

La mer pour la *Vie* Ocean for life

**Development in the field of the algal biofuels:
the need for a partnership in R&D to secure a commercial reality**

**ACCT Canada
Innovation 2011: Canada's R&D Partnership Conference
November 20-22 , 2011
Hilton Bonaventure, Montreal , Quebec.**



Some key points on fossil fuel consumption

The current rate of consumption of fossil fuel is so high that with the most optimistic proven reserve estimates...

- Coal will exhausted in 417 years.
- Natural gas in 167 years.
- Oil in 43 years !!!?

Some news on the algofuels

November 2011. Flying on Chicken Fat. ...United Airline also made a demonstration flight using fuel derived from algae

May 2010. Toyota start algae biofuel research project, ...Toyota will team up with Chuo University of Japan's and Agriculture Minister to begin a research project...

Small-scale projects designed to produce... Energy Steven Chu announced today... federal

May 2011, *Incursion québécoise timide dans le monde de microalgues- Les Affaires*

November 2010. Algae for... but how fast? ...several... projects, including... announced today... federal

September 2010. Canadian company discovers new strain of microalgae, plans to make jet fuel...

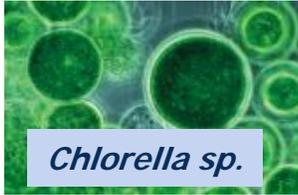
August 2010. ... from promise to reality, recently initiated such scale-up... of oil companies

June 2011. organisms

Oct 2011. China's aviation biofuel test a success ... After the test, Zhang Hongying, an official with the Civil Aviation Administration of China, said that biofuel was now ready to be used for commercial flights.

August 2010. Trading market.com. Repsol Nuevas acquire 20% stake in AlgaEnergy.

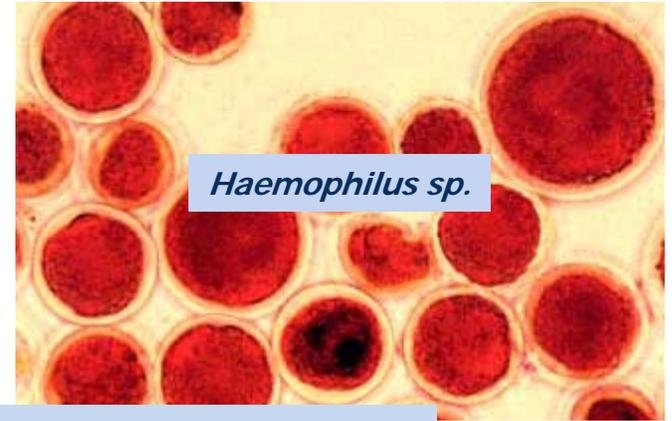
The amazing world of microalgae...



Chlorella sp.



Diatoms



Haemophilus sp.



Dunaliella sp.

"Microalgae" refers to microscopic organisms.

They are one of the earliest life forms developed on Earth. They are credited with producing most of the oxygen in our atmosphere.

These micro-organisms show a high biodiversity, a wide variety of forms, a multitude of metabolic pathways and are from different origins.

The total of species is not yet known: estimates range from 40 000 to a million of different species...only 10 are used in commercial production...

Spirulina sp.



Some key points on biofuel from microalgae

- Microalgae represent the third generation feedstock for biodiesel and for other biofuel.
- Oil yields per unit area or per unit of volume from algae is one of the most researched topics currently.
- Making biodiesel from algae oil is similar to the process of making biodiesel oil from any other oilseed.
- Recent advances in oil extraction and transesterification could reduce the cost of making biodiesel from algae oil.

