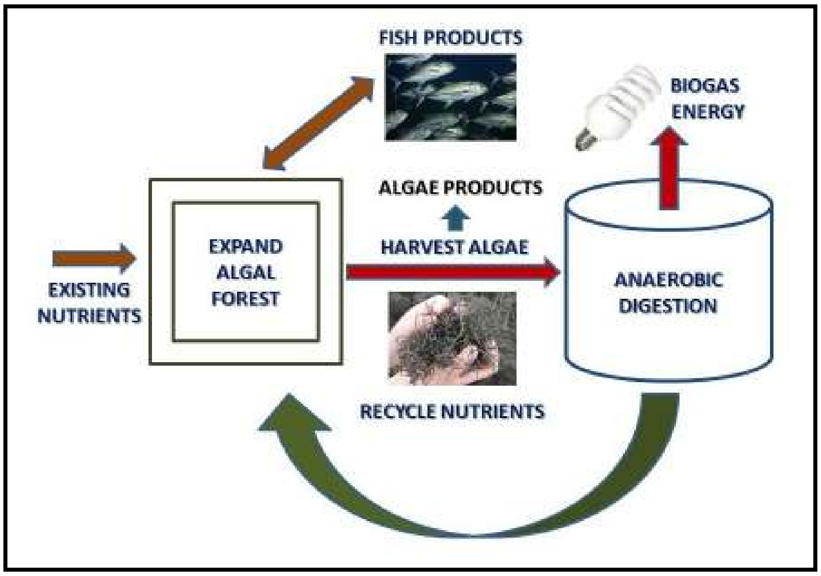
ADVANCED INTEGRATED MULTI-TROPHIC AQUACULTURE WITH RENEWABLE ENERGY PRODUCTION (IMTA+E)

Overview

IMTA plus renewable energy production is food-aquaculture that scales up to meet 100% of world energy demand based on enhancing a natural ecosystem. In the long term, IMTA+E can economically and environmentally replace world fossil fuel use, while expanding food supplies with fish and plants and reversing global warming.

In the short term, a sheltered-water version of IMTA+E can be economically self-sustaining on electricity production within four years. A 2-hectare pilot project in Laucala Bay, Fiji, involves macroalgae growing, harvesting, anaerobically digesting, and nutrient recycling techniques conducted by PODenergy, the University of the South Pacific, and the University of Hawaii. The project is coordinated with the nearby Kinoya Sewage Treatment Plant to measure and flare the produced biogas.



Projections indicate a 2,500-ha forest in Laucala Bay, would generate about 7 MW continuously while measuring the coincident value of fish and plant food. To achieve Fiji's goal of 100% fossil-free electricity with 60 MW of baseload renewable electricity could involve 20,000-ha of macroalgae forests, less than half the area of Fiji's bays. The quantity and quality of additional fish produced are less predictable, but could be about equal in value to the electricity production.

IMTA+E could then gradually expand to the open ocean until, when it covers 6% of the world's ocean surface; IMTA+E can produce sufficient biomethane to fill 100% of world energy needs. Simultaneously, with the same 6% of ocean surface IMTA+E could increase sustainable fishing harvests by up to 1,000 kg/yr/person for all seven billion people while increasing ocean biodiversity.

If carbon dioxide is separated from the biogas and sequestered, the total process could also decrease atmospheric CO_2 concentrations from the current 400 ppm to the target level of 350 ppm in less than 30 years. In addition, the biomethane could be used to produce products such as synthetic diesel, jet fuel, and plastics.

Advantages

The complete IMTA+E ecosystem is an ocean-based sun-algae-biomethane-food producing process. The key process, anaerobic digestion, is routine and extremely robust, in both nature and wastewater treatment throughout the world. Past decades of algae-to-energy efforts, which have been well documented (Chynoweth, 2002), have ignored co-production of marine vegetable products and fish. Also, little attention has been paid to recycling the nutrients remaining after the biomethane extraction process. Most recent work on IMTA, while using seaweeds to recycle fish wastes, does not consider alternate sources of imported nutrients, nor the recycling of nutrients remaining from biogas production.

IMTA+E also differs from past efforts by combining recent advances in ocean engineering, tensile fabric structures, and wastewater engineering, primarily that large engineered geotextiles (plastic fabrics and films) can be formed into ocean-based process facilities whose capital cost ($/volume of process vessel) is 1% of their land-based steel and concrete counterparts. The lower cost process volume allows the use of innovative inexpensive processes for biomass harvest, biomass pre-treatment, slow digestion, nutrient recycling, carbon dioxide storage, etc. The anaerobic digestion container referred to in the figure above is made of geotextiles. It can be at the water surface in a sheltered bay (or large freshwater lake), or in the open ocean at least 50 meters below the surface to protect it from storms.

PODenergy's approach is designed to mimic natural biological processes already occurring in the ocean, thereby supporting natural biodiverse ecosystems without genetically-modified organisms or chemical additives. Nutrient recycling is the key to sustainability.

The technology for algae cultivation and anaerobic digestion is well known. The largest economic unknowns involve the techniques for biomass mariculture in the open ocean: growing, harvesting, moving, and sustaining (through nutrient recycling) the biomass. The sheltered water approach in Fiji has much less risk. There are legal questions of access to the fish profits, which likely depend on governments allowing the right to a royalty on the additional fish. Wherever the price of natural gas is above $10/mmBtu or electricity is above 10¢/kWh $US, our current projections show profitability is not dependent on income from carbon or fish, but these income sources offer large potential additional returns. Eventually the process might even be able to compete with current US prices for natural gas.

The Current Team

The present team includes (detailed biographies are available):

- Antoine de Ramon N'Yeurt, Ph.D. – marine biologist at the University of the South Pacific, expert in macroalgae of the South Pacific.
- Kevin Hopkins, Ph.D. – Director, Pacific Aquaculture & Coastal Resources Center
- David Chynoweth, Ph.D. – leading authority on biological gasification of marine algae, with over 130 scientific publications.
- Mark Capron, M.S., P.E, – California Registered Engineer with expertise in marine engineering and anaerobic digestion and President of PODenergy.
- Jim Stewart, Ph.D. – research physicist from Yale University, now environmental policy expert and Vice President of PODenergy.
- Mohammed Hasan, M.S., P.E. – California Registered Civil Engineer and an experienced businessman with a working knowledge of six languages and Vice President of PODenergy.

In addition, the University of Virginia Department of Civil and Environmental Engineering is preparing a comprehensive life cycle assessment of the sheltered water IMTA+E process. Preliminary results look promising. PODenergy has also engaged in scientific dialog with researchers at the BioMara algae to biofuels project at the Scottish Association for Marine Science, Scotland; Scripps Institution of Oceanography, San Diego; University of California, Irvine; Queen's University, Kingston, Ontario, Canada; Carbon Sciences, Santa Barbara, California; Moss Landing Marine Laboratory, California; The Layfield Group, Richmond, British Columbia, Canada; University of Edinburgh, Scotland; Columbia University, New York; Harvard University, Massachusetts; the University of Utah; and the U.S. National Renewable Energy Laboratory.