# Technical Seminar

# SOLAR ENERGY FOR WATER DESALINATION

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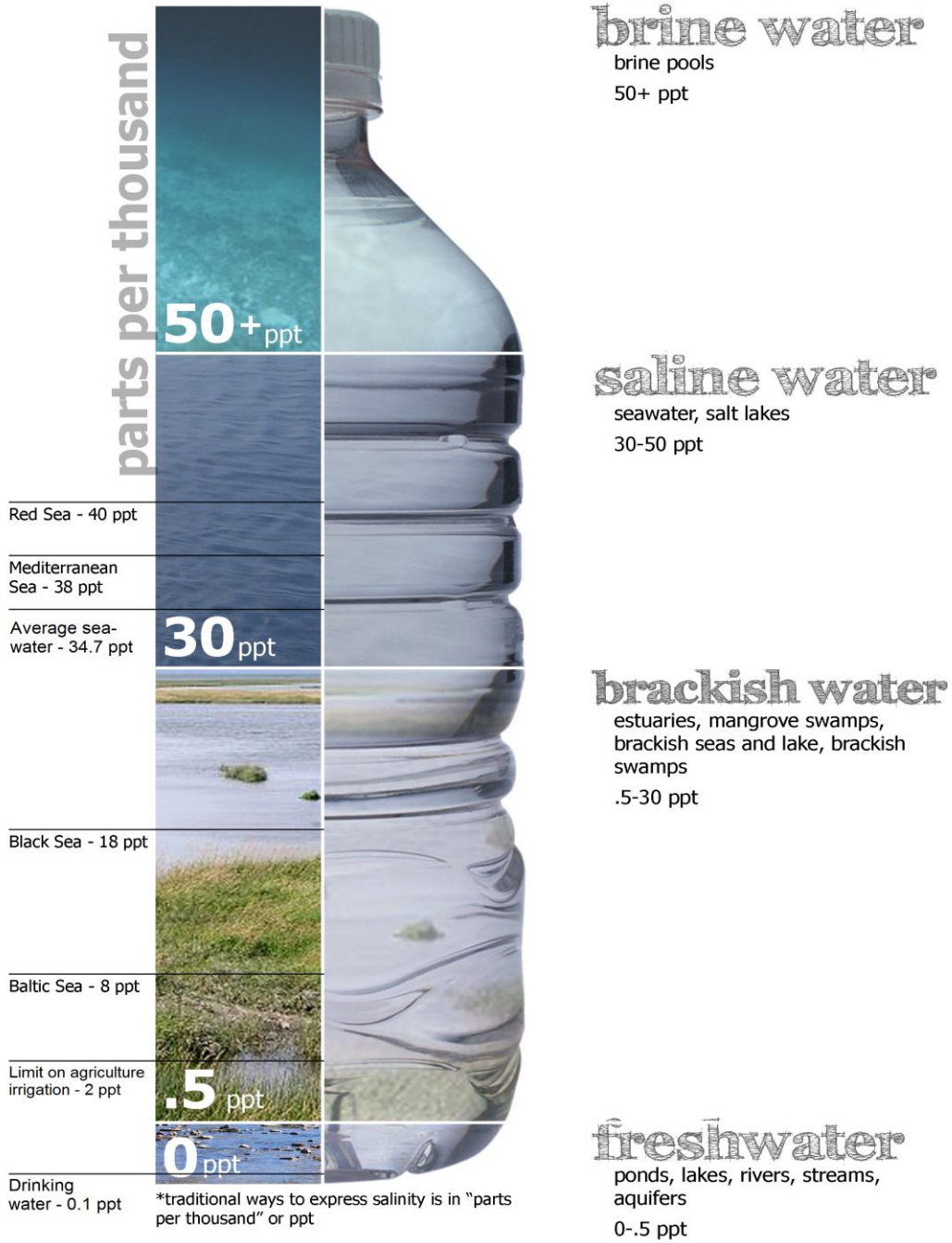
# Contents :

# Introduction

- **Desalination** or Desalinization is a process that removes minerals from saline water. More generally, desalination may also refer to the removal of salts and minerals.
- Salt water is desalinated to produce fresh water suitable for human consumption or irrigation.
- **Solar desalination** is a technique to desalinate water using **solar energy**. There are two basic methods of achieving **desalination** using this technique; direct and indirect.

