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Summer Training Course

[Training Course code]

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Higher technological institute

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[name of Supervisor, font 20]

Dec. 2019

Abstract

[write down short 2 or 3 paragraph about the training and the contains chapter]

All abstracts generally cover the following five sections:(Reason for writing, problem, methodology, results and implications).

Acknowledgment

At first, Thanks to ALLAH the most merciful the most gracious, for this moment has come and this work has been accomplished.

Thanks to the Higher Technological Institute of 10th Ramdan for preparing me to be a successful Engineer and lifting me up to achieve this training in an environment that’s full of encouragement and motivation.

Deepest gratitude is to be delivered to ***Dr.[supervisor],*** my role model in engineering. He understood the nature of my thoughts and guided me step by step till this work brought to light. Endless trust in my potentials guided me till the end. Thank you.

Special thanks to ***[instructor]*** for his help and knowledge in the field of training. There professional touches are sensed within every phase of this summer training.

I’d like to thank my father ***[family name]*** , who is my motivators, visionaries and great supporter ever since my graduation. He always pushes me up and drives me to the success.

Not to forget everyone who helped me, prayed for me, wished me luck or pushed me forwards and beard a lot to help this work come to life. Thanks to my colleagues, friends, labors, technaician and everyone else for everything they did.

Last but never forgotten, Thanks to my dear family, for being supportive and always by my side. No words can express my deepest and sincere gratitude towards the love and care you have granted me in my hardest times. May ALLAH fill your hearts with happiness when we share this success together.

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NOMENCLATURE

A	Current Ampere (A)
AH	Capacity-Ampere Hour (AH)
HP	Hours Power
m^3	Cubic Meter
P_F	Performance Factor
P_{max}	Maximum Power (W_p)
ppm	Part Per Million
SE	Specific Energy
SPC	The specific power consumption
sp_M	membrane salt passage
SP_s	System salt passage
s_r	Salt rejection
T	absolute temperature
TDS	Total Dissolved Solids(ppm)(mg/L)
V	Voltage (V)
W	Watt

ABBREVIATIONS

ADIRA Project	Autonomous Desalination Systems for sea and brackish water in rural areas with renewable energies
BWRO	Brackish Water Reverse Osmosis
CPV	Concentrating Photovoltaic
ED	Electrodialysis
EDR	Reverse Electrodialysis
FAO	Food and Agriculture Organization
MED	Multiple Effect Distillation
MSF	Multi Stage Flash
MVC	Mechanical Vapor Compressor
PH	Power of Hydrogen
PV	Photovoltaic Cells
PV/T	Photovoltaic Thermal Unit
RO	Reverse Osmosis
RO-PV	Reverse osmosis driven by photovoltaic
VC	Vapor Compression
WHO	World Health Organization

Chapter 1

Introduction

1.1 Global Problem

Fresh water is the basis of everything alive on earth. The earth contains more than three quarters of its volume water. More than 97 % on the earth is salty water in oceans and seas while 3 % is fresh drinking water in rivers, lakes and aquifers for human use, agriculture, and industry …etc. The last 3 % fresh water may classified as 79 % in ice caps, 20 % ground water, 1 % accessible surface. The only nearly inexhaustible sources of water are the seas which, however, are of high salinity. Figure(1.1) shows the distribution of the world's water,[1].

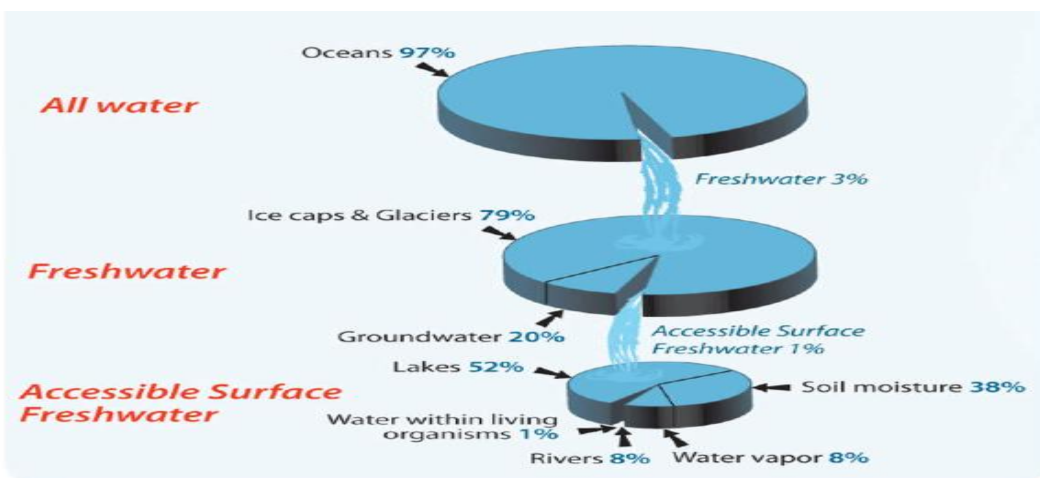

Figure (1.1): World water distribution, [2].

1.2 World Fears

As of today, nearly 25 % of mankind is suffering from insufficient fresh water supply. According to the expected increase in the rapid growth of population in the world, especially the countries, which is suffering economically and is known as developing countries. It worth to mention that, water shortage problems affects more than 80 countries worldwide. The water situation has become difficult and alarming especially in North Africa countries. Based upon the presented studies by the World Health Organization (WHO), it is well known that the water availability per capita is 1000 m^3 in the year, which represents the border line below which it will not be possible to guarantee an acceptable living standard as well as economic development of a country. The international picture will become more darkness if the forecasts made by international Organization called (FAO) on the overall increase in world population are taken into consideration, [3].

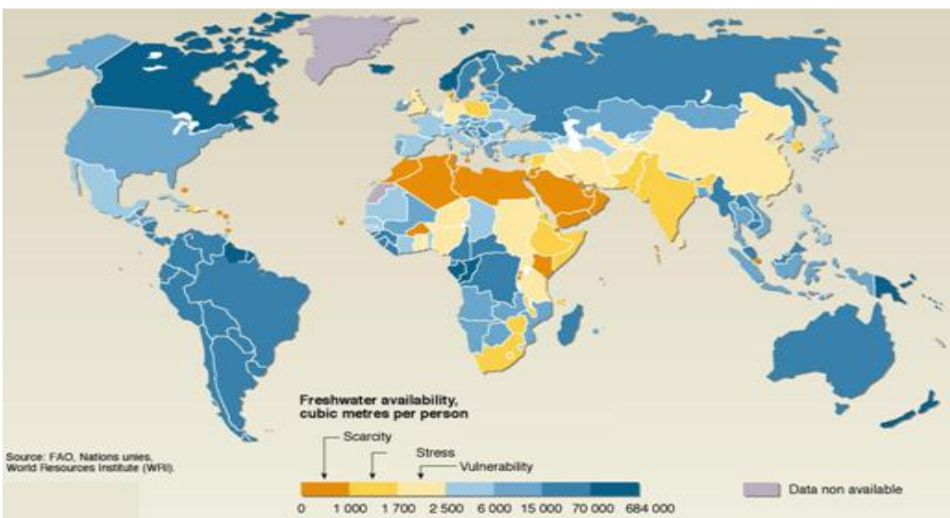

Figure (1.2): World water situation,[4].

It is noted that the world population about more than 6 billions, it is expected to increase to nearly 8 and 9 billions during the year 2025 and 2050, respectively. It is noticed that the percentage increase in population in the period between (2000–2020) will be around 50% in Africa, 14% in the USA, 25% in Asia and - 2% in Europe. It is clear from the above discussion that the world population increases (on the nearly soon future) will be focused mainly in most of the developing countries particularly in Africa, causing acute water shortages, [3].

1.3 Water Situation in Egypt

According to Nile water agreement at 1959 which allocates 55.5 billion m^3 of fresh Nile water per year. Egypt population has been increased to reach more than 90 million. This means that the annual share reduced to 400 m^3 per person by the year 2025 while the moderate standard is about 1600 m^3 per capita, [5].

