

**FEASIBILITY ANALYSIS OF CANAL TOP SOLAR-HYDRO PLANT BASED
HYBRID GENERATION**¹Sandeep M. Nair, ²Prof. S. A. MorkhadePG student, Dept. of Electrical Engg. GCE, Karad¹, Assistant Professor, Dept. of Electrical Engg. GCE, Karad²
nairsandeep0808@gmail.com¹, swapnamorkhade@gmail.com²**ABSTRACT**

With Increasing Energy demand throughout the world and limited availability of fossil fuel resources, there is a need to tap into non-conventional sources of generation. Renewable sources provide green energy and can be scaled up according to the availability of resource and demand of energy. Standalone Renewable Energy sources (RESs) like Wind Power, Solar Power etc. are subjected to intermittency and variability. A Hybrid plant of RES PV and Hydro plant can provide flexibility and Stable Power Supply. This Paper presents a model for study of Hydro PV Hybrid and further a software based Economic and Technical feasibility analysis of hydro PV Hybrid Plant is carried out. Through this study we analyse feasibility of a Solar-Hydro Hybrid plant and Techno-Economic aspects of Power Generation of a specific Hybrid plant with a case study on a specific existing Hydro plant with focus on maximum efficiency, less water usage and successful fulfilment of unit Commitment for Local Load. ETAP and Homer Pro software's are used for analysis.

Keywords: - Solar Canal, Micro-hydro, Grid Tied Inverter.**INTRODUCTION**

With blooming global economies, power demand is continuously rising. Parallel efforts are being taken to shift towards renewable energy sources for power generation (especially photovoltaic and wind power). Photovoltaic and wind power are highly intermittent and unstable when operated in standalone mode. Ideal choice is to compensate with variable nature of such sources by integrating it with existing flexible generation infrastructure such as Hydro-Electric plant which can provide flexibility to deal with such variations.

Since last few years, Northern parts of Maharashtra state have been frequently experiencing severe draught condition during summer. Various Micro hydro plants are operated on irrigation canal network. These plants work on, at its peak generation capacity during rainy season due to excess water while during summer season they operate on irrigation water outlet because of scarcity of water in the region.

Nature of Photovoltaic plant is a total conjugate to the Micro-hydro plant, PV plant are stable during summer while are subject to variation during cloudy and rainy season. Introducing photovoltaic plant to work in conjunction with micro-hydro makes the system more robust. To decrease cost of Transmission and capital cost, PV plant needs to be placed as close as possible to the Micro-hydro so as to use existing infrastructure e.g. Transformer to inject power to the grid.

As these Micro-Hydro Plants are located on irrigation canals, instead of placing PV plant on the neighboring land, PV Panels are mounted on irrigation canal in a Novel concept called Solar Canal which reduces Land Acquisition Cost and uses dead Space above the canal. Discrete Mathematical Simulation based optimization approaches are highlighted by (Jurasz & Ciapała, 2018), this research also takes water retention rate as a constrain, which is an important factor when the surface area occupied by the panels above water reservoir is large. Continuing the approach of above authors, in (C.Bendib, 2019), the authors introduced a different topology consisting of Renewable sources as Primary source and pumped hydro plant as storage system, adding energy storage to a hybrid system, increases its reliability and system stability, but overall cost of system and the

complexity of system increases multiple folds. The Breakeven index considering ROI for such a system may take longer span as the Net present cost during commissioning itself will be high.

Also recent studies have been carried out by (Zilong Yang, 2010) on grid operation mode; various algorithms to ensure stable operation of grid connected micro hybrid were explored. Further a Hybrid topology of Grid integrated system is developed by (Sweeka Meshram, 2013), this research study focuses on synchronization of renewable source with an existing hydro plant, but is less efficient as there are converters for each source separately, i.e AC source of Hydro is first converted to DC and then again to AC to sync both the sources. Recent Classifications, evaluation indicators and various sizing methodologies of Renewable hybrid plants are explored by (Jijian Lian, 2019).

An in-depth Modelling and multi objective modelling is pursued in reference (Fang-Fang Li, 2015), the methodology developed is generalized in nature, hence can be used in study of any specific hybrid plant.

PROPOSED HYBRID MODEL (HYDRO-PV) CASE STUDY

Case Study: -Hanuman Sagar Dam:

Wan Hydro Project Located in a hydro plant located on Hanuman Sagar dam, in Akola district of northern part of Maharashtra. A network of canal is established to deliver water to nearby farmlands. The annual generation capacity of the hydro plant is 4.174 Mus, the plant utilizes irrigation water for generation and is active 333 days round the year. Mean Rated Flow 7330L/S.

