THEME : WATER

Project : Integrated Desalination Plant on Seawater Using Parabolic Boats

IDEA : LOW COST WATER DESALINATION USING SOLAR REFLECTOR PARABOLIC BOATS

BY : TEAM_RABBIT

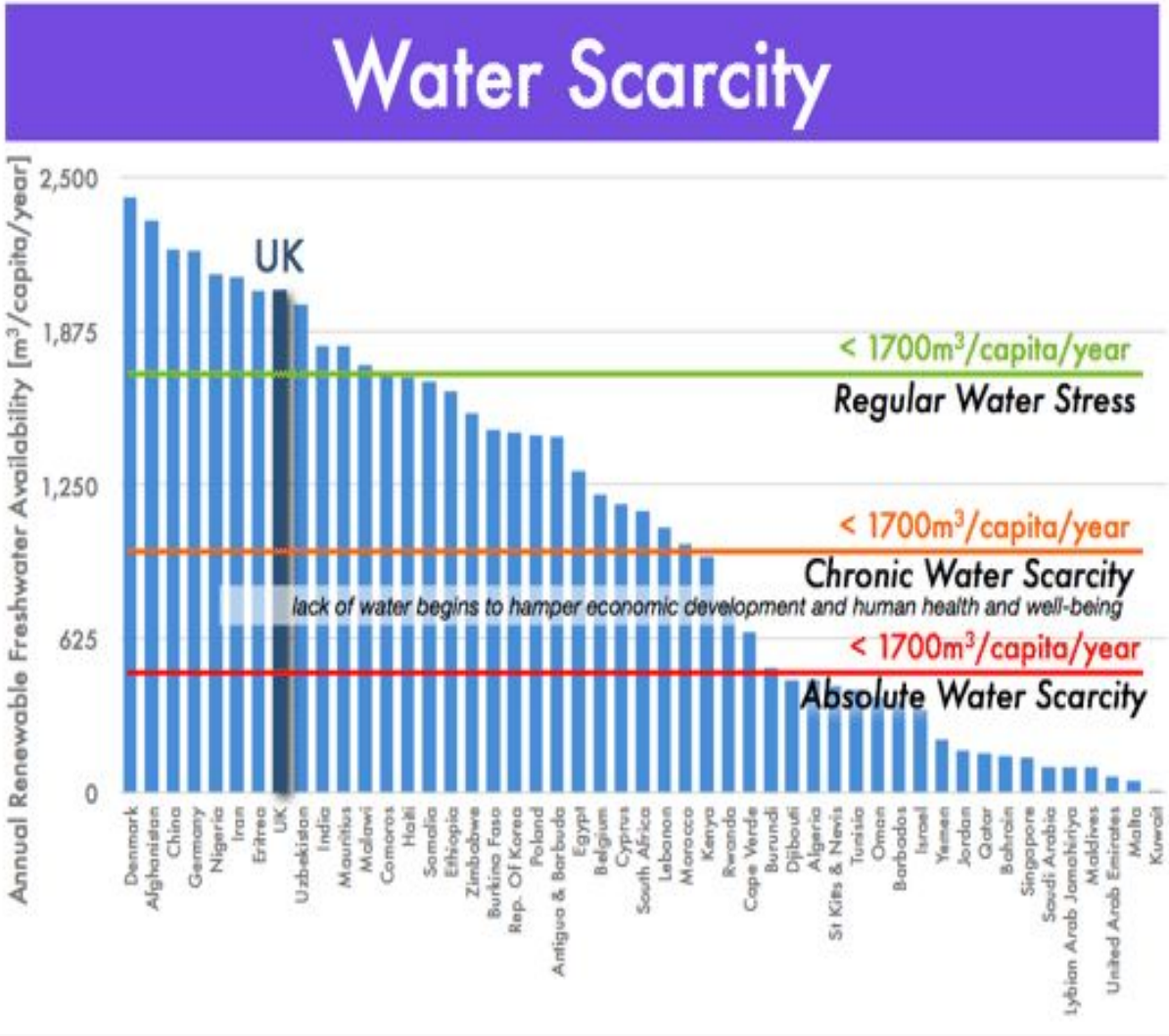
Project/Idea

Problem Statement(1/2) :

The scarcity of freshwater resources and the need for additional water supplies is already critical in many arid regions of the world and will be increasingly important in the future.Many arid regions are becoming scarce of fresh water for their daily usage.They are relying only on underground water resources but even these resources will turn futile after they have been exhausted completely.And, as the population continues to grow, shortages of fresh water will occur more often.