Microalgae Market

Production of microalgae is a commercial reality

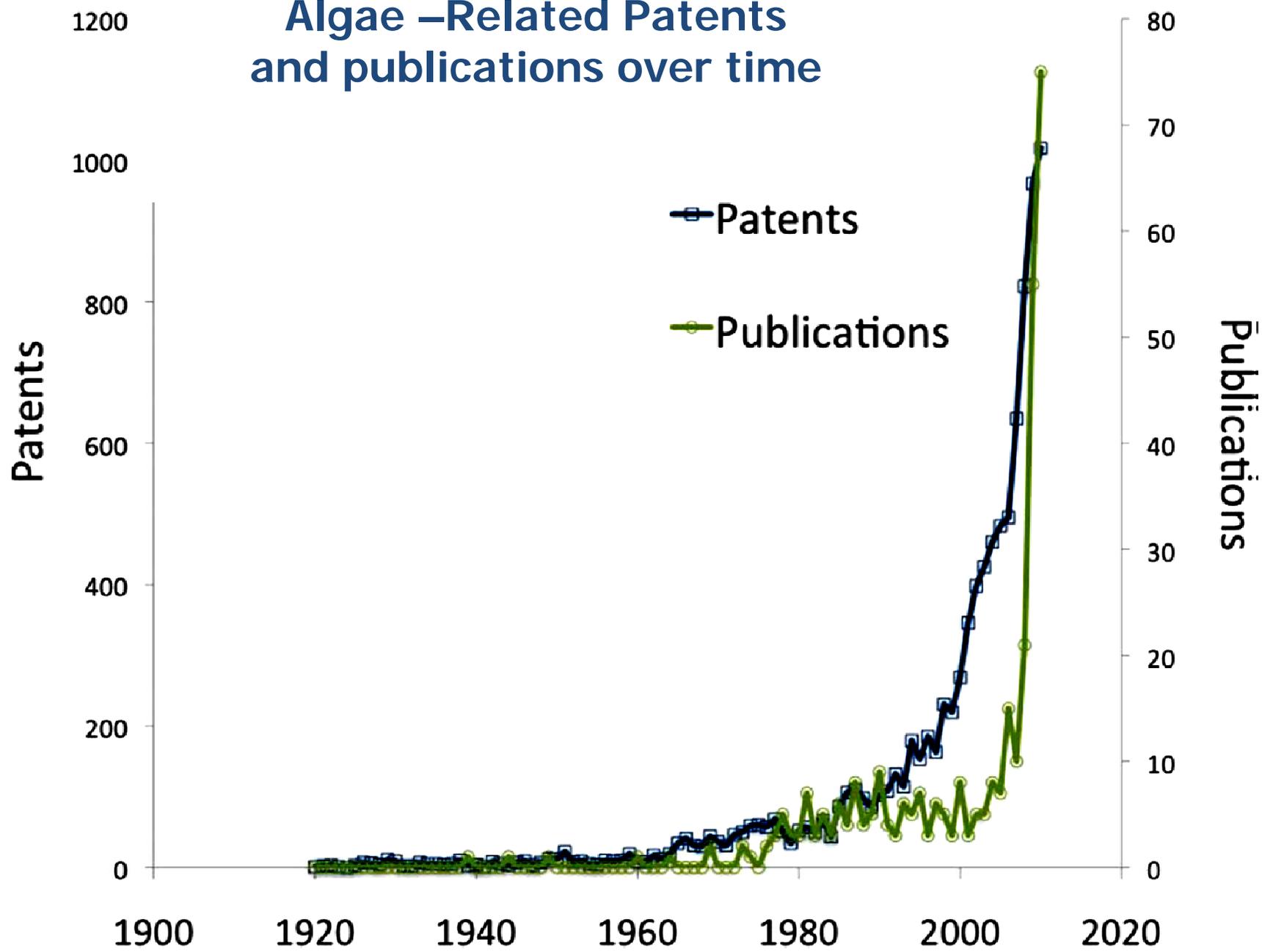
- World production of microalgae between 1975 and 2000 was from less than five to 3,500 tons per year.
- In 2004, world production of microalgae was estimated at least 7 000 tons for a value of more than 4.5 billion US .
- April 2011. The huge potential of microalgae is still to operate, develop or invent. *According to the Market and Business Intelligence company, the total production volume of microalgae for all application is in the tens of thousands of tons.*
- The most important market of microalgae is human consumption: it represents more than 75% of annual world production of microalgae, but...

