Outdoor flatpanel endless foil reactors for onshore and offshore production

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Contact: l.thomsen@jacobs-university.de
Terrestrial Resources

⇒ There is an increasing land demand for food, feed and bio energy production for the rising world population
⇒ The land currently available will develop a strong yield reduction due to climate change

Beringer et. al.: Bioenergy Production Potential of Global Biomass Plantations .., GCB Bioenergy 2011
Marine Resources

98% seawater
1.6% ice
0.4% groundwater, rivers, lakes

2,500 litres of fresh water is needed to produce:
- food for one person for one day
- 1 litre of biofuel (UN)

from Field et al. (1998) and Duarte et al. (2009)
Microalgae-based products for the food and feed sector: an outlook for Europe

- Europe lacks of optimal surface areas for the production of micro-algae. Moreover, Europe has some structural financial-economic disadvantages: relatively high labour costs, lack of venture capital and seed capital for start-up companies, low entrepreneurial activity among researchers and engineers, low R&D investments by large companies, high land costs and low internal demand for microalgae-based food and feed products.
Synergies with industries

Solar energy

Wind energy

Fluegas

Waste water

Waste heat
## Research and Customer Projects

Phytolusions develops and markets technologies and processes for the efficient use of microalgae as a source for high-value products, chemicals and fuels.

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Partner</th>
<th>Aim</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Eon</td>
<td>CO₂ mitigation and biofuels</td>
</tr>
<tr>
<td>2008</td>
<td>Partner Austria</td>
<td>Consulting open pond</td>
</tr>
<tr>
<td>2008</td>
<td>RWE-Installation</td>
<td>CO₂ mitigation, biofuels, development phytobags</td>
</tr>
<tr>
<td>2009</td>
<td>VW</td>
<td>Biofuels</td>
</tr>
<tr>
<td>2010</td>
<td>EFRE-Installation</td>
<td>Wasteheat/Wasterwater Synergies</td>
</tr>
<tr>
<td>2012</td>
<td>EFRE-Installation</td>
<td>Biogas and biochemicals</td>
</tr>
<tr>
<td>2012</td>
<td>EU</td>
<td>Waste-oils and application</td>
</tr>
<tr>
<td>Since 2012</td>
<td>AIREG</td>
<td>Foundation member</td>
</tr>
<tr>
<td>Since 2013</td>
<td>Installation China</td>
<td>CO₂ mitigation and high value products</td>
</tr>
<tr>
<td>Since 2013</td>
<td>TROPOS EU</td>
<td>Offshore platforms and synergies</td>
</tr>
<tr>
<td>Since 2013</td>
<td>Installation Italy</td>
<td>Synergy with solar panels and Greenhouse</td>
</tr>
<tr>
<td>Since 2013</td>
<td>FNR-Aufwind</td>
<td>Aviation fuels</td>
</tr>
<tr>
<td>2014</td>
<td>ILA airshow</td>
<td>Presentation and Exhibition</td>
</tr>
<tr>
<td>2014</td>
<td>EFRE-Installation</td>
<td>Automatisation of production</td>
</tr>
<tr>
<td>2015</td>
<td>Waste water plant</td>
<td>Wastewater, recycling of nutrients</td>
</tr>
</tbody>
</table>

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Development of the **Phytobag** (10 – 15 m long 300 -500 l each)

Contact: l.thomsen@jacobs-university.de
Expertise: Production Site Bremen (-15 to + 40 °C)

Development of 2-step separation

2010

12 m Phytobags, each containing ≈ 300 l

Temperature control via waste heat

Cost- and energy efficient installation

CO₂ from flue gas

Pre-concentration and dewatering method
Volume 16,000 l

<table>
<thead>
<tr>
<th></th>
<th>Data from 2015 Final concentration (g/l)</th>
<th>Total energy consumption (kWh/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvester</td>
<td>15-20</td>
<td>0.37</td>
</tr>
<tr>
<td>Centrifuge 1</td>
<td>150-200</td>
<td>2.56</td>
</tr>
<tr>
<td>Centrifuge 2</td>
<td>150-200</td>
<td>1.11</td>
</tr>
<tr>
<td>Harvester + Centrifuge 1</td>
<td>150-200</td>
<td>0.56</td>
</tr>
<tr>
<td>Harvester + Centrifuge 2</td>
<td>150-200</td>
<td>0.46</td>
</tr>
</tbody>
</table>

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500 m² outdoor photobioreactor installation

Contact: l.thomsen@jacobs-university.de
Expertise: Production Site China (-5 to +45 °C)

2014
15 m phytobags, each containing ≈ 500 l
Temperature control
Cost- and energy efficient installation

Installation phytoplant 1000m² site (40 – 50 m³)

Contact: l.thomsen@jacobs-university.de
Nitrogen starvation and increase of lipid content

- After harvesting the culture can restart and nutrients addition the culture can recover and restart the growth (right)
- Duration and level of starvation must be controlled in order to facilitate the recovery of the culture

Contact: l.thomsen@jacobs-university.de
“The worldwide aviation industry consumes some 250 billion litres of Jet A-1 annually. Analysis suggests that a viable market for biofuels can be maintained when as little as 1% of world jet fuel supply is substituted by a biofuel (or, put another way, 10% of the world’s aircraft fleet is running on a blend of 10% biofuel and 90% Jet A-1)”

www.enviro.aero/biofuels
Project Aufwind : Biokerosine

Contact: l.thomsen@jacobs-university.de
Residual biomass for biogas production and sequestration

Specific cultivation methods

Conversion

1st Extraction

2nd Extraction

Proteins and carbohydrates, antiviral, antioxidants, pigments.

Different pre-treatment and extraction methods

Residual biomass
Going offshore
Nannochloropsis (30t/ha)

Laminaria (10t/ha)

Soy (3t/ha)

25 % Proteins

12 % Proteins

36 % Proteins

25 % Lipids

2 % Lipids

12 % Lipids

Contact: l.thomsen@jacobs-university.de
The Green & Blue Concept

- A concept with Floating offshore platform infrastructure, focusing on the use of Physical and Biological Ocean resources combining
  - aquaculture facilities (producing both fish and algae)
  - energy harvesting units (offshore wind farm, waves, currents, solar, OTEC, etc.)

Pilot scale Algae aquaculture unit at HCMR cage facility

- Synergies
- Environmental Impact
- Monitoring

Contact: l.thomsen@jacobs-university.de
R&D on high value products

Algae Biomass

- Antioxidant Colouring
- Anti-microbial substances
- Feed
- Algae Oils & PUFA

High volume products energetic Use

Oyster feed
Pigglets feed
Pet food
• Jacobs University Bremen: research and training of young academia in algae research

• Phytolutions is open for strong partnerships in regard to moving forward in the high value and biofuel case

• A customer relationship for high value products has been established

• The technology is patent pending in EU and China

• Granted utility patent in China