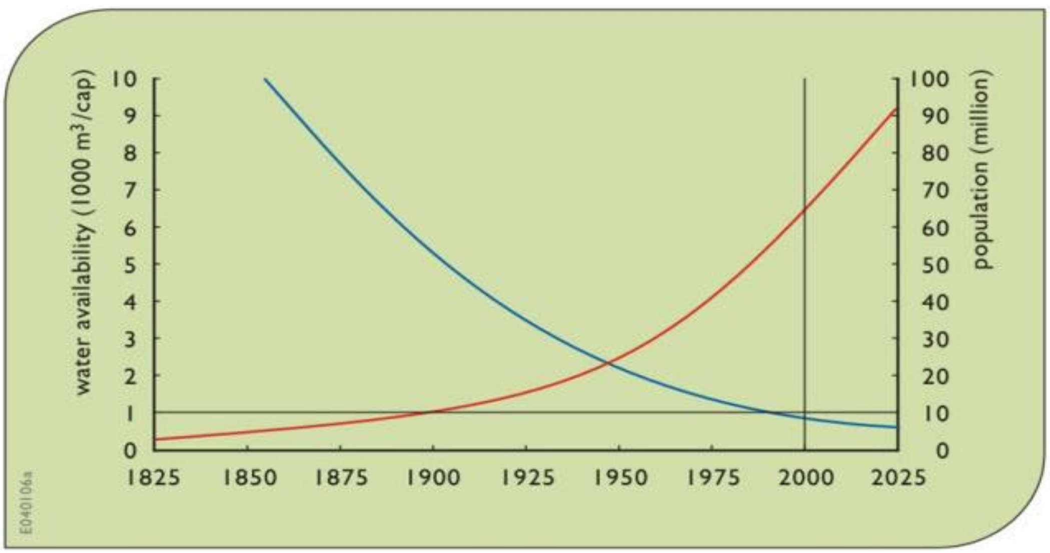

Figure (1.3): Egypt water availability and population by 2025, [6].

The main source of pure water in Egypt is the River Nile that represents 94% of the available resources. It estimated as 55.5 billion m^3 per year. The second place in available resources is deep aquifer that represents 4% which estimated as 2 billion m^3 per year. Finally, rainfall represents 2 % (1.2 billion m^3 per year) of the available resources in Egypt. Figure (1.4) shows the different water sources in Egypt, [7].

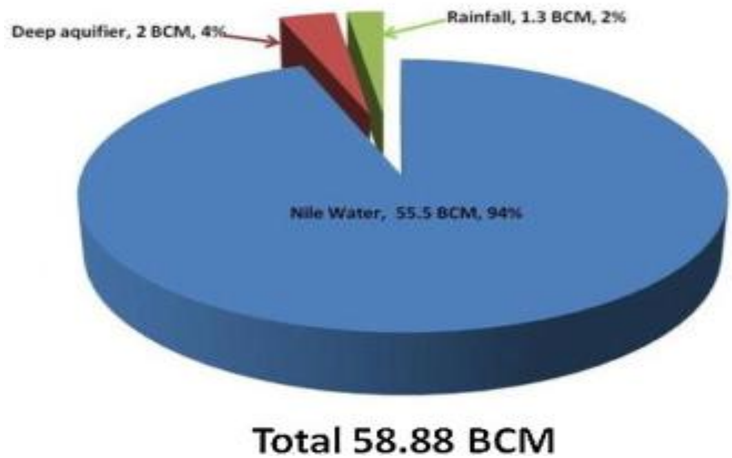

Figure (1.4): Available fresh water resources in Egypt, [7].

1.4 Desalination of Salt Water in Egypt

Due to this situation, desalination has an interesting role in meeting the shortage of fresh water. In general, desalination of seawater is one of the most expensive solution to obtain purified water compared to traditional methods (Nile River). According to high cost compered to ground water, desalination of seawater in Egypt has been given low trend.

In view of these findings, water desalination should be ranked among the most prior solutions for water scarcity problem in Egypt. Taking into account the energy requirements for desalination systems, it could be adequate and efficient the renewable energy source for this process.

1.5 Classifications of Desalination Techniques

Figure (1.5) shows the classification of desalination techniques. The desalination techniques could be divided into thermal desalination and membrane desalination. The first main technique, thermal desalination, includes different thermal methods to produce fresh water such as Multi stage flash (MSF) technique, Multiple-effect distillation (MED) technique and Vapor Compression (VC) technique. While the second one, membrane desalination, includes reverse osmosis (RO), Electro Dialysis (ED) and Reverse Electro Dialysis (EDR) techniques.

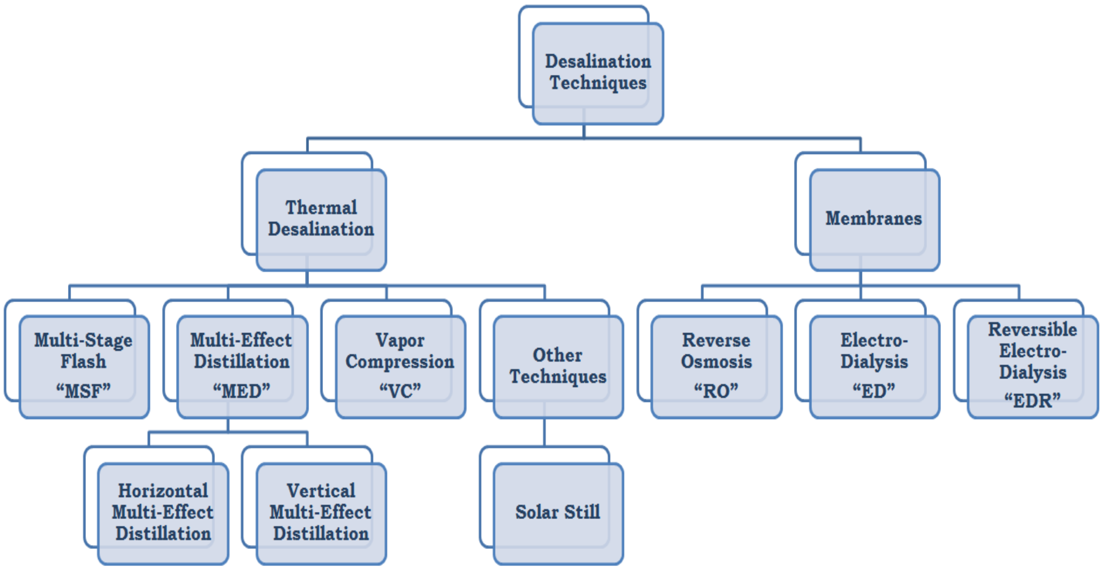

Figure (1.5): Main desalination techniques.

1.5.1 Thermal Desalination

Salts in sea water are separated in this type by heating it to certain temperature in evaporators and then condensing the output vapor to obtain purified water. In Multi stage flash Technique (MSF), shown in fig.(1.6), the salty water is pumped through ascending temperature stages till it reaches the brine heater which considered as primary source of steam to complete the current distillation process(the temperature of salty water is increased). The present type of distillation includes a number of stages in series, each of which is at a lower pressure. The steam rises up to the upper section of the stage and be in contact with heat exchanger condensing coils that make condensation to produce fresh water.

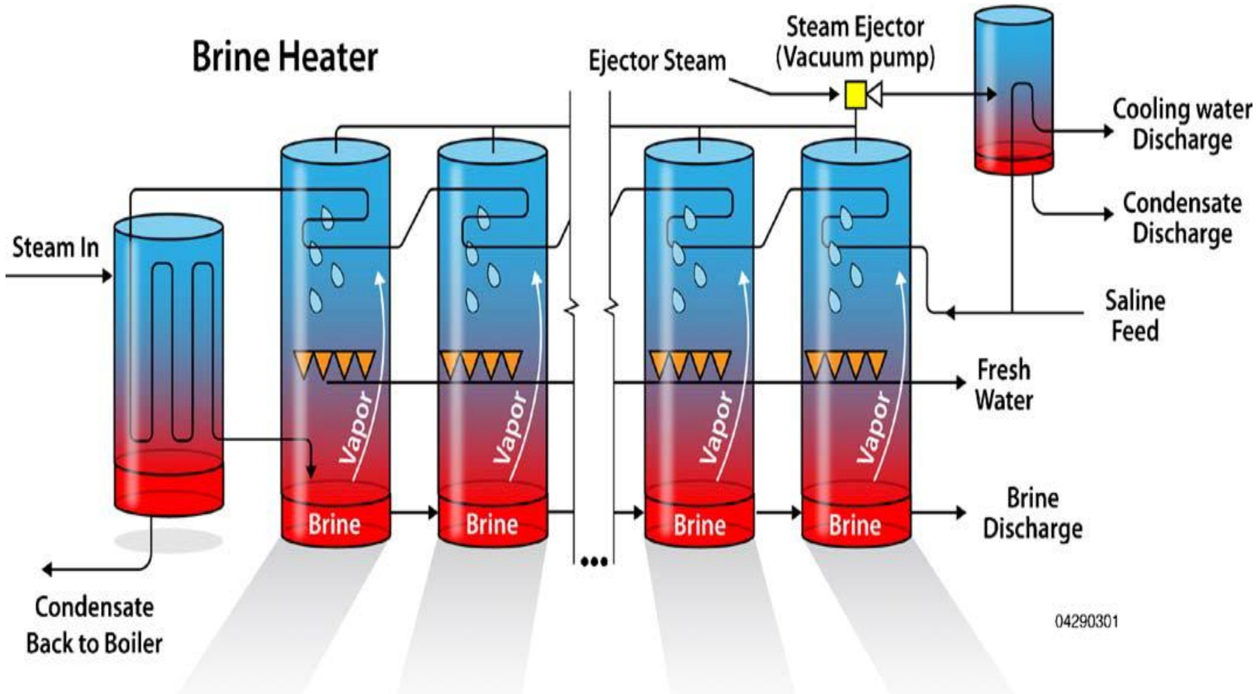

Figure (1.6): Multi Stage Flash (MSF) technique, [8].

