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Renewable Energy Implementing Artificial Intelligence: Applications, Problems, and Challenges

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Abstract: World transformation has meaningfully abridged the chief gas, diesel, and coal power sources. Therefore, substitute power sources based on renewable energy mainly focus on fulfilling the energy demand of the world and avoiding global warming. Among different energy sources, solar energy is the critical substitute energy source for producing electricity using photovoltaic (PV). Conversely, energy engendering performance is highly dependent on cyclical and environmental factors. The changeable version of the environment shakes energy productivity and tends to create a disapproving influence on constancy, dependability, and the grid process. Therefore, a precise prediction of PV productivity is critically required to guarantee the endurance and reliability of the grid. The detailed study reviews the perilous techniques based on PV forecast using machine learning techniques. This paper summarizes different types of renewable energy with their merits and demerits. This paper also demonstrates the key challenges existing in renewable energy using machine learning and various artificial intelligence applications in real-life scenarios. Finally, an inclusive analysis of machine learning techniques in renewable energy through a detailed literature survey is presented to forecast energy production shortly better.

Keywords: Artificial intelligence, machine learning, renewable Energy

1. INTRODUCTION

Electrical energy plays a significant role in today's era due to the demand for globalization in the world. Earlier, oil and coal natural gas were remnant energies used to produce electrical power [1]. Though these cradles of energies are contenting electricity petition, its enormous custom has instigated massive reduction of relic energies and ecological glitches [2]. The cohort of electricity from remnant energy power shrubberies has produced foremost effluence in CO2 release and conservatory gas (GHG) emanation, therefore foremost to foremost environment vicissitudes everywhere of the world [3]. Custody, in the opinion of this evidence, the custom of substitute foundations of energy to encounter electrical petition has been discovered intensively [4]. Amid these substitute possessions, renewable energy has increased primary attention universally. Energy creation from RESs is ecologically approachable, with precise GHG production, long-lasting and fewer charge than conservative dynamism [5] sources. Among various kinds of RESs PV plays a dictate role in diffusion degree in energy arcades because of solar energy of sun-provided ended atmosphere [6]. As per the study, the amount of received energy from solar radiation is 1.8 × 1011 MW. It is probable maintainable energy created from solar with the attention of investors, policymakers, environmental technologies, and governments [7]. Therefore, PV has a large prospective in town and rural electrification [8]. Solar Energy is being used in various forms, such as cooling, heating, energy creation, mutual power, and unreceptive system [9]. PV system also includes minimum preservation cost, prolonged lifetime, and connection cost compensation within a specific time [10].

2. REALTED WORK

Gautam et al. [11] proposed a framework to enhance solar energy power to the grid and solar on a similar node by using similar switching technology with the help of a decision tree ML-based algorithm in a python framework. Hybrid ML technique with extensive data analysis proposed by Sharmila et al. [12] for optimization distribution of existing energy sources targeted to intelligent power management. Alkhnadari et al. [13] developed a machine learning-based hybrid model called MLSHM, which merges ML techniques using the statistical technique for further precise forecasting of future solar energy production using energy plants based on renewable energy. Traditional functions are used to develop MLSHM model, and these functions are given below:

$$r(t) = \sigma(w_r x(t) + u_r h(t-1) + b_r) \quad (1)$$

$$z(t) = \sigma(w_z x(t) + u_z h(t-1) + b_z) \quad (2)$$

$$\hat{h}(t) = \sigma(w_h x(t) + u_h h(r(t) * h(t-1) + b_h) \quad (3)$$

$$h(t) = (1 - z(t)) * h(t-1) + z(t) * \hat{h}(t) \quad (4)$$

The appropriate symbols used in Eq. (1)-(4) are symbolized by author in [13]

An intelligent system model MERIDA is implemented by Marijana et al. [14], which assimilates the collection of big

data and forecast model of power utilization for every power source in public construction. The computation function used to develop this model is as follows:

$$y_c = f(\sum_{i=1}^{n} w_i x_i) \tag{5}$$

where y_c is the calculated output and x_i, and w_i represents the elements of input and weight vectors X and W. Som et al. [15] developed heuristic methods called SOC to assess the formal of responsibility of lead–acid succession through optimum energy cohort in a separate amalgam wind-solar renewable energy distribution method. The specific vector used to design the process is as follows:

$$V_i^t = \frac{(m_{i+\frac{n}{2}} + \varepsilon(m_{i+\frac{n}{2}}))v_{i+\frac{n}{2}}}{m_i + m_{i+\frac{n}{2}}} \tag{6}$$

