



Algal Biofuels and Federal Policy: RFS2 and Other Policy Issues



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OVERVIEW



- **Introduction to the ABO, Algae Industry and Algal Fuels**
- **Treatment of renewable fuel derived from algal feedstocks under the Renewable Fuel Standard, as amended (RFS2)**
- **Legislative Efforts and ABO's Position on RFS2**
- **Other ABO Policy Priorities and Regulatory Issues Critical to the Industry**



ABOUT THE ABO

- **Origins:**
 - 501(c)(6) trade association for the U.S. algae industry
 - Formed following the first Algae Biomass Summit in November, 2007

 - **Mission:** To promote the development of viable technologies and commercial markets for renewable and sustainable products derived from algae

 - **Purpose**
 - Promote commercial applications for algal biomass
 - Facilitate informed business decision based on sound science and best practices
 - Education (policymakers, media, end users, general public)
 - Advocacy

 - **Membership:** Nearly 200 corporate and individual members across the value chain from virtually every state
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THE U.S. ALGAE INDUSTRY



Blue: Research institutions and labs Green: Private companies and projects

ABO CORPORATE MEMBERS





THE U.S. ALGAE INDUSTRY

- More than 100 companies, including 65 research institutions in the U.S. alone
 - Robust private-public partnerships
 - Strong support from the public and private sector
 - Approximately \$1 billion in investment
 - Several key milestones achieved; aviation biofuels
 - A number of (pre)commercial facilities breaking ground this year
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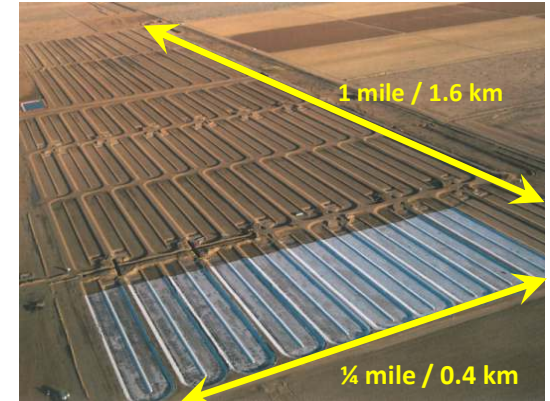
THE U.S. ALGAE INDUSTRY



General Atomics, Kauai Facility, March 2012 | CO₂ is supplied from KIUC power plant (Photo courtesy of General Atomics)



Algenol's facility in Florida (Photo courtesy of Algenol)



Sapphire Energy's Integrated Algal Biorefinery in Las Cruces, NM (Photo courtesy of Sapphire)



Source: Green Plains Renewable Energy | BioProcess Algae Co-Location, Shenandoah, IA



Solix Biosystems' R&D facility in Colorado (Photo Courtesy of Solix Biosystems)

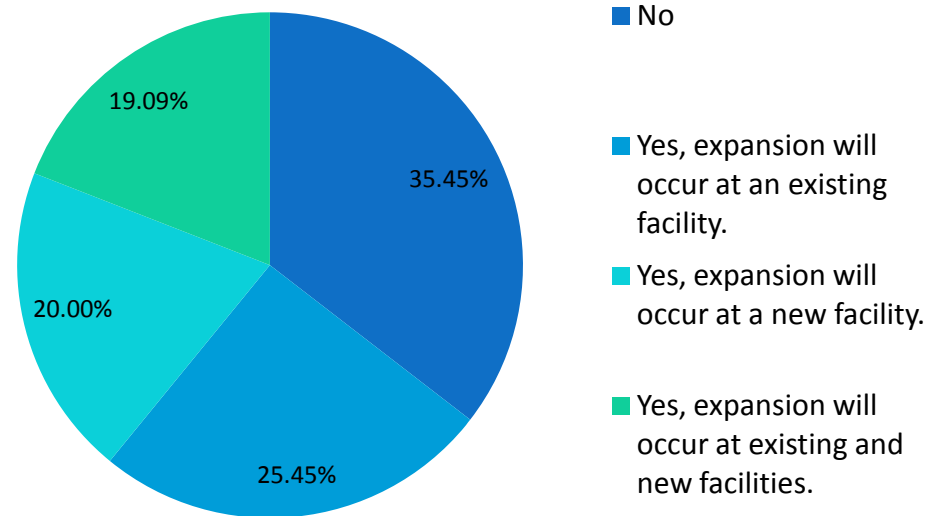


Cellana's facility in Hawaii (Photo courtesy of Cellana)

THE U.S. ALGAE INDUSTRY

65% of survey respondents say they are increasing production in 2012

Do you plan to expand capacity in 2012?



