

Global Algae Innovations

Algae Solutions to Global Dilemmas



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Algae Cultivation for Carbon Capture and Utilization
U.S. Department of Energy, Bioenergy Technologies Office

Algae CC Rural Rejuve

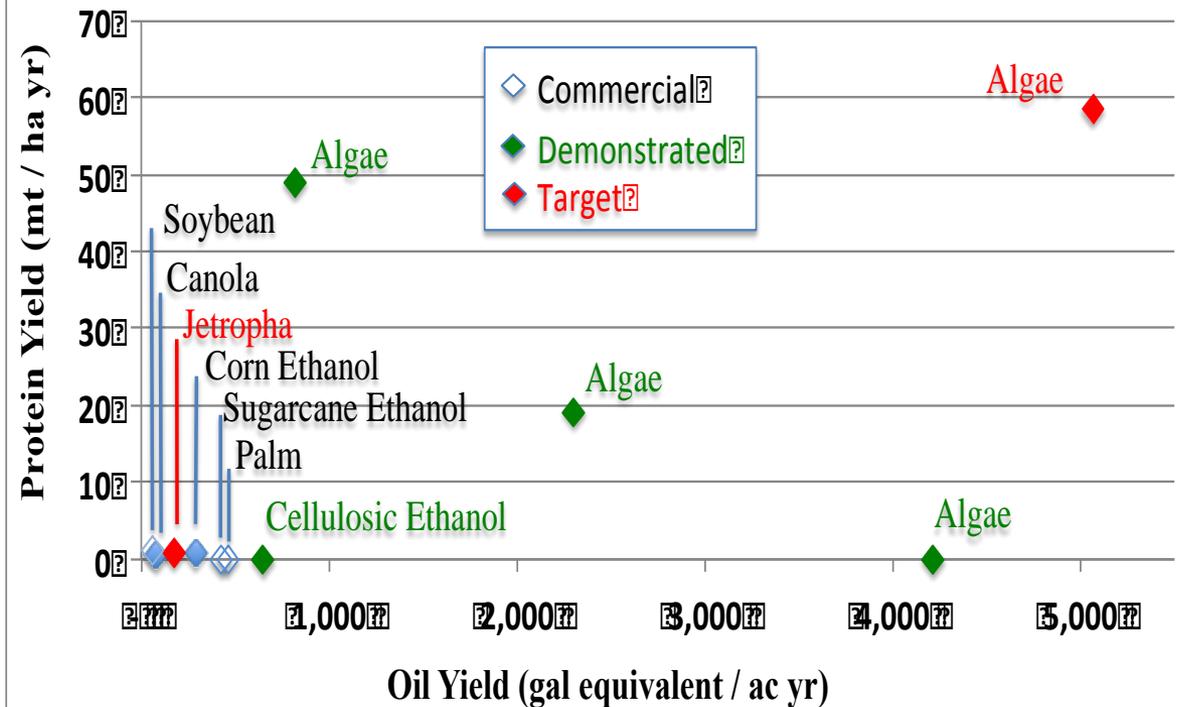
Coal competitiveness

- Algae industry can pay for CO₂ and cost of capture/delivery
- CO₂ becomes co-product

Algae, High tech farming

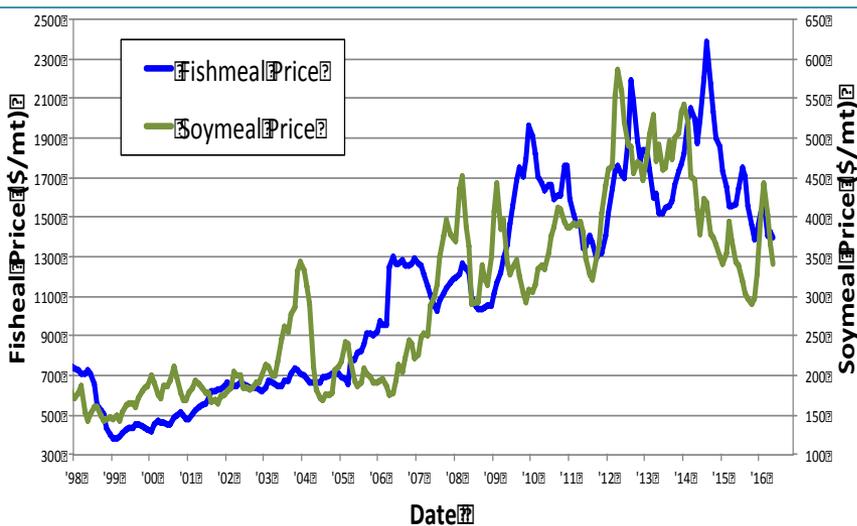
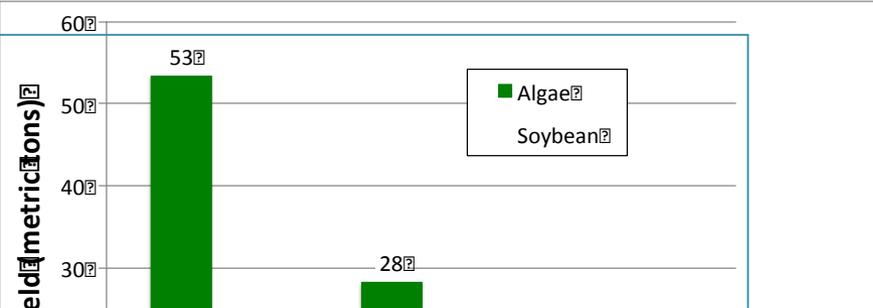
- Economic boon
- Full spectrum of jobs
- Large markets: protein, fuel, polymers

USA needs to invest so we are the world leader



40-50x revenue per acre will transform to rural economy & standard of living

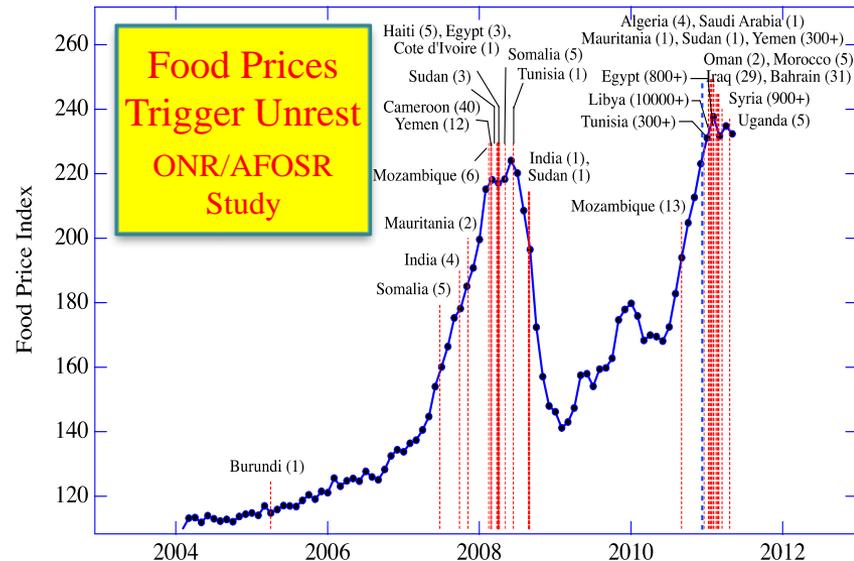
Algae Industry: Solution to the Protein Crisis



FAO projections

- Need 3x aquaculture protein
- Need 2x other protein
- Crop yield increase ~1-1.5%/year

2% of crop land in algae solves problem



Algae Industry: Large Part of Environmental Solutions

- Leading cause of deforestation and habitat loss is food production
- Leading cause of global water impairment is agricultural run-off
- Agriculture accounts for 25% of global greenhouse gas emissions



	CCS Energy Sector Emissions Mitigation						
	0%	25%	35%	45%	55%	65%	75%
BAU	624	563	537	514	491	470	445
BioEnergy	583	525	500	478	456	436	413
Alg-Feed 10%	513	458	435	415	395	376	355
Alg-Feed 20%	496	442	418	398	378	359	337
Alg-Feed 30%	484	429	405	385	364	345	323
Alg-Feed 40%	473	417	393	372	351	332	310

