ICRANET2018-180143

PROPOSAL OF CANAL TOP SOLAR PV FOR EXTRACTION OF SOLAR ENERGY IN PAKISTAN

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Abstract

Pakistan is experiencing severe energy crisis from last decade due to rising population and heavy reliance on imported oil and gas. The geographical location and climatic conditions of Pakistan offers a high renewable energy resource potential mainly solar energy. Different methods for harnessing solar energy are roof top PV system, canal top PV system, floating PV system and ground mounted PV. In this paper canal top solar PV system is proposed for better efficiency and generation of clean and green energy. In canal top solar PV system PV panels are mounted on canal tops to reduce installation area, evaporation of water and growth of algae. Pakistan is agricultural country and has best irrigation system with long branches of canal. Results of experiments have shown that this type of installation on canal tops saves 9 million liters of water per MW per year and produces 1 MW energy per km.

Keywords*: *canal top solar PV; renewable energy; efficiency; land of use

1. INTRODUCTION

Pakistan is a rapidly growing economy with population of over 200 million people and needs of power generation is constantly rising. Pakistan uses reserves of fossil fuels to cater its needs of energy but due to limitation of these resources, difference between supply and demand of energy is rising. Pakistan currently has a shortfall of 5000-6000MW [1] and is expected to increase in coming years. Heavy dependence on imported oil increases energy prices in a country where per capita income is $1000 and 29.3% population live below poverty line [2]. Currently the share of hydro and thermal resources in electricity generation is 30.7% and 60.4% respectively as shown in Fig.1 [3].

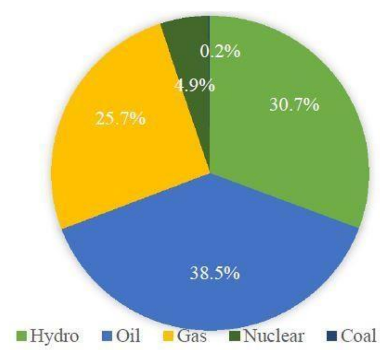

Fig.1. Percentage share in electricity production by different energy resources of Pakistan

Pakistan is richest in renewable energy sources mainly solar, wind, biofuel and biomass. Despite abundance of these resources, their contribution to energy mix of Pakistan is just above 1%. Renewable energy sources provide green and clean energy and help reduce greenhouse gas emissions. Pakistan has monthly average global irradiance of 18.64MJm-2 which can produce 2.334million MW of electricity per year [4]. Pakistan has installed Quaid e Azam Solar Park in least populated desert area of Lal Sohanra, Cholistan, Bahawalpur District having capacity of 100MW. Heavy dust storms in the desert increase the maintenance cost of plant hindering direct path of sunlight. Plant is located very far away from the population, power generated cannot be consumed locally and new transmission lines are required to integrate this power on to the national grid.

In this paper we will propose a relatively new concept of extracting solar energy using canal top solar PV panels. Canal top solar PV panel uses less area as compared to ground mounted solar panel and maintenance costs are low. Population near canals can easily access produced energy without long transmission cables. Pakistan is mainly an agricultural country that has rich irrigation system. This system will be utilized to generate green and clean energy over specified branches of canal in Pakistan.

2. METHODOLOGY

2.1 Resource Assessment of Target Site

2.1.1 Profile of place chosen

A rural community residing at a place called Setal Mari in District Multan, Punjab province in Pakistan is taken as a target site for canal top PV. Multan district has 4 Tehsils,534 villages and 4 towns. Population comprises of 42.2% in urban areas and 57.8% in rural areas [5]. Most population relies on agriculture for its needs. Setal Mari is located at 30° 11' 19N and 71° 31' 47E [6]. Grid and feeder's data at District Multan are used for the load profile. Setal Mari average energy consumption is 3300kwh/day with 443kw peak load in July and 300kw in month of January. Fig.2 shows seasonal load profile of Setal Mari.

2.1.2 Solar irradiation and clearness index

Data of solar irradiation and clearness index of District Multan are acquired from NREL (National Renewable Energy Laboratory) website, obtained values are plotted in Fig 3. Solar irradiation of 5.67kWh/m^2/d makes this place ideal to extract solar energy using canal PV system.

