Iraqi Journal for Computer Science and Mathematics

Volume 4 | Issue 3 Article 4

2023

Main challenges (generation and returnedenergy) in a deep intelligent analysis technique for renewable energy applications

Samaher Al Janabi
samaher@itnet.uobabylon.edu.iq

Ghada S. Mohammed

Thekra Abbas

Iraqi Journal for Computer Science and Mathematics

Journal Homepage: http://journal.esj.edu.iq/index.php/IJCM
e-ISSN: 2788-7421 p-ISSN: 2958-0544

Main challenges (generation and returned energy) in a deep intelligent analysis technique for renewable energy applications

Ghada S. Mohammed[2], Samaher Al-Janabi[1], Thekra Abbas[2]

[1]Department of Computer Science, Faculty of Science for Women (SCIW), University of Babylon, Iraq.
[2] Department of Computer Science, College of Science, Mustansiriyah University Baghdad, Iraq.

DOI: https://doi.org/ 10.52866/ijcsm.2023.02.03.004
Received April 2023; Accepted May 2023; Available online June 2023

ABSTRACT: In recent years, there has been an increasing demand for Renewable Energy (RE), which refers to energy generated from natural sources such as solar and wind power. Consequently, numerous scientific studies have been conducted to explore various approaches for controlling this type of energy. This work aims to highlight the main challenges associated with the generation and return of RE by employing intelligent data analysis techniques, specifically deep learning. These challenges are examined from different perspectives, including pre-processing, the methodology and techniques used in deep learning, and the evaluation measures employed. Some of the research in this area is focused on predicting the highest amount of energy that can be generated at a particular time and location, while others aim to predict the largest amount of electrical energy that can be returned to the electricity grid to optimize the use of surplus RE resources and maximize their benefits. These efforts are crucial to ensure the effective and continuous operation of the electrical grid. However, despite the efficiency and high accuracy of these models, they are hindered by complex calculations that require considerable time to produce the desired outcomes. Additionally, numerous measures are employed to evaluate the models' performance, including assessing their completion rate, quality of performance, accuracy of results, efficiency, error rate, feasibility of investing in RE, and the largest amount of surplus energy that can be returned to the electricity generation network.

Keywords: Deep Learning Techniques, Renewable Energy, Prediction, Returned Energy.

1. INTRODUCTION

The current worldwide tendency is to use renewable sources to generate energy due to the its little cost ,also decreasing in the carbon emissions to keep the human health and the environment so the sources of RE are becoming very popular in the power sector, where These resources include biomass ,hydroelectric , wind energy, , solar energy, and others, [1] these resources used to constructing an environmentally friendly and sustainable electrical system and creating green, intelligent cities [2].These new energy sources can meet the entire world's needs of energy ,also preserving , ensuring energy security , where According to statistics, about of 30% of the energy used worldwide comes from RE sources. Additionally, every year both the production and consumption of various forms of RE rise, the fluctuations in demand, price and the unpredictable nature of the supply of RE all have an impact on the energy scenario. so a robust and accrue model for the prediction of renewable energies is necessary for the energy sector's decision-making, and best possible energy management.

Prediction [2] is a scientific term that denotes the estimation of a continuous observed value based on historical data and a variety of other criteria. Predictions are used to create future schemas using special approaches and considering all things that may have an impact on the future. Additionally, prediction is a particular sort of regression and belongs to the field of machine learning (ML), which is seen as a subset of artificial intelligence (AI) .

Artificial neural networks are used to simulate and resolve complicated issues in the field of deep learning (a branch of machine learning). It takes its ideas from the structure and operation of the human brain and makes use of mathematical formulas and a significant volume of data to try to mimic its processing capability. Deep neural networks include several hidden layers(multi-layer) that are arranged in layered network topologies to form computational models. In addition to frequently employing advanced operations or numerous activations in a single neuron rather than a straightforward activation function, they frequently incorporate advanced neurons.

*Corresponding author: samaher@itnet.uobabylon.edu.iq

In this work determine the main challenge that faced the generation and return energy models in the renewable energy applications such as prediction a maximum generated energy by different sources effectively and with high accuracy , prediction with maximum surplus energy that can returned to the grid of electric energy to worth from it , some others research related to the best location, cost of generating energy , prediction the demand and consumption of energy and many others , all these research although its effectiveness but it still have an open problems (the accuracy of proposed model , the time and computation complexity , and the cost problem) these problem represent the three vertices of the triangle as shown in the Figure 1.

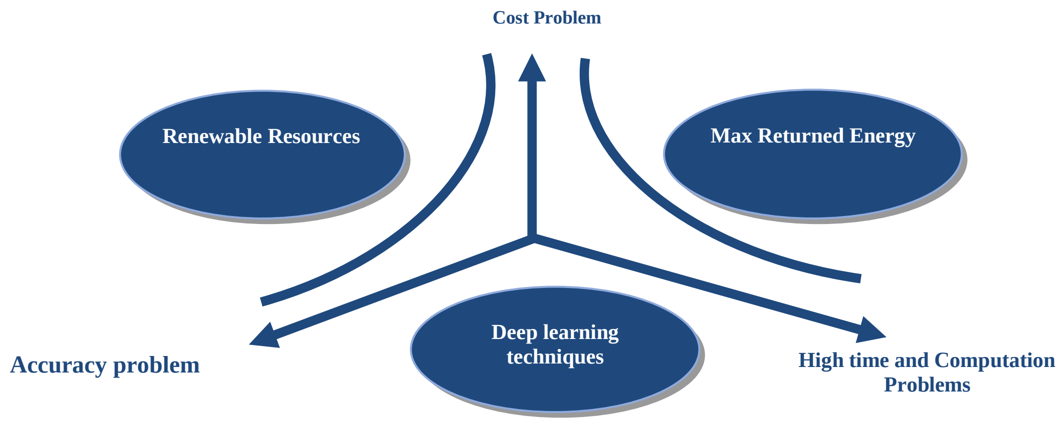

Figure -1 Main open challenges with its solutions

2. Main Still Challenges for renewable energy applications.

There are Numerous applications on energy management in grids or microgrids have been produced with potential solutions. Although there are still open challenged face these applications, so that in this work illustrate determine many challenges with its potential solutions based on (problem challenges , application challenges , and The evaluation measures challenge) as shown below:

2.1 The Problem Challenge

Most of articles that discuss the dealing with specific problem related to RE problem such as (prediction ,estimation , clustering and many others)based on using dataset of single RE source and some others using dataset of hybrid RE sources(multi renewable resources or combination a renewable and nonrenewable energy resources) ; these data can be weather parameters for specific period of time , solar panels ,wind turbines ,reading ,biomass energy reading and many others data format(maps, statistical data , numerical and symbols data) that used as input to numerous models ,also used to training and testing different deep learning techniques to achieve specific task related to RE management.(See Table 2).

