Using TEA/LCA as a Design Tool: Results for a 100-ha Facility

Corresponding Journal Article:
Economically competitive algal biofuel production in a 100-ha facility: a comprehensive techno-economic analysis and life cycle assessment
Algal Research, In Review (Pre-prints Available)

Cornell Marine Algal Biofuels Consortium
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Cornell Marine Algal Biofuels Consortium
(Funding: Shell 2007 - 2011, DOE/USDA 2011 - 2014)

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**Animal Feed Trials:**
Biomass was fed to poultry, swine, and fish

Cornell Animal Science Department:

University of Nordland Biosciences and Aquaculture:
100-ha Facility Design

- **80 Ponds**: 1-ha ea.
- **480 PBRs**
- **92 ha Lit Area**
- **114,000 m³ Culture**
- **Natural Settling Algae**
- **Gravity Flow**
- **Waste CO₂**
- **Nutrient Recycling**
TEA/LCA can be a design tool, instead of an afterthought

10 Cases Evaluated in Texas and Hawaii (20 Total Cases):

Problems: Silica Dissolution, High Ash Content, Low Nitrogen = Low Yield, 24 hr/d Paddlewheels, Expensive Liner, Inefficient Processing Methods
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10 Cases Evaluated in Texas and Hawaii (20 Total Cases):

Major Design Changes Based on TEA/LCA:

1) Green algae are more favorable than diatoms
2) High nitrogen loading outperforms low nitrogen loading
3) Airlift pond circulation is more efficient than paddlewheels
4) Low-cost pond liners or clay pond designs are more economical
5) Wet extraction processes reduce energy demands
6) Renewable electricity sources provide major LCA benefits
TEA/LCA can be a design tool, instead of an afterthought

10 Cases Evaluated in Texas and Hawaii (20 Total Cases):

Technology Process Lineup: Cases 2-10

Wet routes to fuel and feed

Solutions: Green Algae = No Silica & Low Ash Content, High Nitrogen = High Yield, Inexpensive Nutrients, 16 hr/d Airlifts, Less-expensive Liner, Wet Processing Methods, Wind Power
Energy Impacts (GJ/day)
(inputs are negative, outputs are positive)

Categorization of energy inputs and outputs:
- Animal Feed
- Biocrude
- Other
- Extraction Heat
- Extraction Electricity
- Centrifuge or Filter Press
- Silicon
- Phosphorus
- Nitrogen
- Carbon Transport
- Pond Circulation
- PBR Circulation
- Water Supply

EROI = output/input (shown above bars)
Operating Costs and Revenues ($/day)
(costs are negative, revenues are positive)

Min. Feed Price in $/MT (shown above bars)

Min. Biocrude Price in $/L (shown below bars)
Details of LCA impact contributions for Cases 4T, 6T, 7T and 8T (positive is for harmful impacts, negative for beneficial substitutions of products)
Large Scale Impacts: Case 4T & 10T

Case 4T is a Base Case. Case 10T is a Target Case. For satisfying the second generation biofuels mandate in the Renewable Fuels Standards (18.9 billion L/yr):

1) Nitrogen Demand: 2.8 million MT (4T), 3.7 million MT (10T) = 24% & 32% of all U.S. nitrogen consumption

2) Phosphorus Demand: 0.3 million MT (4T), 0.4 million MT (10T) = 16% & 21% of all U.S. phosphorus consumption

3) Land: 750,000 ha (4T), 900,000 ha (10T) = roughly the size of Delaware

4) Displaces 92% (4T) & 158% (10T) of U.S soy meal production

5) Avoided soy production would save 2.2 billion (4T) & 4.0 billion (10T) m$^3$ of fresh water per year = demand of ~8 million & 15 million Californians (6X & 11X the population of San Diego)

6) Roughly zero overall environmental impact (4T) and significant environmental benefits (10T)

7) EROI = 1.16 (4T) similar to corn ethanol and 3.24 (10T)

8) Minimum biocrude and animal feed prices: $2.92/L and $2,400/MT for 4T and $1.60/L and $1,255/MT for 10T
Thank you

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