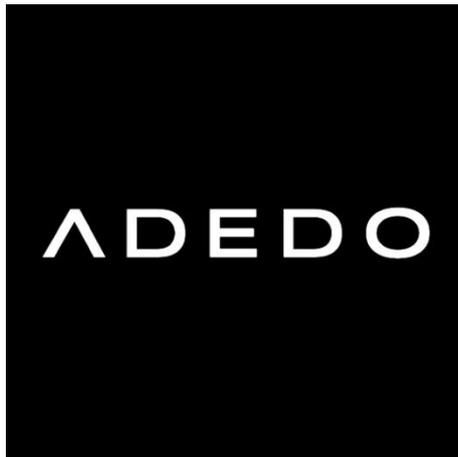


# MASDAR SQUARE: ENERGY LEAVES

Masdar City, Abu Dhabi, UAE.



# MASDAR SQUARE: ENERGY LEAVES

## INTRODUCTION

Accessing from the linear park or from the streets, we will find large and bright leaves with the size of buildings, spatially positioned as natural and technological elements that form structural arches, inviting us to discover the interior spaces and panoramic views to Masdar City.

Inspired by the natural plants' leaves that catch energy from the sun, every leaf-shaped structure is coated with photovoltaic panels to catch and obtain incoming solar energy; and analogously as plants absorb water and nutrients from the roots, the project is interconnected through an underground hybrid system that integrates geothermal energy production. The project works as a hybrid solar-geothermal power generator that optimizes energy opportunities of the local environment, to deliver energy to the city.

The architecture featured in the project represents the national identity inspired by the plants as a symbol of renewable energy sources, by the energy playing on dunes in the desert and on the waves in the sea, and by the traditional Arabic arts, from calligraphy to architecture.

Energy Leaves will be an iconic square and a gateway to Masdar City, positioned as a world landmark and a symbol of renewable energy, inspiring people and setting an example on sustainability for cities around the world.

## HYBRID SOLAR-GEOTHERMAL POWER GENERATOR

Energy Leaves works as a hybrid solar-geothermal power generator that would power Masdar City with an annual total 18 000 MWh of renewable energy, which would be sensibly enough to power 2 000 homes.

The project has three independent hybrid power generators arranged in the underground at the base of every two connected leaves, where solar and geothermal energy is produced, and the power is transmitted to the city through a grid-tied electrical system. The hybrid power generators are connected between them; creating an efficient, secure and powerful interconnected system.

Every leaf is coated on both sides with solar photovoltaic panels arranged in triangle modules, adapting to the irregular shapes. The structure's nine leaves have a combined solar panels' total surface area of 30 000 m<sup>2</sup>, of which 14 000 m<sup>2</sup> receive direct sunlight, 14 000 m<sup>2</sup> partial, and 2 000 m<sup>2</sup> integrate a walkable photovoltaic floor. A total of 11 518 MWh is produced annually from solar energy.

Additionally, the project explores the advantages of the coastal aquifer that may have a steam and hot water geothermal potential. Therefore, the underground systems work not only as a solar power generator but also ideally as a hybrid generator that integrates advanced geothermal systems and a zero-carbon footprint desalination process, where remaining water is treated through a multiple-effect-distillation and adsorption-desalination cycle, and channeled to be ideally used in residential and industrial consumption, or to assist air conditioning in the city. A total of 6 500 MWh is the potential to be produced annually from the geothermal energy concept, and 6.2 M liters of processed water, from geothermal energy in the facility place.

## **PUBLIC SPACE**

Energy Leaves will connect the “Desert Park” with the “Green Finger”, crossing GRT Loop, between the perimeter road and LRT/ BRT corridor.

The park square will integrate the community; promoting activity, interaction and recreation in an innovative and relaxing environment, where the contemporary work of art will integrate native plants such as Date palms, Ghaf trees, and Rimth shrubs. It is also a place to promote creativity and perform cultural events such as music, dance and lighting festivals, sports, movies and theater, workshops and family events, and all kinds of celebrations where people enjoy as a community.

The environment created through the leaves-shaped structure will free up the imagination and inspire people. Some of the leaves extend for more than 20 meters almost horizontally over the place, some rise quasi-vertically, while some others cover the spaces curving obliquely, and others extend as walkable platforms on the opposite ends to enjoy panoramic views to the city.

