Use of Wind And Solar Energy for Desalination of Sea or Brackish Water

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Abstract:

Fresh drinking water in most of the Arab countries is an increasing problem , the system used in this paper for desalination of sea or brackish water has high efficiency to generate electricity by conversion of wind energy and solar energy to evaporate the sea or brackish water, then compensating it to get the fresh water. The special construction of the system guarantees the higher efficiency to nearly 8 litters per square meter per day , the wind energy provide the work of the system day and night and hence the higher output of fresh water. One great option participation of this system is the possibility of pumping the produced water to higher levels above ground level not only the first level without decreasing the overall efficiency .

Key words : desalination , evaporation process, condensation, efficiency, water pumping, wind energy ,wind rotor ,and generator.

I-Introduction:

For many years , most of the Arab countries have had low rates of rain falls in the rainy seasons and records of high temperature in the summer seasons , which have lead to the decrease of water table levels in underground basins , These levels are getting deeper and deeper each year indicating the danger of domination water table levels and many of be the existing water resource at the end , especially if these quantities are used for irrigation as in Libya and other Arab countries [1,2] .

While it is clear that the threatening water crisis cannot be solved by conventional desalination, it can indeed be solved by solar powered desalination combined with efficient use of   water reserves and re-use of wastewater. Building water supply on limited, fossil energy resources with unknown cost perspectives would be very risky, while building a reasonable share of water supply on renewable resources that become cheaper with time would be rather reasonable. CSP-desalination can also help to reduce the subsidiary load of most north African governments , for power and water sectors and liberate public funds that are badly needed for innovation and development

Recently; we have learned about many proposals of using renewable energy sources for the production of hydrogen energy or power generation via thermal conversion process in some locations of the Northern African countries for example dessertech project [3]) and SHEE TREE project [4] , since there are abundance of clean solar and wind energy available at these many locations and good possibility to simply transfer either liquid

hydrogen or electric power via pipelines systems or underground   lines to many of consumption places locally or internationally in EU. countries . In Libya there are an ambitious plans to develop facilities and stations of using renewable energy to contribute to the national power production up to 10% by year 2025 and ,20% for 2030 [5].

In this paper we have combined our ambitions of getting fresh drinking waters and electricity generation in a very special designed system , With the attention on high efficiency and compact system using solar and wind energy[6]. The produced fresh drinking water can be delivered to higher levels above the ground. This new system can be used for large or small consumption capacity. The choice of rotor design permits it to be in areas as small as possible depending to the needed capacity, perhaps 2 m² area and 3 meters   high, [7]. see (figure 1 shows the drawing of the complete system at the end of the paper).

III- System Description :

The desalination system composed of three main parts (see the complete system and the different blade types) .

* The thermal conversion part still type .
* The condensation and heat dissipation part .
* The wind energy conversion and electric power generation part .

Each of these parts is designed to perform specific function but can not be separated from the other parts to complete the process of desalination and production of fresh water or generation of electricity .

The Structure of the system and function details as we mentioned above, are comprised of three main parts .

A – Solar Collections and Water Vaporization .

This part is basically normal basin still with one inclined roof usually facing south ,and consisting , as shown in the figure (1) of the following :

- Basin vaporizer 0.25 x 1×2 m³ , painted black (with or without preheating panels) using sea or brackish water .
- Outside Jacket with insulating layers of dimensions $30\times105\times205$ cm.
- Glass cover 2 mm thick enforced by metal frame inclined 45 degrees with the horizontal and of dimensions nearly the dimensions of the basin's base, see the figure of complete system   [Glass or Transparent plastic].
- Plastic Pipe of 20 cm diameter reinforced by back metal frame , and connected to the top of the glass cover.
- Water inlet and outlet for flushing out the high concentrate, remainder of salt saturated water at the bottom of the basin and jacket.
- Optional one 1×2 m solar collector to preheat the incoming water
- Electric heater , as an auxiliary source for water heating , connected to the wind energy generation of electric power [8].

