1. Introduction
- There are environmental and economic conflicts because of diesel use.
- Biodiesel as a renewable fuel solution:
  - Strategies created by government – financial incentives and mandatory targets and blending;
  - First and second generation biodiesel use cropland – insufficient land to cultivate feedstock;
  - Selected cases: European Union (EU), United States (US) and Brazil (80% of the global biodiesel production).
- Third generation biodiesel from Algae:
  - Higher productivity per area, e.g. in open ponds, photobioreactors or sea (Figures 1, 2 and 3);
  - Higher lipid content;
  - Non-productive and non-arable land is used.

Objective: Calculate the area requirement to produce algal biodiesel.

2. Methodology

3. Necessary Biodiesel Volume Production

<table>
<thead>
<tr>
<th>Directive</th>
<th>Target</th>
<th>Necessary Biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>EU Directive 2009/28/EC</td>
<td>10% of biofuel in transport by 2020 (27 billion litres)</td>
</tr>
<tr>
<td>USA</td>
<td>Energy Independence and Security Act</td>
<td>79.5 billion litres of advanced biofuel by 2022 (56.8 billion litres)</td>
</tr>
<tr>
<td>Brazil</td>
<td>Mandatory Biodiesel Requirement</td>
<td>85 – Blending of 5% (3.5 billion litres)</td>
</tr>
</tbody>
</table>

Necessary biodiesel to replace diesel use = (Diesel consumed 2020 / 0.93) + Biodiesel consumed 2020 – Current Installed Capacity

4. Biodiesel Production

$$BP = BM \times LC \times PE \times \frac{1}{P} \times n \times c$$

- BP: Biodiesel Production (L.ha⁻¹.year⁻¹)
- BM: Dry biomass production per day (g.m⁻².d⁻¹)
- LC: Lipid content (10%, 20%, 30% and 50%)
- PE: Process Efficiency (80%, 90% and 100%)
- P: Oil Algae Density (0.85 kg/l)
- n: number of operation days (210 and 300 days/year)
- c: Factor of unit corrections of mass and area

Results: From 593 L.ha⁻¹.year⁻¹ to 176,471 L.ha⁻¹.year⁻¹

5. Area Requirement

Selected Open Pond Productivity: 30,000 L.ha⁻¹.year⁻¹
Facility: 2/3 cultivation + 1/3 infrastructure

<table>
<thead>
<tr>
<th></th>
<th>Total area (km²)</th>
<th>Necessary area to achieve the targets (km²)</th>
<th>Replacing the diesel percentage of the total area (%)</th>
<th>Comparative scale of area</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>4,132,472</td>
<td>13,500</td>
<td>149,310</td>
<td>3.61</td>
</tr>
<tr>
<td>US</td>
<td>9,826,675</td>
<td>28,400</td>
<td>106,665</td>
<td>1.09</td>
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<tr>
<td>Brazil</td>
<td>8,514,877</td>
<td>1,750</td>
<td>29,720</td>
<td>0.35</td>
</tr>
<tr>
<td>World</td>
<td>148,940,000</td>
<td>-</td>
<td>811,555</td>
<td>0.54</td>
</tr>
</tbody>
</table>

6. Conclusion
- Each assumption in the biodiesel production formula has influence on the final productivity result;
- Improvement in the reliability of sources of productivity data is necessary;
- Minimum of productivity needs to be achieved – Current commercial cultivation at open ponds are not viable for scale up;
- Cultivation area requirement to achieve the current targets is easily attainable;
- It is possible to replace fossil derived diesel based on area requirement;
- Offshore technologies – Photobioreactors and Macroalgae cultivation – should be considered as alternative to land options.

References
1. Figure 1: http://www.nbcnews.com/sites/uploads/2011/04/13/algaecond2.jpg
2. Figure 2: http://blog.huffingtonpost.com/2011/04/13/algae-nursery_016.jpg
3. Figure 3: http://www.minneapollitylist.com/2013/01/seaweed-candy1.jpg
4. Figure 4: http://www.minneapollitylist.com/2013/01/seaweed-candy1.jpg
5. Figure 5: http://www.minneapollitylist.com/2013/01/seaweed-candy1.jpg
7. Figure 6: http://www.minneapollitylist.com/2013/01/seaweed-candy1.jpg
8. Figure 7: http://www.minneapollitylist.com/2013/01/seaweed-candy1.jpg