WEEK 1 REVIEW

WHAT HAPPENED LAST WEEK?

WHAT IS IMPACTLABS?

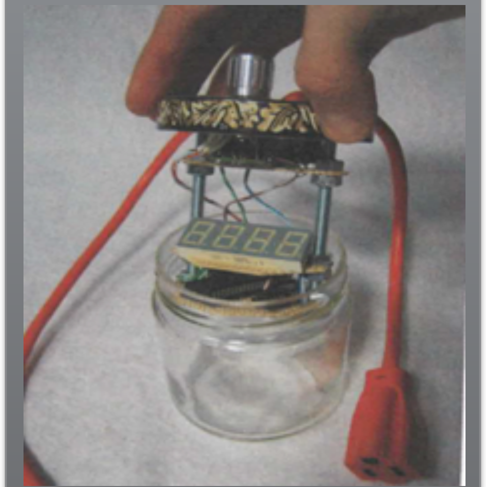
ImpactLabs brings **hands-on education** to passionate young people who want to learn the usage of engineering to make their communities better places to live.

This year's session has three goals:

1. Students will learn concepts from our team of Nigerian engineering students
2. Students will build their own projects and document the process for future students
3. Students will present and implement their projects within their home communities

WHAT DID WE LEARN ABOUT LAST WEEK?

ENERGY



WATER

BIOMASS

WHAT DID WE BUILD LAST WEEK?

CORN SHELLER

SOLAR WATER HEATING UNIT

BAG BIOGAS DIGESTER

CHARCOAL BRIQUETTING

WHOM DID WE MEET LAST WEEK?

BOLA AKEJU

wecyclers

OMOWUNMI AFOLABI

NPHCDA
National Primary Healthcare Development Agency
...Making Nigerians Healthy

WEEK 2 OVERVIEW

- Background concept (green)
- Lesson/ demo (purple)
- Guest speaker (red)
- Discussion (blue)

	Activities	Major milestones
Monday	Desalination unit (purple) Gbenga Ige- MIT (red) Team working session	Begin building
Tuesday	Elevator pitches/ networking (blue) Team working session Ifedapo Omiwole- Rancard Mobility Nigeria (red) Team presentation prep	Building check-in with facilitators
Wednesday	Team working session Olajide Oshinkanlu- Independent innovator (red) Team presentation prep	-
Thursday	Team working session Mock final presentations/feedback	Building complete
Friday	Presentation prep Final showcase and awards Networking/social session	

Week 2 goal: Teams take ownership of projects and are ready to present a full concept and prototype to industry professionals and academic faculty

OUR STORIES - NWIKE

UNN ‘05
MIT SM ’11
MIT PhD ‘15

Massachusetts Institute of Technology

NWIKE'S STORY

- Born and grew up @ University of Nigeria, Nsukka Campus
- Spent childhood climbing trees
- After several falls, switched to climbing hills

NWIKE'S STORY

- Fell in love with flight – aeronautics engineer
- Started building planes with a friend
- Then came soccer, and all was lost

- Studied MechE at UNN
- Picked up web-design during NYSC
- Got interested in power generation
  - Then the Glory days- worked for NEPA/PHCN

- MSc MIT 2011
- 2 years of Power Projects
- Currently @ MIT for PhD
- Besides studying at MIT
  - Executives at MIT energy club
  - Brazil project (Design Lab)
  - Design internship at EDF, France

DESALINATION UNIT

BACKGROUND

OUTLINE

- Intro – my bio
- Get to know the class
- Team exercise
- Summary and presentation of case for device
- Solar desalination techs (pics)
- Fundamental concepts (humidity, saturation, etc)
- Design process for desalination
- Back of envelop estimate of performance
- Condenser design challenge?
- How-to steps
- Building starts

OBJECTIVE

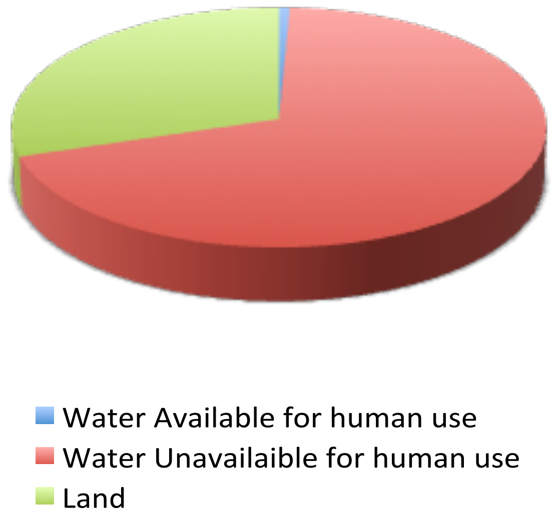
Build a simple system that can extract fresh water from a salt water storage

-using materials you can easily find around you

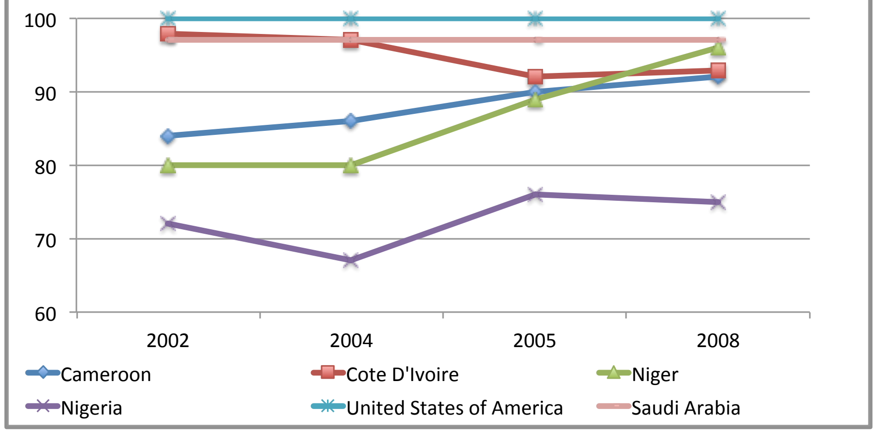
-applying your understanding of some basic physical laws

