Ain Shams University

Faculty of Engineering

Electric Power and Machine Department

Analysis of Concentrated Photovoltaic (CPV) Performance as a Distributed Generator

M.Sc. thesis

by:

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Abstract

For the world problem which is the energy problem; renewable energy resources are being utilized in nowadays projects. From the applicable resources in Egypt are the wind and the solar systems. Due to the high solar irradiance in Egypt, the solar systems have the privilege. The solar systems are categorized into two; the solar thermal systems and the photovoltaic systems. The solar thermal transfers the sun-heat, while the photovoltaic transfers the sun-light.

Hence, the aim of this thesis is to generally investigate the solar energy systems, and to define the most efficient and of best benefit system for the location of Egypt, in order to model it and study its performance. From the search, the CPV system proved its efficiency, financial comparability with photovoltaic systems and also the best land utilization. So, the CPV is modeled in the Matlab. The main concern was to simulate the CPV system electrically and to build up DC to AC conversion system to study the performance of CPV in normal case and under different types of fault and sudden load. The electric system is CPV, which is connected to an inverter with LC filter; this system is connected in parallel with the network for a certain period of time, and then the network is disconnected and only the CPV system is supplying the load completely. In addition, PV system is modeled to compare its performance with the CPV system.

Keywords: Multijunction – InGaP/InGaAs/Ge – concentrated photovoltaic – concentration ratio – solar cell – concentration optics.

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Chapter 1

Introduction

The energy crisis in the world; which is the lack of non renewable energy resources as petroleum products, natural gas and coal; and on the other hand the increase in population all over the world and so more energy is needed. This problem can be solved by using renewable energy resources. So most of the recent researches are concerned with different ways and techniques; which can be used to generate electricity from renewable energy resources [1]. From these techniques are geothermal, wind energy and solar energy. Figure (1) represents the world planning for the energy generation planning in the year 2050. This planning indicates that solar and wind energy generation should have reached 32 % each. And according to figure (2) which illustrates the global solar irradiance in the whole world; the solar irradiance in Africa is the highest compared to other continents. In Egypt the solar irradiance varies from 1900 kwh/m^2 to 2700 kwh/m^2 as an annual sum and from 5.5 kwh/m^2 to 7.5 kwh/m^2 as a daily sum. And therefore, solar energy utilization is very vital for Egypt, in order to overcome the energy problem.

