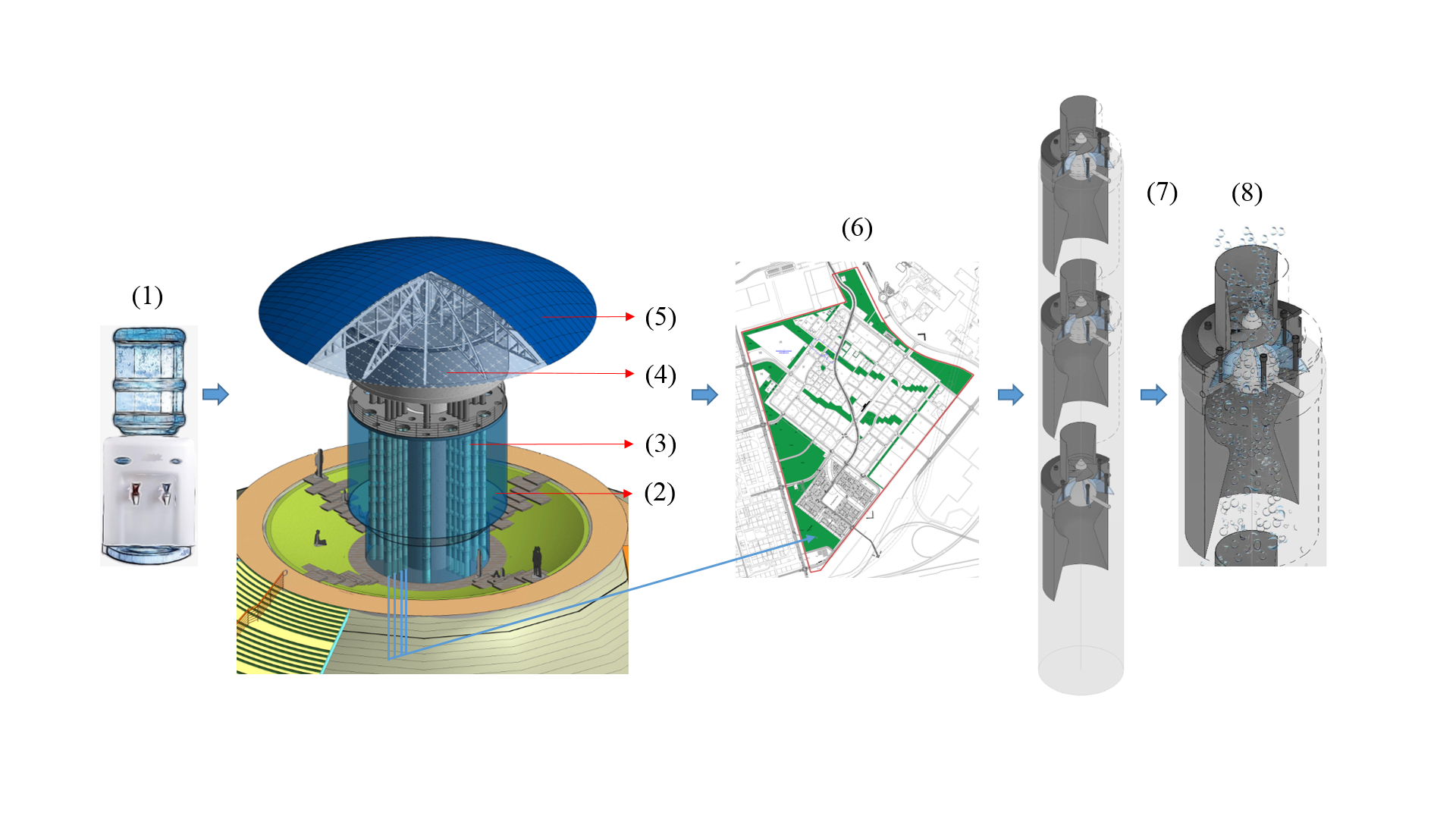
**TURBULENT HYDRO BUBBLE - ENERGY AND RECREATION (THB-ER)**

**Technology used in the design**

The energy area is characterized in the 21st century by three fundamental factors: greater efficiency in the transformation and use of energy, the use of renewable energies, and the creation of new technologies. In this context the project called Turbulent Hydro Bubble - Energy and Recreation (THB-ER) is inscribed, which shows how kinetic energy can be transformed into a new energy by using the motive power of bubbles formed in an aqueous medium to generate electrical energy, also getting a recreational use.

