Research on Optimal Dispatch of Water-Fire-New Energy Power System

Wentao Sun1, a, Zhonghui Wang1, b, Jinjing Hu1, c and Jinda Lian2, *
1State Grid Liaoning Electric Power Co. Ltd, Shenyang 110006, China
2North China Electric Power University, Baoding 071003, China
*Corresponding author e-mail: lianjinda2@.com, a13709840982@163.com, b2422943805@qq.com, c3109504225@qq.com

Abstract. In order to safeguard their own energy security, strengthen environmental protection and prevent climate change, many countries in the world are vigorously developing renewable energy to replace traditional fossil energy. As the largest developing country in the world, China's energy structure and development situation are in a very serious situation, and the energy security problems are threatening the smooth implementation of the national energy strategy. Accelerating the development and utilization of renewable energy has become the best choice to solve the energy crisis in China. Wind and solar energy, as an important part of new energy, are gradually infiltrating into China's power system. However, due to their great randomness, they are bound to bring severe challenges and a series of difficulties to the traditional power system optimal scheduling problem. China is rich in water energy resources, hydropower is the largest renewable energy that can be developed on a large scale at present, vigorously developing hydropower can significantly reduce the consumption of traditional fossil energy, and at the same time it will absorb some negative effects of new energy power generation through controllable adjustment. Therefore, it is necessary to rationally formulate the optimal dispatching strategy of multi-energy complementary power system for the development of China's energy strategy. This paper has carried on a series of discussions and carried out the following work. (1) Comprehensively analyze the reasons for the uncertainty of new energy power generation, study the probability distribution model of prediction error, and discuss the new energy power generation scenario with the scenario analysis method. (2) The traditional combined optimal dispatching model, the combined dispatching model with new energy generation system and the multi-energy complementary power system are calculated respectively, and the optimal dispatching strategy is given through an example analysis. (3) Complex models need efficient algorithms to solve, so this paper proposes a new intelligent optimization algorithm.

1. Introduction
On this article is based on the national natural science fund project "pumping storage energy storage scenery complementary intelligence piconets multi-scale control research", around the modern power system under the background of new energy power generation, hydropower and thermal power
coordination optimization scheduling of the key modeling and technical implementation plan, to the unit combination problem and short-term optimal dispatching of cascade hydropower station as the research foundation, the new energy power generation uncertainty, the establishment of a pluripotent complementary power generation scheduling optimization scheduling model, and proposes the corresponding algorithm to obtain the optimal strategy.

2. Studies the uncertainty of new energy power generation output
This chapter mainly discusses the uncertainty model of new energy power generation output, and studies many factors that lead to its uncertainty. This paper introduces several common prediction error probability distribution models, and according to the optimal time scale of power system, selects the appropriate probability distribution model, and solves the error by inverse function approximate expression. Then, the Latin hypercube sampling technology is used to generate scenes to describe various new energy output scenarios that may exist after considering the prediction error. K-means clustering method is used to cut scenes, which greatly reduces the calculation amount of the model without losing the representativeness of scenes.

According to the different utilization scenarios of new energy generation output forecast, it can be divided into super-short term forecast, short term forecast, medium term forecast and long term forecast. The generating factors of the uncertainty of new energy power generation output prediction mainly include the following two points:

(1) Uncertainty of new energy power generation output prediction model
In the 21/71 pool, the prediction model is a set of formulae summarized according to the statistical law, through the historical load statistics. The characteristics of the department are analyzed to find out the general characteristics of new energy power generation output data. In the model building immediately, according to the output prediction formula can be obtained and the measured value has a similar characteristic structure of the predicted value. In order to adapt to a variety of prediction models have been proposed for the variation of power generation output. Therefore, in order to get better load forecasting. Effect, the selection of a suitable prediction model is an important factor for accurate power prediction. Accuracy is an important criterion to measure a prediction model. The more factors the model considers, the higher the prediction accuracy will be. However, the output prediction model cannot cover all relevant factors, and any power prediction model is built On the basis of definite hypothesis, this will certainly produce a certain difference with the actual situation. Therefore, the objective prediction error will make the prediction model have the inevitable uncertainty.

