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FORECASTING METHODOLOGIES OF SOLAR RESOURCE AND PV POWER FOR SMART GRID ENERGY MANAGEMENT

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Abstract: Due to of the test of atmosphere and vitality emergency, sustainable power source era including sun based era has encountered noteworthy development. Progressively high infiltration level of photovoltaic (PV) era emerges in savvy matrix. Sun oriented power is discontinuous and variable, as the sunlight based source at the ground level is profoundly subject to overcast cover inconstancy, environmental vaporized levels, and other climate parameters. The inalienable changeability of vast scale sun oriented era acquaints noteworthy difficulties with shrewd matrix vitality administration. Exact anticipating of sun oriented Power/irradiance is basic to secure financial operation of the brilliant network. This paper provides a comprehensive review of the theoretical forecasting methodologies for both solar resource and PV power. Applications of solar forecasting in energy management of smart grid are also investigated in detail.

Index Terms: Energy management, forecasting models, photovoltaic, smart grid, solar energy.

1. Introduction

GLOBAL warming and the energy crisis over the past few decades have motivated the use and development of alternative, sustainable, and clean energy sources. Solar energy is inexhaustible and considered as one of the most promising renewable resources for bulk power generation. Photovoltaic (PV) cells are the basic technology for converting solar energy into electric power. By the end of 2014, large capacity PV power generation was installed in Germany (38.24 GW) [1], China (28.05 GW) [2], Italy (18.31 GW), Japan (23.3 GW), U.S.A. (18.28 GW) [1], and Spain (5.39 GW), etc. Among others, Germany is the world's top installer and consumer of PV power [3], [4]. PV power generation has introduced significant economic and environmental interests to the public social awareness, such as reducing emissions of CO2 as well as creating employment [5]. PV power is reaching higher and higher penetration level in the smart grid [6]. An important feature of the smart grid is its high ability to integrate renewable energy generation. However, as an intermittent energy source, PV generation introduces significant volatility to the smart grid, which brings severe challenges to system stability [7], electric power balance [8], reactive power compensation [9], frequency response [10], etc.

To guarantee secure and financial coordination of PVs into the shrewd framework, exact PV control determining has turned into a basic component of vitality administration frameworks. Precise guaging can help enhance electric power nature of the electric power conveyed to the power arrange and, and in this manner decrease the auxiliary expenses related with general unpredictability [11]. Since PV control yield is straightforwardly identified with sun oriented irradiance at the ground level, sunlight based irradiance forecast is likewise similarly imperative to vitality administration in the brilliant network [12]. Additionally, sunlight based expectation with numerous look-ahead circumstances is critical in that it tends to the requirements of various operation and control exercises, including lattice direction, control planning, and unit responsibility in both the dispersion and transmission frameworks [13]. Because of the disordered idea of climate frameworks and the vulnerabilities engaged with barometrical conditions, for example, temperature, cloud sum, tidy and relative stickiness, exact sunlight based power anticipating can be amazingly troublesome. A number of forecasting models have been developed for solar resources and power output of PV plants at utility scale level in the past few years.

2. Characteristics Of Solar Forecasting

Solar forecasting usually yields sunlight based irradiance or PV control. The properties of PV era are fundamental to sunlight based vitality demonstrating and determining. Some vital qualities of sun oriented determining, including related factors and expectation skyline, are illuminated in this area. Institutionalized Performance

assessment records are presented for growing new sunlight based vitality indicators.

A. Pv Generation

The forecasted power output of PV generations is affected by many factors including but not limited to the measurement of solar irradiance, reflectivity, estimation of PV cell temperatures, and the efficiency of the inverter.

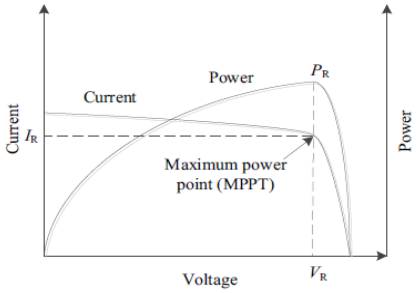

Fig. 1. Characteristic PV array power curve.

B. Major Aspects of Solar Forecasting

The selection of input variables and prediction horizon affects the accuracy of the developed prediction model. In general, the relevant variables available as inputs of the prediction model of solar power include but are not limited to the following factors [14-20]:

1) Historical measurements of PV generation;

2) Historical measurements of explanatory variables, such as relevant meteorological variables, including global horizontal irradiance (GHI), temperature, cloud cover, humidity, wind speed, and so on.

3) Forecasts of explanatory variables, e.g., NWP.

The most important input is the available observations of solar power for forecasts up to 2 h ahead, while NWPs are the most important input for longer horizons. From the point of view of practical use, different prediction horizons will correspond to the specific needs of decision making activities in the smart grid[21-25], as follows:

1) Very short-term forecasting (from a few seconds to minutes): Very short-term forecasts can be used for PV and storage control and electricity market clearing, such as 5 minutes for the Australian electricity market [21]. In the smart grid environment, very short-term forecasting of solar power becomes more important than before.

2) Short-term (up to 48–72 hours ahead): Such forecasts are crucial for different decision-making problems involved in the electricity market and power system operation, including economic dispatch, unit commitment, etc.

3) Medium-term (up to one week ahead): Medium-term forecasting would be useful for e.g., maintenance scheduling of PV plants, conventional power plants, transformers, and transmission lines.

4) Long-term (up to months to years): Long-term prediction/ estimation can be applied for long-term solar energy assessment and PV plant planning.