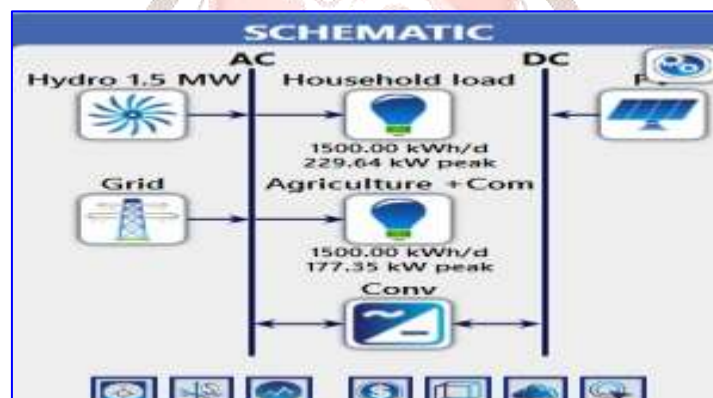


Figure1 Proposed Hybrid Model.

The System Consist of Existing Hydro plant supported by Grid, proposed system components includes PV Plant, DC Bus and a Converter. Local Loads is modelled by classifying broadly as Household Loads and a



combination of Agricultural load and community Load.

METHODOLOGY

Homer Pro Software and ETAP Software are used for Economical and Technical Feasibility analysis of proposed hybrid system. A simulation study based approach is followed, further optimization and modelling similar to generalized model by reference (Zilong Yang, 2010) is implemented on the existing plant of case study. Parameters taken for the analysis of solar are solar irradiation statistical monthly data along with average monthly temperature data for the specific location of dam and the canal pathway. Also a Model Similar to (Sweeka Meshram, 2013), is tested, with single current source controller and a grid tied PV Setup.

SOLAR IRRADIATION DATA: -

The Below Graph represents, available Solar Resource in location of study (Hanuman Sagar), the satellite data is imported through inbuilt resource mapping feature of (HOMERPRO, 2019). Software. Orange line on above graph depicts Clearness of sky and rain shadow region; cloud cover leads to significant drop in Photovoltaic based generation.

Figure 2. Hanuman Sagar –Wan Hydro plant geographic location

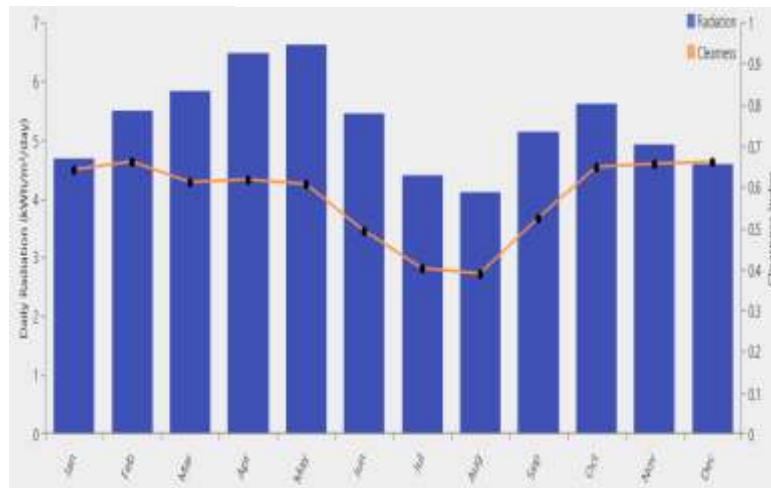


Figure 3. Solar Irradiation Satellite data

TEMPERATURE RESOURCE DATA

Temperate plays an important role in working of photovoltaic installations mounted on solar canal. Water evaporated from canals condenses on back of PV Panels, thereby providing passive cooling to the panels. Below graph represents the monthly statistic of the satellite data for the dam location.