Problem Statement(2/2) :

SOURCE : http://www-g.eng.cam.ac.uk/impee/?section=topics&topic=water&page=slideshow



Project/Idea Solution(1/3) :

The "simple" hurdle that must be overcome to turn seawater into fresh water is to remove the dissolved salt in seawater.That may seem as easy as just boiling some seawater in a pan, capturing the steam and condensing it back into water (distillation). The moment we do this we are done with water crisis .NO MORE WATER CRISIS . Right,, WELL NO!! There seems to be some scientific problem in this methodology.The problem is that the desalination of water requires a lot of energy. Salt dissolves very easily in water, forming strong chemical bonds, and those bonds are difficult to break. Energy and the technology to desalinate water are both expensive, and this means that desalinating water can be pretty costly. The basic and most common method prevailing right now ,for breaking the bonds in sea water is Thermal Distillation. Thermal distillation involves heat: Boiling water turns it into vapor — leaving the salt behind — that is collected and condensed back into water by cooling it down. This involves a lot of energy for doing so . Hence cost of production is high and requires a lot of capital. Here are our parameters for saline water:

Project/Idea

Solution(2/3) :

The best way to save energy is to use natural energy and in this case solar energy from sun.However the direct sun rays falling on sea water is scattered (not focused) and thus not cause evaporation. We need a system that causes evaporation with high efficiency and stores the vapor of sea water and rejecting salt from it. The solution is to use parabolic mirror boats with a inflated plastic cover which has high surface tension so to hold water droplet from separating away and rather slide on the plastic sheet and come down in the holes made in the boat to collect in the reservoir connected to the boat through a pipe.The boat will consist of rectangular shaped box in the middle whose valves will be electronically controlled to inflow the water and valves will be closed when the water is filled.This filled water will be then focused with a beam of sunlight reflected from parabolic mirrors with higher intensity . This high intensity solar waves causes the evaporation process to begin and the formed vapor gets condensed on the plastic sheet which gets slided on to the holes. ...Continued

Project/Idea Solution(3/3) :

After all the water is desalt ,the salt is left on the box and then the valve is opened to leave the salt back and new sea water is brought into the box for continuation.The new water reservoir are attached after the earlier ones are filled.The water collected through this process should be then sent for further treatment such as nanofiltration. The image of prototype is uploaded in the attachment. Beneficiary/User segment this solution is intended for: This water generated from this treatment process would be enough for countries with high temperature weather which have high scarcity of clean water.However this process is not limited to those countries .The packed water may be exported to other countries.The process being really cheap would bring a lot of countries to the table.

Project/Idea

Target Customer(1/1) :

All the countries which have water level less than the critical value(see graph) would love to become a part of this cheap, affordable and sustainable water supply plant.

This would help them boosting their economy as the natural fuels they utilized for water purification can now be used in some other application or alternative.

Project/Idea Uniqueness(1/3) :

History :

In 1952 the United States military developed a portable solar still for pilots stranded on the ocean, which comprises an inflatable 24-inch plastic ball that floats on the ocean, with a flexible tube coming out the side. A separate plastic bag hangs from attachment points on the outer bag. Seawater is poured into the inner bag from an opening in the ball's neck. Fresh water is taken out by the pilot using the side tube that leads to bottom of the inflatable ball.These were called condensation traps.

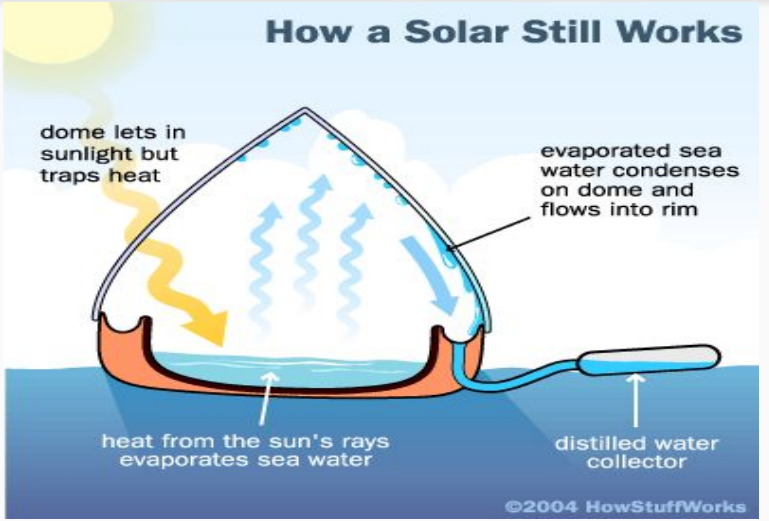


Fig :Obsolete Solar Boat

Project/Idea Uniqueness(2/3) :

Problem :

Condensation traps are not in themselves a sustainable source of water; they are sources for extending or supplementing existing water sources or supplies, and should not be relied on to provide a person's daily requirement for water, since a trap measuring 40 cm (16 inches) in diameter by 30 cm (12 inches) deep will only yield around 100 to 150 ml per day.

Fig :Obsolete Solar Boat

Project/Idea

Uniqueness(3/3) :

Using parabolic boats the amount of water increases drastically and time decreases considerably. The amount of water generated would be sufficient to meet the demand of drinking water supply for 9k people.

The calculation for water generated per day are calculated in the calculation section.

