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Summer Training Course

20

**Instant**

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**Abstract**

The AI training program at Instant is meticulously crafted to provide a thorough and well-rounded education in the fundamental areas of computer science and mathematics that are crucial for the development and application of artificial intelligence technologies. This documentation serves as a comprehensive resource, encapsulating the entire learning journey over the course of the training. The primary reason for compiling this documentation is to create a structured reference that details each aspect of the training, facilitating both current understanding and future learning endeavors.

The training program addresses a significant problem in AI education: the gap between theoretical knowledge and practical application. To bridge this gap, the curriculum is designed to cover a wide array of topics. It begins with the basics of Python programming, laying the foundation for more advanced concepts. Following this, the course delves into Object-Oriented Programming (OOP) with Python, which is essential for writing efficient and maintainable code. The program then covers data structures and algorithms, providing the tools needed for efficient data manipulation and problem-solving. The database module introduces participants to data storage and retrieval techniques, essential for managing large datasets in AI applications. The software engineering section emphasizes best practices in software development, ensuring that participants can contribute effectively to large-scale projects. The operating systems module provides insights into the underlying mechanisms that support software applications. Linear algebra and calculus are included to equip participants with the mathematical tools needed for understanding and developing AI algorithms, while the probability module lays the groundwork for statistical reasoning and probabilistic modeling in AI.

The results of the training are reflected in the participants' enhanced ability to approach AI problems systematically and develop effective solutions using the concepts and techniques learned. The implications of this training are significant, as it equips participants with the skills needed to contribute to AI projects and research. By fostering a deep understanding of AI fundamentals and their applications, the training program at Instant prepares participants to drive innovation and advancements in the field of artificial intelligence.

**Acknowledgment**

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**Nomenclature**

|  |  |
| --- | --- |
| A | Current Ampere (A) |
| AH | Capacity-Ampere Hour (AH) |
| HP | Hours Power |
| m3 | Cubic Meter |
| PF | Performance Factor |
| Pmax | Maximum Power (Wp) |
| ppm | Part Per Million |
| SE | Specific Energy |
| SPC | The specific power consumption |
| spM | membrane salt passage |
| SPs | System salt passage |
| sr | 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 Basics of Python

## Introduction to Python

Python is a high-level, interpreted programming language known for its simplicity and readability. Developed by Guido van Rossum and first released in 1991, Python has become one of the most popular programming languages in the world, particularly in the fields of data science, machine learning, and artificial intelligence. This chapter will provide an overview of Python's core features, basic syntax, and essential programming constructs.

## Installing Python and Setting Up the Environment

To start programming in Python, you need to install the Python interpreter and set up a development environment. Python can be downloaded from the official website (python.org) and is available for various operating systems, including Windows, macOS, and Linux. Additionally, we will explore setting up an Integrated Development Environment (IDE) such as PyCharm, VS Code, or Jupyter Notebook to enhance the programming experience.

* + 1. **Installing Python**
* Download the Python installer from the official website.
* Run the installer and follow the instructions to complete the installation.
* Verify the installation by running `python –version` in the command line.
  + 1. **Setting Up an IDE**
* Overview of popular Python IDEs: PyCharm, VS Code, Jupyter Notebook.
* Installing and configuring an IDE.
* Writing and running your first Python script in the IDE.

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**Figure (1. 1): Python IDEs.**

* 1. **Basic Syntax and Data Types**

Python's syntax is designed to be easy to read and write, making it an ideal language for beginners. This section covers the basic syntax and primary data types used in Python programming.

* + 1. **Variables and Data Types**
* Variables: Naming conventions and assignment.
* Data types: Integers, floats, strings, booleans.
* Type casting and type conversion.

A diagram of a data type

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**Figure (1. 2): Python Variables and Data Types.**

