Dispatching System of New Energy Connected to Grid under Smart Grid

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Abstract. The introduction of smart loads in the dispatching of the distribution network helps to make full use of new energy generation and reduce the dispatch of standby units. Summarize the characteristics of distributed energy generation and load, introduce intelligent load and its application in distribution network dispatching. In view of the distributed characteristics of new energy, neural network is used to predict in the distribution network dispatching with distributed energy access. The coordination of the multi-agent system can achieve good distribution network scheduling effects, and a single agent can also use its own autonomy and learning experience to participate in the distribution network scheduling.

Keywords: Smart grid, new energy, grid dispatch, neural network prediction.

1. Introduction
In order to comprehensively improve the power grid’s ability to optimize the allocation of resources and the operating efficiency of the power system, the State Grid Corporation of the development goal of a unified and strong smart grid with interactive features, and smart dispatch is the key content of building a unified and strong smart grid, and an important means to ensure the safe and stable economic operation of the power grid [1]. The development and construction of new energy is the direction of future energy development, and absorbing as much new energy as wind power as possible is an important content in the field of intelligent dispatching research.

At present, the quantitative analysis methods for studying the consumption of new energy are mainly divided into three directions [2]. The first category considers the static safety constraints of the power system, and the establishment of a mathematical model is used to solve the grid-connected power limit value of new energy; Load characteristics and power structure, after fully considering factors such as peak-peak thermal power unit backup and low-peak thermal power unit minimum technical output, analyse the system's peak regulation capacity, and propose a new energy consumption value calculation method that meets the power balance; the third category proposes coordinated operation The concept of new energy generation and traditional generator sets are considered as a bundle, and the system’s ability to absorb new energy is improved through different combinations of output characteristics.

This article first analyses the characteristics of new energy dispatch and introduces a new energy coordinated and optimized dispatch method based on neural network prediction, including the...
formulation of annual/monthly new energy power plans, and the method of day-ahead and intra-day rolling optimal dispatch [3]. Finally, the framework design of the new energy dispatching technical support system based on the basic platform of the smart grid dispatching control system, the functions of each sub-module, and the application of the system are described in detail.

2. Characteristics of new energy dispatch

Due to the rapid development of new energy in China and the concentration of construction, limited by the transmission capacity of the grid in some areas and the peak shaving capacity of the entire grid, some areas have been unable to fully consume new energy. In order to ensure the safe operation of the system, it is necessary to carry out new energy dispatch and formulate a new energy power generation plan to ensure the maximum consumption of new energy and the safe operation of the power system. New energy dispatch is an effective management method adopted to ensure the maximum consumption of new energy and assist the safe and stable operation of the power grid [4]. At the same time, it is also a part of power grid dispatching, and its purpose is to finely manage new energy sources with strong volatility and many stations to provide technical support for power grid dispatching.

In order to ensure the safe and stable operation of the power grid and promote the standardized management of new energy grid-connected operation, the new energy dispatching should be able to monitor the power and change trend of the field (station) in real time, predict the power generation of wind power (photovoltaic), and formulate a reasonable wind farm (PV power station) power generation plan, and evaluate the grid-connected operation characteristics of wind farms (photovoltaic power stations) to strengthen the management of the stations, coordinate and optimize the dispatching of new energy and conventional power sources, support the safe and stable operation of the entire system, and improve the system New energy utilization rate, that is, new energy dispatch should include new energy real-time monitoring, prediction, dispatch planning and control, and decision-making assistance. Since some of the above functions are not available in traditional dispatching technical support systems, a new energy dispatching technical support system must be developed based on the D5000 platform and coordinated with traditional dispatching technical support systems to ensure the safety and stability of large-scale new energy access power systems run.

