



# **Algae & Energy in the Northeast**

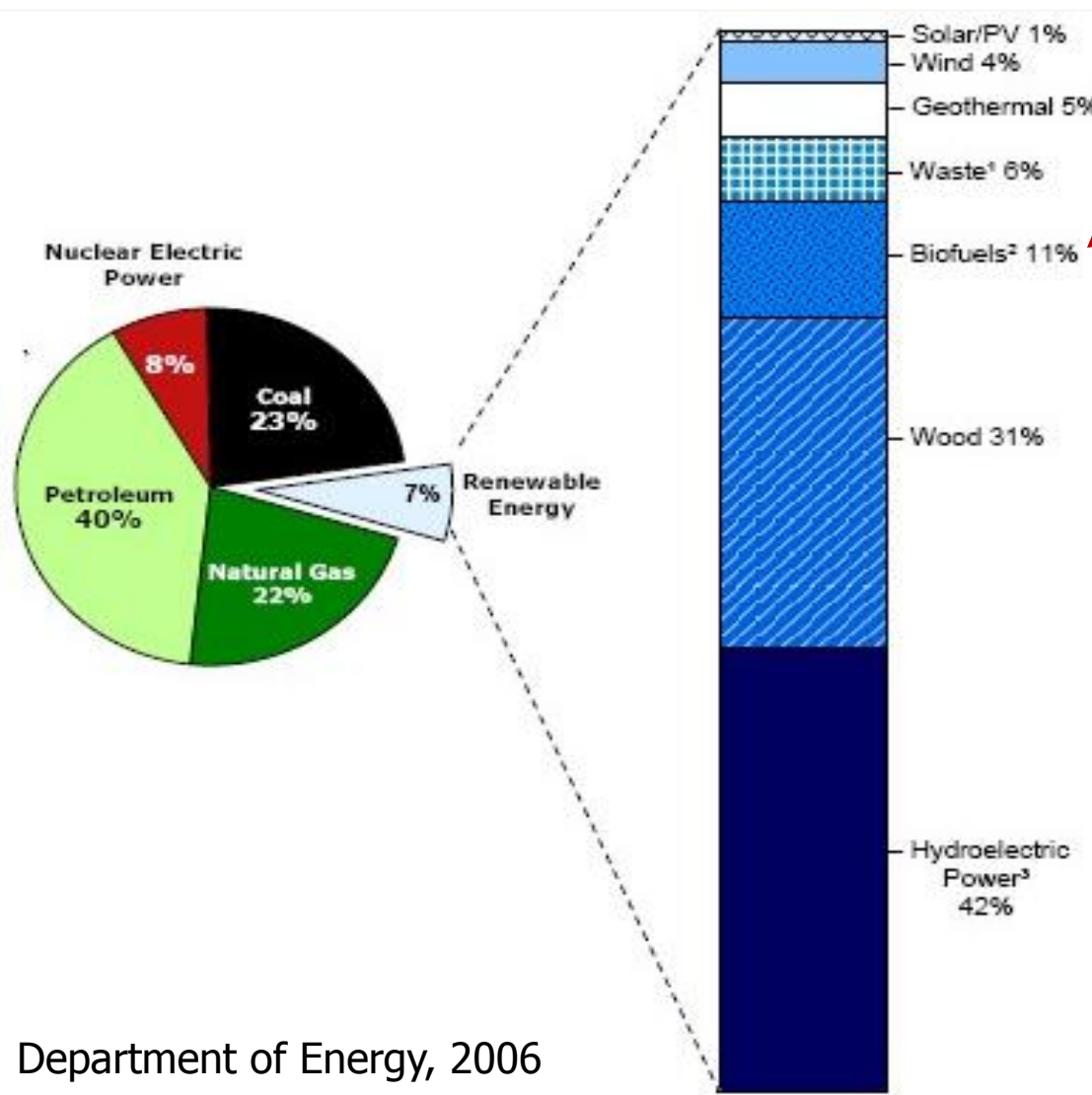
Advancing knowledge, research and innovation



## **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 <sup>2</sup> /day at 15% TAG	1,200
based on actual biomass yields	1,850
50 g/m <sup>2</sup> /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