Walsh et al. *Carbon Balance Manage* (2015) 10:26



Energy Scale CCU Products Required

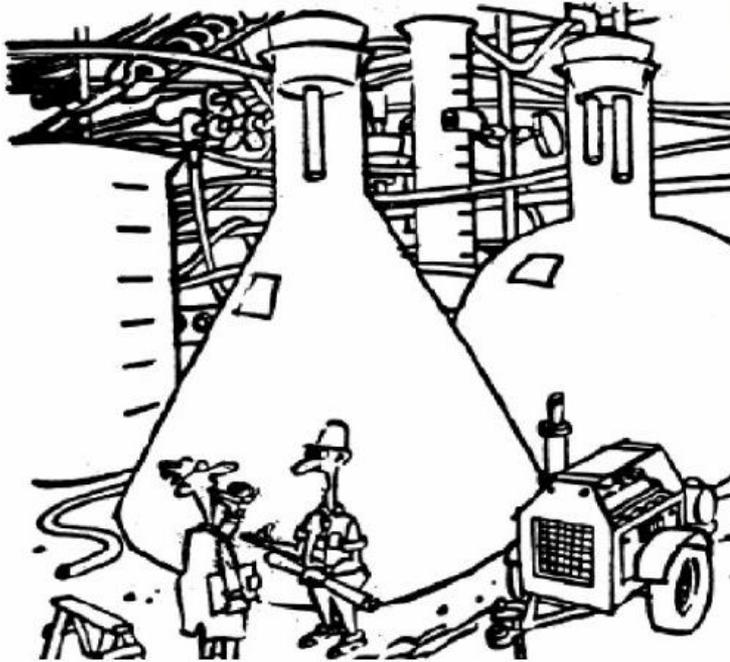
Product	Value (\$/mt)	CO ₂ Utilization (550 MW Coal Plants)
Pigments, Nutraceuticals, Cosmetics, Specialty chemicals	4,000 - 10,000	0.3
Consumer polymers, Food protein	1,000 - 3,000	25
Bulk polymers, Aquaculture feed, Specialty feeds	600 – 1,000	200
Animal feed & Transportation fuel	350 – 550	500
Transportation fuel	250 – 350	8000

**CO₂ supplied from
power plant flue gas**

- 0.1 psi pressure drop
- 24 hr/day capture



Scalable Technologies (550 MW supports 20-30,000 algae acres)



We seem to have a few problems going from lab-scale to full-scale production

20,000-acre facility control points

Conventional CC or direct: 40,000

Global Algae Absorber :

1

Scalable Technologies (Continued)

