Poster Number

M3

Eco-Energy Demonstration Model: Anaerobic Digestion, Algae, and Energy Prosperity

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Problem Definition

- The human impact upon our planet is steadily increasing. Communities of people around the world are consuming more energy than they are producing, relying almost entirely on nonrenewable resources for prosperity. Abundant anthropogenic wastes created in these times of fossil prosperity are detrimental to both human and natural communities.
- Current dilemmas of our unsustainable society include:
  - Fugitive nutrient release causes cultural eutrophication (Figure 1)
  - Unsustainable waste practices emit greenhouse gases
  - Dependence on fossil fuels for prosperity
- Our *Eco-Energy* model illustrates a synergetic ecosystem conceptualization, and demonstrates that we can efficiently use our resources to meet current needs without leading to a diminished quality of life for future generations.

Figure 1: Anthropogenic nutrient loads contribute to cyanobacterial blooms in Guatemala's Lake Atitlán.
Photo: Jesse Allen, NASA / Earth Observatory

Purposes, Objectives, Scope

- Our project strives to move towards sustainable, ecologically-based solutions to current human dilemmas though the integration of naturally prosperous communities of microorganisms.
- The *Eco-Energy* project integrates the ecological processes of anaerobic digestion and phycoremediation with the human system by digesting our wastes and capturing nutrients with an algal consortium. Renewable energy is generated in our model as biogas and an algal feedstock for biodiesel .
  - *Anaerobic Digestion*: Microbial breakdown of organics in an oxygen-free environment, producing methane-rich biogas and nutrient-rich effluent.
  - *Phycoremediation*: Intentional algal cultivation for ameliorating rogue nutrients and fixing atmospheric carbon through photosynthesis.
- The primary objective of our model is to disseminate sustainability awareness to the public at-large, showing solutions that reduce pollutants while producing energy for a prosperous society.

EPA's P3 award

Results

- A working demonstration *Eco-Energy* model was designed and constructed.
- Waste was characterized for important parameters for algal growth and anaerobic digestion (Table 1) .
- Anaerobic digestion of food waste was conducted, while monitoring operational conditions and investigating methanogenic organisms (Figure 2).
- Nutrients from the digester were used for benthic algal cultivation.
- Algae were found to reduce orthophosphate by 80.5%.
- Biomass production potential was measured (Table 2) and phycological diversity was observed (Figure 3).
- Algae were stained and examined microscopically to determine lipid content for potential biodiesel production (Figure 4).
- Photovoltaics were incorporated to provide electricity for components.
- Demonstrations were conducted for class tours, lab visitors, farmers, and local school children (Figure 5)

Table 1: Locally Abundant, Globally Prevalent Anthropogenic Waste Characterization

Waste Stream	pH	TS (g/L)	VS/TS %	COD mg/L	PO4 mg/L	NH4 mg/L
Flushed Dairy Manure[1]	7.45	4.19	64.92	1065	71.26	100
Food Waste[2]	3.75	120.53	95.04	145900	1273.8	0.25
Digested Food Waste[3]	7.12	13.63	55.69	13860	254.13	200
Digested Sewage Sludge[4]	7.9	3.53	57.03	2123	26.32	200
Landfill Leachate[5]	7.63	6.18	18.70	1457	27.16	300
Poultry Manure[6]	7.08	2.83	37.47	1620	186.99	150
Poultry Manure [7]	6.98	1.91	48.28	788	78	100

1 From the University of Florida Dairy Research Unit; 2 Food waste, pretreated with meat grinder and diluted 1:1 with water; 3 Effluent from food waste digester with an OLR of 2 kg VS/m^3m; 4 University of Florida water reclamation facility; 5 Raw leachate from closed landfill in Archer, FL; 6 Diluted poultry manure from large-scale, commercial operation; 7 Diltured poultry manure from small-scale, organic farm

Table 2: Biomass Production Potential of *Stigeoclonium* sp.

Pressed-dry wet weight (g)	Oven-dried weight (g)	Biomass Prod. Potential (g/m^2)
623	21.98	43.95
434	18.70	37.39
398	22.93	45.85

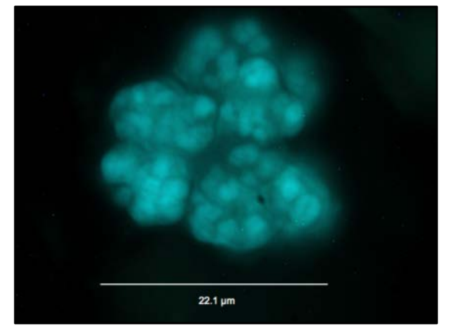

Figure 2: Auto-fluorescence of *Methanosarcina* sp. under epi-fluorescent microscopy.