USEFUL STATISTICS

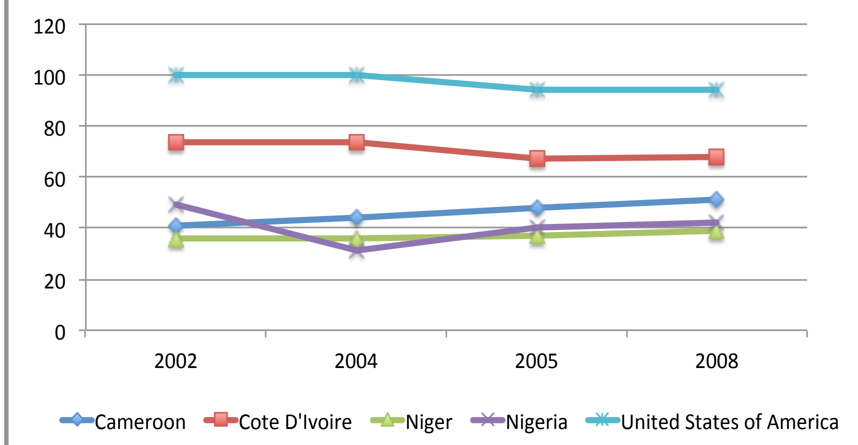
Global water resource stats (% of earth's surface)



Fraction of People with Access to Improved Drinking Water (urban)



Fraction of People with Access to Improved Drinking Water (rural)



USEFUL STATISTICS

- 85% of the world population lives in the driest half of the planet
- 783 million people do not have access to clean water
- Almost 2.5 billion do not have access to adequate sanitation

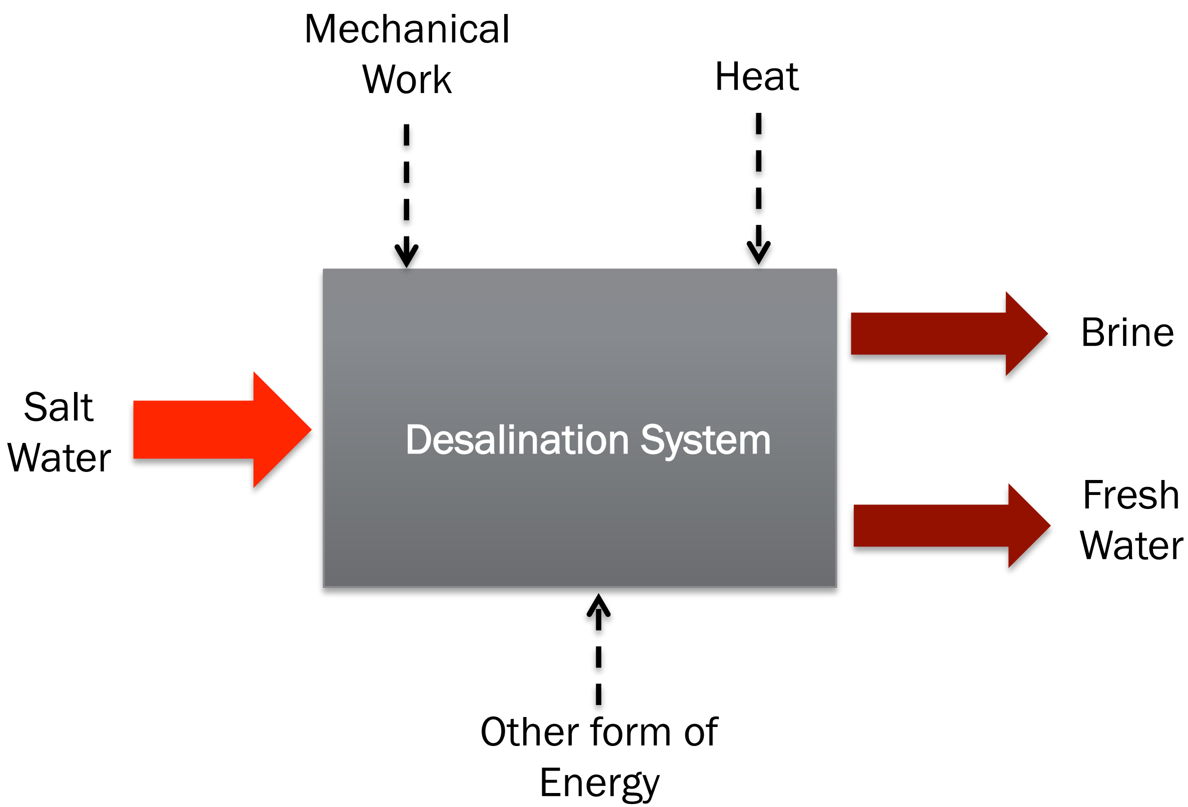
How many people here have access to running water

- All Day?
- Part of the day?

How many have to buy water at least

- Once a week?
- Once a month?