[3] building parallel predictors based on (LSTM,BLSTM MLSTM,GRU, AlexNet ZFNet techniques) to determine the effective one , the predictor that determine based on using LSTM deep learning technique where it give high accuracy in comparison to other used techniques .[4] suggest a DSE-XGB stacked ensemble method that combine (Artificial Neural Network (ANN) ,Long Short-Term Memory (LSTM) ,& Extreme Gradient Boosting Algorithms) to accrue prediction of solar energy and the method is evaluated using by comparative analysis , the result show when the accuracy of prediction increase , the computation time increase , also the proposed model need to be implement on real time data.[5] integrated techno-economic optimization analysis with a methodical decision-making strategy for ideal planning, The proposed Hybrid Renewable Energy system(Solar PV, WT, diesel, and fuel cell energies) reliability is examined using the loss of power supply probability concept (LPSP), while the system correctness is validated by sensitivity analysis. The HRE-based Micro-Grid systems (HRE-MG) check it is validation to an urban city in Egypt to minimize the cost and pollution impact.; the system performance cost examining with uncertain elements. The results indicate the tend to use PV, regardless the variations in load demand, irradiance, speed, and wind , too. It also demonstrates the negative effects of Safaga's use of diesel generators. [6] provide the most effective techno-economic hybrid RES (solar, biomass, and wind turbine) model for three Indian sites in Bihar state. using a hybrid system that combines Particle Swarm Optimization and Grey Wolf Optimization (PSO-GWO), the

optimal planning problem is solved (minimized the Cost of Electricity (COE), Deficiency of Power Supply Probability (DPSP), and higher renewable factor (RF) simultaneously). In comparison to many other algorithms, the algorithm's performance is evaluated, and it also uses sensitivity analysis to evaluate the COE. The results show that the hybrid system's performance is superior[7] present critical indicators by investigating many sustainable Hybrid Renewable Systems(HRS) of electric energy production, Hybrid Optimization of Multiple Energy Resources program(HOMER) used to perform environmental analysis and the system techno-economic analysis , Reducing the CO2 emission, greater electric energy generation, and more cost-effective resulted due to appropriate selection of indicators .[8] present method to select the most appropriate solar plants location by analyzing many data layers (duration of sunshine, slope, aspect, road, solar irradiance, resources of water, power line, residential area, mine areas transformers, and earthquake fault line) and considering priorities of individual or group of variables, perform a qualitative and quantitative evaluation through using mathematical methods; the results show the most suitable area for the solar plant is northeast of the Nigda.80% of the solar power plants have determined their site as suitable to give the greatest amount of performance and efficiency, while 20 %of them were on the contrary.

Based on historical national data of numerous RE resources in Malaysia, conduct a study to examine the performance of research and development (R&D) actions in multiple resources of RE presented by [9]based on utilizing various policies and a regular R&D strategy to make RE technology more affordable and competitive, as well as by evaluating the capability and performance the activities of R&D for RER by the DEA approach, The results indicate that Malaysia's most productive RE resource is micro hydro. While wind is the least effective resource in terms of R&D activity.[10] Present a model that uses algorithm for deep reinforcement learning to determine the strategy of real-time dynamic energy management for hybrid energy systems (HES). The model is trained on a variety of data, including water demand, wind turbine (WT) output, photovoltaic (PV) output, electricity price, and one year's worth of load demand data, to obtain the best management policy for energy. The Weight Factor (WF) is computed using the theory of information entropy to determine the best between different targets. Simulation results show the optimal policy for control and the cost reduce by up to 14.17%. [11] Assessed the feasibility of the project for a configuration microgrid system that consisting of WT, PV, diesel, and battery Based on comparing three multi-objective optimization algorithms (Multiple Objective Particle Swarm Optimization (MOPSO), Pareto Envelope-Based Selection Algorithm (PESA II), and Strength Pareto Evolutionary Algorithm (SPEA2); with consideration of multi-objective functions (Net Present Cost (NPC), Penalty Cost Of Emission, and the quantity that released into the atmosphere) that are depended on the Six Sigma approach and using the sensitivity analysis; The result indicates the better algorithm is SPEA2.[12] Establish a separate energy production system (PV/Wind/Lead Acid ,PV/Wind/Lithium-ion , & PV/Wind/Nickel-Cadmium)for the region located in the southwest of Algeria was sized using an electrochemical storage device, Techno-economic optimization standards were used to minimize the cost of energy production by employing four optimization algorithms. The surplus account of produced energy was also considered to maximize system efficiency. When considering the effect of lifetime, depth of discharge (DOD), and the relative cost of battery technology based on Unit Electricity Cost (UEC), the performance of the system in the future is predicted. JAYA algorithm produces output that is more inclined to the best solutions than other algorithms. [13] Design of a multi-agent system depended on heuristic optimization method is to present an efficient storage strategy of excess energy produced by various RER (Wind, PV-solar, and Hydro). This causes to archiving optimized storage levels of energy to counteract the power shortage caused by weather conditions. The system behaviour of hybrid renewable energy assessed on five regions /12 cities /IRAQ, are implemented based on changes of weather. Analysis of sensitivity is conducted to evaluate the system's efficiency; outcomes of the system demonstrate how high supplier rates affect the electricity exchange and production planning from different RES and achieving optimal use of storage devices with various locations.[30] propose a technique for the best clustering of sites in Sarawak, Malaysia to generate electricity based on (solar , hydropower , and wind energy) , and choose the sites that are situated in the centers of the clusters to determine the effective allocation of a microgrid for RE .the data pre-processing by analyzing the map of remote electricity in Sarawak using segmentation techniques(a. colour thresholding, b. circular Hough Transform) then using ,& K-means technique to clustering the input sits then optimize the results using HOMER software and their cost and performance were reported. The findings indicate that nine out of 420 locations are the best places to install RES. The combination of PV and hydropower (Hybrid Renewable Energy) systems for rural regions produced the finest hybrid RE System.