Multiple-Effect Distillation (MED), shown in figure (1.7), consists of several consecutive cells maintained at a decreasing level of pressure (and temperature). The output vapor from one cell is then used to evaporate water in the next one. MED operates on horizontal pipe or vertical pipe types where steam condenses on one side of the heat transfer surface while seawater evaporates on the other.

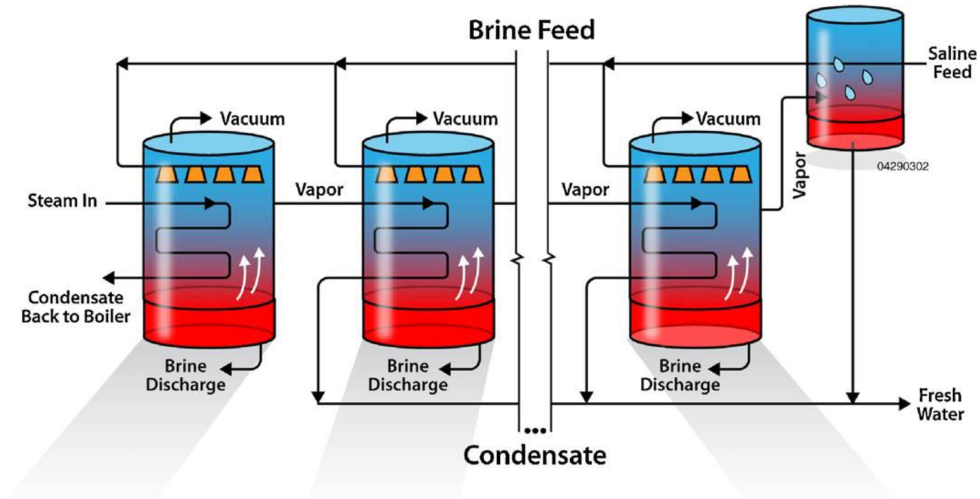

Figure (1.7) : Multi Effect Distillations (MED) technique, [8].

In the Vapor Compression (VC) techniques, it is based on compression of the vapor generated by evaporating water to a higher pressure, which allows reuse of the vapor for supplying heat for the evaporating process. Evaporation of sea or saline water is obtained by the application of heat delivered by compressed vapor. Since compression of the vapor increases both the pressure and temperature of the vapor, it is possible to use the latent heat rejected during condensation to generate additional vapor. Compression of the vapor may be carried out by using a mechanical compressor (the most common way), or by mixing with small amounts of high pressure steam (thermal compression).

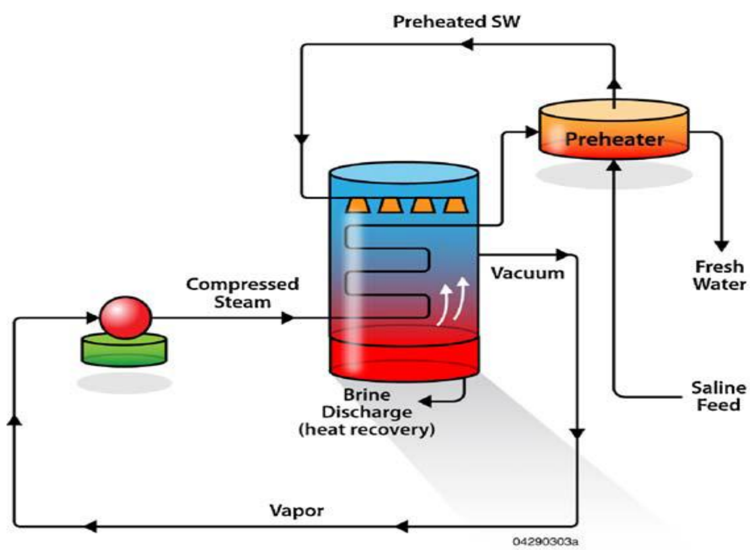

Figure (1.8): Mechanical Vapor Compression (MVC) distillation technique, [8].

1.5.2 Membrane Desalination

In this type of desalinated seawater the salts are separated by the membranes and do not use any thermal energy to heat and then condensate to produce fresh water. The present technique includes Reverse Osmosis (RO) technique, Electro Dialysis(ED) technique and Reverse Electro Dialysis technique (RED).

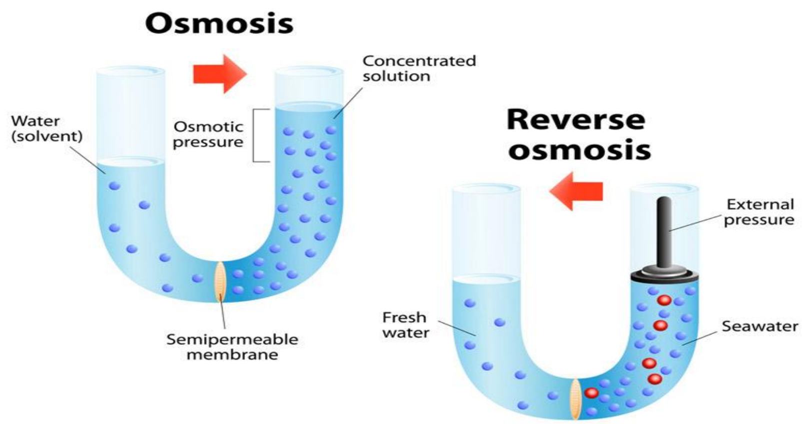

Figure (1.9): Reverse Osmosis (RO) principle, [9].

The reverse osmosis (RO) technique is discussed in the following section. The phenomenon of osmosis occurs when pure water flows from a dilute saline solution through a membrane into a higher concentrated saline solution. The phenomenon of osmosis is presented in Fig.(1.9). The Reverse Osmosis desalination (RO) technique is consist of pressurized filtration in which the filter is a semi-permeable membrane that makes the pure water pass while the salt is rejected through drain stream. Figure (1.10) shows Reverse Osmosis (RO) desalination plant.

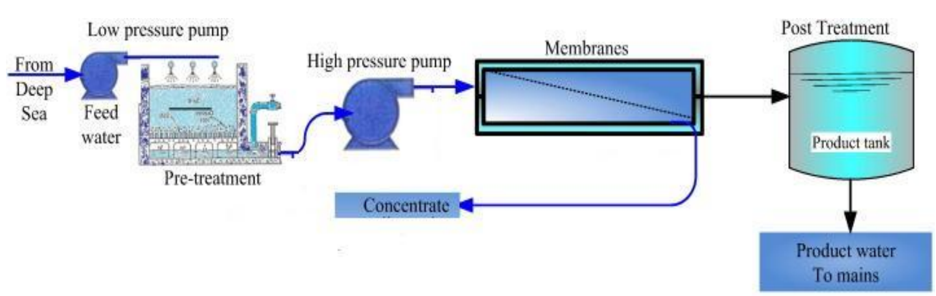

Figure (1.10): Reverse Osmosis (RO) desalination plant.

The traditional RO system includes main subsystems: pretreatment stages, mainly pump (high pressure), salt separation unit (RO membrane), and post-treatment system (relatively). The output salty water from pretreatment stages (that prevent scaling and fouling) forced by high-pressure pump across membrane surface. The permeate water (purified water) is passes through membrane which removes the majority of the dissolved solids and then rejected as pressurized brine (concentrate). Spiral-wound and hollow-fibers membranes are considered the most geometrical convenient forms of membranes which are made to fit the pressure vessels.

The process takes place in ambient temperature and the only energy required is for pumping the water to a relatively high operating pressure. Special turbines may be used in the large scale plants to reclaim a part of the consumed energy. High pressure is needed to allow sufficient permeation at relatively high concentrations of the concentrating brine along the membrane axis located in the pressure vessel. RO desalination system is considered the top ranked systems used in water desalination process as RO plants feed water without being in need for heating in fresh water extraction process , so that the thermal impacts of discharges are much lower and economic. In addition, RO plants have: fewer problems with corrosion, lower energy requirements, higher recovery rates, and require lower surface area when compared to other distillation plants to produce the same amount of the treated water, [5].