BENEFICIAL CHARACTERISTICS OF ALGAL FEEDSTOCKS

- **Land and Water Use**
 - Grown on marginal, non-arable land
 - Can use saline/brackish water as well as wastewater
 - Water use is minimal compared with conventional agricultural crops
- **Minimizes competition with conventional agriculture – food, feed and fiber**
- **CO₂ is a key feedstock for algal growth**
- **Conversion to various fuels using existing refining processes**
- **High Productivity and Efficiency**
 - Growth Rates – a 4-day growth cycle is slow
 - High biomass, sugar and oil yield by volume
 - Photosynthetic Efficiency



City of Jiaonan, Shandong province, China
(Source: boardjournal.com)

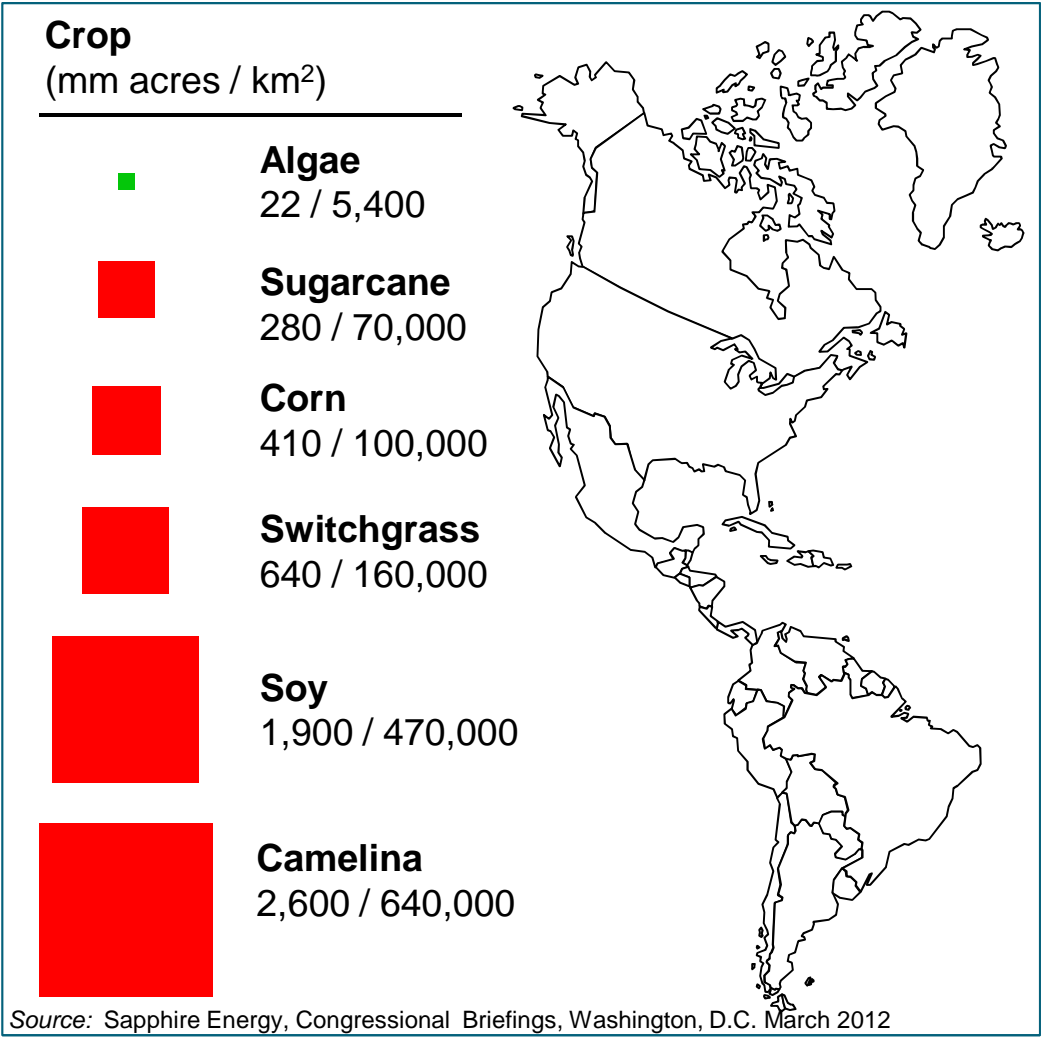


NEXUS OF EFFICIENCY AND LAND USE

To produce 15% of global fuel demand, algae oil production requires far less land than any alternative >>>>>>>>>>>>

Crop	Oil Gal/Acre/Yr
Soybean	48-50
Camelina	62
Sunflower	102
Rapeseed	125
Jatropha	202
Coconut	285
Palm Oil	635
Algae (Done)*	2000
Algae (Credible)	6500

Source: Chisty, Y. Biodiesel from microalgae. *Biotechnology Advances* (2007).
* *General Atomics*, DARPA-funded Kauai algae facility, Congressional Briefings, Washington, D.C. (March 2012)