The design model of the project arises from the reflective perception of the operation of a water siphon (1). The mechanism is simple: when one needs to drink, simply open the tap and as the water is received, a cluster of bubbles is produced inside the hermetic but flexible waterproof container. THB-ER unravels this simple principle of kinetic energy, seeking to develop the use of the mechanics of bubble flows and their transformation into electrical energy, through small Kaplan type turbines.

Each of the eight THB-ER is composed of an external structure and glazed perimeter, which has a large volume of seawater, together with all the technical and biological requirements required to sustain the marine life of a variety of fish (2). Within each of these structures, an equidistant set of glass cylinders for residual water columns (3) is fixed and connected structurally and hydraulically to the cylindrical structure of a large domestic wastewater tank (4), located in the center of each THB-ER that also have solar panels on the roof (5). Both seawater and wastewater have differentiated mechanisms of use, and at no time are they mixed or disposed of in the same way.



The calculation process includes obtaining values for the velocity of the bubbles, forces acting on them, equation of movement, pressure at the beginning of the bubbles and their time of travel, as their exit velocity to obtain the power of the Kaplan type turbines.

The water tank will be supplied by the nearest "Domestic Wastewater Treatment Plant" and the constant flow waters that will fill the water columns are reused to irrigate green areas (6). Under this procedure an area of 29,661 m2 will be irrigated, which due to the abiotic characteristics present in the environment and its interrelation with the ecosystems of the city of Masdar, requires to be subjected to irrigation four times a day; what is equivalent to the fluid of at least 148,305 m3 of water reused and obtained from each THB-ER.

In this hydraulic process, in each THB-ER constant bubble flows are generated that activate 320 small Kaplan type turbines (7), connected in series to obtain electrical energy. The turbines are activated by the motive forces of the bubbles that, transported and directed by technical resources in the design, flow dynamically around the special geometry of the turbines, conveniently displacing the mechanical trajectory of their flow, both around the geometry of the these, as in contact with their shovels (8).

In a complementary way, the variety of fish, such as the flow of bubbles, will be a center of attraction, recreation and contemplation for visitors. Each set of THB-ER will have in the perimeter of its bases, surrounding and at ground level, large circular and concave depreciations, where visitors can see this unprecedented occurrence between bubbles and fish, comfortably lying or sitting in a soft and ergonomic surface of grass and / or wood. These concave surfaces around each THB-ER will, in turn, increase the percentage of green areas.

The project aims to promote the well-being of people by stimulating their capacity for observation and visual perception from an overwhelming influx of bubbles and fish. At night, the observation will be nuanced by a spectacular play of lights in the water, which will be activated by bubbles. The direct contact with these enclaves to obtain electrical energy and allow the recreation of the people, stimulates the creation of a critical mass, necessary for a vibrant and reflective life, where other forms of well-being are felt and built.

**Estimation of energy production in kW / h / a**

For the calculation, the energy income and expenditure to obtain the storage energy per day are considered.

|  |  |
| --- | --- |
| **Calculation of energy for a THB-ER**  **(Kw / day)** | **Energy calculation for eight THB-ER**  **(Kw / day)** |
| **Solar panels** | |
| 212.09 | 1696.37 |
| **THB-ER turbines** | |
| 1328.78 | 10630.24 |
| **Water Pump** | |
| 23.4 | 188.8 |
| **Leed lights** | |
| 5.28 | 42.24 |
| **Electric lift for technical service** | |
| 23.38 | 187.07 |
| **TOTAL ENERGY TO STORE** | |
| 1.488,81 | 11.910,48 |
| 505.122,37 Kw / day | 4.022.553,13 Kw /day |

**Dimensions and list of primary materials of each THB-ER**

1. External, perimeter and glazed cylindrical structure:

   - Each structure of 9 meters in diameter and 12 meters in height.

   - Glass and galvanized steel support structure.

   - Various fastening accessories.

2. Interior glass cylinders for residual water columns:

    - Equidistant set of 32 cylinders of flexible glass with diameters of 40 centimeters and a height

of 11.50 meters.

   - Glass and galvanized steel support structure.

    - Various fastening accessories.

3. Cylindrical reinforced concrete structure:

    - Cement and construction iron rods.

4. Depreciation on the ground, circular and concave:

    - Pasture and wood floors treated for the weather.

