

SIMULATION OF SOLAR PANELS TO IMPROVE ENERGY EFFICIENCY

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Introduction

In recent years, the demand for renewable energy sources has significantly increased due to global concerns over environmental sustainability and the depletion of fossil fuels. Among the various renewable sources, solar energy stands out as one of the most promising and widely accessible options. This thesis focuses on the simulation of solar photovoltaic (PV) systems to enhance their efficiency and reliability under different environmental conditions.

Introduction: Solar panels convert sunlight into electrical energy through the photovoltaic effect. However, the efficiency of solar panels can be affected by several factors such as irradiance, temperature, shading, tilt angle, and orientation. To study and improve the performance of solar PV systems, simulation plays a crucial role. By using simulation tools, it is possible to predict the behavior of solar panels without the need for expensive and time-consuming physical testing.

The main goal of this thesis is to model and simulate solar PV systems to find the most efficient configurations for different scenarios. The study aims to reduce energy losses, increase output power, and support the integration of solar systems into residential and industrial applications.

Simulation Tools and Methodology: Two widely used simulation tools, MATLAB/Simulink and PVsyst, were employed in this research. These programs allow for detailed modeling of solar panels, including the effects of varying irradiance, temperature, and system layout. Simulations were conducted for different geographic locations, seasonal variations, and panel parameters.

Key steps in the simulation process included: Modeling the solar cell using a single-diode or double-diode equivalent circuit.

Inputting real solar radiation and temperature data.

Adjusting the tilt angle and azimuth orientation.

Analyzing the output parameters: voltage, current, power, and efficiency.

Results and Discussion:

The simulation results revealed that panel orientation and tilt angle have a significant impact on the energy output. In optimal conditions, a tilt angle equal to the local latitude provided the best results. Seasonal adjustments further improved performance. Additionally, the use of Maximum Power Point Tracking (MPPT) algorithms within the simulation improved the efficiency of the energy conversion process.

By comparing different scenarios, it was observed that energy output could be increased by up to 20% simply by optimizing installation parameters based on simulation outcomes.

Simulation results indicate that panel orientation and tilt angle significantly impact power generation. A fixed tilt angle close to the location's latitude provides optimal year-round performance. Implementing MPPT improves energy extraction efficiency by tracking the optimal voltage and current. The data also shows that using tracking systems further enhances energy output by 10–20%. Seasonal simulations revealed that summer months yield maximum production, while winter performance can be improved by adjusting angles or using bifacial panels.

Conclusion:

This thesis demonstrates the crucial role that simulation plays in the design, optimization, and implementation of solar photovoltaic (PV) systems. By utilizing powerful tools such as MATLAB/Simulink and PVsyst, various environmental and system parameters were analyzed to assess their influence on solar panel performance.

The study shows that factors such as tilt angle, orientation, temperature, and irradiance significantly affect energy output. Through simulation, it was possible to test multiple scenarios and identify the most efficient configurations without physical installation. Techniques like Maximum Power Point Tracking (MPPT) were also shown to greatly enhance system efficiency, making solar energy more viable and competitive.

The results indicate that careful simulation and parameter optimization can increase energy production by up to 20%. This improvement contributes not only to reducing dependency on fossil fuels but also to advancing sustainable energy solutions.

In conclusion, simulation is not just a theoretical tool—it is an essential step in planning cost-effective, high-performance solar energy systems. As the demand for clean energy continues to grow, simulation-based approaches will become increasingly important in shaping the energy infrastructure of the future.

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