**PRISMATIC STREAMS**

**INTRODUCTION**

Lush, vibrant swaths of color, as if extracted from fields of flowers. Majestic pillars that loom over the terrain like noble sequoias. From afar, *Prismatic Streams* appears to be an expressionist painting framed by the California sunset, but closer inspection reveals the installation serves as a tremendous energy hub, generating biofuel and drinkable water for the Santa Monica community.

Visitors to *Prismatic Streams* wend their way through the installation on grassy paths that run alongside the streaks of color, which in fact are cultivation ponds for algae that will later be harvested to create biofuel. Meanwhile, spiral staircases encircle lofty solar still towers, offering breathtaking views of the vivid design created by the ponds below.

*Prismatic Streams* enhances the surrounding environment without sacrificing the allure of existing structures. The rainbow hues of the ponds echo the bright colors of the Ferris wheel and other amusement park rides on Santa Monica Pier. At night, the towers are illuminated with low-energy LEDs. The entire installation also functions as an outdoor arena for enjoying concerts, dance showcases, and other performances—the perfect ending to a Sunday afternoon at the beach.

**LAYOUT**

Inspired by the living nature of algae, we generated the layout for our installation using the Gray-Scott model of reaction-diffusion systems, which describe how organisms grow over time. Six points, where the towers stand, were chosen as starting points for the system, which then mapped out the rest of the layout. The pattern creates both valleys for the algae ponds and elevated surfaces on which visitors can walk.

The staircase that leads from the pier to the installation also functions as a large-scale stage for outdoor performances.

**ALGAE PONDS**

TECHNOLOGY

Algae promise to be among the most valuable sources of green energy in the near future. Their high oil content makes them ideal for generating biodiesel and biofuels, while their affinity for bodies of water frees up valuable arable land needed to produce crops for human and livestock consumption. One of the largest problems facing algae harvesting, however, is the substantial quantities of freshwater required in traditional cultivation methods.

Our installation solves this problem by using saline water, a limitless resource furnished by the Pacific Ocean, and the halophilic (salt-loving) algae species *Dunaliella salina*, which can survive in saline concentrations of 0.05 M to saturation (5.5 M). *D. salina* is complemented by *Halobacteria*, whose polysaccharide-degrading enzymes are useful in the biofuel production process. Beyond their utility in creating green energy, halophiles also yield large quantities of biodegradable polymers (bioplastics), with applications ranging from eco-friendly packaging to medical equipment.

In *Prismatic Streams*, *D. salina* and *Halobacteria* are grown in evaporation ponds linked to the Pacific Ocean. The algae and bacteria in the various ponds are harvested at staggered intervals every two weeks and transported to an off-site facility for processing. Ponds are replenished with seawater from the ocean and algae cultures from neighboring ponds, restarting the growth cycle without the need for external resources.

Atabani et al. (2012) report that microalgae production of biofuel is between 58,700 and 136,900 L/ha/year. The combined surface area of algae ponds in our installation is roughly 3.96 ha; therefore, even using a conservative estimate, *Prismatic Streams* can produce biofuel at over 232,000 L/year, for an energy production of 2,220,000 kWh/year.

VISUAL APPEARANCE

At baseline, *D. salina* appears as green algae. As sunlight evaporates the seawater ponds, the increased light intensity and salinity cause the algae to produce carotenoids, turning the algae orange and red. Meanwhile, red *Halobacteria*, which require concentrations of at least 1.7-2.6 M, begin to proliferate in the ponds, further intensifying the color.

The result is a field of color that changes dynamically over time.

**SOLAR STILL TOWERS**

TECHNOLOGY

Six 75-meter towers in the shape of large cylinders function as solar stills. Transparent solar cells developed by MIT researchers encase the structure, providing energy to power a mechanical pump that draws seawater up from the base of each tower to a large, domed basin at the top. Sunlight heats the basin and causes the water to evaporate, eliminating it of salt, microorganisms, and other impurities. The water vapor then condenses on the inner surface of the dome, dripping down the sides of its walls, where it is collected.

The staircase that encircles the still is sandwiched by two ducts of water. Excess seawater from the solar still flows into the upper duct, which functions as a stepped solar still: shallow trays are arranged as downward steps into which the water flows. This structure increases the surface area of exposed seawater while minimizing its depth, thereby increasing the efficiency of evaporation and condensation.

Freshwater collected from both the single-basin and stepped solar stills is channeled to the lower duct, which carries it to the base of the tower.

The combined surface area of the solar cells is 28,274 m2. Assuming average solar radiation of 5 kWh/m2/day, the solar cells, which operate at 10% efficiency, generate up to 14,137 kWh/day, or 5,160,000 kWh/year.

The combined surface area of the solar stills (including both single-basin and stepped stills) is 8,610 m2. Assuming that a solar still can generate roughly 3.3 L/m2/day, our installation thus produces over 28,000 L of potable water each day.

APPEARANCE

Each tower is ensheathed in a grid of transparent solar cells that provides a view of the still contained within while shielding it from disruptive winds. Staircases wrap around the towers, providing 360-degree views for visitors to marvel at the algae streams below. Visitors can also look directly above at the stepped solar still to see the distillation process underway.

As distilled water reaches the base of the tower, it is released as a miniature waterfall that visitors glimpse as they pass by.

At night, the energy generated by the solar cells is used to power low-energy LED lights, illuminating the structures in a gradient pattern that mimics the algae ponds.

**DIMENSIONS/MATERIALS LIST**

Algae ponds cover 40% of the site boundary and contain *Dunaliella salina* and *Halobacteria*.

Solar still towers (75 m, ⌀ 20 m) are made of transparent solar cells (developed by MIT researchers), laminated glass, tempered glass, structural steel plates, and recycled steel.

**ENVIRONMENTAL IMPACT**

*Prismatic Streams* provides 28,000 L/day of clean water and 2,220,000 kWh/year of clean energy to the Santa Monica community by harnessing algae and seawater.

*D. salina* grows naturally on salt water, requiring only sunlight and carbon dioxide. The walls of the ponds contain the algae to prevent mixing with seawater beyond the installation. In the unlikely event that spillage should occur, the effect will be negligible, since algae is biodegradable and quickly dispersed by the ocean.

No greenhouse gas emissions are produced by the installation. In fact, *D. salina* actively removes carbon dioxide from the air.

The solar stills utilize seawater and thus do not compete with existing structures that purify wastewater from the city. The water obtained from solar still distillation is ready to drink and does not require additional filtration.

**REFERENCES**

Atabani, A. E., Silitonga, A. S., Badruddin, I. A., Mahlia, T. M. I., Masjuki, H. H., & Mekhilef, S. (2012). A comprehensive review on biodiesel as an alternative energy resource and its characteristics. *Renewable and sustainable energy reviews*, *16*(4), 2070-2093.