Table 1. Numerous problems of RE applications.

Authors	Dataset	Aim of application	Advantages	Disadvantages
[3]	▪Solar Weather	▪ Determine effective predictors based on deep learning technique to dealing with RE data	▪ High-accuracy predictor ▪ Operate with real-time	▪Depended on specific number of deep learning techniques that sharing in comparative analysis
[4]	▪Solar	▪Prediction with maximum generated energy	▪ Prediction with maximum generated energy in good Accuracy	▪Increase the computations. ▪Not implemented on real time data
[5]	▪Solar PV, WT, diesel, and fuel cell energies ▪Https://power.larc.nasa.gov.	▪Assessment the metrological wind and solar data to determine Load demand. ▪Reducing the cost	▪Efficient performance ▪Obtained the requirement of Safage for heat and electricity. ▪ Minimization cost relatively	▪Time complexity ▪High computation
[6]	▪Solar . Https://power.larc.nasa.gov/ ▪WT. ▪Biomass	▪Dealing with power supply shortage (DPSP)	▪Decreasing COE, and the environmental challenges adversities ▪The ten traditional benchmark functions for 30D need an average computing time of 0.1723s for the hybrid approach.	▪The average computation time is not optimal for all cases of comparison within previous algorithm.
[7]	▪PV ,WT ,Diesel Generator, Battery. Collected data from the meteorological organization in Rezvan village in Sudaklen, Iran that located at 37_11_1_N and 55_47_9_E with altitude of 1250 m	▪Dealing with parameters that affecting the optimal system configuration.	▪Minimum CO2 emission. ▪Maximum electric energy generation. ▪More cost-effective	▪High computation complexity. ▪Time complexity
[8]	▪Solar plant Https ://csb.gov.t	▪Determine the effective locations to generate maximum solar energy	▪Determine that 80% of the solar power stations in operation are in Nigde, Turkey, which is the most effective location for generating electricity.	▪High complexity ▪Fail to determine 20% of suitable site. ▪Based on topography that causes decreasing efficiency. ▪Not found maximum energy

[9]	▪Wind, Biogas, Solar ,Biomass ,Mini hydro. ▪Https://umlib.um.edu.my/scontents.asp?Tid=31& cid=144&p=1&vs=en ▪Http://onlineip.myipo.gov.my/index .cfm?CFID=ab16e6f4-bd9a-4719-8faf-5f55d0746914&CFTOKEN=0.	▪Determine the effective method to generate the energy in Malaysia	▪Contribute to Malaysian RE R&D activities. ▪Compare the effectiveness of various RER and (efficiency scores, efficiency ranking)	▪Due to certain limitations, CO2 emissions and economic development were excluded data with many variables inadequate for time series
[10]	▪WT ▪Solar PV, ▪Diesel generator ▪Battery	▪Control the renewable energy system by reducing its cost.	▪Reduction total system cost ▪An optimal policy of control	▪Time complexity ▪Single point failure.
[11]	▪PV ▪WT ▪Diesel generator Battery.	▪The sensitivity analysis ,(NPC, LOCE) functions for system of generating energy and control the emissions	Minimize: ▪Cost of generated energy ▪CO2 emissions & penalty cost of damage that cause by it.	▪Time complexity ▪High computation
[12]	▪PV ▪WT Data collected as one-hour intervals /one year from ten households, s in Adrar (27°52′N, 0°16′W, 262 m)/Algeria	▪Determine a seasonal average consumption. With different ▪HES configurations:	▪Minimize UEC	▪Time complexity ▪High computation
[13]	▪Solar , Wind , Hydro power. ▪Republic of Iraq 2018. Annual Statistical Report on Energy Electricity(page 26)	▪Analysis of various energy loading curves that represent the consumption behaviour, which is measured hourly in five regions / IRAQ	▪Optimal utilization of located storage devices. ▪Determine the energy demand for a specific city	▪The system model must be generalized and be more robust
[30]	▪PV ▪Hydropower ▪Wind ▪Https://power.larc.nasa.gov/	▪Clustering the sites and determine the optimal remote electrification map(centre of cluster) in Sarawak.	▪The system success in determining nine optimal sites out of 420 sits for installation of RES It is found hybrid RES, (PV, hydropower) is the best for the rural areas in Sarawak.	▪System based on data estimated monthly similarly to all locations. ▪Falls to determine 411 out of 420 sits for installing RES High complexity

2.2 Application Challenge

Table (2) illustrated different pre-processing methods and deep learning techniques that used to solving specific problems that related to RE applications such as prediction, maximum generated energy, the feasibility of RE system. Where illustrate them based on their characteristic (the author(s) of study, aim of application , the used dataset(s), the pre-processing method that applied to these dataset(s) , and finally the depended methodology).where [14] Present Find Different Intervals Renewable Energy (FDIRE) algorithm to dealing with real time renewable energy data and related weather data by pre-processing it through merging these datasets and checking if it contain missing data and clean it by deleting the record that contain missing value and removing the duplication from these data that are divided into intervals and saving only different intervals only to reduce the computation and the time complexity . [15]

Proposed a wind speed forecasting model based on using probabilistic methos to pre-processing data and using deep learning techniques (ConvGRU and 3D Convolution neural network) with vibrational Bayesian inference; this model applied by using a historical information for two real-world case studies in the United States ,the results of evaluation this model performance shown that it outperforms other point forecast models (the persistence model , Lasso Regression , artificial neural network, LSTM ,CNN , GPR and Hidden Markov Model) due to the combination between techniques and using a not too wide forecast intervals . As a result, the model must test in more areas and evaluate its performance using sophisticated probabilistic techniques. [16] Suggests a method for predicting solar power based on the Pearson coefficient to exclude unimportant elements from the prediction model as pre-processing step for the data. Where the predictor building based on using a LSTM algorithm, and According to the predictor’s output, the index error of the projected values has decreased due to the enhanced LSTM. The prediction approach, which may limit the effect of noise on PV power forecast and accomplish short-term PV power prediction.

