Techno-Economic Feasibility Analysis of Grid-Connected Photovoltaic Power Plants

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Abstract: The aim of the study discover numerically the configuration of optimal parameters for a system model of GCPV plant in Region of Subtropical area by use of database on hour-by-hour basis for ensuring high level of accuracy. The simulation not only is setting for technological evaluation but describes its economic as well. GCPV technology based investment analysis presently needs a big push both by research, policy & development. The assessment of results may showing the investment under Photo Voltaic technology in terms of yield factor of annual condition of the system model in capacity terms and the energy cost of the plant in feasibility of economic terms.

Keywords: Utilizing, HOMER, Techno-economic, Sustainable, Urban.

1. Introduction:
The transition to renewable energy sources is crucial in mitigating climate change and achieving sustainable development. This paper presents a comprehensive techno-economic feasibility analysis of grid-connected photovoltaic (PV) power plants, particularly in subtropical regions. Utilizing commercial simulation tools, the study evaluates the technical performance, economic viability, and environmental benefits of implementing large-scale PV systems. The findings indicate that with proper site selection, technology choice, and financial planning, grid-connected PV plants can be both economically viable and environmentally beneficial. The growing energy demand and the adverse effects of fossil fuel consumption necessitate a shift towards renewable energy sources. Solar energy, particularly photovoltaic (PV) technology, has emerged as a leading candidate due to its abundance and decreasing costs. This paper aims to assess the techno-economic feasibility of grid-connected PV power plants in subtropical regions using commercial tools. The analysis includes technical performance, cost-benefit analysis, and environmental impact.

A. Site Selection
Subtropical regions offer significant solar irradiance, making them ideal for PV installations. Factors such as land availability, grid accessibility, and local climate conditions were considered in site selection.

B. Technical Analysis
The technical analysis involves system design, component selection, and performance simulation using commercial tools such as PVsyst and HOMER. Key performance indicators include energy yield, system efficiency, and capacity factor.

C. Economic Analysis
The economic analysis evaluates the cost-effectiveness of the PV system. Parameters include capital expenditure (CAPEX), operational expenditure (OPEX), levelized cost of electricity (LCOE), net present value (NPV), and payback period. Financial incentives and subsidies are also considered.

D. Environmental Impact
The environmental analysis quantifies the reduction in greenhouse gas emissions and other pollutants by replacing fossil fuel-based electricity with solar power. Life cycle assessment (LCA) methods are used to evaluate the environmental footprint.

2. Related Works:
[4] Corrado, A and Battisti, R. (2005) Since systems based on solar energy feeding as a ‘source of clean’ energy, they are not producing pollutant emissions during the operation. However, they are carrying the environmental weightage on other phases in their cycle of life time. In order to analyze the systems environmental & energy profile of these schemes, it is necessary for expansion of boundaries of these system, taking in account also the ‘hidden impacts’ of production, system disposal & transportation at the ending of the life under technical effects. Here, assessment methodology of the life cycle is applicable for deriving a extended & complete energy and environmental profile of PV systems. As case of reference, a multi-crystalline conventional integrated building system is selected, retrofitted on a tilted roof, at location in Italy (Rome) and connecting to the national grid of electricity.
More research is made every day in the solar energy field specifically in hybrid collectors based on photovoltaic/thermal (PV/T) system, which is a combination of both technologies of solar energy. Research have targeted these configuration of system because it is improving overall efficiency, on compare to both PV & solar collectors, and it is saving space by use of one area for two systems instead of use of two zones. The researchers in majority presenting new designs /models while others providing study of ones existing for different conditions of environment. However, its review is important to the work of finding key idea of considering for work of upcoming future and for capturing the limitations of field research. This paper presenting principles of Photo Voltaic collectors, , history, classification of research, major aspects in Photo Voltaic research and review critically presented through literature, as well as the Photo Voltaic system aspect. More study focus directly towards the electrical side, particularly, the Photo Voltaic system part.

