John Benemann: "CO_2 Microalgae Utilization - Historical and Global Overview" Orlando, FL, US DOE BETO Algae Cultivation for Carbon Capture and Utilization Workshop, 05/23/17

- Facilities Designs
- Equipment
- Wastewater Reclamation
- Scientific Consulting
- R&D
- Life Cycle Assessments
- Techno-Economic Analyses

μBIO
MicroBio Engineering

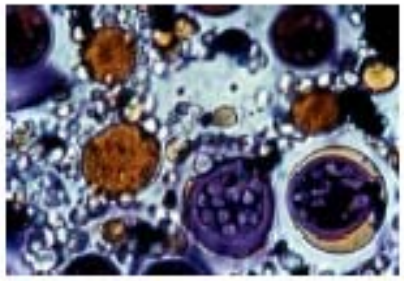

U.C. Berkeley, Sanitary Engineering Research Lab. Ca 1977
US DOE funded algae biofuels and wastewater treatment projects
Micractinium→
Settling
two x 0.1 ha ponds
Prof. Bill Oswald
First use of paddle-wheels for mixing large raceway ponds,
Demonstrated settling algae for harvesting and CO2 fertilization (Benemann et al, 1980)

Aquatic Species Program
U.S. DOE 1980 -1996

NREL/TP-580-24190

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

J. Sheehan,
P. Roessler,
T. Dunahay,
J. Weissman
J. Benemann
(Principal Investigator)



Close-Out Report

Paul Roessler now at Algenol (before that at Synthetic Genomics

Algae-powered cars:
Science fiction or science?

Say algae, and most people think of those unpleasant green organisms found in swimming pools and fish tanks. But to the scientists and engineers of ExxonMobil, algae conjures something far more appealing: Opportunity. Why? Because algae can create renewable energy while absorbing CO_2.

The energy from algae might someday produce biofuels that are compatible with those made from conventional crude oil. That's why ExxonMobil is committed to a major long-term research and development program aimed at developing algae as a viable fuel source. Unlike other biofuel sources such as corn and sugar cane, algae do not compete with our food supply. And because they consume CO_2, algae could help reduce greenhouse gases.

ExxonMobil is partnering with Synthetic Genomics Inc., pioneers in biotechnology, on this groundbreaking research effort. Our goal is to produce biofuels from algae in the future to supplement the fuels we use in our vehicles today, while reducing greenhouse gas emissions. Algae have never looked so inviting.