Project/Idea

Geography(1/1) :

Countries which have annual solar exposure with more than 4 kWh/m^2 are well suited for this project.

Countries like Australia, Kuwait, Saudi Arabia, UAE, Nigeria, Sudan and India to name a few, would be perfect for this kind of model.

For the calculation point of view ,Australia’s government meteorological data has been extensively used.

Project/Idea

Parabolic boat(1/5) :

DESCRIPTION :

The boat consists of the following specifics:

- A pump to fill the water in the container.
- A container of dimensions (.5 x .5 x.6)m^3 to hold the water of capacity 150 liters;fixed at the focus of boat.
- A electronic system to control the filling and exiting rate.

Project/Idea

Parabolic boat(2/5) :

- A solar panel (39 x 65)inch floating sideways on inflated plastic sheet to supply power to run electronic system and pumps.
- Holes on the aperture circumference to collect desalinated water and pass on to the main pipeline system.
- A funnel just below the 150 L container to sweep away the salt back into the sea while container fills back.
- Parabolic mirrors on the surface of boat to concentrate the sunlight on to the container bottom.

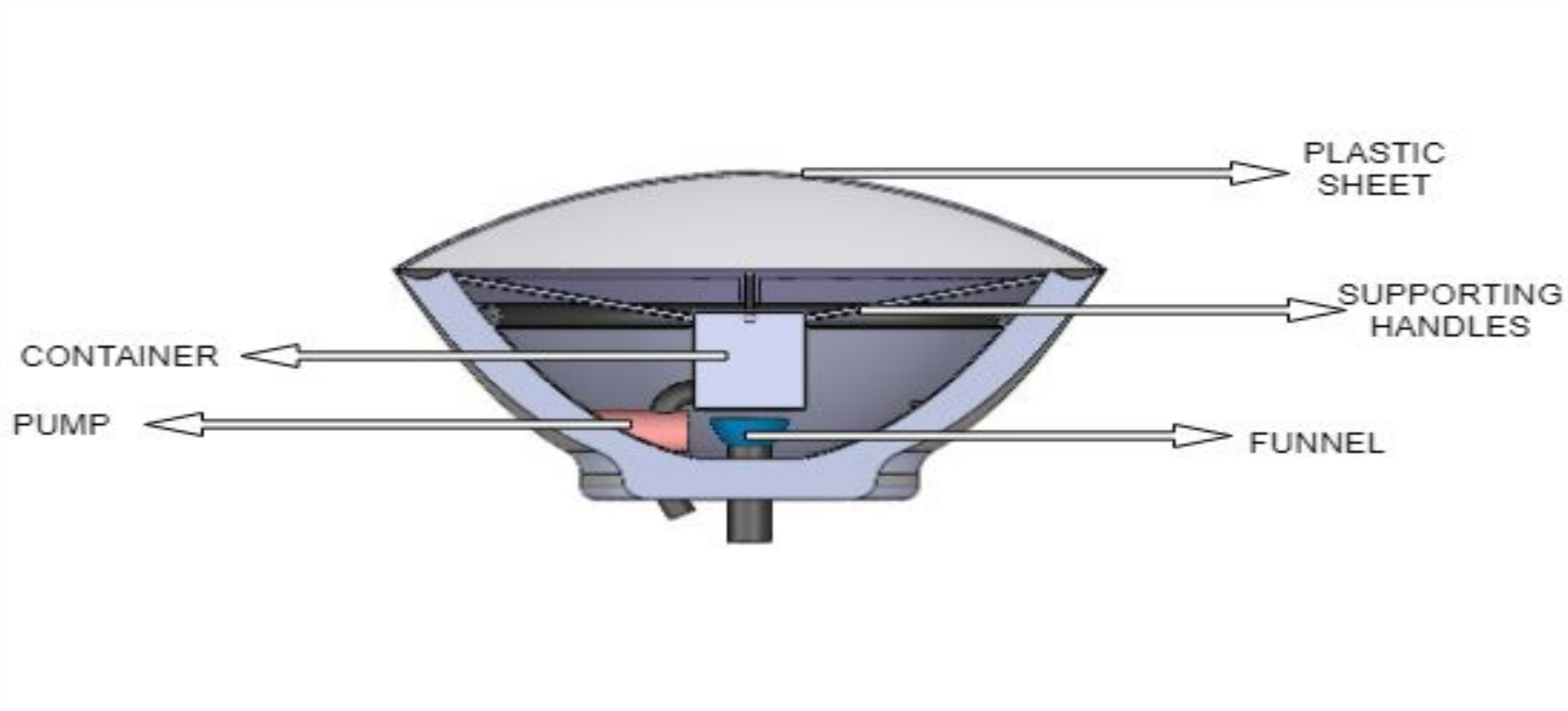


FIG : Snapshot from the CAD model describing various parts

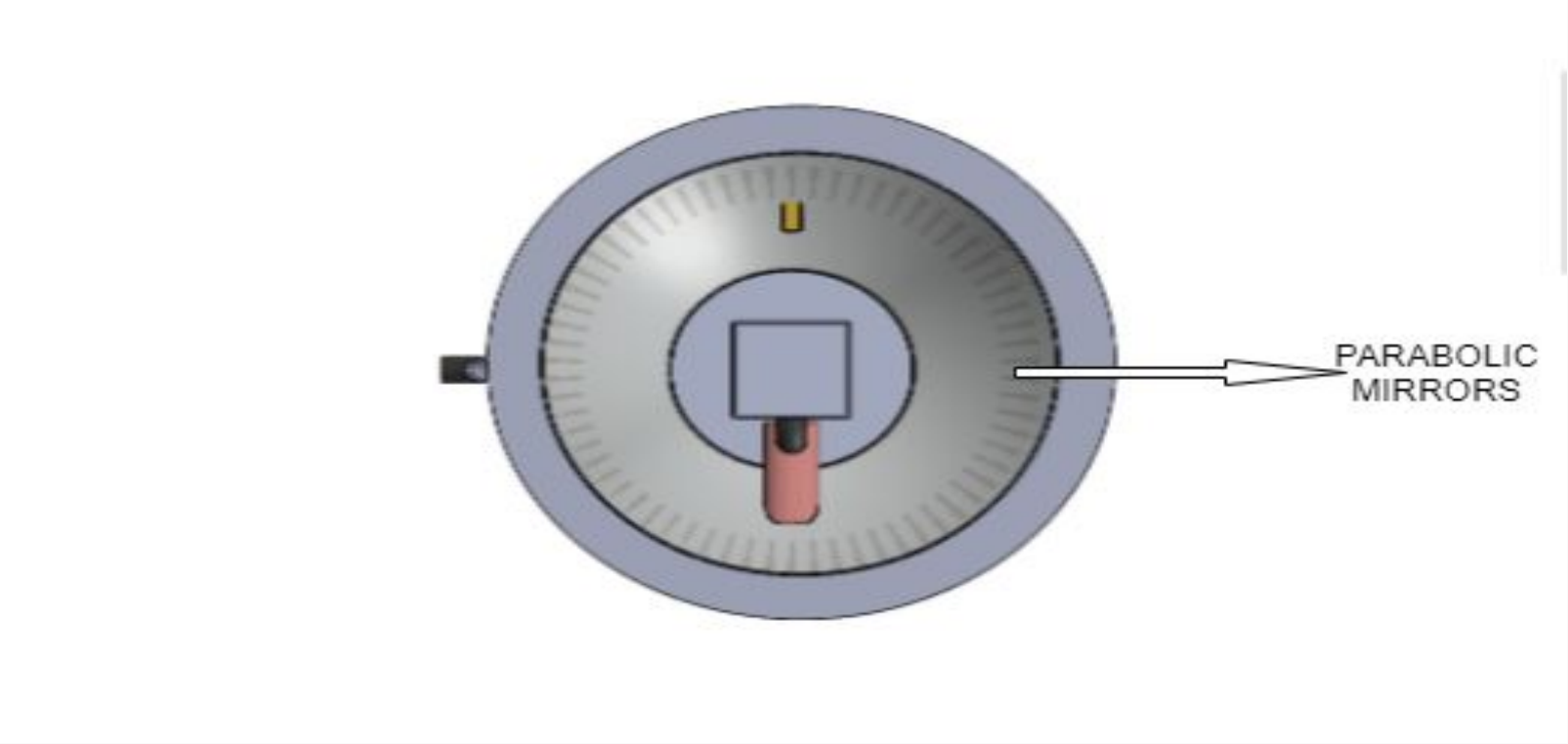
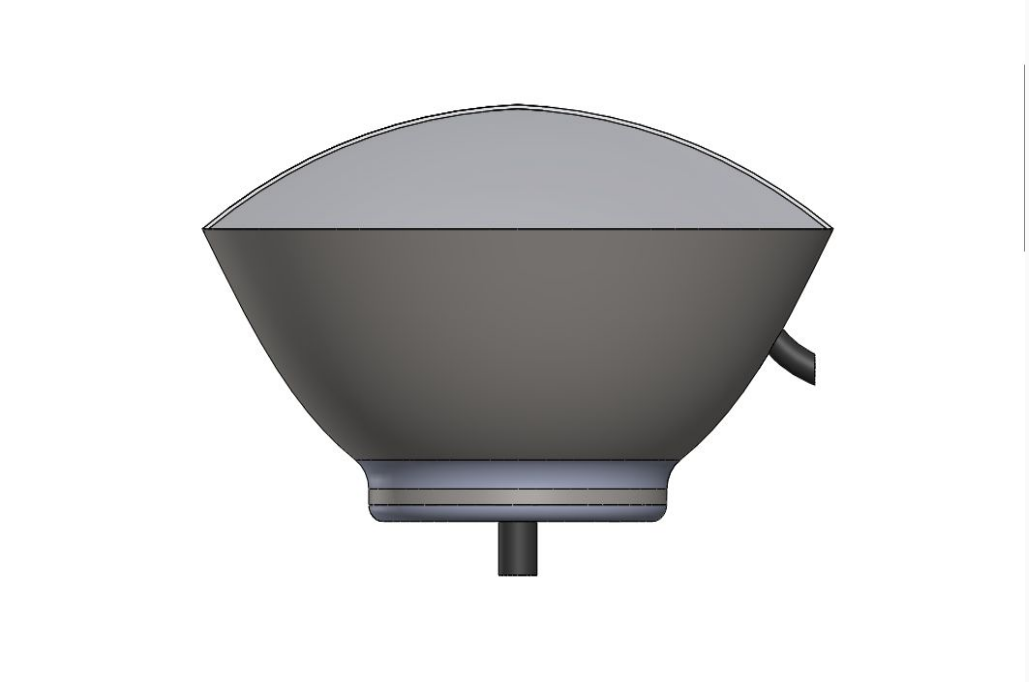


