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PV production forecasting using machine learning and deep learning techniques: Albanian case study

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Keywords
Solar power
Photovoltaic plant
Machine Learning
Deep Learning

Abstract

The increasing use of solar power as a source of electricity in Albania has led to increased interest in energy production forecasting. In this paper is done the forecast of energy production of 518kW photovoltaic plant installed on the terrace of a factory in Tirana. Using this information, the factory can intelligently plan their energy consumption over the coming hours. So, they can increase the rate of self-consumption and even cut their energy bills through greater independence from the grid. To perform the forecast is used a database which provides historical data of energy production, irradiation, ambient temperature, modules temperature and wind speed every 5 minutes for a year (01/01/2021-31/12/2021). The quantities are measured by some sensors which are installed at PV plant. Different machine learning algorithms, including Multiple Linear Regression, Polynomial Regression, Decision Tree Regression, Random Forest Regression, Support Vector Regression, XGBoost and Neural Network with LSTM layer are considered in the study. Using the proposed models, solar energy production for the following hours can be forecasting. Various comparative performance analysis based on the mean absolute error, mean square error, root mean square error, median absolute error, explained variance score and R2 score, between these techniques are provided in this paper.

Introduction

Until now in Albania are installed different PV plants, for example Koorporata Elektroenergjetike Shqiptare (KESH) has completed construction of a 5.1 MW PV facility at the Qyrsaq dam in Vau i Dejës, in Shkodër city, northwestern Albania. The solar park is expected to generate 7,000 MWh per year and operate in combination with the hydropower plant. The economic advantages of these systems are the optimization of installation and operating costs by bulk buying and the cost effectiveness of the PV components and balance of systems on a large scale. In addition, the reliability of centralized PV systems can be greater than distributed PV systems because they can have maintenance systems with monitoring equipment, which can be a smaller part of the total system cost. Furthermore, in Albania are installed many rooftops PV system, one of them is the case of the study of this paper. The increase use of solar power as a source of electricity in Albania has led to increased interest in energy production forecasting. Using the information generated from PV Plant sensors, factories can intelligently plan their energy consumption over the coming hours [1-3]. So, they can increase the rate of self-consumption and even cut their energy bills through greater independence from the grid. Different machine learning algorithms including Multiple Linear Regression, Polynomial Regression, Decision Tree Regression, Random Forest Regression, Support Vector Regression, XGBoost and Neural Network with LSTM layer are implemented to forecast energy production

of 518kW photovoltaic plant installed on the terrace of a factory in Tirana [4-7]. Using these algorithms solar energy production for the following hours can be forecasting.

Material and Method

To perform the forecast is used a database which provides historical data of energy production, irradiation, ambient temperature, modules temperature and wind speed every 5 minutes for a year (01/01/2021-31/12/2021).

Table 1. Parameters taken from photovoltaic plant

Parameters	Values
Ambient Temperature	°C
Wind Speed	m/s
Irradiation	W/m^2
Module Temperature	°C
PV Production	Wh

The forecasting is carried out using Python programming language with various library functions such as scikit-learn, keras, pandas, tensorflow and numpy. Different machine learning algorithms are considered in this study Linear Regression, Polynomial Regression, Decision Tree Regression, Random Forest Regression, Support Vector Regression, XGBoost and Artificial Neural Network with LSTM layer.

Results

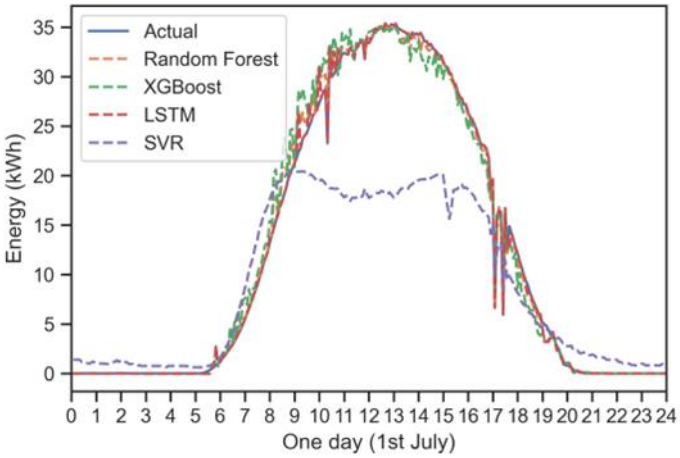

Figure 1. Short-term PV production forecasting

Short term PV production forecasting is performed using data from 1st day of July 2021. Forecasting results are shown in Figure 1. Support Vector Machine is seen to be the last accurate method for PV production forecasting compared to other machine learning and deep learning methods. Random forest regression, XGBoost and LSTM are the best machine learning method for predicting PV production in one day.

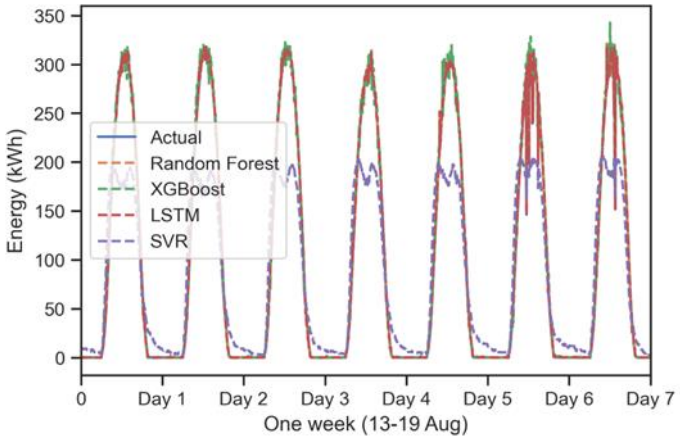

Figure 2. Medium-term PV production forecasting.

Medium-term PV production forecasting is performed using data from one week of August (13- 19 August 2021). As shown in figure 2, even in this case support vector machine seems to be the less appropriate method for medium- term forecasting.

Discussion

Table 2 gives detailed information about the performance of each of the methods used based on some performance metrics such as mean average error, mean square error, median average error, explained variance score and R^2 Score.

Table 2. Performance metrics

	Mean average error	Mean square error	Median average error	Explained variance score	R^2 Score
Decision Tree Regression	0.1089	0.07279	0.00737	0.92673	0.926737
Random Forest Regression	0.09607	0.05667	0.00772	0.94283	0.94283
Linear Regression	0.16511	0.08213	0.077	0.91734	0.91734
Polynomial Regression	0.14939	0.07557	0.06238	0.92395	0.923945
XGBoost	0.10038	0.05702	0.01044	0.94262	0.942614
Support Vector Regression	0.12765	0.07103	0.08057	0.93056	0.930353
Long Short-Term Memory	0.10664	0.05753	0.02335	0.94194	0.94188

The smaller the mean average error, mean square error and median average error the more accurate is the method for forecasting PV production. The higher the explained variance score and R^2 Score the more suitable is the method to forecast PV production.

Conclusion

An analysis of the potential impacts of weather parameters on PV power prediction reveals that the ambient temperature, irradiation and module temperature impact energy output, whereas wind speed appears to be a less significant dominating factor of PV power prediction. For the short-term energy generation forecast, the irradiation condition is the most important parameter. A comparative analysis using various machine learning and deep learning approaches, including Linear Regression, Polynomial Regression, Decision Tree Regression, Support Vector Regression, XGBoost Random Forest regression and Long Short-Term Memory, showed that Random Forest, XGBoost, LSTM performs better than the others in predicting the energy.

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