LAFAYETTE

Biofuels: With a Focus On Third Generation (Algae)

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Types of Biofuels:

-First Generation: extracts from sugars, starches, oil, and animal fats that are converted to fuels using chemical processes

-Second Generation: non-food, agricultural waste, lingo-cellulosic biomass

-Third Generation: Quick growing Biomass (Example: algae)

-Fourth Generation: Engineered biomass or plants to obtain properties like higher energy density, and ideal growing characteristics

Why Third Generations Biofuel

-Helps alleviate Issues from land use for Biofuel feed stock (First Generation)

-Require CO_2 to grow, reducing GHG emissions

-Byproducts can be utilized

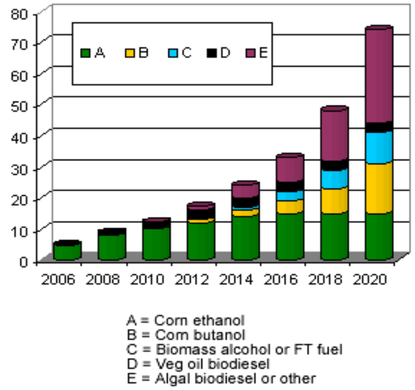
- Algae grows fast (20-30 X quicker than food)

-Versatile growing, ability to be grown in/on unfriendly environments i.e. wastewater

- Require less water use than other Biofuel feedstock's

-Versatility of conversion: can be converted into multiple fuel types: i.e. Ethanol, Biodeisal

-Can be genetically modified to be produce higher fuel conversion yields.



Potential Growth: Figure Analysis

The Figure above shows the estimated future production of Biofuels based on technology trends from there respective feed-stocks. The vertical axis is in Billion gal/year and the horizontal axis is the year. The figure shows that third generation Biofuels, specifically Algae is not abundant but has high aspirations in the future based on its deeming qualities

Life Cycle for Fuel from Algae: Main Options for Each Stage of Life Cycle

-Step 1: Type of Algae: Can choose Macroalgae, Cyanobacteria, Microalgae

-Step 2: Cultivation: Two traditional cultivation techniques, open pond & photo-bioreactor

-Step 3: Havesting/Dewatering: Drying, Flocculation, Filtration, Centrifugation

-Step 4: Oil Extraction: Solvent, Chemical, Enzymatic

-Step 5: Oil Conversion: Pyrolysis, Gasification, Liquefaction, Fermentation, Transesterification

-Step 6: Biofuels & Co-Products: Fuel: Ethanol, Biodeisal. Byproducts: Food Additives, Fertilizer

(Utilization of by products is a big benefit and challenge of biofuel from algae/Biomass

Summary:

The summary above displays there are many options and opportunities for Algae as a source for Biofuel production however due to the great amount of options and possibilities, optimization of the process becomes a more difficult task.

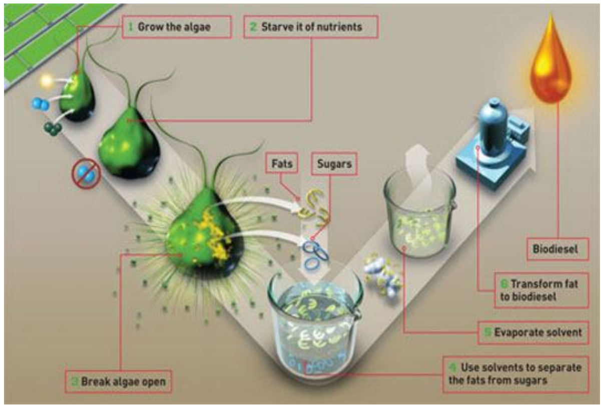
Algae to Fuel process:

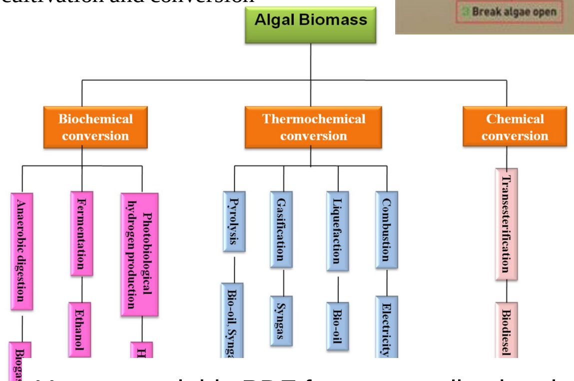
-Once the Algae biomass is grown there are different ways to harvest to fuel.

