



Algae & Energy in the Northeast

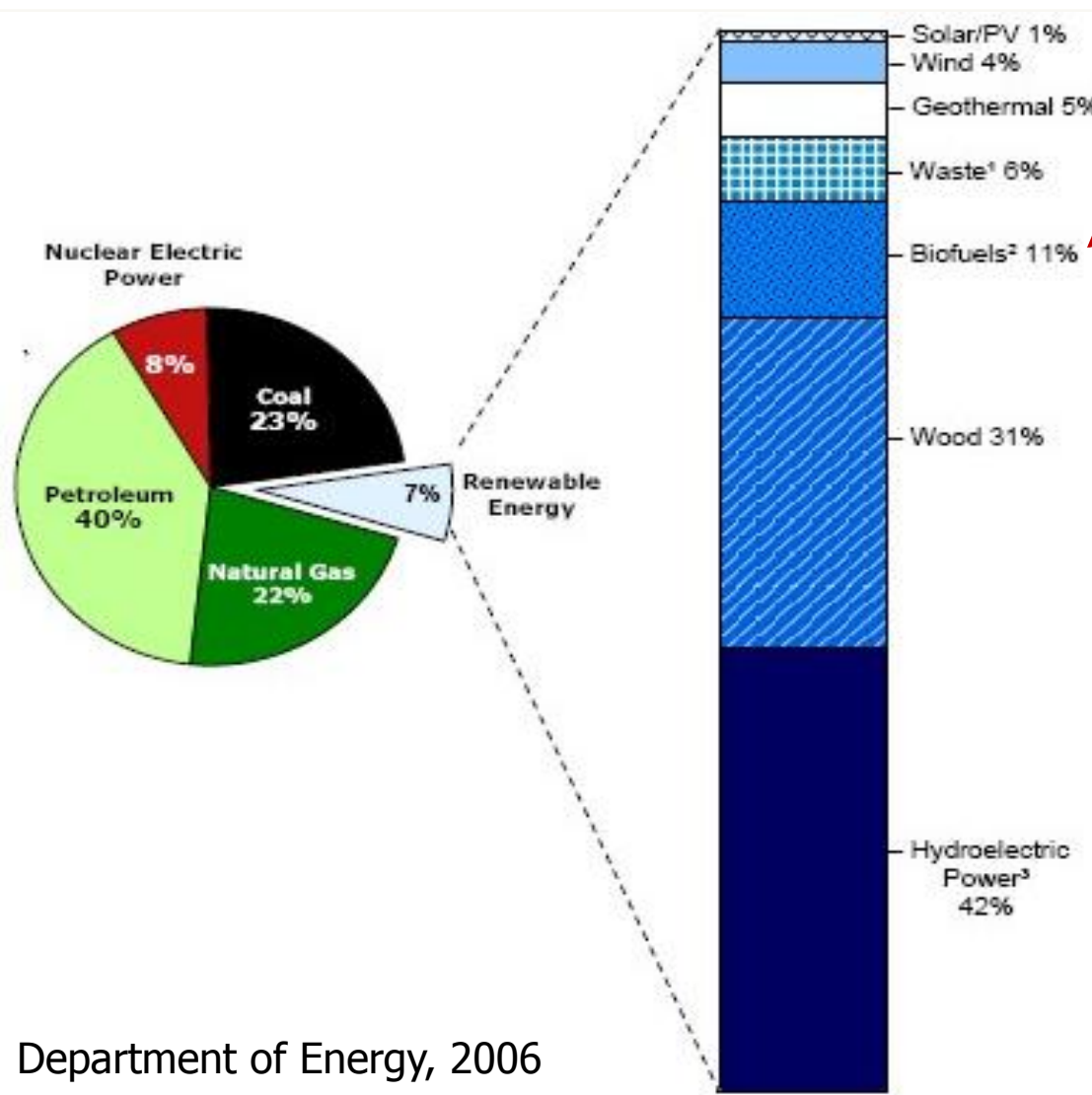
Advancing knowledge, research and innovation



Conference Objectives

Anju Dahiya

Can Algae Biodiesel expand the “Renewable energy as share of total energy” figure?



Department of Energy, 2006

ALGAE BIOFUEL
Target: expand
this figure.?

- In 2007, U.S. Biodiesel Industry produced 500 million gallons of fuel
- It displaced 20 million barrels of petroleum => added over \$4 billion to U.S. economy and supported over 21,000 jobs

Source: Biodiesel Magazine



Biofuels yeilds per year

(Source: NREL, DoE 2007)

<u>Crop</u>	<u>Oil Yield Gallons/Acre</u>
• Corn	18
• Cotton	35
• Soybean	48
• Mustard seed	61
• Sunflower	102
• Rapeseed/Canola	127
• Jatropha	202
• Oil palm	635

US diesel fuel demand 63 billion gallons

Algae

Conservative figures (NREL DoE,2007)

Oil Yield Gallons/Acre

10 g/m ² /day at 15% TAG	1,200
based on actual biomass yields	1,850
50 g/m ² /day at 50% TAG	10,000
theoretical laboratory yield	5000-15000

Figures from private sector:

1. Valcent Products Inc., Texas

(partner Global Green Solutions Inc.)

