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Review on Solar Thermal and Photovoltaic Energy System

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Abstract - *In this review solar energy system is compared, specifically solar thermal and solar photovoltaic system. Solar energy is highly grown over world-wide today because of its visibility, potential availability, and safe use for different application. In solar PV solar radiation is converted into electricity directly, while solar thermal (concentrated solar power) perform the conversion process indirectly. In concentrating solar power (CSP) plants, solar collector is used to concentrate the solar radiation to achieve higher temperature and there by higher efficiency at high irradiance. A PV system has the highest energy production since they are able to provide energy efficiently even at low irradiance. Photovoltaic system for energy production is the most favorable choice.*

Key Words: **Solar photovoltaic system, solar thermal system, efficiency, energy production, storage, radiation, solar panel.**

1. INTRODUCTION

Today the consumer's need for energy is increasing throughout the world because of population growth and industrialization. By 2035, high percentage of energy consumption will be produced by other energy sources in some developed countries [1]. Producing energy by traditional methods has a problem of more gas emission and accelerated global warming. Environmental pollution can be reduced in the future by using renewable energy. Photovoltaic technology is one used for conversion of sun radiation into electricity. Solar cell is the smallest unit of solar system, forms PV module, and PV module forms PV arrays. In hot countries solar cooling and refrigeration technology is used due to high amount of radiation [2]. In California, the first thermal power plant was built between 1984 and 1990, which proved the functionality of the technology, but the more significant dispatch only started around 2006,after a long stagnation. This technology is called concentrating solar power(CSP), since the solar collector used in these plants concentrate the radiation from solar in to have high temperature and there by higher efficiency[3].

Solar energy has good visibility, potential availability, and safe use for all users, so that it has gained the highest potential over the world-wide. The highest addition rate is solar PV according to [4] and the PV power installation and the related research increasing rapidly. Some market analyst expect that the installation of the PV could reaches 25% of generated energy by 2050[5], and in last year's the installation price of the PV system has been decreased by 50% [6]. For the installation of large capacity PV power system, price are commonly blow 1.79 $/W now. The PV system cost reduction was made by world-wide organization to make an economically competitive investment for long run [7]. Photovoltaic system connected with grid is competitive with most energy sources. There are many applications of solar power such as stand-alone and grid connected solar system for water pump [8], in building management systems [9], in micro grids, smart grid, and distributed generations [10], solar feeding of telecommunication towers which is cost effective specially for remote areas [11]. In the aspect of producing electricity photovoltaic system is the best, but non dispatchablity is the limitation of this system. Capital costs expectations of worldwide energy resources in 2025 compared to 2014is shown Fig.1 blow.

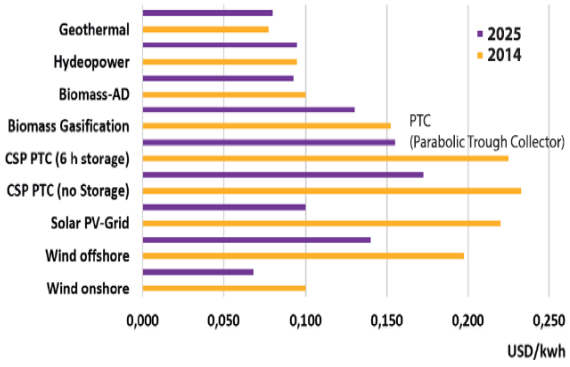

Chart-1: Various energy resources of worldwide capital costs expectations in 2025 compared to 2014[6].

2. CLASSIFICATION OF SOLAR POWER

This technology used as alternative source of energy, which is classified into solar thermal and photovoltaic system. The generated voltage from the PV can be directly used for DC appliances, and converted to AC form for AC appliances. Solar thermal is a promising technology indirectly generating electricity, which is applied particularly in high power generation plants.

2.1 Photovoltaic (PV) Solar power

The conversion of solar energy directly into an electrical form of energy by using PV cells is called solar photovoltaic (PV). Photovoltaic has numerous advantages over other

technologies such as quit energy conversion, easy design and installation, less maintenance requirement, easy transportation and light weight [12]. The research related to PV is currently concentrated on the improvement and solution for higher efficiency and lower price of panels and systems [13].