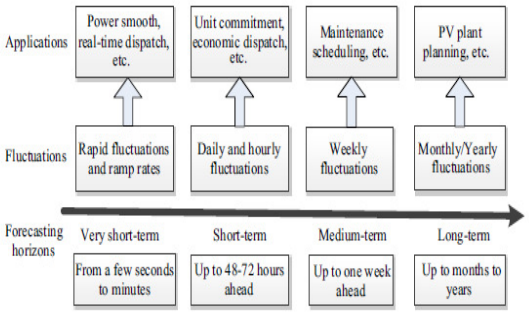

Fig. 2. Forecasting horizons and corresponding decision making activities.

3. Artificial Intelligence Models

AI techniques are being used in various fields, including forecasting, pattern recognition, control, optimization, and so on. Due to the high leaning and regression capabilities, AI techniques have been widely employed for modeling and prediction of solar energy[26-30]

A. Artificial Neural Networks

Theoretically, multilayered feed forward neural networks (NNs) can be universal approximates and have tremendous capability to approximate any nonlinear mapping to any degree of accuracy. The typical structure of an NN is shown in Fig. 3.

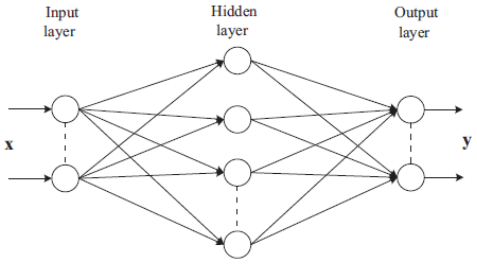

Fig. 3. Typical structure of a feed-forward neural network.

4. Hybrid Models

In practice, various hybrid solar prediction methodologies have been proposed to integrate the merits of different types of prediction models. An advanced model combining ARMA and a nonlinear autoregressive neural network (NARNN) model offers short-term forecasting of hourly global horizontal solar radiation (up to 915 h ahead) and forecasting of a high resolution solar radiation database (1 s to 30 s scales) with look-head time up to 47,000 s using measured meteorological solar radiation . A novel hybrid model incorporating both ARMA and Time Delay Neural Network (TDNN) is able to forecast hourly solar radiation providing excellent results, where the ARMA model is applied to predict the stationary residual series, and TDNN is utilized to fulfill the prediction. The seasonal auto-regressive integrated moving average method (SARIMA) and the support vector machines method (SVMs) are combined for hourly solar power prediction of a small-scale GCPV plant with 20 kWp. A novel approach combing the clear sky, AR and ARX models and taking NWPs as input is developed to predict hourly solar power with look-ahead time up to 36 h, and tested on 21 PV systems located in a small village in Denmark [14]. A hybrid forecasting model is proposed by the integration of satellite image analysis to obtain a cloud cover index by self-organizing maps (SOM) and a hybrid exponential smoothing state space (ESSS) model together with ANN [21-27]. It is tested on hourly solar irradiance in Singapore, showing better performance than traditional forecasting models.

5. Applications In Smart Grid Energy Management

With huge scale entrance of PV control, the negative impacts on the conveyance organize, particularly on the vitality administration of keen framework is drawing a great deal of consideration including issues of voltage change, control stream, lattice misfortunes, cut off of appropriation systems, et cetera .Solar and PV influence expectation could give important direction to framework administrators, power members and in addition leaders of electric influence arranging. Anticipating models with various forecast periods have been utilized for shrewd framework vitality administration. Brief time variance of PV yields can be to a great degree expansive, depending on climate conditions, for example, cloud passing .The precise brief time PV control forecast display with expectation period from 30 s to a few minutes could smooth the PV yields, to stay away from expansive changes of voltage and recurrence of shrewd matrix.

To restrain the incline rate of PV eras, different procedures have been connected to smooth the PV yields. An electric twofold layer capacitor battery stockpiling framework quick sloping generators and electric vehicles are generally used advances to ingest the fast changes of PV generators. Different procedures are proposed to plan intraday electric energy of keen networks with PV era mix. As appropriated era (DG) increments in like manner rehearse, the PV generators will posture noteworthy impacts in the operation of dissemination systems, for example, organize misfortune minimization, dependability improvement and dispersion arrange reconfigurations. Clever vitality administration frameworks with both network associated and islanded operations are demonstrated in which consider the limit and charging rate of capacity, private load varieties, and dissemination arrange power cost also.

In the savvy framework condition, the improvement of day ahead vitality administration devices for cutting edge PV establishments, including capacity units and request reaction, makes adaptability and vulnerability keen network administrators. A various leveled determinist vitality administration technique is proposed to satisfy focal vitality administration of the micro grid and a nearby power administration on the client side. A price based day-ahead vitality administration framework with capacity framework and request reaction to cover the variances of the vulnerabilities of the PV yields is proposed.

Specifically, the neighborhood vitality administration with private PV framework and building-coordinated PV micro grid has been generally examined by scientists. Likewise, day a head power booking is turning into a vital piece of energy frameworks considering the warm generators' moderate incline restriction. The impacts of gauge exactness of extensive scale collected photovoltaic power era is assessed in Day-ahead booking of PV era joined with battery stockpiling in the unit duty issues are proposed. Another use of day-ahead expectation demonstrates is the offering procedure of PV organizations taking part in the day a head power markets.

5. Conclusion

This paper presents important research take a shot at creating PV and sun based power estimating approaches. It depicts the qualities of sunlight based determining. Determining models of PV and sunlight based power are separated in to four classes: measurable models, AI-based models, physical models and cross breed models. The favorable circumstances and detriments of various sorts of expectation philosophies are quickly talked about in this paper. In addition, the utilizations of sunlight based guaging in keen lattice vitality administration are altogether examined. As indicated by the particular

applications, the fitting sun powered determining systems.

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