[17] Presents a hybrid forecasting model for energy generated by distributed PV ,the proposed model detect the patterns of daily fluctuating for solar power series by using distributed GRU Model; the model is applied to Data collected from distributed PV farm in China where the forecasting accuracy outperforms on single GRUM, and the Time complexity increasing, the model needs to improve the forecasting efficiency and accuracy when compared to the numerical weather prediction models it.[18] Proposed an accurate photovoltaic energy generation forecasting method based on Physics constrained (PC-LSTM) techniques, this method adopted a Real-life PV and pre-processing the data by Feature construction, Data normalization, and Data splitting to increasing the efficiency and accuracy; Sensitivity analysis using to evaluate the feasibility and effectiveness of the model that produce forecasting capability stronger than the standard LSTM model. [19] Proposed method for prediction intervals of solar generation based on GRU techniques and kernel density estimation (KDE). The model outperforms other competing methods when applying it on many datasets and pre-processing these datasets to entering them to this model; the model can improve and test on long-time intervals. [31] Propose a prediction model based on pre-processing the data by investigating periodicity of it and using Multiple Convolution neural network to deal with periodicity of multivariate time series data then residual network and autoregressive component added to the proposed model framework in order to enhance its performance; the model applied on two real-world datasets and the model has a considerable advantage when evaluated by comparing it with ConvLSTM(Extended of LSTM, ConvLSTM replaces vector multiplication with convolution operation) ,but the proposed model can’t solve a very complex tasks for time series prediction .

Table 2. pre-processing and deep learning techniques related to RE applications

Authors	aim of application	Dataset	Pre-Processing Method	Methodology
[14]	Reduction the time and computation complexity to dealing with intervals of solar generation	Solar wind	▪Determine missing values and dealing with it. ▪Remove the duplication of data. ▪Dividing the data into intervals & saving only the different intervals only	FDIRE algorithm
[15]	forecasting a wind speed	Wind	Probabilistic analysis	ConvGRU and 3D CNN) with vibrational Bayesian inference
[16]	predicting of solar energy	solar power	Pearson feature selection	LSTM
[17]	forecasting PV generated energy	Distributed PV	Parameter &Resolution Adaptive algorithm, The Ordering Points to Identify the Cluster Structure	Distributed GRU
[18]	forecasting PV generated energy	PV	Feature construction, Data normalization, Data splitting	Physics constrained (PC-LSTM) techniques
[19]	prediction intervals of solar generation	Solar	Probability analysis	GRU techniques & kernel density estimation (KDE)

[31]	time series prediction.	Solar	periodic data analysis	Multiple CNNs

Table 2 illustrate different pre-processing and main deep learning techniques that related to RE applications, most of them still having high computations and high processing time although it can have an accrue results ,except the [14] that produce an accurate method to dealing with a stream of real time renewable data with reduction the time and computation complexity because it dealing with intervals of solar generation and determine only different intervals .

2.3 Evaluation Challenges

Every model performance must be evaluate to check if it applicable or not and typically there are many numerous evaluation methods and metrices used to evaluate the quality of models, but many of them are unreliable for a variety of reasons that depend on the accuracy and precision of the used values [33] bellow illustrate some of RE models and focused on the evaluation measures for each one as shown in the Table 3.

A technique for trade-off multi-objective (practical swarm optimization algorithm and Techniques for order of preference by similarity to ideal solution (TOPSIS)), which was used by [20] to achieve a strategy for energy management in system with optimal configuration; the technique was also evaluated on a real-world scenario; The results show that each component of the TPC/COE/EC set in the (grid-connected, off-grid scheme) is independently optimal in different arrangements. The technique assesses using a variety of perspectives. RE generation forecasting method present by [21] based on pre-processing step using Bayesian probabilistic technique with Bidirectional Long Short-Term Memory (BLSTM), also using vibrational Autoencoder (VAE)to overcome the high complexities that causes by Bayesian deep learning technique where it requires high computations to deal with large probability distributions. Model efficiency was evaluated by using comparative analysis (time complexity, forecasting error), pinball loss, RMSE, reconstruction error and other metrics but not considered the surpluses energy. [22] Proposed a method to integrate multiple algorithms advantages (Autoregressive Integrated Moving Average(ARIMA),Multi-Objective Grasshopper Algorithm(MOGOA) , Singular Spectrum Analysis(SSA) ,Long Short Term Memory(LSTM), Gated Recurrent Unit (GRU) , and Deep Belief Network(DBN) , to achieve accurate and stable results for PV energy forecasting ,the viability of the suggested approach assessed by three datasets of 15-min PV power data from various time during the year in Belgium were used and evaluated using four indicators(Mean Absolute Error(MAE), Mean Absolute Percent Error (MAPE)), Root Mean Square Error (RMSE) ,and Standard Deviation of Error (SDE)).The model need to find a more effective methods to processing the data of solar , decrease the complexity of time while increasing efficiency.[23] Uses the Analytical Hierarchy Process (AHP) approach to assess the key obstacles to the growth of (solar PV, wind turbines, and biomass) in Iran, these obstacles have been divided into 5D-groups(1. Economic and financial; 2. Political and regulatory, 3. Social, cultural, and behavioral ,4 Institutional. , and 5.Technical.) then used The sensitivity analysis that was indicated the priority ranking of resources where it refer to that solar photovoltaics (PV) had less development constraints, followed by wind turbines and biomass. And they evaluated by using the sensitivity analysis, Therefore, in order to develop and create suitable policies and strategies to promote the adoption of RE technologies, the Government and policymakers must first focus more on removing obstacles to the growth of solar PV.[24] recommend the most effective approach for evaluating the performance of several hybrid microgrid designs and putting the hybrid system in place in Long San Village, Sarawak, Malaysia. The proposed system is a mathematical model that supports a maximum load demand at the lowest cost based on Multi-Objective Particle Swarm Optimization (MOPSO) with a variety of weather conditions. The behaviour of the system is assessed by measuring its dependability and voltage security (operational, techno-economic, and comparative) analysis of the environmental impact on the system. A study to examine the sizing of Hybrid Renewable Energy system to estimate and meet the load (need of energy) requirements of a rural island/Bangladesh present by [25] where the configuration of hybrid system is determined using the non-dominated sorting genetic algorithm NSGA-II & infeasibility driven evolutionary algorithm depended on (single objective (COE) and multi-objective (COE, LCE (Life Cycle Emission)). the fuzziness of the decision-making process used to select the most practical options, and the Homer Software to optimize the results the A comparative analysis used for evaluating the results, which indicate the environmental advantages that obtained from multi-objective techniques are better than the single-objective techniques. [26] provide a way to forecast the likelihood of surplus and deficit net radiation in Ibadan, Nigeria using 34 years (1977–2010) of meteorological data. In Ibadan, the step-by-step Penman-Monteith (FAO-56) approach was employed to calculate net radiation. For this study, a two-state Markov Chain model was created. The result shows that the chances of surplus net radiation occurring in the months of February, March, April, May, June, October, November, and December are 69%, 76%, 76%, 74%, 63%, 63%, 70%, and 52%, while the odds of deficit net radiation occurring in these same months are 54%, 64%, 76%, and 55%. January, July, August, and September, in that order.