20,000-acre facility

Conventional Raceways: 10,000

Global Algae Raceways: 100



Zobi Membrane Technology
6 billion gpd installed
228 million gpd plant



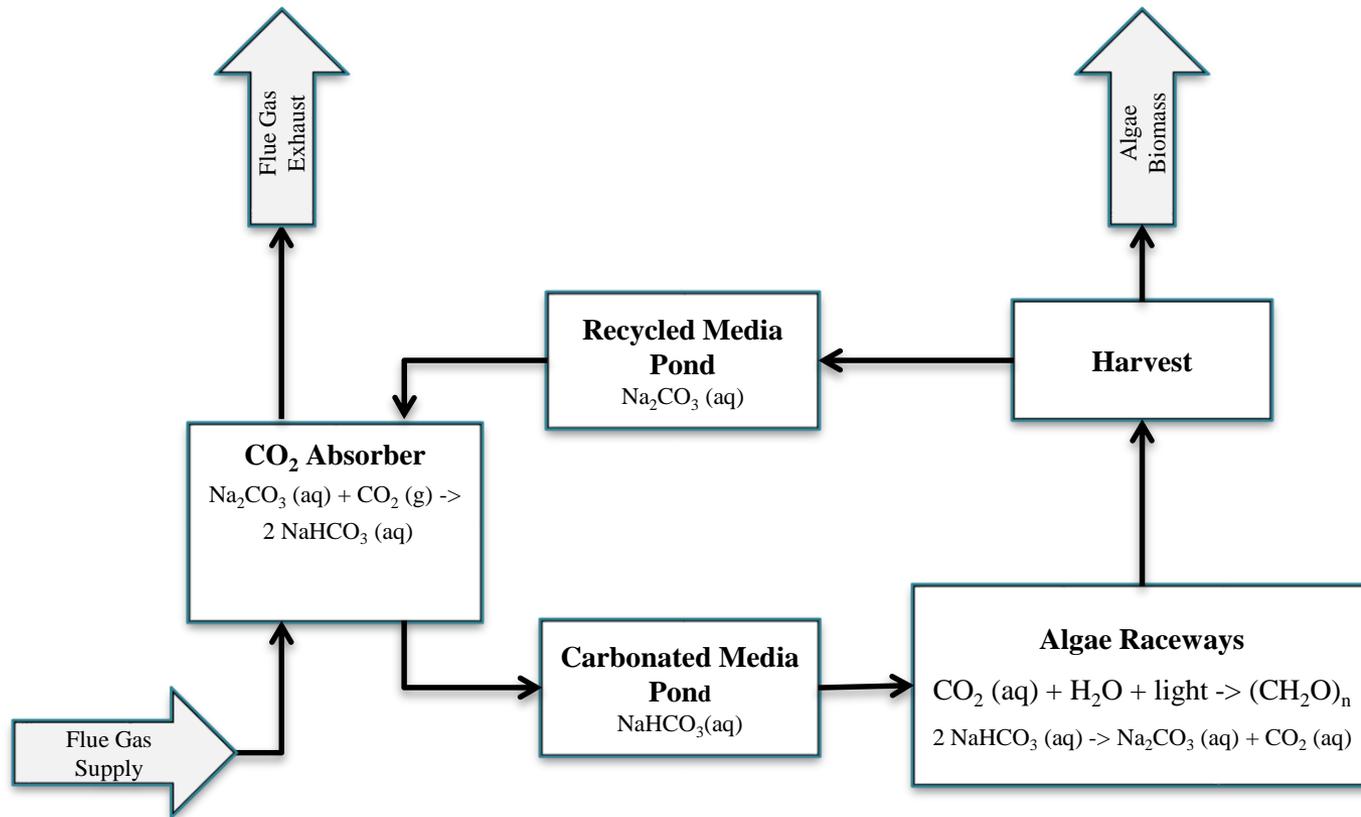
Algae Flue Gas Utilization Obstacles

1. Achieve low cost CO₂ supply
 - Capture & Storage
 - Distribution & control
 - Energy use
2. Capture CO₂ when algae not growing
3. Prevent ground level flue gas release