MICROALGAL CULTIVATION

Cultivation Methods

Photoautotrophic - Terrestrial

Open Ponds

- Lined
- Unlined
- Raceway
- Wastewater Treatment

Closed PBRs

- Vertical
- Horizontal

Hybrid Systems

- Pond/PBR Mix
- Covered ponds

Photoautotrophic - Offshore

Heterotrophic

- Industrial PBRs w/sugar feedstocks
- Wastewater treatment

Harvesting and Dewatering

- Centrifuge
- Filtering
- Decantation
- Bioflocculation
- Autoflocculation
- Dissolved Air Flotation
- Drying
- Biological (enhanced sedimentation)
- Other

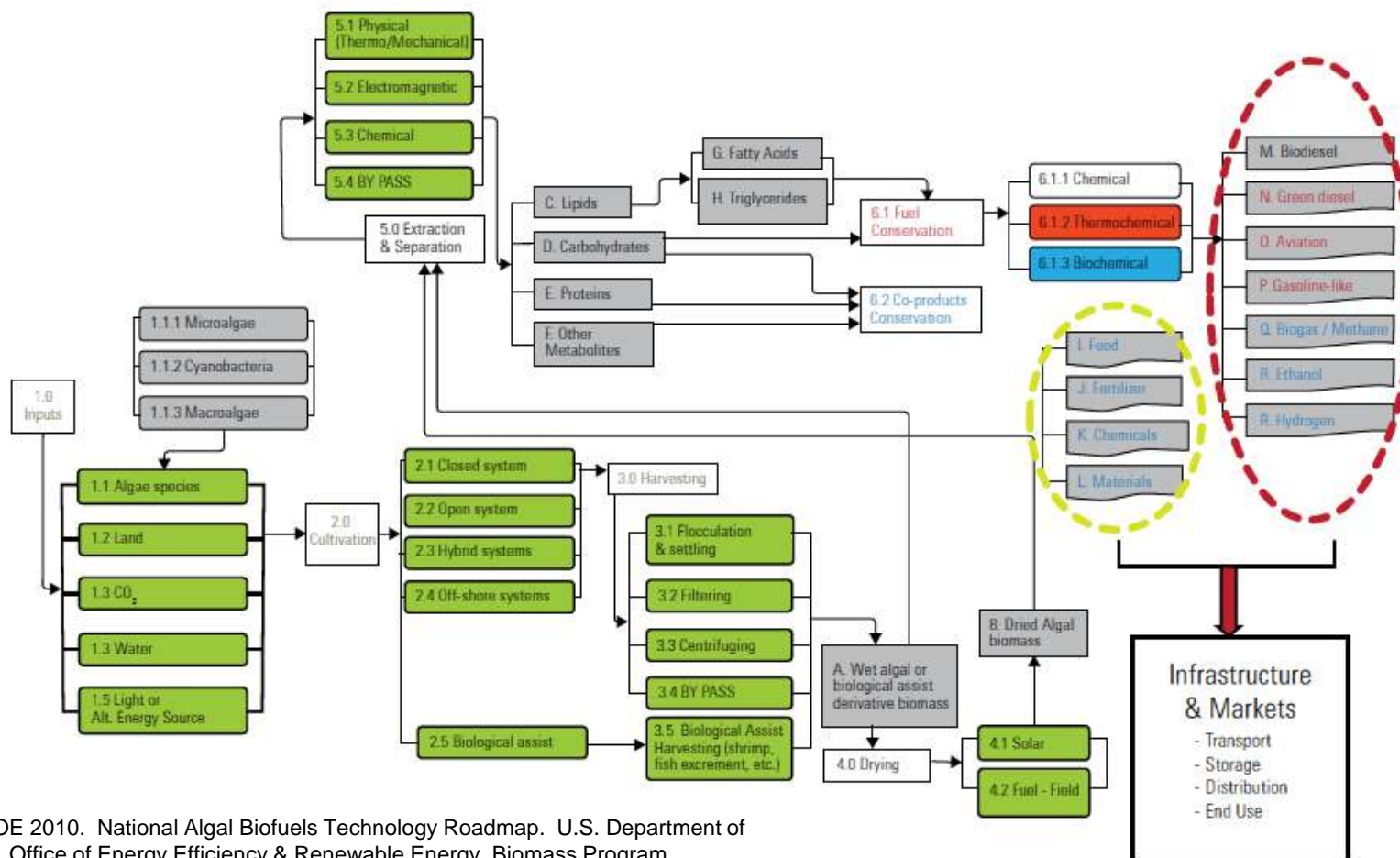
Extraction

- Solvent
- Electroporation (Acoustic)
- Electromagnetic
- Supercritical Fluid
- Other

Separation

- Membrane
- Distillation
- Centrifuge
- Excretion*
(*Skip Harvest and Dewater)

ALGAL BASED PRODUCTS (AND SERVICES)



U.S. DOE 2010. National Algal Biofuels Technology Roadmap. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Biomass Program.

