

# The Algalrithm

Turning Algae into Bio-surfactants

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# Project Definition:

Utilize algae as a way to collect CO<sub>2</sub> emissions from industrial plants, then harvest the algae and extract the energy dense lipids. Our objective is to reduce the carbon footprint in the production of a bio-surfactant, and create this product with an economic and environmentally friendly process.

# Commercial Uses of Algae



Biogas



Bioethanol



Biodiesel



Biobutanol

**Biofuel**



**Bioplastics**



**Feedstock**



**Cosmetics**



**Nutraceuticals  
Pharmaceuticals  
Vitamins**



**Food**



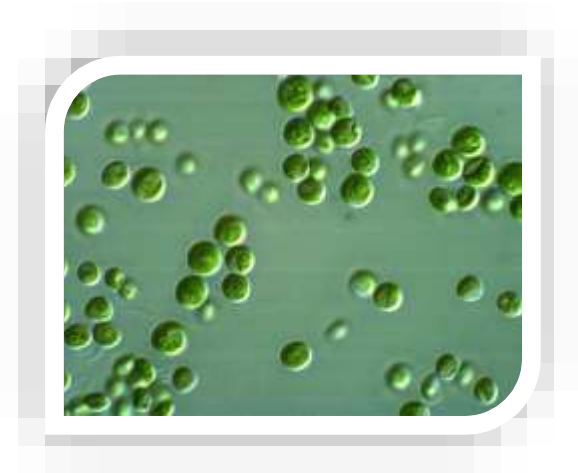
