested with a centrifuge.



## Necton in Belamandil, Olhão, Portugal

necton

Phytobloom is a set of microalgae products and formulations for aquaculture hatcheries.

phyto  
bloom

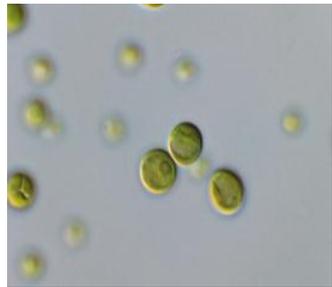


Necton S.A.  
Olhão , Portugal

GreenWall Panel technology licenced from F&M, Italy is used for inoculum production and small scale growth of microalgae that 'prefer' air lift reactors. The GWP as well as the Flat Plate and Tubular photobioreactors are used outdoors all the year round. The first GWP were built during the Summer **2007**. A wide range of microalgae have been grown using this reactors.



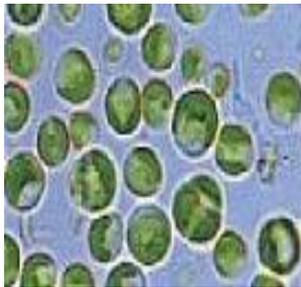
# Necton in Belamandil - Olhão, Portugal



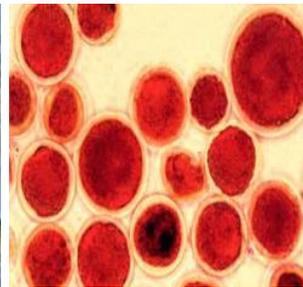
*Chlorella*



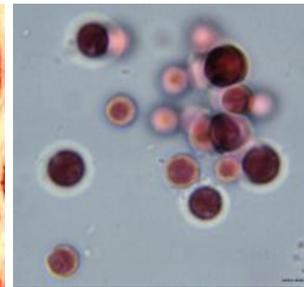
*Phaeodactylum*



*Nannochloropsis*



*Haemotococcus*



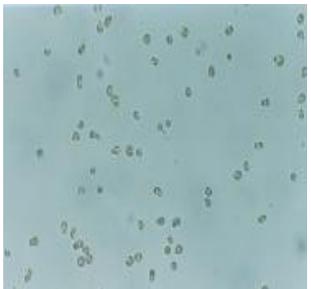
*Porphyridium*



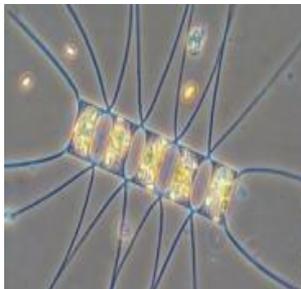
*Dunaliella*



*Isochrysis*



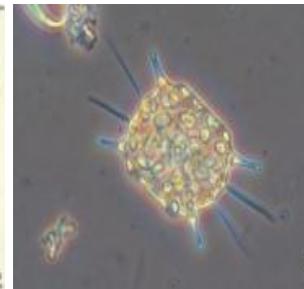
*Pavlova*



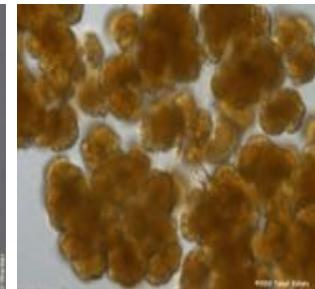
*Chaetoceros*



*Neochloris*



*Odontella*



*Botryococcus*



**Necton** is a company with an extensive R&D curriculum that brings a unique knowledge and experience in the industrial production of microalgae using several production technologies – for the cultivation of more than 12 microalgae genera.

**Astaxa**

Milz, Germany

Started:

Size: 85 m<sup>3</sup> reactor from IGV

Investment:

[www.algae-biotech.com](http://www.algae-biotech.com)





## **Astaxa, GmbH in Milz, Germany**

Microalgal Biotechnology -  
Growing the world's healthiest microalgae

Microalgae-Products

They deliver fresh (chilled to 4°C) or frozen (-20°C) microalgae biomass of different genera.

They also grow other algae on request (contract production).





**Astaxa, GmbH in Milz, Germany**



### ***Nannochloropsis***

green small sized microalgae of 2-5  $\mu\text{m}$  in diameter

source of PUFAs and vitamins

contains valuable proteins and carotenoids

excellent choice for growing zooplankton (e.g. rotifers) and for green water technique

14% dry matter (140 g/L)

### ***Tetraselmis***

green medium sized microalgae of 10-14  $\mu\text{m}$  in diameter

very high lipid level

source of PUFAs (EPA, C20:5) and vitamins

18% dry matter (180 g/L)

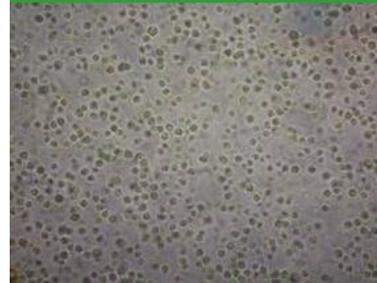
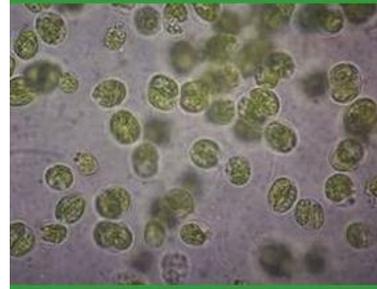
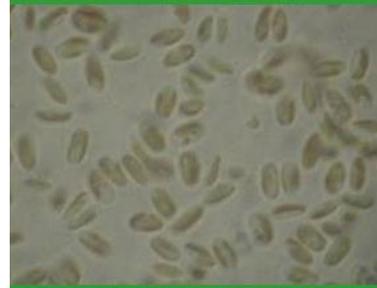
### ***Phaeodactylum***

marine diatom

high contents of w-3 fatty acids (EPA, C20:5 and DHA, C22:6)

10% dry matter (100 g/L)

Products have been developed in years of scientific research together with their partner, IGV GmbH – a private leading-edge institute in algae research.





# Fitoplancton Marino

Cadiz, Spain

Started: 2002

Size: 0.6 ha

Investment: 3 M €

[www.algae-biotech.com](http://www.algae-biotech.com)



# Fitoplancton Marino in El Puerto de Santa Maria, Cádiz, Spain



Fitoplancton Marino is a company specialized in microalgae production systems, conservation systems and nutrition. Fitoplancton Marino has clients in aquaculture, aquarium and cosmetic markets, guaranteeing the highest standards in quality and experience.



They developed an unique microalgae production system based on photobioreactors. This patented system consists of a number of outdoor closed photobioreactor. These closed photobioreactors prevent any type of contaminants entering the system and in this way they provide high quality microalgae. The systems are monitored and automated, which avoids direct manipulation during harvesting and reduces contamination risks.



# Fitoplancton Marino in El Puerto de Santa Maria, Cádiz, Spain



Fitoplancton Marino is a company dedicated to microalgae production since 2002. Since its inception the company has invested 3 million € in the project. The company received the Innovative Initiative Award 2007 of Agriculture and Fisheries counseling Andalucía

Fitoplancton Marino, SL has a project running in two phases: a first take 5700 meters square of land and a second with 4,700 square meters and a staff of 4 technicians and 11 operators.



<p>» <b>aquaculture</b></p> <p>HIGHEST QUALITY FOR FISH LARVAE</p> 	<p>» <b>aquarium</b></p> <p>COLOUR and HEALTH</p> 	<p>» <b>cosmetics</b></p> <p>THE ALTERNATIVE TO MAKE THE DIFFERENCE</p> 
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Arriba: vista de las instalaciones de Fitoplancton Marino.

<-- Izq. Uno de los circuitos dañados el pasado martes.

Carlos Unamunzaga, director gerente  
Dársena Comercial S/N (Muelle Pesquero)  
11500 El Puerto de Santa María - Cádiz – ESPAÑA  
Tel. (+34) 956 561 079 • Fax: (+34) 956 561 079  
E-mail: [info@easyalgae.com](mailto:info@easyalgae.com)



## AlgaEnergy

Almeria, Spain

Started: 2003

Size: 0.6 ha

Investment: 3 M€

[www.algaenergy.es](http://www.algaenergy.es)



## Algaenergy in Almeria, Spain



ALGAENERGY is a technology-based company specialized in the field of microalgae biotechnology which, with substantial R&D programmes costing millions of Euros (both public and in-house funding), is managed by a team of entrepreneurs and scientists with solid financial backing and extensive experience within this field.

