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Optimum Site Selection and Sizing of Distributed Canal–Top PV Plant Based on Load Flow Analysis

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ABSTRACT

The energy crisis has been increased over the year due to an increase in the population and expansion in industries. Pakistan has also been considered not only as an energy deficient country but also been considered as a country where the cost of energy production is at its peak due to the use of fossil fuels for energy production and less use of renewable energy resources for the production of electrical energy. To address these issues the use of renewable energy resources has become inevitable. This research is targeted to highlight the optimal location for the use of solar PV panels over the canal top for the production of Electrical Energy along with distribution techniques to energize the feeders and grid system. Different locations in different districts of Punjab over the branch canals and distributary have been short-listed and the performance of Solar PV panels over these canals has been analyzed for high efficiency. To develop small PV (solar-photovoltaic) plants in urban areas of Gujranwala division, and Rakh Branch canal, Faisalabad on top of canals or nullahs to energize various, industrial, residential, commercial, and agriculture zones. In this research, we identified six potential locations in the Gujranwala division and Rakh branch canal, Faisalabad along with the identification of closest grids and potential power purchasers while in the second step, it provided potential designs of models that can be considered suitable for deployment of small scale PV plants at the identified locations along with the financial analysis including estimated construction cost and the estimated tariff rate for selling power to the potential customer. This research has analyzed the situation of the National grid infrastructure in the project area and has proposed a design of a separate transmission system that can be used to effectively distribute power to industries and can easily be integrated into the National grid in the future. The establishment of a separate transmission system provides the flexibility of expansion in the size of the installed PV plant without upgrading the electrical network which otherwise becomes difficult in the case of national grid usage due to the limited capacities of feeders.

Keywords: *Canal-Top; Solar PV Panels; Renewable Energy Resources; High Efficiency; Land of Use*

RESEARCH HIGHLIGHTS

- This work aims at a quantitative assessment of the impact of canal top PV plant on the net electrical energy demand of buildings in Pakistan.
- 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.
- Performance assessment of a 10 MWp and 25MW canal-top Solar PV plant is carried out. For the distribution of power generated from the plant, 33KV transmission, and 11 kV distribution systems have been designed and analyze the losses from the PV plant to the load end.
- This study can help guide consumers and policymakers to reduce electrical energy demand.