B – Condenser and Water Collection Tank .

Condensation process is progressed through two higher grid of small pipes, of 3 – 5 mm diameter through which the vapor passes and condenses to fresh water and flows to the collection tank . This grid works as heat dissipation element.

C – Wind Energy Rotor and Electric Generation

With start stop control and connection to the auxiliary rotor, the rotor can be chosen one of the three shown types of vertical axis these rotors are of slow speed just enough to generate the electric power for the use of water heating during the night.

Calculating the Wind Power

The formula used to calculate the wind power produced by a wind turbine or windmill is follows:

$$\mathbf{P = c \times d \times (D^2) \times (v^3)}$$

P: Power produced (mechanical) (Watts [W]),

c: constant

d: density of wind (kilograms per cubic meter [kg/m^3])

D: turbine blade diameter (meter [m])

v: velocity of wind (meters per second [m/s^2])

The constant c depends on the system of units used and the specific variables in the equation. The formula implies that once the wind speed doubles, the wind power increases by a factor of eight! Furthermore, if the diameter of the blades is doubled, the power increases by a factor of four! The faster the wind and the bigger the blades, the more power input we can get.

In order for the formula to be more accurate, another variable should be added that is related to the design efficiency as mentioned above.
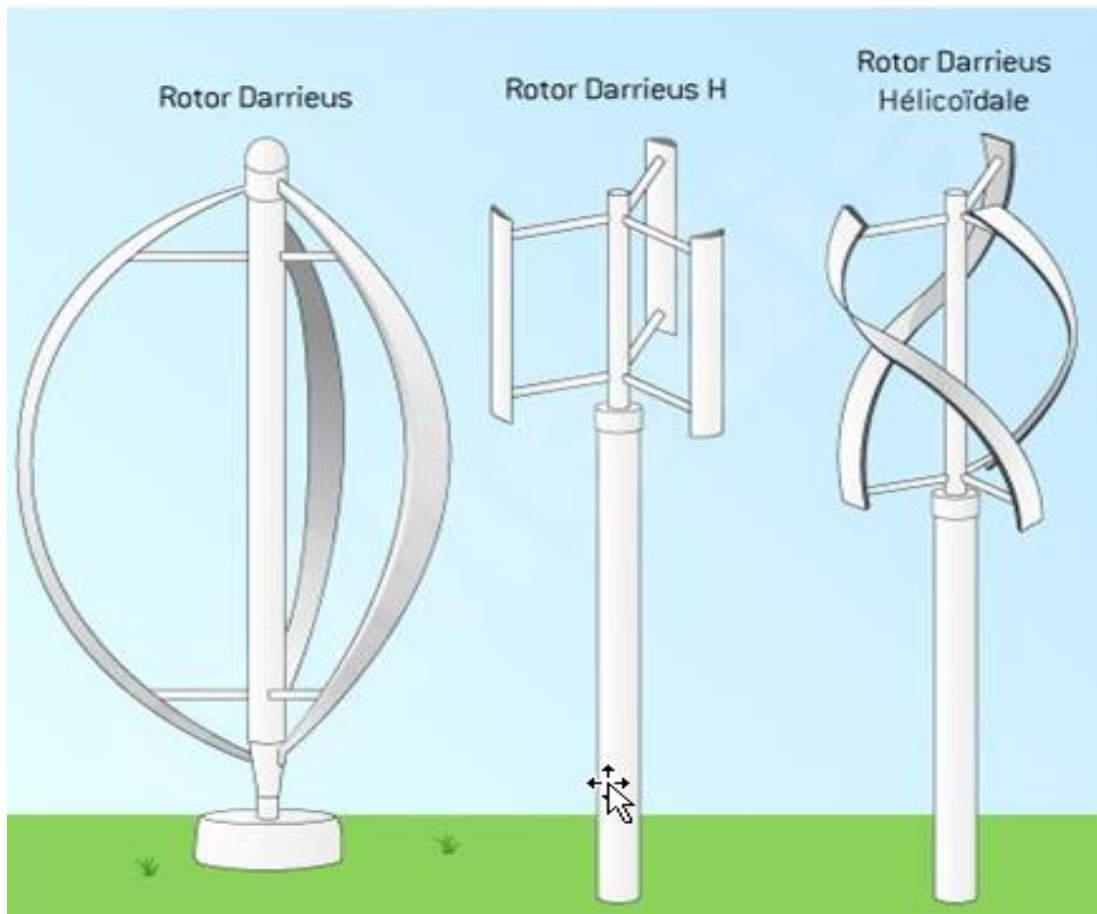
Fig.1 -The three main kind of Darrieus VAWT (including giromill)
Source: eolienne.comprendrechoisir.com