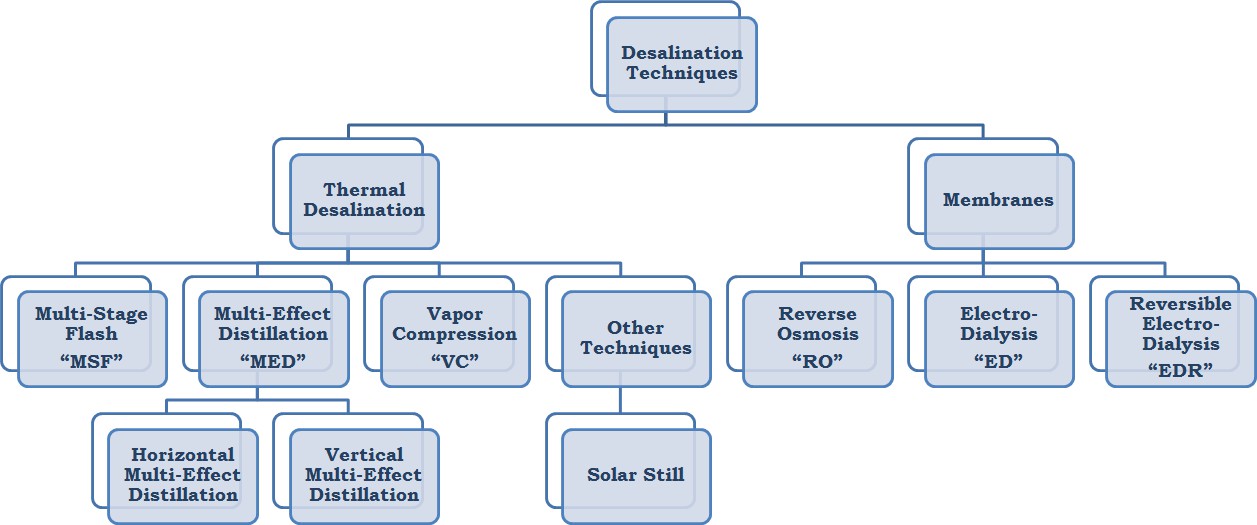
* + 1. **Basic Operators**
* Arithmetic operators: Addition, subtraction, multiplication, division.
* Comparison operators: Equal to, not equal to, greater than, less than.
* Logical operators: And, or, not.
  1. **Control Structures**

Control structures are fundamental in programming as they dictate the flow of execution. This section explores conditional statements, loops, and other control structures in Python.

## 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)

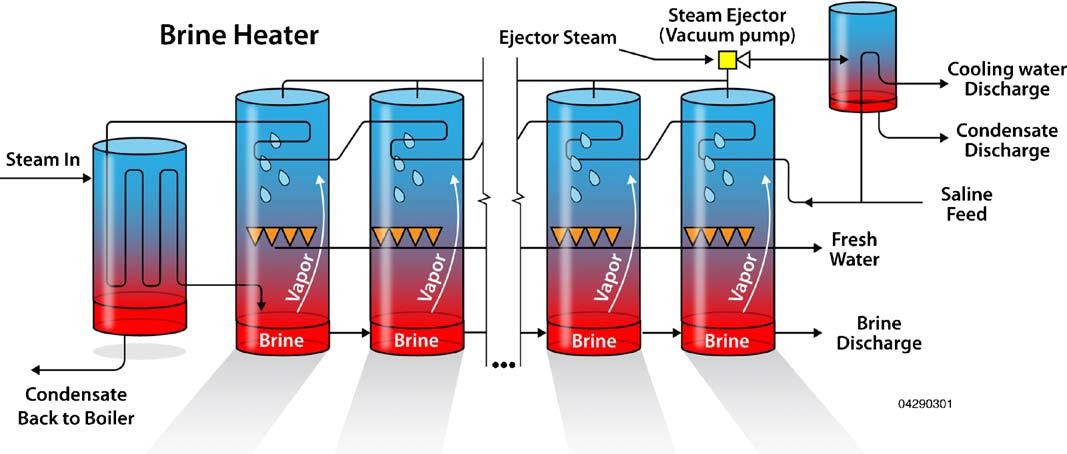
technique and Vapor Compression (VC) technique. While the second one, membrane desalination, includes reverse osmosis (RO), Electro Dialysis (ED) and Reverse Electro Dialysis (EDR) techniques.