The company's mission is to develop novel products derived from microalgae - nutritional, cosmetics and energetic, among others - and to produce them in an economically viable way.

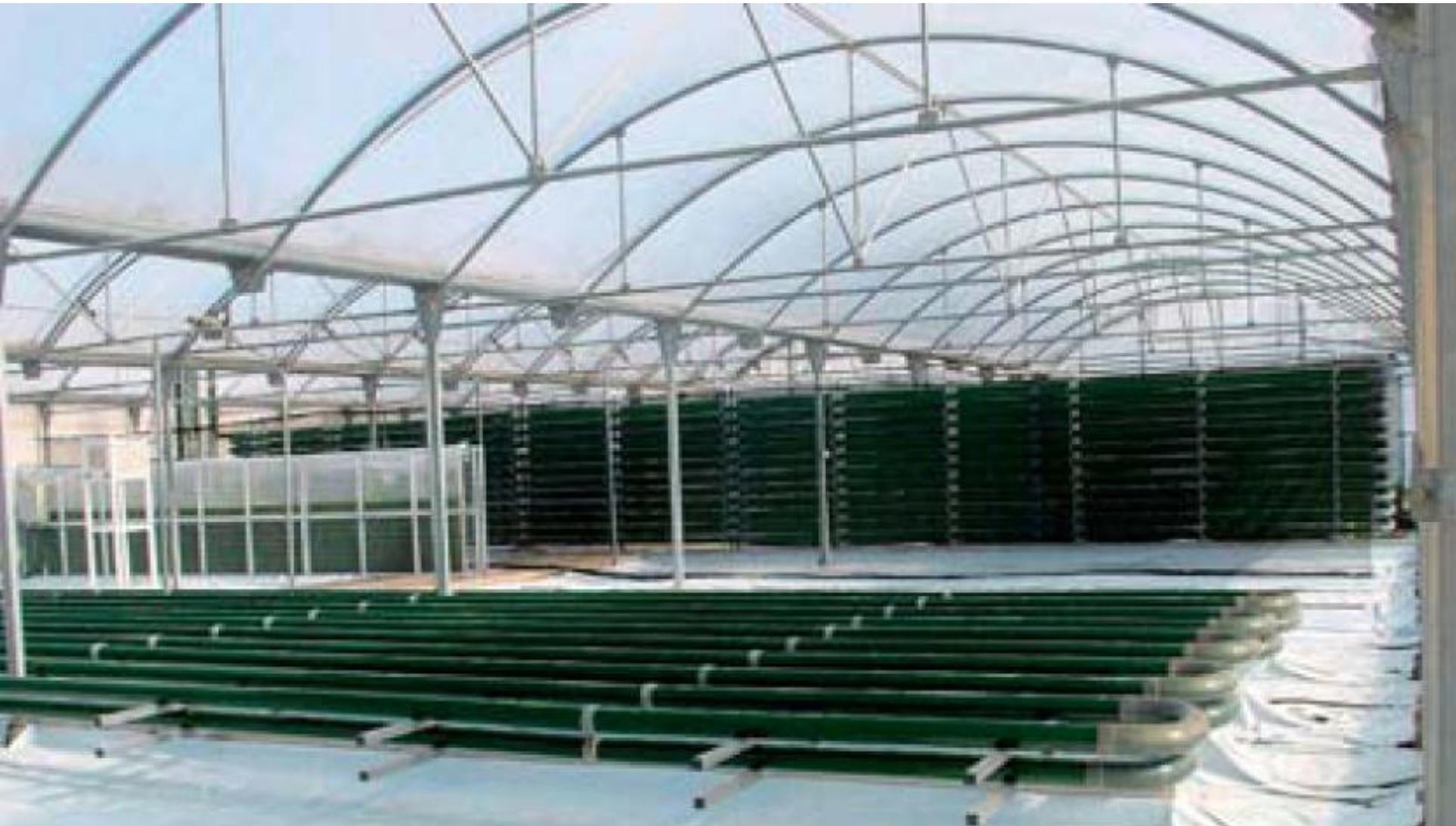
One of the world's largest utilities and the leading player in the global renewable energy sector, IBERDROLA, and a global energy company and one of the world's largest private oil companies, REPSOL, are shareholders and technology partners of ALGAENERGY. Professor Miguel Garcia Guerrero is the chief scientific advisor and board member of the Company.



## Algaenergy in Almeria, Spain



ALGAENERGY Foundation has agreed to exclusively CAJAMAR exploitation of existing production photobioreactor dedicated to the cultivation of microalgae plant "the Palmerillas" located in Almeria





## Algaenergy in Almeria, Spain



ALGAENERGY has an operating agreement with the CAJAMAR Foundation to exclusively exploit their microalgae cultivation plant at Las Palmerillas, located in Almeria.

At Las Palmerillas, ALGAENERGY has developed research programmes in conjunction with the universities of Almeria and Santiago de Compostela and it has also allocated resources for the installation at the Plant of suitable culture processes aimed at the aquaculture and animal feed sectors. Ever since the first phase of this Plant was completed in **2003**, they have been able to ensure the attainment of a superior quality algal biomass, as a direct result of the know-how acquired, the availability of a fully monitored system, the continuous production in a closed circuit system, its proven performance and the accumulated expertise.



### Reactor:

Volume=4.0 m<sup>3</sup>

Self-cleaning system

pH control by CO<sub>2</sub> injection

Temp. Control: recirculating water from pool

Liquid velocity=0.3 m/s

### External loop:

Length=400 m

Diameter=0.1 m

Polymetilmetacrilate

Single loop, two levels

Distance between tubes= 0.3 m

Area occupied=81 m<sup>2</sup>(18x4.5)

### Airlift:

Diameter=0.30 m

Height=3.5 m

Tubular heat exchanger

Air flow=0-500 L/min



The PBR technologies provided by the University of Almeria (Prof. Emilio Molina)

**ENN**



**Hebei Province, China**

**Started: 2009**

**Size: 10 m<sup>3</sup>**

**Investment:**

**[www.enn.cn](http://www.enn.cn)**



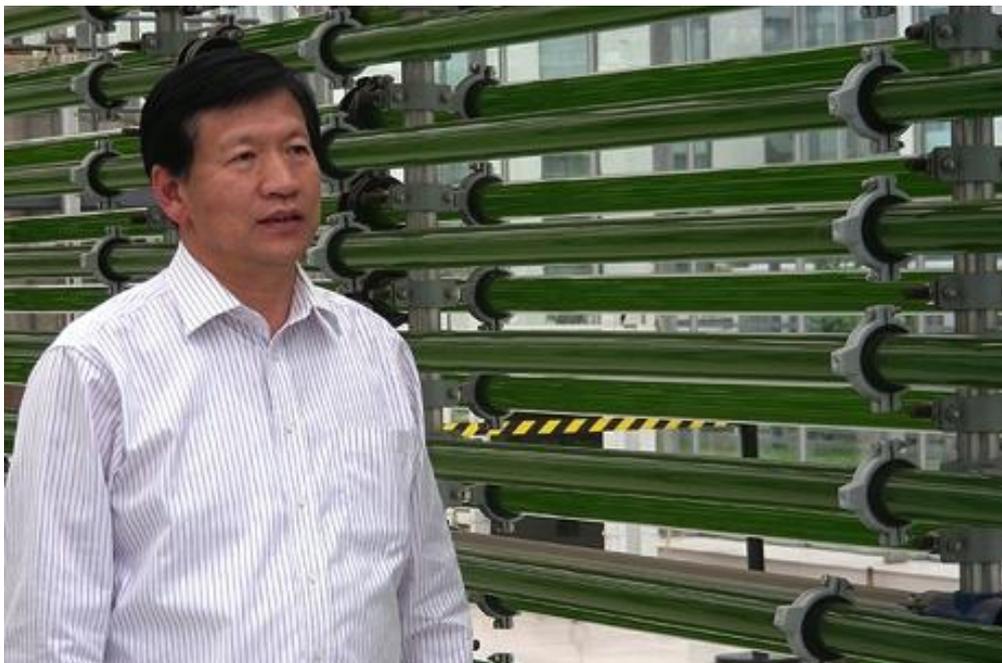
## ENN innovation park in Langfang, Hebei Province, China



2009

### ENN Science and Technology Development Co., Ltd.

ENN is a fast-growing Chinese energy company. The 24,000 employee, 4 US billion company, is heavily involved in the energy business and developing technology to pass carbon dioxide through algae to help reduce China's greenhouse gas emissions from their coal power plants that currently provide 70% of the electrical energy needs of the country.