Actual reported yield	33,000
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Possible Estimate	150,000
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2. GreenFuel, Massachusetts

15 - 45,000



Algae Biodiesel production the realistic figures?

Theoretical maximum algal oil production of
unrefined oil has been found to be:

354,000 L/ha/year (38,000 gal/acre/year)

Source: NREL, 2009

Current & Past Research Efforts for Fuels from Algae

- Early 1950s MIT project – rooftop structure
- 1970s energy shock renewed algoil research
- Two decades of DoE NREL Algae Species program (1978-1996) [\$25 million]: characterization of oil rich algal species; photobioreactors vs. open ponds; open pond project - Rosewell, New Mexico.
- Algoil research ongoing worldwide
- Private organizations: Aquaflo, Greenfuels etc.

Hurdles in commercial scale production of Algae biodiesel

- Problems with algae biomass production
- Cost-effective Oil extraction techniques
- Investment and maintenance costs

Algae Oil: How Close we are?



Aquaflow New Zealand
12/2006 – B-20



10/90 algae/soya
12/2005



Solazyme San Francisco
USA 02/2008 – B100

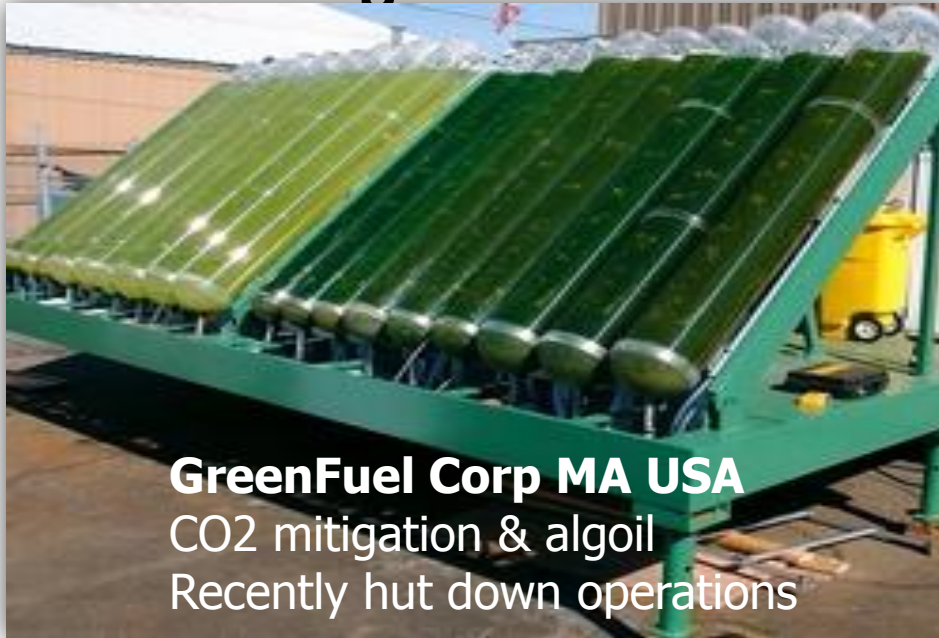


Continental Flight USA
01/2009

Alternative jet
fuel —
aka
Synthetic
Paraffinated
Kerosenes

Flight off Houston - one
engine powered by a 50-50
blend of regular petroleum-
based jet fuel and a
synthetic alternative made
from Jatropha and Algae

Algal Biomass & Oil Production



Cyanotech Corp. Hawaii
aerial view of Spirulina farm 90 acers



**Spirulina and Haematococcus Ponds
at Cyanotech Corp. in Hawaii**

Earthrise Co. CA Open pond system –
World's largest Spirulina farm - 108 acres.



Algae production for energy in Northeast Region: how realistic?



Picture Source:
cmaner5.org/regional-map.aspx

Temperature Conditions:

Generally, northern New England, the parts of New York north of the Mohawk River, highland areas in the Appalachians and some coastal areas possess a warm summer humid continental climate, with **warm, humid summers and snowy, often bitterly cold winters.**

Snowfall: can range from **over 100 inches (2.5 m) per year** in Upstate New York **to only a foot or so** in the coastal areas of southern New Jersey

