Caravanserai

A breathing gateway for Masdar City

Project description:

Caravanserais supported the flow of commerce, information and people across a network of trade routes, most notably the Silk Road. They were places for meeting, resting and exchanging ideas and goods, but also small gateways, collectively enabling travellers and caravans to safely get from one continent to another. Today and in the future sustainable practices need to exclusively support our existence, and Masdar City is an exciting development towards this global goal. In many ways Masdar City can be seen as a modern caravanserai, supporting our route towards a renewable energy future, connecting people, resources and ideas across an international network.

“Caravanserai” is a celebration of this unique and extraordinary aspect of Masdar City. It establishes a pleasant passway to the heart of the city, creating a large shaded space for citizens, researches and visitors to enjoy and utilize in the process. The shear size of the lightweight, breathing, skin makes it an icon and gateway for Masdar City, while cementing the city's aspirations with sustainable solutions of its own.

Inflation and deflation of the skin will happen in direct correlation with the environment, creating a living, breathing, structure, that continuously adapts and reflects light in mesmerizing and sustainable ways. This highlights our need to continuously stay in sync with our environment like a beautifully tuned organism.

It is our vision that the Caravanserai can function as a pleasant gathering space for the inhabitants of Masdar City, become part of its identity, host events and help Masdar City on it’s way to become the gateway towards a better, smarter, greener future; a Caravanserai for all of us on this necessary journey.

Sustainability:

The structure is shaped and formed in accordance with the flow of wind on the site, creating a horizontal wind tunnel to direct air downwards and into the city. This improves the natural ventilation within the city, cooling down the environment.

The skin of the “tunnel” consists out of Large ETFE panels: super-lightweight, 100% recyclable fabric structures which inflate and deflate as well as change opacity, reacting to environmental conditions in real time. By breathing the skin is able to improve the visitors comfort in an automated and efficient way, while inviting the visitors to watch the skin move, bending and reflecting light in mesmerising yet calculated and sustainable ways.

Within the ETFE cushions are placed photovoltaic panels, that, except from powering the structure, produce renewable energy for the Masdar City and Abu Dhabi in general. The entire south-facing photovoltaic area covers more than 2000 m2, allowing a nameplate capacity at more than 2000 kWp.

A plaza made out of polished rammed earth anchors the breathing skin. Through an embedded information stand in the middle, data about the energy performance, production and the skins behavior can be tracked live. The stand also functions as the entrance to the technical space right below. By coating the plaza with titanium dioxide pigment, that acts as a catalyst for removing smog and cleaning up the surrounding air, fresh air is generated within the skin, whenever the coating interacts with sunlight.

Illumination:

Glowing panels are fixed on the backside of the solar panels, facing the interior of the structure. During the day these panels absorbs the UV rays hitting them, but when the sun sets, they start glowing, providing a beautiful and entirely energy neutral way of illuminating the Caravanserai at night.

Program:

The Caravanserai is more than 240 meters long, and can as such host large events, markets, conferences and exhibitions, almost more comparable to an urban street, than a traditional building. Its shape at ground level naturally divides the plaza into several different sized zones, that can be programmed individually. The road dividing the site is continuing through the structure, creating an iconic gateway in the process.

Construction:

The construction of the Caravanserai can optimized and executed fairly straightforwardly. The geometry of the individual steel members can be optimized at no noticeable change to the shape, saving cost and simplifying manufacturing. Additionally the lightweight nature of the ETFE panels, ensures that the primary strain on the structure comes from wind and/or earthquakes. Securing the stability of the steel joints can be assured through selected cross bracing. At ten moments the structure is anchored into the foundation.

Environmental Impact Assessment:

The impact of the installation on the environment and the natural ecosystem is very small, due to the nature and geographic location of the site. Both the ETFE and rammed earth are very sustainable and recyclable, and the steel structure can also be remelted/repurposed after use (though this is more energy intensive than recycling the other materials.) Environmentally the structure will improve the microclimate.

The maximum height of 43 meters visually impacts the city, but is also not a dominating factor, being below the height of the existing wind tower. The structure will at times cast a lot of shade on the buildings north-east of the site. However, due to the varying height of the structure, any shade cast won't be permanent for long.

In the proposal the surrounding is envisioned as a green corridor, as is in the masterplan for the city. The structure has the opportunity to positively affect this green corridor by collecting rainwater from it’s roof and directing it towards the vegetation.

Technology used in the design:

- BIPV (Building Integrated Photovoltaics)
- Breathing ETFE panels for optimal shading, light distribution
- Coating out of Titanium dioxide pigment for combating smog
- Overall monitoring system + integrated RES that makes the structure perform “smart”
- Glow in the dark panels - low tech solutions for illuminating the structure.

Energy output - nameplate capacity:

2051 m2 of solar panels, with an output of 1000 watts per m2, gives a peek capacity at:
2051 kWp

Annual kWh output:

2051 kW x 8760 hours at a capacity of 10% (since not all are placed for perfect conditions) is:
2322 MWh

Budget:

A 20$ per installed Watt establishes a budget framework at 2051000 Watts x 20$: 41 million $
Maximum bud: **41 million $**

Installing the solar panels costs 3$ per installed Watt, amounting to a total cost of 6.15 million $
Leaving the budget for the structure at 34.85 million $.

393 m3 of steel in the structural beams comes in at a cost of 1890$ per tonne: 5.83 million $

From here on we estimate the rest. Since the ETFE is extremely lightweight, the foundation is potentially around 3 million $

The ETFE comes in at 1250 $ per square meter, and a total of 14017 m2 surface gives a budget estimate of 17.52 million $

The rammed earth plaza with furniture is estimated at 4 million $ and an additional 3.5 million $ is kept in reserve for unforeseen expenditures.

Budget overview (in millions USD):

Maximum budget:	41
Solar installation:	6.15
Steel Structure:	5.83
Foundation:	4
ETFE skin	17.52
Plaza	4
Total cost:	**37.5 million $**
Reserve	3.5 million $