

OPTIMIZED PROCESS SYNTHESIS OF BIODIESEL PRODUCTION FROM MICROALGAE

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Motivation and Approach:

- Microalgae- A promising source of renewable energy, especially for India
- Techno-economic feasibility not yet achieved
- Multitude of alternatives at each step
- Model based superstructure optimization
- Integration of flowsheet and design optimization

Optimization model features:

- Mass balance across processes
- Performance of process, a function of design and operating parameters
- Cost expressions for equipments
- Objective: Minimize Net ALCC
- Scheduling based on batch time

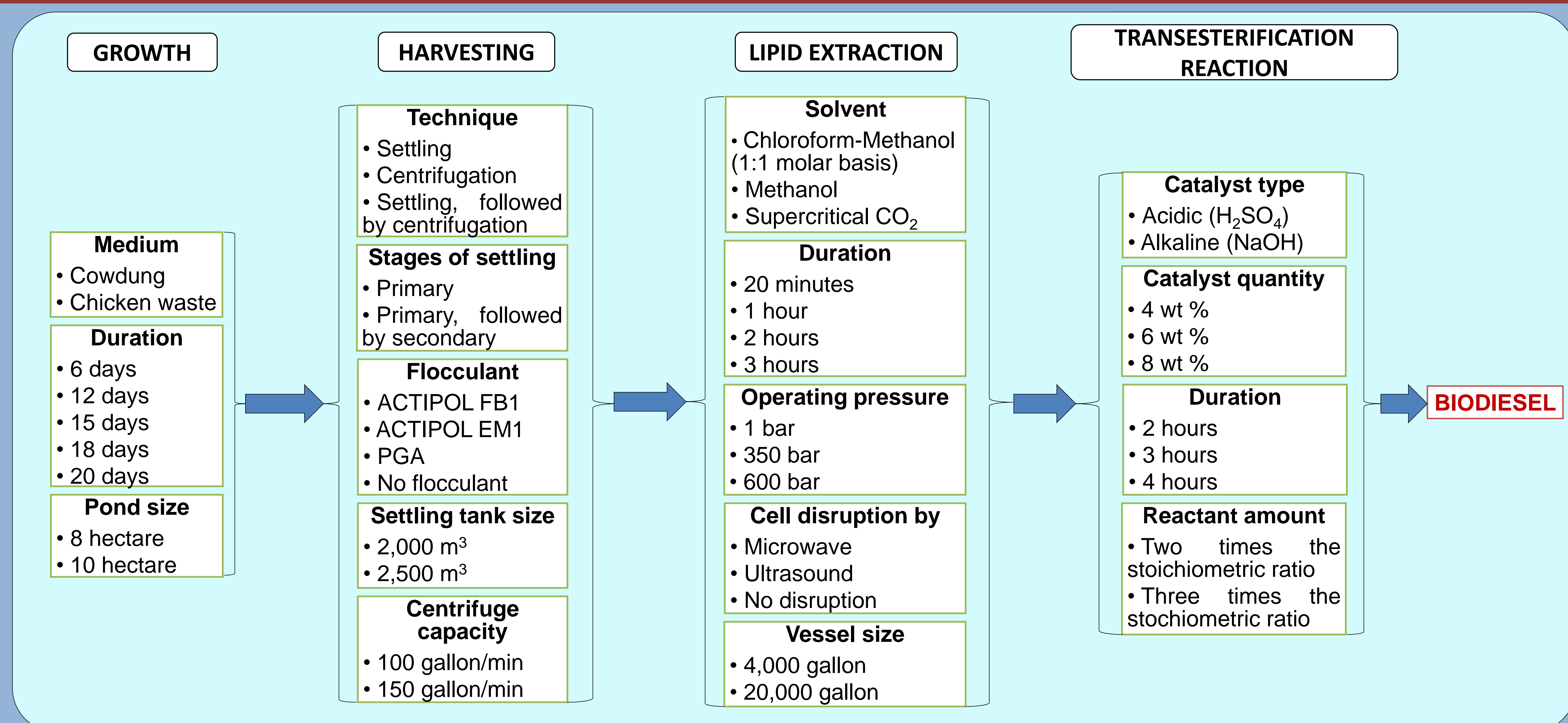
Conclusions:

- Production cost (Base case): **US\$ 13.286/L**
- Step of growth: **88 %** of net cost
- Critical decision making for lipid extraction

Future work:

- Integrated co-generation of products
- Integration with flue gas and waste water

Biodiesel from microalgae: Processes and the superstructure



Results: Scenarios for production of 30 tons/day biodiesel from *Chlorella sp.*

Cases	Base Case		Heterogeneous strain		Supercritical lipid extraction	
	Net cost (US \$/L)	Optimized model decisions	Net cost (US \$/L)	Optimized model decisions	Net cost (US \$/L)	Optimized model decisions
Steps of the process	13.286		3.331		15.032	
Growth of microalgae	11.662	• Medium of chicken waste for 18 days in 3024 ponds (10 ha each)	2.499	• Medium of chicken waste for 18 days in 648 ponds (10 ha each)	2.916	• Medium of chicken waste for 18 days in 756 ponds (10 ha each)
Harvesting of solution	0.829	• Settling with ACTIPOL FB1 (1635 kg/batch) in 218 tanks (2500 m ³ each)	0.173	• Settling with ACTIPOL FB1 (340 kg/batch) in 46 tanks (2500 m ³ each)	0.205	• Settling with ACTIPOL FB1 (404 kg/batch) in 54 tanks (2500 m ³ each)
Lipid extraction	0.13	• Solvent: Chloroform : Methanol 1:1 (4663 L/batch) • Duration: 2 h • Vessel: 223 in number (20,000 gallon each)	0.029	• Solvent: Chloroform : Methanol 1:1 (1146 L/batch) • Duration: 2 h • Vessel: 47 in number (20,000 gallon each)	11.285	• Solvent: Supercritical CO ₂ (960 tons/batch) @ 600 bar • Duration: 3 h • Vessel: 275 in number (4,000 gallon each)
Trans-esterification reaction	0.665	• Alcohol: 2 times the stoichiometric (1241 kg/batch) • Catalyst: Alkaline (6 wt %) (341 kg/batch) • Duration: 4 h • Reactor: 18 in number	0.63	• Alcohol: 2 times the stoichiometric (1233 kg/batch) • Catalyst: Alkaline (6 wt %) (333 kg/batch) • Duration: 4 h • Reactor: 5 in number	0.626	• Alcohol: 2 times the stoichiometric (1241 kg/batch) • Catalyst: Alkaline (6 wt %) (341 kg/batch) • Duration: 4 h • Reactor: 1 in number