## ENN innovation park in Langfang, Hebei Province, China



Founded in 2006, ENN Research & Development Co., Ltd. is a technology innovation platform and profession technology research institution of ENN Group, which is devoted to providing technology support for the sustainable development of ENN's clean energy strategy. Relying on its international R&D and management team, the company strives to make breakthroughs in energy saving and emission reduction and CO2 recycling technology by integrating science & technology resources both in China and abroad.



## ENN innovation park in Langfang, Hebei Province, China



### UNDER EVALUATION:

For the 100 hectare test facility, ENN is looking at sites near the company's 600,000 tonne-a-year coal mine in Ordos, Inner Mongolia, where the cold winters will require a heated greenhouse, and a location on Hainan Island, where the hot weather would allow the algae to be grown more cheaply in open ponds, but further away from China's main coal deposits.

At ENN's research campus in Langfang, an hour's drive from Beijing, scientists are testing microalgae to clean up the back-end of a uniquely integrated process to extract and use coal more efficiently and cleanly than is possible today.



## **Microphyt**

**Montpellier, France**

**Size: 5 m<sup>3</sup>**

**Started: 2007 – oper. 2009**

**Investment: 2-3 M€**

**[www.microphyt.eu](http://www.microphyt.eu)**

## La rupture

Les photobioréacteurs de Microphyt mettent en œuvre un concept de rupture qui va permettre d'étendre considérablement le champ des applications des microalgues en sécurisant leur ...

Microphyt was established in 2007 near Montpellier, France to industrialize the production of biomass of microalgae species of economic interest. For this purpose, an innovative concept and generic photobioreactor was developed. This concept allows to secure the supply of species difficult to grow because fragile and / or slow growth. Based on this concept, Microphyt develops new technologies for the production of microalgae adapted to different needs and sites, with production at low prices for major world markets as an objective.



## Microphyt in Baillargues, Montpellier, France



The company cultivated organisms in a 5,000 litre photobioreactor (built in a greenhouse with the potential to house ten similar machines) that has been operational since December 2009.

Microphyt society, founded in 2007, produced industrially pure stabilized biomass and microalgae species fragile and slow growth. It delivered its first commercial production in early 2010, and just completed his first command, thus validating the economic and technological choices.

Microphyt  
[www.microphyt.eu](http://www.microphyt.eu)  
713 Route de Mudaison  
Baillargues 34670 France





## Microphyt in Baillargues, Montpellier, France



The company has filed Microphyt in partnership with a Swiss company, the ALP (Artificial Light photobioreactor) project within the European funding program Eurostars. The project intends to develop an industrial photobioreactor modular system of 150 L units, with artificial light, producing preparative quantities (50 g of dry matter per day per module) of microalgae with complete control of the parameters influencing growth and quality. For this, the device implements the technology of horizontal co-fluid circulation that has been patented and validated by Microphyt for its industrial units (photo).



## Microphyt in Baillargues, Montpellier, France



Microphyt produces an average of more than one kilogram of dry biomass of microalgae per day.

To achieve its goals, it operates a photobioreactor installed in a greenhouse climate. The set does not take up much floor space: fifty meters long and one meter wide. The device consists of a long glass tube which winds upwards about three meters high, wherein the tube passes back and forth repeatedly enriched water. A reactor can contain 5000 liters of liquid.

The greenhouse itself has mechanisms to maintain a steady temperature around 30 degrees. The device has been the subject of a patent.

The invention of this process allows Microphyt to improve the volume, performance, diversity and quality production of microalgae.

## **Algaetech**

**Kuala Lumpur, Malaysia**

**Size: 2 ha, 500 m<sup>3</sup>**

**Started: 2007**

**Investment:**

**[www.algaetechint.com](http://www.algaetechint.com)**



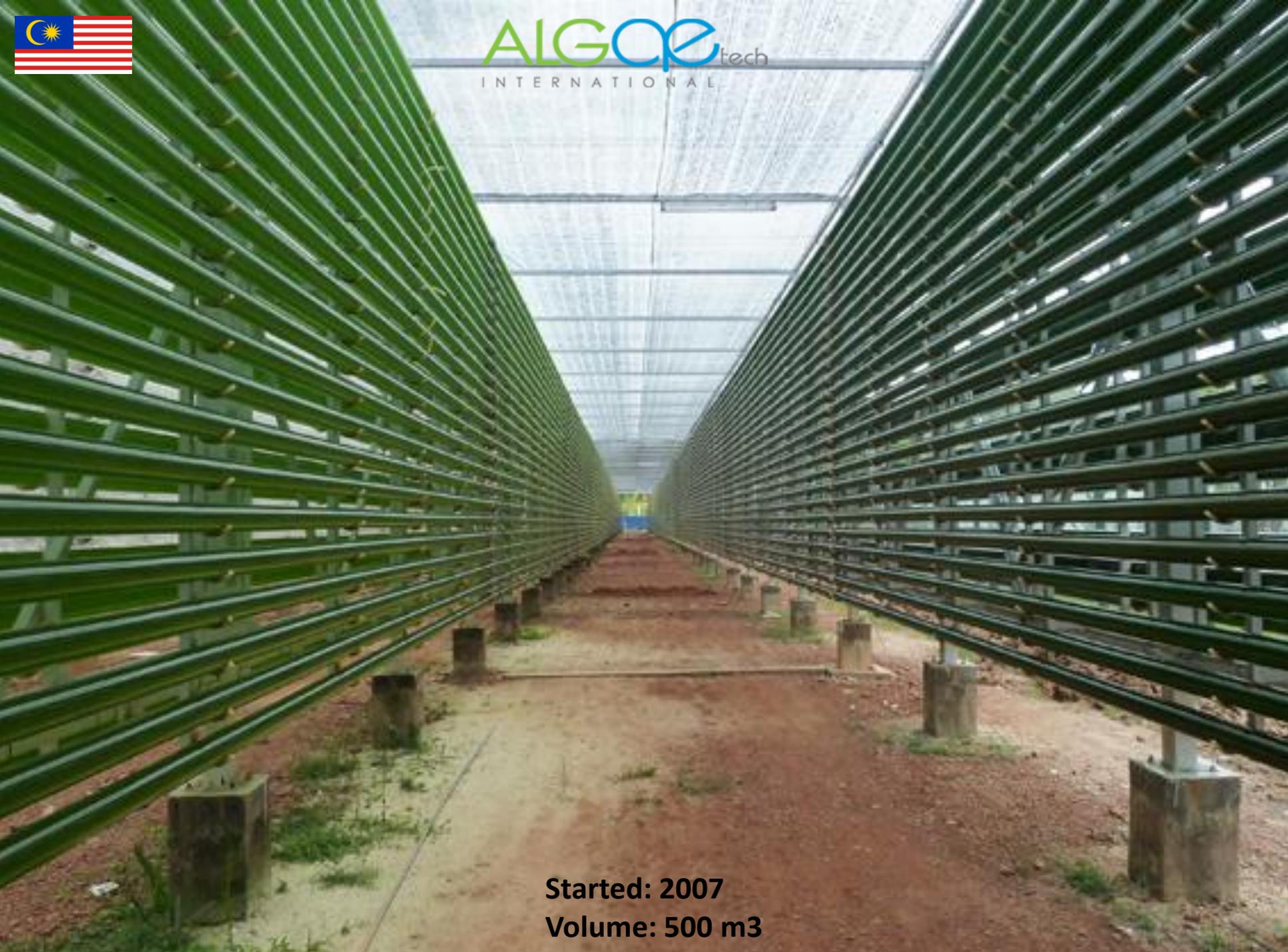
## Algaetech Group in Kuala Lumpur, Malaysia



Algaetech Group entered into the field of microalgal research, development and consultancy as well as production and marketing of renewable energy and high value products since 2004. Algae Integrated Management System (AIMsys) is a combination of closed photobioreactor and open pond systems for cultivation of microalgae.

Algaetech Group possesses an advanced research laboratory situated in the premises of Technology Park Malaysia. At the TPM premises they also grow microalgae in large scale raceway ponds and a model photobioreactor (PBR) system. The raceway pond is an open system with total capacity of 12.686 L, whereas PBR is a closed system with total capacity of 600 L.

The PBR technology was provided by Varicon Aqua, UK – supplier of Biofence systems for Aquaculture



**Started: 2007**  
**Volume: 500 m3**



**Started: 2007**  
**Volume: 500 m<sup>3</sup>**



They had completed a R&D and cultivation of microalgae for production of biodiesel in year 2007 and now they are in the stage to commercialize this algae biofuel. They have also successfully created and developed a huge algae farm in Indonesia for primary production of biodiesel and feedstock. This algae plant is using photobioreactors, and the capacity is 500,000 liter. Technology provided by Varicon Aqua, UK.