FIG : Snapshot from the CAD model describing various parts



SIZE: (65 x 39)inches

FIG : A solar panel with the boat completes the set for producing water

Project/Idea

Parabolic boat(3/5) :

WORKING :

- Filling of water :
  - The pump starts to fill the container and stops when it fills upto the brim using electronic system.
  - The pump we are using in our prototype is of following specifics:
    - 18W
    - Max lifting (1.6m)
    - Flow of water (1100L/hr)

Calculations : Time required for filling

Time required to fill 1100 L = 60 min

As our capacity of container is 150 L„

Time required to fill 150 L = (60/1100)x150

≅8 min

Project/Idea

Parabolic boat(4/5) :

WORKING :

- Evaporating container water :
  - After filling the water , the solar rays are concentrated towards the bottom of container to evaporate the salt water.This would leave the salt and some heavy metals back in the container while pure water is evaporated towards the plastic sheet.
  - The calculations for the quantity of water produced is based on the Australia’s government data for annual solar exposure.

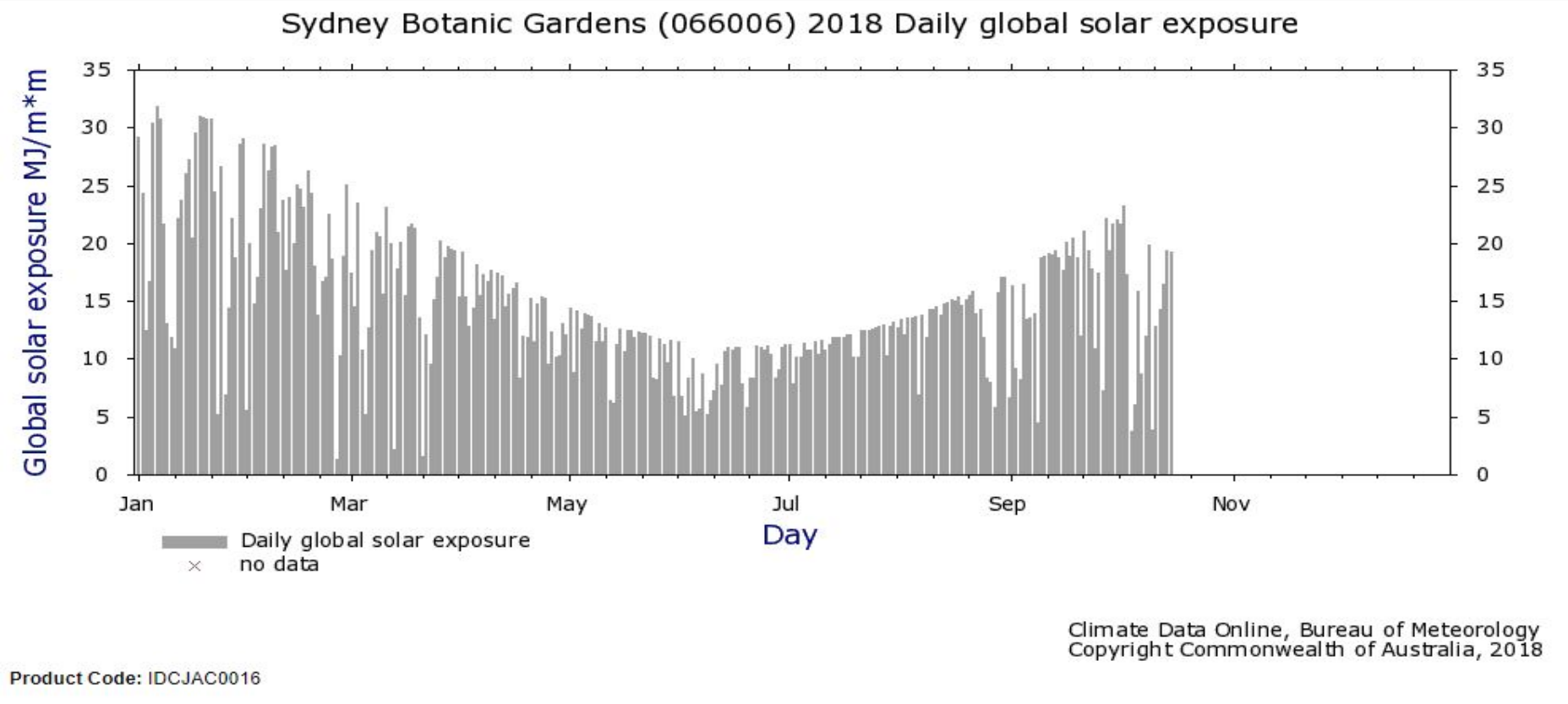
Summary statistics for all years

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	6.4	5.6	4.7	3.8	2.9	2.4	2.7	3.6	4.7	5.5	6.0	6.4	4.6
Lowest	5.4	4.8	3.5	2.8	2.3	1.9	2.1	2.9	4.1	3.9	5.0	5.3	4.1
Highest	7.6	6.7	5.9	4.5	3.2	2.8	3.2	4.2	5.3	6.7	7.7	7.6	4.9

Gaps occur in the table where there are missing valid daily observations within the month. This may have been caused by a problem with the satellite or processing of the images used to estimate the solar exposure. In some instances the missing data will become available at a later date. Small changes may occasionally occur in the values following improvements to the data processing system.

Product Code: IDCJAC0003 reference: 41782990

Source : http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=203&p_display_type=dataFile&p_stn_num=066006



Source :
http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_display_type=dataDGraph&p_stn_num=066006&p_nccObsCode=193&p_month=13&p_startYear=2018