*Figure (1.5): Main desalination techniques.*

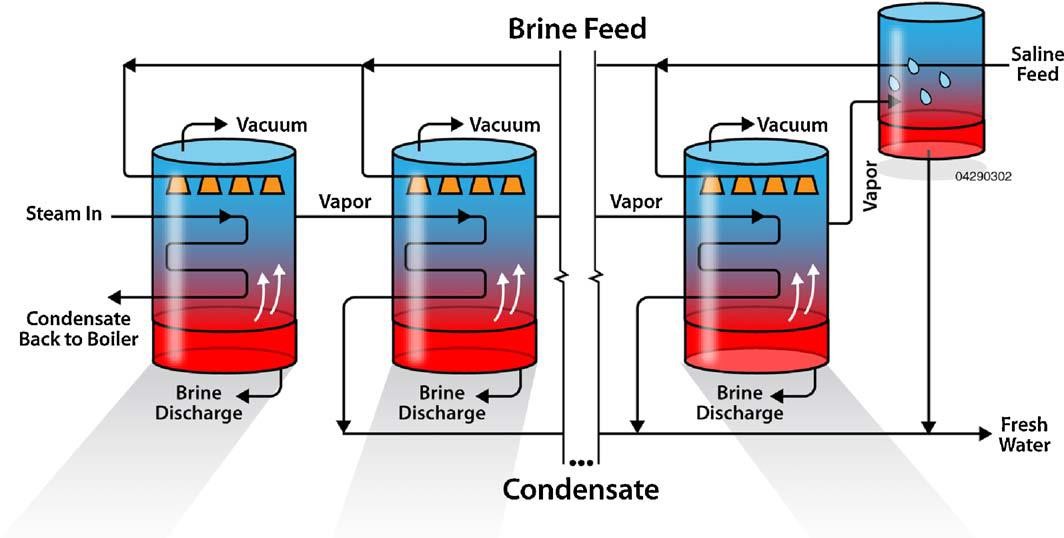
## Thermal Desalination

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.

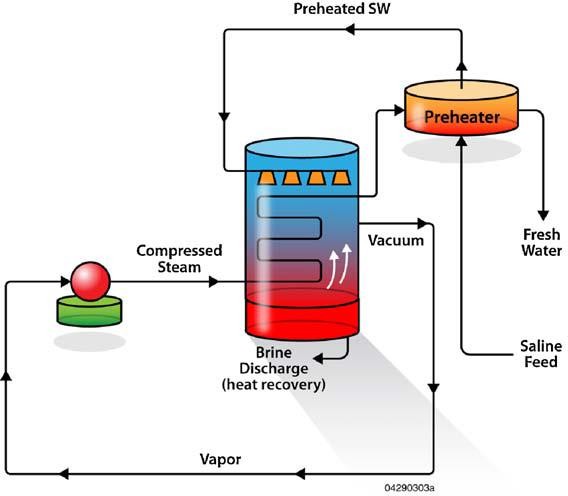


*Figure (1.6): Multi Stage Flash (MSF) technique, [8].*

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].*

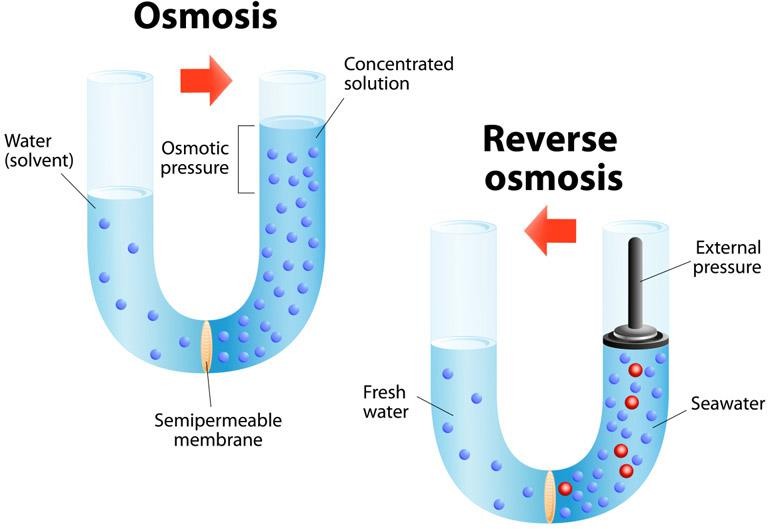
In the Vapor Compression (VC) techniques, it is based on compression of the vapor generated by evaporating water to a higher pressure, which allows reuse of the vapor for supplying heat for the evaporating process. Evaporation of sea or saline water is obtained by the application of heat delivered by 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).

