LIGHT-HEX

LAGI 2019

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Energy Technologies: Flexible Mono-crystalline Photovoltaic, Vertical Axis Wind Turbine, Wind tower

Expected Annual Energy Generation: 4,859 MWh

Nameplate Capacity: 1356.3 KW

Cost/W : 10.70 $/W

Size of hexagon unit : 10m radius x 22m height

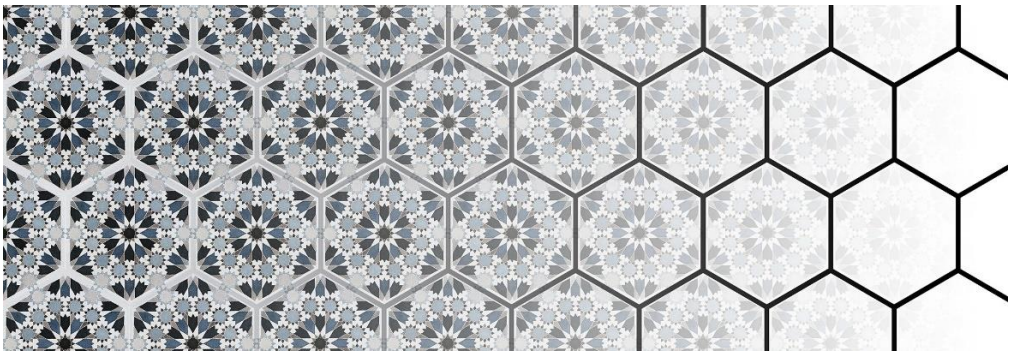
Primary materials: Steel structure, Perforated steel panel

DESIGN BREIF

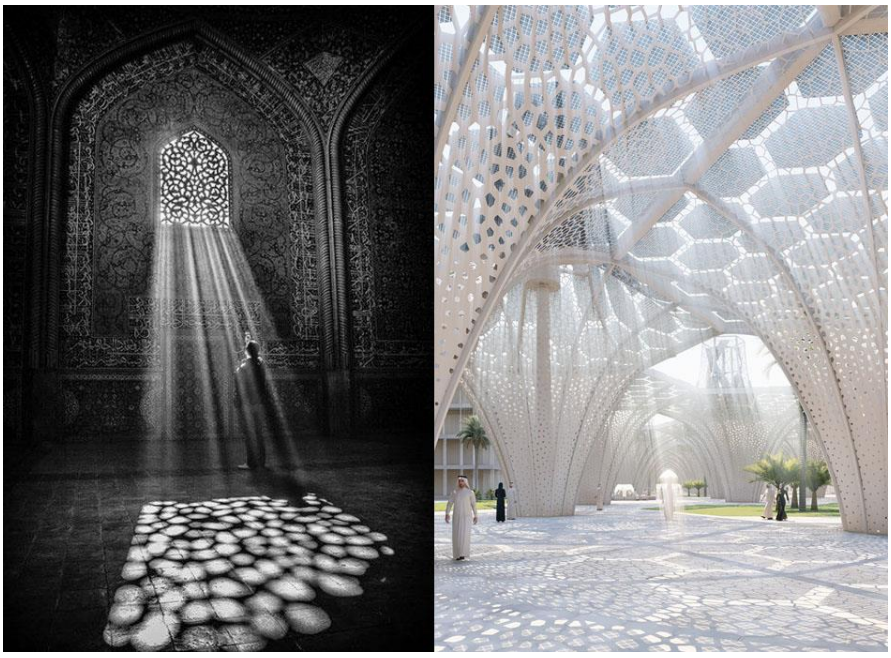
LIGHT-HEX is a modular-based sustainable energy installation. It integrates advanced green technology with local Arabic culture to create not only an installation harvesting green energy, but also a poetic spiritual space to whole Masdar City. Inspired by the traditional Islamic pattern, the design takes hexagon as the primitive geometry to develop the design. Each hexagon unit is a 10-meter radius umbrella-shape steel structure and cover by perforated steel panel, which creates a fantastic rain of light. The modular-based design makes all the standard parts can be massively prefabricated in factory and largely reduce the cost of construction.