**Animal feed**

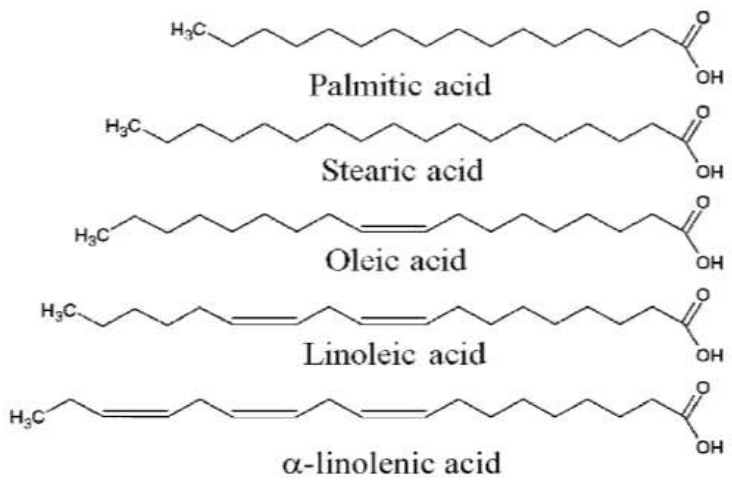


**Fertilizer/nutrients**

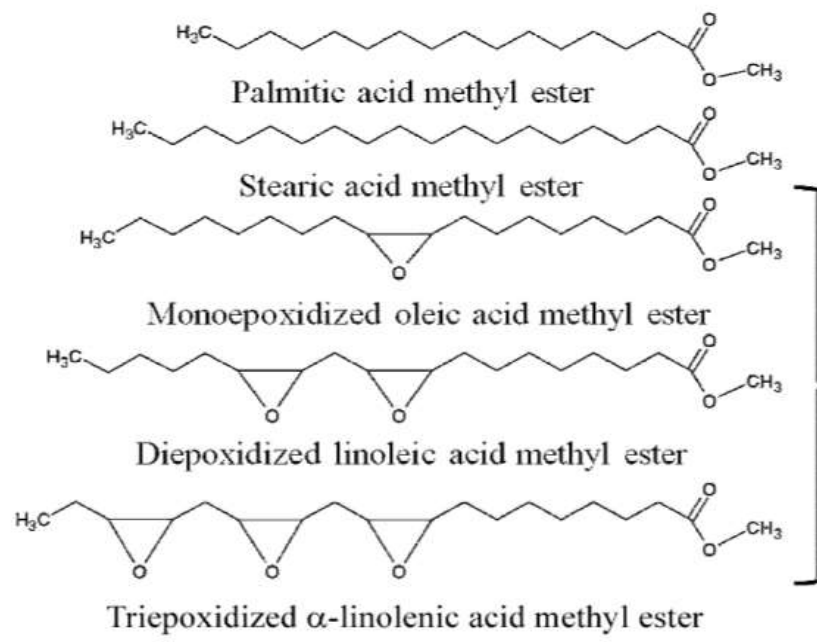
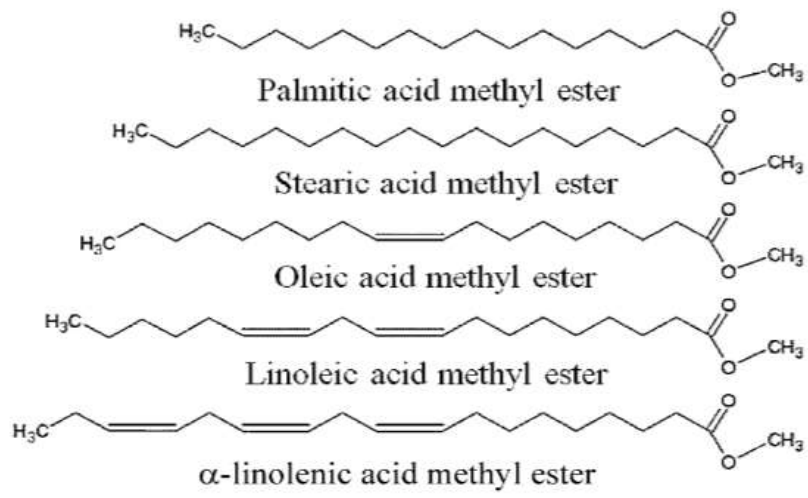
# Bio-surfactants

- Bio-surfactants vs. traditional surfactants
  - Absence of toxicity
  - Biodegradability
  - Eco-friendly
- Bio-surfactants vs. Bio-based surfactants
  - Currently produced by:
    - Soybean, linseed, canola, sunflower, and rubberseed oils





Replace  
 Chloroform with  
 Dichloromethane  
 $\xrightarrow{\text{CH}_3\text{OH}:\text{HCl}:\text{CHCl}_3, (10:1:1, \text{v/v/v})}$

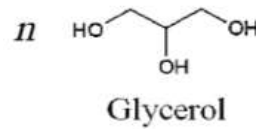
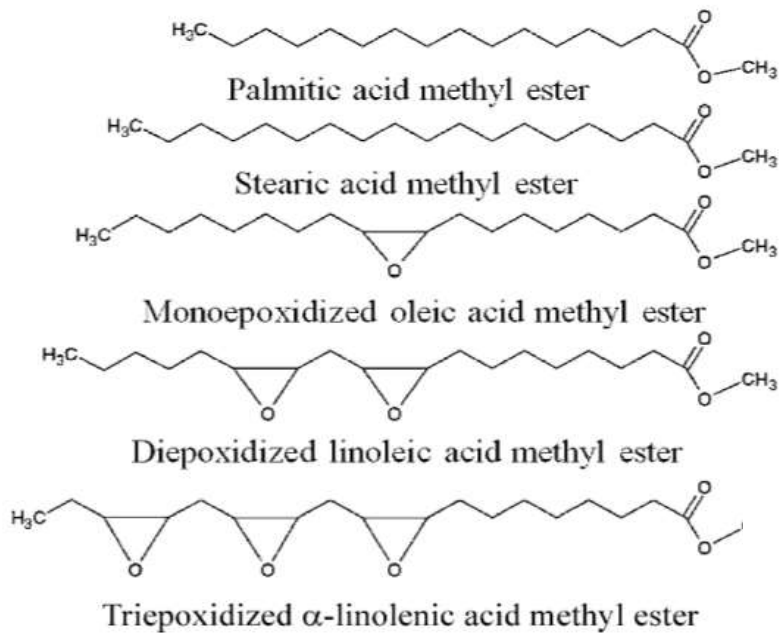


