**The Grove**

**Technical Description:**

**Technology:** Application of **Thermoelectric Generator** **Module** as Solar thermoelectric Generator and Solar Photovoltaic cells

**Total Nameplate capacity in kwP: 772.88 kwP**

**Cost per watt: $ 11.37/ watt ~ $12/ watt**

**Conceptual Cost of Installation= $ 9,495,528 ~ $ 9,500,000**

**Total Annual kWh: 4,216, 377.80 kWh/ year**

**Annual Freshwater production= 11,100 cubic meters**

**Dimension: 8.50m in height, 18.90m in diameter**

**Materials used:** Black aluminium plate, heat sink, high efficiency TEG module, silicone plastic inverted dome, silicon glass, galvanized iron pipes, photovoltaic cells, bladeless fan, transformer, insulator.

The Groves is a solution for creating electricity from an unconventional source: the sun’s heat energy. It also has the potential to produce fresh water, reduce urban heat island, and offset carbon dioxide emissions. Its roots will enhance Masdar City by creating a network of urban systems above and below ground.

“Those who forget their past, compromise their future”

As said by His Highness Sheikh Khalifa bin Zayed Al Nahyan, President of the United Arab Emirates, Ruler of Abu Dhabi and founding father of UAE, Masdar City is a tribute to the country’s rich and evolving culture.

**Mangroves as design inspiration**

*Physical Identity*

Calm water, mangrove island, vast desert, blue sky and constant sun are the defining features of Abu Dhabi’s urban fabric. Abu Dhabi is a place where the desert meets the gulf, making it an ideal condition for mangroves and rich natural life. Mangroves serve as defining backdrop for the urbanized and urbanizing areas of Abu Dhabi. Contrary to other countries where mangrove population are declining, Abu Dhabi’s intertidal ecosystem is in robust growth.

*Cultural Aspect*

Abu Dhabi’s past is rooted in the connection between farming and ranching oases on land and fishing and pearling in water. Creating a mangrove inspired artwork will create a visual and physical link to Abu Dhabi’s natural environment and bustling modern city. Moreover, it will promote awareness in the importance of mangrove population in maintaining the health of the country’s intertidal ecosystem.

*Sustainability and Innovation*

Thermoelectric generators has long been discovered but applications of this technology is yet to be realized commercially. Through the years, efficiency of the TEG modules has been improved. Utilizing of Abu Dhabi’s annual average temperature of 40 degrees Celsius and constant sun, TEG modules is the best option to convert free solar thermal energy into a sustainable source of electrical energy.

*Historical Integration*

The geometric figure of the circle represents the primordial symbol of unity and ultimate source of all diversity in creation. The plan of The Groves is derived from six regular divisions of the circle.

*Social Interaction*

Similar to mangroves’ roots, the Groves is envisioned to be a place of activity and congregation: an exciting public place where people can cool down in the day’s heat, recharge their mobile gadgets, take a quick break and enjoy the park.

**How is works**

The Groves takes advantage of the 2 uses of TEG modules: Cooling and power generation. Cooling occurs when current to applied into TEG module and the hot side is kept cool by a heatsink. Power generation is possible through the Seebeck effect in which a temperature difference between 2 dissimilar electrical conductors create DC electrical current. The higher the temperature difference, the more electrical energy would be produced.

PV solar cells powers the central thermoelectric cooler pod. The high temperature and high humidity will condensed water in the cooler pods. Series of pipes are connected to the cooler pod distribute the condensed water to the bottom chamber thermoelectric generator pods. Temperature can drop low enough to turn condensed water to ice, which will be harvested during downtime. The top side of the thermoelectric generator pods is kept hot by the black aluminium body sealed by glass to trap maximum heat. Cold chamber under TEG pods and TEC pods release mist to keep the temperature cold underneath for pedestrians. Direct current is then transmitted to the “electrical root” towards the transformer underground. Receptacles can also be found on the “frame root” for general use. Finally, melted ice during downtime can be harvested from the “water root” as water supply for gardening.

**Environmental Impact**

A single Groves installation has the potential to offset 773 tonnes of carbon dioxide and 15,866.55 cubic meters of fresh water source annually. It is also projected to mitigate UHI level in the city by the release of mists from cold chamber of TEG and TEC pods and irrigation of surrounding gardens by the freshwater produce. As a result, it increases human comfort level and lower cooling demands of the surrounding buildings.

The Groves is design to have a small footprint to minimize disturbance in the ground. The transformer is located underground for safety and immediate conversion of dc to ac. Thermoelectric generator modules can generate energy from recovered heat from photovoltaic cells in use all over Masdar City.

Harnessing heat energy from the sun is a way of energy diversification. Heat energy is often considered as wasted energy in solar pv as it lessens its efficiency. Solar thermoelectric generator modules can stay operational longer than photovoltaic panels. As long the temperature difference is sustained, electrical energy will be produced.

With this proposal, solar thermal energy is highlighted as another viable sustainable energy source from the sun. The Groves also aims to promote the use thermoelectric generator technology in similar arid climate country with Abu Dhabi’s Masdar City as the lead city. This proposal will further establish Abu Dhabi a contemporary Arab city.

**Calculation**

TEG Module 50mm x 50mm x 4.2mm

Komatsu Brand (basis of specification and cost)

Max output= 24 watts~ 0.024kw

Price per module= ¥30,000 or $ 272.86

Price per watt= $ 11.37/ watt ~ $12/watt

Conceptual price of installation= $ 9,495,528 ~ $ 9,500,000

Area of TEG module= 13.34 sqm x 6 TEG pods= 80.04 sqm ~ 80sqm

Area of PV cells= 10.40sqm x 3 = 31.20 sqm

Number of TEG module= 32,000 pcs

Number of TEC module= 2,800pcs

Nameplate capacity in kwP of TEG Modules: 32,000pcs x 0.024kw =768 kwP

Nameplate capacity in kwP of PV cells: 4.88kwP

Yearly operating hours TEG modules= 365 days x 15 hours

=5,475 hours/ year

Yearly operating hours PV cells = 365 days x 10 hours x 0.65

= 2,372.5 hours/ year

Annual Kilowatt hour generation TEG modules

= 5,475 hours x 0.024kw x 32,000= 4,204,800 kWh/year

Annual Kilowatt hour generation Photovoltaic cells

= 2,372.5 hours x 4.88kwp = 11,577.8 kWh/year

Total Annual kilowatt hour generation of TEG Module and PV Cells

= 4,216,377.80 kWh/ year

Total Annual Freshwater production

= 7 cooler pods x 0.90m x 6.90 sqm= 43.47 cubic meters x 365 days

= 15,866.55 cubic meters x .70 (evaporation loss and misting)

= 11,100 cubic meters

Additional note: A capacity of 1,000 MW can offset 1 million tonnes of carbon dioxide according to UAE State of Energy Report 2015. Applying this concept, a single installation of The Groves can offset 773 tonnes of carbon dioxide.

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