DESALINATION: SYSTEM CONCEPT

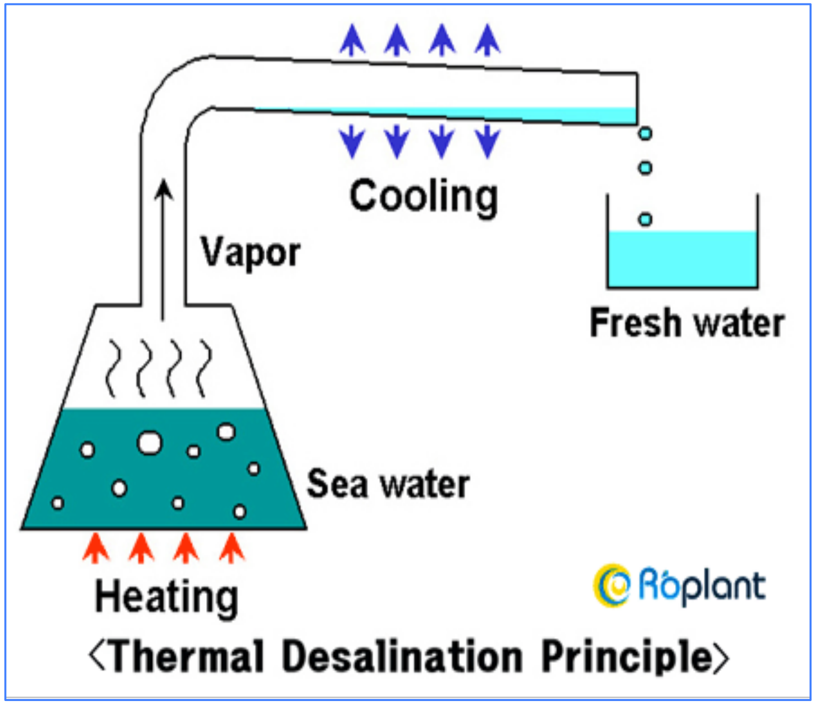


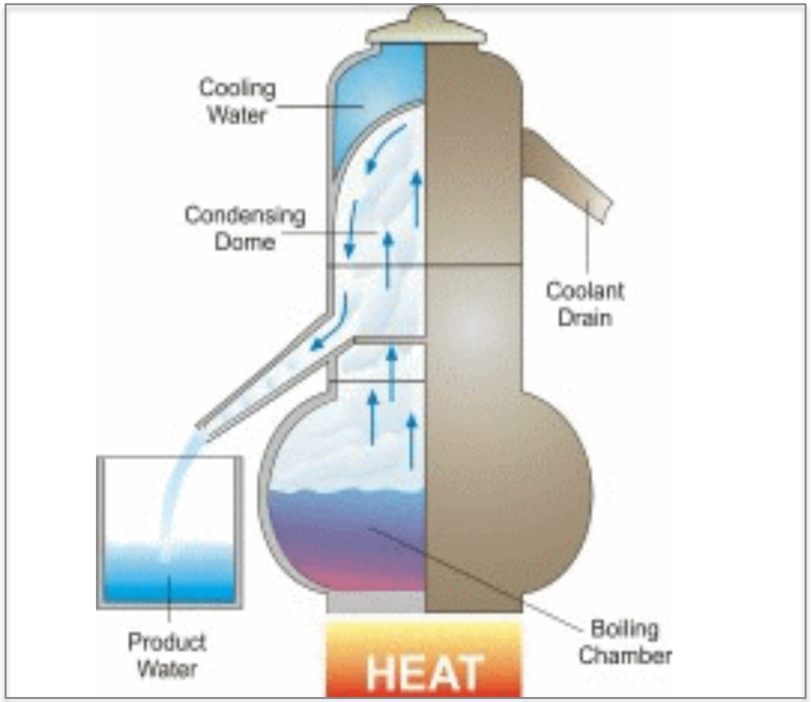
Types of Desalination Technologies

- **Thermal Systems**
  - Direct Evaporation
  - Air Saturation Systems
- **Membrane Based Systems**
  - Selective Membranes
  - Reverse Osmosis