The author in [15] has elaborated on specific notations and symbols used in Eq. (6). Two various ML-based algorithms ELMS and MOGAs, have been proposed by Ronay et al. [16]. Developed techniques are implemented for immediate airstream rapidity forecast from basic information customary of hourly airstream rapidity capacities for Canada and Regina in Saskatchewan. The basic predictions intervals used to develop both ML-based techniques are as follows:

$$P_r(L(x)) < y(x) < U(x) = 1 - \alpha \tag{7}$$

$$PICP = \frac{1}{n_p}\sum_{i=1}^{n_p} c_i \tag{8}$$

$$NMPIW = \frac{1}{n_p}\sum_{i=1}^{n_p} \frac{(U(x_i) - L(x_i))}{y_{\max} - y_{\min}} \tag{9}$$

The appropriate symbols and notations used in Eq. (7)-(9) have been described by the author in [16]. Musaylh et al. [17] developed an ANN model that applied forecast variables for 6-hour (h) and daily prediction power demand (G) conjecturing. The response parameters comprised 6 pertinent weather parameters SILO and 51 Re-investigation parameters attained from ECMWF models. To develop ANN model, a particular technique is used:

$$y(x) = F(\sum_{i=1}^{L} w_i(t).x_i(t) + b) \tag{10}$$

The author in [7] has summarized symbols and notations mentioned in Eq. (10). REMS technique has been proposed by Prakash et al. [18] that efficiently changes conceivable lots to renewable thrilled native power storing centered based on charge-discharge dealings and grid obtainability thus plunging energy ingesting from the grid. Perera et al. [19] proposed HOA technique by uniting Replacement and AEM in directive to haste up optimization procedure though upholding correctness. The efficiency of the solar panel used in the proposed technique can be calculated as follows:

$$\eta_n^{SPV} = p^{SPV}\left[q^{SPV}(\frac{G_t^\beta}{G_0^\beta}) + (\frac{G_t^\beta}{G_0^\beta})^{m^{SPV}}\right] \left[\begin{array}{l} 1 + r^{SPV}(\frac{\theta_t^{SPV}}{\theta_0^{SPV}}) + s^{SPV}(\frac{AM}{AM_0}) + \\ (\frac{AM}{AM_0})^{u^{SPV}} \end{array}\right], \forall t \in T \tag{11}$$

The author in [19] describes specific notations and symbols used in Eq. (11). CRO approach has been developed by Sanz et al. [20], which syndicate dissimilar exploration appliances into a solitary technique, giving a worldwide exploration process of extraordinary excellence. A wrapper method is used as:

$$\sigma^o = \arg\min(\int_{\sigma,\alpha} v(y, f(x^*\sigma,\alpha))\, dp(x,y)) \tag{12}$$

The author in [20] has elaborated on notations and symbols used in Eq. (12). Zhang et al. [21] proposed IESs technique for monitoring the power adaptation has developed an operative technique for refining grid litheness and plummeting functioning charge of IESs. A specific function is used to design IES technique.

$$\theta_{th}(t) = COP_{ave}\Delta P_{HP}(t) \tag{13}$$

Ahmad et al. [22] developed diverse regions of definite conservational and power ingesting statistics that are acquired for effort specifications assortment and demonstrating examination. The specific formula is used for developing diverse regions:

$$b^n = g^n(X^n g^{n-1} g^{n-2}(X^2 g^1(X^1 q + c^1) + c^2 + c^{n-1}) + c^n) \tag{14}$$

The author in [12] has elaborated on precise symbolizations used in Eq. (14). Assessment of various ML techniques used in renewable energy is given in Table 1.

Table 1: Assessment of various ML techniques used in renewable Energy

ML Technique	**Advantages**	**Disadvantages**
ML	Enhances solar power	When employees on

Framework [11]	usage, collects real-time data, exports data prediction strategy, and reduces electricity cost.	large scale affect other environmental factors.
Hybrid ML [12]	Substantial gain ensures innovative energy management leads and relevant data collecting.	Electricity streamlining data demand is very high.
MLSHM [13]	Achieves higher accuracy, and collects data very efficiently.	Training set parameters need to be tested.
MERIDA [14]	Improves energy efficiency, enables reconstruction management plan, and minimizes power utilization.	Potential intelligent power management using macro and micro ML techniques should be enabled.
SOC [15]	Utilizes standalone renewable power and optimized renewable sources.	Enhances electricity and design costs.
ELMS and MOGAs [16]	Employee's good precision prediction predicts airstream.	Need help finding out the methodical analysis impact on hidden neurons.
Hybrid ANN Model [17]	Calculates forest indecision provides high accuracy, and covers multiple horizons.	Need to improve forecasting accuracy. Consumes more electricity.
REMS [18]	Minimizes power utilization, and provides better accuracy.	On large scale performance of REMS decreases.
HOA [19]	It provides better accuracy, reduces operational time, and saves energy.	Unable to provide energy necessity generation on a regional scale.
CRO [20]	It improves wind speed direction and gives an admirable prediction.	Need to explore new methods of deep learning in big FSP.
IES [21]	Solves DM problems, and adapts energy conversion ratio.	Need help to work with a multi agent.
CA & CN [22]	Improves prediction accuracy, and reduces operational cost.	Performance degrades with the selection of ultra-short and ST energy.

