



Biodiesel Production from Algae Growing on Municipal Wastewater: Turning a Nuisance (algae) into Biodiesel

Patrick G. Hatcher, Executive Director VCERC
Batten Endowed Chair in Physical Sciences, Professor of Chemistry and
Biochemistry, Old Dominion University



<http://www.vcerc.org/>



Biomass from Algae for the production of biodiesel

Estimated cost: \$1.40 to \$4.40/gal

Or

\$60 to \$100 per barrel of oil equivalent

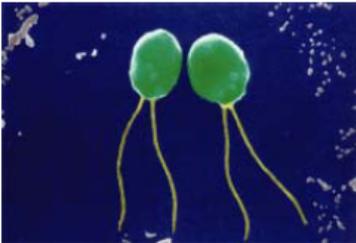
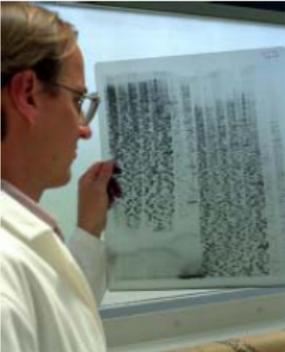
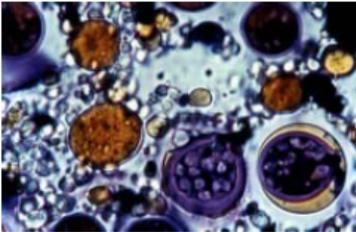
7.5 billion gallons of biodiesel per year requires 500,000 acres of water

At \$1/gal profit, the annual return would be \$7.5 billion

National Renewable Energy Laboratory
NREL

NREL/TP-580-24190

A Look Back at the
U.S. Department of Energy's
Aquatic Species Program:
Biodiesel from Algae



Close-Out Report

Virginia Coastal Energy Research Consortium
VCERC

Why Is It Attractive?



1. Algae outperforms all other plant-based sources of alternative fuels

Gallons of Oil per Acre per Year

% of Agricultural Land Required to Fuel US Transportation

Corn	15
Soybeans	48
Safflower	83
Sunflower	102
Jatropha	175
Rapeseed	127
Oil Palm	635
Microalgae*	1,850
Microalgae**	5,000 – 15,000

CORN	1,700 %
SOYBEANS	650 %
CANOLA	240 %
JATROPHA	154 %
COCONUT	108 %
OIL PALM	50 %
MICROALGAE	2 – 5 %

2. Does not require agricultural land, competing with farm crops

* Actual biomass yields ** Theoretical biomass yields

Why is it attractive?

3. Algal production and ensuing biodiesel can be coupled with numerous industrial processes

- a. Electric power generation to reduce CO₂ emissions-carbon credits (algae need CO₂ as a carbon source to grow)
- b. Agricultural and municipal wastewater runoff to clean up nutrient-laden effluents (algae require the nutrients such as ammonia, phosphates, and nitrates for growth)
- c. Clean-up of algae from eutrofied waterways-can pump and filter algae for use as a feedstock for biodiesel





**Test Facility:
Virginia Initiative
Plant
Hampton Roads
Sanitation District**

Pilot-Scale Reactors at VIP

- Biomass production rate
- Nutrient uptake
- Balance gas transfer (CO_2 input O_2 stripping)
- Instrumentation and controls
- Separation/dewatering