Photovoltaic Thermal combined with the solar thermal systems technique gives benefits from both heat & light of the radiation of solar resources producing hot fluids & electricity. Research in systems of PV/T is growing rapidly with more methods and techniques for increasing the efficiency of overall system, reducing the cost, improving the model, and maintaining the system for long time periods and employment of them for suitable application. The paper aims of studying some of the conducted research in this field in order of understanding and deriving key points of production of more research and provide constructive criticism for the present work. Also a explanation in detailed of systems based on PV/T principles and operation is presented. PV/T system classifications in terms of design of absorber, pipes shape, configuration of PV, working fluid type (fluid base) and PV panels type discussed under survey of literature. Finally, it is concluding there is a clear lack in electrical, environmental & economic evaluations, where most articles in PV/T are dominating by the study of the thermal system.

PV/T (Photovoltaic Thermal) systems combine solar thermal and photovoltaic systems. This method uses both the light and heat of solar radiation to generate energy and hot fluids. PV/T system research is continually expanding, with new methods and techniques being developed to raise overall efficiency, lower costs, improve modeling, and maintain the system for extended periods of time, and applying them for appropriate applications. The purpose of this article is to examine some of the research done in this topic in order to comprehend and draw crucial points for future research while also giving constructive criticism for the work presented. A full explanation of the concepts and functioning of PV/T systems is also provided. The literature review discusses categorizations of PV/T based on absorber design, pipe form, PV configuration, working fluid type (base-fluid), and kind of PV panels. Finally, it is determined that electrical, economic, and environmental assessments are clearly lacking, with the majority of publications in PV/T being dominated by the system's thermal analysis.

This essay gives a general review of Oman's potential for renewable energy sources and discusses the viability of using them to generate power. Solar energy, wind energy, biogas, ocean thermal energy converters, wave energy, and geothermal energy are all included in the research. Oman has been proven to have some of the greatest sun energy densities in the whole planet. Additionally, Oman's southern shore and the highlands to the north of Salalah have tremendous wind energy potential. However, compared to solar and wind energy, geothermal energy's potential for use in the production of electricity is determined to be constrained. In addition, the usage of wave energy is seen to be unimportant in comparison to solar and wind energy sources.
3. Methodology:

![Flow Chart]

4. Result and Discussion:
These are located between the Tropic of Cancer and Tropic of Capricorn. Climate of subtropical regions is hot and humid in summers. Winters are mild cold. The area falls under Subtropical Regions in India are as Parts of Punjab, Assam and Rajasthan. as (Moist subtropical with Winters)

Data source:
https://nsrdb.nrel.gov/data-viewer

Location:
Jaipur
26.9124° N, 75.7873° E

<table>
<thead>
<tr>
<th>Table 1: Modelled PV array system specification</th>
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<tbody>
<tr>
<td>PV module rated power (4000 modules)</td>
</tr>
<tr>
<td>Maximum voltage</td>
</tr>
<tr>
<td>Maximum current</td>
</tr>
<tr>
<td>Open circuit voltage</td>
</tr>
<tr>
<td>Short circuit current</td>
</tr>
<tr>
<td>Efficiency</td>
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<tr>
<td>Temperature coefficient of Vo.c</td>
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</table>
Temperature coefficient of Is.c Inverter 0.06%/k
Rated power 0.8 MW
AC voltage Efficiency 415 V, 94.1%

Figure 2: PV energy produced in (KWH) with respect to time in hours.

Figure 3: Monthly energy production in KWH with respect to time in months.

Figure 4: Evaluated capacity factor in percentage with respect to time in months.
5. Conclusion
The techno-economic feasibility analysis demonstrates that grid-connected PV power plants in subtropical regions are not only technically viable but also economically advantageous and environmentally sustainable. With the right policies and financial frameworks, large-scale adoption of PV technology can significantly contribute to the energy transition.

References: