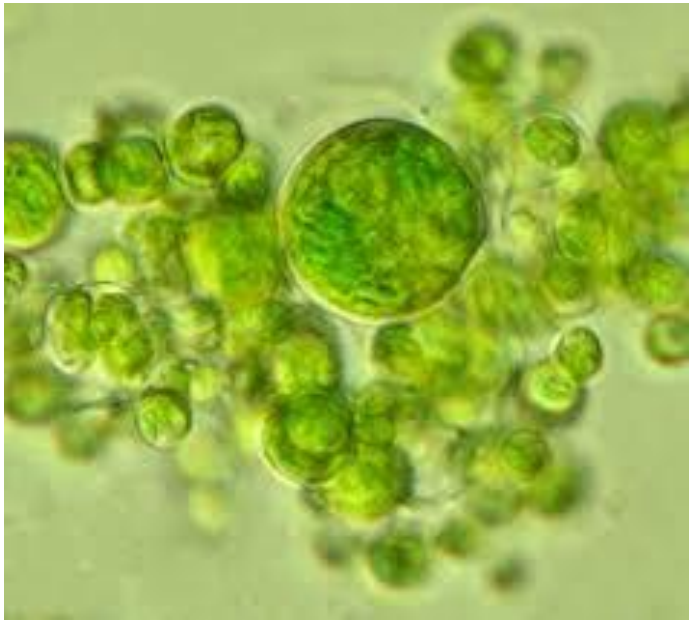
# Algae Growth for Biodiesel Production



Jonathan Pfingsten

# Background

- Research into Biodiesel began in in 1978 out of Carter oil crisis
- Large investment into development of biodiesel from the stimulus package
- Stricter emissions laws have paved way for cleaner fuels (CA especially)
- So-called “Green Revolution” has raised public awareness of alleged climate change pushing for clean alternatives to oil

# Science and Numbers Behind Algal Growth

- Half of algae's weight is lipid oil
- This oil can be converted into biodiesel
- Can be grown in open ponds, bioreactors, or even on the ocean surface
- Simple pond scum -- algae that sit on top of ponds -- is best suited for biodiesel
- Fertilizer and feedstocks can be created from the byproducts
- Can produce more than 100,000 gallons of algae oil per acre per year
- 140-200 billion gallons of algae biodiesel to replace petroleum-based products each year
- 95 million acres of land to build biodiesel plants, compared to billions of acres for other biodiesel products (corn, sugar cane, etc)

# Methods of Growth

# Open Pond

- Open pools, generally in hot regions (productive use of desert or arid regions)
- Non-invasive, yet susceptible to cross-contamination from other algae strands
- Susceptible to weather fluctuations
- Due to evaporation, vast amounts of fresh water are needed
- (picture on previous slide)

# Vertical Growth/Closed Loop

- Algae are grown in plastic containers stacked high (plastic bags can be used)
- Isolated from contamination, rain water (change in water temp)

# Bioreactors

- Closed tanks- Completely isolated systems
- Highly manipulated
- Can be harvested daily
- High output of oil, high production of fuel, easier to pump in additional CO2 and fertilizer but high capital costs

# Closed/Vertical Bioreactor

# Risks, Issues, and Solutions

- Exact water temperature needed
- Carbon dioxide has to be pumped into the ponds
- High risk of contamination  (closed bioreactor system to counteract these issues)
- Large amounts of freshwater, phosphorous, and nitrogen (though highly dependent on technology used)

# Risks, Issues, and Solutions (cont.)

- Current goal for biofuels made from algae: 5 percent of US transportation fuel
- Equates to 10 billion gallons of biofuel
- 33 billion gallons of water
- 6-15 million metric tons of nitrogen (44-107% of the total nitrogen use)
- 1 -2 million metric tons of phosphorus (20-51% of the total phosphorus use)

# Saltwater vs Freshwater

- Studies show that ocean algae can be competitive with freshwater algae
- Spares freshwater for agriculture and consumption
- Industrial enzymes as well as oil can be harvested from genetically engineered strains (Dunaliella tertiolecta)

# Methods of Conversion

- Oil press is the simplest
- Can extract up to 75 percent of the oil from the algae
- Refined using transesterification- catalyst of sodium hydroxide is mixed with alcohol (methanol)
- This creates a biodiesel fuel combined with a glycerol
- The mixture is further refined to remove the glycerol

- Hexane solvent method
- Extracts up to 95 percent of oil from algae
- Press squeezes out the oil
- Then, leftover algae is mixed with hexane, filtered and cleaned
- Transesterification is used to convert the oil to fuel
- Other methods exist reaching 100 percent oil extraction, though the costs are significantly higher