In Electrodialysis (ED) the salt ions is passed from solution across ion exchange membranes to the next solution affected by the applied potential difference as shown in fig.(1.11). The last process is defined as electrodialysis cell.

The cell consists of a dilute chamber and brine chamber created by a cation exchange membrane and an anion exchange membrane laid between two electrodes. Numbers of electrodialysis cells are distributed into a configuration called an electrodialysis stack, with alternating anion and cation exchange membranes forming the multiple electrodialysis cells, [10].

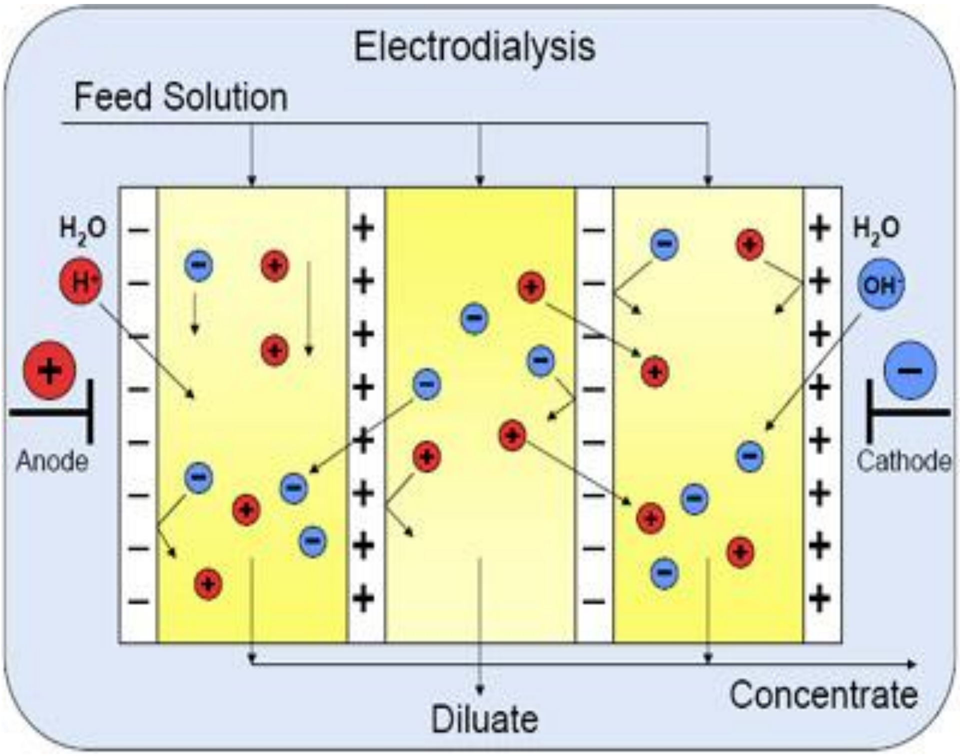

Figure (1.11): Electrodialysis (ED) desalination technique, [10].

In Reverse Electrodialysis (EDR) technique works as the same principle of standard electrodialysis system except that both the concentrate and product channels are identical in construction. At constant period time, the polarity of the two electrodes is reversed, and the flows are simultaneously converted so that the purified-water channel becomes the concentrate channel and the concentrate channel becomes the purified-water channel. The reversal process is used to reject scaling and other deposits in the cells before membrane fouling, [10].

Desalination, in general, consumes energy that is important factor. It, also, has an environmental impact due to pollution when burning fossil fossil fuels. The pollution can be greatly reduced when replacing the fossil fuel by the application of renewable energy technology

1.6 Trend to Renewable Energy

It is known that the sources of traditional energy for the production of electric energy in the world are divided as follows: the first place is fossil fuels by 66.2 % , the hydro energy is come in second place by 16.4 % and in the third place nuclear energy by 10.7 % while the renewable energy counts for 6.8 % of the total energy resources placed in the last ranked, [11]. Figure (1.12) shows the different resources of electric energy generation.

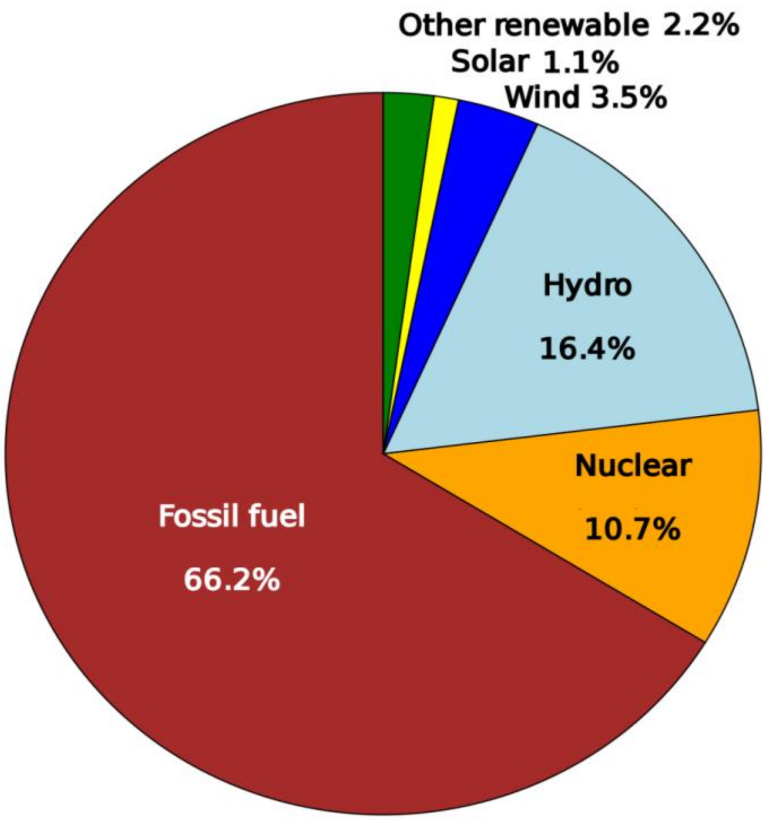

Figure (1.12): World electricity generation, [11].

According to the report and the following figure by Federal Energy Information Administration (US. EIA), the global mainly energy source is petroleum. The estimated decline of conventional petroleum production in the world is the red curve, fig.(1.13), and the consumption of petroleum in the world is the green curve, fig.(1.13).

It worth to mention that, the capacity unite of petroleum in the present figure is Exajoule (EJ). Figure (1.13) shows the predicted production and consumption of oil with time.

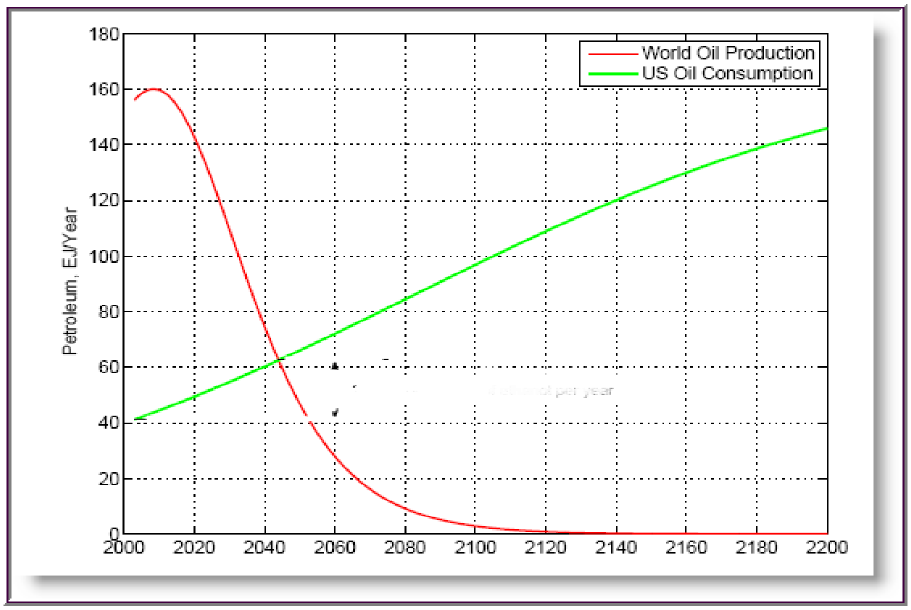

Figure (1.13): World oil production and consumption, [12].

On the other hand, the desalination plants powered with the renewable energy is proper solution to provide purified water and power source in remote areas where both are suffering relatively scarcity.

According to the expected increase in population and the low production of fossil fuels (as it is depleted) over time, and pollution of the environment resulting from its operation, therefore, the renewable energy is considered an alternative solution to overcome this problem.