5. Set of hydraulic equipment, electro-mechanical, solar panels, etc.

**Declaration of environmental impact**

Although for the technical and objective study on environmental impact assessment there is bibliographic information (such as that published on the official LAGI 2019 page), it will only be possible to interpret certain environmental factors on water resources: mainly seawater, and water residuals of domestic use, reusable for the irrigation of green areas. For these purposes, the project does not involve an intensive or extensive use of the land available and does not have impact activities to be developed in a fragile ecosystem, so that the proposal is considered as a type of renewable energy, since it does not emit polluting products and it is an energy obtained with high energy efficiency due to the reusable water cycle, whose availability is constant and assured.

The total energy production is produced through Kaplan turbines and solar panels, clean energies that do not produce toxic emissions, which minimizes the carbon footprint of energy compared to the current production of conventional energy based on fossil fuels.

ANEXO

**TURBULENT HYDRO BUBBLE - ENERGY AND RECREATION (THB-ER)**

**Calculation Process**

Taking into account that there are eight THB-ERs in the intervention area, the total volume of wastewater is first calculated for irrigation of the 32 water columns of a THB-ER, which is equal to 197.74 m3. From this volume we can calculate a water tank emptying at 75%, reaching a THB-ER volume of 148,305 m3. Considering the possibility of using a THB-ER 4 times a day, there will be a volume of 593.22 m3 in a single day (depending on the loading time of the displaced volume).

Note: The percentage of emptying of the tank can reach 90% because the displaced volume of the water columns of the turbines is not considered, which is an indispensable volume for the development of bubbles and consequent activation of the turbines.

By arranging the 8 THB-ER, there is an irrigation volume of 1,186.44 m3 (148.305x8 THB-ER) intended for the irrigation of green areas once a day. Considering the maximum activation of four times a day, a volume of 4745.76 m3 (1,186.44 x 4 hours) is obtained.

Using the volume of irrigation of a THB-ER (148.305 m3), is the volume that will discharge in a column of water of a turbine, obtaining 4.63 m3 (148.305 / 8/4) that will be the total volume discharged in each THB- ER.

Volume equation:

Considering a total watering volume per day of 8 THB-ER V = 1186.44 m3 we can hydrate:

* For 1 cm of h

As it is about watering 4 times a day and watering 2 cm in each discharge, then:

* For 2 cm of h

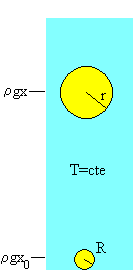
As it is about watering 4 times a day and watering 2 cm in each discharge, then:

**Bubble speed**

For isothermal transformation is considered a bubble of spherical shape of radius "r", which is at a depth "x". The pressure of the air inside the bubble is equal to the pressure due to the fluid column of height "x". The bubble expands isothermally as it rises. Assuming that air is an ideal gas, we will have to:

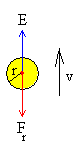
http://www.sc.ehu.es/sbweb/fisica/fluidos/estatica/burbuja/Image1.gif

"r" being the radius of the bubble at the initial depth, when it is born in the glass container.



**Forces on the bubble**

Assuming that the velocity of rise of the bubble has a laminar trajectory, it experiences a frictional force "Fr" that opposes its velocity "V". According to the "Stokes Law":



π: PI number

R: Bubble radius at the beginning

: Surface tension of water

V: Speed

The second force that acts on the bubble is the push force E. According to the Archimedes principle.

http://www.sc.ehu.es/sbweb/fisica/fluidos/estatica/burbuja/Image2.gif

E: Pushing force

Ƿ: Density H2O

g: Gravity of the earth

r: Bubble radius

**Equation of movement**

The mass m and the weight m x g of the air bubble are negligible. The "Newton's Second Law" describes:

When a body moves within a fluid in a laminar regime, after a certain time it reaches a constant limit speed, the resultant of the forces acting on said body is zero.

Ƿ: Density del H2O = 997 (Kg/m2)

g: Gravity of the earth = 9.81 (m/s2)

R: Bubble radius = 0.01 (m)

π: PI number

: Surface tension of water = 1.002

**Time of departure for 4.63 m3**

m3/s

We also have:

t = 981.86 (s) 17 min.