Calculations : Time required to evaporate water per one filling

Container(Receiver) parameters :

Parameter	Dimension
Height	0.6 m
Width	0.5 m
Length	0.5 m

Volume of container = 0.5 x 0.5 x .6 = 150 liters

Bottom Area of container = 0.5 x0.5 = 0.25 m^2

Calculations : Time required to evaporate water per one filling

Parabolic Boat parameters :

Parameter	Dimension
Height(h)	1.34 m
Aperture Diameter(a)	3.97 m
Focus Depth	1.04 m

Surface area of paraboloid boat= 29.19 m^2

Source for area calculation : https://www.vcalc.com/wiki/vCalc/Paraboloid+-+Surface+Area

Calculations : Time required to evaporate water per one filling

$$\text{Concentration Ratio} = \frac{\text{Area of paraboloid}}{\text{Area of receiver(container)}} = \frac{29.19}{0.25}$$

$$= 116.76$$

The amount of energy needed to heat 1 kg of water by 1°C is given by the specific heat of water. This changes slightly with temperature, but it's around 4.2 kJ/kg/K.

So suppose we have a mass m kg of water and we are heating it by ΔT degrees (e.g. from 22°C to boiling would be ΔT = 78°C). The amount of energy needed is:

$$E=4.2m\Delta T \text{ kJ}$$

Calculations : Time required to evaporate water per one filling

If the power of the container is W kW, i.e. W kJ/s, and we assume no heat is lost then the time taken to heat the water is:

$$t = 4.2m\Delta T / W \text{ secs}$$

For 1L of water, energy required is :
Specific heat = 4.2 x 78 = 327.6 kJ
Latent heat = 2256 kJ
Total heat required = 2583.6 kJ
Initial Sea Temperature = 22°C
ΔT = 78°C
Sunshine hours = 12 hrs(6 am to 6 pm)
From the graph of Australia's meteorological department
Annual mean of solar exposure =4.6 kWh/m^2

Continued ...

Calculations : Time required to evaporate water per one filling

$$t_{water} = \frac{2583.6 \times 12 \times 78}{4.6 \times 116.76 \times 29.19}$$

$$= 154.24 \text{ sec/L}$$

$$= 2.57 \text{ min/L}$$

For 150 L ,time required is ,2.57 x 150= 385.6 min =6.4 hrs

Calculations : Quantity of water produced per boat

Total sunshine hours = 12 hrs

Time for 150 L of water formation = $t_{\text{water evaporation}} + t_{\text{filling}}$