1.7 Desalination Techniques Powered by Renewable Energy System.

The greatest danger of the world at present is the scarcity of water, resulting from drought and increased population. To overcome this problem, seawater desalination techniques should be focused on. On the other hand, it is necessary to provide a source of energy to extract fresh water from desalination plants. Since conventional energy is exhausted, expensive and polluted to the environment, it is necessary to turn to renewable energy as an alternative energy source for traditional one, especially in remote areas. Based on the above, using the renewable energy to desalinate salty water (sea water) is a necessity for the future top priority.

The appropriate matching between renewable energy and seawater desalination systems is designed according to special and relative considerations factors as (remoteness, plant capacity, the concentration of the feed water, the location of combined system, the basic physical and organizational structures).

An example of this is in the case of the comparison between RO-PV system and RO-wind system it is shown that in the first case is suitable in places close to the equator due to the increase of solar radiation while the second case preferred to be located on the coasts to take maximum advantage of the wind speed. Finally, there is no the best-combined method between renewable energy and desalination plant but there is the most appropriate system. Figure (1.14) shows the possible combination of renewable energy systems with desalination units

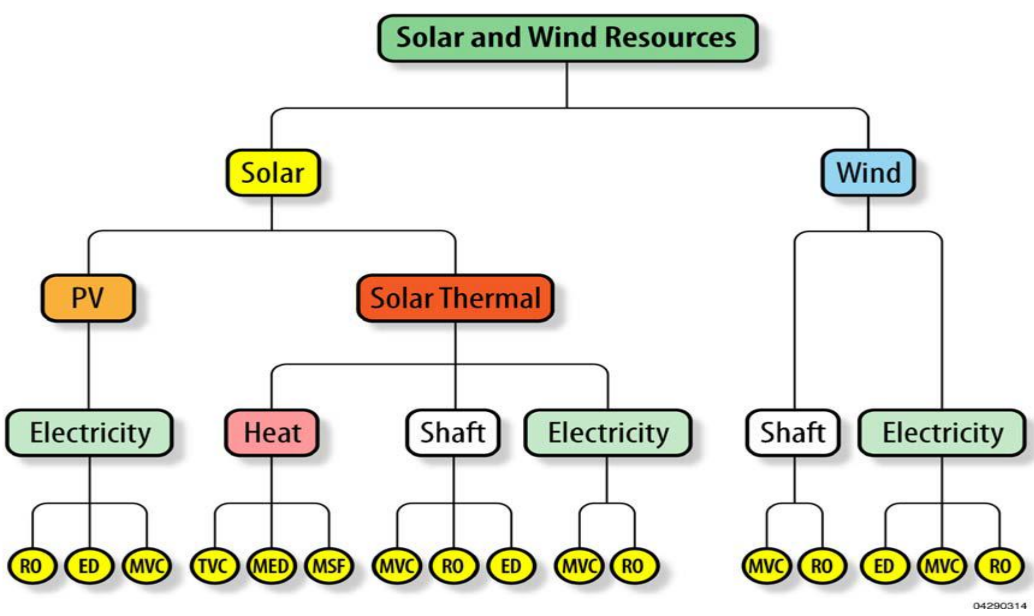

Figure (1.14): Possible desalination techniques powered with renewable energy, [8].

1.8 Selection of the Appropriate Combined System (Water Desalination Plant Driven by Renewable Energy).

Figure (1.15) shows the cost of desalinated water by m^3 using the following techniques: multi stage flash desalination (MSF), multi effect distillation (MED), mechanical vapor compression (MVC) and reverse osmosis (RO) respectively. It shows the MVC and RO are almost have the same production cost in cubic meter per day, while the cost is higher for MSF and MED.

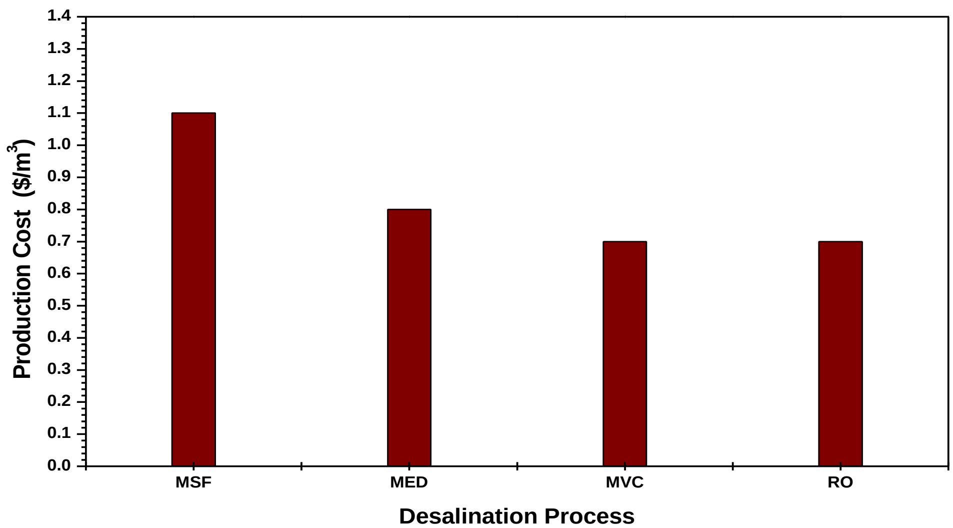

Figure (1.15): The cost of fresh water per m^3 by different techniques, [5].

Figure (1.16) shows the different desalination technologies for inlet feed water of 3500 ppm salinity and outlet produced fresh water of 500 ppm salinity and 70 % recovery ratio, the ratio between flow rate of the fresh water produced (permeate) to the feed water flow rate. The figure under consideration indicates that RO, ED and freeze methods of desalination have the minimum energy requirements respectively in KJ/kg, [5].

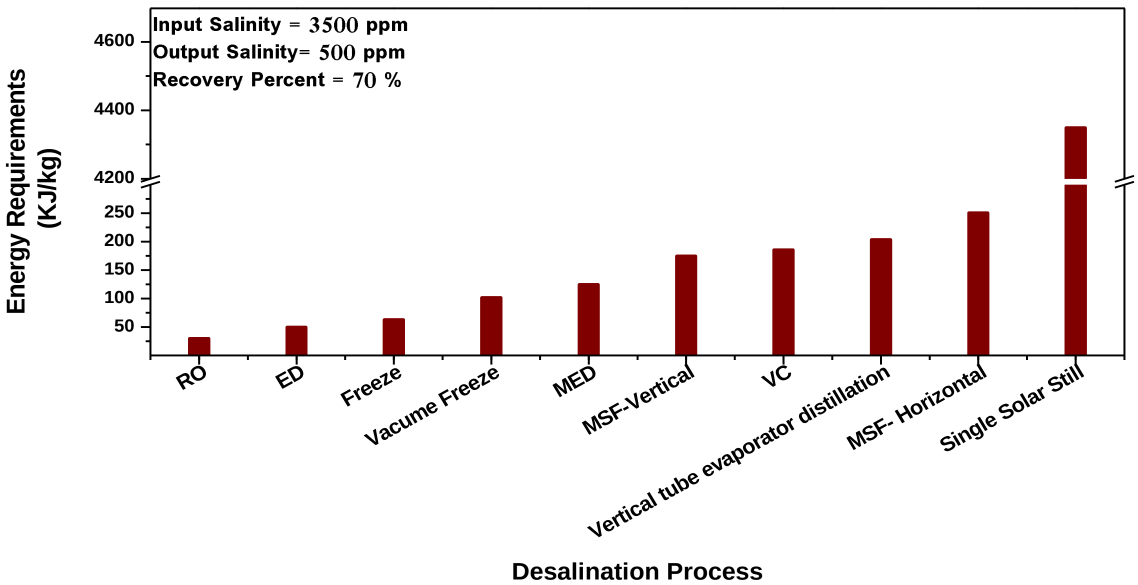

Figure (1.16): The required energy for different desalination techniques, [5].

Figure (1.17) shows that the performance factor for RO is the highest with respect to other methods. The performance factor is predefined as the mass of desalted water in kilograms per 2320 kJ of energy input (the energy required to desalted 1 kg of water is 2320 kJ) and it indicates easily the energy required for desalination.

From the present figures, the RO technique represent the most appropriate method for desalinating water due to the following: lower cost of fresh water per m^3, lower total energy consumption in KWh/m^3 and higher performance factor.

Figure (1.18) shows the price of the energy presents in KWh with years. It illustrates the different types of energy; solar tower, geothermal, parabolic trough, PV arrays (small scale and large scale) and wind.