Plasticizer

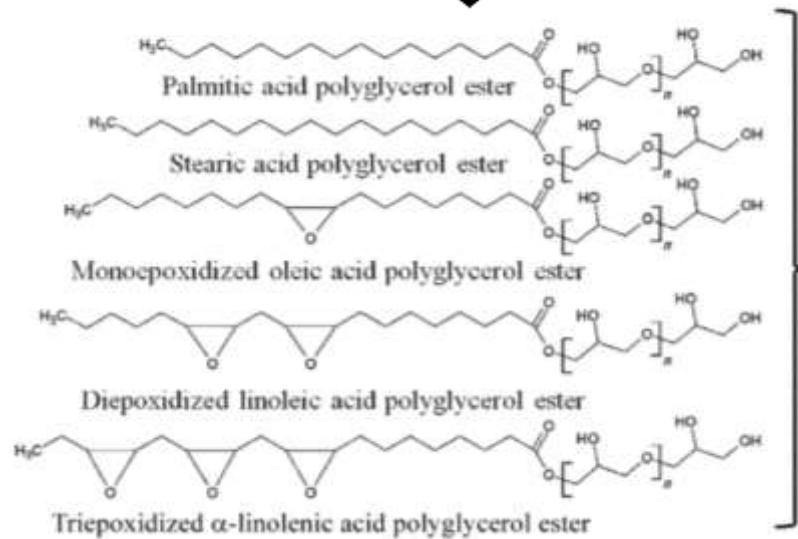
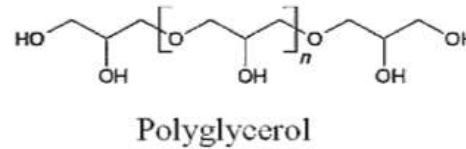
Possible side product

$\xleftarrow{\text{FAMES:30\% H}_2\text{O}_2:\text{toluene} (1:10:5, \text{w/w/v}), 4 \text{ mol CHO OH}}$





Glycerol:NaOH  
(10:1, w/w)



Surfactant

# Business Opportunity



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# Wastewater

- Why use wastewater?
  - Cost effective
  - Low energy requirement
  - Production of chlorella algal biomass
- Agricultural, municipal, and industrial wastewaters
  - Agricultural WW is most common for algae cultivation
- Algal growth will depend on nutrients present in wastewater
- Permit for wastewater discharge will be needed



# Business Opportunity and Plan

- Environmental Benefits:
  - Recycling wastewater
  - Reducing oil-based surfactants and introducing promising bio-surfactants without toxicity
  - Sequestering CO<sub>2</sub> from high-producing industrial power plants
- Carbon Tax

