Assessment of Algae Biodiesel Viability Based on Area Requirement

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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 algae biodiesel.

2. Methodology

Necessary Biodiesel Volume Production in 2020
- Established by targets
- Replacement of diesel

→ Area Requirement ← Biodiesel Production per area

Algae Cultivation

Figure 1: Open Pond[1]

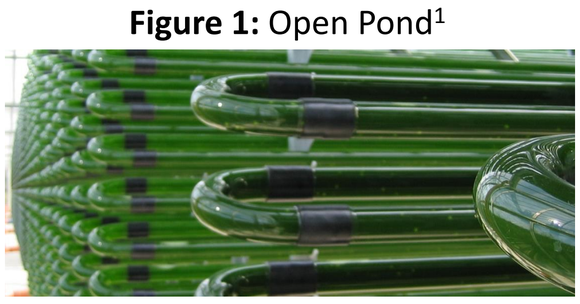

Figure 2: Photobioreactor[2]

Figure 3: Fish Farming[3]

3. Necessary Biodiesel Volume Production

Table 1: Biodiesel to achieve the targets

	Directive	Target	Necessary Biodiesel
EU	EU Directive 2009/28/EC[2]	10% of biofuel in transport by 2020	27 billion litres
USA	Energy Independence and Security Act[3]	79.5 billion litres of advanced biofuel by 2022	56.8 billion litres
Brazil	Mandatory Biodiesel Requirement[4]	B5 – Blending of 5%	3.5 billion litres

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

Table 2: Biodiesel to replace the diesel

	Necessary Biodiesel
EU	298.62 billion litres
US	213.33 billion litres
Brazil	59.44 billion litres
World	1623.11 billion litres

4. Biodiesel Production

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

- 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}

Figure 4: Macroalgae[7]

Figure 5: Microalgae[8]

5. Area Requirement

Selected Open Pond Productivity: **30,000 L·ha^{-1}·year^{-1}**

Facility: 2/3 cultivation + 1/3 infrastructure

Table 3: Area Requirement in 2020

	Total area[7] (km²)	Necessary area to achieve the targets (km²)	Replacing the diesel		
			Necessary area (km²)	Percentage of the total area (%)	Comparative scale of area
EU	4,132,472	13,500	149,310	3.61	1/2 Italy
US	9,826,675	28,400	106,665	1.09	Tennessee State
Brazil	8,514,877	1,750	29,720	0.35	2/3 Rio de Janeiro State
World	148,940,000	-	811,555	0.54	1/10 Brazil

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

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