Exhibit 10.7 High-level multi-pathway algae biofuel process flow diagram for the algae biofuels and co-products supply chain

ALGAL-BASED PRODUCTS (AND SERVICES) – FUELS/ENERGY

Advanced Biofuels and Other Energy Products

- Biocrude
- Biodiesel
- Ethanol
- JP-8
- Methane
- Gasoline
- Renewable diesel
- Isobutanol
- JET-A
- Hydrogen

Exhibit 6.1 Schematic of the potential conversion routes for whole algae into biofuels

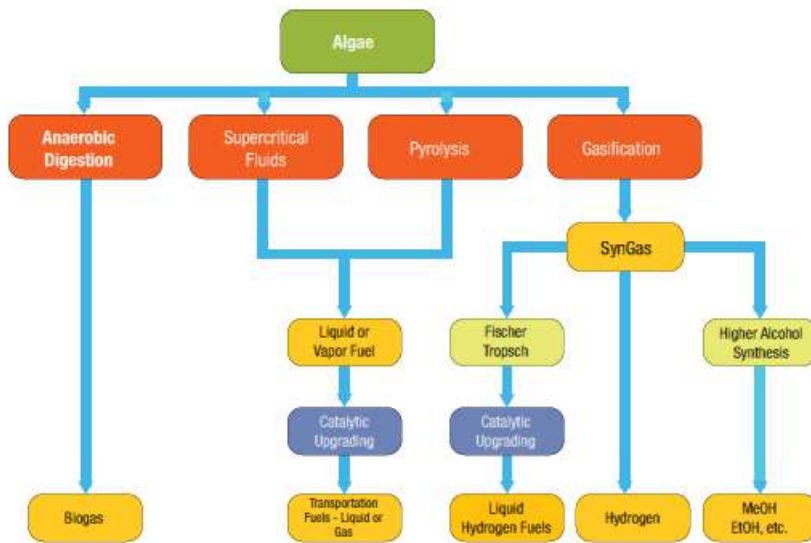
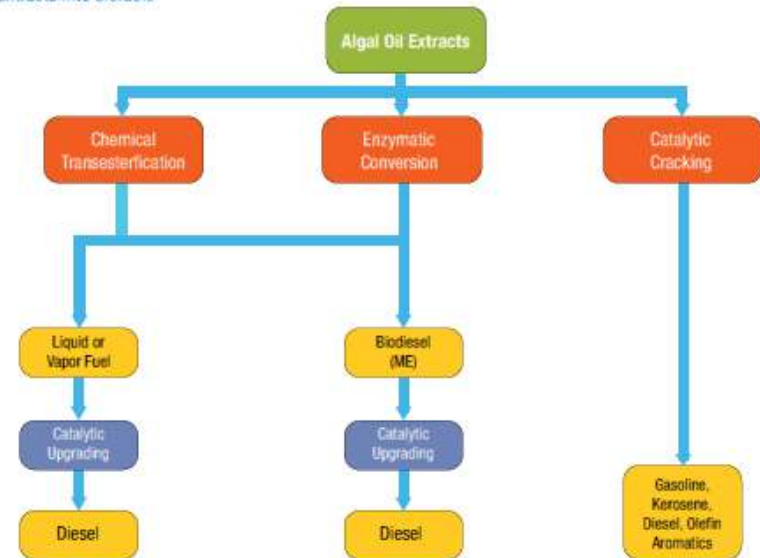


Exhibit 6.2 Schematic of the various conversion strategies of algal extracts into biofuels



U.S. DOE 2010. National Algal Biofuels Technology Roadmap. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Biomass Program.



ALGAL-BASED PRODUCTS (AND SERVICES) – CO-PRODUCTS

- **Human Health Food Supplement; Aquaculture and Animal Feed**
 - Poly-Unsaturated Fatty Acids (PUFAs)
 - Anti-Oxidants