# Economic Benefits

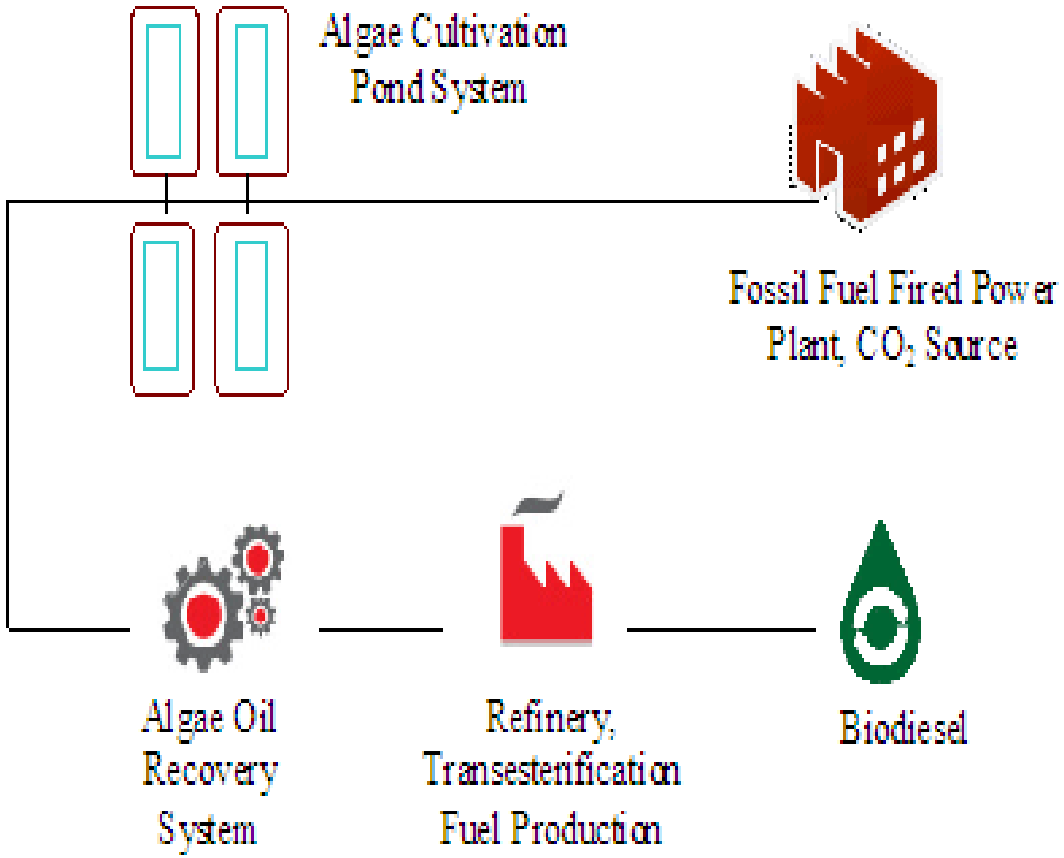
- 466 people in San Diego work in the algal bio-fuels industry
- More than $41 million in payroll and $80.9 million in economic activity for the region in 2011
- After the production of oil, the rest of the algae could be used as animal feed
- BP has invested in the region as a result of the oil spill
- With fertilizers and sewage flowing into the gulf, the water is already rich with nutrients
- With oil companies' investment in alternative fuels, massive amounts of capital are available
- High skilled jobs, sustainable jobs

# Current Status

- Biodiesel B20, is comprised of 20 percent algae and 80 percent petroleum
- Can be used in any vehicle that uses diesel
- Fuel costs slightly less than $4.25/gallon
- Biofuel is created in Solazyme's Illinois plant
- Can be processed into jet and marine-grade fuels as well .
- The Hajek Ford F250, with biodiesel B20 , smashed the diesel land speed record, reaching speeds over 182 mph

# Future Uses

- Scientists hope to place algae growth facilities near power plants or cement plants for enhanced growth and carbon sequestration
- Supplement corn based ethanol additives in fuel with algae based ethanol to alleviate the rise in food prices
- Map out DNA of algae in hopes of producing synthetic petroleum in similar manner to nature's production
- Increase US NAVY's use of biofuels



# References


- http://awakeatthewheel.net/tag/b20/
- http://www.futurity.org/earth-environment/is-biofuel-from-algae-green-enough-yet/
- http://www.flightglobal.com/news/articles/boeing-looks-to-algae-as-alternative-aviation-fuel-213517/
- http://www.greenchipstocks.com/report/algae-biofuel/442
- https://netfiles.uiuc.edu/mragheb/www/NPRE%20498ES%20Energy%20Storage%20Systems/Algae%20Power%20New%20Green%20Revolution.pdf
- http://www.oilgae.com/algae/cult/cos/cos.html
- http://www.sciencedirect.com/science/article/pii/S135943110900297X
- http://science.howstuffworks.com/environmental/green-science/algae-biodiesel.htm
- http://seekingalpha.com/article/1011331-solazyme-develops-vehicle-ready-algae-biofuel
- http://www.utsandiego.com/news/2012/nov/28/tp-algal-biofuel-production-can-reach-the-ocean/