ENERGY ACCUMULATION FROM SOLAR PANELS AND FORECASTING MODELS FOR ENERGY PRODUCTION USING ARTIFICIAL INTELLIGENCE

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Abstract: This paper explores the process of energy accumulation from solar panels and the possibilities of analyzing energy production through forecasting models using artificial intelligence. The efficiency of photovoltaic systems is influenced by various external factors, such as solar radiation, temperature, dust levels, and seasonal variations. Considering these factors, the feasibility of predicting energy output using artificial neural networks, regression models, and machine learning algorithms is examined. Furthermore, the efficiency of modern energy storage technologies like lithium-ion batteries and supercapacitors is discussed. Research shows that implementing AI-based forecast models helps to properly manage energy reserves and reduce grid load.

Keywords: Solar panels, energy accumulation, artificial intelligence, forecast models, energy efficiency

Introduction

In recent years, the demand for solar energy has significantly increased. Global warming, the need to reduce carbon emissions, and international commitments to implement renewable energy sources have considerably enhanced the role of solar panels. Photovoltaic (PV) panels directly convert solar radiation into electrical energy. However, these systems are intermittent—meaning they only generate energy during daylight.

Therefore, it is essential to store the generated energy for later use, especially during the night or on cloudy days. At the same time, predicting energy production, i.e., forecasting the amount of energy based on future solar radiation, plays a crucial role in balancing the power grid load.

Modern approaches rely on artificial intelligence (AI) technologies, offering advanced methods for managing solar energy production and storage. This paper is dedicated to analyzing these technologies.

Main Content

1. Operation Principle of Solar Panels

Solar panels consist of photovoltaic cells that generate electric current through the photoelectric effect when exposed to sunlight. The amount of energy produced depends on solar irradiance, ambient temperature, panel orientation, dust accumulation, and other external factors.

Main components of a solar panel system include:

- Photovoltaic cells (usually silicon-based)
- Glass protective layer
- Inverter (converts DC to AC)
- Monitoring system

Due to the intermittency of solar power, energy storage becomes a necessity.

2. Energy Accumulation Systems

Energy accumulation refers to storing produced energy for later use. The most widely used storage technologies for solar energy include:

Lithium-ion   batteries
Known for their high energy density, long service life, and rechargeability. Widely used in small to medium-scale solar systems. However, they are temperature-sensitive and expensive.
Supercapacitors
Capable of storing and discharging large amounts of energy quickly. Suitable for voltage stabilization and frequency control but not long-term storage.
Pumped   hydro   storage   systems
Used in large-scale power plants. Excess energy pumps water to a higher elevation, which is later released to generate electricity through turbines.
If not properly managed, energy storage systems can result in losses or failure. Hence, predictive models are critical.

3. Forecasting Solar Energy Production Using AI
AI, particularly machine learning methods, is widely used to forecast solar energy production. These models rely on data such as:

Historical solar irradiance
Temperature and humidity
Cloud cover
Panel tilt angle
Panel performance metrics
Commonly used algorithms include:
Artificial Neural Networks (ANN) – Predict energy generation based on radiation and other variables
Random Forest – Tree-based ensemble algorithm evaluating multiple variables
Support Vector Machine (SVM) – A high-accuracy classification model
Long Short-Term Memory (LSTM) – Neural networks suitable for time-series data

Studies (Yang et al., 2021) show that ANN models can forecast daily solar energy production with over 90% accuracy.

4. Model Outputs and Practical Applications
AI-based forecast models enable:

Prevention of battery overcharging
Timely connection to the energy grid
Accurate estimation of stored energy
Efficient system control with minimal energy loss

For example, SmartGrid-integrated solar energy systems with AI support enable real-time monitoring and optimization. As a result, overall energy efficiency improves by 15–20%.

Conclusion
Efficient storage and utilization of energy from solar panels are critical for the stable operation of energy systems. With energy storage technologies, solar power can be used even during cloudy days or nighttime. However, effective operation of these systems requires accurate forecasting of energy production.
AI-based forecast models allow real-time monitoring and control of production, storage, and grid load, enhancing both energy efficiency and system reliability.
Future research should focus on developing new AI models, integrating with IoT devices, and evaluating economic efficiency.

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