To maximize the amount of annual energy generation, the design seamlessly combines solar panel and vertical axis wind turbine to harvest local abundant solar and wind resource together. Meanwhile, the design also uses wind tower technology to cool down the plaza, which also can reduce the energy consumption of surrounding buildings. The design developed 3 different types of hexagon unit. The Solar Unit is 10-meter high and with flat top covered by semi-transparent flexible solar panel. The Solar + Wind Unit is extruded to 22-meter high and contains a 20KW large vertical axis wind turbine. The Solar + Wind Tower Unit has the similar profile but have a wind tunnel inside to blow the plaza with cool air. Those technology working together to provide Masdar City a sustainable and comfortable city living room.

CULTURE

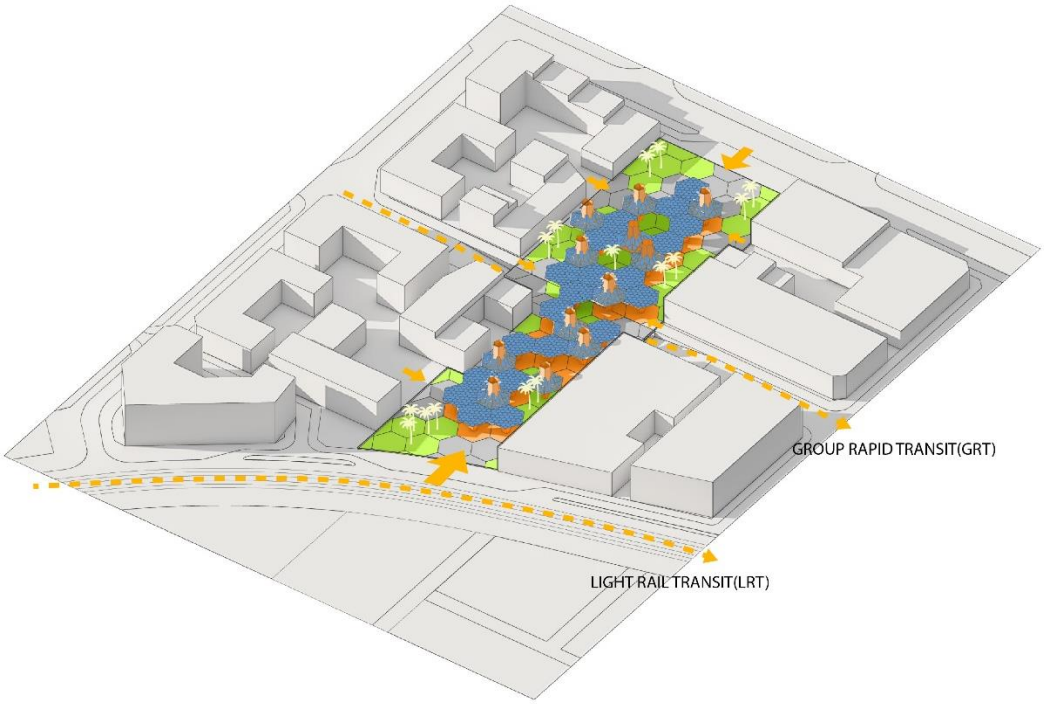


In Islamic culture, geometry always plays an important role. The intricacy of geometric pattern makes Islamic art and architecture fascinating and mysterious. However, behind the complex pattern, it's the simple rule of mathematic and the most primitive geometries. Hexagon is one of the most important and classic. The benefit of hexagon shape is you can assemble it seamlessly in 6 directions and you can find diversity from the repetitive unit. Therefore, the scheme takes hexagon as base geometry to develop the design.



Light and shadow is another significant theme of Islamic architecture. By using the complex pattern to decorate the window, Arabian refracted the harsh desert sunray into elegant dance of light and shadow. To resonate with tradition and create a beautiful shading, the design uses the perforated steel panel as a filter to sunlight and cast a delicate shadow on the ground. The pattern of perforation becomes opener gradually from bottom to top, which resolves the structure into sunlight.

MASTERPLAN



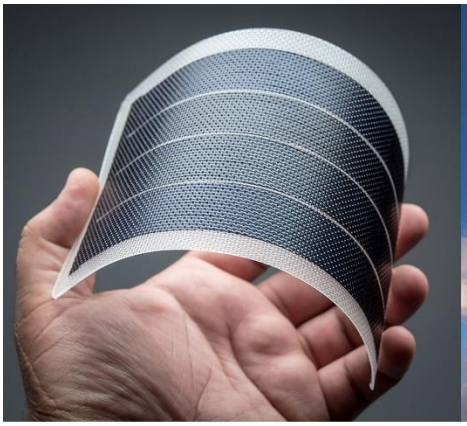
The site is located between a group of residential building and office building. There is a Group Rapid Transit(GRT) line cut the site into two parts. The first step of design is connecting the two parts and makes the transit line cross under the landscape. The design divides the site with hexagon grid and infill the grid with different program. The long spine of the site is with same direction with prevailing wind, so the design arranges several wind turbines to capture wind power. Besides the tower units, there are units with flap top covered by solar panel to generate solar energy. At each entrance of the site, the site plan leaves a plaza space as a buffer area and provides an open space for activity and event. Interspersing on the site, the design provides a lot of green space to improve micro environment on the site.