**Pressure at the lowest point or start of the bubble of the water column of the turbines**

From the definition of pressure P = F / A where "P" is pressure, F the force on the applied area and the area where the force is applied. It is also known that density ρ = m / V representing the density as "m" which is the mass and "V" the volume; do not forget that V = A × h where "V" is the volume, "A" the area and "h" the height. The sum of forces in equilibrium F = m × g, F of force is equal to "m" mass by gravity; so:

**Output speed**

By the "Bernoulli Theorem" we have in an ideal fluid, without viscosity and friction, in whose circulation regime in a closed conduit, the energy possessed by the fluid remains constant along its path, conserving energy, so that It is supposed to have a laminar flow.

Considering point 1 as the water outlet and point 2 the highest point of each water column of the turbines; it will have:

**Bubble pressure**

From the "Laplace equation"; you have to:

*Pressure inside the bubble*

*Pressure on the outside of the bubble.*

*Surface tension of water 0.073*

*Transverse radio*

*Tangential radio*

Since the bubble is a sphere, thenare equal, therefore, the equation will deduce:

Considering the presence of internal pressures inside the water tanks, so that they can easily achieve the entry of oxygen, which allows the creation of bubbles for the operation of the turbines; You see the convenience of using a special material, such as flexible glass. In the upper tanks, concrete tank and inside a polymer tank, like the basically born the idea of ​​the water siphon, that once we remove liquid it empties our hall and reaches the point where the polymer tries to return to its normal state and replace all the water that came out that gives way to enter the oxygen and then the creation of the bubble.

**Pressure scheme**

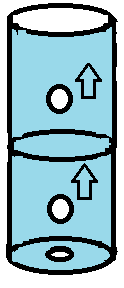
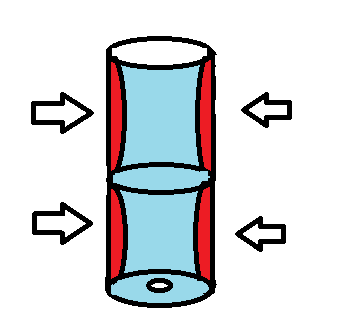
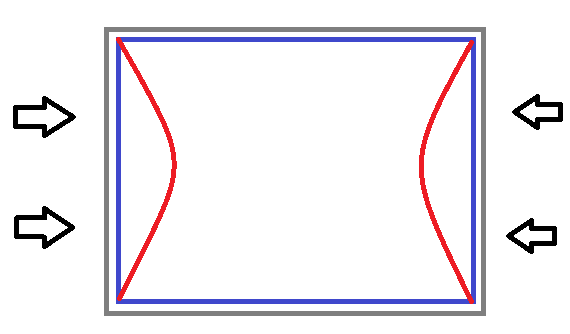


Diagram of the reinforced concrete tank, inside, polymeric coating that allows lateral deformations:



**Time of travel of the bubble in the entire column of turbine water**

Since the speed is constant because of having a laminar flow, the speed equation is used; so:

**Power of the Kaplan type turbines**

Remember (1 W = J/seg.)

From the equation of theoretical power, we have:

Where:

water density

Acceleration due to gravity

Height of the water column

Flow rate

Power of a turbine water column: P= 305.53 w

A THB-ER contains 4 turbines per row, and as the whole set has 8 rows, so:

The displacement of the bubble that runs through the 11 meters of water column, will be equal to:

To arrange the irrigation volume of 148,305 m3 of the eight THB-ERs, previously a time of 17 min was calculated, making the conversion to seconds, we obtain:

entonces:

There are 17 minutes required to remove the irrigation volume of 148,305 m3 As the THB-ER will be used four times a day, the power will change:

Considering a very good maintenance of the turbine columns 3 days of each month of the year, we obtain

**Energy from solar panels**

Whereas you have:

And knowing that a solar panel has a dimension of 1 m × 1.7 m gets to have an area of ​​1.7m ^ 2; The number of panels for each THB-ER is calculated:

With 179 panels for each THB-ER, energy equivalent to

of panels: Number of panels (unit)

Solar Peak Time, considered 11 hours of operation (hour)

Security factor

With the 8 THB - ER, a solar energy of 1696.37 Kw / day will be obtained; energy that can be stored or immediately used.