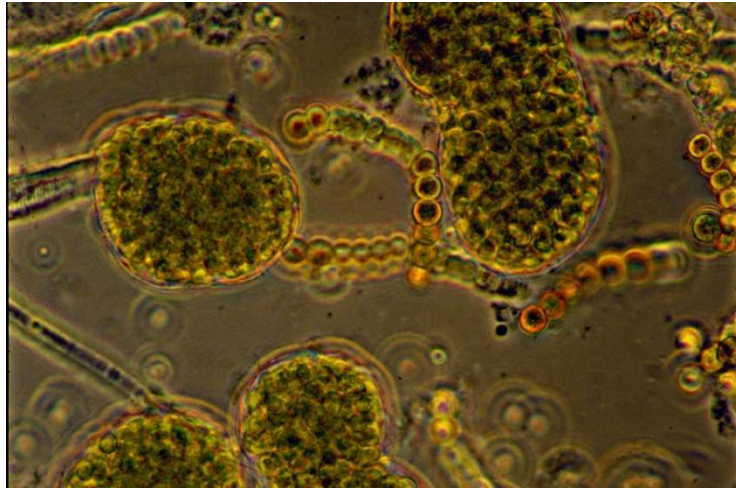
- **Coloring Substances/Pigments**

- **Fertilizers, growth promoters, soil conditioners**

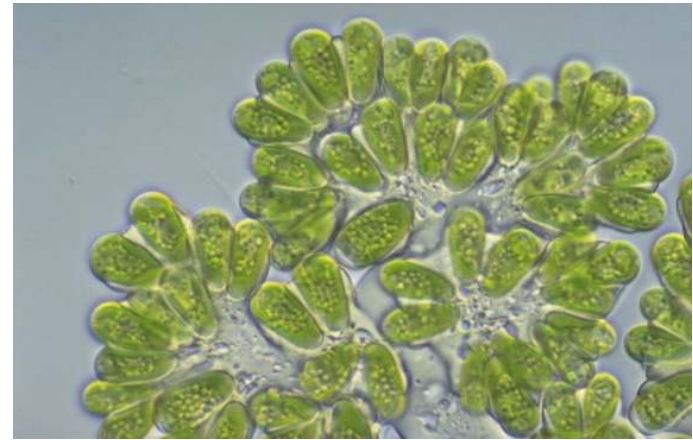
- **Chemical intermediates, polymers, bioplastics**

- **Services**
 - Carbon Recycling (Carbon Credits?)
 - Wastewater Remediation (Nutrient Removal)

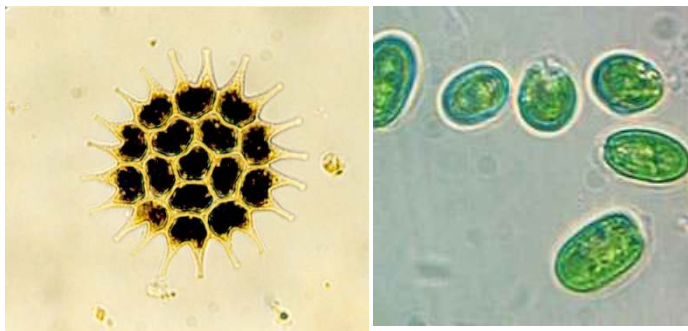
ALGAE DEFINED



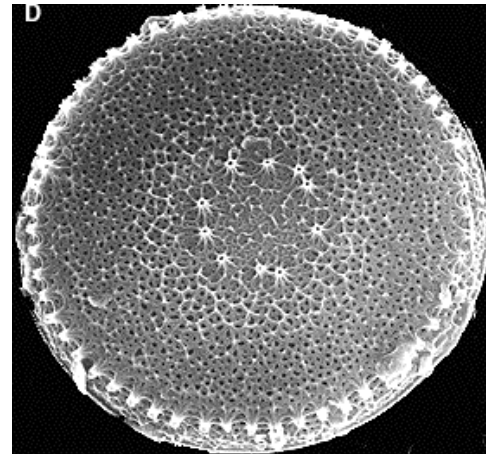
Nostoc sp. – Cyanobacteria (photo courtesy of J. Weissman)



B. Braunii – Green microalga (photo courtesy of the National Institute for Environmental Studies)



Chlorophyceae – Green algae (photo courtesy of G. Mitchell, Scripps Institution of Oceanography, UCSD)



Bacillariophyceae – Unicellular diatom (photo courtesy of G. Mitchell, Scripps Institution of Oceanography, UCSD)

