**Solar Triangle**

**Formal Development**

What are the available clean energy sources at the site? It is majorly solar energy, more accessible and stable than wind energy. What is the existing identity of the site? The first word jumping to the mind is ‘Triangle’.

The site in its triangular plan view has been well-known as a symbol of the planning reconciliation between the local community and the developer, as filmed in The Triangle Wars, featuring thousands of passionate people from St Kilda. Despite the adjacent historic icons, the Lunar Park and the Palais Theatre, the notion of ‘St Kilda triangle’ has been gradually forming a secondary icon of the locale in a collective memory. As the local community demanded more open public space that can flexibly accommodate a wide range of civil events and social activities, one may envision a form that takes the opportunity of integrating renewable energy generation into the public space with an easily identifiable appearance showcasing the local identity.

As a triangle in its planar nature coincides with the existing solar panels, at the first design phase of Solar Triangle, a conceptual super-triangle composed of solar panels is slanted at 38° (as this angle makes solar panels most efficient in Melbourne region) over the whole site, creating a huge semi-open space for the public. This super-triangle has the maximum area for the absorption of solar energy ove the site. Next, due to height restrictions and constructability, the super-triangle is divided into seven substructures by six east-to-west lines such that the first six parts are below 20 m in height and only the southmost triangular substructure, which is less than 400 m2 when viewed in plan, is just 42 m in height. Viewing from the esplanade, the height of the front most six parts are lower than the adjacent Palais Theatre and the Lunar Park, while the south most part humbly strikes out behind the Palais Theatre. Hence, this spatial volume below the slanted parts not only respects the surrounding historic buildings, but also maintains the overall sea view along the esplanade, while the tallest spiky substructure attracts pedestrians to walk through the triangular site, to reach a semi-open outdoor theatre beneath the tallest part, and get impressed by the welcoming beach panorama. Next, to encourage all-directional movement of the pedestrians across the site, the bottom belt of 5.6 m width, which is also overlapped by the shadow of the previous substructure, is removed from each substructure to give 3.5 m clearance for all-directional permeability. Next, structural columns and beams are positioned to support all the substructures with robust stability. In the final design phase, the seven substructures are divided into mosaic fan shapes that are actually multicolour solar panels constructing together into one piece of aboriginal artwork on the surface of each substructure. This reminds people of the deepest part of the local identity – aboriginality.

Moreover, to complement the Solar Triangle and to resonate with the existing palm trees that give inspirations of how natural form absorb maximum solar energy, several Solar Palm Trees are positioned along the esplanade to substitute existing street light poles.

**TECHNOLOGY**

One of our technologies used in the Solar Triangle is highly efficient solar panels, which was owned by SunPower brand [1], attached on the art installed roof top. The efficiency received reaches satisfied value at 22 %, making this panel as one of the promising technologies for the clean energy production, whereas the majority of conventional panels range from 15% to 17% in efficiency rating. The other applied technology installed is coloured building integrated photovoltaic (BIPV) panel [2], which offers an aesthetically pleasing alternative without sacrificing too much power. BIPV panels are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. The advantage of integrated photovoltaics over more common non-integrated systems is that the initial cost can be offset by reducing building materials cost and labour.

Another highlight in Solar Triangle the is the Solar Palm Tree. It is an integrated design that imitates the leaves and trunk of a natural palm tree. It consists of one layer of leaves (8 pieces) with Sunpower folding and flexible solar panel [3] on top and multi-colour smart LED layers at the bottom; rain water collecting and filtration system at the crown; and embedded adjustable quick washing facilities attached on the trunk. The efficiency of the flexible Palm Tree solar firm is around 20-25%, which is about 30% higher than traditional solar panels. In addition, this design collects the solar energy with less occupation of ground space compared with ground-stand solar panels. It can supply the power for lighting during night and other electrical facilities around with excessive power, recycle and save the water resource, and provide shades in summer. Both the location and size of the Solar Palm Tree can be flexible based on varying demands.