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

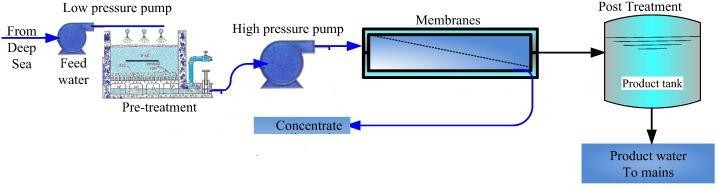
## Membrane Desalination

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.**

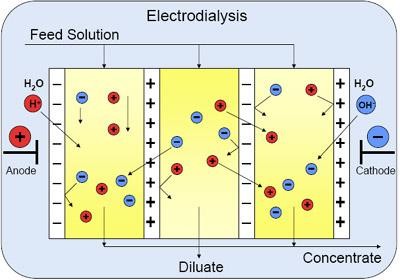
The traditional RO system includes main subsystems: pretreatment stages, mainly pump (high pressure), salt separation unit (RO membrane), and post-treatment system (relatively). The output salty water from pretreatment stages (that prevent scaling and fouling) forced by high-pressure pump across membrane 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].



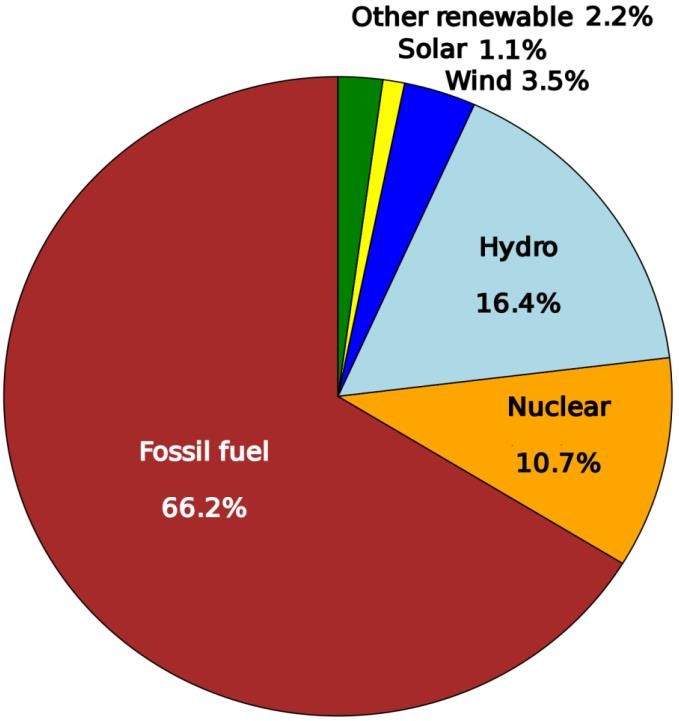
**Figure (1.11): Electrodialysis (ED) desalination technique, [10].**

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

## Trend to Renewable Energy

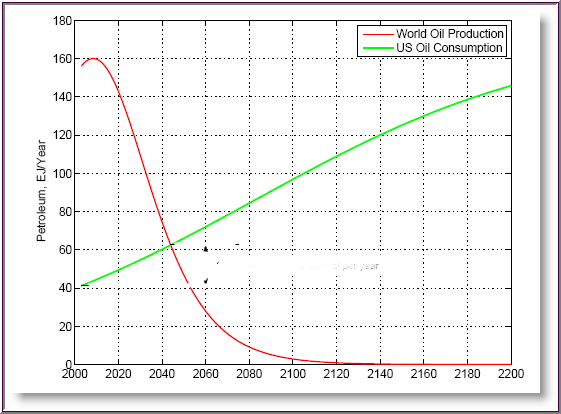
It is known that the sources of traditional energy for the production of electric energy in the world are divided as follows: the first place is fossil fuels by 66.2 % , the hydro energy is come in second place by 16.4 % and in the third place nuclear energy by 10.7 % while the renewable energy counts 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.

