Petal Power Place

A framework for Agrivoltaic symbiosis

The Problem Statement: The climate crisis has been fueled by mankind's increasing need for energy and has severe implications on the soil, water, food and human health among other ecological impacts which threaten human existence. Globally, countries are pivoting from the use of fossil fuels as the primary source of energy to cutting-edge renewable energy technologies to meet the energy needs of the future generations. While there have been advances in this direction, energy systems and infrastructure are not pleasing to eyes and are usually located in the outskirts of the cities, rather than being integrated as a part of our urban environments.

Petal Power Place combines innovative technologies to explore ideas of decentralized renewable energy systems that are not only being beautifully integrated into our urban environments but also SHARE infrastructure with urban farming to maximize the utility of existing structures.

Art Form, Symbolism and Story:

In the light of the horticulture event BUGA ’23, the design explores a form of a blooming flower. A flower is universally a symbol of beauty. Integrating renewable energy in the form of a flower symbolizes the beauty of change- the change in our approach, life-styles and environments that will be shaped by the process of global energy transition. The form of a flower lends an opportunity to exhibit the innovative technologies to showcase biophilic renewable energy forms that are organic in addition to fostering water conservation.

Petal Power Place stems from a single idea, and explores two models that emerged from two different approaches of making use of existing structures for Agrivoltaics:

MODEL 1 is a showcase for incorporating solar technology where shade structures for farming exists- for eg. Greenhouses could replace glass or polymer sheet envelopes with the LSC to produce energy.

MODEL 2 is a showcase for incorporating productive urban landscape/ energy crops on the structures that support energy technologies. For Example, the structure supporting a wind turbine, or the parking structure supporting the solar panels can provide infrastructure for landscaping. The idea is that while the energy technologies reach out for the sky, the structure creates an engaging experience at ground.

Both the sculptures boast a 15.2 meter diameter flower canopy that sits 3.6 meters above the ground. All 34 units produce 10,200 MWh energy per year.

Technologies and their significance:

1. AGILE (Axially Graded Index Lens) non-tracking solar concentrator array by Stanford University: These 3D printed concentrators eliminate the need of the solar tracking infrastructure, increase efficiency of the panels by the concentration factor of 2, and conserves resources such as precious semiconductors such as silicon required in the manufacturing of solar arrays.

2. LSC (Luminescent Solar Concentrator): Boasting potential in the realm of BIPV as windows, it can be a great application for greenhouses, and provides a beautiful biophilic experience of day-time transparency and night-time luminescence making it a perfect material for flower sculptures

3. GreenStudios smart, lightweight, hydroponic skin: Eliminating the weight and maintenance issues of soil-based green walls, this sensor controlled, and water-efficient hydroponic skin can be easily applied to any form of structure serving as an artistic canvas for upside-down and vertical farming. Energy crops can be farmed on the skin to produce biomass energy.

Integrity to the Site

The concept of Petal Power Place is scalable to any site receiving sunlight, but these net positive sculptures are designed integrally to the Spinelli Park masterplan. The sculptures have different plug-and-play components that allow for a versatile use across the park.

17 LSC sculptures (exhibiting the 17 colors the UN goals) of Model 1 are placed in the Westside of the park and 17 sculptures of Model 2 are integrated in the 17 vertical garden squares of the BUGA exhibition.

Model 1 sculptures are located along the bike expressway, standing for the country's record in mobility innovation, and provides electric charging for bikes, phones and educational tablets. The different colors of the LSCs help with wayfinding in the park, and provide shade and playfulness that is inviting to the children.

Model 2 sculptures are located in the BUGA exhibition to provide shaded resting spaces to visitors, along with providing the BUGA landscape designers with a canvas to design with plants that can integrate with the landscape design of BUGA. After the event, they can be used to farm energy crops/ plant food. The Model 2 sculptures are located towards the north of the site which is closer to the biomass production facility planned near the climate park section of Spinelli. The sculpture itself performs as an on-going ‘flower’ show as it lights up at night.

Environmental Performance Assessment and alliance with the UN goals

The environmental performance of each sculpture is as follows:

- Energy: With around 3% efficiency Model 1 sculptures produce a total of 62MWh/yr and Model 2 generates 540 MWh/yr, producing a total of 10,255 MWh/yr through 34 sculptures installed at the Spinelli Park.The biomass generated from plantations supported by the hydroponic skin can be processed to produce 12,000 kWh of additional energy. The hydroponic system uses a circulating pump which due to the presence of sensors has a low energy requirement of about 2000kWh per year, making the installation a NET POSITIVE energy sculpture.
- Water: The sculpture, through its form, collects 40,600 liters (assuming 725 l/sq. m. yearly precipitation) over 56 sq. m. area of the structure yearly. The hydroponic skin sensors measure water content, pH, EC and temperature to minimize any water wastage. The hydroponic skin consumes about 32,656 liters of water which may vary based on the type of plants being planted (calculation for a tomato produce) making it a NET ZERO water system.
- Food: The hydroponic skin would support about 8000 kg of food production which would generate approx. 2700kg of leaves and stem biomass that can be used for producing biomass energy at a near-by facility.
- The plants grown under the solar structure would supports biodiversity and fosters objectives of the green corridor
- Embodied GWP of Materials: The polymer based 3D printed AGILE solar concentrator reduces semiconductor resource necessities by 50%. The major greenhouse gas emissions will be a contribution from the structure which is designed to be a 90-100% recycled steel structure, which could reduce the greenhouse gas emissions by 58%. Polymer based LSCs would also contribute to greenhouse gas emissions. However, the energy offsets gained by the system

and carbon sequestration offered from approx. 952 sq. m. of plant life supported by the hydroponic skin, the sculptures have the potential to be carbon neutral within 10 years.

The sculpture through its different colors supports and educates the visitors of the UN sustainable development goals. This helps spread awareness about the goals itself and the people can act as change agents within the society to support these goals in their own ways. Apart from this, the sculpture itself through its features supports 13 out of the 17 goals of the UN including Zero hunger, Good health and well-being, Quality education, clean water and sanitation, Affordable and clean energy, Decent work and economic growth, Industry innovation and infrastructure, Sustainable cities and communities, Responsible consumption and production, Climate Action, Life on land, Peace justice and strong institutions and Partnerships for the goals.

Prototype summary: The AGILE solar concentrator technology may be proprietary to Stanford University, who may need to be contacted to prototype the technology. Alternatively, the solar technology can be substituted with dye-sensitized solar cells, which may not provide as much output as the AGILE concentrators but would be able to provide a similar green-blue transition look. Approximate cost of installation per unit would be between the range of $75,000- $100,000 per unit. The form of the art could possibly be simplified to reduce cost for the purpose of prototyping the technologies.