Las algas marinas como recurso energético

Enrique Espí, Centro de Tecnología Repsol

Seminario “Energía y Medio Ambiente en el Mar”
Santander, 16 octubre 2018

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Situación

Historia

Prehistoria

"*On the arid lands there will spring up industrial colonies without smoke and without smokestacks; forests of glass tubes will extend over the plains and glass buildings will rise everywhere; inside of these will take place the photochemical processes that hitherto have been the guarded secret of the plants, but that will have been mastered by human industry which will know how to make them bear even more abundant fruit than nature, for nature is not in a hurry and mankind is. And if in a distant future the supply of coal becomes completely exhausted, civilization will not be checked by that, for life and civilization will continue as long as the sun shines!*"“

Ciamician, G. The photochemistry of the future. Science 36, 385-394 (1912)

Historia

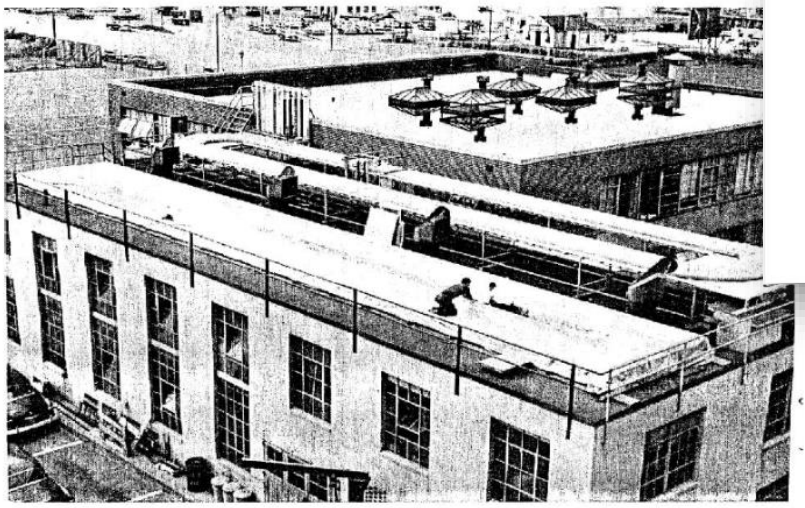
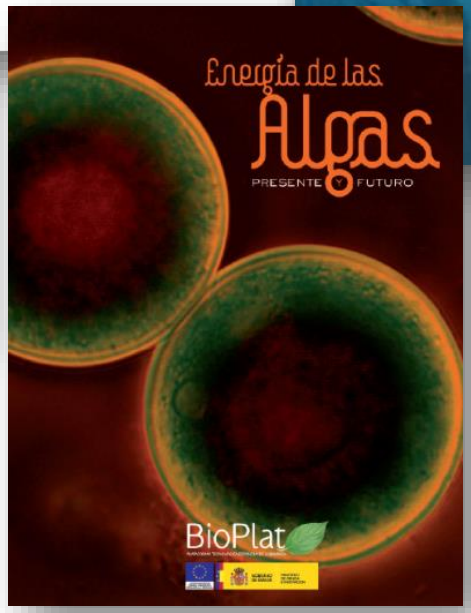
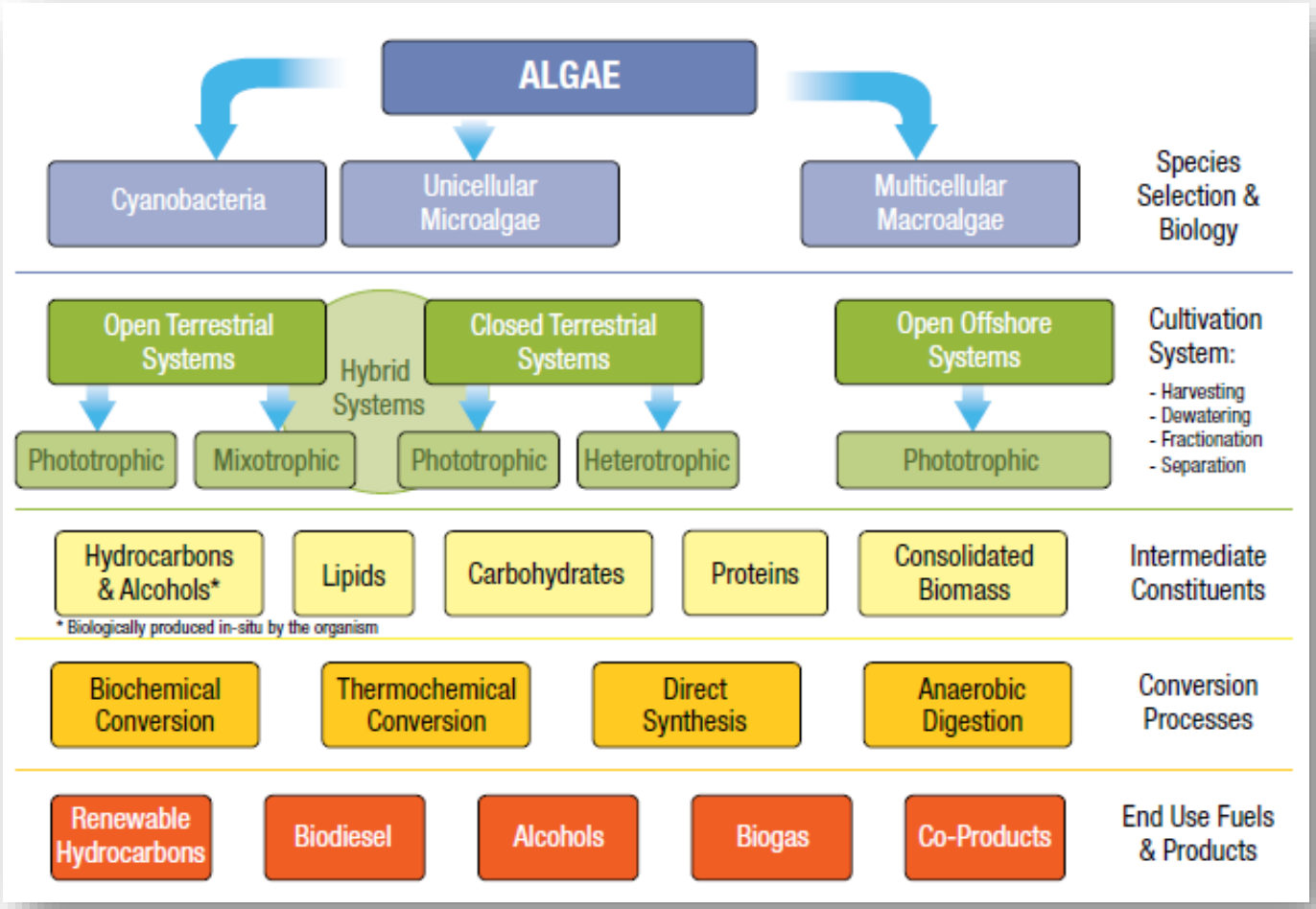


Figure 2.7: First Algae Mass Culture Experiments on a Rooftop at MIT (Burlew, 1953).

