A Systematic review for Solar Energy Predictionusing Artificial Neural Network system

Pravin Shankarrao Rane[1], Dr. Rahul Kumar Budania[2], Dr.Pravinkumar Rajkumar Badadapure[3]
[1]Research Scholar, Shri JagdishprasadJhabarmalTibrewala University, Vidyanagari, Rajasthan, Electrical Engineering

[2]Professor, Shri JagdishprasadJhabarmalTibrewala University, Vidyanagari, Rajasthan, Electrical Engineering
[3]Professor, Shri JagdishprasadJhabarmalTibrewala University, Vidyanagari, Rajasthan, Electrical Engineering

***Abstract*— Global acceptance of sustainable development and renewable energy is rising as a result of climate change's growing effect on national and local governments. The EU 2030 agenda, which aspires to give everyone access to affordable, dependable, and sustainable energy in the future, reflects this. A barrier to achieving this goal is some renewable energy sources' limited reliability. While both private citizens and governmental organizations work to produce enough renewable energy to meet their needs, it is not clear about the investment will be needed to lessen the unreliability caused by environmental factors such seasonal variations in wind speed and daylight. In this regard, a tool that helps predict the energy output of sustainable sources throughout the course of the year for a particular location can significantly help in boosting the efficiency of sustainable energy investments. In this study, we use open data sources to build such a tool utilizing artificial neural networks. We investigate the effects of various factors on the estimation of energy production as well as the potential use of public data to predict the expected output of sustainable sources. We give users the information they need to decide what investments to make based on the necessary energy production for their particular location. Our method offers an abstraction layer that is focused on energy production rather than radiation statistics and can be taught and customized for different locations using open data, in contrast to cutting-edge alternatives.**

***Index Terms*—Renewable, Internet of Things, sources, estimation, energy, production**

I. Introduction

Due to deregulation of the market, growing demand, and environmental concerns, the traditional energy network has undergone numerous changes recently. These modifications have created difficulties that conventional energy networks might not be able to resolve. A solution that the standard network alone cannot offer may be offered by distributed generation in conjunction with the use of renewable technology. The improvement of reliability, the reduction of power loss, and the incorporation of clean energy are some advantages of distributed generating. However, adding dispersed generation to the established network increases the number of agents that need to be managed, so making the grid more complex. Negative consequences may also manifest, such a grid that is unable to maintain frequency and voltage stability or a traditional network control system that is insecure. Microgrids can be utilized in this situation as a platform to incorporate dispersed generating technologies into the current network and counteract these negative consequences. As is well knowledge, the current local weather directly affects the generation of solar energy. It is important to remember that solar power is not simply diurnal in nature, but also changes as the sun's irradiance changes throughout the day. For this reason, if a balanced system is intended, a calculation of future power generation by this kind of source is required. But for these calculations to be accurate, it is necessary to understand the future weather variables that will impact these technologies.

II. LITERATURE REVIEW

Vikas Khare et. Al. (2023) states that population growth and technological improvements are driving up energy demand at all over the world. Due to the lavishness of sunlight, the demand for solar energy for electrification has exploded. This paper describes various trending aspects of the solar energy system under different circumstances. This comprehensive review on solar energy system is based on the different parameters. At the initial level design prospectus of solar cell is assessed through the quantum dots based solar cells, recent trends of solar energy system are explained through the solar powered tree and floating solar power plant, further analysis is application of trending technology such as internet of things, artificial intelligence, data analysis and cognitive approach in the area of solar energy system. The significant answers to the problem of rapidly rising energy consumption is the development of various solar energy (SE) systems. This could be accomplished by improving the performance of solar-powered products in specific operating situations. Solar photovoltaic (PV) power output is quickly expanding in wide-ranging power sectors, thanks to greater dispersion of solar as an inconstant power resources(IPR). PV systems' power output is highly dependent on the weather condition, therefore unexpected swings in power output may increase the power system's running expenses. Furthermore, one of the most significant challenges in assimilating this IPR into the grid is its irregularity, as continuous production cannot be assured at any given time period. This discourages efficacies from deploying PV electricity since grid general balancing and planning become extremely difficult. For successfully integrating IPR into the grid, developing a trustworthy method that can diminish the mistakes linked with estimating predicted PV power generation is particularly beneficial. PV power prediction has the potential to help solve these problems [1]