Concurrent laboratory culturing ongoing using VIP effluent

What We Are Currently Focusing On



Interfacing



Design Solutions

Optimizing

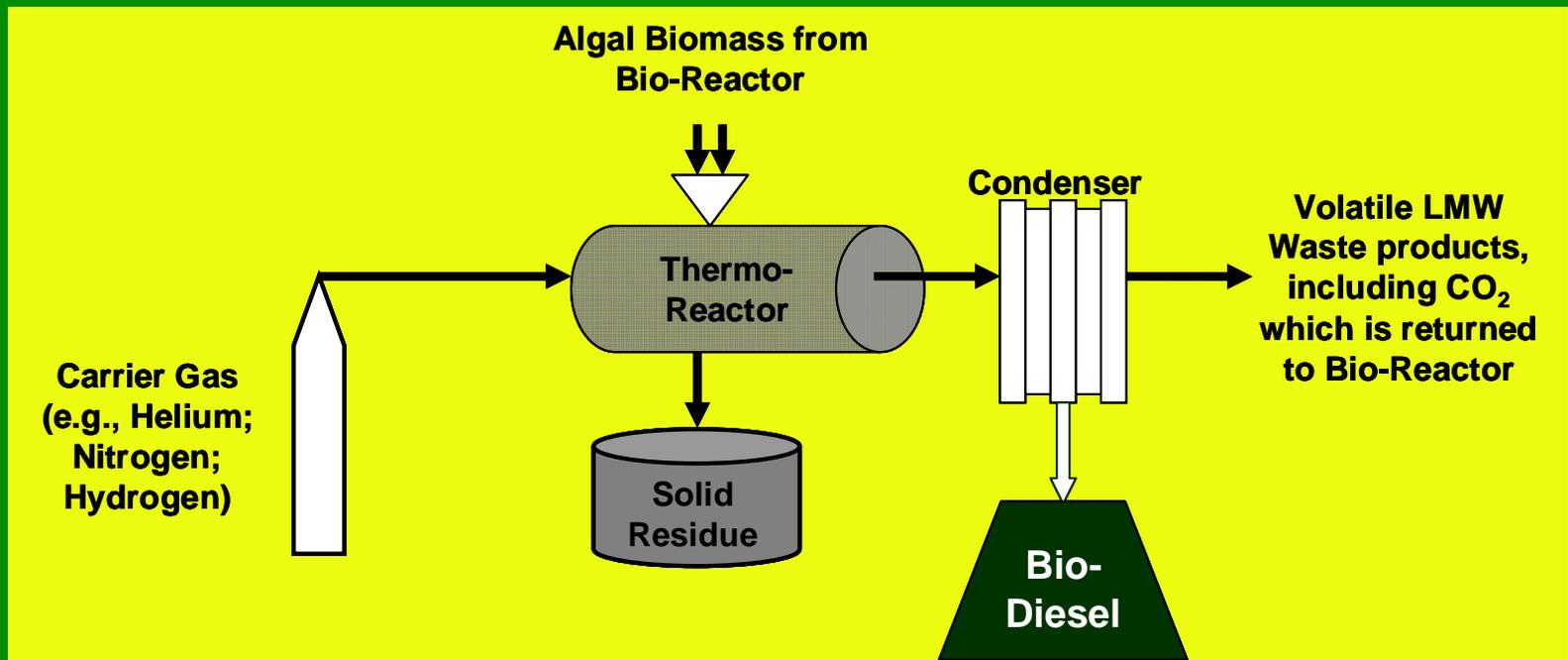


Scaling



Batch-Mode Chemo-Reactor :

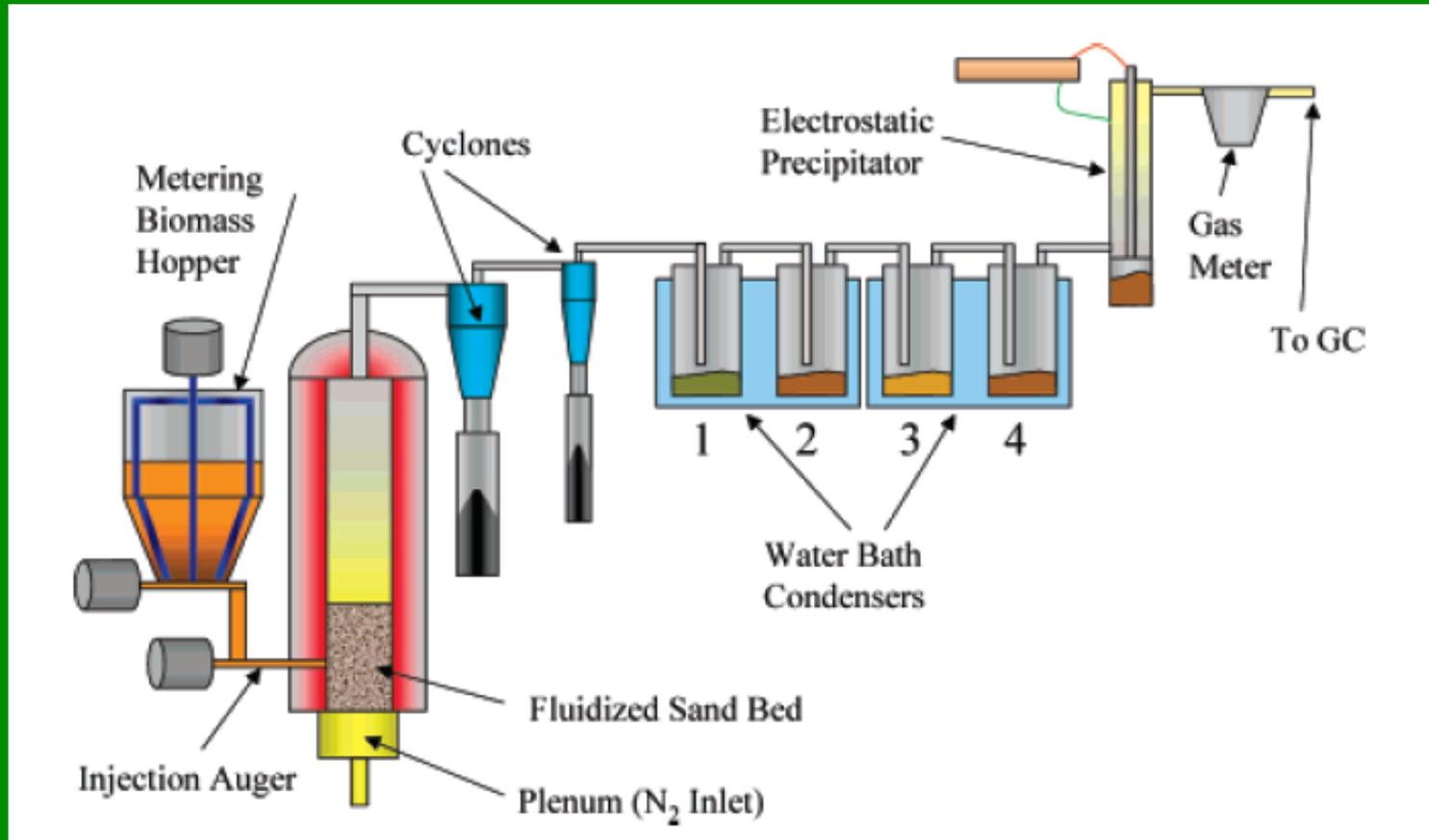
for conversion of algal biomass to biodiesel-filed provisional patent