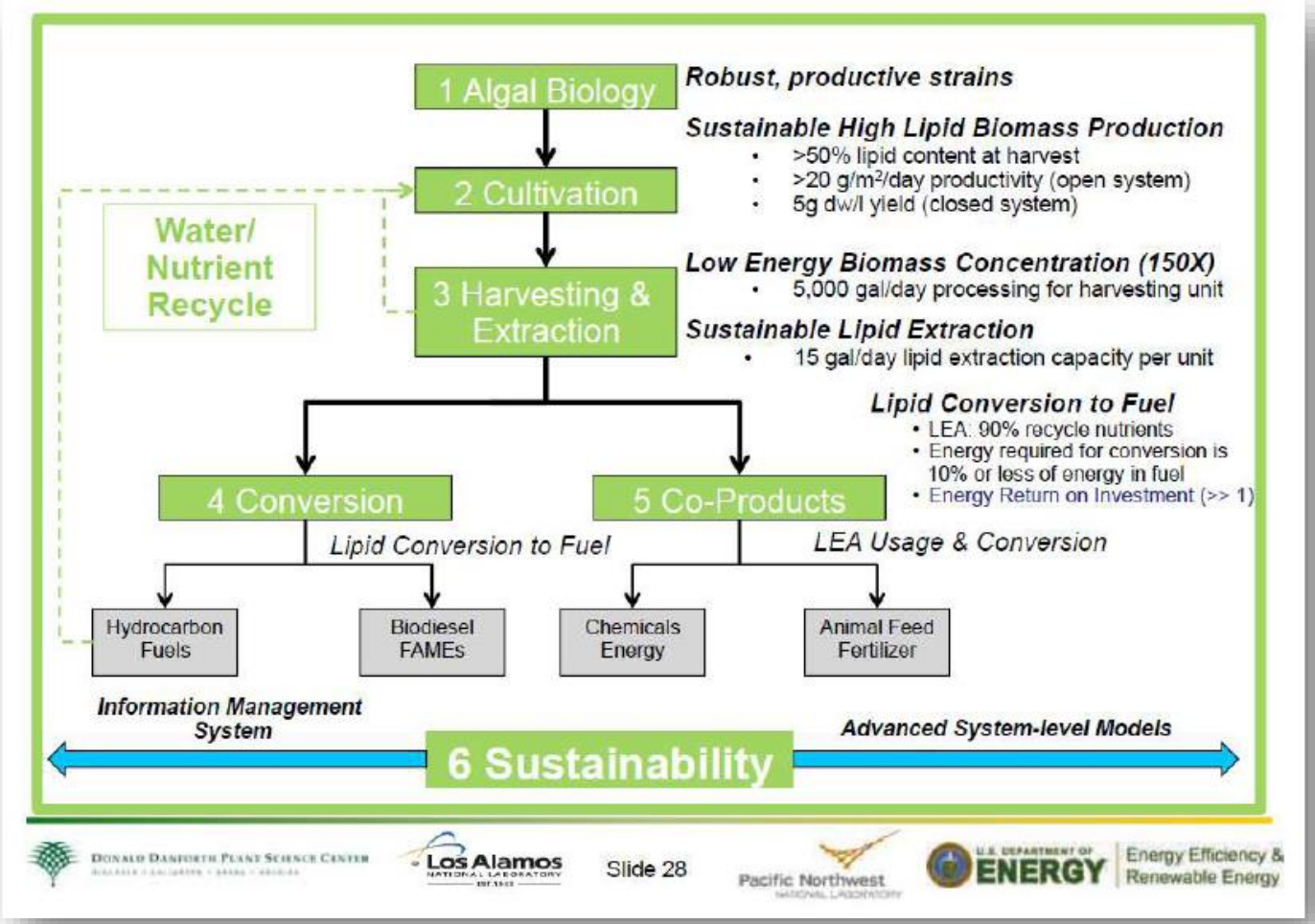


Estado de la tecnología

Rutas para aplicaciones energéticas



Ruta más estudiada



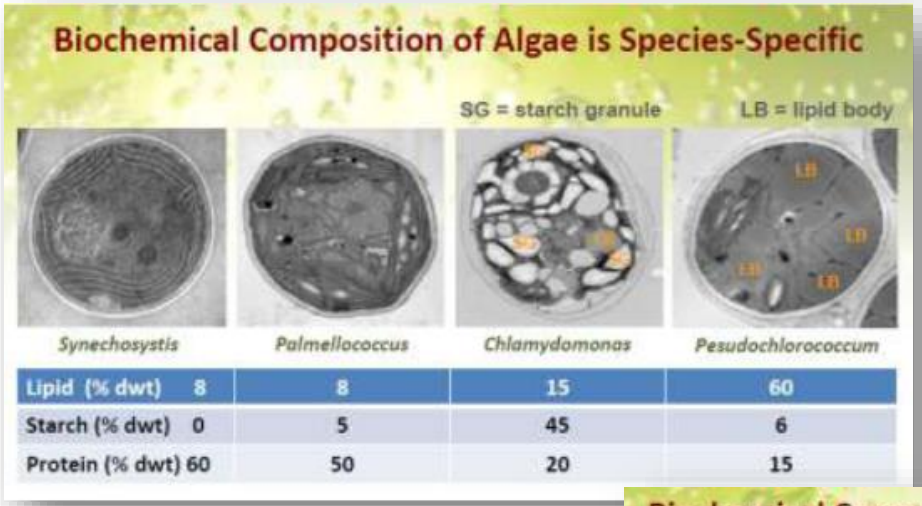
Biología de algas

Selección de cepas:
- Cepas silvestres
- Bancos de algas

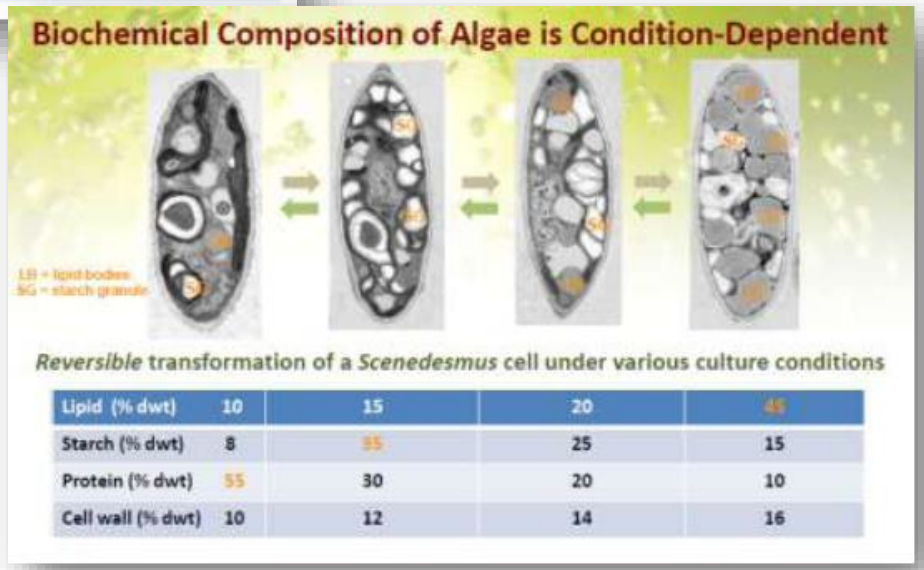
Mejora de cepas:
- Métodos no genéticos
- Modificación genética

Objetivos:
- Maximizar la producción de biomasa
- Maximizar la producción de metabolitos
- Optimizar la robustez de la cepa
- Facilitar la recolección y extracción

Mejora de cepas



Lipid (% dwt)	8	8	15	60
Starch (% dwt)	0	5	45	6
Protein (% dwt)	60	50	20	15



Lipid (% dwt)	10	15	20	45
Starch (% dwt)	8	35	25	15
Protein (% dwt)	55	30	20	10
Cell wall (% dwt)	10	12	14	16