TECHNOLOGY AND PRACTICABILITY

“Be pragmatic and constructible, and employ technology that be scalable and tested.”

As stated in the design brief, the scheme takes practicability as same important as aesthetics. Therefore, instead of creating some imaginary and unpractical sustainable solutions, the design decides to play with currently proven and mature technology. The technologies used in this project, Flexible Mono-crystalline Photovoltaic, Vertical Axis Wind Turbine and Wind tower, are all the mainstream of green energy market. The efficiency and reliability are ensured. It makes

the design a feasible green energy generator rather than only an eyecatching art installation. The modular steel structure also makes the project easy and inexpensive to construct.



Flexible Photovoltaic

Vertical Axis Wind Turbine

Wind Tower

FLEXIBILITY

More than an installation fixed on specific site, the assembly of hexagon unit can be super flexible and be easily applied to a variety of scenario. The single unit can stand between the buildings, providing shaded area for passengers. The multi-unit can be applied to small city park and create a public space for recreation, events and interaction. The massive units can become a visitor center or iconic spot in desert. This design is not only for Masdar City but can be a product to bring the idea of sustainability to all the middle east.

Single Unit Between Buildings

Multi-Unit In Park of City

Massive Unit In Open Area

CALCULATION

(The calculation is based on the hourly weather data of Abu Dhabi International Airport area)

Solar Energy:

Abu Dhabi Average Annual Solar Radiation/m^2 = 2285 KWh/m^2

Solar Panel Area = 6972 m^2

Annual input energy= 15,931 MWh

Solar panel energy conversion rate= 25%

Solar panel capacity (9.7 solar hour/day) = **1116.3 KW**

Expected Annual Solar Energy=**3,983 MWh**

Wind Energy:

Size of vertical wind turbine= wheel height 9m, wheel diameter 6m

Capacity of each wind turbine = 20KW

Number of vertical wind turbine =12

Total wind turbine capacity = **240 KW**

Expected Annual Wind Energy = 240kw (Wind capacity) x 10 (Avg. 10 windy hour/day) x 365 (Days) = **876 MWh**

Total Expected Annual Energy Generation= 3,983 MWh +876 MWh= 4,859 MWh

Name Plate Capacity = 1116.3 KW + 240KW = 1356.3 KW

Cost Estimate:

Flexible Monocrystalline solar panel = 400 \$/m^2

Total solar panel cost = 400 x 6972 = 2,788,800 \$

Each 20KW vertical wind turbine = 60,000 \$

Total wind turbine cost= 720,000 \$

Estimate Steel Structure + perforation steel panel = 5,000,000 \$

Construction = 6,000,000 $

Estimate Total cost = 14,508,800 $

Name Plate Capacity = 1356.3 KW

Estimate Cost per watt of installed capacity = 14,508.8 ÷ 1356.3 = 10.70 $/w

ENVIORNMENTAL IMPACT SUMMARY

The design tries to keep minimal impact to the environment. The generator does not produce any greenhouse emission, air pollution and water contamination. Each 20m diameter hexagon umbrella-shape steel structure only needs 7m^2 shallow concrete foundation. The whole design is unit-based and easy to disassemble and relocate, which makes the unit can be recycled and reapplied to anywhere else. All the material and product used in this product are common and can be supplied by local market which reduced the transit impact. The steel structure and steel perforation panel are composed of recycled and renewable material. The photovoltaic and wind turbine used in this project can also be recycled. The modular-based components are all prefabricated in factory and reduce the impact of construction.

The design provides a large shaded public area and uses wind tower technology to cool down the area. It will effectively reduce the temperature of surrounding area and lower the electricity consumption for cooling. It provides the neighborhood a more livable environment. Meanwhile, the project generates 4,869 MWh per year which can provide energy for surrounding institute and residence with saving emission of CO2 3,072 tons per year (0.631 kg/kwh), which helps Masdar city move a step forward to net-zero city.