Seed funds from ODURF (\$50,000 in FY08) were used to develop "proof of concept" chemoreactor

Second generation flow-through chemoreactor

Fluidized bed chemoreactor being constructed from monies provided by ODURF and VCERC



Boteng et al., *Ind. Eng. Chem. Res.*, 2007

USDA, facility- being used for
switchgrass conversion to bio-oil

Accomplishments

- NSF funding to examine the fate of effluent organic N: VIMS/ODU/Michigan collab. For 3 yrs
- SBIR DOE grant with Acent Laboratories to develop new technology for harvesting algae
- Submitted DARPA proposal with SRI to demonstrate production of jet fuel from algae- not selected
- Secured VCERC funding
- Commenced the building of algal raceway and tank pilot-scale facilities

Perceived Needs

- Scale-up to a pilot-scale on the following:
 - Algal raceways and harvesting
 - Chemoreactor applied in a continuous mode
- Before anyone will invest in a large-scale algal biodiesel operation we will need to demonstrate the economics of a pilot-scale reactor

Current Activities

Commenced the building of algal raceway and tank pilot-scale facilities

Collaborative with HRSD VIP plant near campus

Collaborative with “algal” farmer in Hopewell, VA area

Collaborative with Hopewell, VA wastewater facility

High throughput, second-generation chemoreactor under construction

Designing of harvesting technology (preparing IP disclosure)

Collaborating with Acent via SBIR

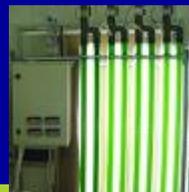
Possible Commercial Ventures

1. Algal biodiesel production for wastewater industry- \$40 million/yr profit
American Biofuels Corporation (ABC)- Donn Dresselhuys
2. Algal farming/topsoil- Sprouse Industries- \$20 million/yr profit
3. Algal farming/large-scale for production of biofuels
 1. Use of Navy OLF site (20,000 acres)- \$50 million/yr profit
 2. In association with Danville/Southside racecar industry
4. Algal farming associated with Powerplants for CO₂ sequestration and fuels
BIOCO collaborative
5. Biodiesel production from algal/other feedstocks

Basic Biological Processes to Produce Algal Biomass

Bio-diesel from Algae – CO₂ Emissions

- MIT/Green Fuel Technologies, Inc.
- Green Star Products
- Colo State Univ/ Solix, Inc.
- Solazyme
- Live Fuels
- Bio King
- Blue Sun Bio-diesel
- Valcent products-Vertigo
- New Mexico State



Bio-diesel from Sewage Effluent

- * Aquaflo Bionomic (NZ)