Microalgae Market

Algae 2020: Biofuel Markets and Commercialization Outlook (2009)

« The global market for Algae biofuels is poised for explosive growth in the next ten years. Algae is attracting increased investment and interest for energy, aviation, and biofuels companies. ...The US and Europe can not grow enough corn, soy, or rapeseed to meet their biofuels targets. Demand for biofuels in the US, EU, and Asia will create new opportunities for algae and other non food-feedstocks to meet ambitious targets for biodiesel, ethanol, and next generation renewable fuels. »

Algae –Related Patents and publications over time



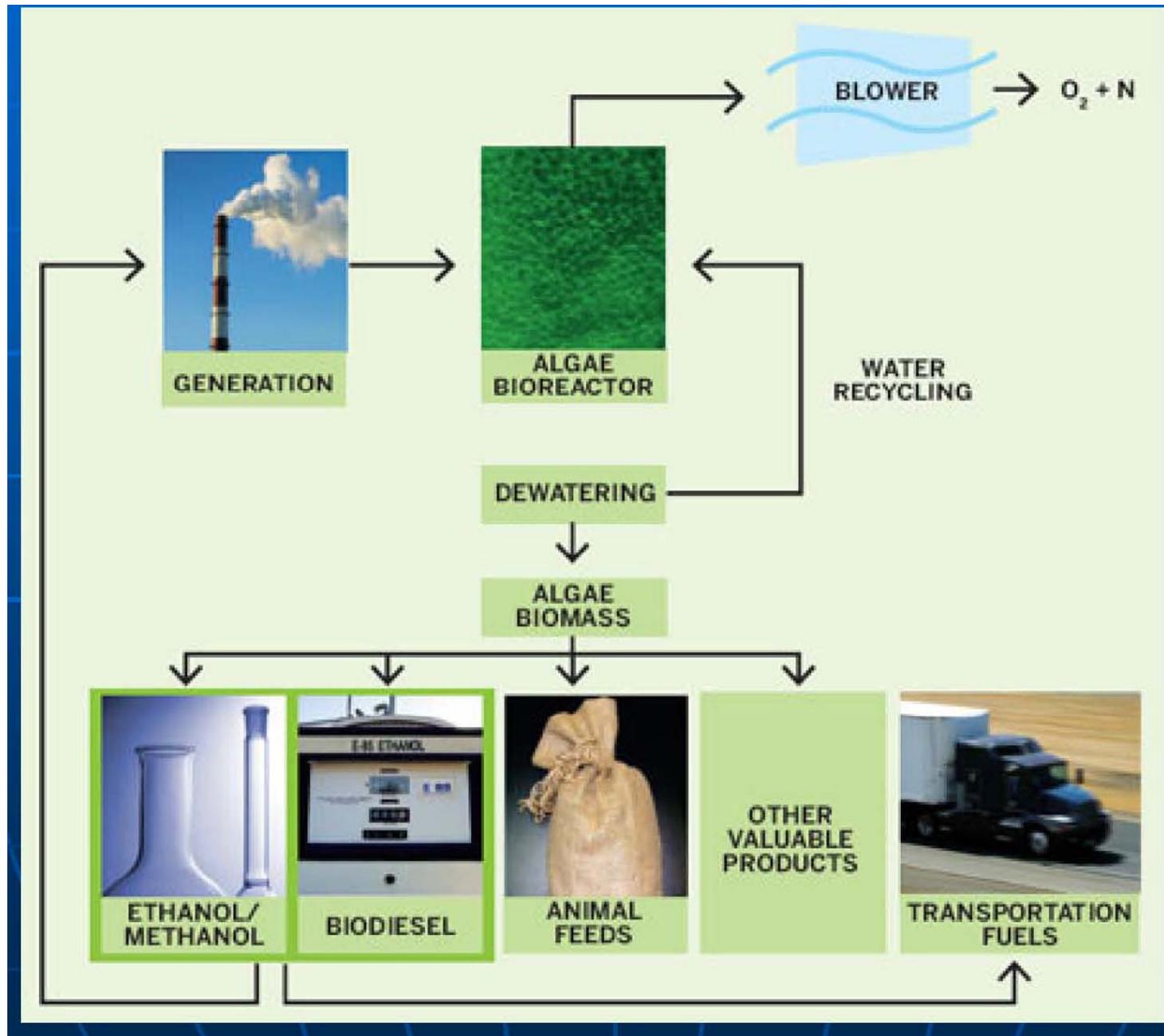
Source: Green Chem., 2011, 13, 1399

The microalgae biorefinery approach

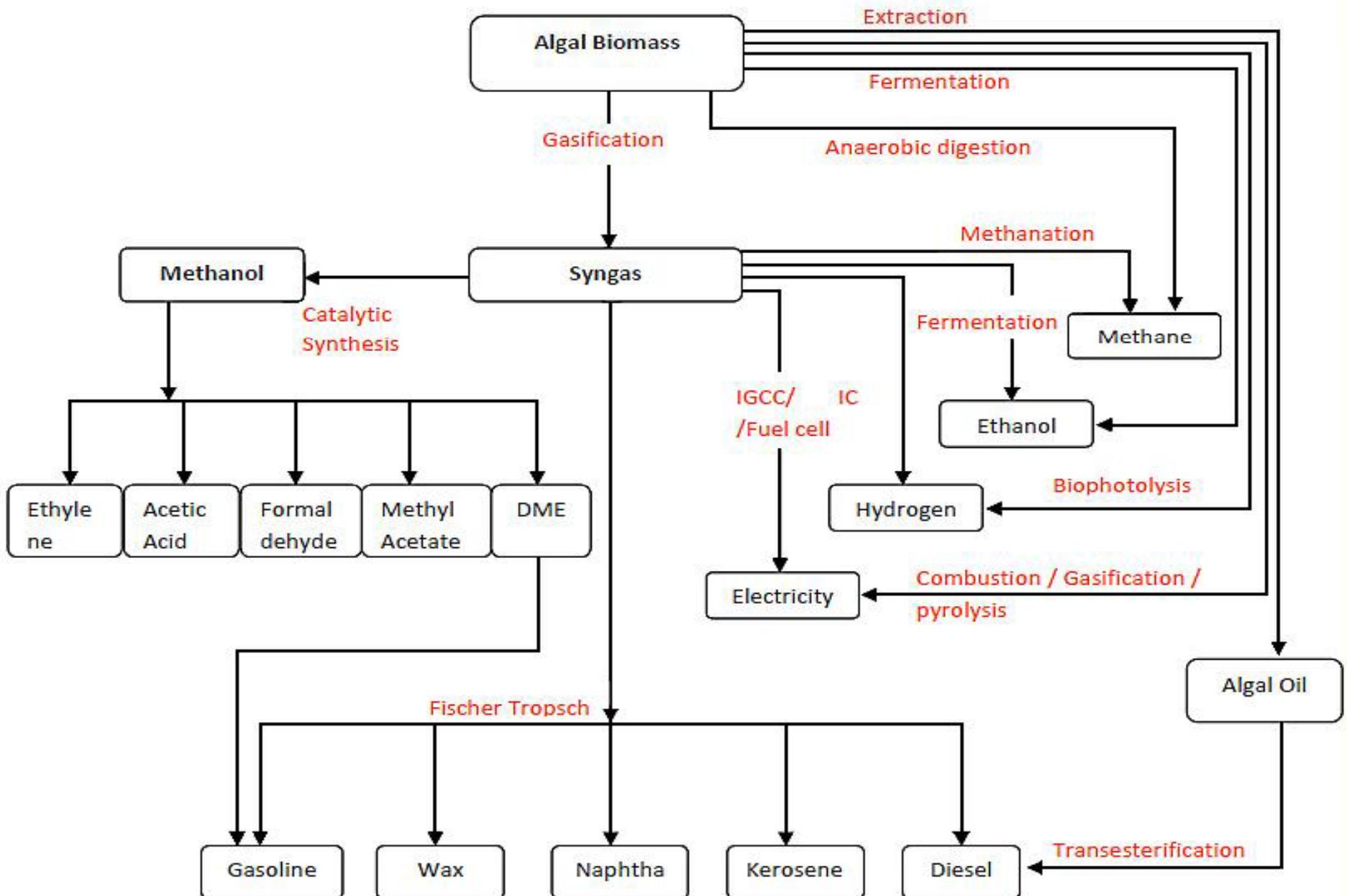
As an excellent crude material for biorefinery, microalgae has characteristics of production of biofuel, biological reagents (pigment, enzymes) and bioactives substances (proteins, polymers, etc).