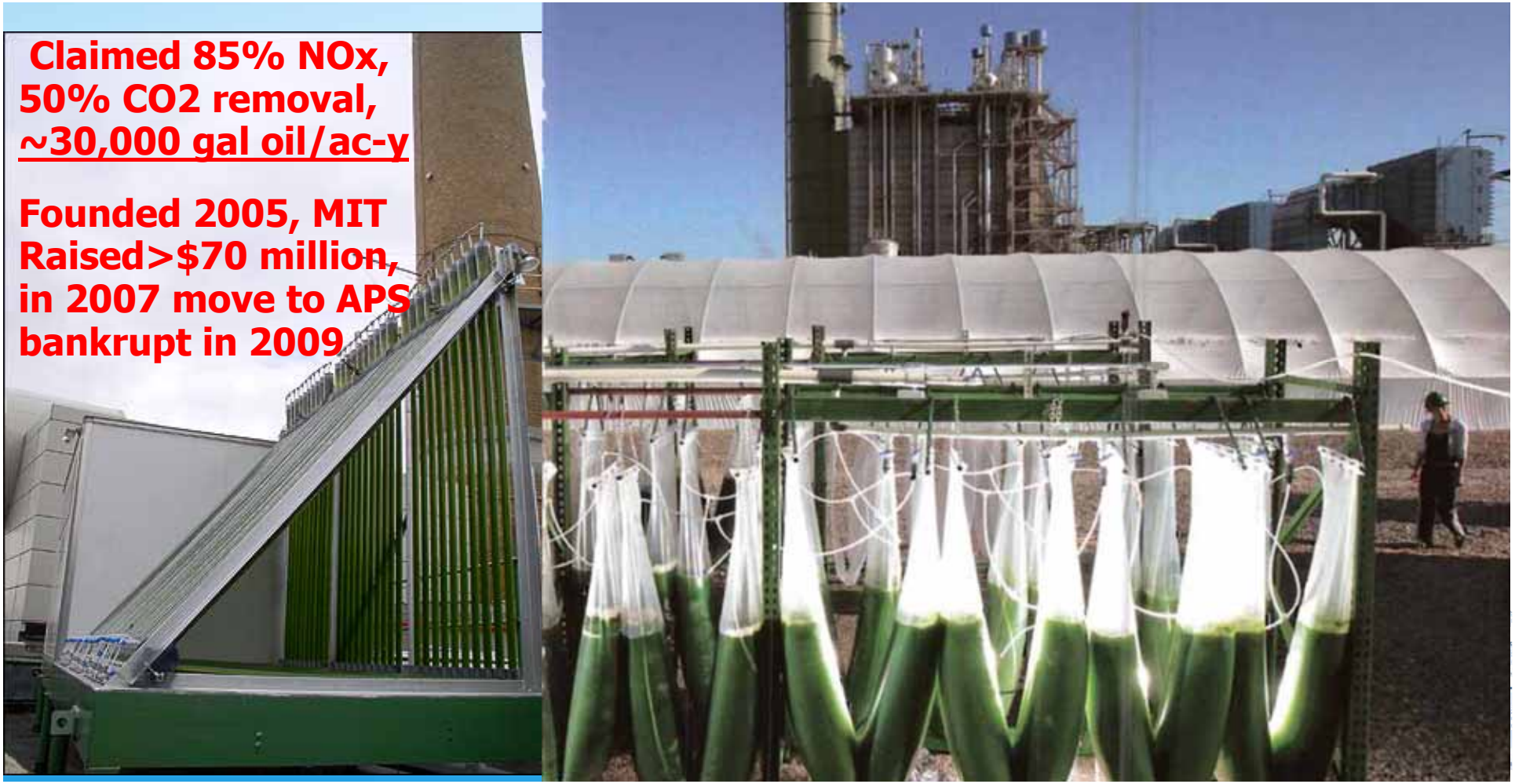
exxonmobil.com

Joe Weissman

ExxonMobil

ExxonMobil
Taking on the world's toughest energy challenges

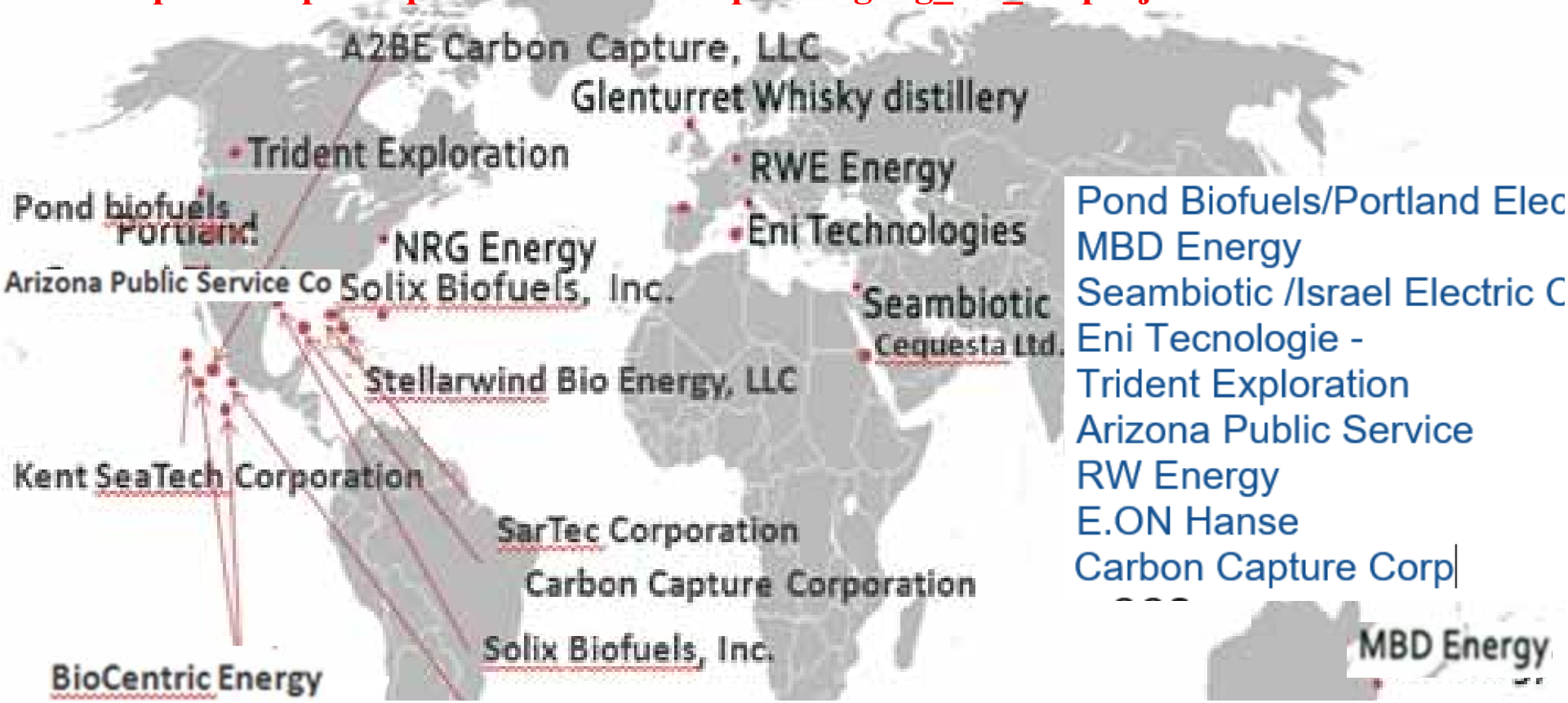
GreenFuel Technologies & Arizona Public Services (APS)



