Potential in microalgae production in developing countries

GBEP Bioenergy Week, Maputo Mozambique, 2014

Food and Agriculture Organization of the United Nations
Microalgae has highest yields and can be grown everywhere

**Highest yields!**

<table>
<thead>
<tr>
<th></th>
<th>Liter per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapeseed</td>
<td>1,500</td>
</tr>
<tr>
<td>Palm</td>
<td>5,200</td>
</tr>
<tr>
<td>Algae*</td>
<td>45,000</td>
</tr>
</tbody>
</table>

* Algasol Renewables’ business case with productivity of 35 g/m²* day and oil content of 40%.

**Can be grown everywhere!**

**Multiple application areas!**

Algae biomass production based on active CO₂ sequestration:

- Human and animal nutrition (high value products)
- Transportation fuels
Limitations of Alternative Cultivation Systems

Open ponds
- High contamination risk
- Very low biomass concentration
- High energy consumption
- Fixed design
- Shading impacts concentration
- Need to circulate entire biomass
- Temperature control needed

Tube & Flat panels
- High CAPEX
- Shading impacts concentration
- Need to circulate entire biomass
- Temperature control needed

Fermentation
- Very high CAPEX
- Not industrially scalable
- Requires additional feedstock (sugar)
- Food versus fuel debate
Algasol versus conventional growth systems

**Algasol**

USD$ 52,500/ha

**Open ponds**

USD$ 500,000/ha

**Tube & Flat Panels**

USD$ 8,000,000/ha

**Fermentation**

USD$ 18,000,000+/ha
Algae Market Opportunities

Algasol enables access to numerous multibillion dollar industries, including:

animal feed (fishmeal), biofuels, nutraceuticals (DHA/EPA omega-3s), and pharmaceuticals
High Value Target Markets

- **Nutritional & Consumer Products**: $50+ Billion
- **Animal Feed**: $100+ Billion
- **High Value Chemicals**: $200+ Billion

Total: $350+ Billion

Source: FAO, Jeffries Research, US Grain Council, Index Mundi, IBISWorld
What makes Algasol’s floating PBR technology unique?

“Algasol Renewables provides a critical and innovative method for micro algae biomass production. Its modular floating bag technology, a new variation of photobioreactors (PBRs), provides a low-cost design coupled with industrial scalability, optimal light exposure, high biomass concentration, low energy consumption, and efficient system control.”

Floating PBR technology with superior ILUC profile

- Corn ethanol
- Cellulosic ethanol
- Brazilian sugarcane ethanol

ILUC?

- Algasol’s floating PBR technology
- Deployment directly in the ocean or in ponds on land (non-arable land)
Competitive Advantages Summary

1. **Universal Deployment**: non-arable land (in ponds) and in the oceans

2. **Lowest-Cost PBR**: both CAPEX & OPEX; Industrial Scalability

3. **High Yields and Concentrations**: optimal light exposure (limited photo inhibition), efficient stirring, temperature control, internal aeration system

4. **Resource Efficient**: water, energy, nutrients, CO2, material components of technology

5. **No Biofouling**

6. **Weather Protection System**
Outstanding Micro Algae Biomass Yields & Concentrations

Algasol’s biomass growth and concentrations exceeded lab and outdoor targets, achieving yields and concentrations as high as 70g/m²/day and 12g/L/day, respectively.

- Up to 100x greater biomass concentration than open ponds
- 2 to 3x greater biomass concentration than tube reactors
Highest Micro Algae Biomass Concentration

What determines biomass concentration (solid matter to total volume)?
• Light exposure, CO₂ distribution, PBR (sub-unit) volume, type of micro algae etc.

Dewatering through centrifuging a significant cost factor

• Centrifuge capacity [CAPEX]
• Energy consumption [OPEX]

➥ 40x more water in open ponds than tube reactors
➥ 70% less water in Algasol PBR compared to tube reactors
➥ Business case target exceeded in Alga4 PBR
PBR Price List

“Plug-and-play” PBR – low cost, high yield and industrially scalable

<table>
<thead>
<tr>
<th>PBR</th>
<th>Surface Area [(\text{M}^2)]</th>
<th>Reactor Volume [(\text{M}^3/\text{Liters})]</th>
<th>Price* (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alga4</td>
<td>10</td>
<td>0.5/500</td>
<td>2,175</td>
</tr>
<tr>
<td>Alga5</td>
<td>40</td>
<td>2/2,000</td>
<td>2,475</td>
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<tr>
<td>Alga6</td>
<td>250</td>
<td>12.5/12,500</td>
<td>3,375</td>
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*X-Warehouse, excluding, if applicable, sales tax
3 main components of the patent:

1. Concept of controlling the position of a closed photobioreactor by providing a density difference between the algae culture inside the photobioreactor and the surrounding water

2. Density Management System for submerging/angling the PBR

3. Internal Aeration System
Questions?