OMEGA: For cultivating a sustainable future

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"The greater danger for most of us lies not in setting our aim too high and falling short, but in setting our aim too low and achieving our mark." Michelangelo

From a planetary perspective, *Homo sapiens* is a relatively recent arrival in the biosphere (~200,000yrs) and for most of its history it has been a minor species. In the last two hundred years however, using energy from fossil carbon, our species has grown to unprecedented numbers, surpassing an estimated population of seven billion last year. Using fossil fuels, a lifestyle has developed, which is having global impact. Now, with the realization that environmental changes may be have unacceptable consequences and with the limits of fossil fuels approaching, there is a growing effort to find renewable, carbon-neutral, and sustainable energy sources. For liquid fuels, vegetable oil is being investigated. Oil yields from soybeans are approximately 470 liters/hectare/year; Jatropha 1850 liters/hectare/year, palm 5,610 liters/hectare/yr, and it is estimated that yields from some species of microalgae could be >18,700 liters/hectare/year. Microalgae have the potential added benefit of not competing with agriculture for water and fertilizer provided they are cultivated on municipal wastewater and if they can be cultured at appropriate offshore sites they would also not compete for land.

Offshore Membrane Enclosures for Growing Algae (OMEGA) is a system of closed photobioreactors (PBRs) constructed of flexible, inexpensive, and durable plastic filled with municipal wastewater from offshore wastewater outfalls and provided with CO_2 from wastewater facilities, coastal power plants, or other near-shore CO_2 sources. The OMEGA modules float just below the surface, the surrounding saltwater provides structural support and temperature control, while surface waves provide mixing for the freshwater algae cultures inside. The salinity gradient from inside to outside drives forward osmosis, which concentrates nutrients in the wastewater to enhance algal growth, and slowly dewaters the algae to facilitate harvesting. The FO also cleans the wastewater released into the surrounding coastal waters or can be incorporated into a water recovery system. If the OMEGA system leaks during any phase of its operation, it leaks wastewater approved for ocean discharge and it releases freshwater algae that cannot survive in saltwater. The supporting infrastructure for OMEGA can be used for solar panels above water and can be used to support aquaculture below water. The infrastructure also provides access to offshore sites for wave or wind energy generation.

The OMEGA system integrates algae production for biofuels with wastewater treatment, fertilizer, and food production, while sequestering CO_2. OMEGA is an *"ecology of technologies"* in which wastes from one part of the system are resources for another part. If implemented, OMEGA will be part of the transition from hunting-and-gathering energy to cultivating a sustainable and environmentally sensitive energy source that will support a new era in human civilization.

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