3. Neural Network Predictive Controller

3.1. Local neural network predictive controller

The paper uses the local dynamic model as the predictive model, and establishes a group of local neural network predictive controllers, each of which has the same structure, as shown in Figure 1, which are initially designed independently [5]. Each neural network predictive control system includes a controlled object, a neural network model, and a performance index function minimization algorithm used to determine the control input to produce the expected performance of the controlled object.
3.2. Performance index function
Like generalized predictive control, the basic idea of neural network predictive control is to use an iterative algorithm to solve the minimum value of the following performance index functions in a limited predictive time domain:

\[
J = \sum_{j=N_2}^{N_1} [y_r(n+j) - y_p(n+j)]^2 + \sum_{j=0}^{N_1-1} \lambda(j)[\Delta u(n+j)]^2
\]  

(1)

Where \(N_1, N_2\) is the minimum prediction time domain; \(N_2\) is the maximum prediction time domain; \(m\) is the control time domain; \(y_r\) is the future set value; \(y_p\) is the predicted output after feedback correction; \(\lambda\) is the control weighting constant \(\Delta u(n+j) = u(n+j) - u(n+j-1)\).

3.3. Feedback correction
In actual situations, there are often errors between the output of the predictive model and the output of the process. To do this, we need to detect the actual output of the object, and use this real-time information to correct the model-based predictions, and then perform new optimizations. Suppose the output of the process at time \(n\) is \(y(n)\) and the output of the prediction model is \(y_m(n)\), then the prediction error is:

\[
e_m(n) = y(n) - y_m(n)
\]  

(2)

The corrected predicted value is:

\[
y_p(n+j) = y_m(n+j) + e_m(n)(j = N_1, \ldots, N_2)
\]

(3)

3.4. Neural network model

3.4.1. The neural network expression of nonlinear systems. In the neural network predictive control system, the predictive model is realized by a multilayer forward neural network with a delay structure. This kind of network is often called a nonlinear autoregressive moving average (NARMAX) model with
external input, which can express a large class of nonlinear discrete systems. Its dynamic characteristics can be expressed by the following formula.

\[ y(n) = F[y(n-1), y(n-2), \ldots, y(n-n_{y}), u(n-1), u(n-2), \ldots, u(n-n_{u})] \]  

(4)

This article uses the network structure shown in Figure 2, and its expression is

\[ y(n) = f_2 \left\{ \sum_{j=1}^{N_{hid}} w_{j} f_{j}[\text{net}_j(n)] + b \right\} \]  

(5)

\[ \text{net}_j(n) = \sum_{i=1}^{n_{u}} w_{j,i} y(n-i) + \sum_{i=1}^{n_{y}} w_{j,i+n_{u}} u(n-i) + b_j \]  

(6)

Figure 2. Multi-recurring forward neural network with delay structure

Where \( f_2(\cdot) \) is the activation function of the output layer node; \( f_{j}(\cdot) \) is the activation function of the j node in the hidden layer; \( N_{hid} \) is the number of hidden layer nodes; \( n_{u} \) is the number of input nodes about \( u(\cdot) \); \( n_{y} \) is the number of input nodes about \( y(\cdot) \) Number; \( w_{j} \) is the connection weight from the j hidden node to the output node; \( w_{j,i} \) is the connection weight from the i input node to the j hidden node; \( b \) is the output node threshold; \( b_j \) is the J hidden node threshold [6]. The initial training of the neural network model is usually performed offline in advance, using the series-parallel mode (that is, there is a teacher to learn).

3.4.2. Prediction using neural networks. The neural network predictive control algorithm predicts the dynamic characteristics of any input from the current time \( n \) to a future time \( n + k \) through the model of the controlled object:

\[ y_{m}(n+k) = f_2 \left\{ \sum_{j=1}^{N_{hid}} w_{j} f_{j}[\text{net}_j(n+k)] + b \right\} \]  

(7)
min(1, )

\[
\min_{j=1}^{n} w_j y(n+k-j) + \sum_{i=1}^{n} w_{ij} y(n+k-i)
\]

Where \( f_j(\cdot) \) uses a hyperbolic tangent type function

\[
\phi(x) = \frac{2}{1 + \exp(-2x)} - 1
\]

Positive \( f_2(\cdot) \) uses a linear function

\[
\psi(x) = x
\]