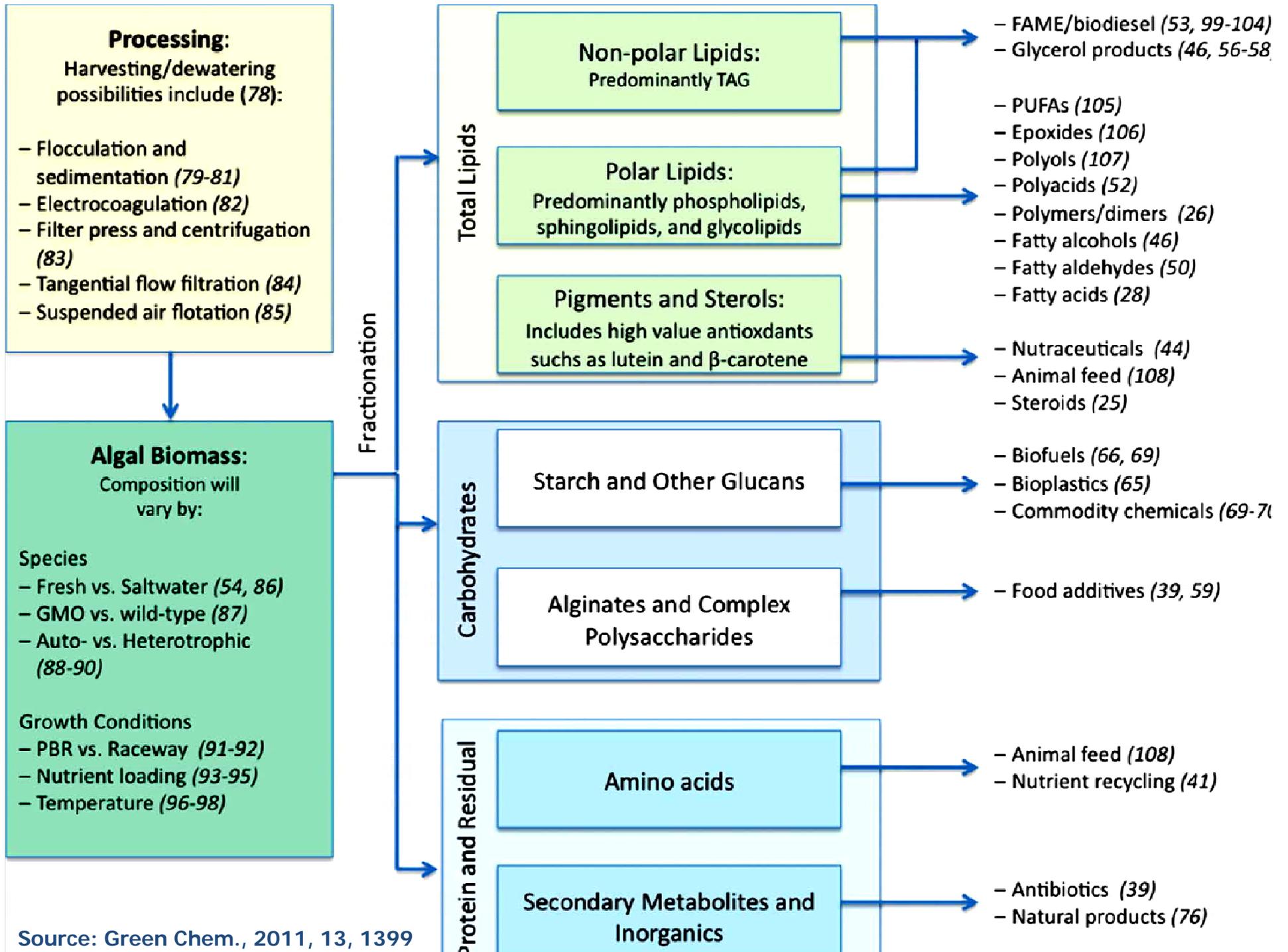
An innovative approach combining upstream algae production and downstream biorefinery systems is necessary. The biorefinery technology process reduces costs and maximizes the economic potential of algae by producing a range of high-value products and renewable fuels.