**BTM**

**Cadiz, Spain**

**Started:**

**Size: 2.4 ha / 100 m<sup>3</sup>**

**Investment: 10 M€**

**[www.aurantia.es](http://www.aurantia.es)**





## BTM in Cadiz, Spain



**Aurantia / BTME / Exeleria**

Spain, Cadiz

[www.aurantia.es](http://www.aurantia.es)

Surface: 2,4 ha

Vol. 100 m<sup>3</sup>



**BTM in Cadiz, Spain**



# BTM in Cadiz, Spain



**btm**  
biotecnología de microalgas



## **Salata AG**

**Ritchenhausen, Germany**

**Started: 2006**

**Size: 0.2 ha / 85 m<sup>3</sup>**

**[www.salata.de](http://www.salata.de)**

**Investment: 1.5 M€**

15 m<sup>3</sup> PBR for 500 m<sup>2</sup> for approx 200.000 k



## Salata AG in Ritzenhausen, Germany



Salata GmbH is broadly positioned in the processing and production of food and diversified into three divisions: (1) Processing of herbs and dried foods, (2) Processing of pre-cooked legumes, and (3) Production of microalgae in photobioreactors.

In 2005 Salata GmbH GmbH expanded to an innovative new business: the cultivation of micro algae. On the basis of existing experience in horticultural production, the use of waste heat from the legume processing and existing certifications, infrastructure, this new division was successfully established quickly.

The PBR technologies provided by IGV, Germany.



## Salata AG in Ritschenhausen, Germany



Today the Salata GmbH operates on about 2,000 sqm of the world's closed microalgae culture systems, with 40,000 m glass tubes and 85,000 litre cultivation volume. Their products are currently sold mainly to the cosmetics industry. Future applications include the production of polyunsaturated omega-3 fatty acids and further processing to high-quality nutritional supplements.

Important partner in scientific research includes the IGV GmbH, which is the applied research and development in the consolidated company profile and implemented in cooperation with international partners on the market.

**SALATA AG,  
Ritschenhausen, Germany,  
operating since 2006  
15, 25 and 45 m<sup>3</sup> PBRs**



**LGem**

**The Netherlands**

**Started: 2007**

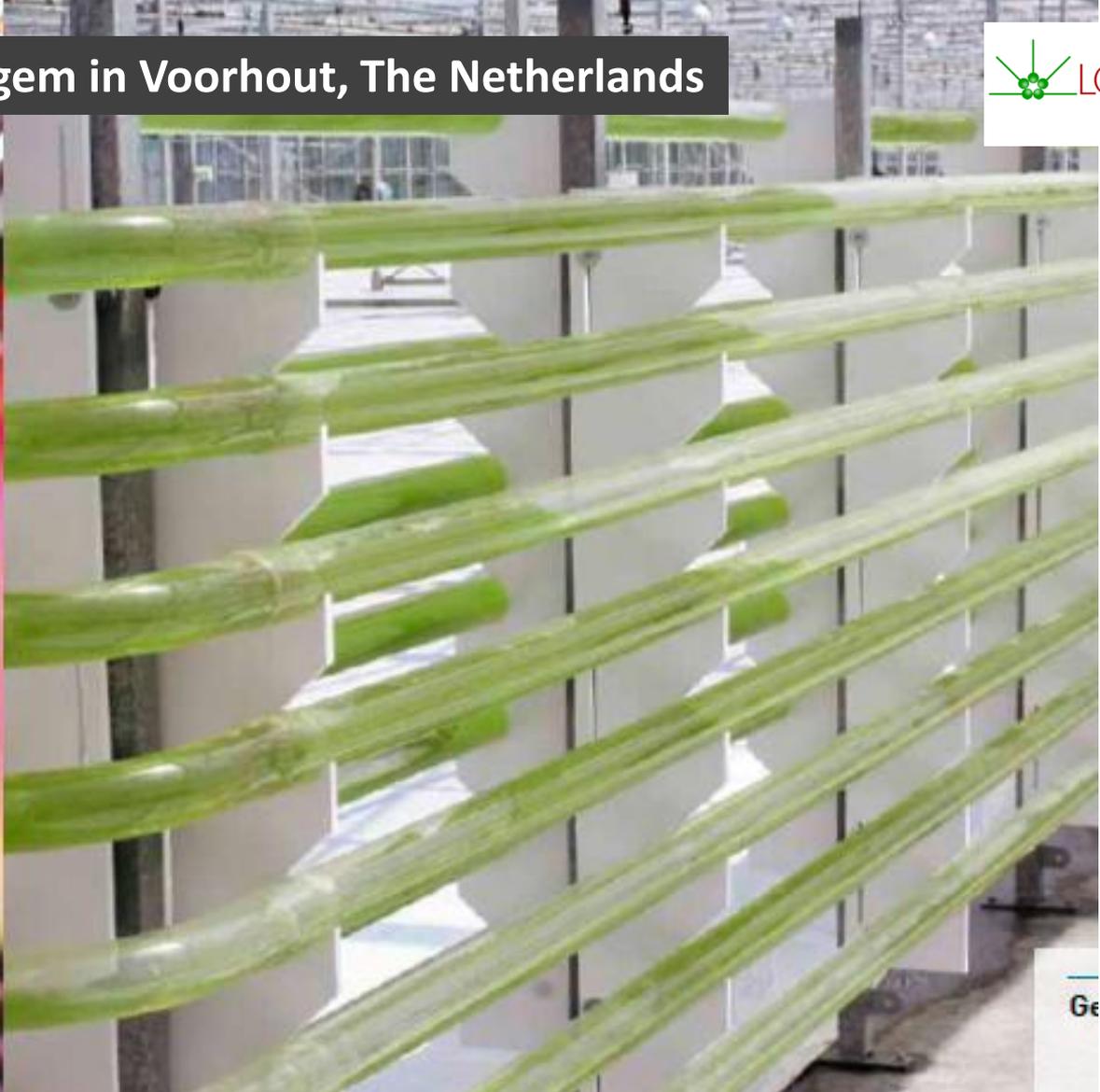
**Size: 260 m<sup>3</sup>**

**Investment: 1.8 M€**

**[www.lgem.nl](http://www.lgem.nl)**



## Lgem in Voorhout, The Netherlands



LGem is the first Dutch company to use closed photobioreactors to produce microalgae on a commercial scale. Since 2007 freeze-dried algae powder has been produced and sold all over the world as a food supplement. In 2009, GF Piping Systems joined the development team, introducing new components. As a result of this fruitful collaboration, the tubular PBR has evolved into a cleverly designed system, with low operating costs.

## Why using tubular photobioreactors (PBR)?

- It is a closed system for a high hygienic level and biomass product quality;
- Effective illumination for higher yield of biomass compared to open ponds;
- Ideal for research and development;
- Lower operating costs and reduced carbon footprint;
- Proven commercial value on an economic scale;
- Relatively easy to scale to large production farms.



## Lgem in Voorhout, The Netherlands



GemTube RD1-250

PBR-type	RD 1 – 250	MK1-750	MK1-18,000	MK1 - 1 Ha
Req.floorspace	4 x 1,2 m	18 x 1,2 m	125 x 4 m	100 x 100 m
Total tube length	84 m	250 m	6 km	120 km
Total volume	250 L	750 L	18 m <sup>3</sup>	360 m <sup>3</sup>
Liquid volume	160 - 200 L	500 – 600 L	13 - 15 m <sup>3</sup>	250 - 260 m <sup>3</sup>
Volumetric Productivity*	0.2 – 0.6 g.dw/L.day			
Areal Productivity*	15-45 MT/ha.y (1.5-4.5 kg.dw/m <sup>2</sup> .y)			
<b>Price</b>	<b>€ 30.000</b>	<b>€ 25.000</b>	<b>€ 180.000</b>	<b>€ 1.800.000</b>

All piping components of the PBR system products, ensuring highest possible quality for growing various algae strains. Essential elements have been patented.