Cepas o consorcios: ecología sintética

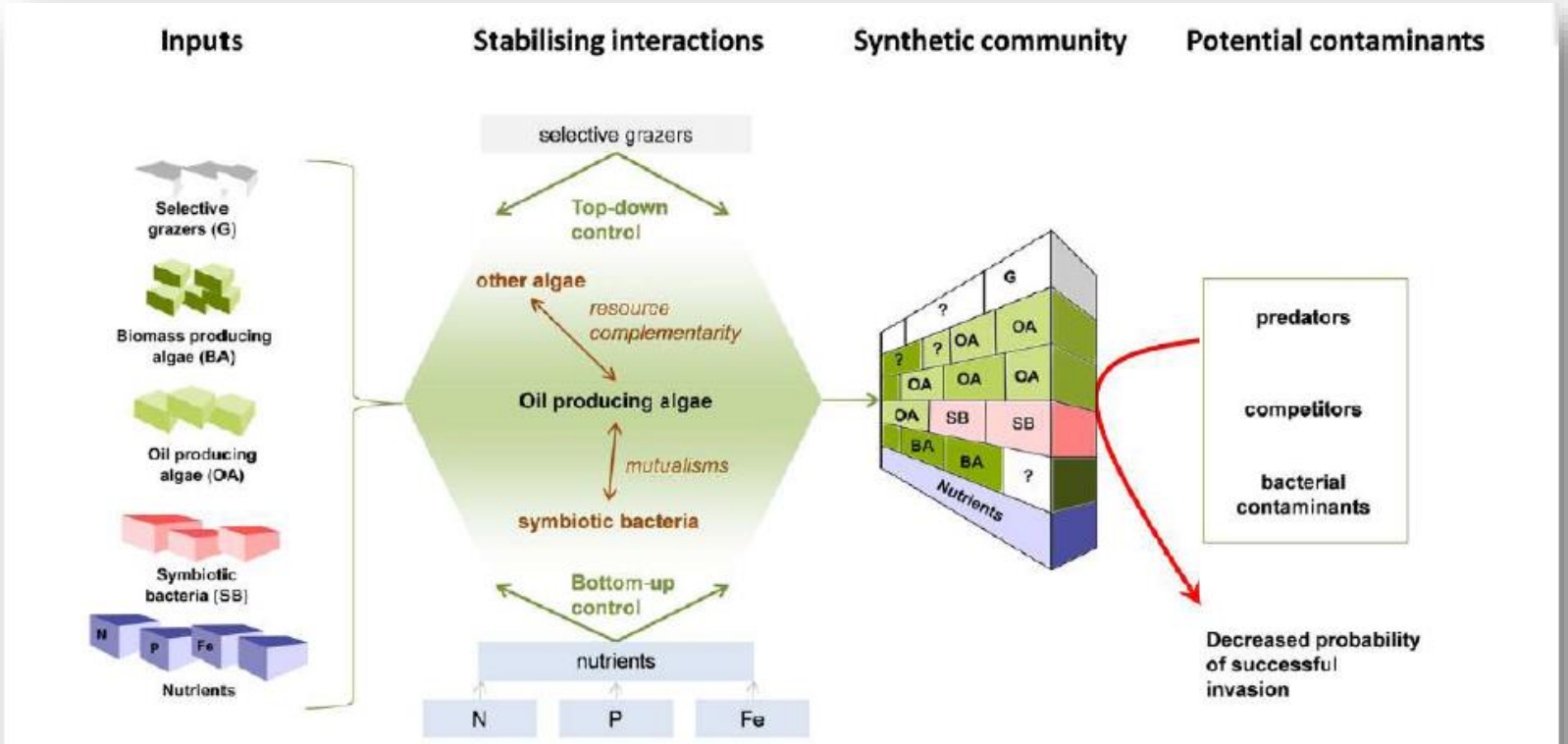


Fig. 3. Principles of "synthetic ecology" to assemble an ideal algal community for industrial cultivation. A synthetic community, aimed at stabilising growth of oil-producing algae (OA), might be achieved by an assembly of different organisms. Bottom-up control is achieved through the manipulation of the nutrient status of the medium (N, P, etc.), which will select for certain algal species over others. Inclusion of vitamin B_{12}-producing bacterial symbionts (SB) mitigates the need to supplement the medium with an expensive micronutrient, but also fill the bacterial niche, so as to exclude other bacterial contaminants. Algae with complementary nutrient requirements may be co-inoculated into the growth medium (BA). They may not be in direct competition with oil-producing species, and will serve to enhance the overall biomass output of the culture. Top-down control is achieved through carefully selected grazing zooplankton (G), which preferentially eat either competing algae or the predators of oil-producers. Invading competing predators are less likely to establish if grazing zooplankton are introduced from the start.

Sistemas de cultivo

Sistemas abiertos (*open ponds*)

Sistemas de cultivo

Sistemas cerrados (fotobiorreactores)

Sistemas de cultivo

Sistemas cerrados
(fotobiorreactores integrados en entornos urbanos)

Sistemas de cultivo

Sistemas para macroalgas

Sistemas de cosechado y secado

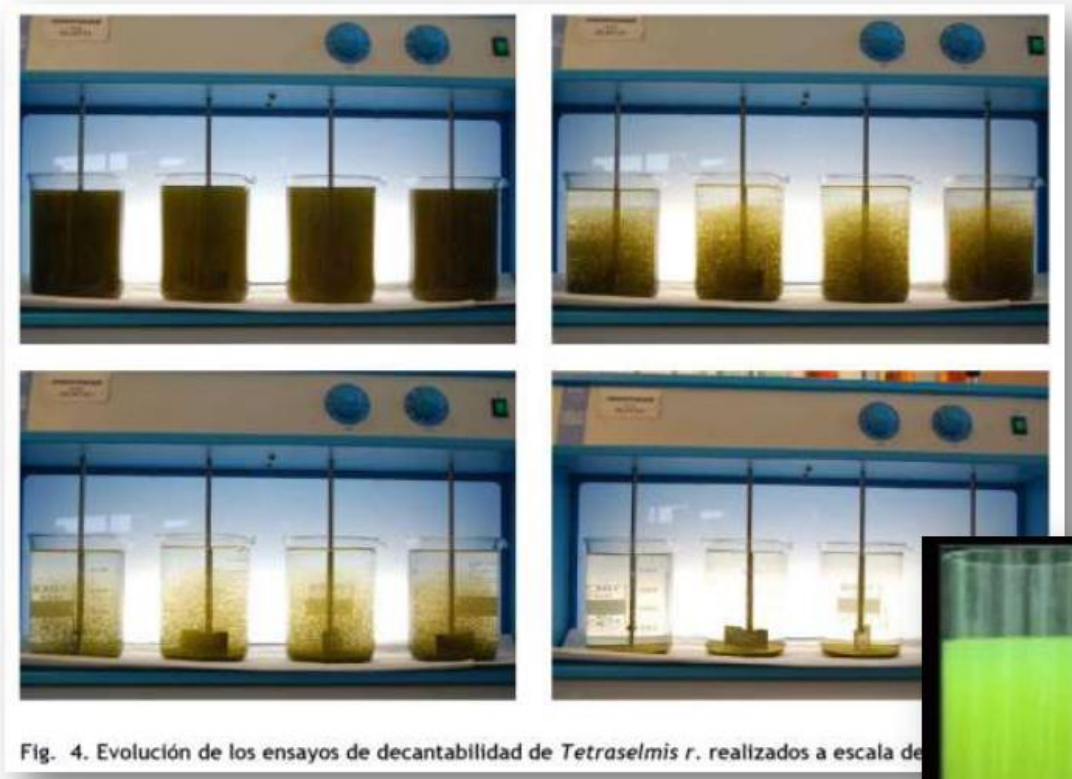


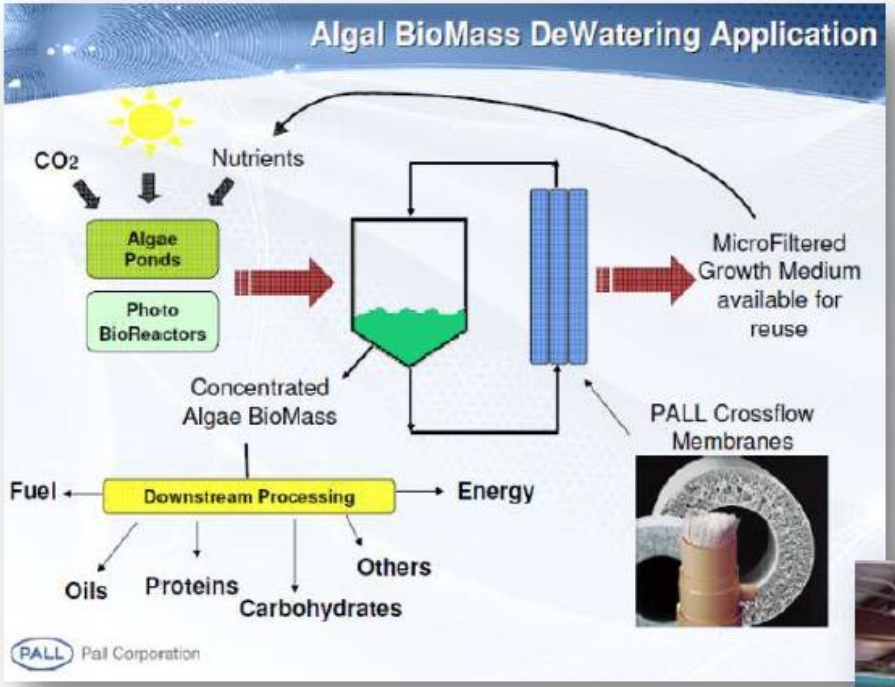
Fig. 4. Evolución de los ensayos de decantabilidad de *Tetraselmis r.* realizados a escala de