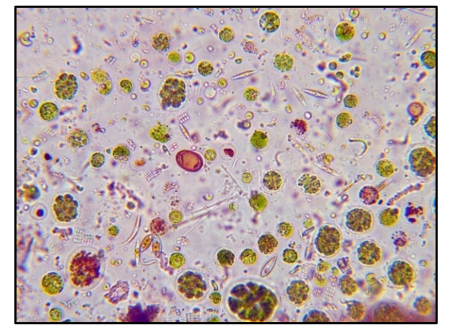

Figure 3: Algal diversity in a single sample under light microscopy, 300x

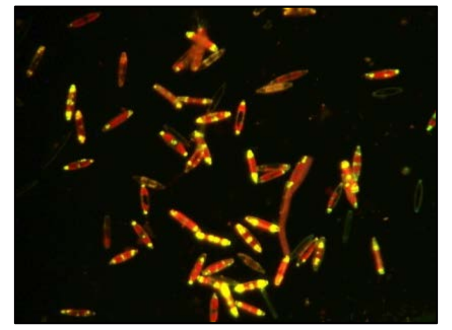

Figure 4: Lipid-rich diatoms stained with the lipid fluorochrome under. epi-fluorescent illumination, 300x

Figure 5: Demonstrating Eco-Energy to eager young minds.

Conclusions

The *Eco-Energy* philosophy actively integrates the P^3 principles of people, prosperity, and the planet. *Eco-Energy* is an environmentally beneficial process that reduces fugitive nutrients and greenhouse gas emissions from wastes, while offsetting fossil fuel use through production of carbon-neutral energy. By utilizing abundant anthropogenic waste as a feedstock for clean energy, *Eco-Energy* is closely tied to the human environment. The production of two renewable fuels from wastes makes the model economically favorable, and if implemented on a large scale could significantly reduce the human planetary impact (Figure 6).

In Phase I, we found an astounding diversity of native algae and robust methanogens. Likewise, the diversity of organic wastes that are possible to anaerobically digest are numerous and abundant. Future research should look to this biological diversity to harness the natural ecological energy of the planet Earth.