Some properties of vertical axis wind turbine (VAWT)

- The generator, gearbox and other components may be placed on the ground, so the tower doesn't need to support it, and it is more accessible for maintenance.
- Relatively low cost of production, installation and transport compared to horizontal axis turbines.

- The turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where the wind direction is highly variable.
- Hilltops, ridgelines and passes can have higher and more powerful winds near the ground than higher up because due to the speed up effect of winds moving up a slope. In these places, vertical axis turbines are suitable.
- The blades spin at slower speeds than the horizontal turbines, decreasing the risk of injuring birds.
- It is significantly quieter than the horizontal axis wind turbine. As a result, vertical axis wind turbines work well on rooftops, making them particularly useful in residential and urban environments. They may also be built in locations where taller structures are prohibited by law.
- The VAWT is particularly suitable for areas with extreme weather conditions, like in the mountains where they can supply electricity to mountain huts.
- Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration. This can include noise and bearing wear which may increase the maintenance or shorten the service life.

D – Optional Battery for Electrical Energy Storage and Outdoors System Use .

In the case of generation more power than needed , the excess of generated power can be stored in any commercially available batteries suitable for the over generated power, which can be used for heating of water or night time lighting or any other domestic use .

IV – Results and Analysis .

Using four different designs of wind rotors, different length of plastic pipe lengths ,condenser types and orientation, we were able to obtains the following results for (30 days) of the month of June, and 31 days of the month of December of the year(2012) , which represent the summer and winter time at the region of Zawia , Libya [9],see table (1)below .

Average solar Radiation = 1.3 , 1.1 kw / m² / day in June , and December months respectively , and the annual average wind speed 6 m /S
Useful average of sunshine time nearly (8 hrs /day) , with different rotors , water temperature (without side collectors) (50 C°) month June ,

Month	Time(h)	Water collect	Height of pipe	Rotor Type	Electric-energy	Storage	Solar collect
June	18- 10	9.5	4m	Vert. Axis	none	none	None
Month	Time(h)	Water collect	height of pipe	Rotor Type	Electric-energy	Storage	Solar collect
December	10- 16	6.5	4m	Vert. Axis	none	none	None

From these results of the systems performance under the indicated data and at the two different months of solar radiation where we have chosen June to represent summer time (high Radiation) and December to represent the winter time (low Radiation) .

We can conclude the following .

1- The average amount of water collect per (24 h) by the system per square meter have reached ~ 9.5 liters per day during the month of

June and ~ 6.5 litters in the month of December so the overall average output of the system is 8 litters / m²/ day

2- The role of wind energy was significant, with vertical axis rotor , the system continued to work after sunset and in cloudy days , which have pushup the efficiency of the system . 3- The source of electricity provide the auxiliary heater with power day and night,, and without outside connection, that makes the need for additional outside solar collector unnecessary ,and subsidies the drop in solar radiation in winter , where more wind speed is available , More bonus was provided by to rotor blade motion , pushes the air across the condenser leading to acceleration of vapor cooling and more condensation process leading to increase in water output.