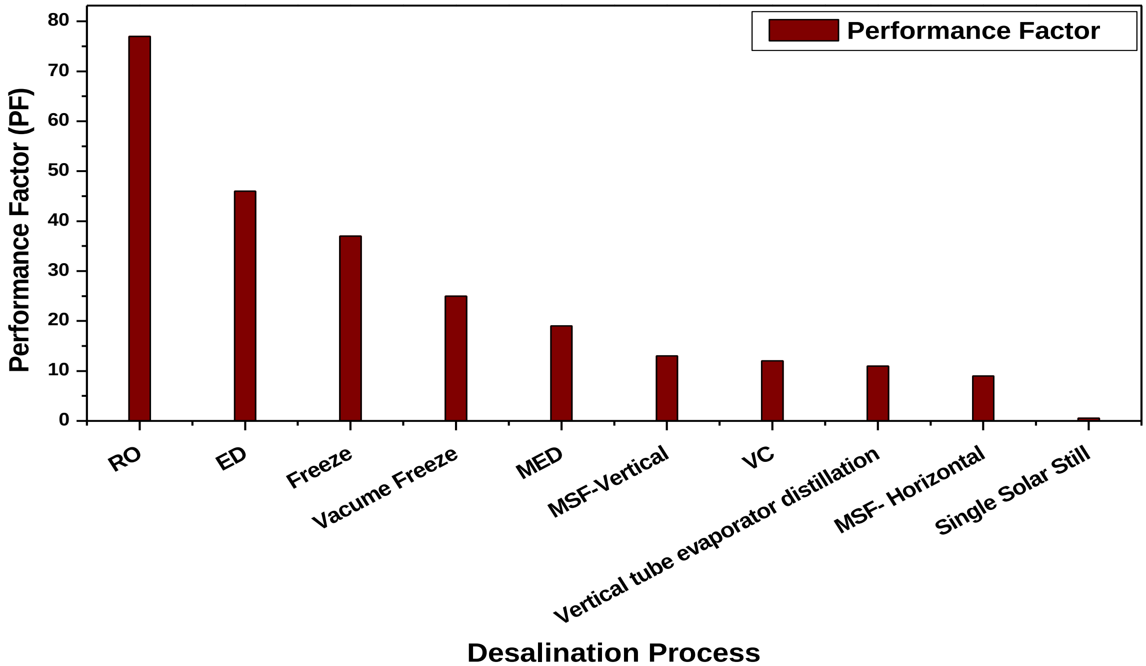

Figure (1.17): Performance factor for different types of desalination techniques,[5].

The figure presents the tendency of cost of energy is decreasing in the near future. The best source of renewable energy in cost is geothermal energy that nearly constant. The PV panels price shows a noticeably decreasing with the year 2020. This is due to the material manufacturing development in photovoltaic with higher efficiency and low price.

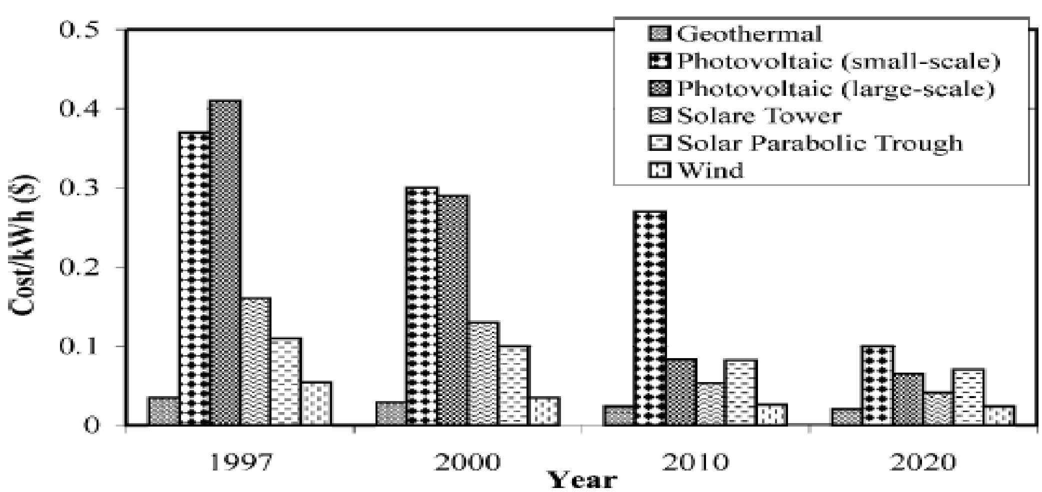

Figure (1.18): Cost of various renewable energy resources for several years, [13].

The following figure is presents a comparison between the photovoltaic panel, the solar thermal and conventional energy. It can noticed that the lower cost to obtain cubic meter fresh water by conventional energy, while the solar thermal energy and photovoltaic energy are nearly identical in the second place according to capacity of permeate water produced per day. On the other hands the conventional energy is exhausting and producing pollutions, and eventually the conventional energy will be limited for producing energy. Figure (1.19) shows water cost as a function of plant capacity by PV-RO , solar thermal-MED and a Conventional One.

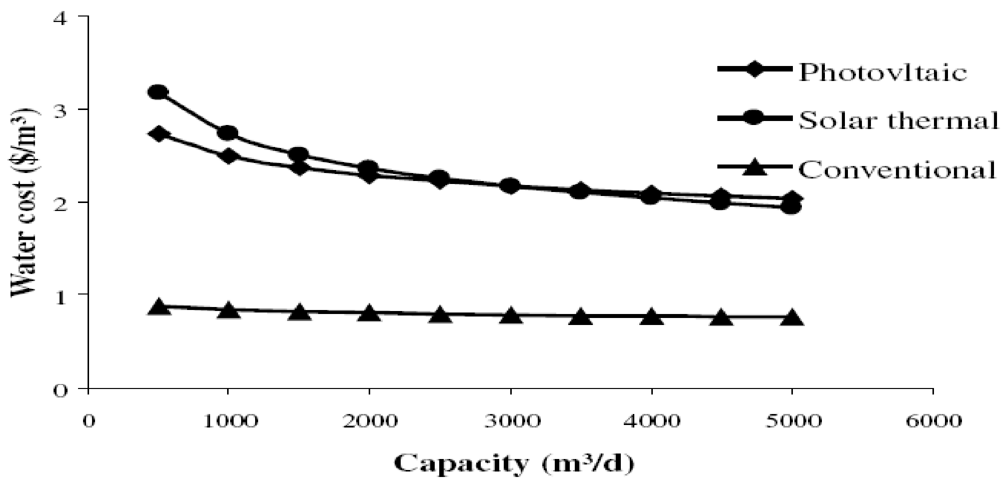

Figure (1.19): Water Cost as a function of Plant Capacity by different solar systems (PV-RO, ST-MED and conventional one), [13].

Finally, it is clear from all the previously mentioned discussion that the combination between RO with PV represents the optimum choice for water desalination (especially in Egypt) due to the sunlight continues all the day. Figure (1.20) shows the different usage percentage of possible desalination techniques combined with renewable energy as a power supply.

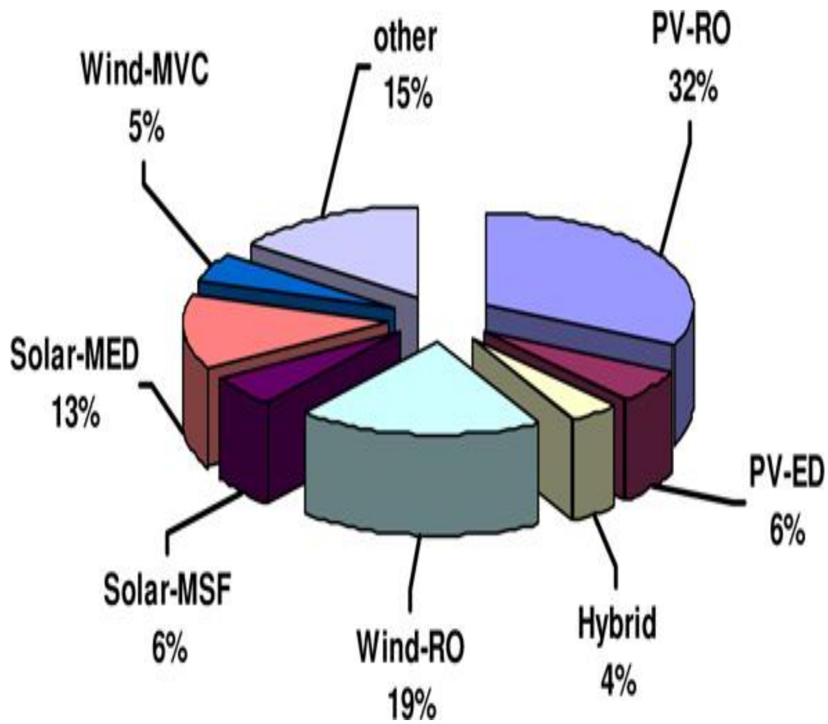

Figure (1.20): Distribution of renewable energy powered desalination technologies, [14].