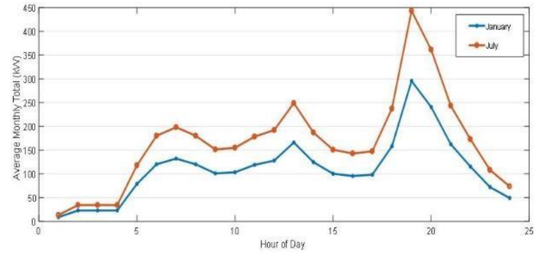

Fig.2. Seasonal load profile of Setal Mari

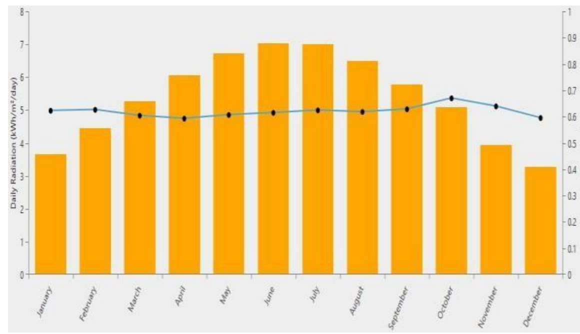

Fig.3. Solar irradiation and clearness index data at District Multan

2.2 Design types

2.2.1 Photovoltaic

Semiconductor devices that convert sunlight directly into electricity are called photovoltaic material. Semiconductors convert photons to electrical voltage. The process has no moving parts and does not produce any pollution or noise. PV panels must be placed in unshaded locations and are better efficient in hot weather conditions of Multan. Technological limitations, ambient heat, alignment with the sun and shading of panels due to extreme weather reduces PV panels efficiency. In canal top PV system, efficiency and power production of panels will increase due to cooling effect of canal.

2.2.2 Crystalline Silicon photovoltaic

Crystalline silicone PV cells are widely used for commercial purposes. CSPV are modules built using crystalline silicone solar cells(c-Si). CSPV have high efficiency making them an interesting technology where less space is available.

2.3 Design Assumptions

Following assumptions are made to calculate the cost of 1MW of power produced from canal top PV system.

- Steel frameworks should be wide with no center support.
- Spacing between frameworks will be approximately 25 feet.
- Steel frameworks foundation should be installed on canal banks.
- Underground cables and ductwork will be done near canal banks.
- Panels will be placed in near to NTDC transmission network to reduce cost of long cables for transmission.

3. PROPOSED MODEL

PV panel array is chosen to find feasible arrangement and setting for system. Fig.4. shows the proposed model for system. Specification of PV panel listed in Table 1 [5].

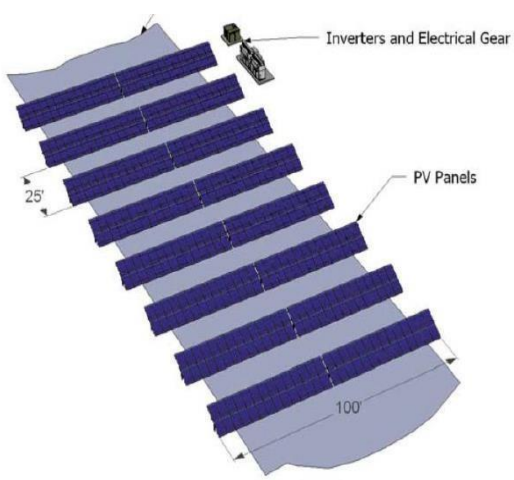

Fig.4. Proposed arrangement of Nau Bahar Canal top PV panels for 1 MW Capacity

Table 1. Specifications of the solar panel.

Panel length	0.35m
Panel width	0.30m
Type	Poly crystalline
Power rating	10 Wp
Voltage at Max Pont	17 V
Current at Max Point	0.59 A

The proposed section of Nau Bahar Canal is 900m and has a width of 100 feet as shown in Fig.5.

Fig.5. Proposed section of Nau Bahar Canal

The main constraint coming up with solar array is shading. Location of solar project receives only 5-6 full sun-hours per day, thus shading of panels that reduces incoming sunlight, must be minimum. Shading on one side of panel or module will reduce its power production to half, so shading must be avoided. In the proposed system, reflectors are placed in spaces between PV modules. By using reflectors, there is an increase in solar irradiation inducing on the panels. Rise in temperature is minimum due to the water present in the canal, providing cooling effect.