Table 3. Description of different evaluation measures related with RE applications.

Authors	Dataset	Pre-Processing Method	Evaluation Measures	Obtained results
[20]	▪Under water compress air energy	▪A multi-criteria decision analysis method ▪TOPSIS	▪Comparative analysis	▪TPC, COE, EC in an ideal off-grid system with a 705/8/900 m3 configuration is 4.076 106/2.305 kWh1/566.254 kg. ▪reduce the carbon emission
[21]	▪solar generation data from Ausgrid distribution network (300 smart homes) with 30 min interval (1/7 / 2011 to 30/5 /2012)	▪forecasting the solar energy generation by variational autoencoder VAE-Bayesian BiLSTM model	▪time complexity, forecasting error (RMSE, MAE ,R-score , CPU-Time (s), weights)	▪RMSE (0.0907 ▪RMSE (0.0450) , R-score(0.1404) , CPU-Time (0.3855) ,Wights (0.0235
[22]	▪three PV datasets of 15-min PV power data from various time during the year	▪Ensemble forecasting frame	▪MAE, MAPE, RMSE , And SDE	▪The lowest average MAPE Each dataset was obtained from PEFF with values of 2.89, 1.43, and 1.60%, which were reduced by 3.82, 1.78, and 1.54%, respectively, ▪Compared with the maximum values obtained from SSA–ARIMA.
[23]	▪PV ▪WT ▪ Biomass	▪Analysis of five-dimension group	▪Checking the Consistency Ratio (CR) based on Random Index (RI) and the Consistency Index (CI)., Priority of resource	▪percentage of difficulties to the enhancement of (PV, , wind turbine, and biomass are (0.212 ,0.364 & 0.424) respectively
[24]	▪Hybrid energy systems	▪Dynamic price estimation algorithm developed by ▪Combined (MOPSO)& regression method. ▪HOMER software ▪ PSCAD software	▪Comparative analysis ▪ Techno-economic analysis ▪Dynamic analysis	▪The lowest total net present estimated cost is $ 694,284. ▪Solar radiation average is 5.29 kwh/m2/day. ▪Fifty sites/ 20 GW of total hydropower are available in Sarawak.
[25]	▪Solar ▪Wind Https://power.larc.nasa.gov/	▪Optimization data by nsga-ii ▪Infeasibility driven evolutionary algorithm		▪Do not examine the cost of battery degradation. ▪Don’t considered another solution to deal with surplus energy. ▪Impact of dirt or pollution on the effectiveness of solar pv

[26]	▪Using 34 years (1977–2010) of meteorological solar irradiation data (Ibadan, Nigeria's international institute of tropical agriculture (iita))	▪Forecast the probability of surplus and deficit net radiation.	▪The daily net Radiation Calculated using the penman-monteith (fao-56) step-by-step approach.	Chances of surplus net radiation occurring in the months of February, march, April, may, June, October, November, and December are 69%, 76%, 76%, 74%, 63%, 63%, 70%, and 52%, while the odds of deficit net radiation occurring in these same months are 54%, 64%, 76%, and 55%.

From above Table can notes that there are much research illustrate to prediction renewable energy generated energy but there are less than researches dealing with prediction of amount returned (surplus) energy to the grid of electric distribution, in high accuracy, and these researches considered very critical to increase the investment of renewable energy for both the provider and customers to contribute in reduction the cost of energy investment.

3. DEEP LEARNING TECHNIQUES

This section shown Deep analysis to Neurocomputing techniques (RNN, GRU, LSTM, BiLSTM, AlexNet, and GoogleNet); This analysis focus on (the main programming steps, main parameters, advantages, and disadvantages) for each algorithm as shown in table 4.

3.1 AlexNet algorithm

AlexNet is a DL algorithm, its architecture consists of 8-layers,5-layers are convolution layers with combination in max-pool layers follow them 3-fully connected layered also it has approximately (60 million) free Parameters; it has many characteristics such as instead of sigmoid, tanh function this algorithm used ReLU (Rectified Linear Units)activation function(it adopted at each layer except the output layer used SoftMax function) so the speed will increase, also this algorithm reduced the size of the network and achieved high performance(reduce dimensionality and computation) based on using overlap pooling layer, and it deals with overfitting through using dropout layer and data-augmentation techniques to reduce it ; this technique achieved the measure (top-5 error rate) with 15.3%.. Goal of The model makes CNN deeper and using numerous strategies to Parameters optimizations ; also this model improve the learning capacity the model has a good accuracy rate and high performance, especially for classification, its considered a prominent CNN architecture .