**Solix**

**Colorado, USA**

**Started: 2009**

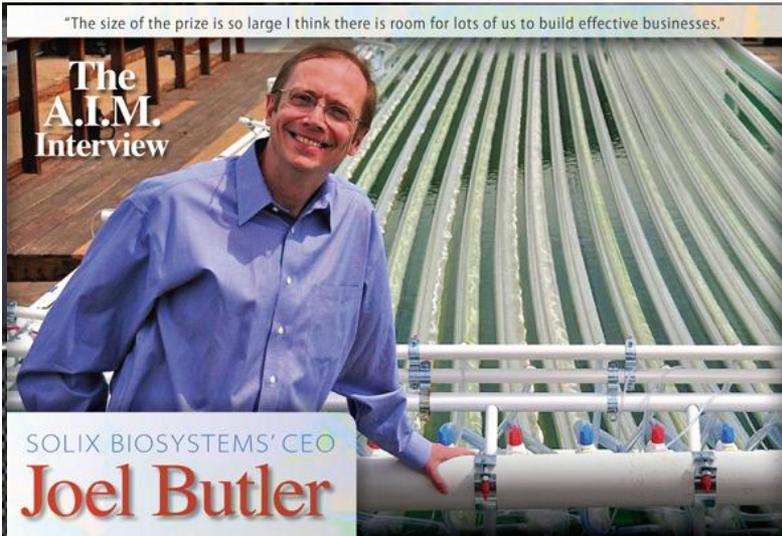
**Size: 150 m<sup>3</sup> – 0.3 ha**

**Investment: 10 M US\$**

**[www.solixbiofuels.com](http://www.solixbiofuels.com)**



# Solix Inc in Fort Colins, Colorado, USA



Solix began in 2009 operating its Lumian technology by more than 15 x per basin, going from a 4000 liter cultivation scale to over 50,000 liters per basin.





# Solix Inc in Fort Collins, Colorado, USA





# Solix Inc in Fort Colins, Colorado, USA



Coyote Gulch AGSTM Demonstration Plant is the first of its kind anywhere in the world. It is located in southwestern Colorado near the city of Durango on land provided by Solix partner the Southern Ute Alternative Energy Fund. It has three algae cultivation basins totaling 3/4 of an acre (0.3 hectares). The plant has over 150,000 liters of algae under cultivation.



**Exenia Group**

**Padova, Italy**

**Started: 1995**

**Size: 0.1 ha**

**Investment:**

**[www.exeniagroup.it](http://www.exeniagroup.it)**

The company Exenia Group Srl was founded in November 1995. The company covers a total area of 1000 m<sup>2</sup> of which 600 are covered. The space reserved for laboratories is about 400 m<sup>2</sup>, distinguishing between pilot plants (350 m<sup>2</sup>) and unit of analysis for quality control and product certification.



It's FITOPLAN system resulted to be particularly effective for the cultivation of photosynthetic microalgae such as *Nannochloropsis* spp., *Phaeodactylum* spp., *Chlorella* spp., *Tetraselmis* spp., *Pavlova* spp., *Isochrysis* spp, *Thalassiosira* spp. and other species, obtaining variable daily productivities, depending on the strain, between 0.3 and 0.5 g l<sup>-1</sup> d<sup>-1</sup>. The first FITOPLAN system was set up in 1996.

Exenia Group S.r.l.  
Via Leonino da Zara, 13  
35020 - Albignasego (PD)  
[www.exeniagroup.it](http://www.exeniagroup.it)

The Company Separeco Srl was founded in 2005 by a group of people with experience in environmentally friendly processes that use CO<sub>2</sub> as a solvent and in the cultivation of photosynthetic microorganisms. Separeco builds plants using fluids in supercritical state for the extraction processes from vegetable and manufactures industrial applications in the field of biotech and microbiology. In order to develop core technologies for which it is addressed, Separeco has units devoted to engineering and process development and production of natural products from plant matrices.



Along the years Separeco distributed numerous microalgae production plants to utilize in the fish farms producing gilthead. These systems have been optimized for the production of two particular species of microalgae, universally utilized in this field: *Nannochloropsis* and *Isochrysis*.

## **EEM & BFS**

**Madeira, Portugal**

**Started: 2011**

**Size: 600 m<sup>3</sup>**

**Investment: 48 M€**

**[www.biopetroleo.com](http://www.biopetroleo.com)**





# EEM & BFS in Porto Santo, Madeira, Portugal





# EEM & BFS in Porto Santo, Madeira, Portugal



600 m<sup>3</sup> = 132.000 gallons

EEM & BFS - Energy, S.A. Portugal (Porto Santo). 600 m<sup>3</sup> with 600 reactors  
investment of 48.024.208,15 €, with a support from the European Commission of 15.264.072,40 €



**EEM & BFS in Porto Santo, Madeira, Portugal**

[www.biopetroleo.com](http://www.biopetroleo.com)

**CleanEnergy**



**Chile**

**Started: 2012**

**Size:**

**Investment:**

**[www.cleanenergy.com](http://www.cleanenergy.com)**



Inauguration of the pilot plant 2012-08-16 1:49:08



Clean Energy SA is a company dedicated to developing and Energy Business Projects, using the most modern concepts of eco-sustainable biotechnology for the integrated production of microalgae biomass, biofuels of second generation (2G) and high-value compounds simultaneously with the capture of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases (GHG).



**CleanEnergy in Chile**

The system generates as a byproduct biomass of microalgae, which has great potential for reuse in various applications, among which are: extraction of functional compounds (DHA, EPA, Omega 3, Omega 6) and antioxidants, energy potential recovery by burning directly, among others. The system ensures constant production throughout the year.





CleanEnergy in Chile





**CleanEnergy in Chile**



## CleanEnergy in Chile



Permanently Clean Energy has sought to improve its processes, and increase skills and capabilities through strategic alliances and partnerships with the Laboratory for Energy and Geology of Portugal, Germany's Fraunhofer Institute, Universidad Complutense de Madrid, Catholic University of Valparaiso, among others, who have experience and prestige in the field of bioenergy and development of biorefineries for sustainable diversification of new sources of biomass, as well as the development of biocomposites beneficial to human and animal health.



Instituto Fraunhofer de  
Alemania



Laboratorio de Energía y  
Geología de Portugal



Pontificia Universidad  
Católica de Valparaíso





Energy Algae Group

## Qibebt

Pingdu – Qingdao, China

Started: 2009

Size: 0.2 ha

Investment: 5 MUS\$

[www.qibebt.cas.cn](http://www.qibebt.cas.cn)



2000 m2 Algae cultivation system



# QIBEBT in Pingdu – Qingdao, China



QIBEBT

Energy Algae Group



2011/05/16



Flotation Harvesting system



2011/08/31

# Plastic bags

**ALGAGEN**

**AlgaGen, LLC**

**Vero Beach, Florida**

**Started:**

**Size:**

**Investment:**

**[www.algagen.com](http://www.algagen.com)**



**AlgaGen, LLC in Vero Beach, Florida**

**ALGAGEN**

AlgaGen LLC. PO Box 1734. Vero Beach, FL 32961



**AlgaGen** LLC is a biotechnology company utilizing microalgae to develop new products for the human health, animal feed additives, aquaculture and aquarium industries. One of their goals is to produce and commercialize, anyone of a number of high value proteins and fine chemicals pertinent to target markets. Their immediate targets include the aquaculture, research and aquarium markets. Phase II targets include human health and animal nutrition products.

AlgaGen LLC has developed a unique culture production and management system. It utilizes an approach called ultra-high cell density culturing that leads to high quality, high yield and cost effective product. It is an intensive approach to culturing that is very efficient and functions as a platform technology, applicable to all future AlgaGen products.

AlgaGen LLC has been involved in a number of consulting operations that have increased production, increased quality and reduced labor. Current clients include Florida Institute of Technology, University of Miami, Shrimp Improvement System (Florida Keys), IboChem Natural Products, University of North Carolina Wilmington, the Oceanic Institute Kona Hawaii, Florida State University Marine Lab, and Southern Cross Sea Farms, Inc.

**Proviron**

**Belgium**

**Started: 2009**

**Size: 500 m<sup>2</sup> pilot / 175 reactors**

**Investment: 5 M€**

**[www.proviron.com](http://www.proviron.com)**



Proviron in Belgium

# Provifeed™ Nannochloropsis

A natural source of omega 3 fatty acids, antioxidants and vitamins

**Proviron**

Belgium

[www.proviron.com](http://www.proviron.com)

PoviAPT system

500 m<sup>2</sup> pilot / 175 reactors

*Nannochloropsis* and *Isochrysis*

“A human and ecological approach to chemistry”

[HOME](#) > [PRODUCT GROUPS](#) > [MICROALGAE](#) > [ALGAE FOR SALE](#)

# Algae for sale

[Check out our products](#)

In the short term, our production is mainly aimed at feed and aquaculture purposes as well as for scientific research. Future applications include food, chemicals, cosmetics and pharmaceuticals. After all, our ProviAPT photobioreactor produces algae in a closed environment under rigorously controlled conditions. Proviron currently offers *nannochloropsis* sp. and *isochrysis* sp. respectively renowned for their EPA and DHA content. The ProviAPT photobioreactor has also been proven to successfully host a variety of sensitive, recalcitrant species.