4. Distribution network dispatching after the introduction of new energy

4.1. Scheduling basics

After the distribution network with distributed energy access adopts smart load, the load participates in the dispatching of the distribution network in an appropriate form. For the load users participating in the dispatch, the power quality of the load is reduced to meet the requirements of the distribution network. Dispatching needs, in the case of no difference in electricity costs, users usually choose their own load as the key load, rather than as the intelligent load participating in the dispatch. Based on maintaining the stable operation of the distribution network, the dispatching of the distribution network will give priority to ensuring the maximum power generation of new energy sources such as photovoltaics and wind power in accordance with the operating characteristics of photovoltaic and wind power generation systems [7]. At the same time, the possible adverse effects of intermittent power generation from new energy sources such as photovoltaics and wind power on the power balance of the distribution network are adjusted by the load, and technically intelligent loads eliminate power fluctuations. The dispatching process of the distribution network is shown in Figure 3. The dispatching centre first collects the power generation of the distribution network including distributed energy sources, and at the same time collects the load information of the users of the distribution network; The market charges classify the load and clarify the load capacity that can be used for dispatching, so that it can be judged whether the dispatching requirements are met according to the existing power generation and load conditions.
4.2. New energy grid dispatching system
Multi-agent (MAS) technology can not only give play to the control advantages of each member in the organization, but also realize the optimization of the overall control function through efficient cooperation between members. As an important part of distributed artificial intelligence, MAS began to develop rapidly at the end of the 20th century, and it has also been widely used in the power industry to solve complex problems such as large scale and nonlinearity that are difficult to complete by individuals alone. Through the MAS technology, the distribution network scheduling problem will be decomposed into coordination, management, control, cooperation, and communication among the various agents in the distribution network, reducing the difficulty of control. Distribution network dispatching adopts MAS technology [8]. The distribution network bus is equipped with an Agent that manages the bus, and each electrical branch of the distribution network is also equipped with a corresponding Agent, as shown in Figure 4.
The MAS distribution network dispatching based on smart load, based on maintaining the safe and stable operation of the distribution network, not only satisfies the good user experience of the distribution network users, but also maximizes the use of new energy for power generation, the specific distribution network dispatch situation as shown in Figure 5.

When the new energy power generation agent such as photovoltaic and wind power learns that the bus voltage of the distribution network is normal, it adopts power generation measures such as photovoltaic control and wind power to generate power at the maximum power and make full use of new energy. At the same time, the bus agent collects the bus voltage in real time, and collects the power from the connected branches through the MAS system, so that it can analyse the power flow distribution of the local distribution network. In the dispatching of the distribution network, it is necessary to quickly deal with the various complex situations that appear in the operation of the distribution network. The component unit of distribution network dispatch based on MAS, realizes the information interaction of the distribution network through the communication network, each agent realizes joint control under the coordination of the bus agent, and realizes better distribution network dispatching effect through joint adjustment, to the greatest extent Locally increase new energy power generation, reduce standby units and energy storage equipment, and increase the utilization rate of new energy.

5. System Simulation

5.1. When the smart load is not used

In the simulation, first test the case where the load configured by the distribution network is a general load, not an intelligent load with a regulating function. In the simulation, only two new energy sources, photovoltaic and wind, are used for power generation [9]. The gas turbine is not put into use, and only a small amount of battery energy storage A6 is put into use. In the simulation, it is first assumed that photovoltaic and wind power are generated at peak power at the beginning, and the generated energy can just meet the load demand configured by the distribution network. At 0.15s, due to the intermittency of new energy sources, the wind power generation decreases due to changes in wind energy. Observe the voltage changes of the distribution network bus connected to A1, as shown in Figure 6.
5.2. When smart load is activated

In the simulation, only two new energy sources, photovoltaic and wind, are used for power generation. The gas turbine is not put into use, and only a small amount of battery energy storage A6 is put into use. In the simulation, it is first assumed that photovoltaic and wind power are generated at peak power at the beginning, and the generated energy can just meet the load demand configured by the distribution network. Different from the load used in the simulation in Figure 6, this simulation assumes that 30% of the load is intelligent load that can be used for dispatch. At 0.15s, due to the intermittence of new energy, the power generation decreases. Observe the voltage change of the distribution network bus connected to A1, as shown in Figure 7.
6. Conclusion

In view of the current situation of large-scale centralized development of new energy in China, this paper analyses the necessity of new energy dispatch and the characteristics of new energy dispatch. On this basis, a new energy coordinated and optimized dispatching technology based on neural network is introduced, including annual/monthly power plan formulation, day-ahead and intra-day optimal dispatching. With the cooperation of multiple time scales, it gradually reduces the new energy forecast errors. The impact of this ensures the safe consumption of new energy.

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