3. RENEWABLE ENERGY AND ITS TYPES

Renewable energy, frequently mentioned as spotless energy, originates from natural cradles or continually replaced procedures. Such as airstreams or sunlight preserve admirable and blustering, and their obtainability is contingent on weather and period [23, 24].

3.1 Solar Energy

Hominids have been binding solar power for a whole year to produce harvests, stay earnest and parched foods. As per NREL, new power from the sun sprays on the ground in a single hour and is used by everybody in the ecosphere throughout the year. In today's era, sun rays are used through different types, including warmth hospices and trades, warm marine, or energy devices [25].

3.2 Wind Energy

We have returned from windmills of old fashioned, now day turbines as high as towers using turbines closely as extensive in thickness standpoint at courtesy everywhere the ecosphere. Breeze power chances a turbine's knife-edges, which fodders a power-driven producer and harvests power. Airstream, which explanations for slightly more than 6 % of U.S. cohort, has developed an inexpensive power source in various portions of the nation [26].

3.3 Hydroelectric Power

Hydropower is a prevalent renewable power cradle for power in the United States. However, airstream power is rapidly predictable to revenue over the chief. Hydropower trusts on water characteristically rapid marine in an extensive waterway or quickly sliding marine from a high theme and changes the strength of marine into power by rotating a generator’s turbine knife-edges [27].

3.4 Biomass Energy

Carbon-based biomass derives from florae and faunae and comprises trees, waste wood, and crops. Once the biomass is scorched, the biochemical energy is unconfined as warmth and can produce power with a vapor turbine. Biomass is frequently incorrectly pronounced as spotless, renewable firewood and an olive green substitute to firewood and further relic coals for creating power [28].

3.5 Geothermal energy

If you are always unperturbed in the warm mainspring, you use geothermal energy. The ground's core is warm as the sun's superficial because of the sluggish deterioration of harmful atoms in pillars at the earth's midpoint. Puncturing bottomless shafts carries subversive hot water to superficial as a hydrothermal source, formerly impelled over a turbine to generate power [29].

3.6 Ocean

Tidal and wave power energy are quiet in the growing stage, but oceanic will continually be lined by the moon's magnitude, which brands yoking its influence and a beautiful

selection. Specific tidal energy methods may damage the environment, e.g., tidal bombardments that seem like barriers and are situated in a marine inlet or cove [30].

3.7 Solar Power

At the lesser gauge, we can yoke the sun's emissions to influence the entire community, whether over PV cubicle plates or inert solar home-based enterprises. Inert solar households are intended to be comfortable in the sun over south-facing spaces and then recollect the balminess through concrete tiles, bricks, and other resources that stockpile warmth [31].

3.8 Geothermal Heat Pumps

A geothermal system is a novel revenue on an identifiable procedure. The loops at the spinal of your fridge are a slight warmth impel, eliminating warmth from the inner to save nourishments renewed and unruffled. At home-based, geothermal impels custom the ground's constant temperature to calm households in the summertime and earnest households in wintertime and smooth to warm water [32].

3.9 Hydrogen

Hydrogen desires to be joined with extra rudiments, such as oxygen, to create water, not to happen logically to gas on its individual. While hydrogen is unglued from alternative components, it can be second handled together with petroleum and Energy [33]. Merits and demerits of different renewable energies have been shown in Table 2.

Table 2: Renewable energy merits and demerits

Types of Energy	**Merits**	**Demerits**
Solar	Infinite functionality of sunshine, unlimited supply of solar energy.	Solar Energy is an impractical cost for some households.
Wind	Its unsoiled energy source avoids air pollution; it does not produce CO_2 and other harmful products.	It increases the cost of transition lines. Some cities oppose rising noise pollution; certain birds are killed by striking the turbine while flying.
Hydroelectric	It is used for projects working on a large scale. Such as hoover dam, and also covers small projects, including small dams on small rivers.	It creates disturbance and negative distress for animals and living lives. It also changes water status and ecosystems.
Geothermal	It signifies the potential of energy; it avoids footprints on the earth.	It takes maximum cost to build infrastructures and susceptibility to the earthquake.
Ocean	It is predictable energy, more reliable, and plentiful; it is a clean energy source.	It disturbs the ocean environment, habitats, and sea life, and rough weather creates lower energy.
Hydrogen	It is used as a clean scorching fuel and creates low pollution.	It is incompetent when it originates to stop contamination.
Biomass	It is used for personal use at home, in business, and in our daily lives.	Though fresh florae require carbon dioxide to cultivate, florae revenue time to cultivate.