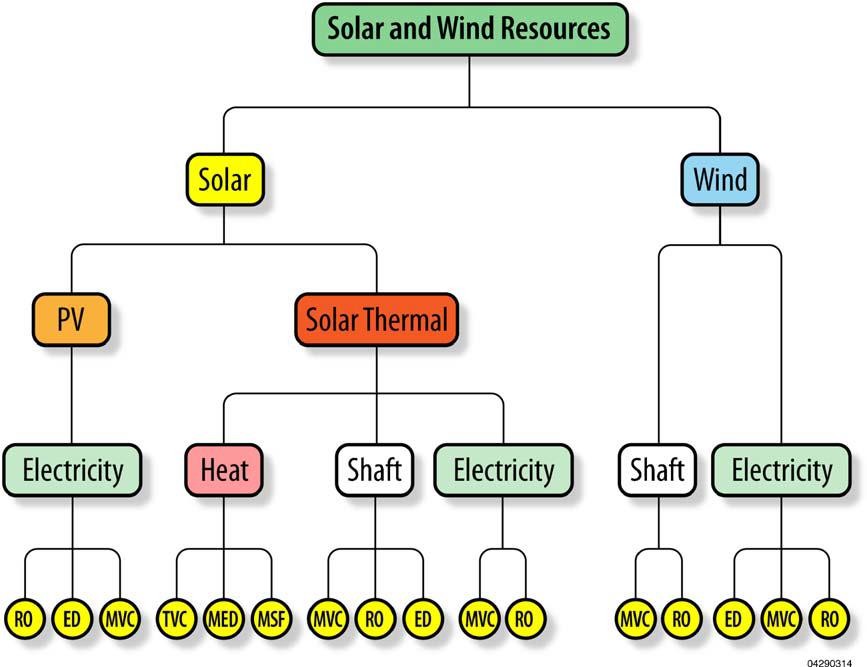
## Desalination Techniques Powered by Renewable Energy System.

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].**

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

Figure (1.15) shows the cost of desalinated water by m3 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.

**1.4**

**1.3**

**1.2**

**1.1**

**1.0**

**Production Cost ($/m3)**

**0.9**

**0.8**

**0.7**

**0.6**

**0.5**

**0.4**

**0.3**

**0.2**

**0.1**

**0.0**



**MSF MED MVC RO**

**Desalination Process**

**Figure (1.15): The cost of fresh water per m3 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].

**4600**

**Input Salinity = 3500 ppm Output Salinity= 500 ppm Recovery Percent = 70 %**

**4400**

**Energy Requirements (KJ/kg)**

**4200**

**250**

**200**

**150**

**100**

**50**

**RO**

**ED**

**Freeze**

**Vacume Freeze**

**MED**

**MSF-Vertical**

**VC**

**MSF- Horizontal**

**Single Solar Still**

**Desalination Process**

**Vertical tube evaporator distillation**

**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 m3, lower total energy consumption in KWh/m3 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.

**80**

**Performance Factor**

**70**

**60**

**Performance Factor (PF)**

**50**

**40**

**30**

**20**

**10**

**0**

**RO**

**ED**

**Freeze**

**Vacume Freeze**

**MED**

**MSF-Vertical**

**VC**

**MSF- Horizontal**

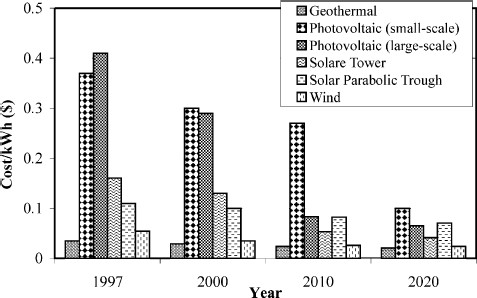
**Single Solar Still**

**Desalination Process**

**Vertical tube evaporator distillation**

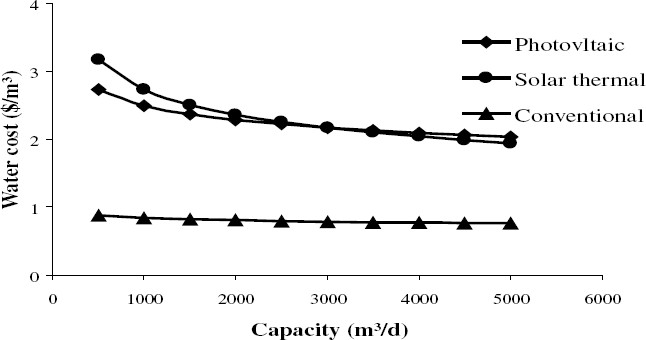
**Figure (1.17): Performance factor for different types of desalination techniques,[5].**

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.