= 6.4 + 0.13
= 6.53 hrs

Water produced by per boat in sunshine hrs = 275.65 L/boat

Project/Idea

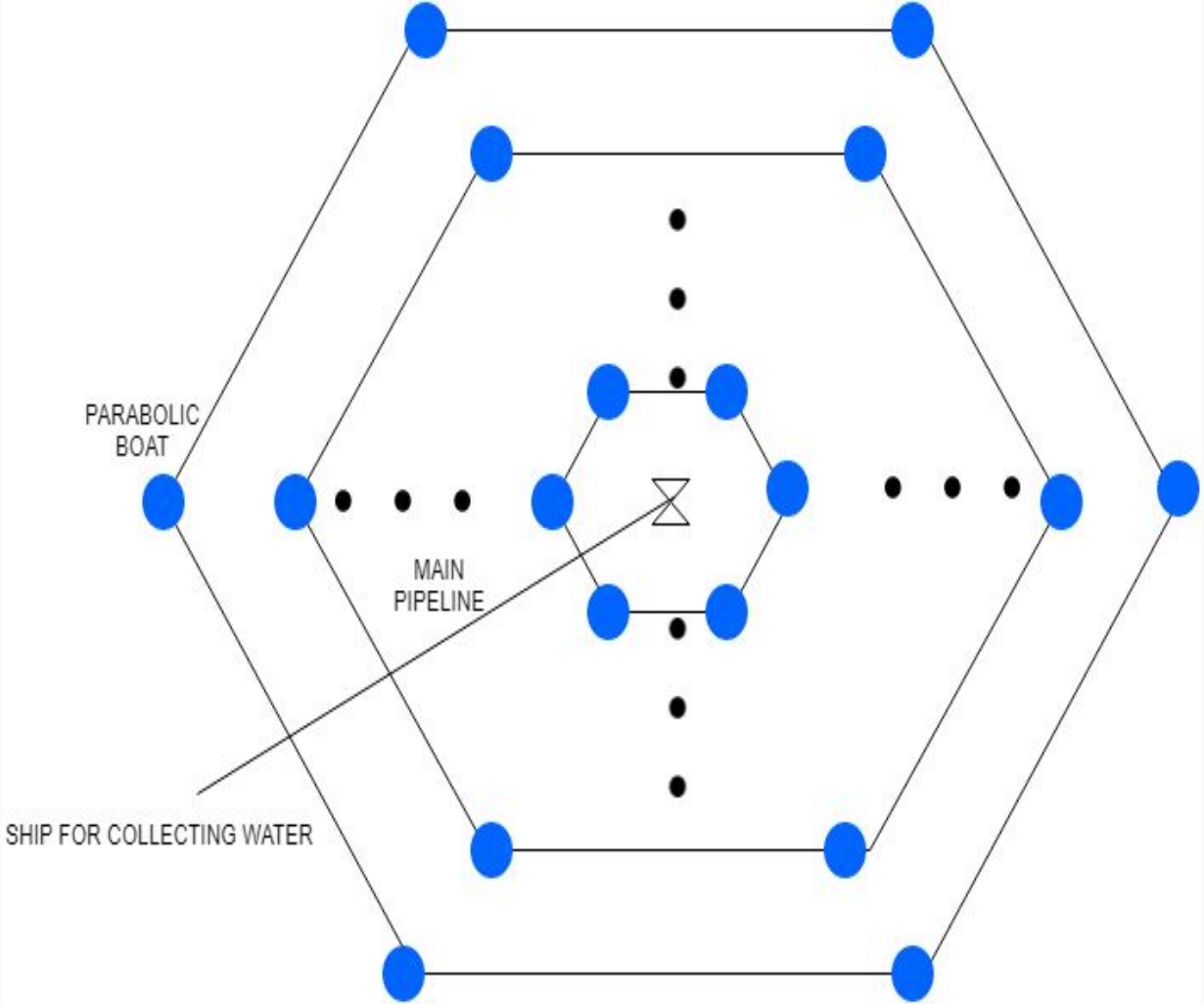
Parabolic boat(5/5) :

WORKING :

- Integrated plant :
  - The integrated plant would contain 60 boats distributed at the positions defined by a hexagon(as it the closest structure) on the sea. Each boat will be connected to other boats using a pipeline system. These pipelines collect the water generated by each boat over every cycle and deliver to the ship or a collector; which then process the water for further purification using nano or ultra membranes. The final processed water is then sent on to the packaging unit for distribution.

Integrated Plant

- The side diagram shows the arrangement of boats on the seawater.
- Blue dots represent the location of each parabolic boat.
- A total of 60 boats are used(6 in each hexagons) connected through main pipeline.



Calculations : Quantity of water produced per integrated plant

Water produced by per boat in sunshine hrs = 275.65 L/boat

Water produced by one integrated plant = 275.65 x 60

=16539 L/day

Population to be fed on ,assuming it requires 2 L per day per person
= 9k (approx)

Project/Idea

Risk Associated(1/1) :

Corrosion:

- The hurdles involved with these boats seamless working are corrosion and jamming of water in pipes.

Rectification :

- The corrosion rate can brought down by using mostly plastics.
- The jamming problem can be solved using pumps which can create high pressure.