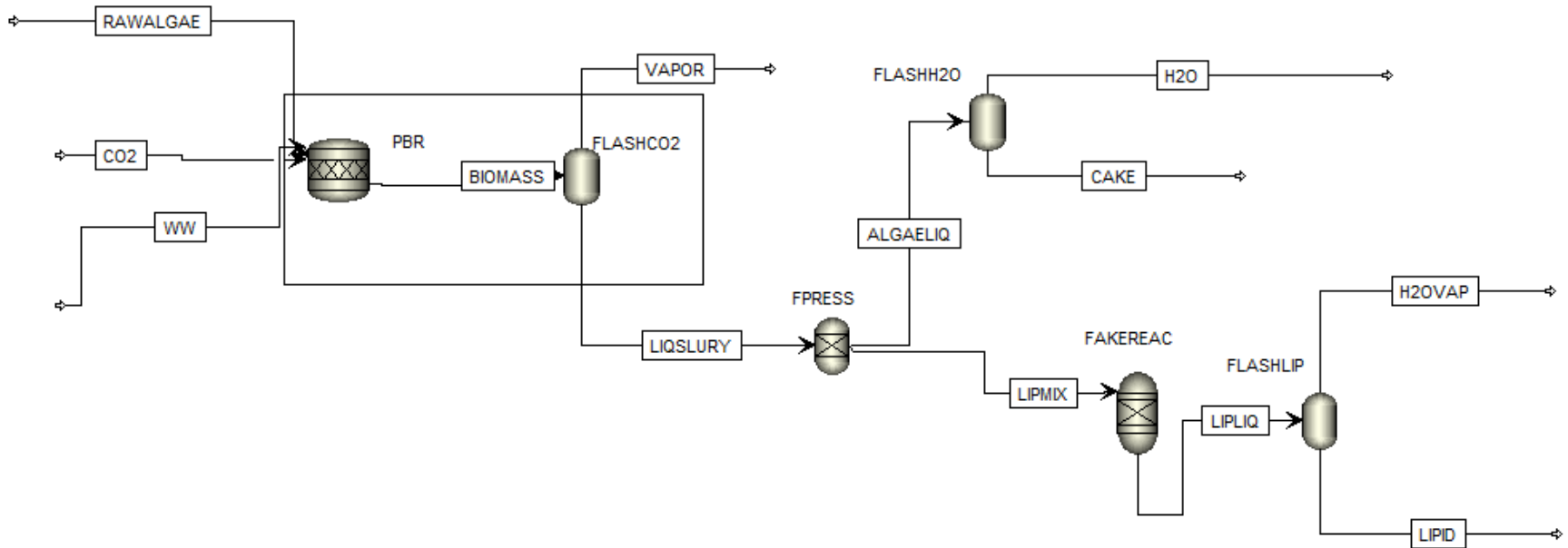


# Bio-surfactants Process Design

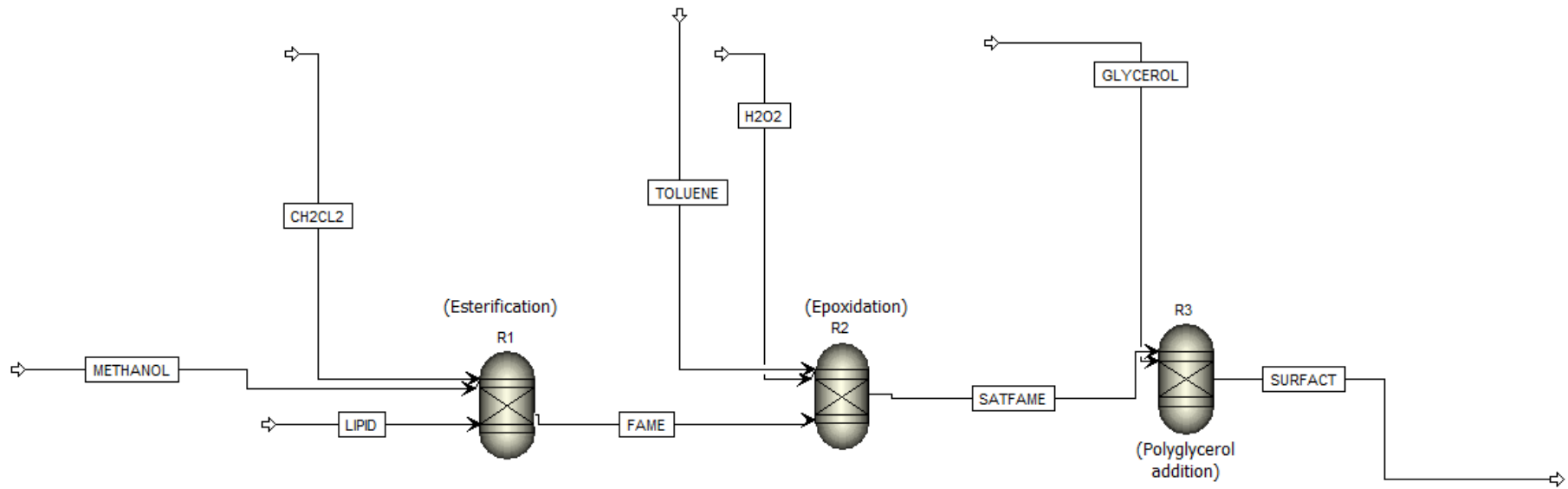


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# Algae Cultivation and Lipid Isolation