4. AI APPLICATIONS IN RENEWABLE ENERGY

Investigators and corporations are sightseeing customs to influence AI and recover the competence and convenience of predictable power technology. These tools work within three predictable energy compasses: Energy Forecasting, Energy Efficiency, and Energy Accessibility [34].

4.1 Energy Forecasting

4.1.1 Nnergix

It touches the energy source produced from atmosphere-reliant power such as solar and wind; it tends to challenge renewable power. Nnergix is called predicting application based on web and data mining energy. Nnergix uses data from satellites and trains that data using ML to analyze companies' data to be better accurate and predict [35].

4.1.2 Xcel

Xcel is applying AI that goals at lecturing the contests allied with the undependability of climate-reliant power sources such as wind and solar. Xcel can express energy sources will vary in métier. Xcel is applied in retrieving climate intelligence having sophisticated correctness and glowing comprehensive [36].

4.2 Energy Efficiency

4.2.1 Google DeepMind

Google brings this AI application in 2014 to improve energy usage. It aims to decrease power ingesting and releases

subsequent when power is recycled. The application is utilized for cooling Google's information servers by 40 %, minimizing power utilization and bills [37].

4.2.2 Verdigris Technologies

This scheme deals an s/w technology that influences AI to enhance power ingesting. It is intended for big profitable constructions and executives of innovativeness amenities. The connection procedure instigates with IoT h/w connection. Shrewd sensors are devoted to the customer's electrical board to discover power ingesting [38].

4.3 Power Efficiency

4.3.1 Verv

It is a powered-based AI and is being used as a homegrown subordinate in power organizations. It delivers data on household utilization power utilization. Verv allows the employer to understand annals in what way every utilization at household customs power. It also assistances consumers in controlling their power expenditures [39].

4.3.2 PowerScout

Its goals at refining punter tutoring and admittance to the renewable power system. It customs AI-based model possible reserves on usefulness prices consuming manufacturing data. PowerScout influences analytics of data to recognize "shrewd homespun development" based on exclusive topographies and power customs at household customers [40].

5. CHALLENGES IN RENEWABLE ENERGY

Renewable energy is demarcated as power composed of natural assets. Newly, there has been rising attention to renewable power and converted one of the critical causes of energy cohort. Unmoving, there are numerous disputes and contests specified as [7]:

5.1 Availability of Power

The significant anxieties in renewable power are energy cohort contingent on usual assets that are irrepressible by persons. Such as, solar power current is produced only when sunlight is obtainable and goes off at nighttime; airstream energy also be influenced by the obtainability of the airstream. Therefore, if the airstream hustle is exactly little, turbines will not cause seizure, resulting in zippo energy movement to gridiron [9].

5.2 Issue in Power Quality

Dependably extraordinary energy excellence is desired to guarantee constancy and extraordinary competence of the system. The excellence of the energy source permits the scheme to effort glowing with super dependability, and inferior outlays [13].

5.3 Resource Location

Maximum renewable power florae that stake their power with the grid necessitate ample space. Maximum, renewable power generations are verbalized by the position which can be repellent to consumers. Certain renewable power generations are not obtainable in different areas [29].

5.4 Information Barrier

Improvement in this field is going on; deficiencies exist regarding information and consciousness, almost the welfare and requirement of renewable power. Speculation and assets stipends have been completed and are obtainable for enacting renewable vitalities. The vibrant necessity for administration assistance to support and guide contenders and possible receivers how smearing for renewable power inducements [33].

5.5 Cost Issue

The extraordinary preliminary connection fee is a key sprint in improving renewable power. Though the enlargement of petroleum herb necessitates around $6 apiece megawatt, it is clear that airstream and solar energy shrubberies are also great essential speculation. Therefore, stowing methods of the produced power is affluent and signify an actual contest in megawatt fabrication [38].

6. CONCLUSION

Current energy production and dissemination technology tendencies demonstrate that the smooth diffusion Grid has enlarged significantly. End manipulator utilizations are satisfying further slightly to energy excellence condition. This scenario offers a methodical evaluation of sources of energy excellence difficulties connected with renewable dispersal-produced systems (airstream and solar power). Power reduces with airstream infiltration and intensification with solar infiltration. In this paper, specific issues and challenges have been discussed in current renewable energy, paving the path for future investigations for researchers. The paper also discusses various types of renewable energies with its merit and demerits. Most recent applications in renewable energy, which show the basic idea for researchers for further improvements in energy generation, are also discussed.

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