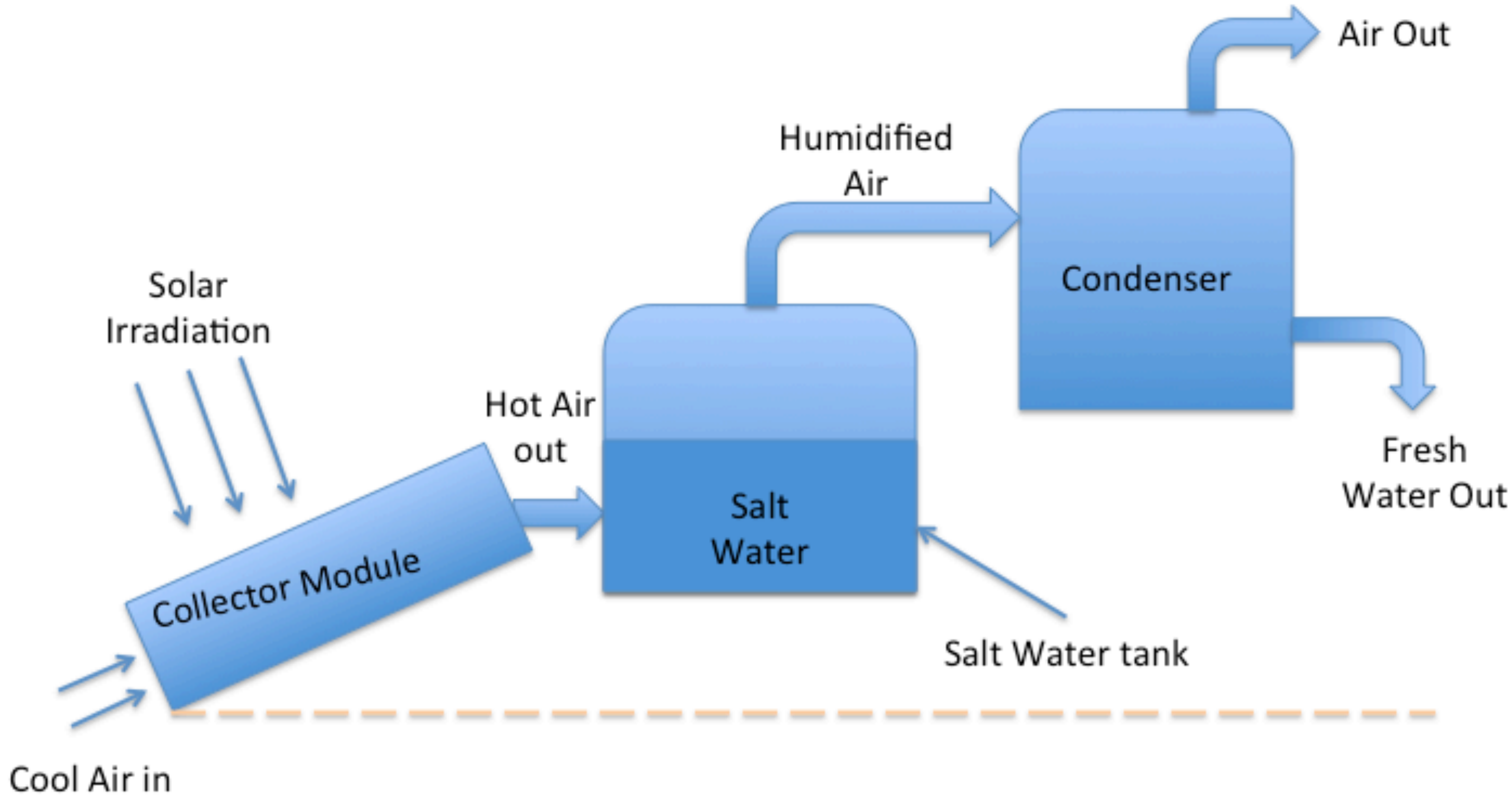
THERMAL (DIRECT) DESALINATION

Directly Evaporate water from the salt solution and condense



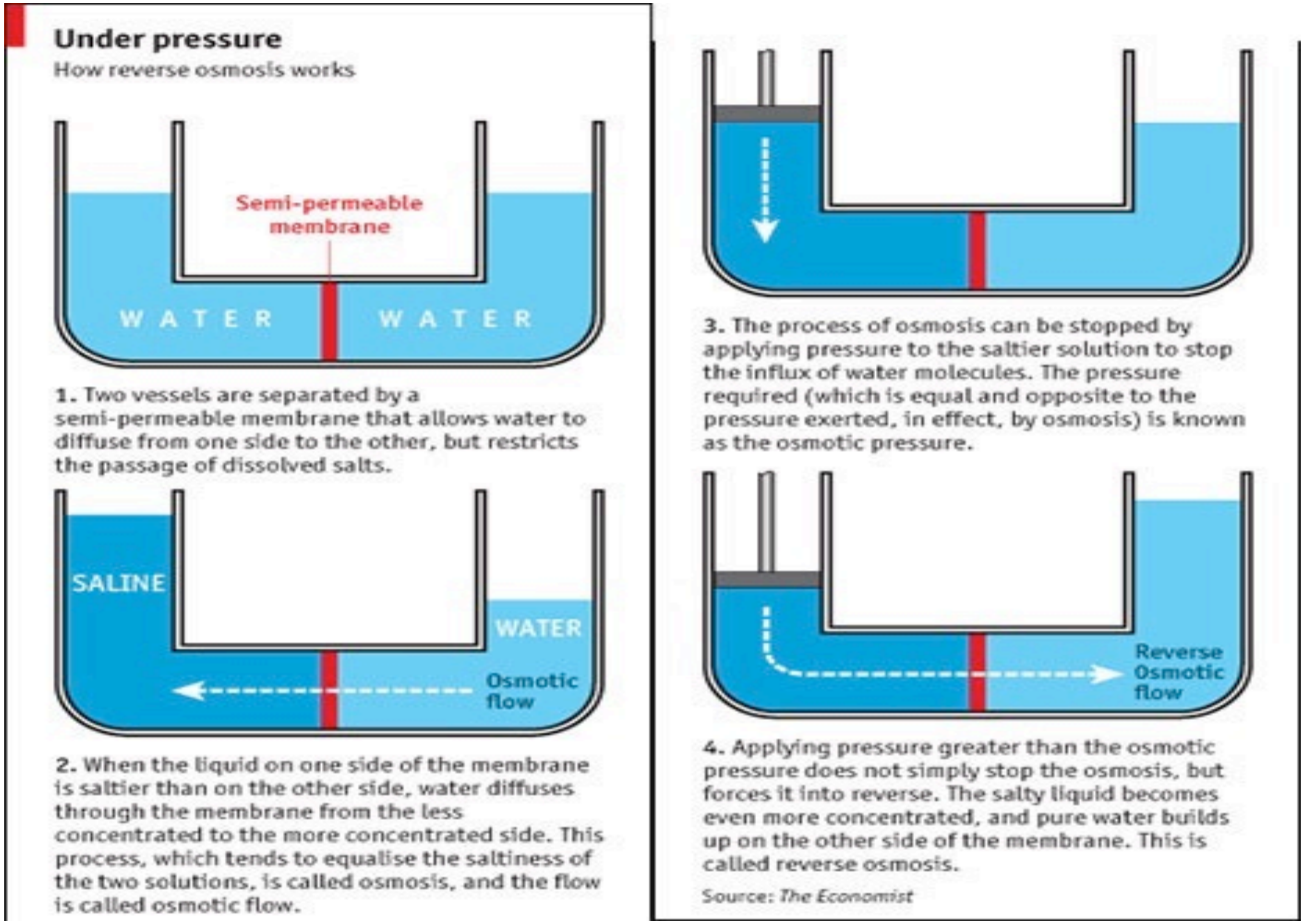


