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A Review of Time Series forecasting Techniques: Predicting Solar energy using AI and Statistics Techniques

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Abstract

The overuse of fossil fuels and their detrimental effects on the environment must be considered in the current electrical energy crisis scenario. This promotes sustainable development by encouraging the use of renewable resources. The overall capacity of the energy systems was enhanced by adding such unpredictable renewable energy sources; however, the design of these hybrid systems is extremely important, which is why many academics have come to trust this area. Normally, in order to advance sustainable growth in the current electrical market, renewable resources like solar energy have been integrated into existing grid systems, but such systems have faced numerous challenges in terms of energy management. Energy management in solar-integrated electric grid systems is challenging because of a number of factors, such as temperature, wind speed, air pressure, and precipitation, that have erratic and volatile properties, and all such factors impact solar energy generation. Further, due to this, the power grid may become unstable if all of these unstable variables are disregarded, as voltage fluctuations may arise. In order to handle all of this, solar energy prediction is necessary so that the required actions can be taken based on the data available for renewable energy. Hence this paper reviewed the articles on statistical and AI-based solar irradiance forecasting in order to provide classifications for employees based on the situation.

Keywords: *Solar Energy, Statistical and AI-based Solar Irradiance Forecasting.*

Introduction

Recently, significant improvements have been made to the electric power industry in order to increase efficiency. A more intricate network must result from that as well. Therefore, in this new environment, enhancing the power system's performance is becoming more and more crucial. However, businesses in the energy markets seek to send as much electricity along transmission networks as they can in order to

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maximize revenues. Transmission lines are become increasingly crowded as a result, and power systems are often operating extremely close to their boundary conditions. However, as today's power market transactions are directly impacted by the energy transfer capacity of power lines, the expansion of the electrical network is becoming more and more significant.

Further, electric utilities controlled the system's voltage and frequency centrally, and electric power systems used to generate energy in response to demand. It is projected that in the future, renewable energy generation facilities such as wind and solar energy would account for even more than 20% of global energy production, but numerous nations have already begun the process of decarburizing their power systems and incorporating them into their current systems [1].This typically led to power imbalances because the system was unable to precisely calculate and regulate the total amount of power generated in real time.

As renewable energy sources rapidly permeate the current power grid, demand-side management will likewise become more and more important in modern power system networks [4–8]. Such important systems will continue to be used globally as a paradigm shift occurs away from traditional centralized control of dozens of power plants and towards decentralized management of millions or billions of loads to balance energy supply and demand. All such systems suffered from the drawback of energy management. Thus, studies in this area are currently being conducted. There are also a non-renewable energy sources that is being used up faster than it can be created. Due to the rising cost of fossil fuels and their potentially dangerous environmental effects, there has been a noticeable increase in interest in utilizing this solar energy in recent years [9].

Hence, solar energy is considered a promising replacement for fossil fuels. But due to existence of various variables including precipitation, temperature, wind speed, and atmospheric pressure, it exhibits intermittent and volatile characteristics [10]. If all such unstable variable are ignored, voltage fluctuations may result that must be lead to instability in the power grid [11]. In contrast to this, if conventional power networks are integrated with renewable energy sources a precise balance between the supply and demand of electricity is necessary.

But in reality, maintaining this balance with conventional energy producing technologies can be difficult, especially in small or remote electrical networks. The electrical system's reliability is thus determined by its ability to withstand expected and unplanned variation and interruptions while maintaining a standard

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and progressive level of service for such consumers. The power system is unstable and has problems with voltage fluctuations, poor local power quality, and stability as a result of the irregular and unpredictable nature of solar energy [12].

As a result, accurate energy flow control into the solar energy supply system or optimal grid network functioning depend on the ability to estimate solar system energy output [13]. As a result, predicting solar radiation is becoming more crucial. Hence in this paper, various articles has been reviewed on statistical and AI-based solar irradiance forecasting in order to provide classifications for employees based on the situation

Literature review

This section of the article has been designed to showcase the choice of power quality issues, methodology or technique, and results obtained in the reviewed article.Table 1, present in this section, has demonstrated the complete analysis of the reviewed article in terms of author, year of publication, and outcome.