The figure shows that PV-RO counts for 32 % of the total combinations that dominates other combination methods. With this figure and the above discussion, it could be concluded that desalination using reverse osmosis powered by photovoltaic solar cells is a promising combination for desalination of salty water. The present study aims to discuss the different parameters that affect the performance of (RO- PV) system.

Chapter (5)

Conclusions

The purpose of this chapter is to provide a summary of the whole report. In this context, it is similar to the abstract, except that the abstract puts roughly equal weight on all report chapters, whereas the conclusions chapter focuses primarily on the findings, conclusions and / or recommendations of the project.

There are a couple of rules- one rigid, one common sense, for this chapter:

- All material presented in this chapter must have appeared already in the report; no new material can be introduced in this chapter. (rigid rule of technical writing)
- Usually, you would not present any new figures or tables in the present chapter.

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Appendix (A): Measuring Devices Calibrations

A.1. Thermocouples

Preliminary calibration work was performed for the presented copper-constantan (K-type) thermocouples. A certificated mercury thermometer with a temperature range of (0 to 200 °C) was used as a reference thermometer. Both thermocouple and thermometer were immersed into the inner container of a water boiler. The calibration was carried out up to the boiling point of the water. Figure (A.1) shows a sample of calibration curve which was plotted between the temperature indicator output and the thermometer reading. Also the governing equation resulted from the calibration curve is shown.

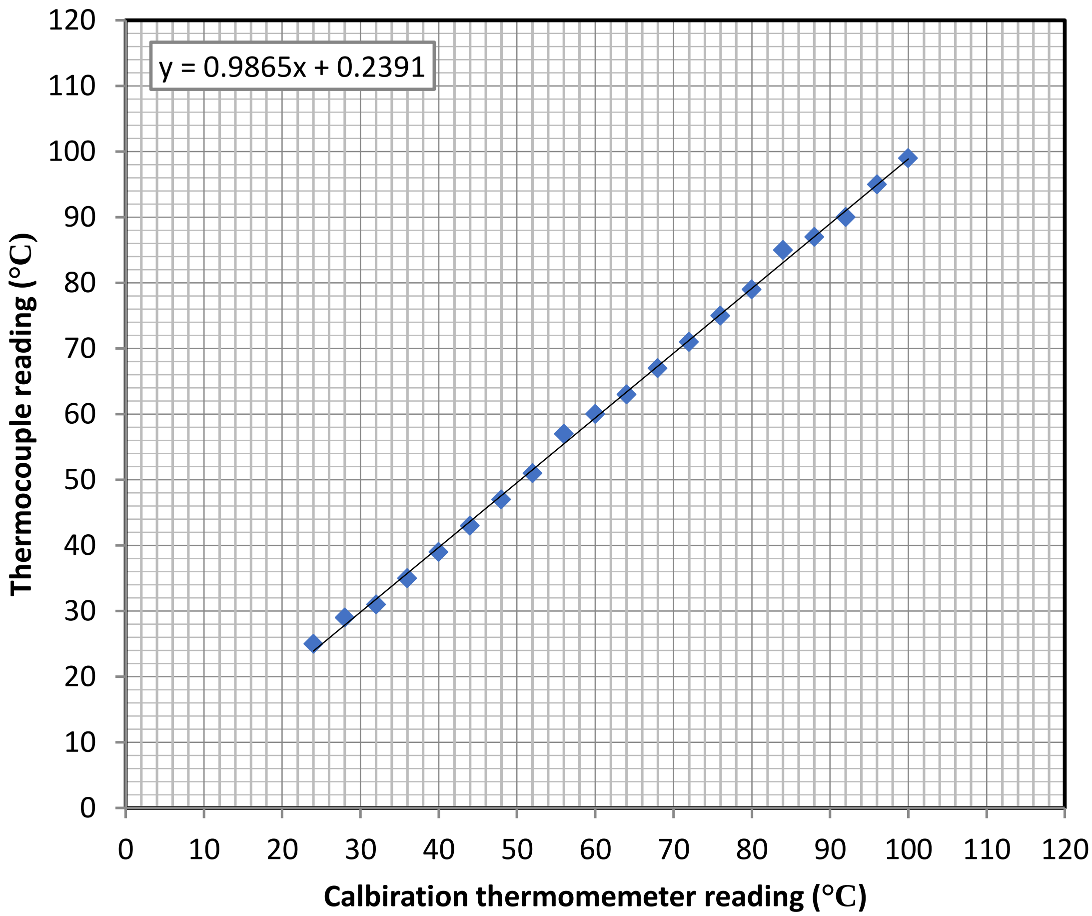


Figure (A.5): Calibration curve for applied thermocouple.

A.2. Flow Meter (Rotameter)

Calibration for both flow meters used is made with the aid of (milliliter scaled jar) and stop watch of 5 decimals approximation. Tests are repeated 10 times for each flow rate and the average time lap for filling a specific volume of the jar is recorded and calculated. The linear relation between flow meter readings and those of calibration flask is presented in Fig. (A.2).

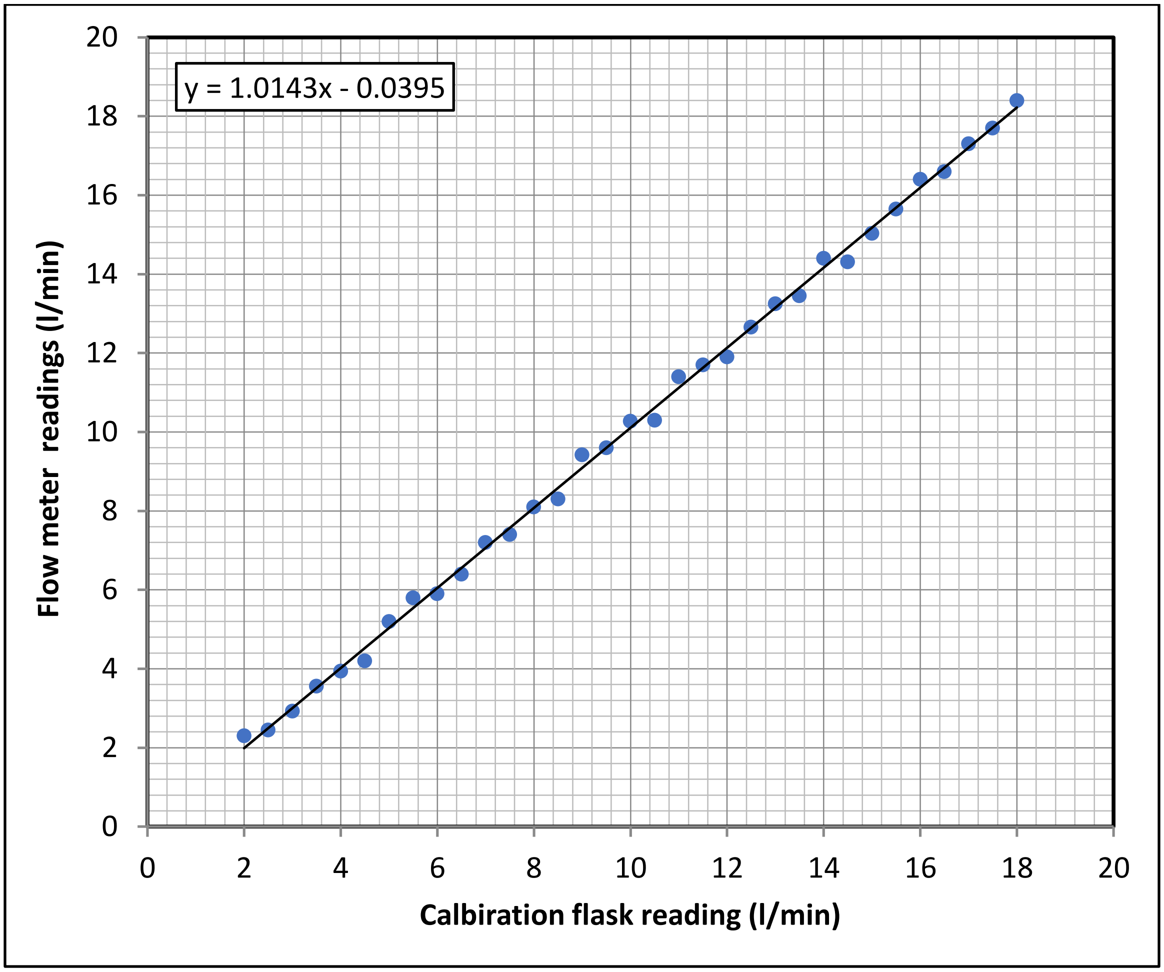


Figure (A.6): Flow meter calibration curve.