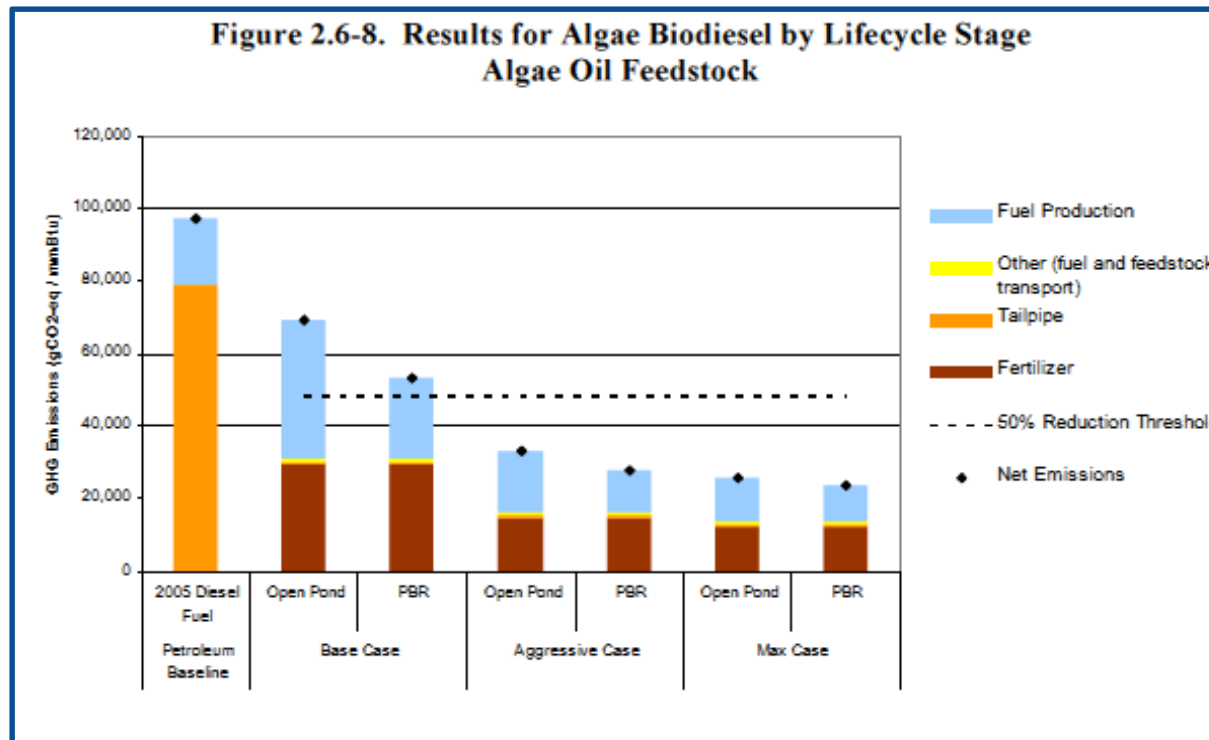


RFS2 AND ALGAL-BASED RENEWABLE FUEL

- **“Renewable Biomass” (summarized)**
 - i. Planted crops & crop residue harvested from existing ag. lands cleared/cultivated prior to 12/19/07
 - ii. Planted trees and tree residue from actively managed tree plantations on non-federal land
 - iii. Animal waste and byproducts
 - iv. Slash & pre-commercial thinnings from non-federal forestlands (+ other restrictions)
 - v. Biomass obtained from the immediate vicinity of buildings/public infrastructure at risk of wildfire
 - vi. **Algae (includes cyanobacteria)**
 - vii. Separated yard waste or food waste, including recycled cooking and trap grease
- **Land Restrictions – None (in the RFS, at least)**
- **“Planted Crops”**
 - all annual or perennial agricultural crops from existing agricultural land that may be used as feedstocks for renewable fuel . . . provided that they were intentionally applied by humans to the ground, a growth medium, a pond or tank, either by direct application as seed or plant, or through intentional natural seeding or vegetative propagation by mature plants introduced or left undisturbed for that purpose
 - *Examples:* Grains, oilseeds, sugarcane, switchgrass, prairie grass, duckweed, and other species **(but not including algae species or planted trees)**.

RFS2 AND ALGAL-BASED RENEWABLE FUEL

- EPA-Approved Pathways in 2010 Rulemaking for Biomass-Based Diesel
 - Biodiesel from soy oil;
 - Renewable diesel from waste oils, fats and greases;
 - **Biodiesel and renewable diesel produced from algal oils**





RFS2 AND ALGAL-BASED RENEWABLE FUEL

Table 2.4-56. Inputs for Algae Cultivation

Input	Base Case		Aggressive Case		Max Case	
	op	PBR	op	PBR	op	PBR
Water Use:						
Net water demand [MMgal/yr]	9,740	720	3,830	320	2,710	250
Net water demand [gal/gal lipid]	974	72	383	32	271	25
Land Use [acre]:						
Pond/PBR land size	4,743	1,897	1,482	593	823	329
Total plant land required	7,079	3,795	2,212	1,186	1,229	659
Nutrient Use [ton/yr]:						
Fertilizer for algae	23,920	23,880	12,000	11,980	10,010	10,000
Nutrients for anaerobic digester	2,960	3,000	1,440	1,460	1,190	1,200
CO₂ Use:						
CO ₂ consumed [lb/lb algae produced]	2	2	2	2	2	2
Net CO ₂ used from offsite flue gas [ton/yr]	290,000	290,000	150,000	150,000	120,000	120,000



RFS2 AND ALGAL-BASED RENEWABLE FUEL

- **Other LCAs Performed Since Final Rule was Published:**
 - GREET (Argonne)
 - ExxonMobil
 - Others by individual companies