## **DESIGN AND CONTEXT**

If we look at the design, we find curves, arches, oblique angles, rhythm and repetition, flexibility, and free and wavy forms in leaves, pointed vertical elements as structural supports, patterns generated by the solar panels coating, green areas and water; all elements present in the traditional Arabic arts, from calligraphy, dance and music, to design and architecture.

The leaves have heights similar to those of buildings in the surrounding context (about ~30 meters), with the exception of two leaves that exceed such height, reaching 45 meters (the height of the wind tower).

The creativity of the spaces and the variety of shapes and views will make this place one of the favorite places to visit, and at the same time, the great power generator of Masdar City.

## **STRUCTURAL CRITERIA AND MATERIALS**

In the structure, most leaves work via a counterweight system between every two adjacent leaves connected in the underground. Above the surface, most of the leaves are also supported between other leaves, as vertical elements and loads, or in opposite directions as aerial counterweights. This concept allows the leaves structures to have longer spans and thus the project achieves something unprecedented.

The leaves are formed by a reticulated structure of recycled steel, coated on both sides by solar photovoltaic panels, which are anchored to the main structure by a light steel frame. As an exception, one leaf works as a cooling tower, and is designed in low carbon reinforced concrete, also coated by solar photovoltaic panels.

The main steel structure of leaves continues to the underground and is integrated to a heavy base in low carbon reinforced concrete, forming the foundations and the counterweights structures, as well as the underground technic floors.

## DIMENSIONS, ENERGY AND COST ESTIMATES

Items	Surface area (m <sup>2</sup> )	Efficiency (%)	Nominal Power (MW)	Energy per day (MWh)	Energy per year (MWh)	Water per year (ML)
Solar PV panels (direct sunlight)	14000	24	3.36	19.62 *	7167 *	-
Solar PV panels (partial sunlight)	14000	12	1.68	9.81 *	3583 *	-
Walkable solar PV floor	2000	18	0.36	2.10 *	768 *	-
<b>Solar Photovoltaic Systems</b>	<b>30000</b>	-	<b>5.40</b>	<b>31.53 *</b>	<b>11518 *</b>	-
<b>Geothermal System Potential</b>	-	-	<b>3.04</b>	<b>17.79</b>	<b>6500</b>	<b>6.2</b>
<b>Total Energy Potential</b>	-	-	<b>8.44</b>	<b>49.33</b>	<b>18018</b>	<b>6.2</b>
Ground level (pavements, green areas and pool)	25000	-	-	-	-	-
Underground levels (technic floors)	5000	-	-	-	-	-
<b>Total Surface area</b>	<b>60000</b>	-	-	-	-	-

\* Peak Sun Hours per day factor= 5.84

<b>Cost estimate to build the project</b>	<b>\$75 M USD</b>
Calculation based in solar energy	\$75 M USD / 5.4 MW = 14 USD per watt of installed capacity.
Calculation based in total energy	\$75 M USD / 8.4 MW = 9 USD per watt of installed capacity.

The estimates total cost to build the project is \$75 M USD, yielding 11 518 MWh Solar Energy per year, with a Nominal Power of 5.4 MW, which corresponds to 14 USD per watt of installed capacity.

The potential for total Energy produced, including Geothermal Energy, is 18 018 MWh per year, processing 6.2 M liters of water in the period. This total is consistent with a Hybrid Nominal Power of 8.4 MW, which corresponds to 9 USD per watt of installed capacity.

## ENVIRONMENTAL ASSESMENT

The project has been designed taking special care of the environment, and aiming to optimize the energy of the locality:

- The materials used in the structure are made from recycled steel and low carbon reinforced concrete.
- The leaves are strategically located and oriented to catch energy throughout the day, and at the same time to serve as roofs, to protect people primarily from the sun.
- The leaves are strategically located and oriented to allow airflow. In this way, the project makes the most of the wind to ensure a naturally ventilated environment.
- The native plants will create a connection with the surrounding areas, providing additional shades, and creating a comfortable microclimate.
- The energy production systems, transformation and storages are located in the underground, making it a safe installation for the public.
- The project applies and integrates proven technologies.
- The project is designed following a modular concept, where in the long term (+50 years) the materials are replaceable, from the solar photovoltaic panels and systems, to the entire structure formed by its different parts.
- This project will create a world landmark and a symbol of renewable energy, inspiring people and setting an example on sustainability for cities around the world.