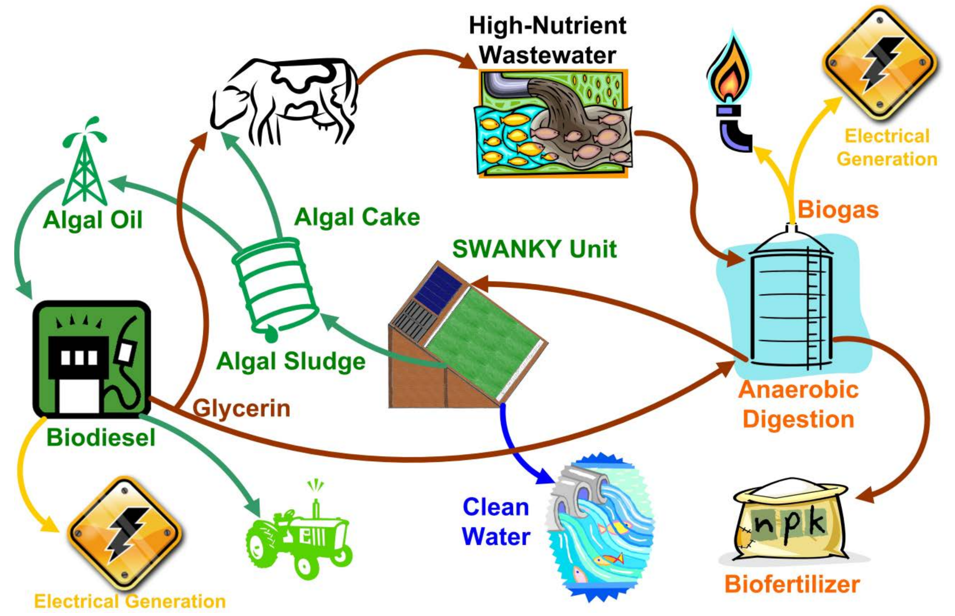

Figure 6: *Eco-Energy* process flow diagram

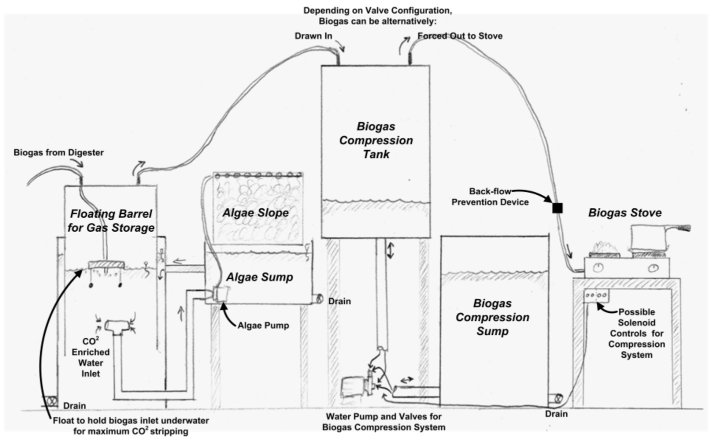

Figure 8: Proposed algal biogas cleaning schematic

Proposed P3 Phase II Project Description

To build upon our phase I successes and overcome remaining challenges, we propose the following as key strategies for successfully developing and implementing this technology through phase II and beyond:

- Further develop and implement the *Eco-Energy* concept in a self-sufficient pilot-scale research and teaching unit: **S**olar-powered, **W**aste-treating, **A**naerobic-digesting, **N**utrient-capturing, **K**itchen-demonstration **Y**urt (**SWANKY**) pilot-plant (Figure 7).
- Focus and optimize anaerobic digestion of food waste.
- Further integration of the *Eco-Energy* model utilizing algae to purify biogas to biomethane quality (Figure 8).
- Advance our phycological studies of the dynamic algal assemblages that colonize the benthic algal treatment slopes.
- Develop algal biofuel and anaerobic digestion teaching modules for undergraduate and K-12 students.

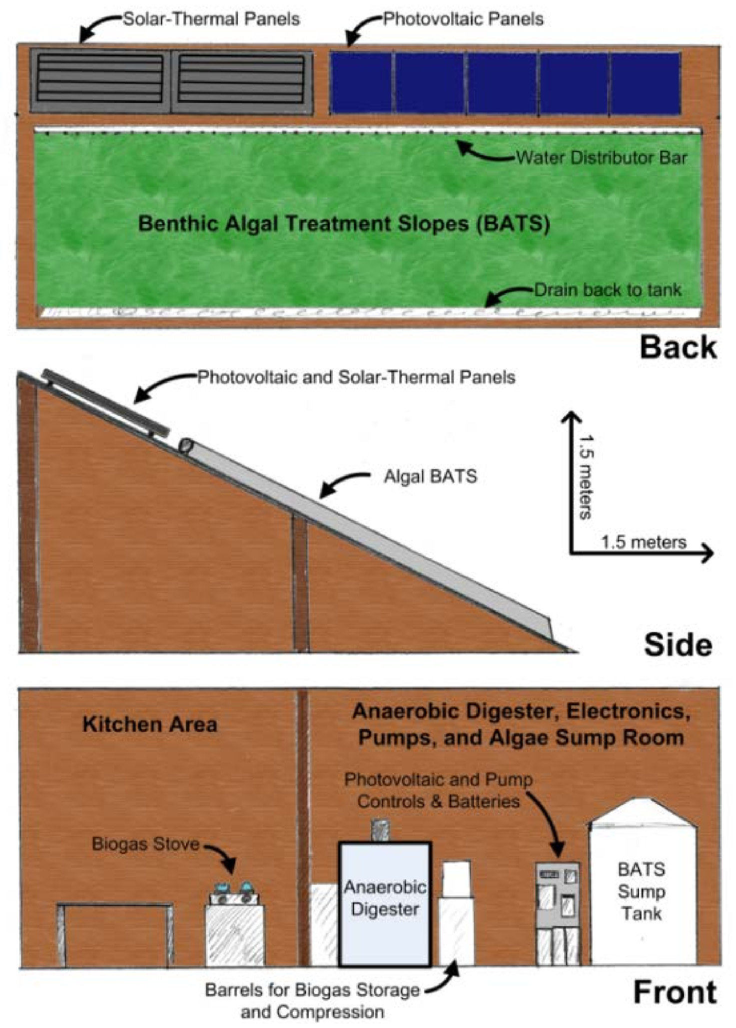

Figure 7: Proposed SWANKY Eco-Energy teaching facility for development in P3 Phase II.

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