THERMAL (AIR SATURATION) DESALINATION



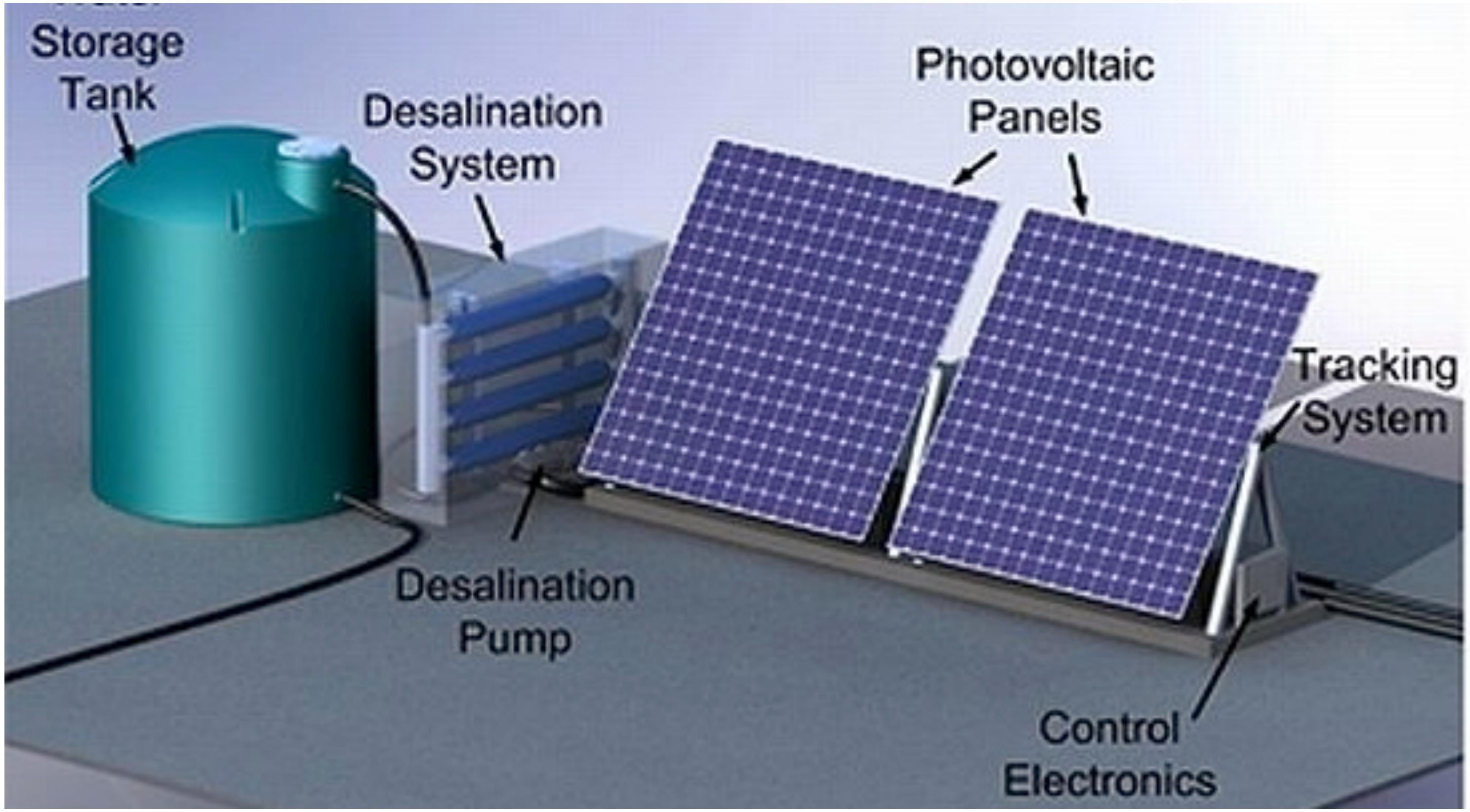
Concept of Saturation & relationship with temperature: the water carrying capacity of air increases with temperature