Lin Chen1 et. Al. (2023) states that Climate change is a major threat already causing system damage to urban and natural systems, and inducing global economic losses of over $500 billion. These issues may be partly solved by artificial intelligence because artificial intelligence integrates internet resources to make prompt suggestions based on accurate climate change predictions. Here we review recent research and applications of artificial intelligence in mitigating the adverse effects of climate change, with a focus on energy efficiency, carbon sequestration and storage, weather and renewable energy forecasting, grid management, building design, transportation, precision agriculture, industrial processes, reducing deforestation, and resilient cities. We found that enhancing energy efficiency can significantly contribute to reducing the impact of climate change. Smart manufacturing can reduce energy consumption, waste, and carbon emissions by 30–50% and, in particular, can reduce energy consumption in buildings by 30–50%. [2]

Mokhtar Jlidi et. al. (2023) states that in recent years, researchers have focused on improving the efficiency of photovoltaic systems, as they have an extremely low efficiency compared to fossil fuels. An obvious issue associated with photovoltaic systems (PVS) is the interruption of power generation caused by changes in solar radiation and temperature. As a means of improving the energy efficiency performance of such a system, it is necessary to predict the meteorological conditions that affect PV modules. [3]

Mohammad Reza et. Al. (2023) states that Renewable energy resources can be deployed locally and efficiently using the concept of microgrids. Due to the natural uncertainty of the output power of renewable energy resources, the planning for a proper operation of microgrids can be a challenging task. In addition, the information about the loads and the power consumption of them can create benefits to increase the efficiency of the microgrids. However, electrical loads can have uncertainty due to reasons such as unpredictable behavior of the consumers. This paper will study the recent works related to deep learning, which has been implemented for the prediction of the output power of renewable energy resources (i.e., PVs and wind turbines), electrical loads, and weather conditions (i.e., solar irradiance and wind speed). In addition, for possible future directions some strategies are suggested, the most important of which is the implementation of quantum computing in cyber–physical microgrids. [4]

Susan Gourvenec et. Al. (2022) states that thousands of structures are currently installed in our oceans to help meet our global energy needs. This number is set to increase with the transition to renewable energy, due to lower energy yield per structure, growing energy demand and greater and more diverse use of ocean space (e.g. for food, industrial or scientific activity). A clear and comprehensive picture of the spatial and temporal distribution of ocean energy assets is crucial to inform marine spatial planning, sustainable design of ocean infrastructure and end-of-engineered-life management, to prevent an exponentially increasing asset base becoming an economic and environmental burden. [5]

Maymouna et. al. (2022) states that traditional electricity grid (TEG) is based on one-way transmission within a hierarchical communication network. Electricity utilities have to realize the need to address the critical challenges faced, including the ever-increasing electricity demand, the low efficacy, rising electricity costs, and the bad environmental impact of existing grids. With current power network requirements, the TEG may not be able to meet those needs, which necessitates the development of the smart grid (SG). An SG uses bidirectional power transmission and information flow, making it the next generation of the power grid. The SG is conceptually divided into seven domains: generation, transmission, distribution, customers, operation, market, and service provider. The first four domains are involved in power flow, while the rest are related to control and communication in the SG system. These domains are enabled by new technologies, such as the Internet of Things (IoT), Supervisory Control and Data Acquisition (SCADA), and Advanced Metering Infrastructure (AMI), especially smart meters. [6]

Quentin Paletta et. Al. (2022) states that improving irradiance forecasting is critical to further increase the share of solar in the energy mix. On a short time scale, fish-eye cameras on the ground are used to capture cloud displacements causing the local variability of the electricity production. As most of the solar radiation comes directly from the Sun, current forecasting approaches use its position in the image as a reference to interpret the cloud cover dynamics. However, existing Sun tracking methods rely on external data and a calibration of the camera, which requires access to the device. To address these limitations, this study introduces an image-based Sun tracking algorithm to localise the Sun in the image when it is visible and interpolate its daily trajectory from past observations. We validate the method on a set of sky images collected over a year at SIRTA's lab. Experimental results show that the proposed method provides robust smooth Sun trajectories with a mean absolute error below 1% of the image size. [7]

III. PROPOSED SYSTEM

As is well knowledge, the current local weather directly affects the output of solar energy [6]. It is important to remember that solar power is not simply diurnal in nature, but also changes as the sun's irradiance changes throughout the day. For this reason, if a balanced system is intended, an estimate of future power generation by this kind of source is required. But for these estimates to be accurate, it is necessary to understand the future weather variables that will impact these technologies. putting up a fresh forecasting model for solar energy production that will be used in a microgrid. The tool created here is based on an artificial neural network (ANN), despite the fact that other prediction approaches are offered in the literature. In the near run, 10 min, the ANN that we have created is highly accurate at forecasting the solar energy that the PV producers will generate. The microgrid's control receives this information so that it may make the best choices at any given time and so increase dependability.