Floculación

Sistemas de cosechado y secado

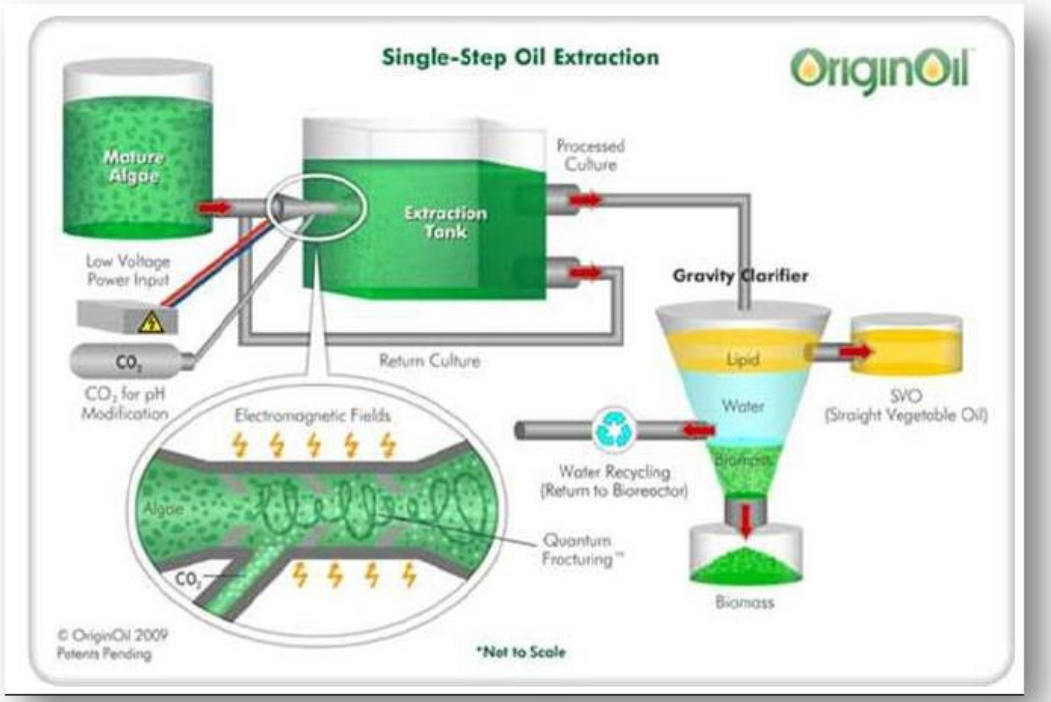
Centrifugación

Sistemas de cosechado y secado



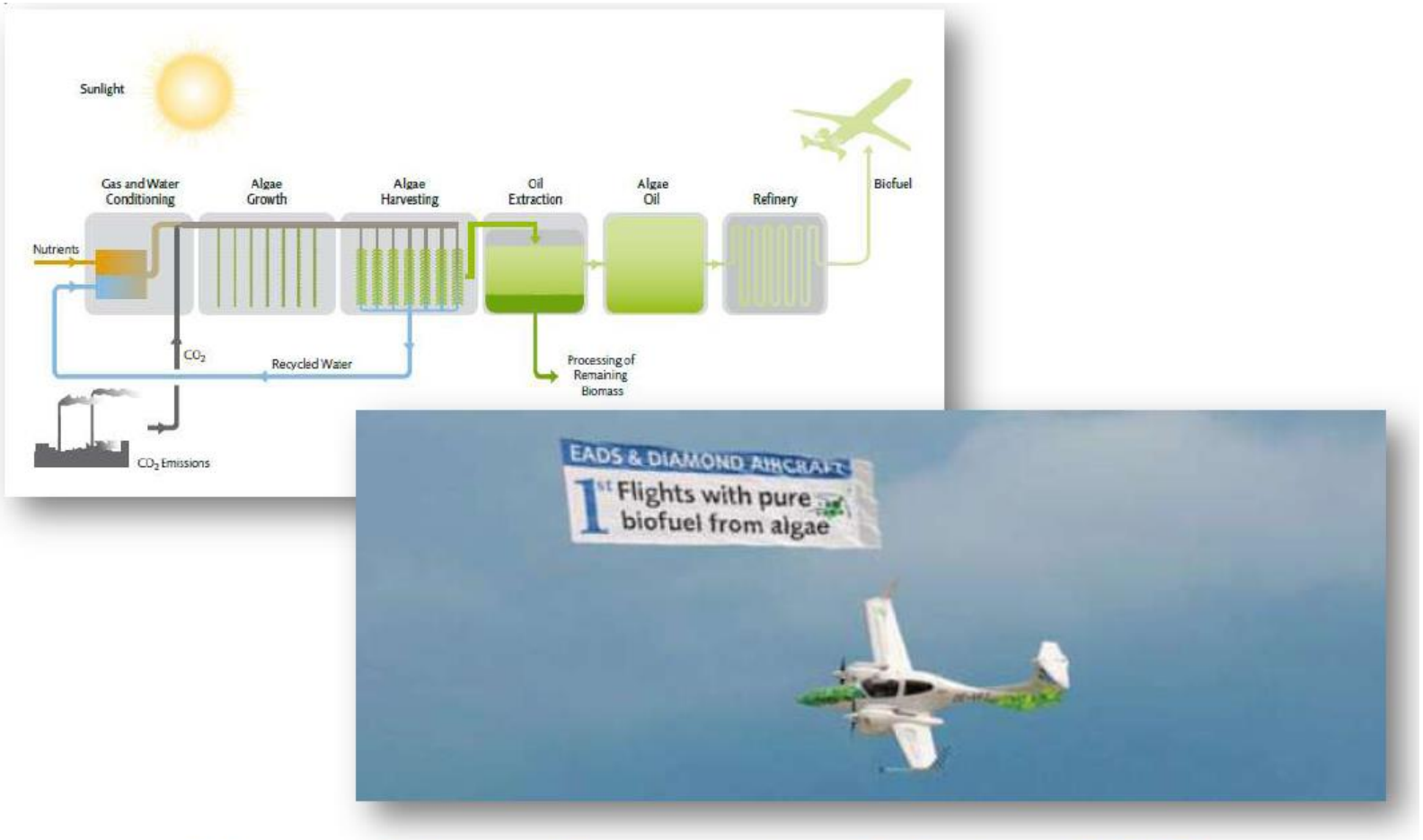
Microfiltración

Sistemas de extracción de aceite



Sistemas de extracción no convencionales

Aplicaciones energéticas

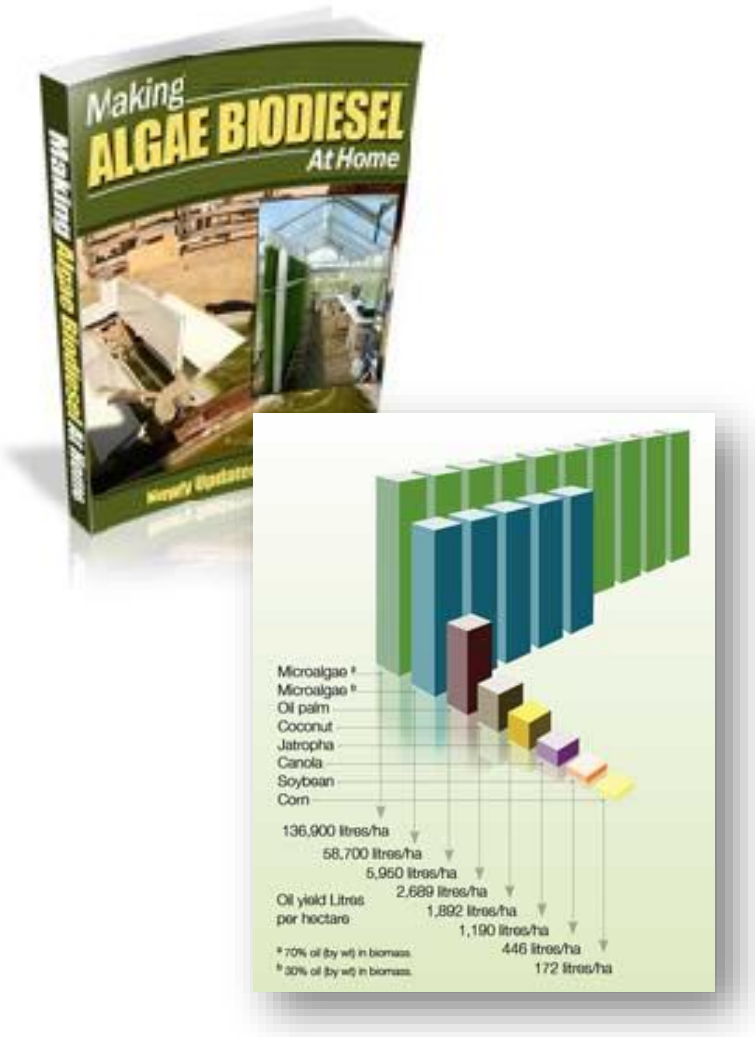


Primer vuelo de un avión con combustible de algas (EADS)