- Desalination is one of the most traditional processes to generate potable water.
- Today, developments in desalination technologies are specifically aimed at reducing energy consumption and cost.



# Steps In Desalination Process

1. Pumping water (from sea, estuaries or saline aquifers)
2. Pre-treatment of pumped water (filtration, chemical addition)
3. Desalination Process
4. A post treatment if necessary (in some case, adding few minerals).

# Desalination Technologies

- There are different ways to produce freshwater with desalination technologies. More common technologies are:

1) Reverse Osmosis
2) Multi-stage Flash Process
3) Multi Effect distillation.

# 1) Reverse Osmosis

- The RO technology is based on the properties of semi-permeable membranes which can separate water from a saline solution, when excess of osmotic pressure is applied on the membrane systems

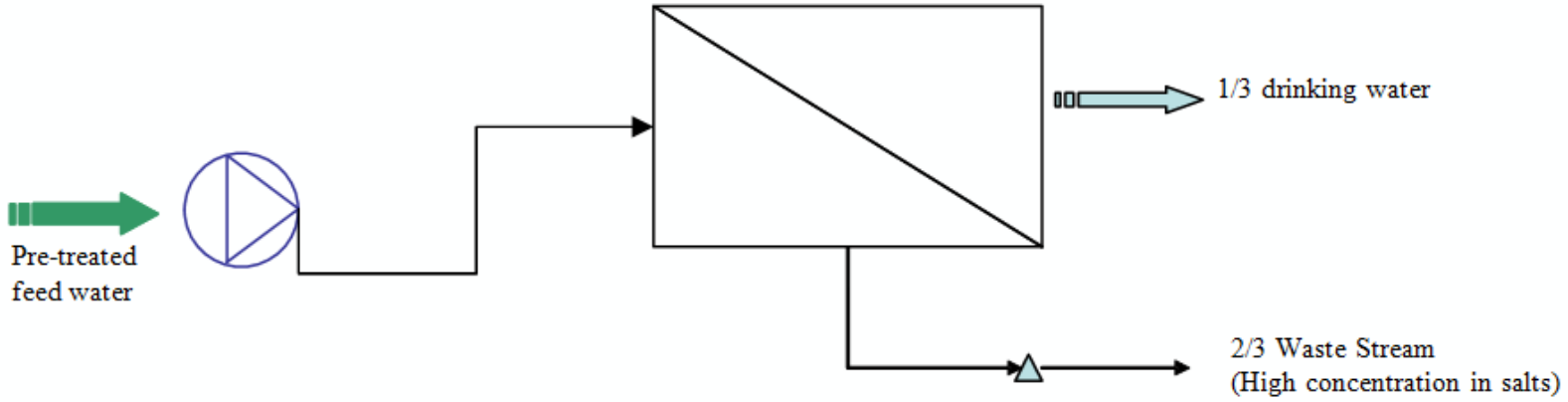
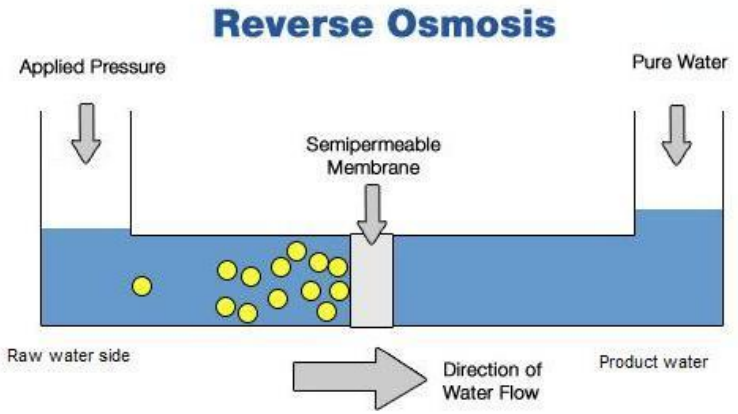



Fig. 1. Schematic of membrane RO systems



## Key features of the RO process are the following:

- Low energy consumption
- Easy and ready to use : immediate stop and start
- Needs important pre-treatment : pre-filtration and chemical (anti-scalant) to avoid fouling on the membrane.
- Outlet salt concentration around 500 ppm

# 2) Multi Stage flash

- In the MSF process, seawater is heated in a vessel called the brine heater, up to a temperature of 120°C, and then flows into another vessel, called a stage, where the ambient pressure is lower, causing water to boil.
- Steam is then condensed on a range of tubes passing through the vessel.
- Low pressure ensures seawater cooling down to 40°C.