Claimed 85% NOx, 50% CO2 removal, ~30,000 gal oil/ac-y

Founded 2005, MIT
Raised>$70 million,
in 2007 move to APS
bankrupt in 2009

http://www.powerplantccs.com/ccs/cap/fut/alg/alg_ccs_liveprojects.html



Major algae-based CO_2 capture /utilization projects in 2010

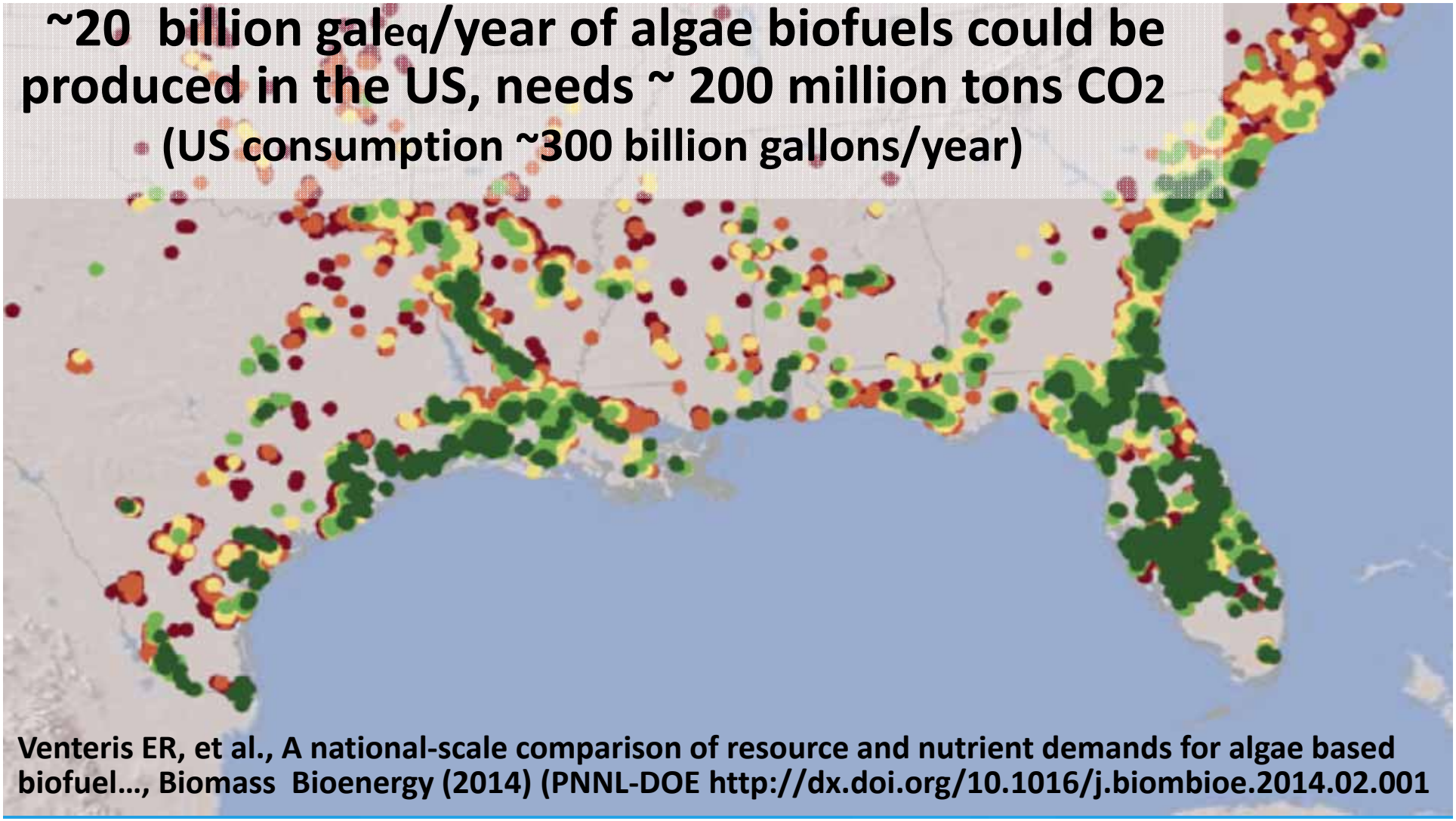
Reality Check: None still active in this field

Some more recent examples of algae CO2 Utilization Projects:

Reality Check: CO2 flue gas utilization not yet commercial

~20 billion gal_{eq}/year of algae biofuels could be produced in the US, needs ~ 200 million tons CO_2

(US consumption ~300 billion gallons/year)



Venteris ER, et al., A national-scale comparison of resource and nutrient demands for algae based biofuel…, Biomass Bioenergy (2014) (PNNL-DOE http://dx.doi.org/10.1016/j.biombioe.2014.02.001

MicroBio Engineering Inc. RNEW® Process for wastewater treatment, biofuels and CO_2 utilization

Recycle
Nutrients
Energy
Water

THANK YOU !

- CO_2 addition for complete nutrient removal
- Algae harvesting by bioflocculation (settling)
- Biofuels co-products (anaerobic digestion, HTL, etc.)
- Low cost and low energy vs. conventional treatment