Perspectivas

Pros y contras

Pros

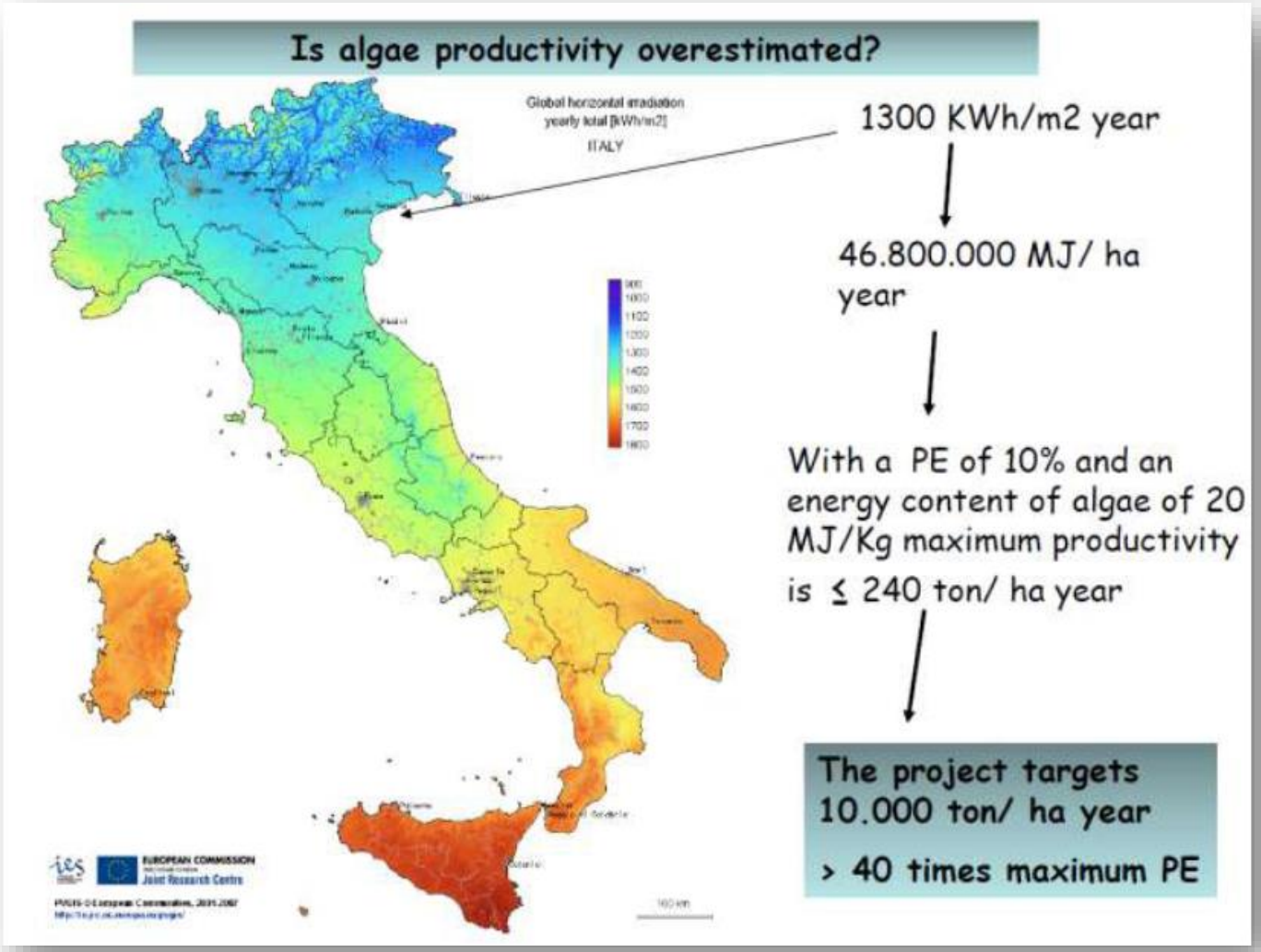


- ✓ Alta productividad
- ✓ Capturan CO_2
- ✓ No necesitan suelo cultivable
- ✓ No necesitan agua dulce
- ✓ No contaminan suelos o acuíferos
- ✓ Cosechado continuo
- ✓ Coproductos de alto valor

Contras

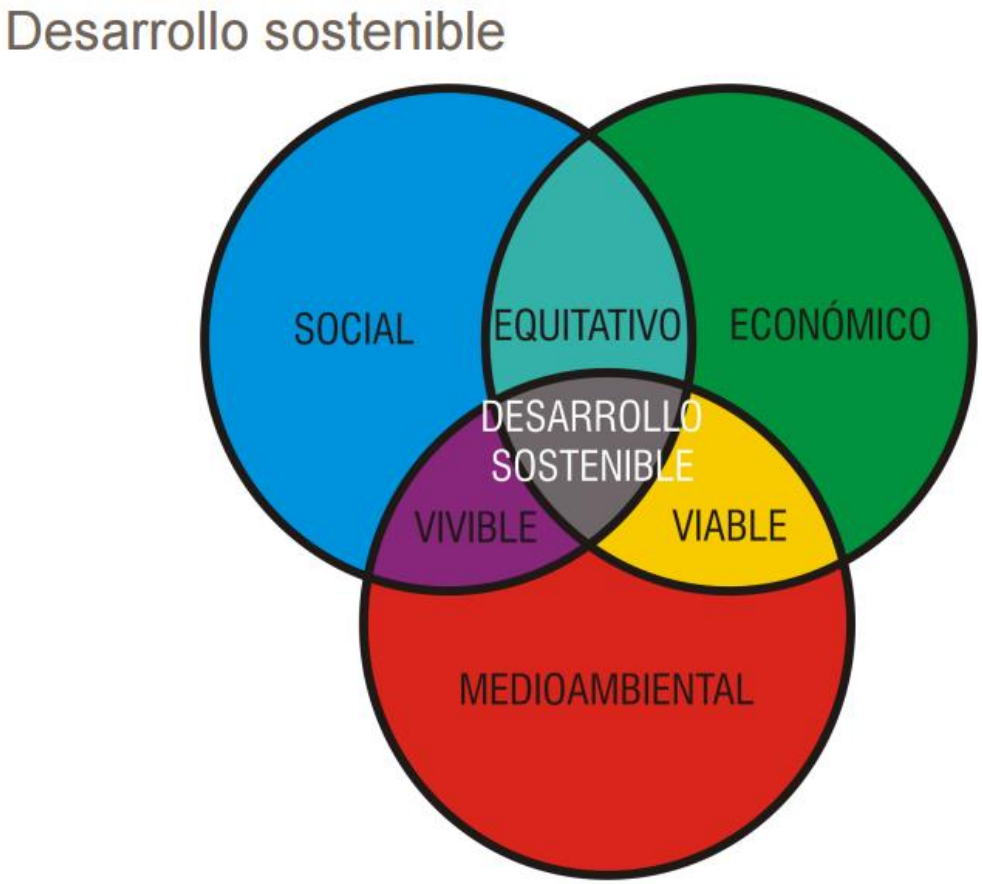
- ✘ Tecnología poco madura
- ✘ Productividad a gran escala limitada
- ✘ Altos costes de producción
- ✘ Lípidos no siempre aptos para biocombustible
- ✘ Sostenibilidad cuestionada