3.2 ZFNet Algorithm

it is a visualization technique that reveals why CNN models perform so well. It's considered an extension of AlexNet; the model of this algorithm is composed of an 8-layer (five convolution layers, two fully connected layers, and the SoftMax layer; these techniques achieved the measure (top-5 error rate) with 14.8%. main goal ZFNet reduces the network Parameters number and improves the overall accuracy by significantly reducing the number of weights where instead of 11x11 windows, it is using 7x7 windows; ZFNet intends to scientifically depict network activity effectiveness to track CNN performance.

3.3 Long Short-Term Memory Algorithm (LSTM)

It type of Recurrent Neural networks techniques (RNN) that demonstrated clear superiority, the default behaviour is remembering the context for long intervals, so it is capable of facilitating detection the long-term dependencies. In LSTM, the memory cell is used as opposed to the activation function of the hidden state.; LSTM consists of Memory cell with three gates. These three gates regulate the preceding information (the flow of information to next step) while the cell used to remember the values (maintain the state) over different intervals. Each gate has its special Parameters that need to be trained. Main goal of LSTM proposed to overcome the limitations of RNN (such as being difficult to train, and often suffering from the exploding / vanishing gradient problem), improve the learning process but also it required more computational resources .In the predictions based on time series data the important events may have an unknown delay in time; due to LSTM gated structure especially the forget gate ,it allow the useful information to pass along the network and can deal with long-term dependencies in an effective and scalable manner. LSTM is used in numerous fields such as (classifying, Natural Language Processing, Image, and Video Captioning, Time Series Prediction, and many other fields) The activation function In LSTM is hyperbolic tangent(tanh) that used to regulate the data flow and avoid the exploding gradient also , the sigmoid function is used ,Where its output value range is (0, 1) ,if it 0 or close to 0 it considered irrelevant and should be forgotten otherwise it kept

3.4 Bidirectional LSTM Algorithm (BLSTM)

BLSTM is an extension of traditional LSTM that can improve model performance on numerous problems. This technique differs from LSTM in that the input pass in two dimensions whereas in LSTM techniques the input pass in one dimension (forward or backward).In BLSTM neural network, the data that follow in the chain of unit it regulates by the gates and the current state is identify by the past and future information ; BLSTM can be trained by back-propagation over time and each unit In it has two separately hidden states(forwards and backwards hidden layer) to remember the information in the past and future to give current input. Also, the hidden states are updated in each training batch. The BLSTM used the same LSTM equation of update except the output(y) that based on output sequence of the forward layer ($\vec{\mathbf{y}}$) and output sequence of backward layer ($\vec{\mathbf{y}}$) the function (*f()*)can be a concatenating, summation an average or a multiplication functions. After training, the two hidden states forward and backward can be concatenated to represent the final output of a BLSTM layer.
Goal of BLSTM can be used for natural language processing, speech recognition, text classification, and forecasting applications ; the bidirectional networks proved that is substantially better in many fields but not all prediction problems

3.5 Multiplicative LSTM Algorithm (MLSTM)

A hybrid network that combines the multiplicative RNN (MRNN) and (Gating framework) LSTM. based on using connections from the intermediate state in MRNN to each gate in LSTM that increase the flexibility more than traditional MRNN and enhancement of the performance by increasing the fast of changing the hidden without losing the information, MLSTM outperformed in NLP and related applications. Main goal of it is taking the advantage of the flexible transitions that it is input dependent in MRNNs with the information control and long-time lag of LSTMs

3.6 Gated Recurrent Unit Algorithm (GRU)

It is a type of newer version of RNN, it is considered a similar network to the LSTM model [Mirzaei & Chu 2022]. GRUs is fast than LSTM networks but only in low complexity data sequence (due to using limited number of Parameters) while LSTM is fast , more accurate and outperformed on the high complexity data sequence [Cahuantzi et al. 2021] ; it exposes the whole state each time because there is not found any mechanism to control the degree of exposing the state in it; [Chung et al. 2014] ,The GRU able to memories the sequential input data by storing the prior input into network internal state without use separate memory cell; GRU consisted of gating units as follow : **Update gate:** this gate controls the information (units) that is updated where the value of this gate related positively to the information that is transferred to the next state cell; the input and forget gates in the structure of LSTM is replaced by (update gate) in the structure of The GRU. **Reset gate:** responsible for how to combine the currently entered information with the previous one; the value of this gate related positively to the preceding details of the prior cell that should be ignored .GRU proposed by Kyunghyun Cho et al. in t 2014, many of modifications performed on the structure of GRU to overcome the problems that suffering from it such as (the efficiency learning rate is low, the convergence state is slow and the complexity of the state of time series information) . This network is a modification of the LSTM, it aims to minimize the computational cost of network, perform the tasks of ML that related with memory and clustering, machine translation, speech signal modelling , handwriting recognition **,** also overcome the limitations that RNN suffering from it. The (tanh) function is used to regulate the data flow and avoid the exploding gradient.GRU used when need fast results with little memory consumption.

Table 4. **Comparison among some prediction techniques**

Algorithm	Advantages	disadvantages	Main Parameters	Secondary Parameters
AlexNet	▪It uses multi-GPU so faster training process. ▪Good ability to feature extraction due to deep and wide architecture. ▪Not a lot of features loss and not restricted the output due to using (ReLU) activation function that considered faster than other activation function. ▪Improve the speed of model training because not activate all neurons at the same time.	▪Due to using a large window size, there are Aliasing artifacts in the feature maps that learned ▪Time complexity to achieve results with acceptable accuracy in comparison to other models (it has 60 million Parameters) ▪Using SGD (Stochastic Gradient descent) optimizer that is difficult to train due to its needing to a suitable training schedule	▪F (), # nods in each layer, ws, s-size ▪	▪Input size, Network depth, W, #Window ▪LR, DR, #Epochs, #Iterations, Batch size ▪ ▪
ZFNet	▪Visualizing the output of intermediate layers served as an introduction to the concept of parameter tuning. ▪Reduced the stride size in Alex Net's first two layers as well as the filter size. ▪Compared to AlexNet, it reduced classification error rate.	▪The visualization process required processing Extra information. ▪using SGD optimizer that is difficult to train	▪F (), #neurons in each layer, ws , s-size	▪Input size, Network depth ▪W, # neurons in each layer, ▪#Window, LR, DR, #Epochs, #Iterations ,Batch size
LSTM	▪It's well for real world applications. ▪LSTM is fast and outperformed on the high complexity data sequence, more accurate on lager data set ▪Solving the limitations of RNN. ▪Store more information about Patterns more than other methods ▪Its performance better than other method's due ability to learn and select the information that keep or discard. ▪Contain memory cell ▪ It used Adam optimizer achieves fast and efficient results. ▪It easily performs unbounded counting	▪Required more memory bandwidth to training. ▪ ▪Can fall in overfitting. ▪ ▪Take long time to train ▪ ▪Sensitive to different weights that randomly initialization	▪F (), i(), fg() , c() ,cs() ,o()	▪Input size, Network depth, W, LR, Decay rate ▪y (),# Neurons in each layer ,#Epochs ,#Iterations ▪Batch size ▪
BLSTM	▪Find a solution to fixed sequence to sequence prediction problems. ▪it is more effective unidirectional model. ▪ Improve the performance of model on sequence classification problems	▪It is costly due to using double LSTM cells. ▪Don't good fit for some problems such as Speech Recognition	▪F (), i(), ,fg() , c() , cs() ,o()	▪Input size, Network depth, W, # Neurons in each layer, #Epochs, ▪#Iterations, Batch size

