*Diurnal shadow*

“Time is the measure of change.”

Physics (Book IV, part 10-13), Aristotle

*Diurnal shadow* is an artwork to celebrate the sun as the main source of energy on earth on the occasion of the 24th world energy congress.

An arch - understood as the archetypal shape of a gate - gently leans towards the sun and provides indispensable shadows for the people of Masdar in its exceptionally sunny weather.

The idea of *Diurnal shadow* comes from a wider reflection on the concept of time, primarily based on the relationship between earth and sun. The design of the artwork is inspired by the sundial - the oldest known device used to measure time by the apparent position of the sun in the sky - but the most common configuration with the gnomon casting shadows is reversed. The time of the day and the amount of energy being produced are indicated by the sunlight projected through a series of openings into a surface of photovoltaic modules capable of generating solar power and shade.

Time is a central theme for both science and daily life, it is one of the gifts the sun has given the earth. Several aspects of life, such as the five daily prayers in Muslim countries like the United Arab Emirates, are performed at times determined by the apparent position of the sun in the sky. The clockwise direction - commonly used in devices and tools - was originally informed by the diurnal motion. The concept of time continues to inspire new discoveries and scientific development, also in the field of renewable energies.

*Diurnal shadow* focuses on the relationship between the amount of renewable energy generated and the time of the day. It displays them on the publicly accessible ground shaded by the artwork. By using the diurnal motion of the sun as a medium to link time and renewable energy generation *Diurnal shadow* makes viewers aware of the production of energy in an intuitive and playful way. The calculation of the average amount of kW being produced during an hour is according to the intensity of the sun and the surface of photovoltaic modules exposed to the solar radiation in that particular time of the day.

The definition of the shape of the sculpture began with the observation of the diurnal motion in the sky of Masdar throughout the year. The path that the sun describes in the sky has then been enlarged around noon and tapered at sunrise and sunset. This configuration optimizes the exposure of the surface of photovoltaic cells by increasing it in correspondence with the peak sun hours.

While tracing the path of the sun, the overall form is reminiscent of an arch. This feature is meant to emphasize the function of the artwork as a gate to the city of Masdar. *Diurnal shadow* is both a monumental passage and a place to linger and experience.

The different hours are displayed by the sunlight cast in the shape of symbols reminiscent of the face of a clock in which the hour hand is represented by the amount of kW being produced. The different sun intensities throughout the day and their influence on the renewable energy generation became apparent.

In the East/West section adjacent segments 15° apart project the sunrays from the different hours through these graphic symbols. Ten parallel sets of louvers each oriented towards each of the daily sun hours only let the sunlight through one hour at the time while shading all the other inclinations. The sun shines through the louvers for less than 60 minutes or 15° (360° / 24h = 15° / 1h). The length of the louvers is defined by the sunlight shining between -/+ 7.5° of inclination. This configuration turns the sunlight on and off at the right time on the ground of the park at the center of the shadow cast by the arch.

In the North/South section the shape of the openings is defined by the solar declination from the angle of the Summer solstice to the angle of the Winter solstice. The Equinox line is perpendicular to the photovoltaic surface. The openings indicating the time and the amount of kW generated are shorter than the parallel louvers allowing the sun rays to illuminate the hours at all angles of incidence from solstice to solstice and defining the space for the structural beams.

Environmental impact summary

The intense sunlight of Masdar and the dark and sharp shadows cast by it are the main materials of the artwork. The technology chosen to generate energy is CIGS solar cells. The production process of CIGS solar cells uses less energy compared to crystalline silicon solar cells. The main environmental advantage that CIGS solar cells have over Cadmium Telluride solar panels is that they use a much lower level of cadmium. CIGS solar cell panels have better resistance to heat than silicon-based solar panels and this makes them especially suitable for the specific climate of Masdar. Avancis PowerMax Skala has a very high shading tolerance and spectral sensitivity that allows the photovoltaic modules to produce solar energy under different conditions and times of the day. The louvers directing the sunlight to indicate the hours are made of recycled copper. The structure is made of steel, also a recyclable material. The shape of the arch tapers towards the ground, occupying the smallest possible area. As a consequence, the use of concrete for the foundations is minimized. The proposal follows the guidelines from the master plan by leaving the entire site as an urban park while introducing a monumental entrance to the city.

Technology used: CIGS, Copper indium gallium selenide solar cells. Avancis PowerMax Skala, thin-film PV modules, black.

Nameplate capacity: 145W for a 1587mm x 664mm standard module. For 2000sqm, 290 kW total.

Annual kWh: 350 MWh calculated with 13,8% capacity factor.

