LAGI 2019

Description of the project

**Spiral pavilions**

The project tries to interconnect cultural and geographical aspects with technological advances to create an attraction within the city of Masdar.

Inspired by sufi whirling an array of spiraling shapes with changing scale spread over the area, sometimes standing alone and sometimes connected together to larger shapes. They enclose spaces which are bioclimatically regulated providing a place for relaxation meanwhile they produce electricity and convert carbondioxide to oxygen.

**Energy production**

Since Masdar is a very hot place dominated by sunshine the pavilions use only technologies for electricity production which are harnessing energy from the sun. Two methods, a strongly technological and a much more natural one with lots of environmental benefits meet for energy production and are creating a unique athmosphere together. These are thinfilm solar cells and photobioreactors using microalgaes, both technologies are built on photovoltaism. Solar cells are generating a much larger amount of electricity which can be connected to the electrical grid of the city. Algaes using the wonderful natural process of photosynthesis produce only a small amount of energy compared to PV cells which is enough for the LED lighting and the ventilation system of the pavilions but they have many benefical environmental qualities.

**Energy production with thinfilm solar cells**

Every year solar cells are more and more developed while they cost less money. Thin-film technology is typically cheaper than conventional crystaline silicon solar cells and they produce less energy, however their efficiency rises and soon they will reach the same efficiency level as conventional photovoltaic cells.

Thin-film solar cells are light-weight and can be integrated in the covering material of the pavilions, which is ETFE (ethylen-tetrafluorethylen) foil. This is attached to a tensed cable network hanging down from steel columns.

The area of the solar cells is 1600m2 (a rest around them is black printed mask, about 400m2) and 230 Watts can be produced in one squaremeter.

Peak ouput: 368 kW

Annual: 365 x 12 x 216 ≈ 1400MWh

This could rise with better technologies in the near future.

**Energy production with photobioreactors and fuel cells**

A lot of researches and improvements happened with algaes in the past years. Algaes, especially microalgaes are excellent air cleaning organisms, they can recycle CO2 to oxygen twenty times more efficiently than trees. Due to photosynthesys energy industry could benefit from algaes like heat, electricity and oil, which could be used again for the production of bio fuels. Technologies get better and cheaper and in the near future algae could be a real alternative for energy production.

Recent researches at the University of Cambridge has shown that the separation of the photosynthethic process from the power generation process leads to much higher efficiency in electricity production and easier . With this methode 0,5W/m2 could be reached.

In the pavilions at the beginning of the process microalgae is cultivated under controlled conditions in smaller amounts in basins with nutrients and C02. Thenafter mixed with CO2 microalgaes are pumped up to the highest point of the pavilion through the columns of the structure and from this point gravity moves alges downward inside of the roof. The way downward is slowed down with wavy routes within the double layered ETFE roof structure which provides large areas for the photosynthetic process the growth of the algaes.

Leaving the lowest point algaes flow to power generation units. At the end of the circle a part of the algaes are pumped up again to the roof, and another part must be harvested as oil and biomass. This could be used either for biofuel production or the production of bioplastics. The biophotovoltaic process converts C02 to oxygen.

Area of the ETFE roof: 1800m2

Peak output: 900 W

Annual: 365 x 24 x 900 ≈ 7,9MWh

**Total peak output: 369 kW**

**Annual: 1408mWh**

**Bioclimatic concept**

The pavilions are spaces for relaxation. The interiors are cooled down by natural processes, using shading, adiabatic cooling and air movement using the effect of solar chimney, well known in arabic countries.

The floor of the pavilions is lower than ground level for keeping cold air here which is heavier than hot air. Thin-film Pv cells and algaes are shading the interior.

As first step of the cooling process air is led into the pavilion interiors through small underground tunnels, which cool down air by the lower temperatures of the ground. Air will be moved by fans outside the pavilions from the entrance of the tunnels.

Arriving in the pavilions air rises up through shafts. Inside the pavilions air will be cooled again by adiabatic processes with water. Water of the basins and waterdrops sprayed into the air collect heat from it.

The process closes with the solar chimney effect. The heat produced by the algaes warms up at higher parts of the roof, which generates the chimney effect. Warm air rises up and leaves the pavilions at the top openings. Fans accelerate this process.

The interior of the pavilions is 10-12 Celsius degrees colder than the outside.

**Cost estimation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cable network** |  |  |  |  |
| Diameter (mm) | Total length (m) | Volume (m3) |  |  |
| 10 | 34000 | 2,67 |  |  |
| (1m3 = 7850kg and 1000kg ≈ 2000USD) | | |  |  |
|  |  |  |  |  |
| **Cost of cables:** | **42000 USD** |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| **Steel columns** |  |  |  |  |
| Diameter (cm) | Heigth (m) | Thickness (cm) | Pieces | Volume (m3) |
| 20 | 7 | 1 | 16 | 0,67 |
| 20 | 8 | 1 | 18 | 0,86 |
|  |  |  |  | 1,53 |
| (1m3 = 7850kg and 1000kg ≈ 2000USD) | | |  |  |
|  |  |  |  |  |
| **Cost of columns:** | **24000 USD** |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| **ETFE foils** |  |  |  |  |
| Amount (m2) | 1800 x 2 |  |  |  |
| Cost (USD/m2) | 75 |  |  |  |
|  |  |  |  |  |
| **Cost of all ETFE:** | **270000 USD** |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| **Thin-film photovoltaic cells with all installation equipments** | | | |  |
| Amount (m2) | 2000 |  |  |  |
| Cost (USD/m2) | 690 |  |  |  |
| (Calculated with 3$/W) | |  |  |  |
|  |  |  |  |  |
| **Cost of all thin-film PV: 1380000 USD** | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| **LED lighting** |  |  |  |  |
| **2000 USD** |  |  |  |  |
|  |  |  |  |  |
| **Ventilation system** | |  |  |  |
| **100000 USD** |  |  |  |  |
|  |  |  |  |  |
| **Basement of the pavilions made of concrete** | | |  |  |
| Volume (m3) |  |  |  |  |
| 500 |  |  |  |  |
| (110 USD/m3) |  |  |  |  |
|  |  |  |  |  |
| **Cost of concrete basement: 55000 USD** | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| **Total cost: ca. 2million USD** | |  |  |  |

**Environmental impact**

The pavilions are built mostly of recyclable materials, like ETFE which can be reused to 100%, structural elements made of steel can be recycled several times, as well.

The great benefit of the project beside using renewable energy is the cleaning of air from CO2 and so reducing greenhouse effect.