## **PROVIFEED™ ISOCHRYISIS**

A natural source of omega 3 fatty acids, antioxidants and vitamins ►

## **PROVIFEED™ NANNOCHLOROPSIS**

A natural source of omega 3 fatty acids, antioxidants and vitamins ►



**Archimede Ricerche Srl**

**Camporosso, Italy**

**Started:**

**Size: 0,1 (0,25 acre) 2 ton/year**

**Investment:**

**[www.archimedericerche.com](http://www.archimedericerche.com)**



## Archimede Ricerche Srl in Camporosso, Italy



Archimede Ricerche Srl, part of A&A Fratelli Parodi group (Genoa), is the first Italian company to run an industrial plant for microalgae biomass to be used in natural cosmetics (oils, pigments), in aquaculture and as food supplement (nutraceuticals). The company produces high quality biomass of different species such as *Nannochloropsis*, *Isochrysis*, *Tetraselmis* and *Chaetoceros*.

Archimede Ricerche Srl has developed not only an industrial photo-bioreactors system, but also an integrated and sustainable process: energy comes partly from sunlight, thanks to the algae photosynthetic function, and partly from the heat of an endothermic co-generative station, powered by vegetable oil.



# Archimede Ricerche Srl in Camporosso, Italy



**Archimede Ricerche**  
Italy, Camporosso  
[www.archimedericerche.com](http://www.archimedericerche.com)  
Surface: 0,1 (0,25 acre)  
Prod. Capacity 2 ton/year

**Novagreen**

**Germany**

**Started:**

**Size: 600 m<sup>2</sup> / 52 m<sup>3</sup>**

**Investment:**

**[www.novagreen-microalgae.com](http://www.novagreen-microalgae.com)**





## Novagreen in Germany



Projektmanagement GmbH

Novagreen is a developer and provider of novel bioreactors for the production of microalgae in a contained environment. It is also a producer of selected bulk microalgae and ingredients therefrom in these bioreactors for the food, cosmetic- and pharmaceutical industries. Novagreen's patented a production platform using a unique three-layer foil system (bag system) can be set up in nearly any standard greenhouse facility worldwide thus providing new cash crops for the agroindustry.

Novagreen provides products derived from a wide spectrum of microalgae like *Scenedesmus*, *Nannochloropsis*, *Spirulina* and others.



**NOVA Green - Project Management GmbH**  
49377 Vechta Langförden



Greenhouse in Bassum 2012 / after completion and before starting the reactors

Bassum greenhouses were built and piece by piece with microalgae production facilities equipped. Work on the integrated photovoltaic system, completed since 2011.

## BASSUM

INVESTMENT COSTS APPROXIMATELY € 10 MILLION.

Groundbreaking for algae farm Bassum in the construction of the biggest indoor breeding facility for high purity microalgae in Europe has begun.

Ten million euros invested a Berlin-based company, which already operates several algae farms in Germany. To be won over three tons of biomass from mid-September every day here.





Dreischtrom GmbH [www.dreischtrom.de](http://www.dreischtrom.de)



Future GmbH now [www.zukunftjetzt.eu](http://www.zukunftjetzt.eu)



Energy strategists GmbH [www.energiestrategen-gmbh.de](http://www.energiestrategen-gmbh.de)



Projektmanagement GmbH

Novagreen Project Management GmbH [www.novagreen-microalgae.com](http://www.novagreen-microalgae.com)



Schumann & Schumann GmbH [www.zwoschumann.com](http://www.zwoschumann.com)



## AHLHORN SOUTH

INVESTMENT COSTS APPROXIMATELY € 7.5 MILLION.

Ahlhorn south of an existing 2.5-acre greenhouse is converted and also equipped with photo-voltaic production plant and algae.

## LÜBESSE (MECKLENBURG VORPOMMERN)

INVESTMENT COSTS APPROXIMATELY € 13.4 MILLION.

In a commercial area in Lübesse a system is planned for microalgae production. It is planned to build 19,200 m<sup>2</sup> of greenhouses. The greenhouse roofs are also equipped with photovoltaic modules and the entire area will be heated by CHP.



**NovaGreen / RWE Power**

Germany

[www.novagreen-microalgae.com](http://www.novagreen-microalgae.com)

Surface: 600 m<sup>2</sup>

Vol. 52 m<sup>3</sup>



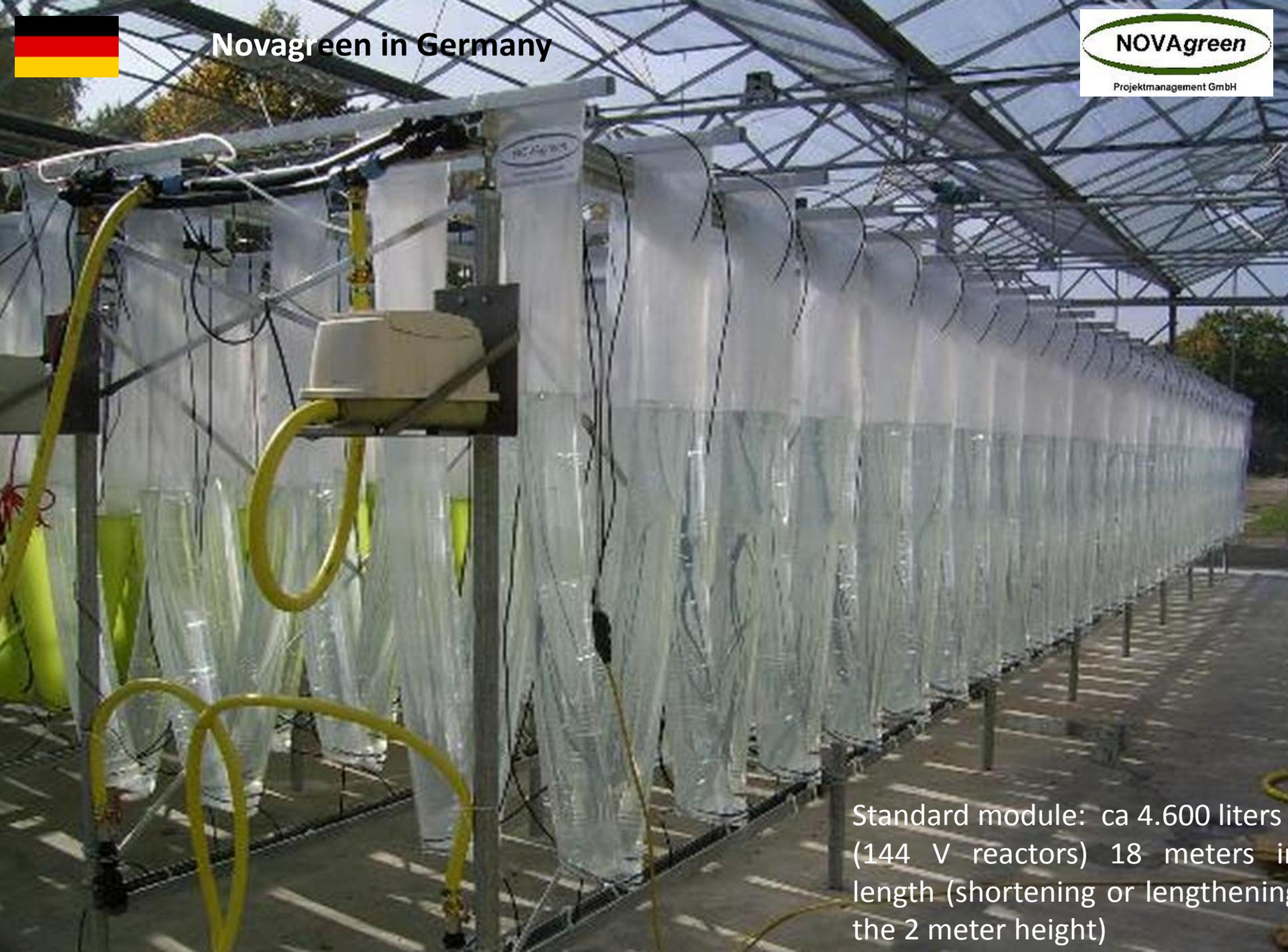
# Novagreen in Germany



Novagreen uses pre-existing, well established horticultural production systems, distribution and marketing channels. Novagreen is introducing production of microalgae as an integral part of modern horticulture.