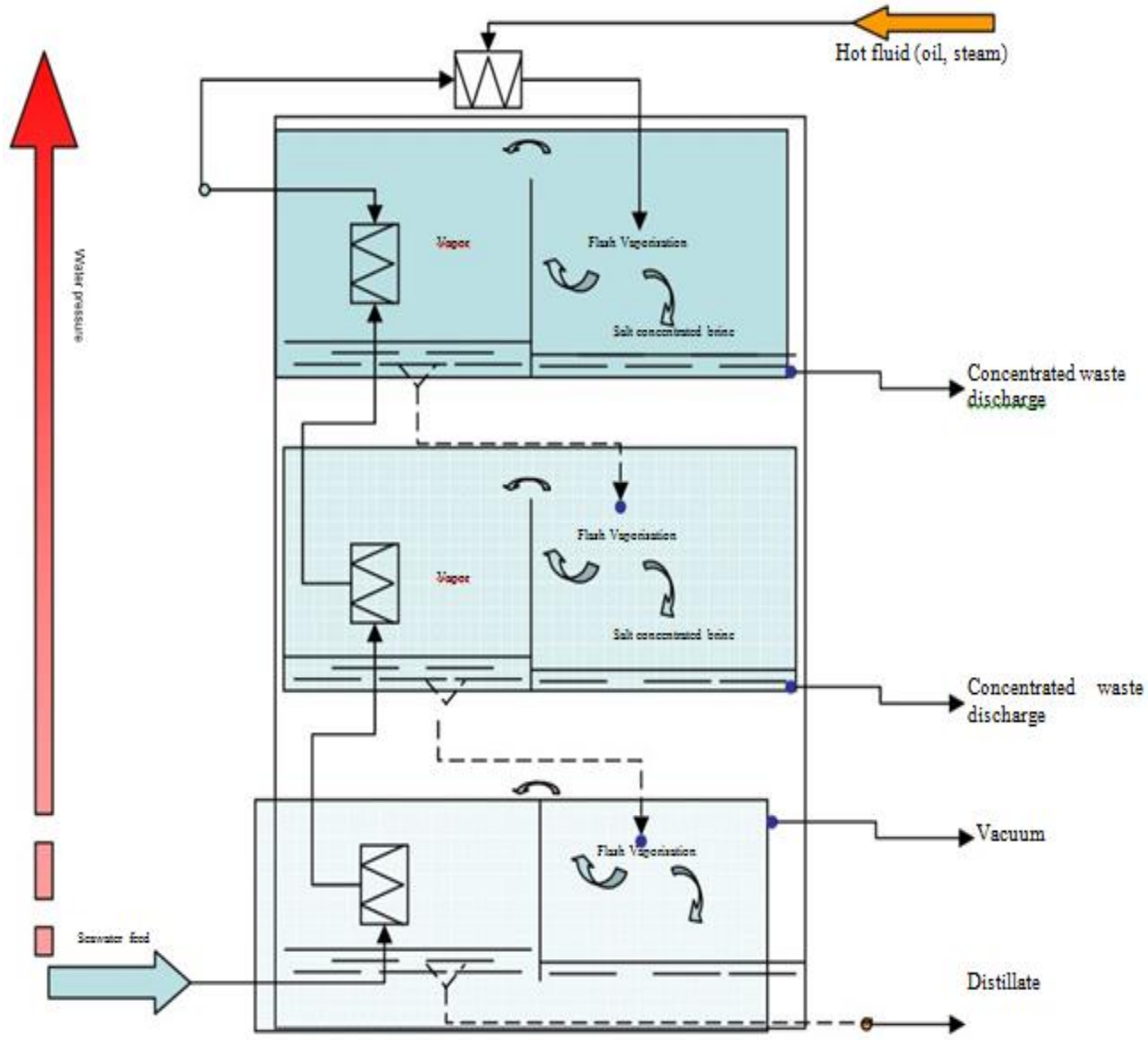



Fig. 2. Schematic drawing of MSF process

# Key features for MSF are the following:

- High reliability
- No need for complicated pre-treatment due to very limited scaling: simple filtration, and anti-scalant
- High investment cost
- High quality of produced freshwater (depending on the number of cells): salts concentration below 50 ppm
- Low running flexibility (low variation in flow rate)