MEMBRANE SYSTEMS: REVERSE OSMOSIS



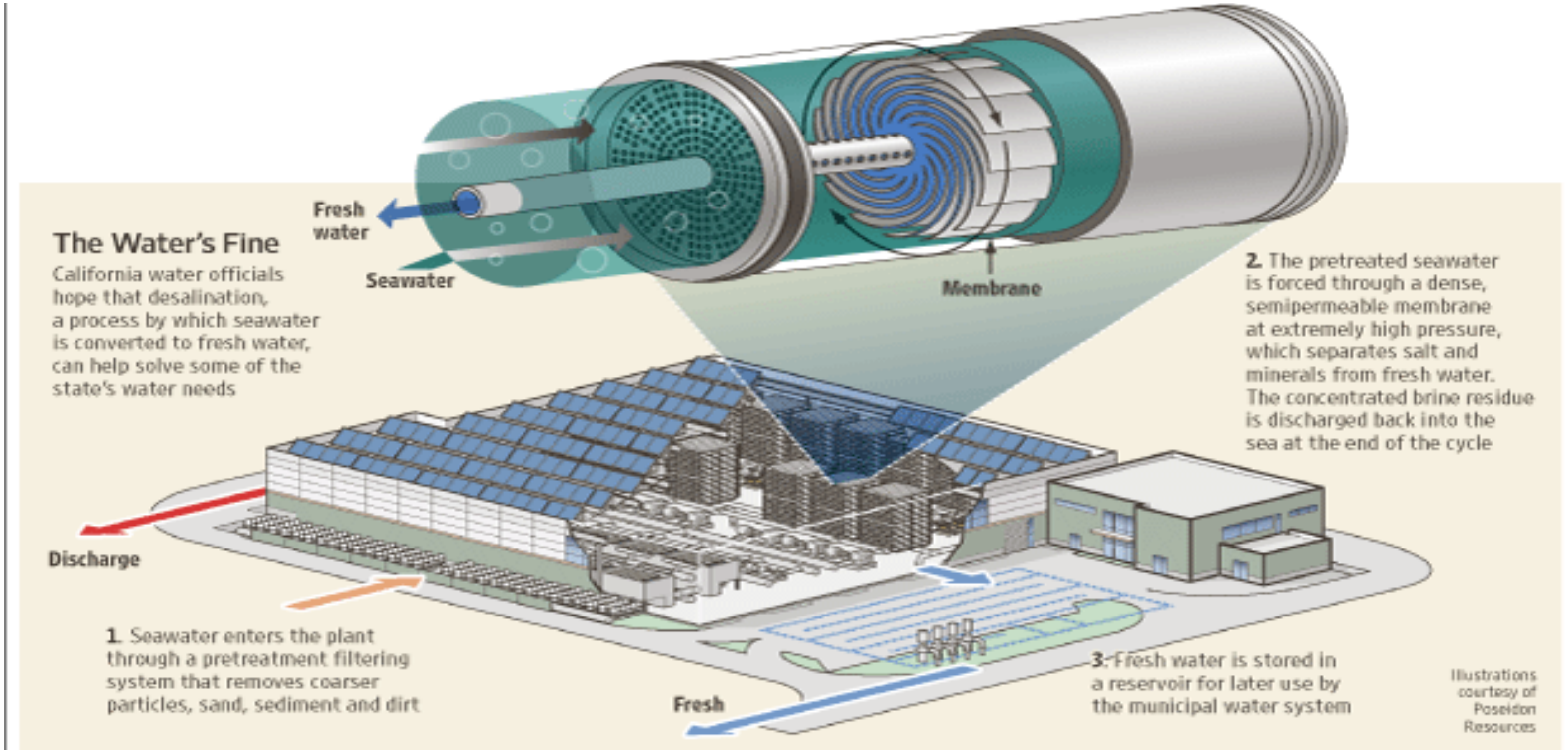
OTHER CONFIGURATIONS

PHOTOVOLTAIC-POWERED MEMBRANE SYSTEM



MIT Prototype:
Size: 80 gallons per day Cost:
Size: 1000 gallons per day cost: $8,000

INDUSTRIAL SCALE SELECTIVE PERMEABLE MEMBRANE SYSTEM



SIMPLE SOLAR THERMAL SYSTEMS

Simple stills - up to 1m^3 per day production

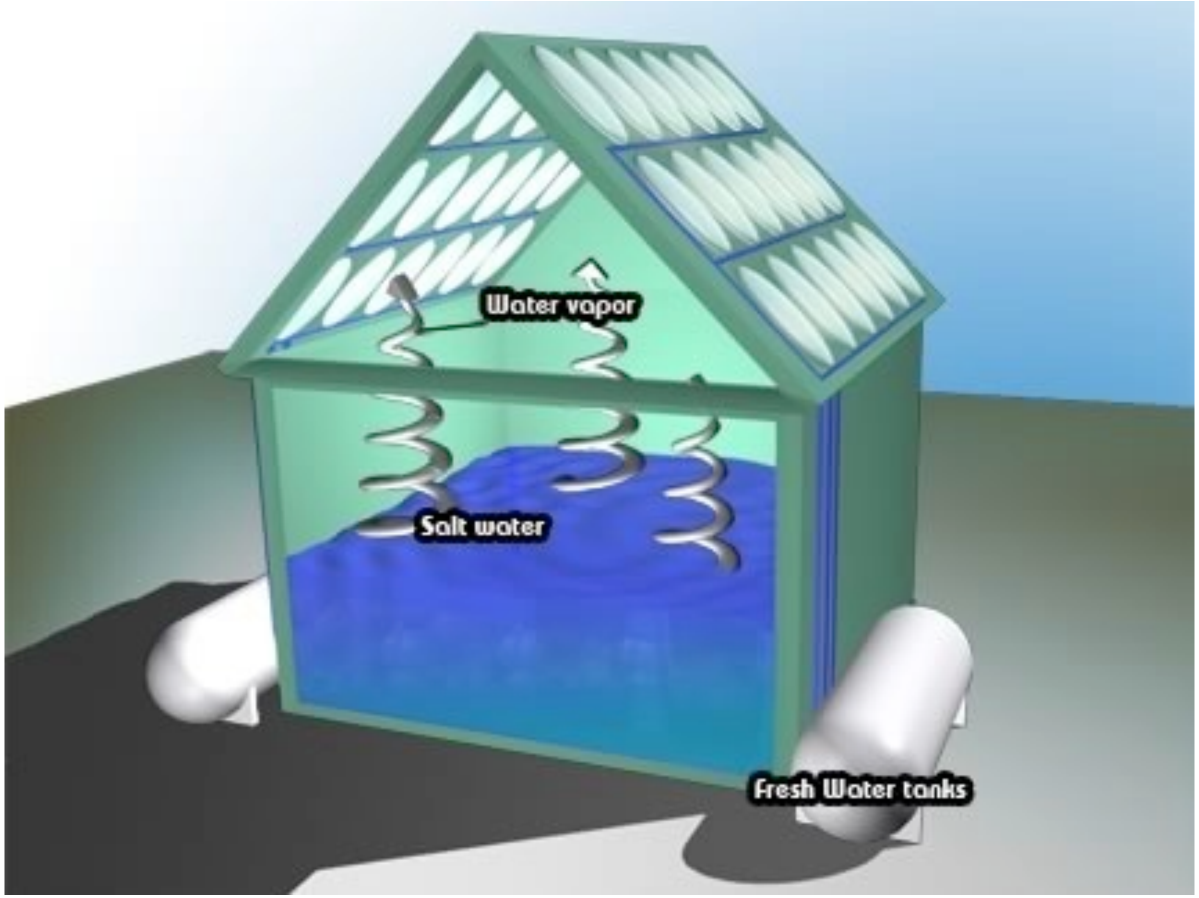
Not just good for desalination, but for water purification

Credit: Landfall Navigation

Why not go all the way out to sea?