- **General Thoughts on LCAs/Takeaways**

- **Companies using algal biomass feedstocks will have to undertake the petition process (43 C.F.R. 80.1416) for fuel pathways not yet modeled**
 - Fuel type (Green crude/gasoline, jet fuel, ethanol, etc.)
 - Cultivation or production process that differs from modeled pathway
 - EPA has indicated it may review and update approved pathway for those renewable fuel pathways that were in “early stages of development” in 2010



RFS2 AND ALGAL-BASED RENEWABLE FUEL

- **Algae is Excluded from Most of RFS2 Volumetric Mandates**

- It's not corn ethanol or cellulosic biofuel
- Only applicable mandates are Biomass-based Diesel and Other Advanced Biofuels
- Many fuels derived from algal feedstocks do not fall into the biomass-based diesel category

- **Administrator's Authority to Increase (and Decrease)**

- EPA must establish biomass-based diesel volume requirements for 2013 and beyond
- Volumes discretionary, but EPA is required to set volume requirements at levels higher than 2012 (not higher than the last year's volume)
- Waiver Authority

Year	Biomass-Based Diesel (bgj)	Other Adv. Biofuel (bgj)
2012	1.00	0.50
2013	1.28*	0.75
2014	1.00	1.00
2015	1.00	1.50
2016	1.00	2.00
2017	1.00	2.50
2018	1.00	3.00
2019	1.00	3.50
2020	1.00	3.50
2021	1.00	3.50
2022	1.00	4.00

** Proposed volume but not finalized. EPA must establish volume requirement 14 months.*

Algal-based fuels are excluded from almost 85% of RFS2's annual volumetric requirements



ABO'S POSITION ON RFS2 AND CURRENT RFS2 LEGISLATION

- **ABO's Position**

- Don't weaken the RFS or the cellulosic biofuels mandate. Rather, improve it by fostering technologies to help meet the mandate.
- Parity of algal fuels with cellulosic biofuels, which can be achieved in several ways

- **Administrative "Fix" Not Possible**

- **H.R. 1149 (Bilbray) – The Algae Fuel Parity Act**

- Would amend Section 211(o)(1)(E) (42 U.S.C. 7545(o)(1)(E)) of the Clean Air Act to add the following at the end: "The term *cellulosic biofuel* also includes algae-based biofuel."

The term 'algae based biofuel' means liquid fuel:

(i) derived from the biomass of single or multi-cellular organisms which are inherently aquatic and classified as non-vascular plants (including microalgae, blue-green algae (cyanobacteria), and macroalgae (seaweeds)); and

(ii) that has lifecycle greenhouse gas emissions, as determined by the Administrator, that are at least 60 percent less than the baseline lifecycle greenhouse gas emissions.

- **S. 1564 (Udall) – Renewable Fuel Parity Act**



ABO'S FY2012 LEGISLATIVE PRIORITIES

■ **Tax Parity**

- The Algae Fuel Parity Act (H.R. 1149, Bilbray – CA)
- Algae-Based Renewable Fuel Promotion Act (S. 748, B. Nelson – FL)
- S.Amdt. 1723 to S. 1813 (MAP-21 – Transportation Re-Authorization Bill) failed.
- S.Amdt. 1812 to S. 1813 (D. Stabenow) failed.

■ **DoD Long-Term Contracting Authority**

- Domestic Fuel for Enhancing National Security Act (H.R. 1847, Inslee – WA)
- “ ” (S. 1079, Murray – WA, Cantwell – WA)

■ **Energy Title and mandatory funding in the Farm Bill**

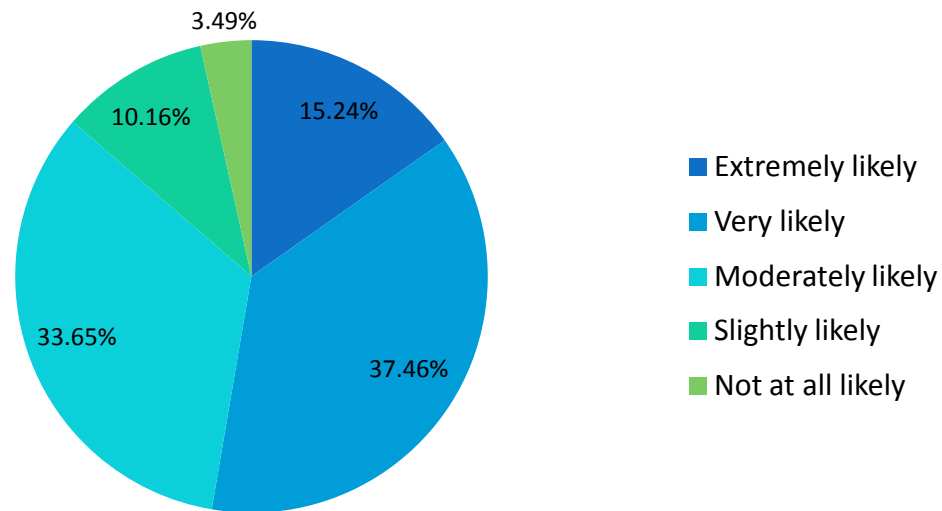
- Energy Title in jeopardy
- 9003 Biorefinery Grant and Loan Guarantee Program
- Mandatory funding (Conrad-Luger Amendment - \$800m in Mandatory Funding)



The Importance of Federal Regulation and Policy – Industry Perspective

Tax Parity is Key

In your view, if algae-derived fuels received similar tax treatment as other biofuels, how likely would the industry expand on current production plans?