# 3) Multi Effect Distillation :

- Multi Effect Distillation process is based on using latent heat of condensation of the vapour from the first cell to provide heat to a second cell.
- The evaporation takes place in cells where equilibrium temperature (Te) liquid / vapour is between 40°C and 68°C.
- In the first cell, the steam produced is injected into the second effect, in order to ensure the evaporation and condensation at a lower temperature.
- This is then repeated in all following cells

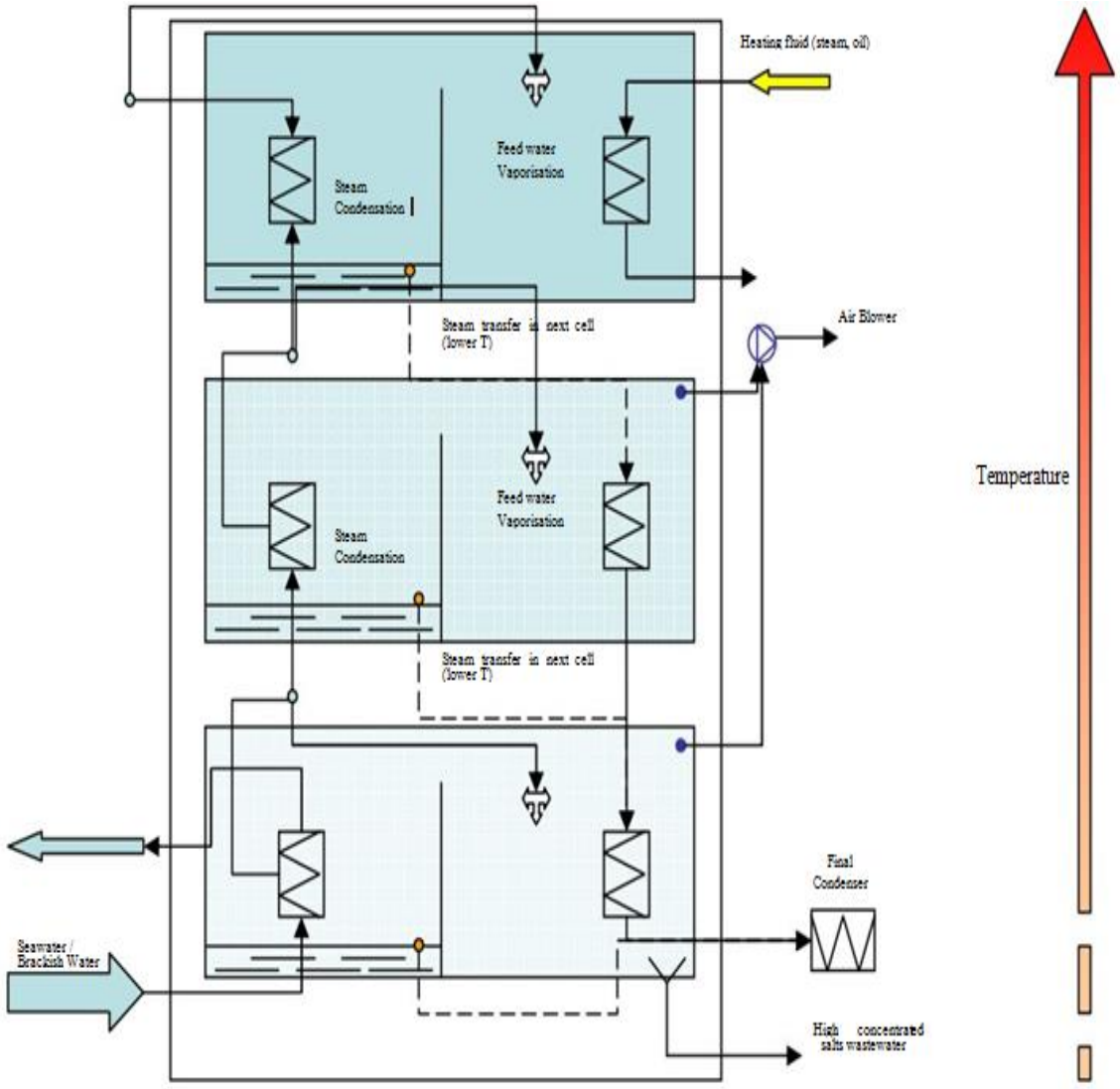



Fig. 3. Schematic drawing of MED process

# Key features for MED are the following:

- High reliability, easy start of the system (less than 1 hour)
- High quality of produced freshwater (depending on the number of cells): salts concentration below 50 ppm
- No need for complicated pre-treatment due to very limited scaling: simple filtration, and anti-scalant
- Can be used on low temperature heat (from 60°C), which can be easily recovered as by-product in industrial plants

# Energy consumption for the different desalination technologies (per m3 of produced freshwater)

| Consumption of desalination technologies | RO | MSF | MED |
|---|---|---|---|
| Heat power consumption | N/A | 80 -120 kWth/m3 | 50 - 90 kWth /m3 |
| Electricity power consumption | 3 - 6 kWeh/m3 | 2.5 kWeh/m3 | 1 - 3 kWeh/m3 |

# Solar Technologies

- All desalination technologies described mainly use thermal energy. Knowing that desalination needs are mainly in dry countries receiving huge intensity solar radiation, it comes as an evidence to use solar power for the running of the plants.

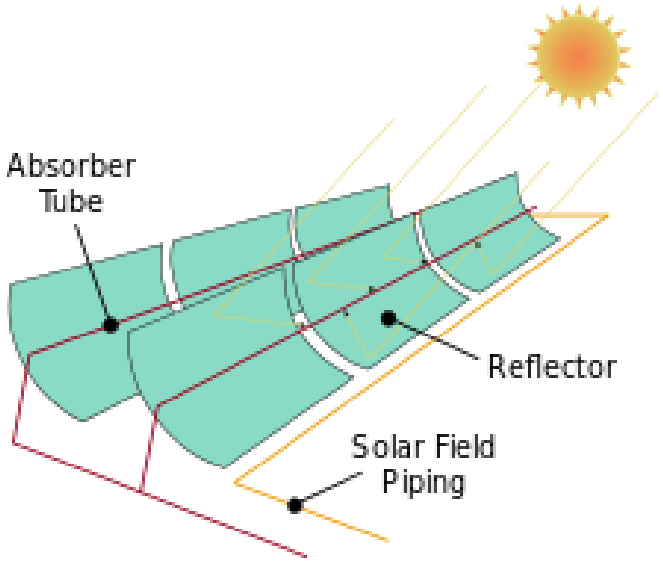
- Solar technologies can be divided in two categories:

1) concentrating solar power (CSP) technology
   a) Parabolic trough
   b) Linear Fresnel reflector systems
   c) Central tower receiver

2) photovoltaic(PV) technology
   a) Flat Plate Photovoltaic
   b) Concentrating Photovoltaic

# Parabolic Trough

- CSP parabolic troughs produce steam and electricity through the use of a parabolic reflecting surface that concentrates direct normal solar radiation (DNI) onto a receiving tube surrounded by a glass element.




# Photovoltaic

- Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting material that exhibit the photovoltaic effect.
- The photovoltaic effect is the creation of voltage or electric current in a material upon exposure to light and is a physical and chemical phenomenon.

# Coupling Solar Energy and Desalination

1. Photovoltaic / Reverse Osmosis

- Many demonstration plants were carried out coupling RO systems with solar PV electricity. Most common way is to convert DC from PV panels through an inverter, to produce AC immediately used in pumps.
- Developments were done on connecting panels to a brushless DC motor, powering a low pressure pump, thus allowing direct use from PV panel to pump.
- Furthermore, battery banks are added to the system to store energy during night time to allow continuous running of RO operation.
- Cost reductions have been investigated, smartest approach is to eliminate storage battery (giving 15-20% of cost reduction) with varying flow of seawater through membrane with regards to available energy

## 2. Parabolic troughs / MSF

- The MSF process as a thermal process can also use solar power with parabolic troughs. Steam produced by parabolic troughs is used as heat source through a heat exchanger for MSF inlet.