A.3. TDS Meter (Conductivity Meter)

Figure (A.3) shows the calibration certificate for the TDS meter used in the experimental test rig.

Shenzhen BCTC Technology Co.,Ltd.
NO.101,Yousong Road,Longhua New District,
Shenzhen,Guangdong P.R.China

BCTC

Certificate of Compliance

Certificate Number: BCTC-150911862

Applicant	:	Jinan Huiquan Electronic Co., Ltd. C3, Area A, Xingquan Industrial Park, North of Kaiyuan Road, Lengshuigou Village, Wangsheren Town, Licheng District, JInan, shandong, China .
Manufacturer	:	Jinan Huiquan Electronic Co., Ltd. C3, Area A, Xingquan Industrial Park, North of Kaiyuan Road, Lengshuigou Village, Wangsheren Town, Licheng District, JInan, shandong, China .
Product	:	TDS Meter
M/N	:	TDS&EC meter TDS-01, TDS-02, TDS-3, TDS-04, TDS-05, TDS-06, TDS-07, TDS-08.
Test Standard	:	EN 55022: 2010 EN 61000-3-2: 2014; EN 61000-3-3: 2013 EN 55024: 2010 EN 61000-4-2: 2009, EN 61000-4-3: 2006+A1: 2008+A2: 2010 EN 61000-4-4: 2012, EN 61000-4-5: 2014 EN 61000-4-6: 2014, EN 61000-4-8: 2010, EN 61000-4-11: 2004

The EUT described above has been tested by us with the listed standards and found in compliance with the council EMC directive 2014/30/EU. It is possible to use CE marking to demonstrate the compliance with this EMC Directive. It is only valid in connection with the test report number: BCTC-150911862.

CE

BCTC TECHNOLOGY CO.,LTD
APPROVED
Manager
Sep. 24, 2015

This certificate of conformity is based on a single evaluation of the submitted sample(s) of the above mentioned product. It does not imply an assessment of the whole product and relevant. Directives have to be observed.

Tel: 400-788-9558 0755-33019988 Http://www.bctc-lab.com Http://www.btc-lab.com

Figure (A.7): TDS meter calibration certificate.

A.4. Pressure Gauge

Figures (A.4) shows the calibration certificate for the pressure gauges used in the experimental test rig.

WIKA ALEXANDER WIEGAND SE & Co. KG

Abnahmeprüfzeugnis 3.1 nach DIN EN 10204

Acceptance Test Certificate 3.1 according to EN 10204

WIKA

Öl- und Fettfreiheit / *Free of oil and grease*

Muster

Lieferant / *Supplier*	WIKA	Datum / *Date*	10.08.2016
Kunde / *Customer*		Auftrag / *Order No.*	
Werkstoff / *Material*	CrNi-Stahl, Elgiloy Sensor	Position / *Item*	1
Sach-Nr. / *Part No.*	7735.70	Bezeichnung / *Typ*	CPG1500
Messgerät / *Measuring instrument*	Bruker Modul Transmission	Geräte-Nr. *Analyser No.*	50330

Prüfergebnisse / *Test results:* Kohlenwasserstoff Grenzwert / *Hydrocarbon limit value* Soll / *Reference:* < 200 mg/m²

Serien-Nr. / *Serial – No.*	Bauteil / *Part*	Prüffläche / *Test area*	Kohlenwasserstoff [mg/m²] / *Hydrocarbon*
1A00AF1S6I0	AUT	Medienberührende Oberfläche	21,6

Figure (A.8): Pressure gauge calibration certificate.

A.5. Avo Meter

Figures (A.5) shows the calibration curve for avo meter used in the experimental test rig.

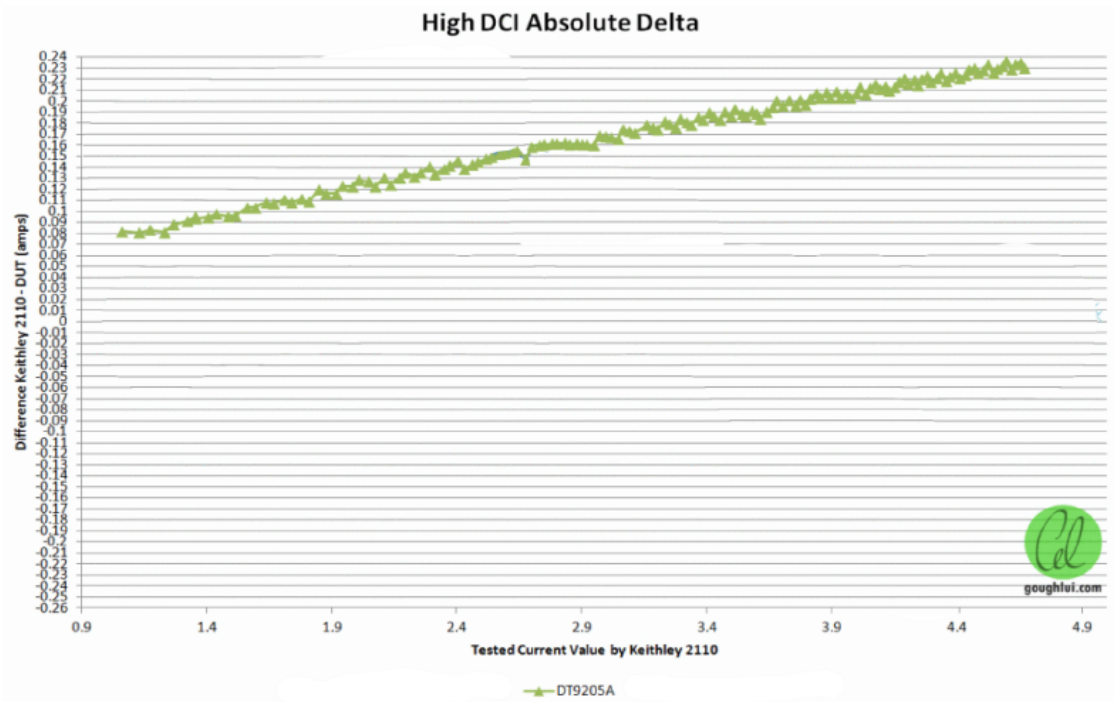


Figure (A.5): Avo meter calibration curve.

A.6. Radiation Sensor

Figures (A.6) shows the calibration certificate for Vantage pro 2 weather station used in the experimental test rig.

Egyptian Meteorological Authority
Cairo Regional Instrument Center
RIC/Cairo

الهيئة العامة للأرصاد الجوية
مركز القاهرة الاقليمي للأجهزة والمعايرة

CALIBRATION CERTIFICATE

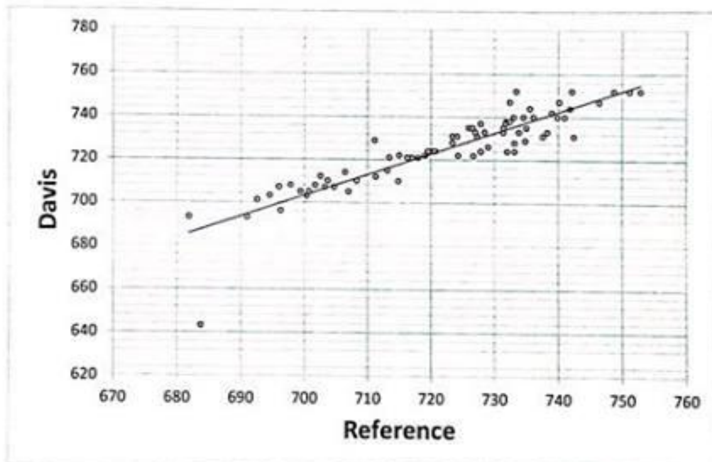
Certificate No.	:	239/2018
Issued for	:	المعهد التكنولوجي العالي – مدينة العاشر من رمضان
Date	:	27 / 2 / 2018
Calibration validity	:	One Year

Sensor: Semiprofessional Weather Unit Davis Vantage Pro2 - Radiation Sensor

Standard: Epply Radiometer - Model PSP - No. 35131F3

Method of Calibration: Comparison

Correction Value: ± 0.906292297 W/m²



Note:

1-Actual readings can be obtained by adding the correction algebraically to the sensor reading.
2-The instrument under calibration displays integer values only

د/ احمد عبد العال
رئيس مجلس الإدارة

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Figure (A.6): Radiation sensor calibration certificate.