In terms of the energy storage system, the amount of energy generated through these systems is accumulated and stored in storage system using lithium-ion battery [4]. This system works as an electricity collector while being able to supply the electricity at the same time. This capacity is moderately enough to power Melbourne, at least 200 households, with clean and reliable energy.

**ENERGY PRODUCTION AND MANAGEMENT**

The total area of solar panel is 11240 m2. Given current capture rates of comparable technology and the weather data provided, our team has estimated that solar panels can harness approximately 80% of the potential energy. The area and rated output of solar panels we assumed are 2 m2/panel and 300 W/panel, respectively [5]. About 1.7 MW solar panels can be installed in the design area. Annual power generation was estimated on the basis of annual global solar exposure (MWh/year/m2) [6] and the efficiency.

$$1.72 {[MWh}/{year}/m^{2}] × 11240 [m^{2}] × 0.15= 2,900,000 [kWh/year]$$

 (Annual global solar exposure) × (Design area) × (Efficiency) = (Annual power generation)

For one Solar Palm Tree, taken the average efficiency of 22.5% [4], for eight units of leaf with leaf’s dimension of 4m\*2m, the annual power generation is about 19,000kWh/tree.

The area and capacity of lithium-ion battery we assumed are 0.1 m2/pack and 1.7 kWh/pack, respectively [7]. About 200 MWh batteries installation was assumed in this design area. We have estimated that the energy system with 1.7 MW solar panels and 200 MWh batteries can cover about 2000 MWh/year electricity demand according to the calculation based on daily profile of global solar exposure (kWh/day/m) [5].

**ENVIRONMENTAL IMPACT SUMMARY**

It is essential to consider the potential disturbances to the local environment and ecosystem, by any addition or implementation of the technology to the project site. The site occupies a natural habitat, which is no less important to the community’s image. The habitat consists of a variety of life forms from animals to insects, which can be affected by surrounding artificial structures.

This project is basically designed to produce clean energy by using strong solar power at the site. It works as a solar radiation receiver that consists of a major multi-colour solar panel roof groups and a range of integrated Solar Palm trees.

The panels itself consists of Silicon which consequences high efficient electricity production in long turn. It is a promising zero greenhouse gas emission material that will not generate any form of environmental pollution. And will become one of the backbone of the Victoria’s Net zero greenhouse gas emissions for 2050.

The primary structure is built majorly by steel to ensure the stability. Other construction materials such as steel reinforced concrete, are recyclable and have no greenhouse gas emission during the function time.

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| Renewable energy components | Materials  | dimensions |
| Main architecture | coloured building integrated photovoltaic (BIPV) panels | 11240m2 |
| Solar Palm Tree | Sunpower folding and flexible solar panel | 4m\*2m\*0.0045m\*8(unit/tree) |
|  | Recyclable steel trunk | 12m\*1.5m |
| Battery | Lithium ion battery | 117.7m2 |

However, considering the project site is located near the sea shore, strategies to mitigate foreseeable issues are: 1) An online monitoring electricity performance system should be involved to make sure all the panel models are working properly; 2) it is suggested to install bird-friendly devices especially at the top the Palm Tree structure to avoid birds’ nesting, which may lead to blockage of the rain water collection system, or rather just provide nesting space for birds; 3) Anti-rusting methods should be considered to prevent exposed steel components from corrosion in high salinity environment.

**Reference:**

[1]<https://news.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/>

[2]<https://kameleonsolar.com/customization-options/#4>

[3]<https://m.made-in-china.com/product/Sunpower-100W-Folding-and-Flexible-Solar-Panel-for-High-End-Market-823086725.html>

[4]<https://pse.com/aboutpse/EnergySupply/Documents/IRP_2015_AppL.pdf>

[5]<http://www.bom.gov.au/climate/data/index.shtml?bookmark=193>

[6]<https://news.energysage.com/average-solar-panel-size-weight/>

[7]<http://www.hitachi-chem.co.jp/english/report/057/57_tr01.pdf>