Contras: exceso de expectativas

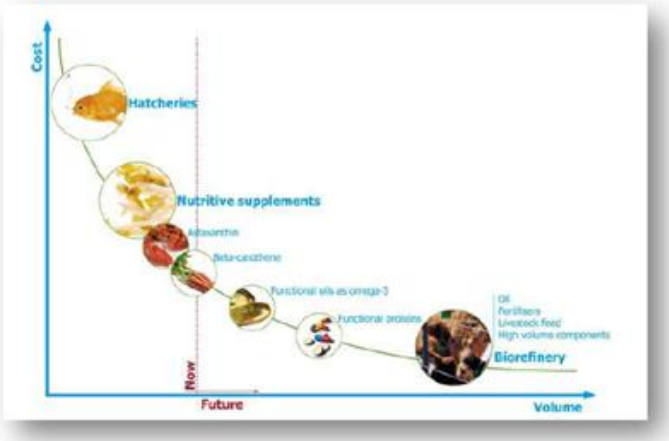


Retos

Retos: sostenibilidad



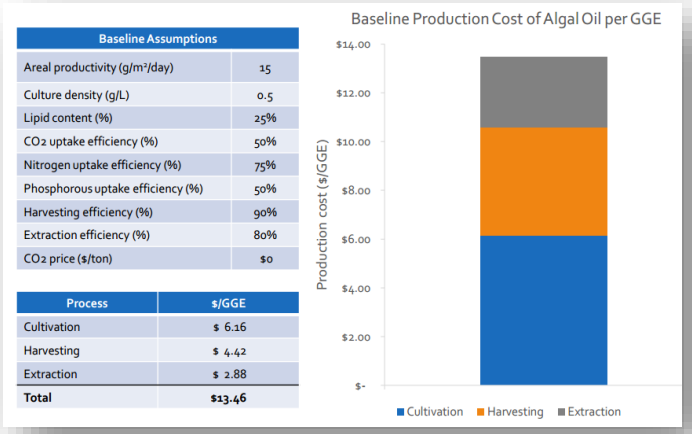
Sostenibilidad económica



Fuente: Proviron

Baseline Assumptions	
Areal productivity (g/m²/day)	15
Culture density (g/L)	0.5
Lipid content (%)	25%
CO_2 uptake efficiency (%)	50%
Nitrogen uptake efficiency (%)	75%
Phosphorous uptake efficiency (%)	50%
Harvesting efficiency (%)	90%
Extraction efficiency (%)	80%
CO_2 price ($/ton)	$0

Process	$/GGE
Cultivation	$ 6.16
Harvesting	$ 4.42
Extraction	$ 2.88
Total	**$13.46**



Fuente: Lux Research

Precio actual de los biocombustibles de algas: 2 a 20 €/l

Precio actual de otros biocombustibles: 0,5 a 1 €/l

Sostenibilidad medioambiental


Sustainable Development of Algal Biofuels in the United States

NATIONAL RESEARCH COUNCIL

SUMMARY FINDINGS FROM THIS AND EARLIER CHAPTERS

Based on a review of literature published until the authoring of this report, the committee concluded that the scale-up of algal biofuel production sufficient to meet at least 5 percent of U.S. demand for transportation fuels[2] would place unsustainable demands on energy, water, and nutrients with current technologies and knowledge. However, the potential to shift this dynamic through improvements in biological and engineering variables exists. (See also Chapters 2 and 3 on improvements in biological and engineering variables.)

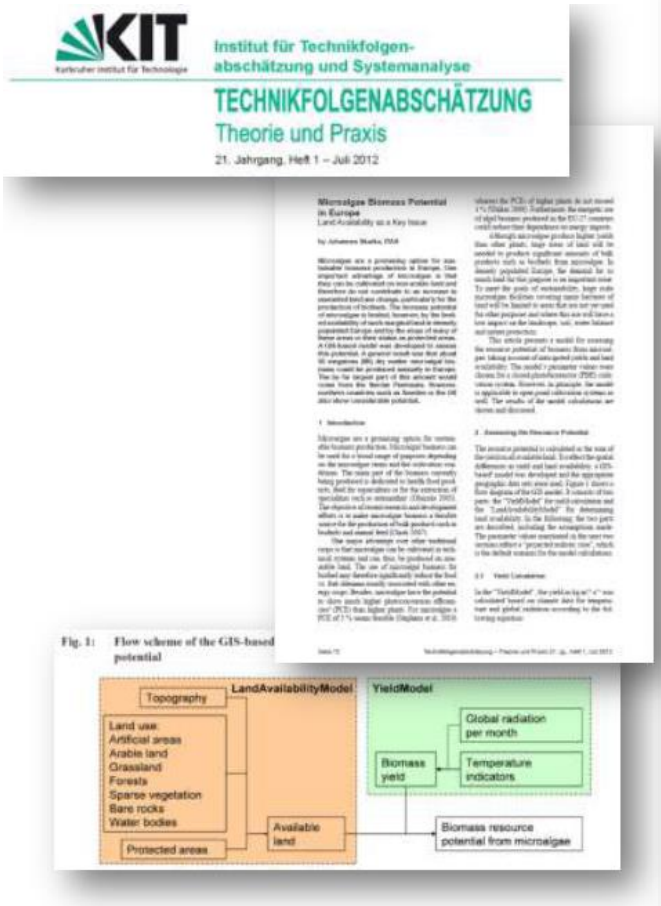
Sustainable development of algal biofuels would require research, development, and demonstration of the following:

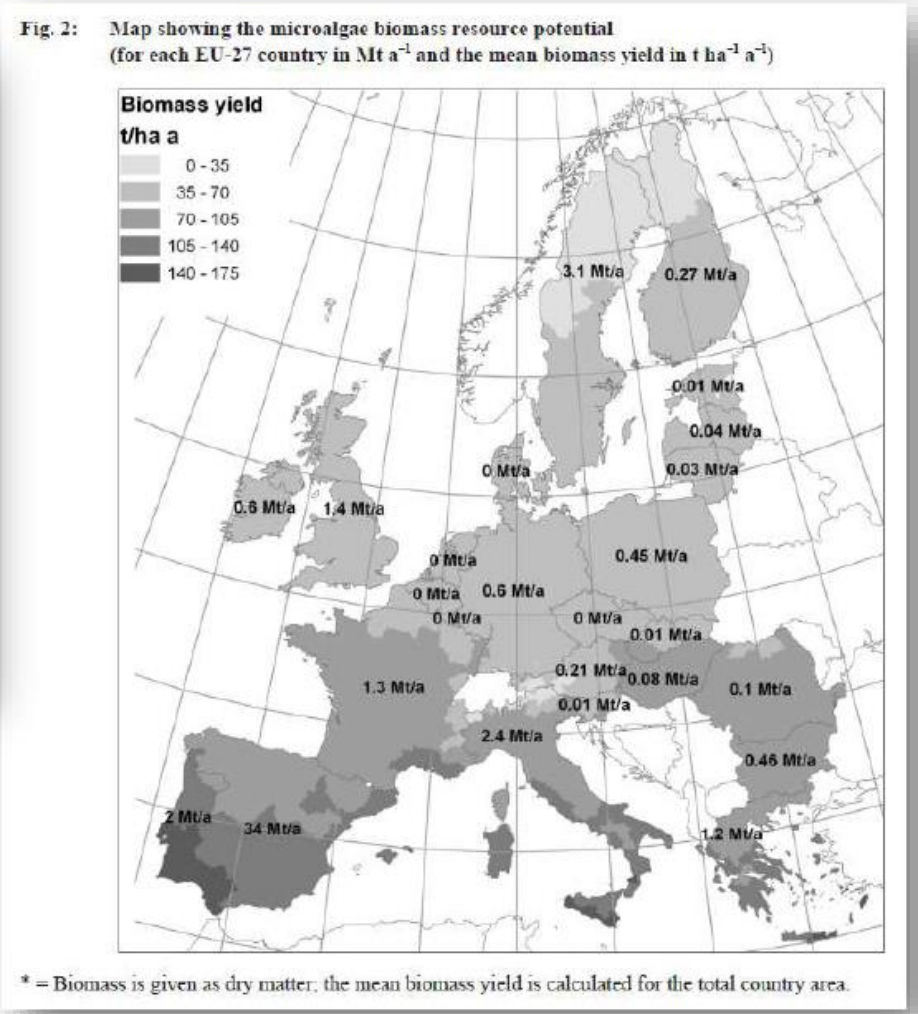
- **Algal strain selection and improvement to enhance desired characteristics and biofuel productivity.** (See Chapter 2.)
- **An EROI that is comparable to other transportation fuels, or at least improving and approaching the EROIs of other transportation fuels.**
- **The use of wastewater for cultivating algae for fuels or the recycling of harvest water, particularly if freshwater algae are used.**
- **Recycling of nutrients in algal biofuel pathways that require harvesting unless coproducts that meet an equivalent nutrient need are produced.**

A national assessment of land requirements for algae cultivation that takes into account climatic conditions; freshwater, inland and coastal saline water, and wastewater resources; sources of CO_2; and land prices is needed to inform the potential amount of algal biofuels that could be produced economically in the United States.