**Output volume, tanks for each THB-ER**

As each turbine will deliver 4.63 m3, and as in each row there are four turbines and for each TBH-ER there are eight rows; Thus:

Although it is 148.16 m3 that each THB-ER must discharge, it is required to leave a surface free of water for the entry of air to the turbines, since the generation of bubbles is due to the displaced volume of water. Considering the total area of ​​the glazed cylindrical structure, we have a radius R = 9/2 m, which is subtracted the cross-sectional area of ​​the cylinder, where will be the pipe that will raise the water to fill the tank that has a radius of r = 3/2 m. Then the calculation of the total area corresponds to:

Considering a height of 300 cm for the general tank, we have:

Then we have a volume of air, for the free volume of the tank that is equal to:

With a free air volume of 21.32 m3 it is guaranteed that the air enters the water columns of the turbines of each THB-ER

**Power and energy of the pump to bring water to 14.5 m.**

Sopower found

so:

Power found:

5.9 Kw that will be used four times a day; so:

Coming to a consumption of 8 pumps for 8 THB-ER and using 4 times per day, you have a power of:

.

The power is calculated for a flow rate equal ; having to raise a Volume ; then the time that will fill the downloaded volume is calculated:

And how it is possible to replace "V", so:

en 1 Hour.

**Energy for the luminaires of the turbines.**

To calculate the energy used for the operation of the luminaires, "The energy equation" is used:

The use of LED luminaires for fish tanks is considered, with a consumption of 3 W per luminaire. As in each water column there are 11 turbines; you have:

**Electric elevator for 450 Kg**

In the case of being an elevator with capacity for 2 people, we have that the maximum load capacity will be 300 Kg. (75 Kg per person and 300 Kg of extra load is calculated). The energy consumption required for its operation of its hydraulic systems is 9.5 KW / hour and 13 KW / hour; while for its electromechanical systems it is between 4.5 KW / hour and 5.5 KW / hour. It is estimated for the latest generation engines, between 3 KW / hour and 4.5 KW / hour. Then, the maximum total mass that the elevator can move:

**Total consumption**

Required 23 Kw / day is required for the operation of the elevator of a THB-ER for a load capacity of 450 Kg and with approximate dimensions of 1.60m × 1.60m; obtaining an area of:

Considering that the lift will be used for maintenance and cleaning for six days a month, both from the fish tanks (3 days), as well as from the water columns of the turbines (3 days), as well as 2 days for emergencies and considering that each day an average of 100 climbs is used (remember that to lower energy is not used); we will have:

To climb, an elevator speed of 0.5 m / s or 1800 m / h is considered, so it takes 36.6 seconds for the average route of 18.3 m of each climb.

Taking into account that 50 daily rises will be made, there is a use of:

Its use will be eight times a month, so:

**Power for monthly use**

**Total, energy obtained**

Taking into account that you have both income and energy expenditures, the following table has the storage energy per day or ready to be used.

|  |  |
| --- | --- |
| **Energy calculation for 1 THB-ER per day** | **Energy calculation for 8 THB-ER per day** |
|
| **Solar panel** | |
| 212,09 Kw/day | 1696,37 Kw/day |
| **Turbinas THB-ER** | |
| 1.328,78 Kw/day | 10.630,24 Kw/day |
| **Water Pump** | |
| 23,4 Kw/day | 188,8 Kw/day |
| **Electric lift for technical service** | |
| 23,38 Kw/day | 187,07 Kw/day |
| **Led lights** | |
| 5,28 Kw/day | 42,24 Kw/day |
| **TOTAL ENERGY TO STORE** | |
| 1.488,81 Kw/day | 11.910,48 Kw/day |
| 505.122,37 Kw/year | 4.022.553,13 Kw/year |

Note: For the annual calculations the following considerations were taken; for solar panels, a 365-day operation; for each of the THB-ERs, an operation of 329 days, as they are considered 3 days a month for the cleaning of turbines. For the water pump, 329 days were considered for filling the tank with domestic wastewater. For LED lights, 329 days because they were disconnected for the maintenance of each turbine. Finally, for the elevator 8 days of use per month and each day 100 increases.

Es posible observar en el anterior cuadro que por día podemos almacenar o utilizar 1.488,81 KW/día de una sola THB-ER y 11.910,48 KW/día de las 8 THB-ER. Anualmente tendremos una producción de energía total de 505.122,37 KW/ año por cada THB-ER, haciendo un total de las 8 THB-ER de 4.022.553,13 KW/año.

It is possible to observe in the previous table that per day we can store or use 1,488.81 KW / day of a single THB-ER and 11,910.48 KW / day of the 8 THB-ER. Annually we will have a total energy production of 505,122.37 KW / year for each THB-ER, making a total of 8 THB-ER of 4,022,553.13 KW / year.