Table 1: Analysis of Reviewed articles

S.No	Year of Publication	Author/s	Summary	Ref
1	2020	Pilati et al.	By taking use of the short-term estimates of environmental and economic characteristics, a proper operation management can result in financial gains.	14
2	2020	Toopshekan et al.	An environmental analysis of a hybrid renewable system has been completed, and MATLAB Link has been used to create a unique dispatching strategy for a grid-connected PV/WT/DG/Battery system. controller in HOMER	15

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			software.	
3	2020	Murugaperumal et al.	Employing short-term load forecasting methodologies, the village's accessible load patterns were analyzed and their day-by-day and time-step variations were computed. This study also includes the AI based HRE sizing optimization for the best techno-economic configuration.	16
4	2020	Wu et al.	The findings show that, for air compressors employing variable speed drives, either artificial neural network perform well. However, only the short-term, long-term memory model performs well for air compressors employing on/off control and load and unload type air compressors do not produce satisfactory results.	17
5	2020	Raju et al.	As per author of the article, for smart grid functions like power dispatch and managing load, Short Term Load Forecasting (STLF) is crucial. IOT is a new technology that is permeating all fields of engineering and research.	18
6	2020	Shadab et al.	The study determined that seasonal ARIMA simulations can be effectively used for predicting spatial time series solar radiation data. It also evaluated the ARIMA models as a feasible strategy to forecast the average monthly insolation data across an area of 18904 square kilometres around India's capital Delhi.	19
7	2020	Pazikadin et al.	The instrumentation used to detect solar irradiance and the use of ANN algorithms for forecasting solar power generation were both thoroughly reviewed in the current study. By emphasizing the various perspectives found in the literature on solar power forecasting, the	20

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			review expands on earlier studies. The primary source of prior documentation for the review was four major databases, which made a substantial addition to the corpus of knowledge..	
8	2020	Yagli et al.	An ensemble of 1-hour-ahead clear-sky score forecasts produced by 20 commercial machine-learning and combinational models that were trained using ground-based data gathered at 7 research-grade stations are post-processed in this work. The models that use data are selected from many model families with diverse prediction processes, including time series, rule- or tree-based, linear/nonlinear, and kernel-based models.	21
9	2019	Srivastava et al.	This case study analyses the solar radiation predicting achievements of the CART, MARS, M5, and random forest models. For the Gorakhpur, India , the model's abilities were analyzed hourly for solar radiation forecasts ranging from one day to six days in advance..	22
10	2019	Yagli et al.	Employing satellite-derived irradiance information collected from 7 locations across 5 distinct climate zones on the US mainland, a total of 68 machine learning (ML) models were evaluated in this study. During all-sky conditions, tree-based approaches were found to be better in long-term average nRMSE, while under clear-sky conditions, MLP and SVR versions were the most effective.	23
11	2019	VanDeventer et al.	By contrasting the results with those of the original SVM and the suggested GASVM, the effectiveness of the suggested approach is confirmed. By contrasting the SVM without optimization with the suggested	24

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			technique with optimization, a performance measure can be developed based on the assessment of performance findings.	
12	2019	Qiu et al.	Utilizing data on solar radiation from Solargis as well as the EU solar power geographically data system, this research defines an improved computational framework that forecasts solar rays using a weighting technique that calculates the amount of sunlight along six the primary navigation routes, ensuring the accuracy of the forecast results.	25
13	2018	Mohan et al.	Electric load forecasting is critical to power system security, stability, and energy demand management. For the grid to operate reliably on a daily basis, a short-term load forecasting (STLF) model that is fast, resilient, and accurate enough is required.	26
14	2018	Ghritlahre et al.	In the current study, an Artificial Neural Network (ANN) model has been created and compared with real experimental data to forecast the transfer of heat from a textured absorber plate to air travelling via the solar air heater's ducts.	27
15	2018	Zendehboudi et al.	This study examined the use of SVM modelling in the solar and wind energy industries. Because of this model's consistency and precision in forecasting, it has drawn the interest of numerous academics globally and been extensively employed. Nonetheless, based on the related articles that were assessed in the wind and solar sectors.	28

Table 1's analysis reveals that while many studies have attempted long- and short-term solar irradiance predictions, artificial intelligence (AI) techniques have produced the greatest results.

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Conclusion

Solar photovoltaic power generation technologies enable developing countries to meet their effective load demand. Suggestions for suitable solar systems for different sites require pragmatic approaches guided by relevant international engineering standards. The off-grid solar PV design approaches and the techno-economic and life cycle impact assessments that have yielded comprehensive results of academic value and interest are presented in this study. This study reviews both statistics and artificial intelligence methodologies. Planning and developing distributed solar power systems for off-grid applications in developing countries may benefit from this.

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