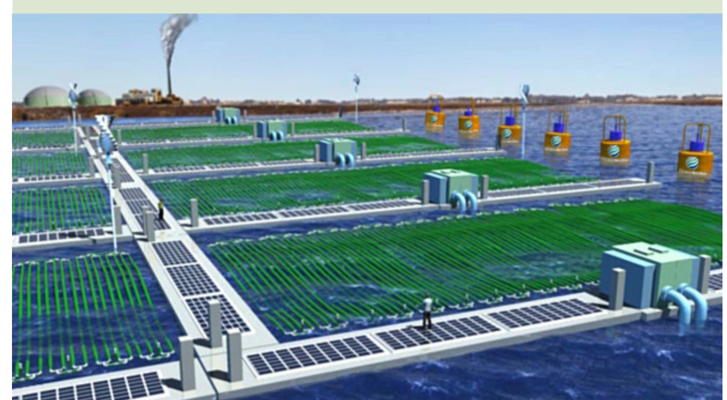
Critical Questions

The limits and liabilities of fossil fuels are apparent; evidence that microalgae may provide a sustainable substitute fuel is accumulating.

- Is large-scale, environmentally sensitive, economical microalgae cultivation possible?
- Can it be done without competing with agriculture for freshwater, fertilizer, or land?

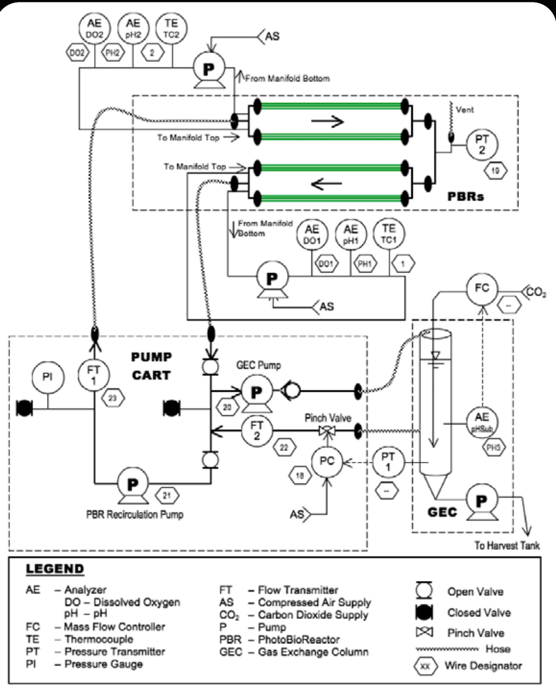
OMEGA Could Be the Answer

In OMEGA, oil-producing freshwater algae are grown in flexible, clear plastic photobioreactors (PBRs) attached to a floating infrastructure anchored offshore in a protected bay. Wastewater and CO_2 from coastal facilities provide water and nutrients. The surrounding seawater controls the temperature inside the PBRs and kills algae that escape from the system. The salt gradient between seawater and wastewater drives forward osmosis, to concentrate nutrients and facilitate algae harvesting. The OMEGA infrastructure also supports aquaculture below the surface and provides surfaces for solar panels and access to offshore wave generators and wind turbines. Integrating algae cultivation with wastewater treatment, CO_2 sequestration, aquaculture, and other forms of alternative energy creates an *ecology of technologies* in which the wastes from one part of the system are resources for another. In addition, the parts economically support the integrated whole. By treating wastewater, sequestering CO_2, and providing a marine habitat, the system is environmentally friendly. By using wastewater for water and fertilizer and operating offshore, OMEGA does not impact agriculture.



OMEGA Project

The OMEGA project, funded by NASA ARMD, along with a separate project supported by the California Energy Commission, have two general goals: 1) to investigate the feasibility of OMEGA and 2) to transfer the technology. Feasibility depends on engineering, biology, economics, and environmental issues. We therefore built floating PBRs with monitoring and control systems, grew algae, estimated costs and energy requirements, studied biofouling, observed impacts on marine animals, and considered coastal permitting issues. To transfer the technology, ideas and information were presented in lectures, papers, animations, and videos, and shared on the Internet. The goal is to motivate other OMEGA projects to develop the technology rapidly and significantly decrease the use of fossil fuels globally.



The schematic of the OMEGA system shows flow from PBRs to the gas exchange and harvesting column (GEC). Algae are harvested semi-continuously from the column until grazers that eat algae or pathogens that kill them are detected, at which time the whole system is harvested and flushed with seawater to clean it out before restarting.

Santa Cruz-CDFG

1. Cal Fish & Game lab showing seawater tanks (upper center) and aquaria (center).
2. Instruments for monitoring algae growth tested in lab.
3. Outdoor control systems optimize algal growth.
4. Gas exchange and harvesting column
5. Floating 100-liter photo-bioreactors (PBRs) in seawater tank.