The framework's high-level description is given below:

A. Flowchart of the system

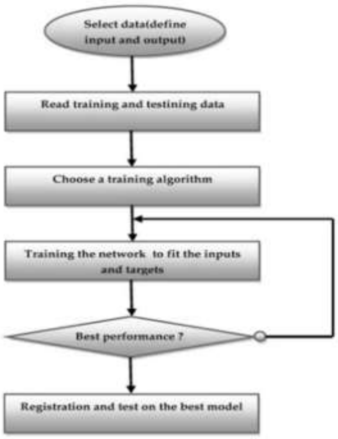

Fig. 1 Flowchart for the proposed system

The NN-based prediction technique of the temperature and the irradiation (T and G) follows these steps:

- Step1: Data assembly, pre-processing, data conversion, and normalization. The data set used to predict the temperature and solar radiation reflected on the PV
- Step2: Statistical analysis.
- Step3: Neural Network objects design.
- Step4: Training
- Step5: Simulation of network response to new entries.
- Step6: Approval and testing.

IV. OBJECTIVES OF PROPOSED SYSTEM

Following are the objectives in which the work will be achieved

- To presents a new prediction model for solar energy generation that will be implemented in a several systems
- To predict the future trends based on historical data
- To integrate distributed generation technologies into the traditional network and overcome these negative effects
- To facilitate training, normalized numerical features such that they have a comparable scale.
- To developed a tool for the improvement on the efficiency and reliability of the control system, as the back-up systems will be switched on only when they are really needed
- To analyse various data for perfect prediction using various Artificial Neural Network Algorithm

V. RESEARCH METHODOLOGY

Several crucial steps must be taken in order to develop a framework for predicting solar energy utilizing an artificial neural network (ANN) and open data. The framework's high-level description is given below:

A. Data gathering and preparation

Find and collect relevant open data sources for solar energy, such as historical data on energy production, weather information (such as solar irradiance, temperature, and cloud cover), location information, and time of day. In order to train the neural network, the data must be preprocessed to accommodate missing values, normalize numerical features, and translate categorical variables into acceptable representations.

B. Splitting data

To create training, validation, and testing sets, divide the pre-processed data. The testing set examines the model's performance on untested data while the validation set aids in hyperparameter tuning. The training set is used to train the neural network.

C. Engineering of Features (Optional)

Utilise feature engineering to extract new valuable characteristics from the existing data that may enhance the predictive performance of the model. For instance, time-based characteristics like the day of the week or hour of the day may be important for predicting solar energy.

D. Neural network architecture design

Select the neural network architecture that is best for the purpose of predicting solar energy. Depending on the type of input and the needs for prediction, common options include feedforward neural networks, recurrent neural networks (RNNs), or convolutional neural networks (CNNs).

E. Model Education

Utilise the training dataset to train the neural network. To reduce the prediction error (for example, mean squared error) between the anticipated solar energy output and the actual values from the training data, the model optimises its weights and biases. Utilise the validation set to do hyperparameter tweaking to determine the ideal setting for variables like learning rate, batch size, number of hidden layers, and neurons per layer. This enhances the model's ability to generalise and perform well with new data.

F. Model assessment

To gauge the training model's accuracy in predicting solar energy production, compare it to the testing dataset. Mean absolute error (MAE), root mean square error (RMSE), and coefficient of determination (R-squared) are common evaluation measures.

G. Actual deployment and forecasting

Utilise the trained neural network as a service or application to create real-time forecasts about solar energy based on fresh weather data and other pertinent factors.

H. Updates and Continuous Monitoring

Keep an eye on the model's performance all the time, updating the neural network whenever fresh data becomes available or the distribution of the underlying data changes. Understanding the variables that affect solar energy generation can help with energy planning and grid management by analysing the model's behaviour and interpreting its forecasts. It is crucial to guarantee the integrity and quality of the open data utilised during the framework's development as well as to take ethical and privacy concerns linked to data usage into account. Collaboration with stakeholders and subject matter experts in the field of renewable energy can also assist to improve the framework and make it more useful for practical implementations.

VI. CONCLUSION

In this way after utilizing open data sources, Internet of Things (IoT) sensors, and installations spread across Europe, we build such a tool in this study which helps to predict the sources of renewable energy. Also looking at how many factors affect the forecasting of energy production as well as the potential use of open data to predict the expected output of sustainable sources. In accordance with the necessary energy output for their particular area, we give users the information they need to make investment decisions. Our method offers an abstraction layer that, in contrast to cutting-edge methods, is focused on energy production rather than radiation statistics and can be taught and adjusted for different locations using open data.

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