MLSTM	▪The MLSTM characterizes by its being more meaningful for autoregressive density estimation. ▪Flexible. ▪For every input have different recurrent transition functions	▪ Outperformed only in language modelling and related problems only	▪F() , i() ,fg() ,o() , M() , $h'()$	▪Input size, Network depth ▪W ,# Neurons in each layer ▪#Epochs, #Iterations, Batch size
GRU	▪Use less memory than LSTM. ▪Without using separate memory cells, you can alter the information flow inside the device. ▪Less number of Parameters than LSTM ▪Fast with low complexity data sequence. ▪Find solution to limitations of RNN ▪able to memories the sequential data	▪Limited accurate for long data sequence ▪Low learning efficiency than LSTM ▪The convergence rate is slow ▪It cannot perform unbounded counting	▪F() ,z() , r() , n() ,h() ,	▪Input size, Network depth, W ,# Neurons in each layer , #Epochs , #Iterations , Batch size ▪

4 CONCLUSION

Renewable energy has become increasingly important due to the growing need for sustainable energy sources. Deep learning techniques have been widely used for predicting the amount of energy generated from natural sources, as well as the surplus energy that can be returned to the grid. However, these models face challenges in terms of pre-processing data, selecting appropriate methodologies and deep learning techniques, and evaluating the performance and efficiency of the models.

In this study, several challenges facing the generation and return of energy using deep learning techniques were identified and classified based on the type of problem, application, and evaluation process. The study found that there is a rapid increase in the use of deep learning techniques to solve accuracy problems, and that hybridizing these techniques can be effective in managing renewable energy resources.

Despite their efficiency and high accuracy, deep learning models face challenges related to the complexity of computations and time required to obtain accurate results. Therefore, there is a need to develop more efficient and scalable algorithms. Additionally, several evaluation metrics are used to assess the performance and efficiency of the models, which can help in determining the feasibility of investing in renewable energy resources.

In conclusion, managing renewable energy resources is crucial for achieving sustainable development goals, and accurate forecasting of energy generated from natural sources and surplus energy is essential for effective management. Overcoming the challenges associated with deep learning techniques can help in achieving this goal, and developing more efficient algorithms will enable the practical implementation of these models. Some novel points that can be derived from the above are:

- The use of renewable energy sources has become increasingly important for achieving sustainable development goals and reducing the dependency on fossil fuels.
- Deep learning techniques have been widely used for accurate forecasting of energy generated from natural sources and surplus energy that can be returned to the grid.
- Pre-processing data, selecting appropriate methodologies and deep learning techniques, and evaluating the performance and efficiency of the models are significant challenges faced by deep learning models.
- Hybridizing deep learning techniques can be effective in managing renewable energy resources and solving accuracy problems.
- Developing more efficient and scalable algorithms is necessary to overcome the challenges related to the complexity of computations and time required to obtain accurate results.
- Several evaluation metrics are used to assess the performance and efficiency of the models, which can help in determining the feasibility of investing in renewable energy resources.
- Overcoming the challenges associated with deep learning techniques can help in achieving sustainable energy management and practical implementation of these models.
- There is a need for continuous research and development to improve the efficiency and accuracy of deep learning models for renewable energy management.

Funding

None

ACKNOWLEDGEMENT

None

CONFLICTS OF INTEREST

The author declares no conflict of interest.

REFERENCES

[1] S. Aslam, H. Herodotou, S. M. Mohsin, N. Javaid, N. Ashraf, and S. Aslam, 'A survey on deep learning methods for power load and renewable energy forecasting in smart microgrids', Renewable and Sustainable Energy Reviews, vol. 144, p. 110992, 2021.

[2] S. Al-Janabi and Z. Al-Janabi, 'Development of deep learning method for predicting DC power based on renewable solar energy and multi-parameters function', Neural Comput. Appl., vol. 35, no. 21, pp. 15273–15294, Jul. 2023.

[3] G. S. Mohammed, S. Al-Janabi, and T. Haider, 'A comprehensive study and understanding—A neurocomputing prediction techniques in renewable energies', in Hybrid Intelligent Systems, Cham: Springer Nature Switzerland, 2023, pp. 152–165.

[4] W. Khan, S. Walker, and W. Zeiler, 'Improved solar photovoltaic energy generation forecast using deep learning-based ensemble stacking approach', Energy (Oxf.), vol. 240, no. 122812, p. 122812, Feb. 2022.

[5] M. R. Elkadeem, S. Wang, A. M. Azmy, E. G. Atiya, Z. Ullah, and S. W. Sharshir, 'A systematic decision-making approach for planning and assessment of hybrid renewable energy-based microgrid with techno-economic optimization: A case study on an urban community in Egypt', Sustainable Cities and Society, vol. 54, p. 102013, 2020.

[6] G. K. Suman, J. M. Guerrero, and O. P. Roy, 'Optimisation of solar/wind/bio-generator/diesel/battery based micrograms for rural areas: A PSO-GWO approach', Sustainable Cities and Society, vol. 67, p. 102723, 2021.