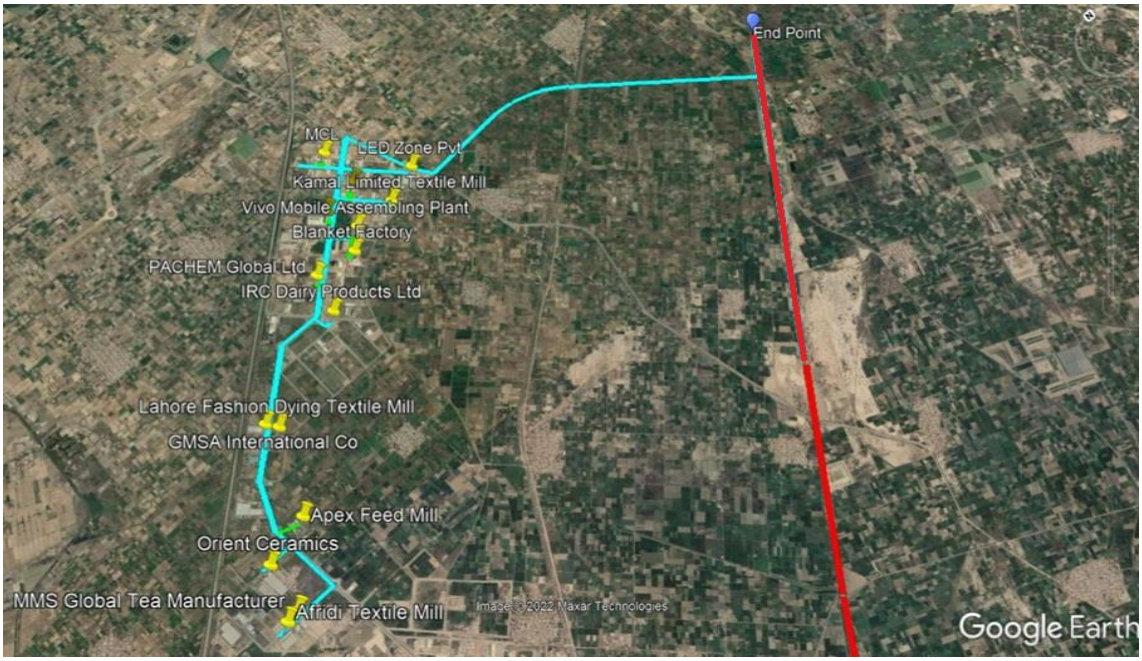
Research Objectives

The main objective of this research is to propose renewable to establish small solar power plants in congested urban and suburb areas of Gujranwala division as well as Rakh Branch Canal, Faisalabad. In these congested areas where land allocation for the development of

solar plants is a challenge, canals and nullahs were to be surveyed for the deployment of solar power plants. The power from these plants is proposed to be fed through 11 kV and 33kV lines to the residential, industrial, and/or commercial units.

Methodology

- A PV plant of size 25 MW is to be deployed on this distributary. For the distribution of power generated from the plant, 33 kV transmission, and distribution systems have been designed and analyzed in 'OpenDss' software.
- In this case, three 10 MVA transformers are used to transmit 8.7 MWp in three different directions. The power is directly stepped-up and stepped down from 440 V to 33 kV and vice versa without using 11 kV as an intermediate stage. The conductor used for transmitting power from the source to load is ACSR 'Panther'. The loss limit was set as +/- 5%.



- This analysis has been done on canal i.e end of canal an 8.7 MWp system will be deployed on nearly 12 km. A route that will be covered to distribute power to power purchasers is represented by a yellow place mark in the figure.

Results

- Transmission results along with their losses concerning their routes are given in the table.

	Location 5,Transmission at 33KV		Location 6,Transmission at 33KV	
Path/Route	Line Distance (KM)	Losses(KW)	Line Distance (KM)	Losses(KW)
PV Plant	0	0	0	0
Route 1	12	1.30%	10	1.05%
Route 2	4.7	1.34%	-	-

	Location 5, Transmission at 11KV		Location 6,Transmission at 11KV	
Path/Route	Line Distance (KM)	Losses(KW)	Line Distance (KM)	Losses(KW)
PV Plant	0	0	0	0
Route 1	4	4.07%	3.5	3.89%
Route 2	4	4.25%	4	4.01%
Route 3	4	4.37%	-	-

The future proposed system of transmit power at 132 kV towards the National grid.

132kV systems are used to transmit power up to 150 MW. For the pilot 10 MWp project, a 132kV line can be set up with minimum losses using Lynx ACSR which will be helpful in the future expansion of the installed PV plant. Setting up a transmission system at a higher voltage will result in the effective delivery of large amounts of power without the need for any major up-gradation in the transmission system.

In a 132 kV system, there is no need to fragment the large PV plant into small plants. The power-up to 150MW can be easily transmitted using ACSR or AAC conductors as per the grid code of Pakistan. For the sake of analysis ACSR 'Lynx' has been considered to deliver the power of 10MW along the route shown in figure 14. As 132 kV lines are used to transmit power of 40MW or above, the losses observed due to transmission of 10 MW power are negligible.

Findings

Canal top solar PV is an innovative idea that efficiently saves land and loss of water. It proposes an efficient administrative model for the smart industry and irrigation of land.

Canal top PV system has better efficiency than ground-mounted PV which increases the overall life of the system.

The proposed system benefits canal sustainability by producing energy from renewable sources, causing no danger to nature-protected areas. With the reduction in installation of canal top PV, they are expected to have a large share in solar energy production. Large capacity canal top PV systems may provide a faster and more economical solution to the problem of energy shortfall in Pakistan.

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