Project/Idea Stakeholders(1/2) :

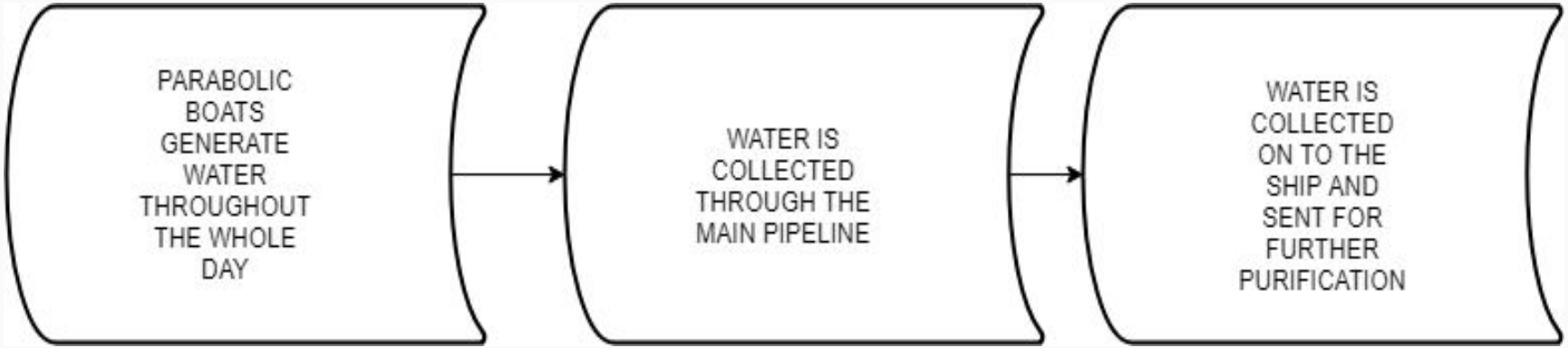
- The deployment of this product may require permissions from State government ,Central Government and some of the manufacturers who are crucial for building this plant.
- Manufactures involved :
  - Plastic manufacturer (For boat and plastic sheet)
  - Glass manufacturer(For parabolic mirror)
  - Pump manufacturer
  - Solar panel distributor (For running pumps and electronic system)

Project/Idea Stakeholders(2/2) :

- Miscellaneous :
  - Assembling unit (After collecting all the parts)
  - Deployment unit (To make it to the seawater)
  - Processing unit (For further purification)
  - Electronic unit

Project/Idea

Plant in a nutshell :



Intellectual Property Assessment

Patent(1/3):

- The idea is patentable as it has not been implemented anywhere, and only members of Team_Rabbit has the rights for it.

- Yes, the idea is built upon existing work as it has been stated in the Uniqueness section(History).

Intellectual Property Assessment

Patent(2/3):

How it’s different ?

- The earlier model use to produce 1L in 5 hrs and did not have any automatic functionality to fill the container again and again.

- This made them limited to use for a single individual everyday.

Intellectual Property Assessment

Patent(3/3):

How it’s different ?

- The new model put forward by us, uses parabolic mirrors to increase the concentration of sun rays and help in evaporating water in less than 3 min /L .
- Also the automatic filling pump makes this system reusable without requiring human intervention.
- This would serve a population of 9k(approx),as stated in calculation section.

Prototype/Proof of Concept:

- As the real prototype was difficult to produce , we went for the CAD modelling
- CAD model and flow sheet for the boat has been uploaded as a zip file in source code.
- CAD model was implemented in the SOLIDWORKS software.

Supporting Details:

Business Plan :

- After installation of the plant , we could sell the water to the consumers.
- As the purified water produced is through sustainable model ,it would be much cost effective and accessible.
- As this model does not require fossil fuels for desalination, plant may sustain long enough.
- The plant would not require much maintenance as it is completely solar and automatic dependent.
- This would not require the constant presence of human force ,thereby reducing the cost.

Supporting Details:

Rough Estimate for Plant Setup :

- The plant would only require the initial cost for setup and a minor afterwards as it totally run by solar power.

Continued ...

Estimated cost of Plant

ITEM	ESTIMATED COST
BOAT PLASTIC AND MANUFACTURING	$1361.05
PARABOLIC MIRRORS	$1300
SOLAR PANEL,CONTAINER,PIPES, AND PUMPS	$1200
TOTAL COST/BOAT	$3861.05

Total cost for plant(approx) = $3,861.05 x 60 = $231,663

Supporting Details:

Amount of Revenue/Volume(Water) Generated in the first Year :

- The amount of water generated per year is 603 kL.
- This water would satisfy a population of 9k /dayand selling each liter for $0.08 would bring in $262,800 each year from one integrated plant.
- The company is at break even in its first year itself and would only bring profits from the following years.

Water bottle price of different companies(selling in India):

COMPANY	ESTIMATED COST /LITER*
KINLEY(COCA-COLA)	$0.20
AQUAFINA	$0.27
BISLERI	$0.20
TEAM_RABBIT	$0.08

*The prices are converted to dollars from Indian Rupees

This plant/idea will not only provide solution to long quest for the search of fresh water but will also help in saving previous fossil fuels which were earlier used for water desalination

“Let’s join hands in hands to make the world a better place to live in”

- Team_Rabbit

This may not be the best solution but may pave path for better and efficient processes.

Thanks!

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