Solar Grove

## Project Description

Towards the center of the site is a diagonal line cut into the earth of Masdar City. Ramps, pathways and stairs descend into a cool and shady green that slows time and space. Above tower wonderful and strange structures that capture energy and water. These iconic climate sculptures give meaning and use to the site. They expand the boundaries between the built, culture, technology and nature.

Solar Grove seamlessly integrates art, energy, architecture, climate design and landscape within a public, urban landmark site. It is designed with respect to its surroundings as a gateway to one of the world’s first emerging eco-cities. The design draws its inspiration from the topography as well as the endemic flora of the Rub' al-Khali desert. Combined with a state-of-the-art climate design concept, Solar Grove contributes towards a sustainable city in the desert by providing electrical energy for 907 two person homes as well as collecting 86,000 liters of fresh water every day, whilst also providing cooling shade. Therefore, it integrates perfectly into the architectural master plan for Masdar City.

### A Welcoming Landscape

A diagonal cut structures the site from east to west into two zones of different functionality. Approaching from the north-west, the ground level decreases alongside the cut, providing an open view into the park area. By simultaneously ramping up the ground level starting from the surrounding buildings and streets, topographical edges emerge like polygonised dunes, providing terraced spaces and walkways at different levels. These edges shape a permeable urban landform while contributing to an exciting and pedestrian-focused spatial experience. A passe-partout-style boulevard on ground-level with the surrounding buildings frames the park landscape and provides unobstructed access to the existing infrastructure and buildings in an urban context.

The emerging edges enable visitors to submerge into the park landscape, changing their perspective. Alongside this topography, zones of different micro-climate emerge from the interplay between the landscape and the climate sculptures. Through a series of vegetation areas as well as water ponds, welcoming areas form alongside the edge, inviting people to roam around, meet up or linger in the shade by a pond of water, transforming the site to a one-of-a-kind public space.

### Solar Leaves – Climate Sculptures

The topographical edges are populated with arrays of medium to large-scale sculptural installations called *Solar Leaves*. These sculptural elements combine active energy harvesting with passive shading. They are arranged in a way that is optimal for the collection of solar energy through their translucent leaf-like organic photovoltaic panels. In the cool of their shade a kind of urban ´Wadi´ emerges, providing a unique atmosphere and a pleasant, public outdoor environment.

In addition to generating electricity on the top side of the sculptural *Solar Leaves*, fog-catching membranes are attached to their bottom side that enable the collection of fresh water. This effect is facilitated by prevailing winds with moist air from the sea that cross the site in longitudinal direction. The water is collected in ponds as well as distributed to the vegetation areas of the park via a network of underground streams. Fog catching membranes and photovoltaic panels form an enclosed funnel that is used to channel cold air. Cool air is generated by spraying vapor mist inside this interstitial space.

### Zoning

The southern plaza functions as a solar field where arrays of *Solar Leaves* generate electricity during the day and provide shading for the underlying park area with its pedestrian walkways and public spaces. The atmosphere on the northern side is enriched by the interplay of the sun and shadows, reflecting openness and closure. The topography emerging from the landscape design is used to house cafés, restaurants and event locations as well as auxiliary functions such as underground storage for electrical energy and water.

### Hardscape And Softscape

Although the sculptural *Solar Leaves* are already generating a lot of electricity, we also propose a photovoltaic pavement. Its tiling pattern is driven by the solar radiation analysis – increasing its density in areas with high radiation while decreasing density in shaded areas. Furthermore, the photovoltaic pavement tiles can be equipped with LED lightning to allow for atmospheric lighting during the night.

### Energy Concept

Solar Grove combines a series of climate design strategies with the production of clean energy. While the overall design employs multiple energy harvesting and climate technologies, organic photovoltaic cell structures (OPV) are the main driver of the sculptural installations we call *Solar Leaves.* However, their purpose and pleasure are so much more than a conventional photovoltaic farm.

OPV-cells are flexible, lightweight and have a low primary energy demand for production that makes them the ideal technology for harvesting solar energy. The proposed leaf-like panels installed on the topside of the sculptures enable 12,000 m² of active OPV area. Radiation analysis shows an average of 1,200 kWh/m² of annual solar radiation which leads to an annual OPV capacity of 108 kWh/m² at 9% efficiency of the OPV cells. The resulting annual capacity is 1,290 MWh. As proprietary solution, we recommend the use of OPV cells by Heliatek or OPVIUS, or a comparable product.

In addition, the proposed photovoltaic pavement covers an area of 4,200 m². Radiation analysis shows an average annual solar radiation of 1,726 kWh/m² for the photovoltaic pavement. This results in 276 kWh/m² of annual energy output, assuming 16% efficiency for the PV pavement cells. The resulting annual capacity of the photovoltaic pavement is 1,159 MWh. As a proprietary product we propose Onyx Solar PV-pavement or a comparable solution.

The combined use of OPV cells for our *Solar Leaves* as well as the use of photovoltaic pavement results in a total annual capacity of 2,449 MWh of electric energy. This is enough energy to power 789 two-person homes!

Furthermore, the proposed *Solar Leaves* allow the installation of 8,609 m² of fog-catching membrane that leads to 86,000 liters of fresh water generated every day. That is the equivalent of an Olympic-sized swimming pool every 40 days!

### Dimensions and Materiality

For the sculptural *Solar Leaves,* which are between 12 m to 30 m in height, we propose a lightweight construction where the trunks of the sculptures are fabricated as a sheet-metal construction. This allows for very efficient material use resulting in only about 200 t of stainless steel necessary for the construction of these primary structural elements. As carrier-structure for the OPV panels, we propose a similar, lightweight and material-saving approach.

While a lack of system stiffness is usually considered disadvantageous for the usability of the structure, the proposed system deliberately factors in movement and can thus be considered a ‘loose’ approach. This is not averse to the overall robustness of the structure as the flexibility of the components transforms a portion of the acting external forces such as down- or updraft winds into movement.

### Cost Calculations

We estimate the overall cost for the climate active *Solar Leaves* at 1,000 USD per m², including the OPV-cells. The cost per Watt installed for these 12,000 m² is approximately 11.11 USD. This generates an approximately 10.6 Mio USD surplus. The 4,200 m² of photovoltaic pavement cost 4 USD per Watt installed. This leaves another 4.2 Mio USD and amounts to 14.8 Mio USD to develop the landscape architecture.

## Environmental Impact Summary

#### Landscape and geology

The proposed landscape architecture is designed to adopt to the surrounding buildings and provide unobstructed access and walkways to the existing infrastructure. The proposal integrates well with the detailed master plan for Masdar City.

#### Vegetation

Our proposal does not plan to remove any existing vegetation from the site. Instead, we propose additional vegetation around the park area, nourished by the water generated from the proposed climate sculptures.

#### Fauna

The sculptural elements employ translucent but matt surfaces. Strong glare is not be present and the effect on local bird species is therefore minimal.

#### Energy Storage

Nowadays, lithium-polymer or lithium-ion batteries are often deployed for storage of electrical energy. These solutions, although state-of-the-art, have a vast environmental impact in their production. As an alternative solution, we propose the use of recycled car batteries for the storage of electrical energy.

#### Carbon Footprint

Through the predominant use of flexible OPV-cells in our proposal, the primary energy demand for production of these cells is drastically lower in comparison to traditional photovoltaic solutions. Since solar gains are extremely high in Abu Dhabi, we deliberately chose to exclude other less efficient technologies and those that use far more primary energy for production, such as piezoelectric generators or comparable dynamos.