Potencial

Potencial en Europa





El modelo “sólo energía”

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Exxon Makes a Biofuel Breakthrough

By **Jennifer A Dlouhy**
19 de junio de 2017 17:00 CEST
From **Climate Changed**

- J. Craig Venter's Synthetic Genomics teamed with Exxon Mobil
- Technique could lead to commercialization of algae-based fuels

It's the holy grail for biofuel developers hoping to coax energy out of algae: Keep the organism fat enough to produce oil but spry enough to grow quickly.

J. Craig Venter, the scientist who mapped the human genome, just helped Exxon Mobil Corp. strike that balance, with a breakthrough that could enable widespread commercialization of algae-based biofuels. Exxon and Venter's Synthetic Genomics Inc. are announcing the development at a conference in San Diego on Monday.

They used advanced cell engineering to more than double the fatty lipids inside a strain of algae. The technique may be replicated to boost numbers on other species too.

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BIOFUELS

Genetics Pioneer Craig Venter and Exxon Claim Algae Biofuel Breakthrough (Again)

We're still not much closer to commercialized algae biofuels.

ERIC WESOFF | JUNE 21, 2017

Genetics Pioneer Craig Venter and Exxon Claim Algae Biofuel Breakthrough (Again)

Photo Credit: CSIRO creative commons

Every few years, J. Craig Venter of Synthetic Genomics and Exxon issue a joint proclamation about progress in biofuels derived from algae. Venter gets funded, Exxon gets green cred, breathless articles get written in the business press, and we are once again reminded that algae is the fuel of the future.

Venter has made brilliant contributions to modern genetics. He was part of the team that sequenced the second human genome.

Still, the team of Exxon and Synthetic Genomics have been working on algal biofuels since 2009, and although they are claiming a biofuel "breakthrough" in their latest release, the time frame for commercialization verges on generational as opposed to the decade-scale

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El modelo “sólo energía”

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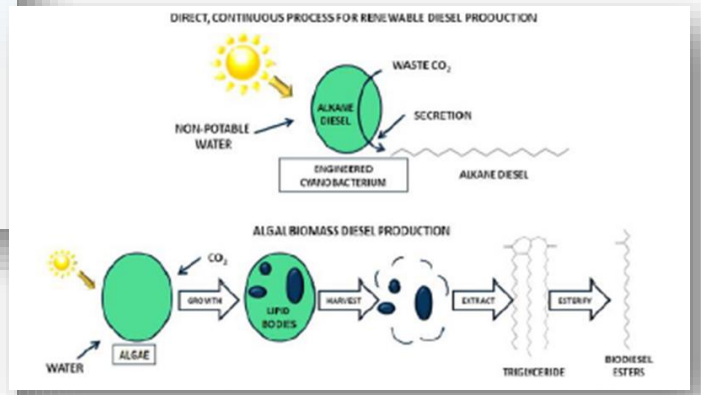
Press Releases

JOULE AND RED ROCK BIOFUELS ANNOUNCE INTENT TO MERGE, CREATING AN INDUSTRY-LEADING CARBON-NEUTRAL FUEL PRODUCTION PLATFORM

11/12/2015 Bedford, MA and Ft. Collins, CO Joule, the pioneer of liquid fuels from recycled CO2, and Red Rock Biofuels, a leading developer of renewable jet and diesel fuel bio-refineries, today announced their intent to merge. Red Rock adds a proven technology pathway to Joule's own Helioculture technology and strengthens Joule's platform for global supply of carbon neutral fuels. The transaction is expected to close during the coming 30 days.

In association with this merger, after a year of important service at a critical transition phase for the company, Joule also announced that President and CEO, industry veteran Mr. Serge Tchuruk, will return to his previous board role. Dr. Brian Baynes, a current board member of both Joule and Red Rock and partner at Flagship Ventures, will succeed Tchuruk and will lead Joule as it enters a commercial deployment phase.

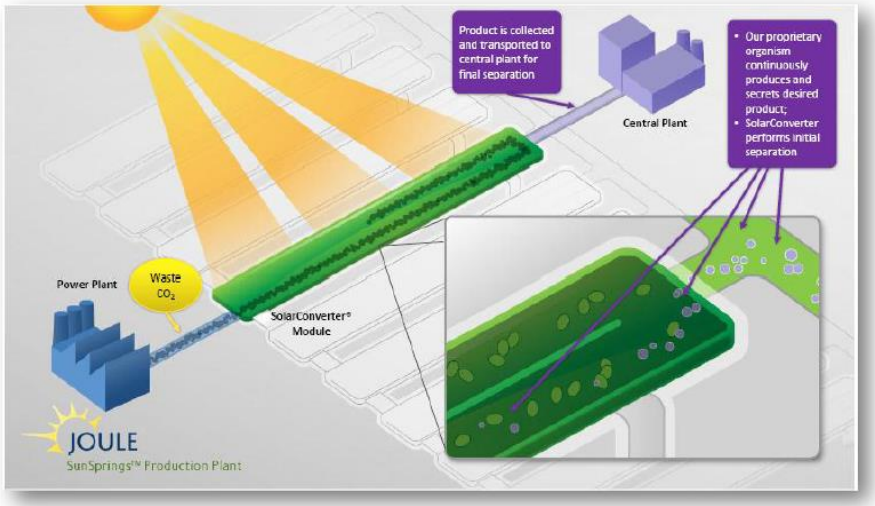


Joule *Sunflow-E*

- ✔ Requires only waste CO_2, sunlight and non-potable water
- ✔ Produced in a single-step conversion, with no downstream processing
- ✔ Available in high volumes at competitive costs, targeting 25,000 gal/acre/year at approximately $1.28 per gallon
- ✔ Requires no depletion of agricultural land, fresh water or crops

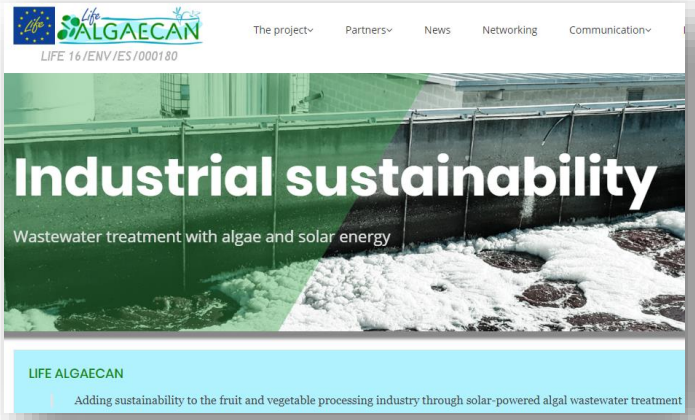
Conventional Ethanol

- ✖ Requires biomass feedstocks that fluctuate in price and availability
- ✖ Produced in a multi-step conversion, including biomass growth, collection and processing
- ✖ Productivities are limited (200 gal/acre/year for corn ethanol and 2,000 gal/acre/year for cellulosic ethanol)
- ✖ Requires use of agricultural land and, in some cases, f