[7] A. Razmjoo, L. Gakenia Kaigutha, M. A. Vaziri Rad, M. Marzband, A. Davarpanah, and M. Denai, 'A Technical analysis investigating energy sustainability utilizing reliable renewable energy sources to reduce CO2 emissions in a high potential area', Renew. Energy, vol. 164, pp. 46–57, Feb. 2021.

[8] O. Soydan, 'Solar power plants site selection for sustainable ecological development in Nigde, Turkey', SN Appl. Sci., vol. 3, no. 1, Jan. 2021.

[9] S. Mohd Chachuli, S. Mat, N. A. Ludin, and K. Sopian, 'Performance evaluation of renewable energy R&D activities in Malaysia', Renewable Energy, vol. 163, pp. 544–560, 2021.

[10] S. Al-Janabi and A. Alkaim, 'A novel optimization algorithm (Lion-AYAD) to find optimal DNA protein synthesis', Egyptian Informatics Journal, vol. 23, no. 2, pp. 271–290, 2022.

[11] A. Kaabeche and Y. Bakelli, 'Renewable hybrid system size optimization considering various electrochemical energy storage technologies', Energy Conversion and Management, vol. 193, pp. 162–175, 2019.

[13] N. A. Mohammed and A. Al-Bazi, 'Management of renewable energy production and distribution planning using agent-based modelling', Renewable Energy, vol. 164, pp. 509–520, 2021.

[14] G. S. Mohammed and S. Al-Janabi, 'An innovative synthesis of optmization techniques (FDIRE-GSK) for generation electrical renewable energy from natural resources', Results Eng., vol. 16, no. 100637, p. 100637, Dec. 2022.

[15] Y. Liu et al., 'Probabilistic spatiotemporal wind speed forecasting based on a variational Bayesian deep learning model', Applied Energy, vol. 260, p. 114259, 2020.

[16] H. Chen and X. Chang, 'Photovoltaic power prediction of LSTM model based on Pearson feature selection', Energy Reports, vol. 7, pp. 1047–1054, 2021.

[17] Y. Qu, J. Xu, Y. Sun, and D. Liu, 'A temporal distributed hybrid deep learning model for day-ahead distributed PV power forecasting', Applied Energy, vol. 304, p. 117704, 2021.

[18] X. Luo, D. Zhang, and X. Zhu, 'Deep learning based forecasting of photovoltaic power generation by incorporating domain knowledge', Energy, vol. 225, p. 120240, 2021.

[19] C. Pan, J. Tan, and D. Feng, 'Prediction intervals estimation of solar generation based on gated recurrent unit and kernel density estimation', Neurocomputing, vol. 453, pp. 552–562, 2021.

[20] P. Zhao, F. Gou, W. Xu, J. Wang, and Y. Dai, 'Multi-objective optimization of a renewable power supply system with underwater compressed air energy storage for seawater reverse osmosis under two different operation schemes', Renewable Energy, vol. 181, pp. 71–90, 2022.

[21] S. Al-Janabi, H. Majed, and S. Mahmood, 'Chapter 11 - One step to enhancement the performance of XGBoost through GSK for prediction ethanol, ethylene, ammonia, acetaldehyde, acetone, and toluene', in Data Science for Genomics, A. K. Tyagi and A. Abraham, Eds. Academic Press, 2023, pp. 179–203.

[22] S. Al-Janabi, A. Alkaim, E. Al-Janabi, A. Aljeboree, and M. Mustafa, 'Intelligent forecaster of concentrations (PM2.5, PM10, NO2, CO, O3, SO2) caused air pollution (IFCsAP)', Neural Comput. Appl., vol. 33, no. 21, pp. 14199–14229, Nov. 2021.

[23] B. Oryani, Y. Koo, S. Rezania, and A. Shafiee, 'Barriers to renewable energy technologies penetration: Perspective in Iran', Renewable Energy, vol. 174, pp. 971–983, 2021.

[24] A. M. A. Haidar, A. Fakhar, and A. Helwig, 'Sustainable energy planning for cost minimization of autonomous hybrid microgrid using combined multi-objective optimization algorithm', Sustainable Cities and Society, vol. 62, p. 102391, 2020.

[25] B. K. Das, R. Hassan, M. S. H. K. Tushar, F. Zaman, M. Hasan, and P. Das, 'Techno-economic and environmental assessment of a hybrid renewable energy system using multi-objective genetic algorithm: A case study for remote Island in Bangladesh', Energy Conversion and Management, vol. 230, p. 113823, 2021.

[26] A. Khamis, T. Khatib, N. Amira Haziqah Mohd Yosliza, and A. Nazmin Azmi, 'Optimal selection of renewable energy installation site in remote areas using segmentation and regional technique: A case study of Sarawak, Malaysia', Sustainable Energy Technologies and Assessments, vol. 42, p. 100858, 2020.

[27] S. Al-Janabi and Z. Al-Barmani, 'Intelligent multi-level analytics of soft computing approach to predict water quality index (IM12CP-WQI)', Soft Comput., vol. 27, no. 12, pp. 7831–7861, Jun. 2023.

[28] Z. A. Kadhuim and S. Al-Janabi, 'Codon-mRNA prediction using deep optimal neurocomputing technique (DLSTM-DSN-WOA) and multivariate analysis', Results in Engineering, vol. 17, p. 100847, 2023.

[29] I. Al-Janab and S. Al-Janabi, 'Smart micro-grid model to generated renewable energy based on embedded intelligent and FPGA', in Recent Advances in Material, Manufacturing, and Machine Learning, CRC Press, pp. 278–293.

[30] I. Jebli, F.-Z. Belouadha, M. I. Kabbaj, and A. Tilioua, 'Deep learning based models for solar energy prediction', Adv. Sci. Technol. Eng. Syst. J., vol. 6, no. 1, pp. 349–355, Jan. 2021.

[31] G. S. Mohammed and S. Al-Janabi, 'An innovative synthesis of optmization techniques (FDIRE-GSK) for generation electrical renewable energy from natural resources', Results Eng., vol. 16, no. 100637, p. 100637, Dec. 2022.