OTHER REGULATORY ISSUES

- **Regulation of “GE” Algae – Coordinated Framework for Regulation of Biotechnology**
 - **EPA:** Toxic Substance Control Act (TSCA)
 - **USDA-APHIS:** Plant Protection Act (PPA) and Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)
 - **FDA:** Federal Food, Drug and Cosmetic Act
 - **Facility Permitting; Other Regulatory Requirements**
 - NEPA Compliance and state equivalents
 - Endangered Species Act
 - Clean Air Act
 - Coastal Barrier Resources Act
 - Coastal Zone Management Act
 - Wild and Scenic Rivers Act
 - National Historic Preservation Act
 - Archeological and Historic Preservation Act
 - Safe Drinking Water Act
 - Water Discharge/Stormwater
 - Wetland Protection (Executive Order 11990)
 - Floodplain Management (Executive Order 11988)
 - State aquaculture licenses and state requirements on the use of hybrid algae (FL, TX, LA, CA, HI, others)
 - Water Rights (some states)
 - Liquid waste/septic tank
 - Local building permit and construction permit
 - Fire Protection
 - Conditional Use Permit
 - State equivalents to federal law
 - **Fuel Certification (ASTM) and Registration (EPA)**
-



CLOSING THOUGHTS

Is the industry on-track? RFS2's Preamble

TABLE IV.B.4-3—SUMMARY OF PROJECTED BIODIESEL AND RENEWABLE DIESEL FEEDSTOCK USE IN 2022
[MMgal]

Feedstock type	Base catalyzed biodiesel	Acid-pretreatment biodiesel	Renewable diesel
Virgin vegetable oil	660	.....	.....
Corn oil from ethanol production .....	.....	680	.....
Rendered animal fats and greases .....	.....	230	150
Algae oil or other advanced source	100	.....	.....

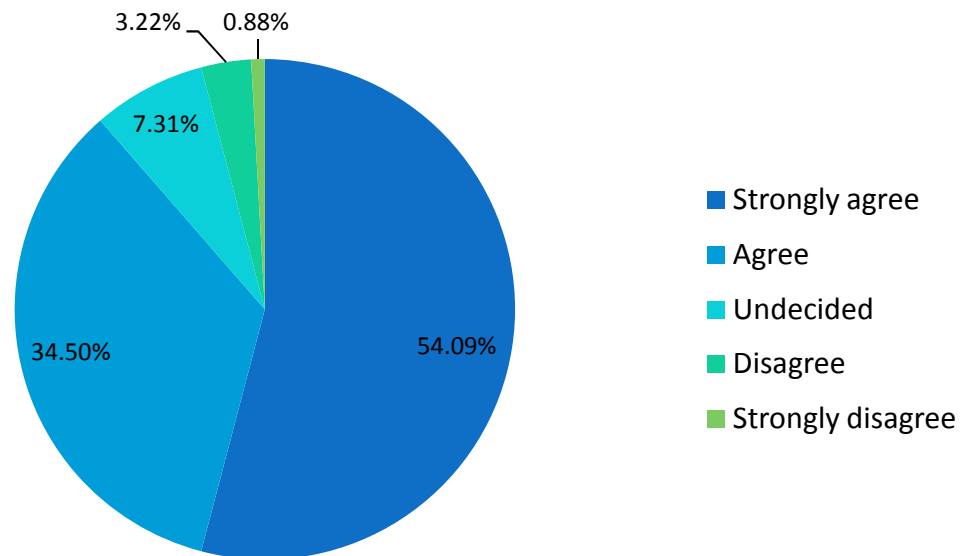
- **2012 will be an important year, as facilities come on-line and data is generated**
- **Policy and policy certainty matters**
- **Surgical improvements to the RFS would help the algae industry and may improve the chances of meeting the cellulosic biofuel targets**



The Importance of Federal Regulation and Policy – Industry Perspective

88% agree or strongly agree that federal policy will accelerate development of the algae industry

Please rate your agreement with the following statement:
“Stable and supportive federal policy would accelerate development of the algae industry.”





For more information, please visit:



**A Joint Effort Between the
National Biodiesel Board and the Algal Biomass Organization**