Source: Wikipedia



Algae bloom in VT Lake
Source: Lake Champlain Land Trust

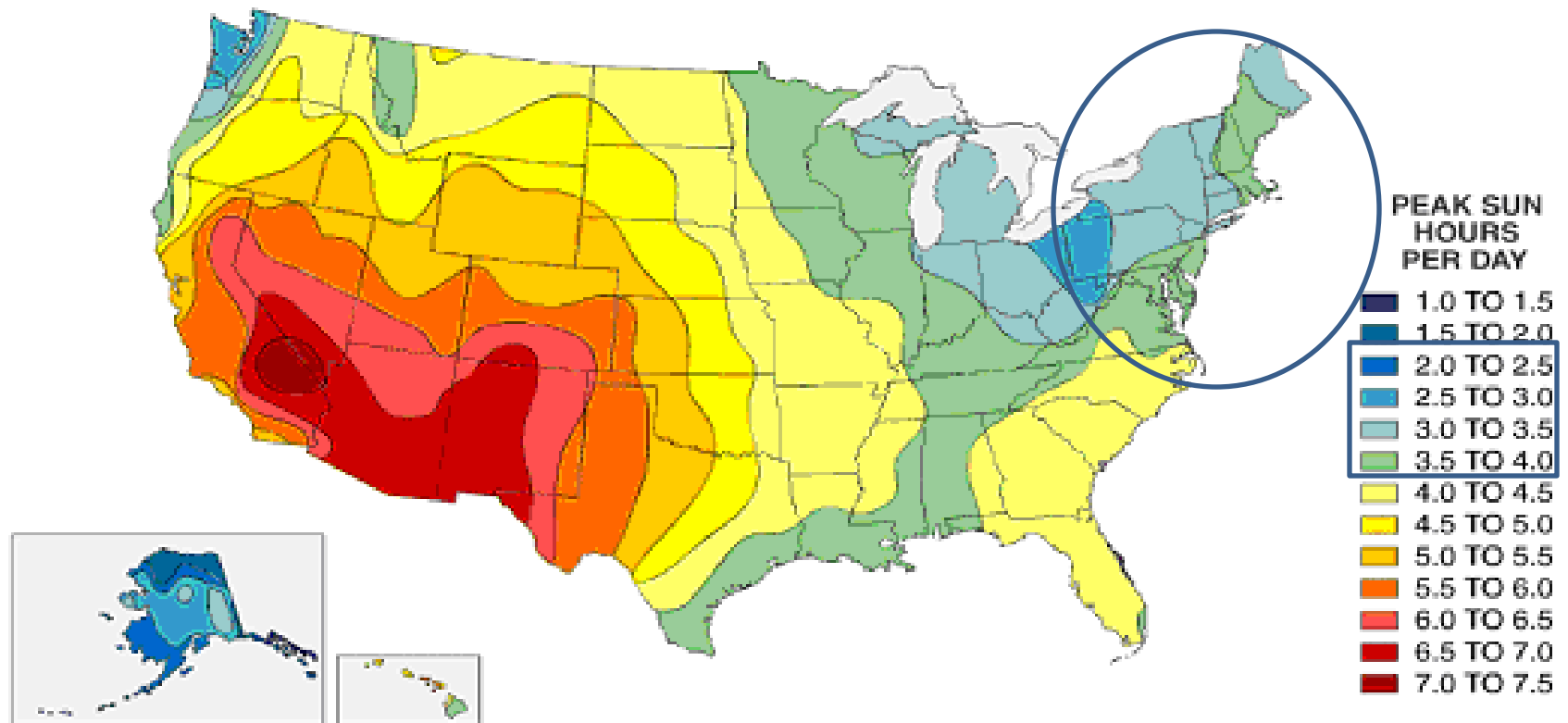


Source: HealthVermont.Gov

Sun hours/Light Conditions:

Average Annual Insolation follows next

Average Annual Insolation Map



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Source: <http://www.adrosenergy.com/Technology.html>

Algae grows Where not!



pink snow in the alpine Sierra
Nevada of central California

© W.P. Armstrong 2004



Image from Shuzo Shikano/Kyodo News



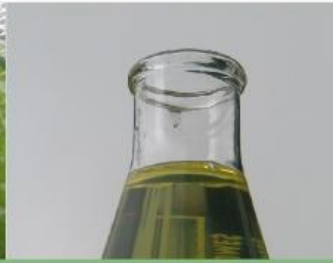
Big Question: Suitable Algae Production Systems for northeast?

- Photobioreactors
(closed system)
- Open ponds
- Hybrid system

Open Ponds vs. Closed Photobioreactors

<u>Parameter</u>	<u>Relative</u>	<u>Note</u>
Contamination risk	Ponds > PBRs	Just a matter of time for either
Space required	Ponds ~ PBRs	A matter of productivity
<u>Productivity</u>	Ponds ~ PBRs	NO substantial difference except at low temperatures
Water losses	Ponds ~ PBRs	Evaporative cooling needed
CO2 losses	Ponds ~ PBRs	Depends on pH, alkalinity, etc.
O2 Inhibition	Ponds < PBRs	O2 greater problem in PBRs
Process Control	Ponds ~ PBRs	no major differences (weather)
Biomass Concentration	Ponds < PBRs	function of depth, 2 -10 fold
<u>Capital/Operating Costs</u>	Ponds << PBRs	Ponds 10 -100 x lower cost!

CONCLUSION: Photobioreactors better than ponds? Sometimes but advantages **way** overstated. For biofuels **can't afford** PBRs



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- * Overcoming challenges to algae feedstock production in the Northeast
- * Algal harvesting, lipid (oil) extraction, biofuel conversion
- * Uses and markets for algal oil and by-products