LAGI Competition Entry

From the initial stages of conceptualisation, technology took a crucial role in the generation of form. Much like how the intent of the design required a contemplative and engaging mindset towards the awareness of renewable energy resources, a similar approach was adopted in the generation of architectural form. Exploring the potentialities of parametric design, a definition was created utilising the computer three-dimensional generating program Rhinoceros and its plug-in, Grasshopper. This generated a canopy-like structure, which utilised a network of magnetic field lines to generate the underlying geometry. Coupled with catenary vaults, this sort to create a purely compressive structure.

The notion of reflection and reflectivity were integral to the chosen renewable energy source as well as to the characteristic elements of the form. Our concept centred around the desire to create a serene and contemplative environment, showcasing the potential of renewable energy as being integrated and seamless, rather than acting in an imposing manner, as is often depicted. This notion of reflection was reiterated both metaphorical and literally. By incorporating a solar pond into the design, this created an aesthetically serene environment, whilst simultaneously generating the energy required for the canopy, with additional surplus electricity supplied to the city.

To further elaborate on the operational components of this renewable source, a solar pond is essentially a body of water, separated into three divisions through various brine saturations. The three layers are defined as the upper convective zone (UCZ), non-convective zone (NCZ), and the lower convective zone (LCZ). In a normal body of water, the penetration of solar radiation creates convective current within the system, resulting in the continual absorption and release of heat energy. This convective nature is suppressed in a solar pond due to the introduction of several salinized layers. The salinity concentration of the LCZ can reach levels of 26% by weight, in contrast to the UCZ layer whereby the salinity levels range from 1-4% salt by weight. The weight of the salt in the LCZ ultimately inhibits the heat energy retained in the water from rising to the surface, increasing the temperature of the LCZ to the temperatures as high as 95 degrees Celsius. Meanwhile, the NCZ, acts as a thermal insulative layer, retaining the heat within the lower most layer of the pond. This stratification has enabled its dual function as a solar collector as well as a thermal storage device. The efficiency of solar ponds vary between 15-25 percent, dependent on its contextual and structural elements. Nevertheless, the size of the site and its proximity to water, lends itself to being an ideal renewable energy source without the added acoustic and aesthetic intrusions.

In terms of generating electricity, the ponds are often coupled with a Rankine Cycle Heat Engine, whereby the heat stored in the bottom most layer of the solar pond, is collected via the circulation of water pipes through the pond. This heat energy is consequently used to vaporise the working fluid, otherwise known as R-134a, in the evaporator. As the working fluid moves from a high pressure to a low pressure, it spins the turbine, whereby the mechanical energy is thus transformed into electrical energy.

Taking into consideration the abundant availability of water, the solar pond can be consistently replenished with seawater. Moreover, the residual hot water from the evaporator can be incorporated as part of the hot water supply for the city of Copenhagen. A supply of water will be required to operate the condenser, which can be similarly drawn from the sea. It is this output of water from the condenser at a temperature of approximately 24 degrees celsius, that will be carried throughout the architectural infrastructure. The water will be pumped to the highest points within the structure and then allowed to flow through the pipes, where multiple sprinklers have been intermittently spaced throughout the structure in order to allow for the spraying of hot water onto the copper mesh.

Overtime, the built up of residual evaporated salt on the surrounding mesh, will create a dynamic and consistently evolutional form, moulded and strengthened by the meteorological conditions of Copenhagen.

**The estimated generative electricity has been calculated in the following table:**

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| --- | --- |
| Average Annual Insolation in Copenhagen:  Net Pond Efficiency:  Total collected energy from pond: | 1026.78 kWh/m2  18%  1026.78 x 0.18  = 184.482 kWh/m2 per year |
| Turbine efficiency:  Resulting effective cycle efficiency:  Total electricity produced from Rankine Engine: | 80%  10%  184.82 x 0.10  = 18.482 kWh/m2 per year |
| Area of Solar Pond:  Total electricity produced: | 36,000 m2  665,352 kWh per year 1,822.88 kWh per day **75.95 kWh per hour** |

The following lists the primary materials in the design:

* **Rubber Tubing:** To carry water throughout the structure
* **Steel:** Acts as the structural support
* **Galvanised Copper Mesh:** Provides a surface for the salt to adhere to
* **Stainless steel and glass panelling:** Railings
* **Glue-laminated timber:** Decking

**Environmental Impact Statement**

When you’re dealing with such an expansive ecosystem, such as the ocean, minimal changes in the immediate context can have certain ramifications on the surrounding environment, as well as neighbouring contextual environments.

In order to build a solar pond, the body of water and land under the current site, must firstly be partitioned from the ocean. These natural water movements would circulate the salt and heat energy hence, rendering the solar pond inoperative. Moreover, the capacity to stratify the pond into three layers requires an enclosed environment. This may result in the loss of current flora and fauna currently situated under this site. Nevertheless, this loss has been weighed in accordance to the potentiality of the new infrastructure and renewable energy resource.

Furthermore, the removal and re-input of seawater to and from the site may also be harmful for sea creatures in the surrounding areas. Hence, precautions would be taken to ensure that sufficient meshing was placed over the underwater piping to ensure the safety of sea life. Moreover, the water utilised as coolant in condenser, may also be harmful to sea life, if immediately introduced back into the sea. This is due to the increase in the water temperature as it absorbs the heat energy in the condenser. This mere hike in temperature may have potentially altering ramifications if not properly addressed. In order to circumvent this potential detriment, this output of water will be utilised as the fluid spraying throughout the structure.

Lastly, the salt installation will ultimately lead to increased dry salt exposure on land. This may be blown around by wind conditions, potentially impacting on the surrounding infrastructure. Frequent harvesting of salt for agricultural purposes may be necessarily to reduce significant impact of salt in times of significant climatic conditions.