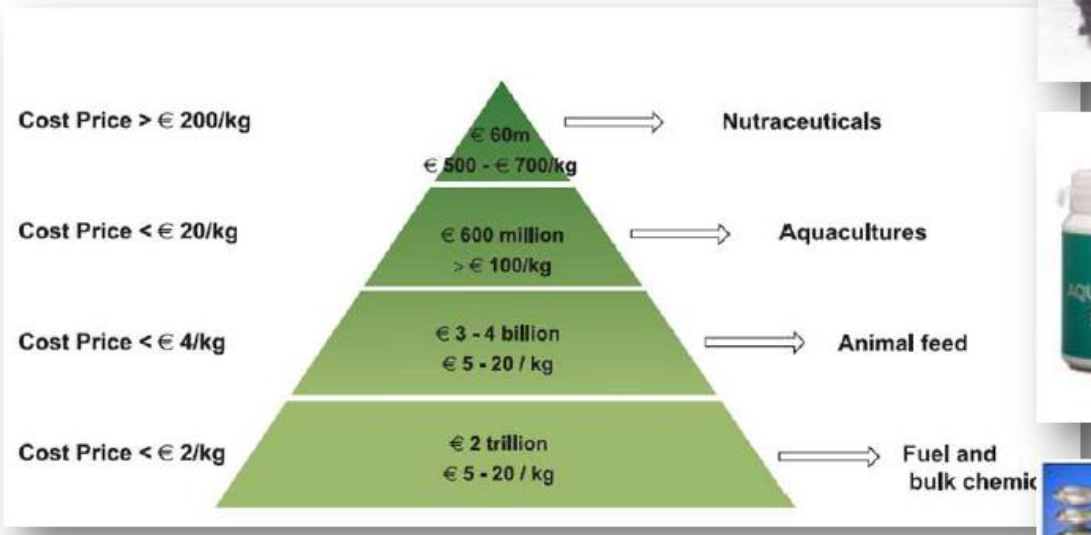


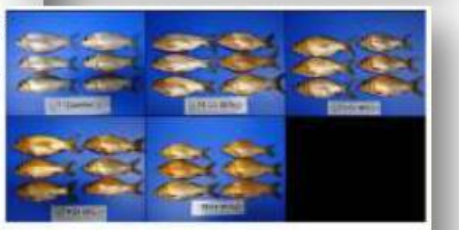
Sinergias con otros sectores

Sinergias con tratamiento de aguas residuales



Co-productos no energéticos

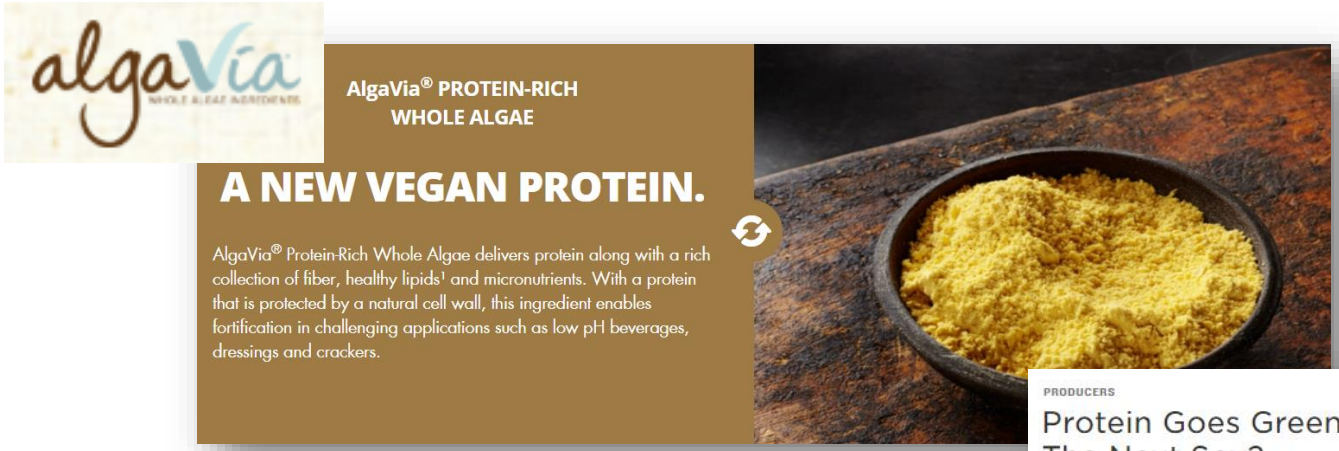


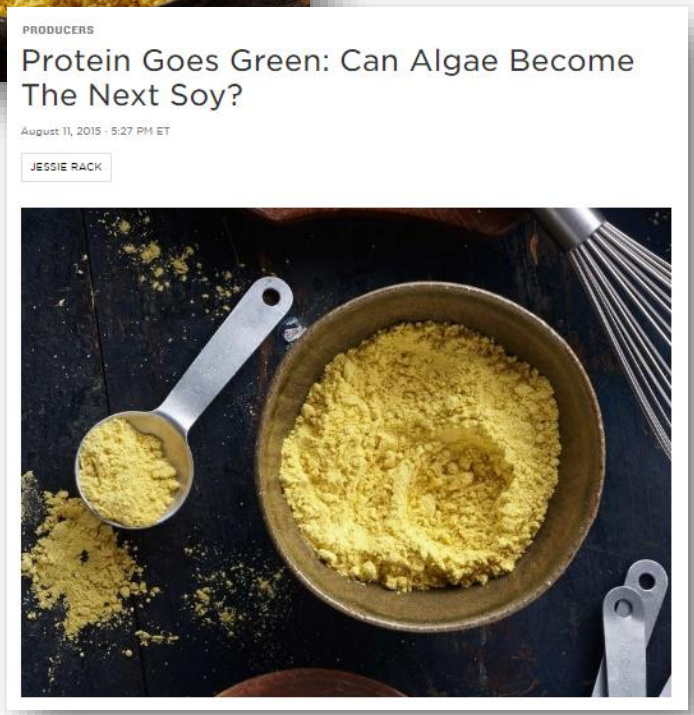


Carp grown on algae meal instead of fishmeal

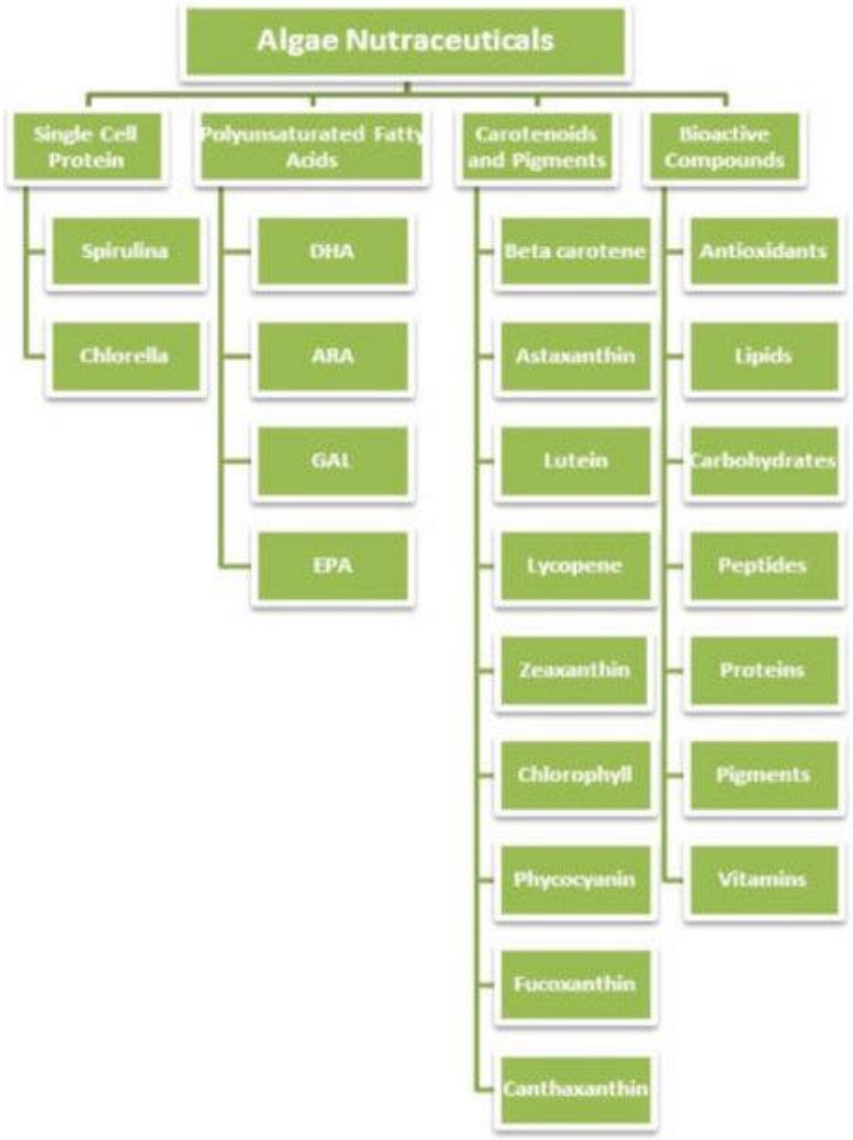
Co-productos no energéticos

Sinergias con producción de proteínas





Sinergias con producción de nutraceúticos



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GRACIAS