San Francisco Southeast Treatment Plant-SEP

1. Treatment plant in San Francisco (arrow shows tanks)
2. The NASA research trailer.
3. Portable greenhouses to grow algae inoculant.
4. Photobioreactors floating in seawater tank with gas-exchange harvesting column (upper center).

Accomplishments

(NASA OMEGA project: Jan 2010 - May 2012)

- Demonstrated controlled microalgae growth on wastewater in floating PBRs
- Operated 100, 200, 1,600, and 3,200-liter PBR systems for repeated algal growth cycles.
- Treated wastewater and recycled nutrients effectively
- Showed efficient uptake of CO_2 using gas exchange column
- Developed protocols for harvesting algae and controlling grazers
- Determined impact of biofouling
- Attracted more than 16,500 global viewers of OMEGA YouTube videos

What Next?

- *Complete experiments and publish results from Santa Cruz and San Francisco test facilities*
- *Transition equipment from existing facilities to others*
- *Establish an OMEGA test-bed in SF with outside funding*
- *Raise support, develop, and deploy the first OMEGA demonstration in a protected bay*
- *Continue advocacy for OMEGA development globally*

Algae do not currently contribute significantly to biofuel production because of logistical and economic issues. Large-scale algae farms (millions of acres) require huge pipelines for wastewater and CO_2, the farm infrastructure, and a transportation network for the diverse products. On land, neither the required energy nor the economic returns on investment can be met. It is not known if OMEGA, using existing offshore wastewater outfalls, coastal CO_2 sources, ships, and local energy sources (solar, wave, and wind), can meet the required returns, but the results of the OMEGA team show promise, a lot is at stake, and at this stage OMEGA warrants further investigations.

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or see:

http://www.nasa.gov/centers/ames/research/OMEGA/index.html

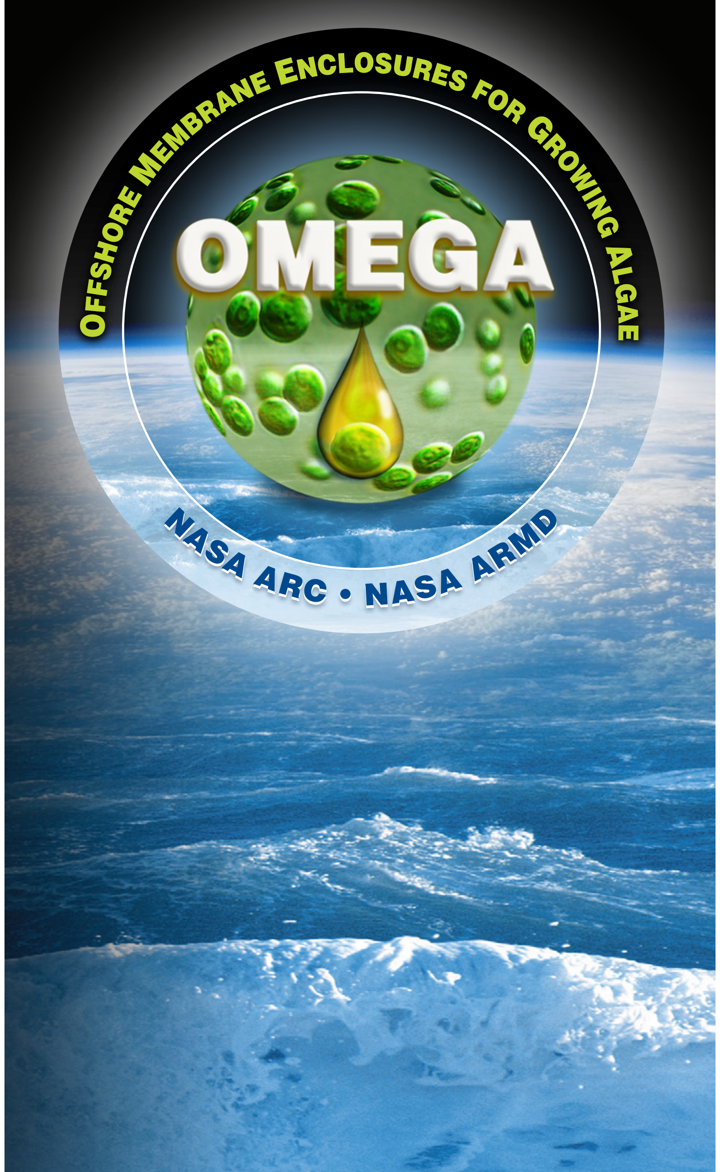
http://www.algaeindustrymagazine.com/nasas-omega-scientist-dr-jonathan-trent/

http://www.youtube.com/watch?v=A6oekxl0JAs,

http://www.youtube.com/watch?v=1_z-LnKNlco

http://www.youtube.com/watch?v=c7Goyg12Reg.

National Aeronautics and
Space Administration



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