# Algal Lipid to Bio-surfactants



# Design Alternatives



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# Algae Cultivation Method

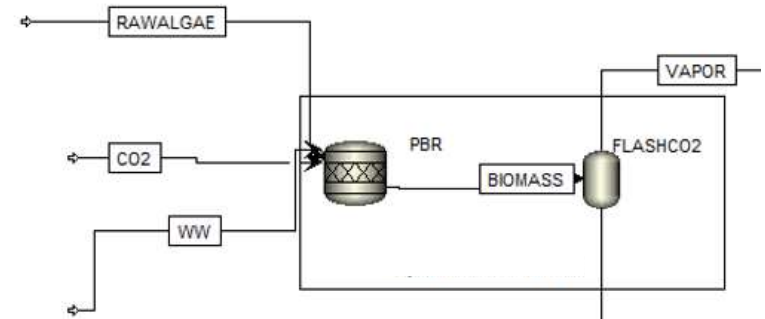


- Open Pond System

- Autotrophic growth (requires sunlight, no sugars required)
- Less expensive, variable production

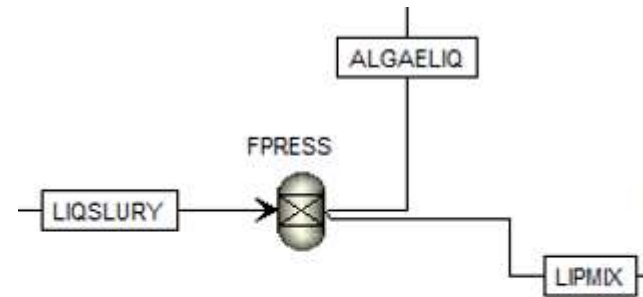
- Algae Fermentation Tank

- Heterotrophic growth (no sunlight, sugars required)
- Controlled, sterile growth
- More expensive, but greater efficiency and lipid yield



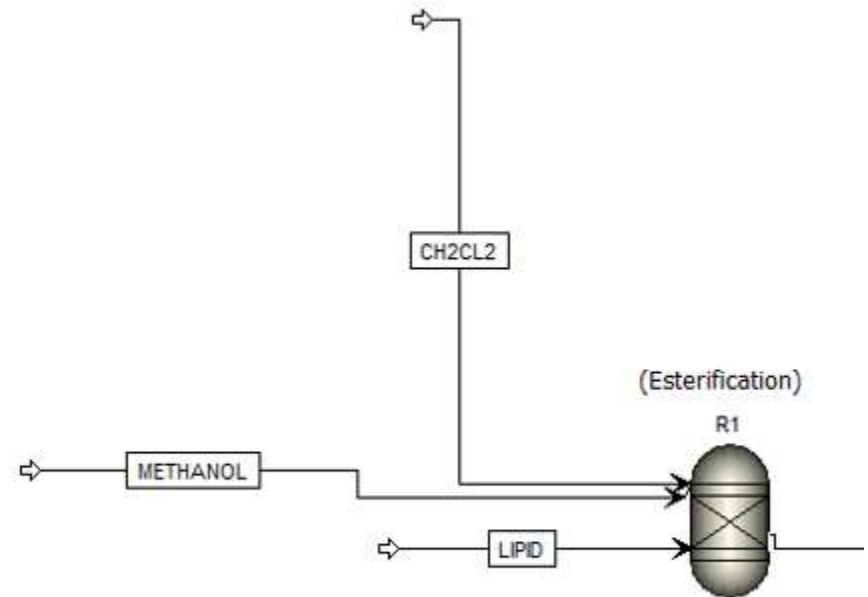
# Lipid Separation Method

- Mechanical Separation
  - Oil Press
  - Centrifuge
- Thermal Separation
  - Heater
  - Dryer
- Dissolved Air Flotation