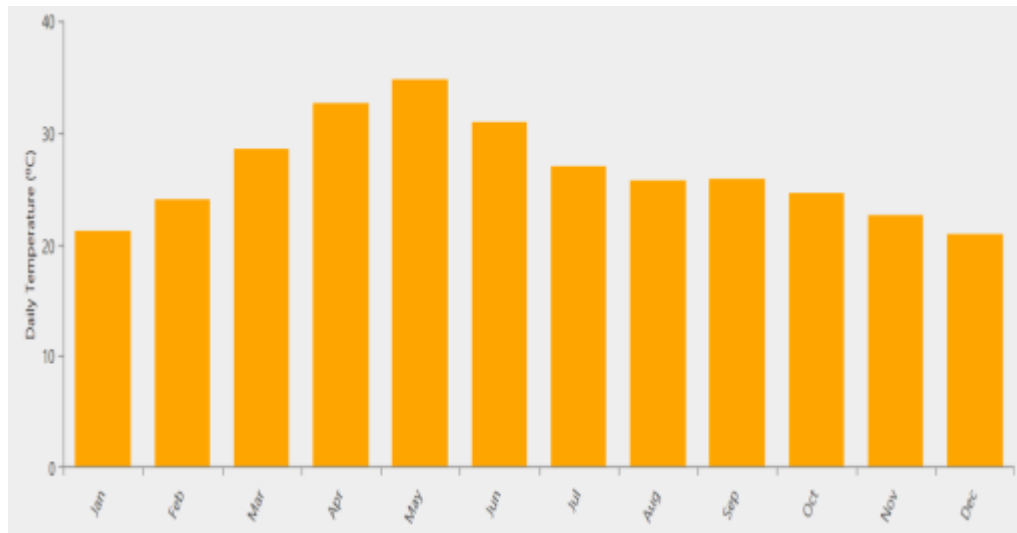


Figure 4 Temperature resource Satellite data

WATER RESOURCE DATA

The above Water Resource data shows the average flow rate round the year. The main canal includes water vent through spillway, water output from Power generation and irrigation water. Annually main canal of Wan hydroelectric project has rated flow rate of 7330 L/s. Flow rates decrease significantly during summer, and the water resource curve is replenished in rainy season.

Based on the data shown in figure 3, 4 and 5 simulation model is created and tested for the feasibility analysis.

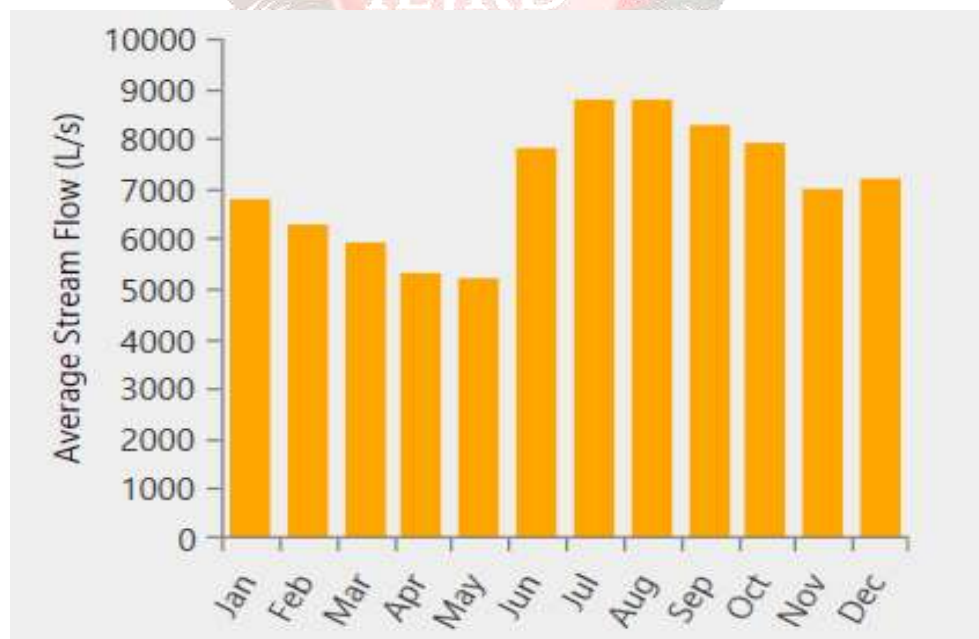


Figure 5 Monthly statistical data for water flow from dam

SIMULATION & TECHNICAL ANALYSIS ON ETAP SOFTWARE: --

Technical Analysis is carried by modelling proposed Hydro-PV Hybrid Plant and a model of Existing Hydro plant with grid support. Real and Reactive power flow is mapped throughout the network and the transactions with the grid and from proposed PV plant is metered.

The SLD represented in figure 6 is the proposed Hydro-PV hybrid plant. The above model is developed in Etap software, the Model consists of photovoltaic plant, hydro plant, connected load, metering and protective devices. To monitor energy transactions from grid and hydro -PV hybrid, metering setup is installed in prime points of networks

Existing System of Case Study includes, Hydro power plant with Grid Support, the present Setup is modelled in Etap as above. Circuit breaker connecting Proposed PV plant to Main Bus is opened, such that the proposed part is isolated out of the main network.