-The figure to the right shows general method on the start-to-finish process of extracting fuel from algae biomass.

-The figure below demonstrates the different options for converting Algae Biomass to useable fuel and the respective fuel types

-The two main areas for research in third-generation Biofuels are in cultivation and conversion





Types of Conversion:

Three main types of Algae to Biofuels:
Direct production of fuel from algae-Heterotrophic fermentation
Processing of Whole Algae: Directly processing fuels from the Algae
Conversion of Algae extracts (demonstrated in the figure above), conversion is the conventional way to get fuel from Algae.

Cultivation:

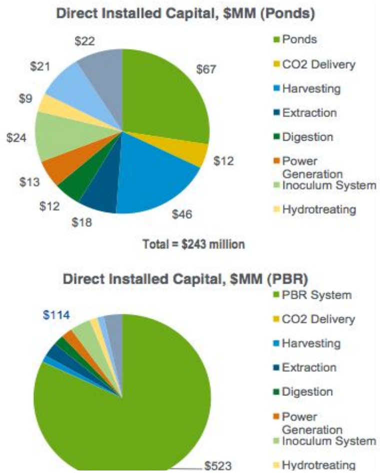
-Two main types of Algae Cultivation:

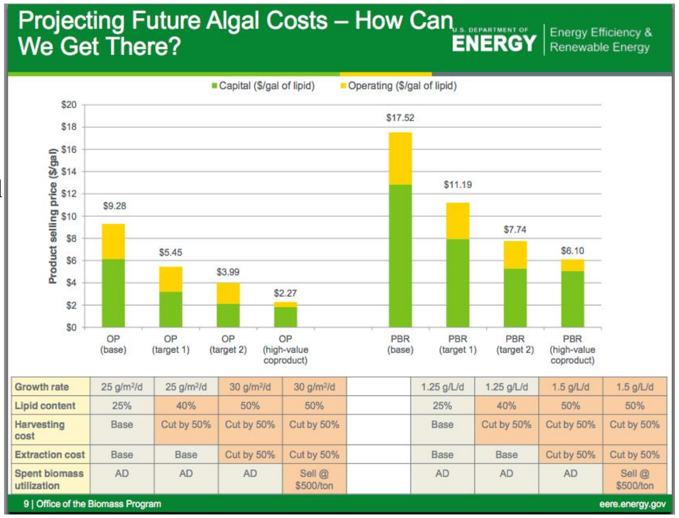
-Autotrophic: require inorganic compounds & light energy source for growing

-Hetertrophic: not photo-synthetic and require external source

-Two main types of sources: Open Pond & Photobioreactors

-External energy input for cultivation and conversion (as opposed to crops) 20-30% of productions costs





	OP (base)	OP (target 1)	OP (target 2)	OP (high-value coproduct)		PBR (base)	PBR (target 1)	PBR (target 2)	PBR (high-value coproduct)
Growth rate	25 g/m²/d	25 g/m²/d	30 g/m²/d	30 g/m²/d		1.25 g/L/d	1.25 g/L/d	1.5 g/L/d	1.5 g/L/d
Lipid content	25%	40%	50%	50%		25%	40%	50%	50%
Harvesting cost	Base	Cut by 50%	Cut by 50%	Cut by 50%		Base	Cut by 50%	Cut by 50%	Cut by 50%
Extraction cost	Base	Base	Cut by 50%	Cut by 50%		Base	Base	Cut by 50%	Cut by 50%
Spent biomass utilization	AD	AD	AD	Sell @ $500/ton		AD	AD	AD	Sell @ $500/ton

Economic Figure Analysis:

-Figure above shows the operating/capital price for algae based fuels under current & estimated scenarios.

-OP stands for open pond production of Algae

-PBR- stands fro Photo-bioreactor production

-Diagram shows that OP production based on the best estimated technological improvements in the future can obtain operating costs as little as $2.27/gal of lipid.

-Figure to the left shows Capital Investment based on which Algae generation is utilized (OP or PBR)

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