Reflector should be properly oriented to optimize the solar radiation falling on it. For that, an expression for x, which is the maximum distance covered by the reflected ray on the panel at a time, is derived as [5],

$$X = \frac{hsin(\alpha - t_r)}{sint_r \sin(2t_r + \beta - \alpha)} \quad (1)$$

Where,
d - Maximum distance covered by the reflected ray on the panel at a particular time
tr – Reflector tilt angle
α - Incidence angle
β - Tilt angle of panel

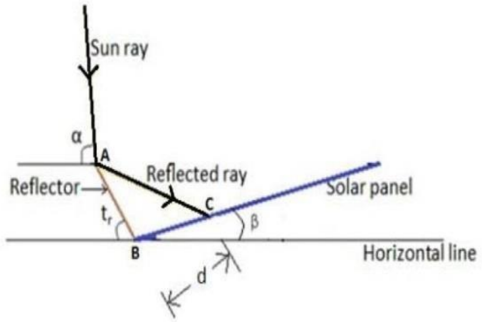

Fig.6.Reflector orientation

4. CHALLENGES

Several environmental and socioeconomic challenges are linked to canals. They are more prone to impacts of climate change. Canals are more vulnerable to increasing natural risks such as erosion of canal banks, extreme weather conditions, floods and droughts.

Challenges to be considered are

- Canal top PV installation could be costlier as compared to typical ground mounted PV.
- Transmission of power over large quantities of water is risky.
- O&M maintenance costs and responsibilities
- Canal embankment availability
- Increased loadings on canal embankments
- Public safety for maintenance workers
- Trespassing needs to be addressed through security, fences and barriers

5. ADVANTAGES

Installing canal top solar PV has technical benefits as compared to ground mounted or rooftop solar panel installation. Construction and development of canals infrastructure makes it ideal for canal top PV system. Road networks adjacent to canal provide easy access to installation area. Already built road network facilitates maintenance and construction of PV system. The proposed system saves valuable land and saves water for irrigation and other useful purposes. Capital is saved as no land is acquired and there are no resettlement or rehabilitation issues.

5.1. Better efficiency of solar panels

Canals provide natural cooling for the PV panels. PV module's performance varies with rise in operating temperature. Efficiency of PV module decreases as temperature increases and this change is different for various solar cell type and cell design. Typically, a standard crystalline silicon PV module loses about 0.4–0.5% of its rated power per ℃ increase in temperature [6]. Canal top PV modules will have lower operating temperature than ground mounted PV. Narmada project developers have calculated that the lower operating temperature of canal top PV system will increase its efficiency by 7% as compared to ground mounted PV. Long exposure under various stresses showed that even extreme conditions does not deuterates the high-level performance of canal top PV module [7].

5.2. Irrigation water savings

Canal top PV panels would reduce loss of water due to water evaporation. Rate of evaporation from flowing channels varies and according to the literature can take values as high as 5–20 mm/day [8].

To calculate loss of water, the amount of water evaporated per year is given as [9]

$$E = 4.57T + 43.3 \quad \text{-----(2)}$$

E – Evaporation (cm/year)

T – Yearly average temperature (°C)

According to results, 1MW plant of canal top solar PV approximately saves 9 million liters of water.

The actual amount of water saved depends on key parameters such as temperature and flow rate of water, how the modules are mounted, as well as the solar irradiance and air temperature at each location.

5.3. Strengthening of grid

Canal top PV provide clean and green energy generation at the doorstep of farmers. Reliability and strength of grid is increased by generation at remote consumption centers. Costs of transmission and distribution are widely decreased. Canals mostly run through rural areas where there is less electricity available and more power outages, this system will provide uninterrupted supply of electricity enhancing lifestyle of local community.

6. CONCLUSIONS

Canal top solar PV is an innovative idea that efficiently saves land and loss of water. It proposes an efficient administrative model for smart village, and irrigation of land.
Canal top PV system have better efficiency than ground mounted PV which increase overall life of system. The proposed system benefits canal sustainability by producing energy from renewable sources, causing no danger to nature protected areas. With reduction in installation of canal top PV, they are expected to have large share in solar energy production. Large capacity canal top PV systems may provide faster and more economical solution to problem of energy shortfall in Pakistan.

ACKNOWLEDGEMENT

I would like to thank ALLAH Almighty who helped me carry out this work. I would like to thank my supervisor Dr. Pervaiz Akhtar with his guidance, understanding and encouragement I was able to write this paper.

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