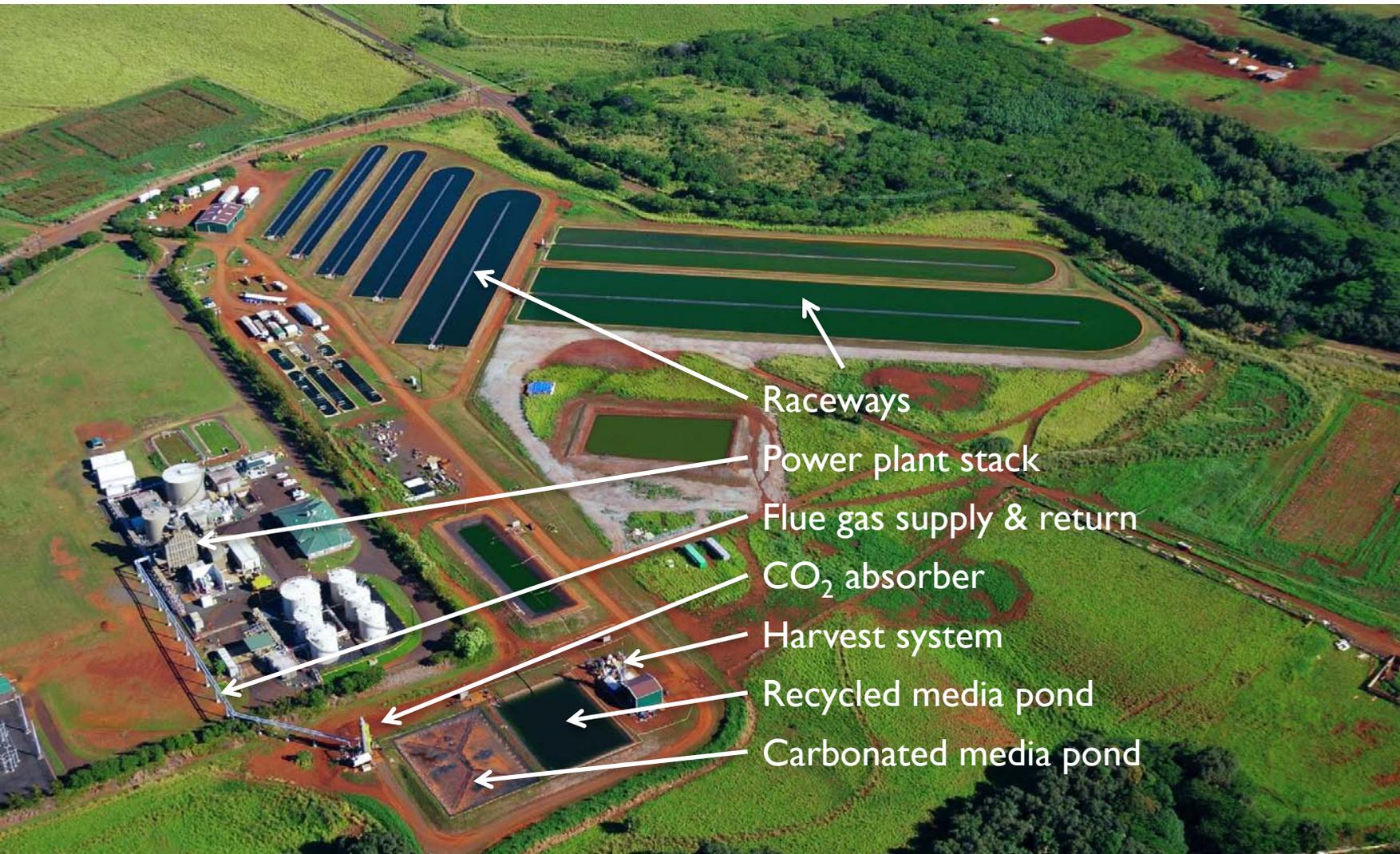
Key Attributes of Algae CO₂ Supply Options

System Attribute	Bubble Flue Gas	Carbon Capture	Global Algae Innovations	Direct Air Capture
Cost of CO ₂ supply	\$\$\$	\$\$\$	\$	\$
CO ₂ storage	N/A	\$\$	\$	N/A
Gas distribution	Miles	Miles	None	None
Control points	40,000	40,000	1	None
Gas pressure	2-10 psi	0.1 / 900 psi	0.1 psi	N/A
Prevent ground level flue gas release	\$\$	0	0	N/A
Capture when algae is not growing	No	Yes	Yes	No

Global Algae Innovations CO₂ Supply System



All algae cultivated on CO₂ supplied from power plant flue gas



Power Plant Flue Gas CO₂ Supply



- 50' tall, 5' diameter absorber
- Power plant off-gas returned to stack after CO₂ recovery
- For past three years, all CO₂ for growth from power plant flue gas



All CO₂ Supplied From Power Plant Flue Gas



- 24 hour per day CO₂ capture
- Store in media: 80-90% capture limit instead of 5%
- Very low energy: 2.5" water pressure drop on flue gas
- Eliminates need for gas distribution or controls

Conclusions

- Algae CCU can lower electric rates
- **Addresses some of world's largest markets**
- Re-establish US as bread basket of the world
- Full-scale implementation would create economic boon that transforms rural standards of living and job quality
- Scalable and economic approaches have been demonstrated at reasonable scale
- USA investment needed to maintain world leadership

Thank you

