**CACTi**

CACTi is a system of renewable energy infrastructural art encompassing algaculture - a form of aquaculture involving the farming of species of algae - and monumentality of classical order structure to create a unique atmosphere in harmony with barren landscape of the Fly Ranch project geography.

1. Technology used in your design

With rising energy consumption and expected depletion of fossil fuels in the near future, many scientists, architects and inventors are looking to replace conventional energy with natural renewable energy sources. Algae, a simple nonflowering protist, are known to mitigate the CO2 and generate oxygen through photosynthesis. Algae are indispensable organisms because they produce about half the oxygen in Earth’s atmosphere. Also, algal biofuels are a promising replacement for fossil fuels. All algae have the ability to produce energy-rich oils and several microalgal species naturally accumulate high levels of oil in their dry mass. They are found in diverse habitats and can reproduce quickly. We are using an algae bioreactor technology to cultivate and harvest algae in an enclosed system reactor, which are isolated to varying extent from the atmosphere. Algae bioreactors can be used to produce fuels such as biodiesel and bioethanol, to generate animal feed, or to reduce pollutants such as CO2 in flue gases of power plants. Because the bioreactor is based on the photosynthetic reaction performed by the chlorophyll-containing algae itself using dissolved carbon dioxide and sunlight energy, its procedure is renewable and safe from any environmental damage. Strong sunlight in the open field of the Fly Ranch will become an indispensable resource for the bioreactors.

CACTi consists of vertically tiered modules that can be stacked on top of each other to expand. Within the individual module system, solar panel system and a ring of LED light are installed to operate algae mixing circulation of a closed loop system and injection of CO2 and nutrients such as nitrogen, phosphorus, and potassium which serve as fertilizer for algae. Residual solar energy stored during the day will be saved in a battery to be used as an energy source of lighting up LEDs at night, which can be used as a streetlamp and wayfinding mechanism. At night, a spectacle of illumination enhances the dynamics of the column landscape with lights. The density of columns creates a pleasant environment further enhanced by green shade from algae tubes, through which the installation will become a playful social space.

1. List of activities your design would support

Due to the transparency of tubes containing algae bioreactors, the color of green organic hue is projected onto adjacent landscapes through reflection and refraction of sunlight shining through. The vertically stacked tapering massing of an individually assembled module is sculpturally influenced by long and upright cactus that can be found in the surrounding landscape.  An array of tubes containing algae are placed compactly to form a semi-enclosed cylinder, creating an intimate space housing one or two people at a time. It becomes an individual shelter and a chapel for people seeking meditation, contemplation, and emerging oneself to nature in a peacefully isolated manner. Whether it is diurnal or nocturnal, lights passing through algae tubes create exotic and novel atmosphere.

When the CACTi system is laid out in a grid, it creates ancient temple-like spaces of colonnade series in both directions, forming a maze-like phantasmal space. It can be organized to create a rectangle in plan to define a room/space with fabric tent overspaning the columns to provide weathered shelter under harsh sunlight and occasional rain. A linear organization of a system can establish axes throughout the Fly Ranch to work as streetscape with function of light ramp and wayfinding mechanism. A circular enclosed organization creates agora-like spatial qualities that are appropriate for artistic performance stages with a gathered audience.

1. List of system inputs (what is required to operate your system on an annual basis and what kind of maintenance is required?)

Main system input for CACTi is an algae harvesting system including algae photobioreactor, sensors, heat exchanger, degasser, airlift, air and co2 blower, and algae itself. This would require a minimum electricity for system operation.  In addition to the algae harvesting system, it will have a mini-solar panel system for powering LED light for nighttime usage.

1. List of system outputs (how many kilowatt-hours or cubic meters of water, what waste materials are generated and where do they go?)

Main output is biofuel gained by algae harvest. To obtain 1 liter of biofuel from microalgae with 50% lipid content, 10 to 20 liters are needed. (5~10% efficiency). We calculated with 7.5% efficiency as below:

Total volume of algae photobioreactor = 1,830 liters.

Biofuel extract efficiency = 7.5 %

1,830 liters x 7.5% = 137.25 liters of Biofuel.

In terms of solar energy, it will be able to create 234 watts with 20% efficient solar panel installed at the top of each tier. The energy produced by solar panels will support the lighting of CACTi at night, giving illumination which enhances the dynamics of the column landscape with lights.

1.44 sm x162.57 watt/sm (20% efficiency solar panel) = 234.11 watt

1. List of the primary materials used in your design and major dimensions

* Primary structure - Metal
* Primary material - Acrylic tube as algae photobioreactor (PBR), green painted metal, and dark green pigmented concrete.

* Dimension
  + Overall Height = 10.65 meter
  + Base (Concrete) : Height = 1.12 meter, Radius=1.370 meter.
  + Tier 1      : Height = 3.5 meter, Radius = 0.75 meter
  + Tier 2 & 3: Height = 3.0 meter, Radius = 0.75 meter

6. Order-of-magnitude conceptual cost estimate



1. A short summary of your strategy for on-site prototype development in the event that you are chosen for an honorarium grant

Cast-in-place concrete foundation and stair structure would be constructed first. Steel structure including horizontal waterjet-cut prefabricated metal ring pieces will be assembled and connected by field welding. Each horizontal metal ring will receive mini-solar panels at the top and LED in circular configuration will be installed with connection to the solar panels.

MEP including sensors, heat exchanger, degasser, airlift, air and CO2 blower would be laid out inside of the stair pedestal structure on the ground level. Algae photobioreactors would be installed and fixed vertically and filled with living algae. Designated algae photobioreactors at the lower tier will be connected to MEP so co2 and nutrients are provided from the system below.

Environmental Impact Summary

With rising energy consumption and expected depletion of fossil fuels in the near future, many scientists, architects and inventors are looking to replace conventional energy with natural renewable energy sources. Algae, a simple nonflowering protist, are known to mitigate the CO2 and generate oxygen through photosynthesis. Algae are indispensable organisms because they produce about half the oxygen in Earth’s atmosphere. Also, algal biofuels are a promising replacement for fossil fuels. All algae can produce energy-rich oils and several microalgal species naturally accumulate high levels of oil in their dry mass. They are found in diverse habitats and can reproduce quickly. We are using an algae bioreactor technology to cultivate and harvest algae in an enclosed system reactor, which are isolated to varying extent from the atmosphere. Algae bioreactors can be used to produce fuels such as biodiesel and bioethanol, to generate animal feed, or to reduce pollutants such as CO2 in flue gases of power plants. Because the bioreactor is based on the photosynthetic reaction performed by the chlorophyll-containing algae itself using dissolved carbon dioxide and sunlight energy, its procedure is renewable and safe from any environmental damage. Strong sunlight in the open field of the Fly Ranch will become an indispensable resource for the bioreactors.

After its installation and use in the Fly Ranch, due to its modular/ stackable design, individual bioreactors can be recycled and donated to institutes and universities studying algal science throughout the world, including ones participating in ICABBB; International Conference on Algal Biomass Biofuels and Bioproducts. Cast-in-concrete pedestals can be recycled and reused as a streetscape bench and furniture.