- ❑ Inflatable stills system
- ❑ Portable
- ❑ Large yield from larger collector area

GREEN HOUSE WATER DESALINATOR/PURIFIER

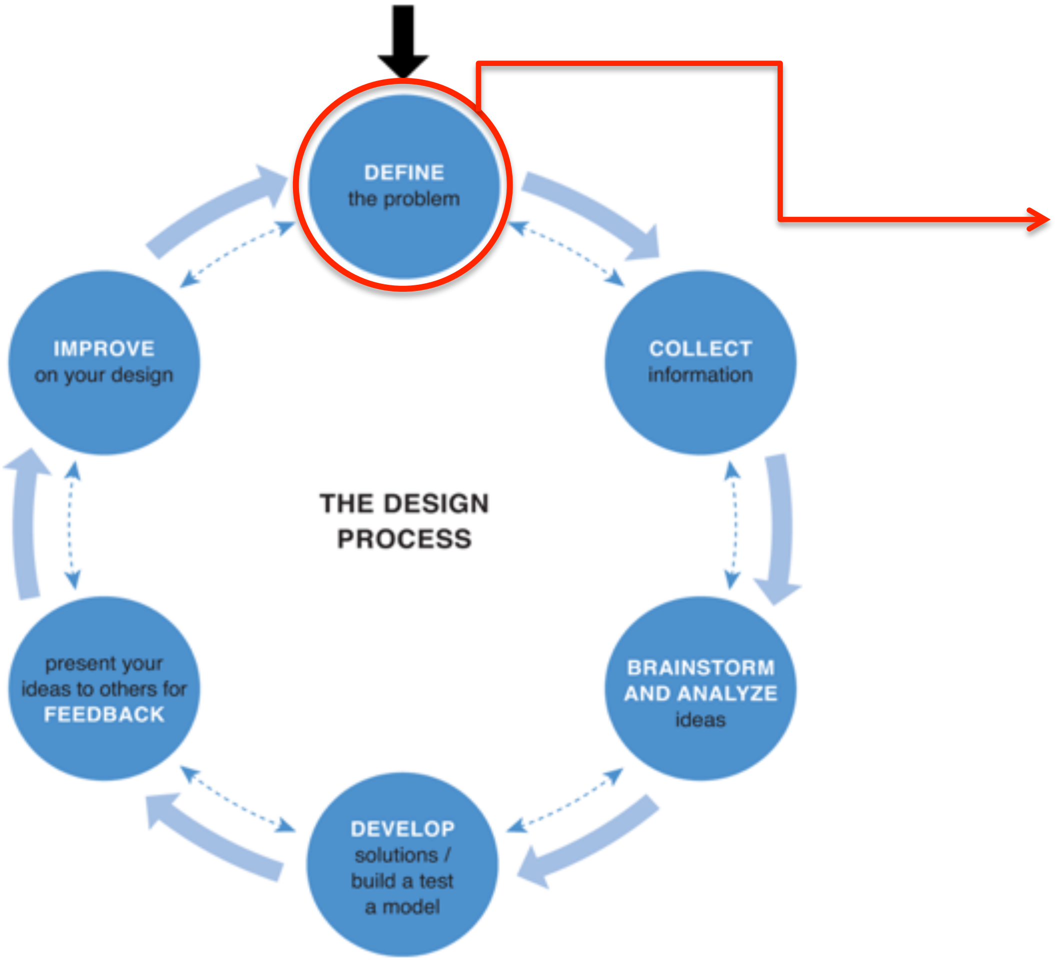


Why Transparent walls and roof?

DESALINATION SYSTEM

DESIGN

ESTIMATION: YOU CAN'T MAKE THINGS UP!



- One of the first Steps in defining the problem is estimating the 'Size' of the system.
- By size we mean both geometrical dimensions and performance

EFFECTIVE ESTIMATION STRATEGY

- Identify a problem system
- Identify a quantity with a system
- Provide a value for a quantity
- Count a set of things
- Compare two systems for a quantity
- Identify a relationship between quantities
- Change a system scope
- Identify a similar system

BACK OF ENVELOPE ESTIMATION EXERCISE

Are you Familiar with the difference between Energy & Power, Joules & Watts?

How much energy do you need to heat water to boiling point (100C)?

- How much energy do you need to evaporate it?

How much energy in a square meter surface?

- How much power in square meter

Given a mass flow rate (0.00001 kg/sec), how much power is needed to heat up air by 10 degrees?

How much water do you need to satisfy the drinking needs in Lagos?