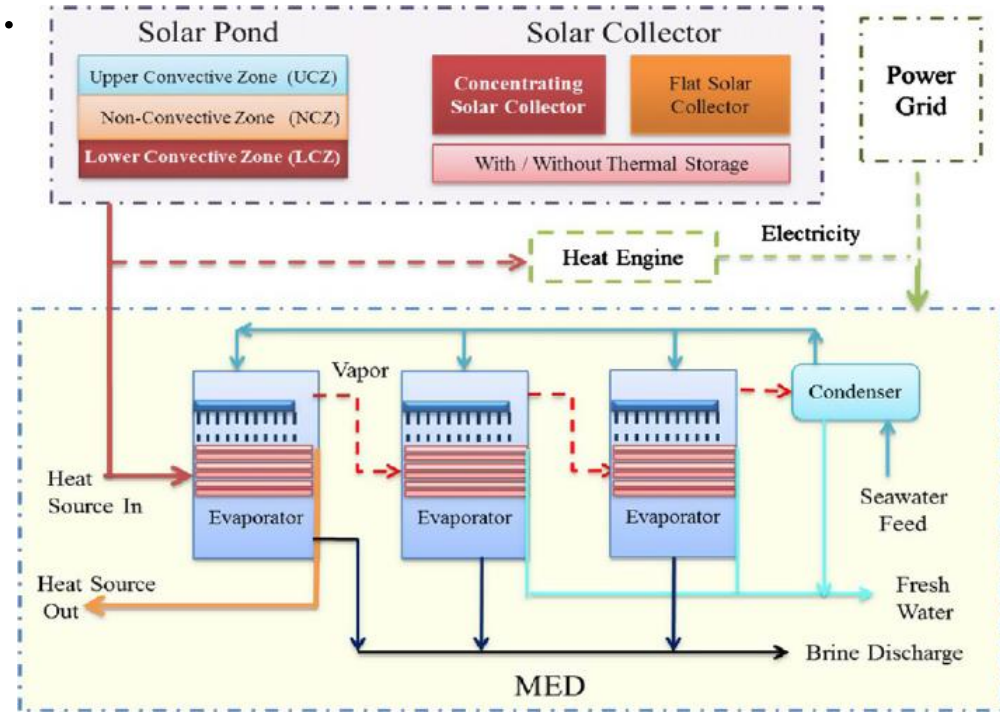
- A thermal storage system can be added to the system to smooth variation of thermal energy supply and allow the continuous production of fresh water (during nighttime or low radiation period)

- There are commercially available small-scale units combining MSF process with steam generating parabolic troughs, whose approximate costs is 7-9 US $/m3 of produced freshwater

# 3. Parabolic troughs / MED

- We can find more installations of MED worldwide, coupled with solar energy from different technologies (tower, parabolic troughs, others…).

- Water production cost for seawater desalination with MED coupled with a solar field has been proven to be quite dependant from plant capacity: for large planst (5000 m3/d), cost is around 2 US $/m3 and is increasing up to 3,2 US$/m3 for smaller plants (500 m3/d) .



# Advantages and Disadvantages

Advantages:

- No energy costs due to the use of solar panels.
- Costs of solar panels are decreasing.
- Very low maintenance.

Disadvantages:

- Requires a lot of space.
- Initial investment cost due to the price of land.
- Current costs of panels are expensive.
- No economy of scale.

# Conclusion

- Solar MED and MSF, though appearing to be natural and tempting solutions, cannot be taken as proven technologies. More and more developments in both solar power and desalination technologies are expected to keep these solutions competitive compared to RO systems coupled with conventional power plant.

- Somewhere, solution lies in combination: combination of heat sources and combination of processes.

- The range of possibilities is widely open in desalination. Need for fresh water will always be present, therefore desalination technologies must be enhanced to become cleaner, more efficient and more virtuous.

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# THANK YOU