The small fan inside the upper end of reinforced plastic (concrete) pipe connected to rotor base, has the effect of vapor movement upward reaching the condenser part very quickly . This fan provides two results ,**First,** extra output in less time , whether in winter or summer , day or right., **Second**, lower vapor pressure inside the vaporizer increases the vaporization process inside the basin still . **Third,** we get free fresh water left to higher levels above the ground , which is necessary for multilevel buildings or houses .
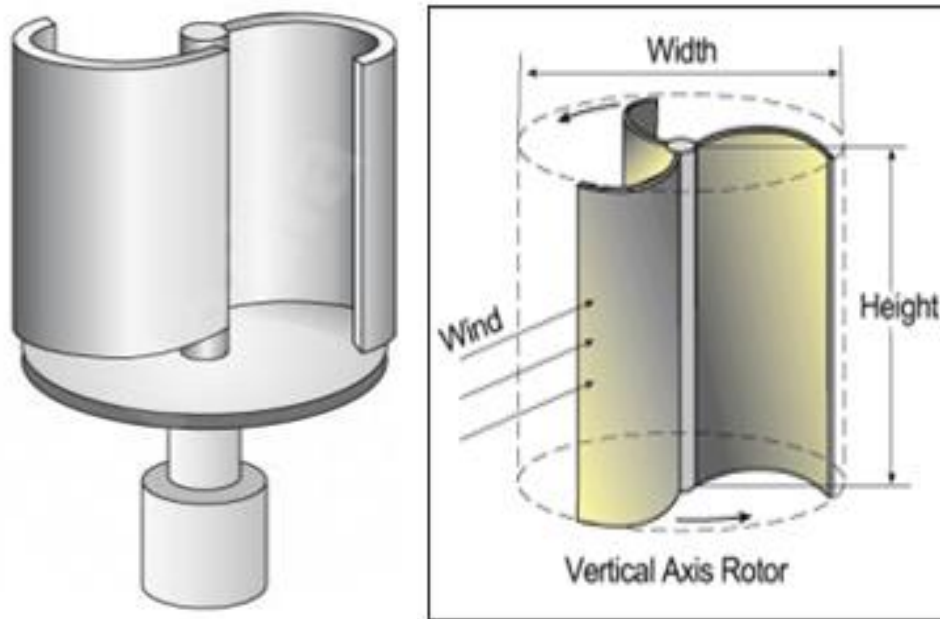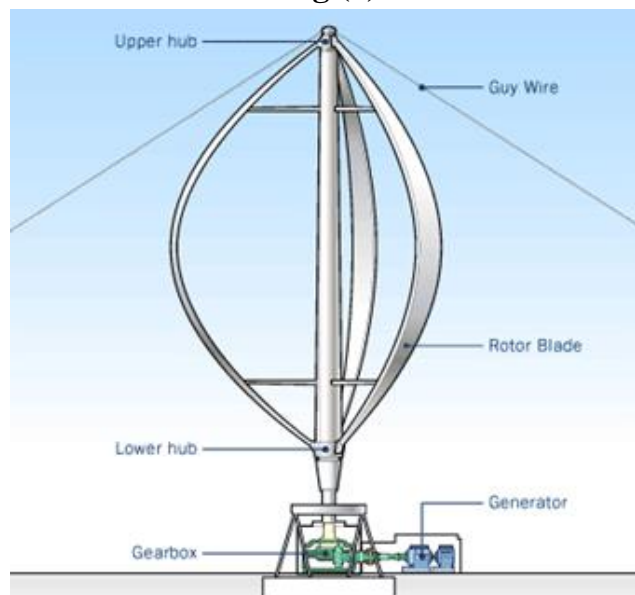
Fig.(1)