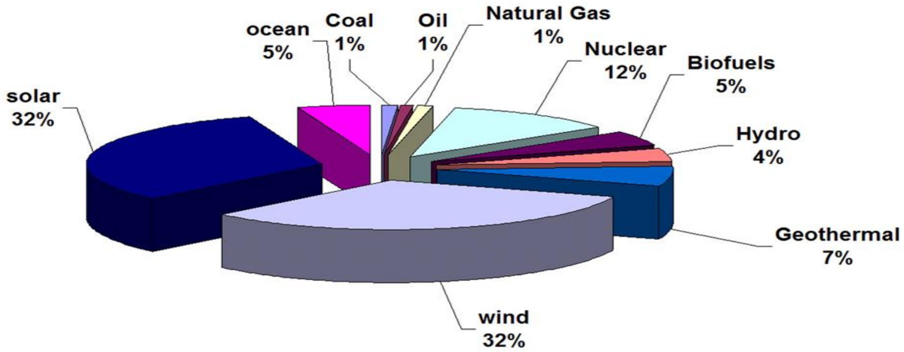

Fig. (1) The world planning for the energy generation

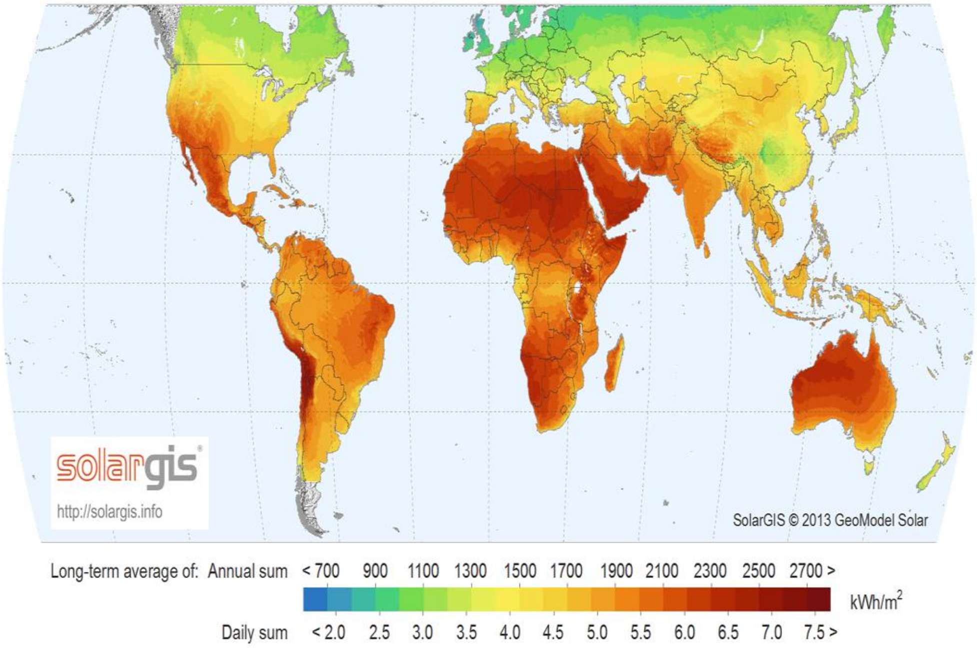

Fig. (2) Global solar irradiance

The solar irradiance can be utilized either by using the sun heat or its light. Using the sun heat is solar thermal systems, while the sun light is photovoltaic system. So, a survey was done on these systems in order to indicate the best system to investigate and study its performance in normal case and under different conditions.

Survey of the solar thermal systems shows, that four systems are efficient in the market. Those are domestic, parabolic trough, central receiver or solar tower, and parabolic dish solar thermal system.

1.1) Solar thermal systems:

1.1.1) Domestic solar thermal system:

The solar thermal module is place on the roof of the building; it absorbs the sun heat and transfers it to the water in the pipes and then this heated water in stored in tanks for the daily use. This system supplies heated water for the domestic use, and also saves the electricity or the natural gas that are needed for water heater.

1.1.2) Parabolic trough solar thermal system:

This system consists of parabolic reflector, absorber tube and solar field pipes. The parabolic reflector is parabolic shaped mirrors that reflect and concentrate the sun heat on the absorber tube which is placed in the center. These tubes contain synthetic thermal oil; which can be heated up to 400°C. This heated fluid is used to produce steam; this steam under high pressure and temperature rotates turbines to generate electricity.

1.1.3) Central receiver or solar tower thermal system:

This system is composed of solar tracking mirrors and solar tower. The solar tracking mirrors reflect and concentrate the sun heat on the solar tower. The solar tower can also be mentioned as central receiver or heliostat; which absorbs the sun heat. This solar tower contains molten salts or liquid sodium, because it can be heated up to 565°C; that produces steam and this steam under high pressure and temperature rotates the turbines and generates electricity.

1.1.4) Parabolic dish solar thermal system:

This system construction is parabolic mirror focusing the sun heat on a receiver. The focal center point or the receiver contains air; the fluid to be heated. The air in the receiver is heated up to 750°C. The receiver also contains stirling engine or micro-turbine. Therefore, the micro-turbine uses the heated air to generate electricity. And so, electricity is produced from this modular system. The advantage is that no needed for pipes or large turbines.

1.2) Photovoltaic system:

PV uses the sun light to generate electricity. The types of PV modules are single crystalline, poly-crystalline and thin film.

* Single crystalline has the highest efficiency, which varies from 15% to 20%. It is the most expensive among the three types of PV modules.
* Poly-crystalline has less efficiency from 13% to 16%, and its cost is less than single crystalline.
* Thin film such as amorphous module efficiency is from 7% to 13%, and it is the cheapest type of PV modules.

Researches and laboratory experiments are carried out on the photovoltaic system. And searching how to improve its performance and develop the system efficiency, and also enabling the system to work under high temperatures without affecting the system efficiency. Because single crystalline, poly-crystalline and thin film modules efficiency decreases in high temperature operation; there best efficiency is when working at 25°C.