# Novagreen in Germany



Standard module: ca 4.600 liters  
(144 V reactors) 18 meters in  
length (shortening or lengthening  
the 2 meter height)

**Phytolutions**

**Germany**

**Started: 2008**

**Size: 0.5 ha**

**Investment: 0.7 M€**

**[www.phytolutions.com](http://www.phytolutions.com)**





## Phytolutions in Bremen, Germany



700,000 euro project

In a small pilot plant near Cologne in Niederaussem the algae processing of a coal power plant of the RWE energy group operates since 2008.





**Algaecom**

**Groningen, The Netherlands**

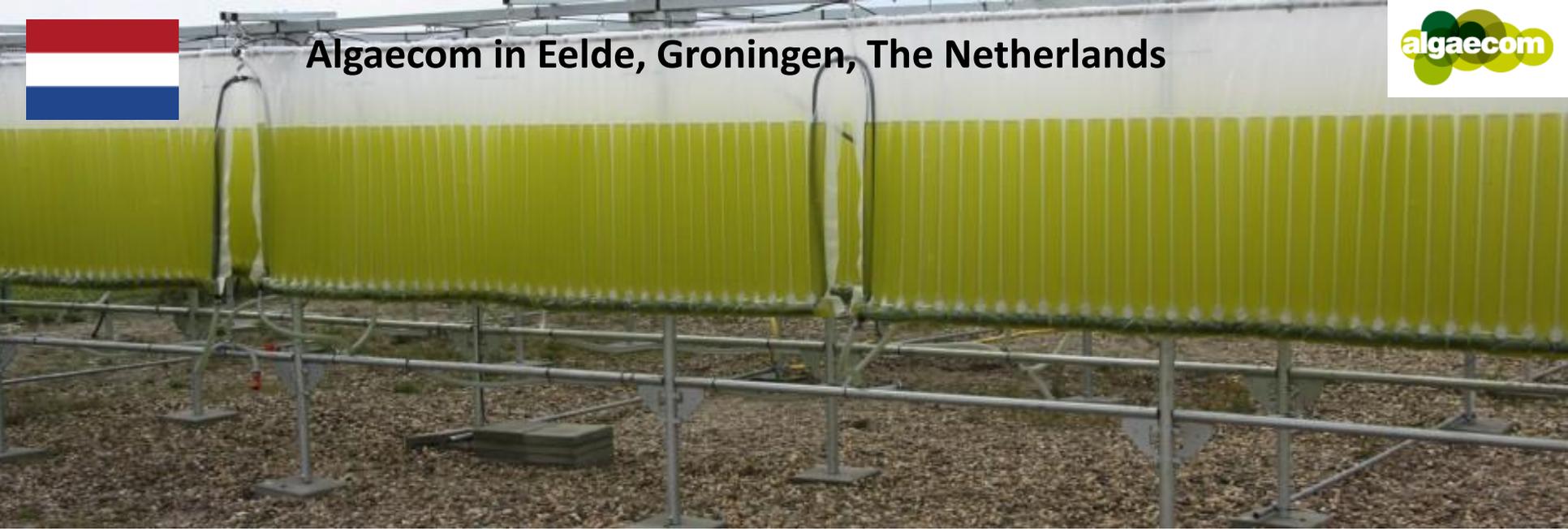
**Started: 2010**

**Size: 0.5 ha**

**Investment: 2 M€**

**[www.algaecom.nl](http://www.algaecom.nl)**

## Algaecom in Eelde, Groningen, The Netherlands



Algaecom develops algae production sites, using residual waste and heat streams. With those inputs only sunlight is required to let the photosynthetic process flow. In this way they are developing an industrial method of renewable biomass production.

Algaecom develops, builds and operates algal production sites that meet these important requirements. The ambition of Algaecom is to operate production sites of 2 to 5 hectares, using residual heat and CO<sub>2</sub> from flue gases produced by host companies. The founders of Algaecom are Dr. Monique Schoondorp and Bert Knol.



Algaecom. Hoofdweg 101. 9761 EC Eelde. [info@algaecom.nl](mailto:info@algaecom.nl)



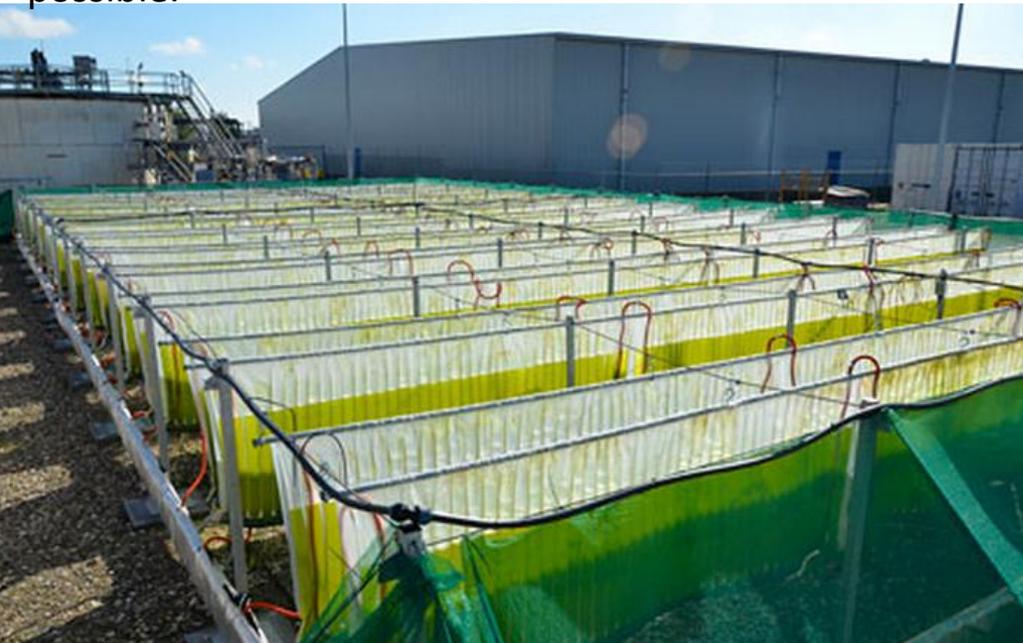
## Algaecom in Delfzijl, The Netherlands



One of the Algaecom production plants is located in Delfzijl. At the Zeolyst C.V. factory a production site of 240m<sup>2</sup> was started in the summer of 2011. To provide the carbon dioxide necessary for algal growth the flue gases are utilized. Furthermore, residual heat from Zeolyst C.V. is used in the winter season to enable a high productivity.

A second production plant is based in Hoogkerk. At the ICOPAL factory the flue gases are similarly used to provide carbon dioxide for algal growth. On this site the main goal is to separate the oil fraction from the algae produced. This oil is then used as a renewable raw material in the ICOPAL manufacture process.

A third production plant is under construction. The goal is to take the previous pilot production units and scale-up the by a factor 10 to an algal production area of approximately 2500 square meters. Integrated within the algae production is a scrubber to clean-up biogas from an anaerobic digester. Algaecom has developed its own low-cost growing system that makes growing algae in a closed system on a large scale possible.



## Seasalter Shellfish, Ltd

UK

Started:

Size:

Investment:

[www.seasaltershellfish.co.uk](http://www.seasaltershellfish.co.uk)



SeaCAPS



**Seasalter Shellfish, Ltd**

[www.seasaltershellfish.co.uk](http://www.seasaltershellfish.co.uk)

Managing Director, John Bayes, travelled in 2000 over 35,000 miles to evaluate the industry's need for top quality algal feeds. During that World tour he also spoke at NSA 2000, Seattle and FRDC Hatchery Feeds Workshop in Cairns, Queensland. What he learned along the way moved him to set up a new company, **Seasalter - Continuous Algal Production Systems Ltd** ("SeaCAPS ") to fulfil the need for providing systems and a consultancy service, not only for the more fortunate operators, but in areas where "angels might fear to tread."

SeaCAPS are world renowned for their innovative approach to economical Continuous Algal Production Systems. Technological advances developed over the past three decades with these systems along with customised hatchery designs have been installed at both **fish and shellfish farms in 16 countries**. Their training programmes, consultancy and after-sales back up service is most unique because it is supported by an exclusive hands-on operation.