Fig. (2) VAWT *Darrieus wind turbine with the different components*
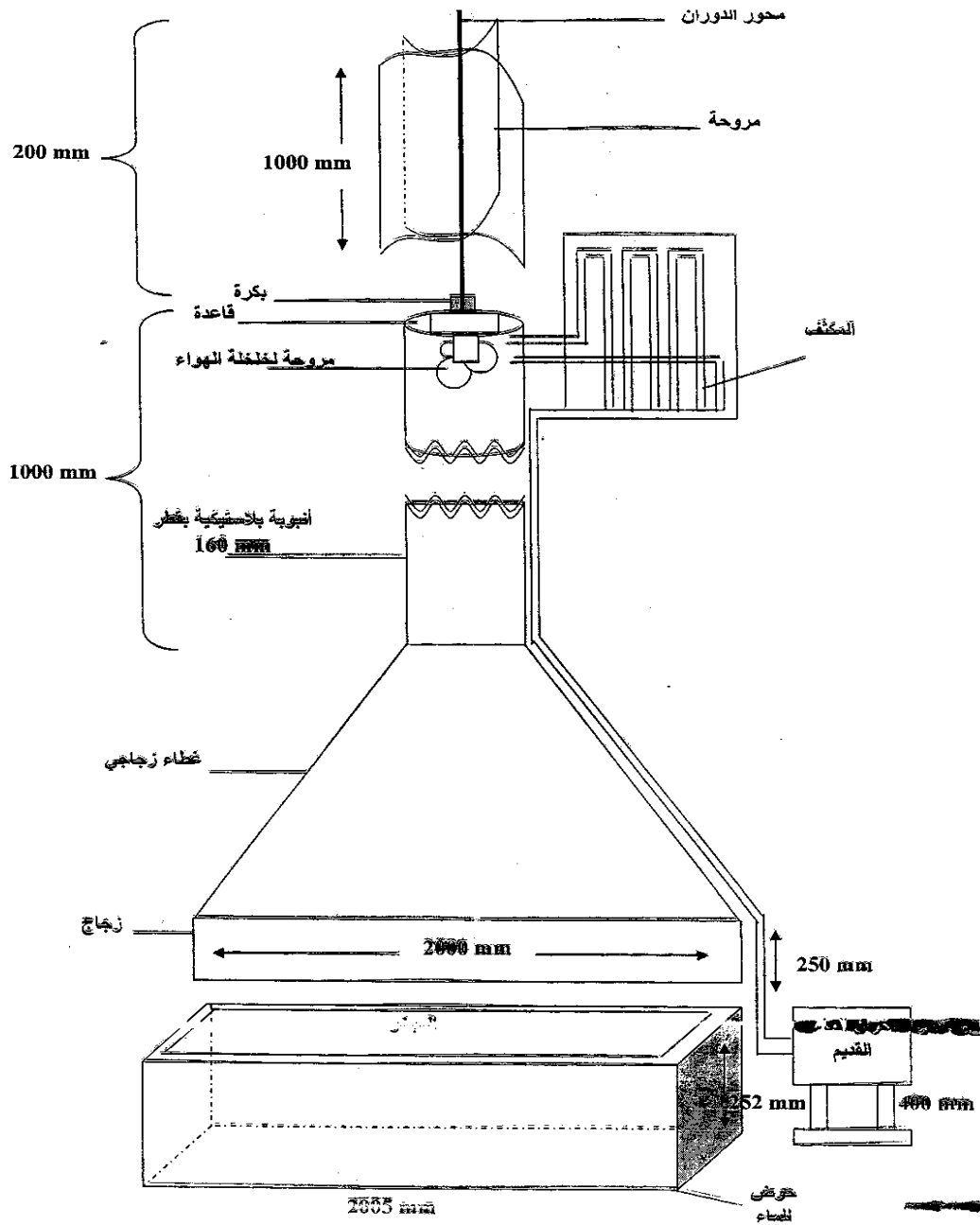*Source: science.howstuffworks.com*

Fig.(3) Complete System (without batteries ,and pre water heating parts)

V - Conclusion .

There was significant improvement of the output of the new desalination system through the 24 hours work , and extra source of energy the auxiliary heater , The efficiency reached nearly 8 litters / m² / day for the relatively small occupied area ,in addition to the possibility of water pumping to higher levels above ground and the option of using surplus electric power with the aid of storage batteries.

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