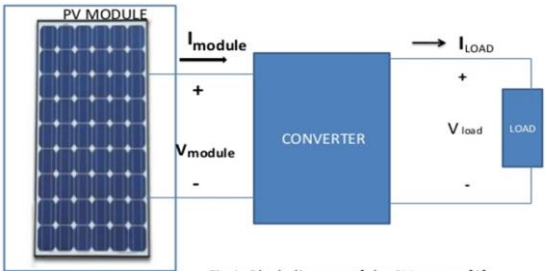

Fig.2. PV system block diagram

2.2 Concentrated solar power (CSP)

The CSP is known as indirect form of electricity generation. The solar radiation energy is converted into heat first, and then to electricity called thermal solar power. The tracking mechanism is used in CSP power system for concentrating solar radiation to heat a liquid, gas or solid. The CSP technology includes dish string, power tower, parabolic trough, Fresnel reflector [14]. Over 60% of application use long parabolic through system, this may achieve more than 25% efficiency. Photovoltaic is the second type of CSP system. It is categorized as indirect method because sun light is first concentrated, and then electricity will be generated. In hybrid configurations it is used because of concentrating steam power generator with other power plants for power when there is no light. Thermal is used for water heating, solar cooling and water desalination. Compare to other technologies, thermal system allows storing of energy for several hours.

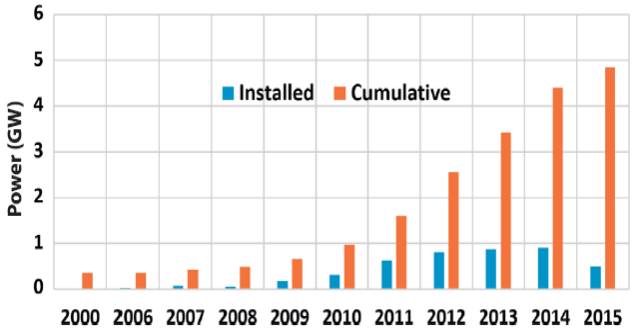

Chart-3: Worldwide CSP electrical generated energy evaluation [6]

Description on solar power systems

In this report photovoltaic power system and solar thermal were examined, and because of the large variety of non-concentrating collector and great differences with other types, three plants were chosen. That includes PV systems, ORC with flat plat collector, ORC with evacuated tube collector, ORC with evacuated flat plat collector, ORC parabolic trough collector. Efficiency has secondary importance in solar power plants, because fuels are not used. The efficiency mainly influence the required collector or module area to achieve a given nominal power, thereby also the specific investment cost, also the efficiency is not enough in determination of the prices since the different collectors have different cost for a given area. The specific energy production directly determines the expected revenues from the sold electricity, but payback period in its self cannot be determined because of cost variation in each plant types. Temperature has its own effects on the efficiency in PV system, and in solar thermal power plants this linear characteristics only applies to air cooled system, where the condensation temperature can follow the change in ambient temperature, the efficiency change if much less significant in case of water cooling. Efficiency is best at high irradiance in thermal power plants, and significantly decreases at lower irradiance due to irradiance dependence of the collector efficiency. Improvement in energy sustainability based on solar PV, risks in photovoltaic are installation costs; by considering the fact defines the opportunities address several global problems. Solar energy coupled with battery storage is technically simple to install and different level of deployment [15]. On solar system many papers was done on comparison by researchers such as; building integrated combined PV thermal with other building integrated solar technology [16], high performance photovoltaic module for net zero energy building systems application [17], discussion on advantages, limitation and application of photovoltaic thermal technologies in terms of performance parameters and efficiencies[18].

Photovoltaic system energy generation may be the best choice, but CSP offer the option of combined heat and power generation and storage of thermal energy, but not in PV systems. Electricity directly produced from the solar radiation in PV system, therefore only storage opportunity is the storage of electricity, commonly with batteries. The battery costs in photovoltaic system is very high, so that they does not have any storage capability; the output power is fully dependent on the weather, these makes the PV system to be not dispatchable energy source. Thermal energy storage is a low cost in solar thermal power plants and common storage possibility that allows dispatchable energy production the whole day. CSP has the advantages of dipatchablity, and unlike the non dispatchable generating unit's increase of spinning reserve do not necessitated.

3. CONCLUSIONS

Solar energy has potential availability, good visibility, and safe use for all users from small to large scales, so that it has gained high potential over world-wide. Many researches are done on solar system, and some of the literatures are reviewed here. Thermal and photovoltaic energy are the two types of solar system. Solar PV directly convert sun radiation

into electricity, were the storage battery is only the storage opportunity. Parabolic trough types of thermal power plants have high temperature capability with most economical storage. In solar thermal power plants, collector is used for capturing solar radiation at high irradiance to achieve high temperature and then efficiency. PV systems utilize efficiently even at low irradiance, so that they have the highest energy production, and the only important benefit of CSP over solar Photovoltaic power system is its dispatchablity.

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BIOGRAPHY

Ararso Taye was born in Oromia, Ethiopia in 1990. He earned his bachelor's degree in 2015 at Debre Markos University, Ethiopia in Electrical and Computer Engineering dept. Currently he is attending his masters degree in Power System at Parul University,India, and his main field of interests are renewable energy sources.