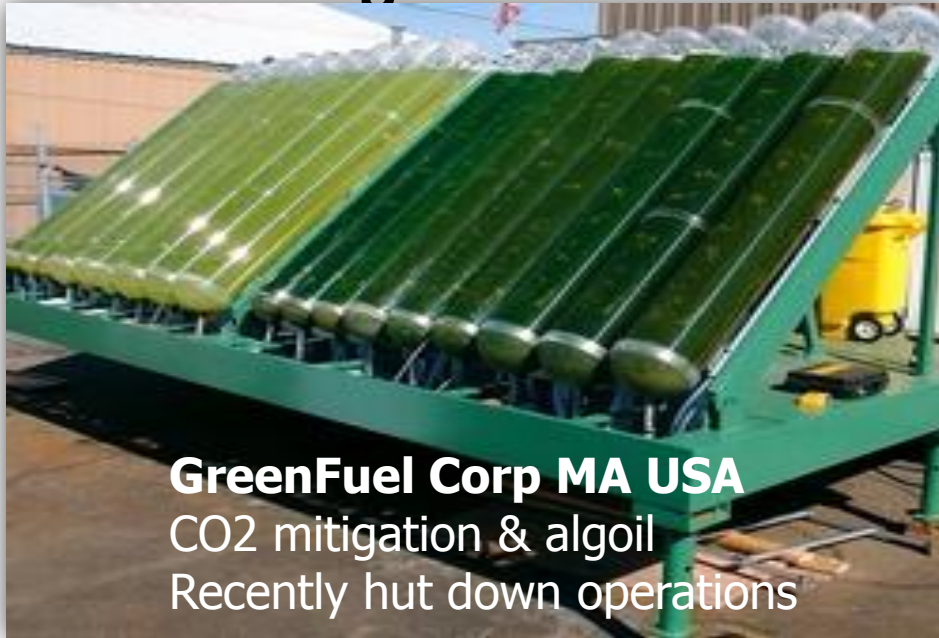
Continental Flight USA  
01/2009

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



**GreenFuel Corp MA USA**  
CO2 mitigation & algoil  
Recently shut down operations



**Valcent Corp. Texas USA**  
vertical bio-reactor

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](http://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

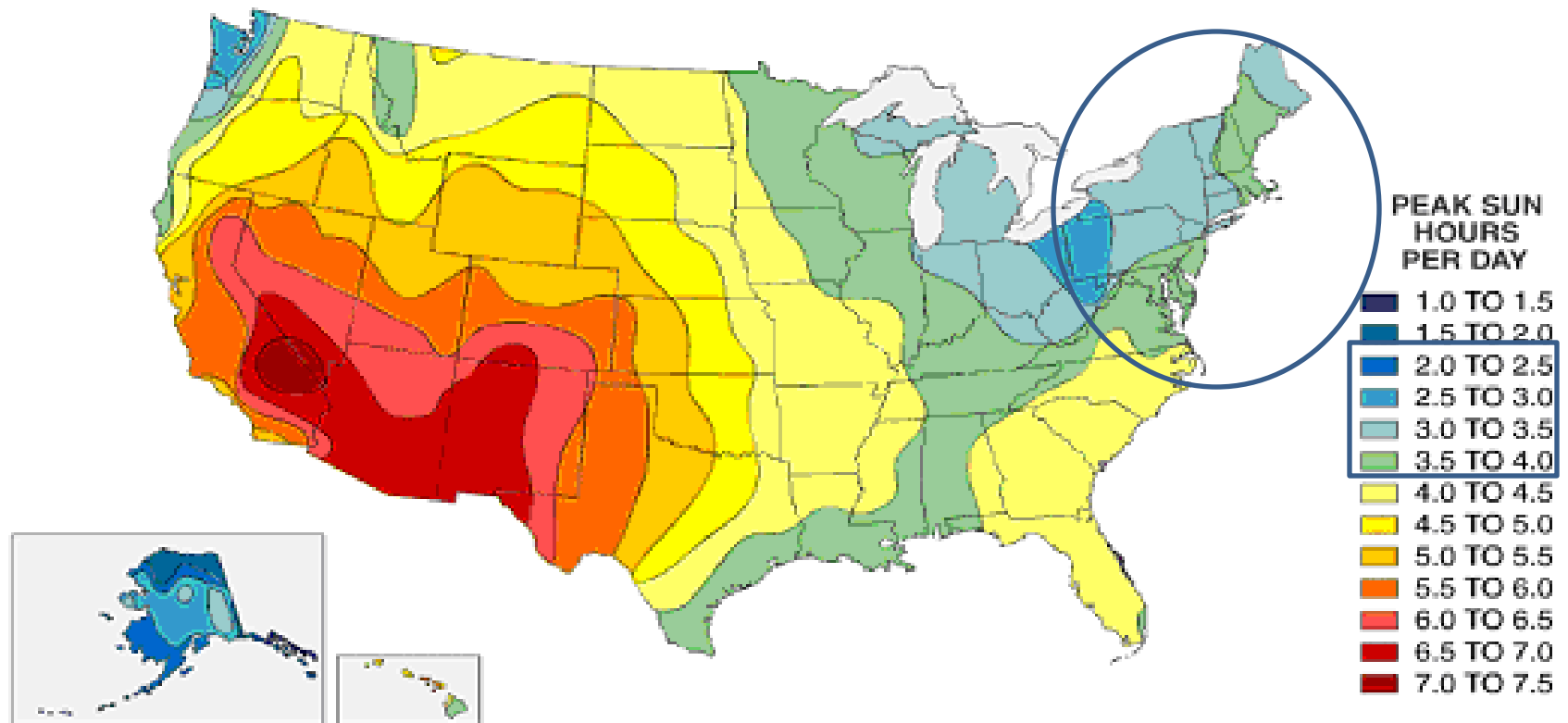


Source: HealthVermont.Gov

## 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?

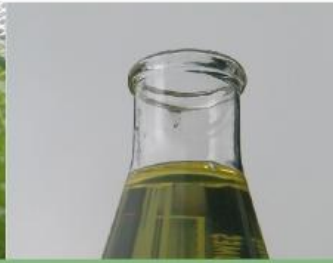
- Photobioreactors  
(closed system)
- Open ponds
- Hybrid system

# 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	<b>NO</b> 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





# Algae & Energy in the Northeast

Advancing knowledge, research and innovation



- \* 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