RESULT AND DISCUSSION

Technical Analysis: -

The above modelled system, when simulated without PV array, requires to buy electricity from grid to meet existing local load demand, while the PV Array is connected back to the Model, the system sells excess power to grid, hence turning the modelled system to a Grid connected self sufficient Micro grid. Which can transact with grid depending on the availability of the resource e.g. during rainy season, because of excess availability of water resource and Lower irradiation due to rain shadow /cloud cover, the system can run on existing hydro plant, conversely during summer, Generation through PV Panels can be prioritized using optimization algorithms.

Metering block modelled for above system manages the transaction with grid, generation through PV Panels, and Generation through Existing Hydro plant. The Hybrid System designed in this research study stands feasible and is in line with the results from case studies mentioned in literature. In Below Result, Red to Orange contour shows the load, green contours represent source. And blue contour reflects renewable source (I.e. PV source).

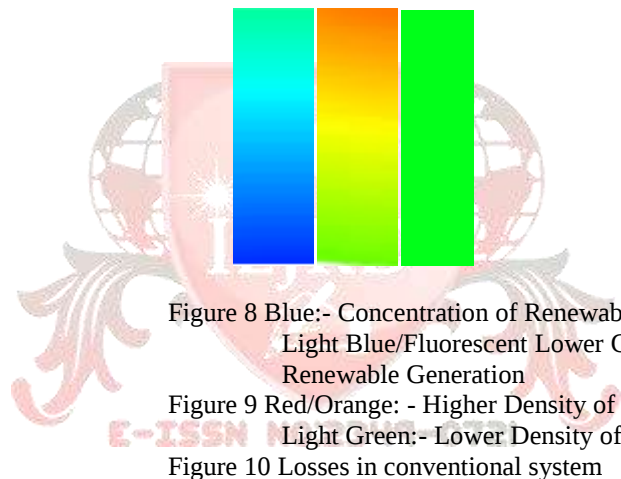


Figure 8 Blue:- Concentration of Renewable Generation.
Light Blue/Fluorescent Lower Concentration of Renewable Generation

Figure 9 Red/Orange:- Higher Density of Load
Light Green:- Lower Density of Load

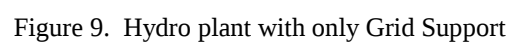
Figure 10 Losses in conventional system

HYDRO WITH PV AND GRID SUPPORT

Hybrid simulation of PV- Hydro plant, shows, that Local Load demand is satisfied and excess energy is sold to the grid. With conjugate nature of both plants in hybrid, the proposed system is more efficient.



HYDRO PLANT WITH ONLY GRID SUPPORT



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Breaker. Metering Section and protection schemes are in normal operation and no overloading of cables or device is noticed, which is important as Local load is modelled with a concentrated point source.

Technical Profile of Proposed Hybrid Plant:-

Local loads are met with unit commitment with surplus sold to the grid, Load Profile consisting of Local Loads represented by concentrated Lumped load and static loads standing for community load and agricultural load are met with their unit commitment. PV plants generation reflects generation during day time, the curve represents an averaged out output, with spikes in minutes scale. Hence during implementation phase a suitable waveform trimmer may be required. During simulation study same cables/ protective circuits used before implementing proposed pv plant was used and no overloading of Cable/gear is recorded in simulation report.

ECONOMIC ANALYSIS:

Financial analysis of the proposed plant is simulated on Homer Pro Software

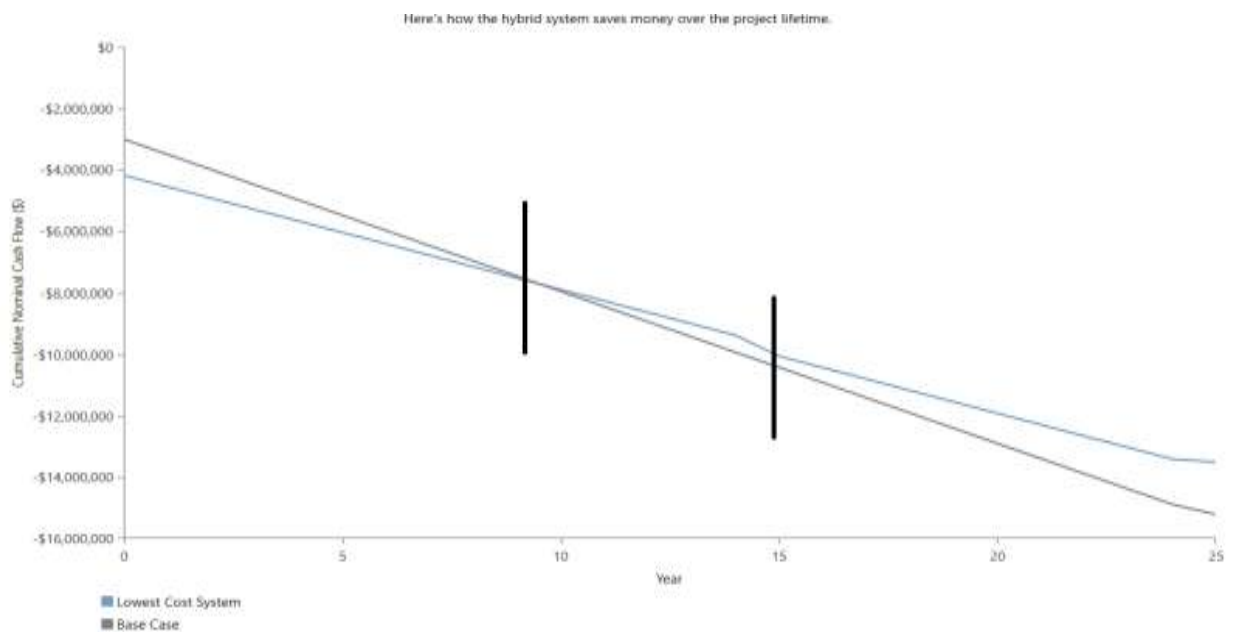


Figure 10 Economic Analysis

Even though NPC of the proposed system is higher than the base model, the simulation result reflects early break-even with trajectories of both models overlapping in 8 years and significant profit after 10 years. The operation and maintenance cost of base model is higher than the proposed plant. Converters are the weakest link in-terms of economy in-case of proposed plants. As converter failure may need replacement, hence in model replacement cost is considered.

Cost Summary

	Base Case	Lowest Cost System
NPC ⓘ	\$9.36M	\$9.05M
Initial Capital	\$3.00M	\$4.18M
O&M ⓘ	\$492,205/yr	\$377,030/yr
LCOE ⓘ	\$0.0647/kWh	\$0.0504/kWh

Table 1 Simulation Based Cost Summary

Base Case represents Existing Plant with grid support and proposed system is represented as Lowest Cost System. The cost of Energy is lower in case of proposed plant as it bypasses Grid side cost such as transmission line usage surcharge, lower maintenance cost due to conservative usage of distribution transformers connected to grid etc.

OBSERVATION



Figure 11 Electricity Production Rate

Hydro power in conjunction with proposed PV Plant satisfies unit commitment of local load and excess power is sold to the grid.

The amount retrieved through selling energy to the grid is not significant but the existing grid connection increases the reliability of the system as hydro- pv hybrid are conjugate sources of generation and in case of lower generation, grid acts as an added support.

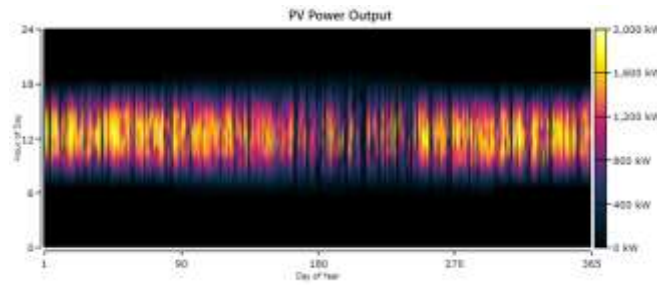


Figure 12 Daily PV Power Output

The Solar irradiation in region of case study, is high being in equatorial band, the above graph shows daily and annual Photovoltaic based power generation, daily the generation time ranges around 10am to 5pm while the irradiation satisfies the rated PV, fluctuation's are seen during rainy season as the region experiences cloud cover due to rain shadow region during June -august months.

CONCLUSIONS

Simulation data of proposed Hybrid system's successfully reflects fulfilment of per unit commitment and provides energy for lower COE. With the High Capital cost for initial installation of PV system (Photovoltaic panels/converters), and lower operational cost, leads to early break-even. And a Grid connection to Hydro -PV hybrid system increases system reliability. Additionally solar canals acts supports water retention and the canal water helps in cooling of PV Panels as temperature rises, evaporated water condenses on back of panel and Solar canal uses dead spaces for installation of PV Plant thereby leading to lower cost. Hence Solar Canal based Hydro-PV Hybrid with grid support is a viable option and will lead to penetration of renewable s into the main stream power system.

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