# Solvent Extraction

- Dichloromethane & Chloroform Extraction
- Potential Hazardous Byproducts
- Dissolved Air Flotation
  - Hexane Removal





# Economics



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# Economics

- Assumptions:
  - 10 Photobioreactors, 1000m<sup>3</sup> ---> 475 lb<sub>m</sub>/hr product
  - Projected market to sell at 98 ¢/lb
  - Utilities, equipment, miscellaneous costs

Economics Summary (\$MM)	
Fixed Capital Investment	\$30
Start-Up Costs	\$1.12
Annual Revenue	\$13.41
Net Present Value (R= 12%)	\$9.54
Internal Rate of Return	16.7%
Pay Back Period(yrs)	4.7
Minimum Acceptable Rate of Return	12%

# Opportunities for Improvement

- Realistic carbon tax as a source of revenue
- Room for improvement on:
  - Equipment costs
  - By-product revenue sources
  - Utility/heat duty costs from our unit ops
- Second part of process
  - Cost of chemicals, and permits for waste

# The Future of The Algorithm



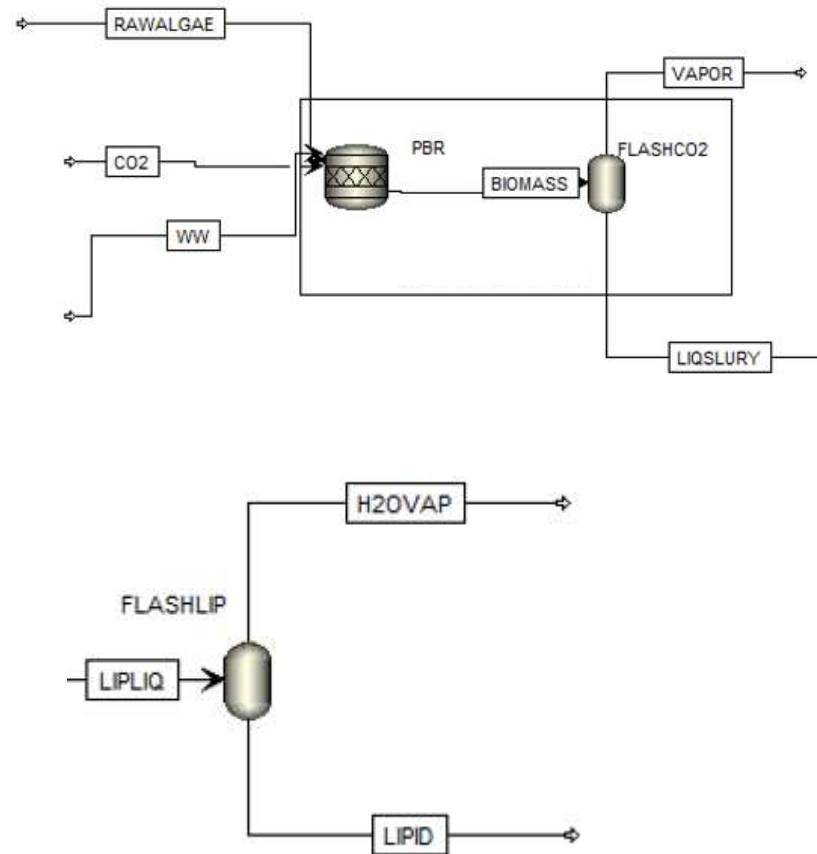
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# Moving forward with Bio-surfactants

- End-product verification
  - Molecular analysis
  - Physical property analysis
- Detailed economic analysis
  - Current & future market analysis
  - Unit operations and operating conditions of Part II

# Simulation Future Work

- PBR
  - Wastewater
  - Photosynthesis reaction
  - Separator for Vapor Stream
    - N<sub>2</sub> Gas
    - O<sub>2</sub> Gas
    - CO<sub>2</sub> Gas
    - Flare
- Water-Lipid Separation
  - Distillation Column
- Specifications of Part II



# Acknowledgments

- Special Thanks
  - John Oakey
  - John Myers



Questions?



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