Algal biomass and biofuels conversion



Path to the various Energy Products from Algae





Innovation in microalgae production system

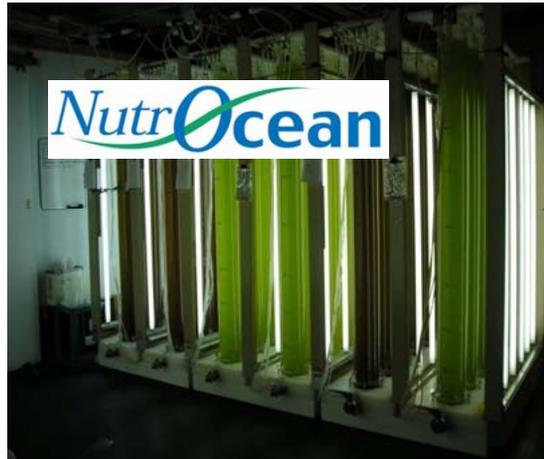
Phototrophic

Heterotrophic

Open systems

Closed systems

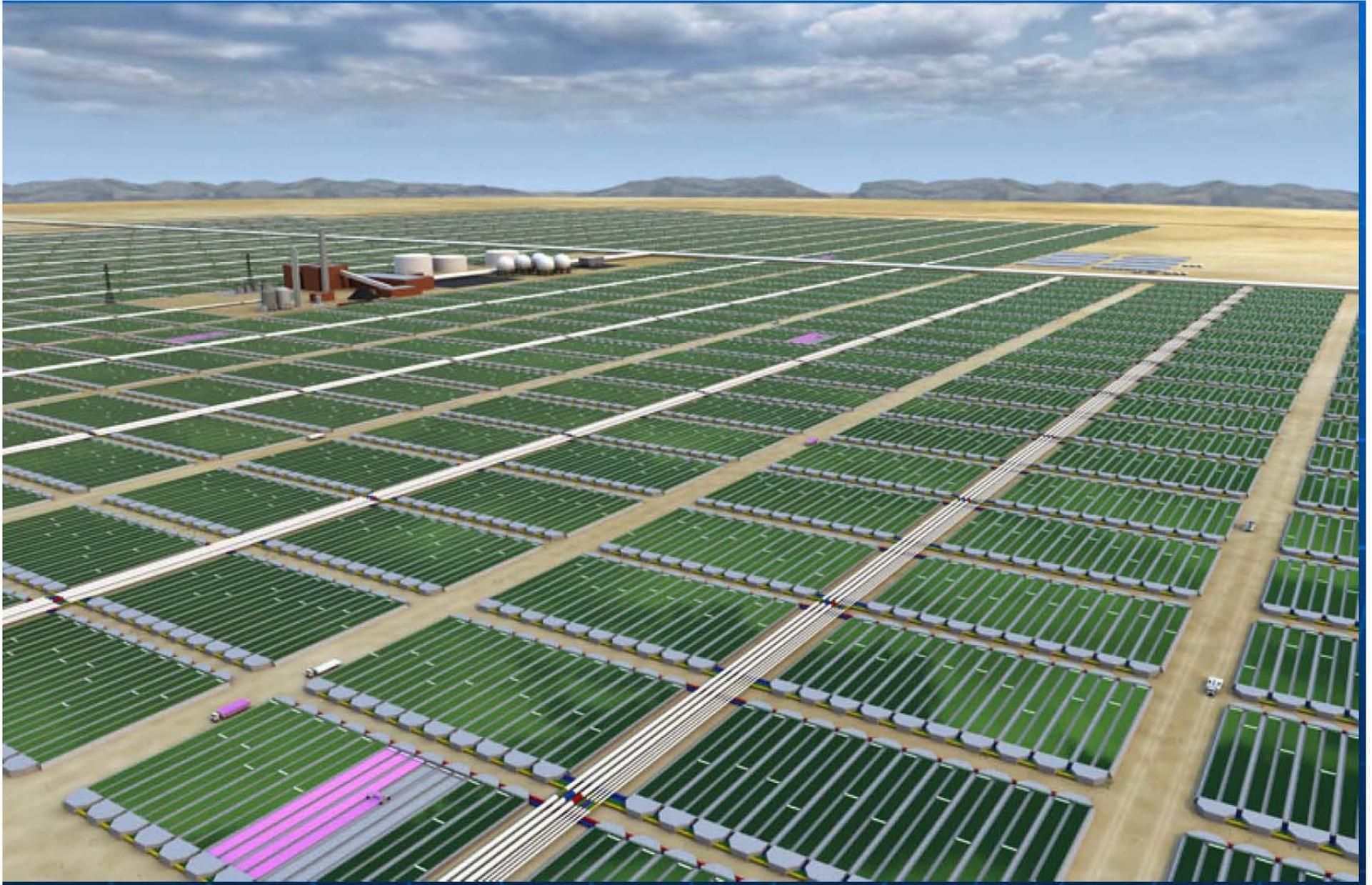
Fermentation



PRODUCTIVITY



Future models for "algal" farms
Source: Solix Biofuels - Vision 2012-2020





Martek Biosciences Corp.

- 10 à 270 m³
- Omega 3
- 300 M\$

Microalgae production : some observations

- While feasible in geographic locations with high insolation, **raceways** are unlikely to produce algal oil at prices competitive with fossil fuels in Nordic countries like Canada *but new design of ponds are under development and demonstration in Canada.*
- **Photobioreactors** are unable to economically produce bioenergy from algae (... **new design are on development also in Canada**).
- **Fermentation appears to be the most promising option to make biofuels from algae.** In addition, it is independent of climatic conditions, while the costs and energy balance may be equivalent to the first-generation biofuels (if yields and oil content can reach high levels) ... and could be use for other oil producing microorganisms.

Technological challenge...a multidisciplinary approach

- Maintenance and update of a bank of original strains (preparation of culture necessary for the inoculation of the productions, genetic selection).
- Typing of original strains (microalgae strains must be isolated, cloned and characterized).
- Optimization of production conditions
- Quality control: contamination, purity, etc.
- Upgrading full production (biomass, oil).
- Upgrading extraction process, and biodiesel production.
- Injection of CO₂ and nutrients.
- Illumination optimization.
- Byproducts development (biorefinery).

Development in the field of the algal biofuels: the need for a partnership in R&D to secure a commercial reality

- **There is a global boom in the interest of the use of microorganisms, especially algae as a source of oil to obtain biodiesel. Globally, intensive developments and major investments are made.**
- **Algae to bioenergy technology are still pre-commercial or near industrial scale, and will require significant R&D to increase productivity and to reduce costs.**
- **Intensive innovation works are necessary to allow at least for certain geographical locations or for specific technology a profitable production of algal biomass and oil at low-cost.**
- **There are several emerging avenues in the Canada of development of various technologies. It appears clearly that the partnerships will need to accelerate research, development and demonstration in Canada.**

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