**Reed Mariculture Inc.**

**California, USA**

**Started: 1995**

**Size:**

**Investment:**

**[www.reedmariculture.com](http://www.reedmariculture.com)**

# Reed Mariculture Inc

## Reed Mariculture in Sacramento, California, USA



**Reed Mariculture Inc. was founded in 1995** to grow "tank raised" bivalve shellfish. Reed Mariculture developed tank raised shellfish technology for three years and during this same time developed and refined the technology for large-scale grow out of marine microalgae, which is the feed for shellfish.

In **1998** RMI determined that there was a more lucrative market in selling the microalgae directly to other hatcheries and shut down all shellfish operations. RMI's core technology is a proprietary closed-system photobioreactor design that allows microalgae to be grown in laboratory sterile conditions.

In **2004** RMI entered the home aquarium market with the introduction of the Phyto-Feast products. Phyto-Feast is a super concentrate of marine microalgae formulated for feeding exotic filter feeders such as clams, corals, sponges, and tunicates that are popular in marine reef tanks.

In **2005** RMI expanded offerings into the Marine Ornamental industry with the Reef Nutrition product line. This product line includes marine microalgae, macroalgae, rotifers, copepods, mysid shrimp.

Reed Mariculture is the world's largest producer of marine microalgae concentrates. They supply algal feeds and zooplankton to universities, marine ornamental growers, and over 500 fish, shrimp, and shellfish hatcheries in 80+ countries around the world.

# Instant Algae<sup>®</sup> Applications

Overview and comparison of our Whole-Food, Whole-Cell microalgae feeds

Products	Finfish	Shellfish	Shrimp	Description
<b>SINGLE SPECIES</b>				
Nanno 3600 <i>(Nannochloropsis)</i>	●	●		Our most popular feed since 1998. Widely used in finfish and mussel hatcheries, it has proven to be very effective with established protocols and it provides an EPA and ARA pre-enrichment boost for use with high DHA enrichment protocols.

Nanno 3600 is their original high-yield rotifer feed. It is single-species (*Nannochloropsis*) and produces phospholipid-rich rotifers. It also provides a high Feed Conversion Rate with minimal organic waste in the tank, and gives an EPA and ARA pre-enrichment boost for use with high-DHA enrichment protocols.



# **What can we do?**

Knowledge, Experience and Reputation

# **A4F AlgaFuel SA**

**Portugal**

**Started: 2008**

**Size: SECIL Project: 1 ha / 1300 m<sup>3</sup>**

**Investment:**

**[www.a4f.pt](http://www.a4f.pt)**

# SECIL Project



In 2009, A4F and the cement producer SECIL joint together to develop a project of microalgae production technology implementation.

After a first study for evaluating the specific client and project conditionings, and the project global viability, Stage 0 was initiated. It allowed to identify the best microalgae local strains, and the project specific features.

The prototype unit, Stage 1, in operation since March of 2009, allowed A4F to optimize the microalgae technology platform and to adapt it to the cement factory reality. After the technology consolidation, and the process and production parameters optimization, Secil advanced to a new Stage of 1ha area, that will already be an industrial production unit.



# Prototype Unit (2009-2012)





# algafarm

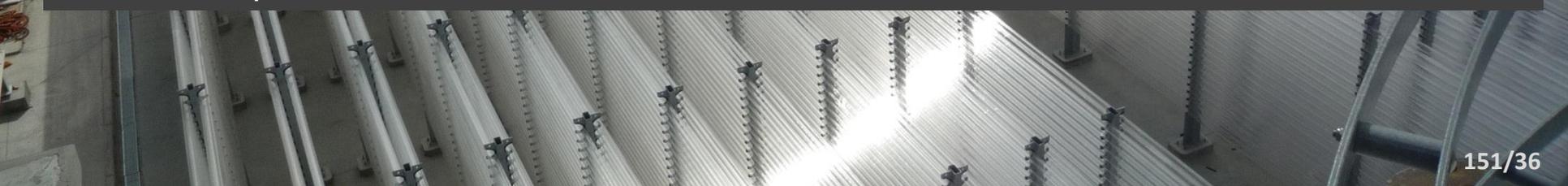
UNIDADE DE PRODUÇÃO DE MICROALGAS - PATAIAS



# SECIL Project 1st Production Unit



The unit will have a total 10.000 m<sup>2</sup> area, and will work with more than 1300 m<sup>3</sup> volume of production photobioreactors, being the world's largest unit of microalgae production with closed photobioreactors.





## Membrane Filtration System



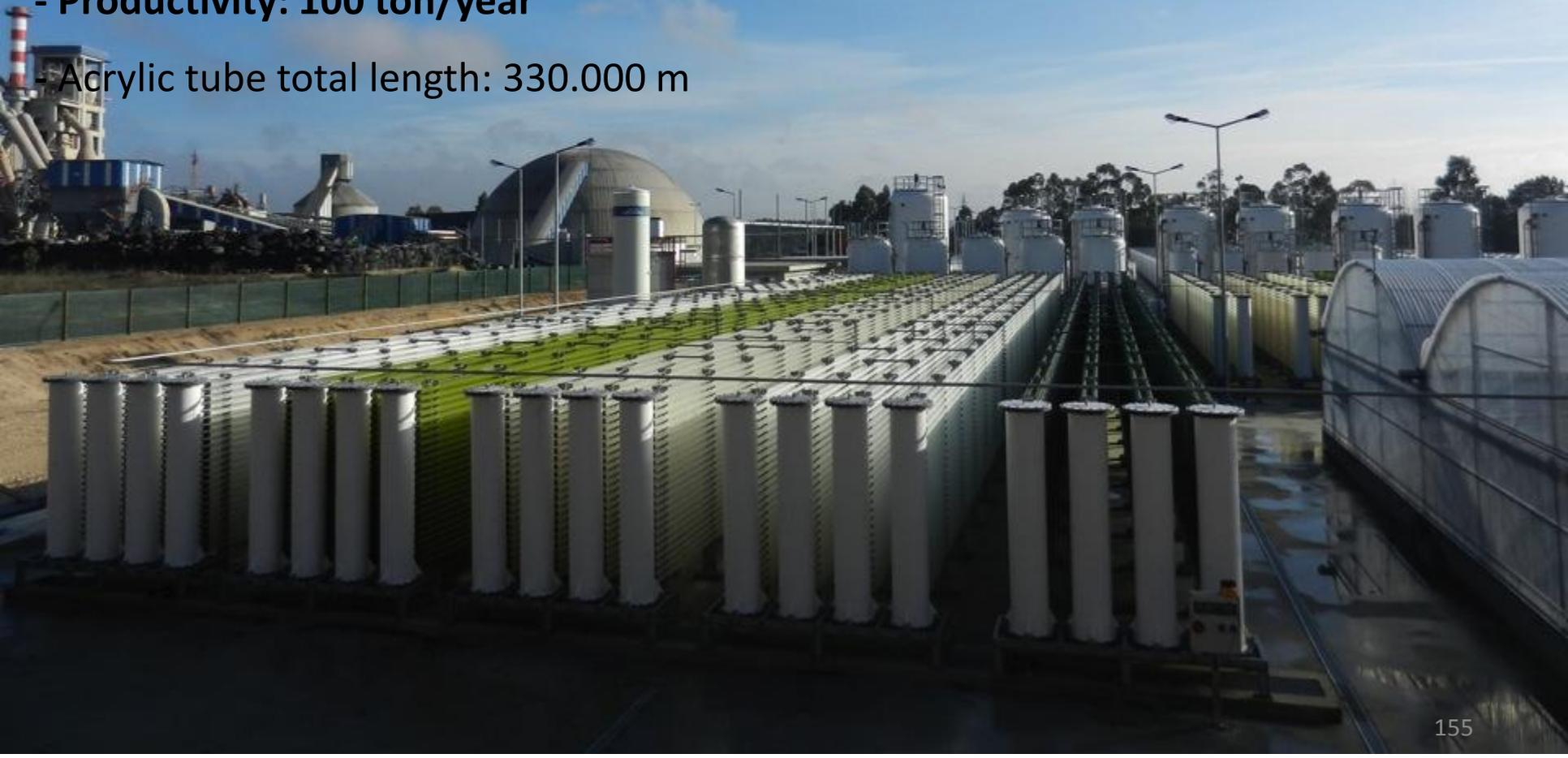






# AlgaFarm's Project – Main Figures

- Unit total area: 11.000 m<sup>2</sup>
- Unit total volume: 1.3000 m<sup>3</sup>
- Total project investment (2007-2012): 8M €
- Productivity: 100 ton/year
- Acrylic tube total length: 330.000 m









Thank you !

A4F · [www.a4f.pt](http://www.a4f.pt) · [vvv@a4f.pt](mailto:vvv@a4f.pt)

Vítor Verdelho Vieira

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