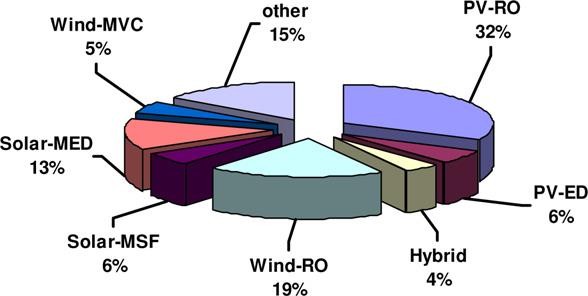
**Figure (1.18): Cost of various renewable energy resources for several years, [13].**

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*

## 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.

120



y = 0.9865x + 0.2391

110

100

90

**Thermocouple reading (°C)**

80

70

60

50

40

30

20

10

0

0 10 20 30 40 50 60 70 80 90 100 110 120

**Calbiration thermomemeter reading (°C)**

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

## 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).



**Calbiration flask reading (l/min)**

20

18

16

14

12

10

8

6

4

2

0

18

16

14

12

10

8

6

4

2

0

y = 1.0143x - 0.0395

20

**Flow meter readings (l/min)**

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

## TDS Meter (Conductivity Meter)

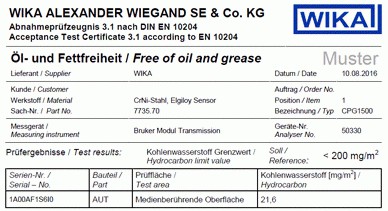
Figure (A.3) shows the calibration certificate for the TDS meter used in the experimental test rig.



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

## Pressure Gauge

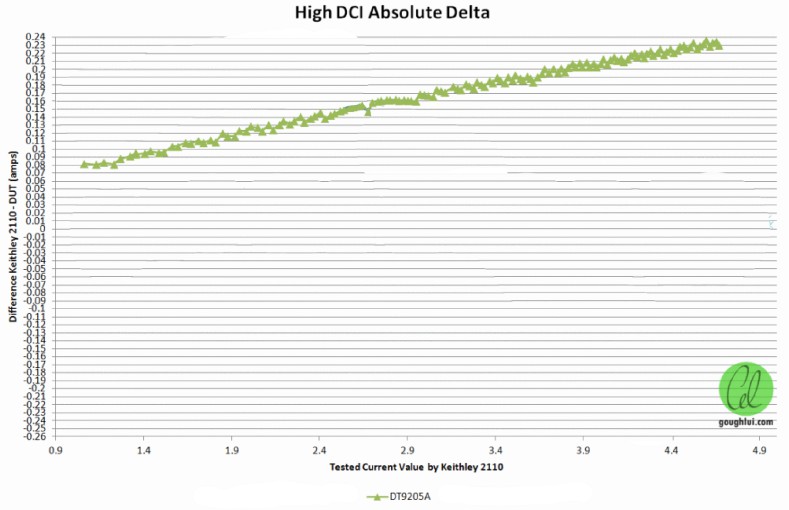
Figures (A.4) shows the calibration certificate for the pressure gauges used in the experimental test rig.



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

## Avo Meter

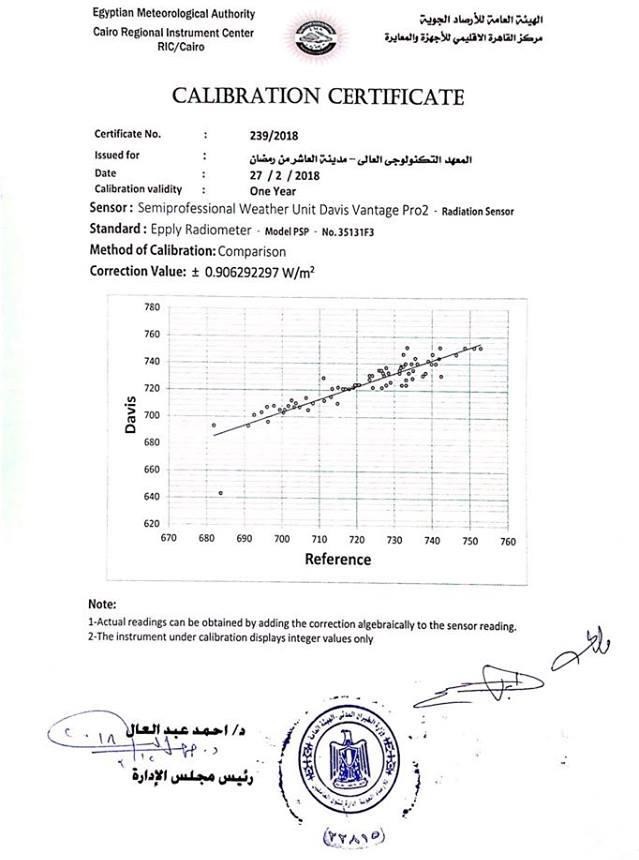
Figures (A.5) shows the calibration curve for avo meter used in the experimental test rig.



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

## Radiation Sensor

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



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