IMPROVEMENT

Ideas for condenser

- Aluminum foil in condenser tank
- Pebbles/packed bed

What if you want the desalinator to work at night? (sand, pcm)

How can you improve performance? (concentration, longer heating channel, etc)

Big can vs smaller can

DESALINATION UNIT

BUILDING INSTRUCTIONS

WATER DESALINATION– HOW TO

Materials:

- Pepsi/Coke/beer cans: 12
- Wood boards (for the base, long sides and short side)
- Wood glue (or nails)
- (Enamel) black paint
- Transparent plastic sheet (glazing material)
- Salt water tank (e.g., plastic bucket)
- Fresh water Condenser tank (e.g., plastic bucket)
- PVC pipe: ~ 1-2 meters
- PVC L- connectors (elbow)
- PVC straight connectors
- PVC valve
- PVC glue
- Rubber sheet (for sealing)

Tools:

- Metal Cutter / blade
- Hole puncher
- Hand drill (useful but not essential)
- Hammer
- PVC cutter
- Steel rules
- Table Clamps
- Wood saw

STEP 1: DEFINE SYSTEM SIZE

- The larger the collector assembly, the hotter the air gets, and the higher the freshwater yield.
- The size will also be limited by the number of coke cans you have at your disposal and the amount of space you have.
- For now let us build a small assembly that is **5 pepsi cans long** and **4 pepsi cans wide!**
- Of course if you prefer coca cola, you could use coke cans . . . or beer cans . . . or several combinations

STEP 2: PREPARE THE CANS

1. Wash and dry the pepsi cans
2. Bore/cut holes at the top and bottom of the cans. One approach is to make two or three smaller staggered holes on each face. A single large hole could also work.
   - Q. Of a single large hole or multiple smaller holes, which would work better? Why?
   - Hint: how does the air heated?

STEP 3

1. Arrange the cans in 4 rows of five cans each
2. Glue the cans end to end using an aluminum glue to form pipes
   - An all-purpose glue can also be used
   - The cans could also be welded together
3. Allow some time to dry (you may want to apply some pressure, using clamps or weights, to ensure the glued parts are held firmly together)

STEP 4: COLLECTOR CASING

1. Prepare the casing for the collector assembly. In this case, we will build a three-chamber open-top wooden box
2. Measure and cut out wooden boards for the base, sides and partitions of the outer box.
3. Sketch out the partitions for the three chambers on the base board. The first partition marks out the inlet chamber, the middle chamber will contain the Pepsi can pipes and the last chamber is the exhaust chamber.
4. Measure and bore holes in the partition boards. These holes should be placed such that they will align with each row of the Pepsi cans.
5. Bore a (set of) hole(s) in the side board that will be form the rear end of the box for connecting a (set of) ½ inch PVC pipe(s).
6. Glue or nail the wooden boards together to create the outer box and the first inlet-side partition
7. Insert the Pepsi-can pipes and glue the the front ends to the inlet partition. Make show the holes in the partition are completely covered by the rims of the cans
   - Q: Why do you want the holes in the partition board to be completely covered?
8. Add the exhaust side partition and glue it to the bottom end of the Pepsi-can pipes. Make sure that the pipes align completely with the holes and that the Pepsi-can pipes cover the holes completely so that there is no leakage
9. You may use clamps to hold it together under pressure for firmer binding
10. Spray / paint the cans and the inner box surface black
    - Q: Why black? Why not white? Or blue? Or even maroon red?
11. Cover the entire box with a transparent plastic plate or sheet
    - Q: Why cover the plate with a transparent plastic plate or sheet?
      - Hint: What is a glazing sheet?
    - Q: Why a transparent plastic? Why not translucent? Or even opaque?

STEP 5: SALT WATER TANK

Remember that you want to bubble the air through the water, and that air rises through water

- Q: Why does air rise through water? Why does it not flow to the bottom?
  - Hint: What is density? What is buoyancy?

You will bore a (set of) holes in this tank for the hot air inlet on the side of the tank and the second on the top face/cover for the saturated air exit.

The water level should always be higher than the inlet hole

- Q: Why should the water level be higher than the inlet hole?

It is best if the outer surface of this tank is black in color

- Q: Why do you want a black salt water tank?

Note that the ‘tank’ could be any container that can hold water (a large BP tank, a bucket, bowl, basin, etc., as long as it has a water tight cover.

STEP 6: CONDENSER

The air coming from the salt water tank is warm and saturated with water. There are two key ideas to keep in mind

- The amount of water the air can carry is proportional to its temperature
- The larger the cool surface the air comes in contact with, the more condensation can take place

So you want a cool vessel, and you want lots of contact between the gas and the solid surfaces inside. How would you design it? I can give you a few suggestions:

- Prevent tank from heating up from solar radiation: use plastic material, paint white, wrap with a very reflective material
  - Q: Why paint white?
  - Q: Why wrap with reflective material?
    - Hint: what is reflectivity?
  - Q: What reflective materials can you find at home, your neighborhood, your school, at the market?
- Increase condensation surface area: Make a bed of pebbles and let the gas flow through it, what else?
- Natural refrigeration: Can you use a clay vessel, or at least a specially prepared clay vessel?
  - Have you heard of earthen ware pots, and how your great great grand parents managed to keep water cool in hot (but preferably dry) climate? Can you apply a similar concept here?

STEP 7: CONNECT

Connect up the three components of the desalination assembly

Note that the collector should be inclined at least at 15 degrees, and the salt water tank should be placed higher than the collector assembly, and the condenser level above that of the salt water tank

- Q: Do you know why?
  - Hint: what happens to air when you heat it up?

Take it outdoors and set it up. Make sure there are no leaks anywhere. Let it operate for a day and see how much fresh water you are able to collect.

THINK 2 IMPROVE

How can you make this device work better?

- Hints:
  - The hotter the air (or the salt water solution), the greater the amount of water the air can absorb
  - The faster the air flow, the greater the yield of the system
  - The cooler the condenser, the higher the fresh water recovery
  - The larger the collector assembly, the hotter the air gets

How can you make it cheaper?

- Hint:
  - Wood is expensive. Can you think of something you can replace the wooden box with, something you could find at home, in your neighborhood?

Other suggestions or ideas to improve it?