(2) The uncertainty of the external operating environment of the new energy power generation system
As an important criterion for new energy power generation output prediction, prediction accuracy affects the safety, stability and economic operation of the power system. High-precision generation output prediction can improve the power quality of the power grid, so it is necessary to improve the accuracy of power prediction. However, due to the new energy power generation output prediction needs to consider many factors, these factors are complex and changeable, different rules, caused a certain obstacle to the improvement of prediction accuracy. For technical operation, such as emergency, line fault and maintenance; For the natural environment, such as the change of seasons, climate change and sudden natural disasters on the new energy power generation system; For the social level, such as new energy power generation industrial structure, national policies, etc. Therefore, the uncertainty of new energy power generation system is caused by the interference of various objective factors. By analyzing the degree of interference of various factors to the model and setting different parameters of the prediction model, the accuracy of the prediction results can be effectively improved. However, some unknown factors always interfere with the prediction process, which is also the reason for the uncertainty in the prediction of new energy generation output.
Figure 1. Generated 1000 wind power.

Figure 2. Classic wind power scene.

3. Study on unit combination of new energy electric power system

Compared with the traditional fossil energy, the new energy generation has unique advantages in environment and economy. With the increasing energy demand of the society, new energy generation represented by wind power and photovoltaic power is gradually penetrating into the current power system. All new energy generation has almost no exhaust emissions and is regarded as a clean energy that does no harm to the environment, so new energy generation is playing an important role. However, the volatility and uncertainty of new energy have a negative impact on the power system. In general, wind power and photovoltaic power generation, as uncertain variables, are bound to have a certain impact on the reliability of the power system when formulating the dispatching strategy of units. At present, the accuracy of new energy output forecast has a large room for improvement, and the unit scheduling plan is faced with many difficulties. In the current society of vigorously developing new energy power generation, the penetration rate of new energy power generation will be higher and higher, and the impact on the power system will gradually increase. Therefore, it is of great significance to analyze the uncertainty of new energy output in the study of unit combination optimal dispatching of new energy power system. The unit combination problem is a np-hard problem. Due to the addition of new energy generation, the unit combination problem is more complex than the unit combination problem in traditional power dispatching, so it is necessary to find a better method to solve it. In terms of theoretical research, some researches use optimization techniques to solve unit combination problems. Most of the commonly used optimization algorithms are heuristic optimization algorithms. Heuristic optimization algorithm is an important branch of modern optimization methods. Most of its ideas come from natural laws, including biological phenomena and physical laws. For example, genetic algorithm, particle swarm optimization algorithm. In addition, there are some
optimization methods for unit combination, including dynamic programming method and priority sequence method. Each has its merits, but it also has obvious drawbacks. Dynamic programming method is prone to "dimension disaster" [12]; The accuracy of the priority order method is poor. Genetic algorithm to reproduction, crossover and mutation operation, the evolution speed slow, prone to premature convergence, and its performance on the dependence of the parameters have larger [173], PSO algorithm in solving complex optimization precious, fall into local minimum, such as less than 7, these defects may cause algorithm is unable to get the optimal mix of new energy power system operation strategy. In this chapter, based on the traditional unit combination problem, Binary Artificial Sheep Algorithm (BASA) is proposed, and its effectiveness and optimization are verified by horizontal comparison with other algorithms. The corresponding scenario analysis parameters are set to quantitatively analyze the uncertainty of new energy generation with different prediction error levels.

Figure 3. Coal consumption curve of thermal.

4. Studies on multi-objective optimal scheduling of water - fire - new energy power system
In China's current power system structure, hydropower and thermal power occupy the dominant position. In response to the national construction of resource-saving and environment-friendly social energy development strategy, the role of hydropower in the current power system is enhanced, and the system load is shared for thermal power units, thus reducing the demand for coal for thermal power generation and reducing the emission of carbon dioxide and pollutants after coal burning. At present, the country is vigorously developing the new energy strategy, and has planned to build many wind farms and photovoltaic power stations in some regions with abundant wind and light resources. With the increasing scale, they are gradually becoming an important part of the power system. It can be seen that the current structure of the power system is tending to develop in a diversified way, and the simple analysis of the optimal dispatching of hydropower and thermal power systems can no longer meet the requirements of the multi-grid power generation dispatching, so it is urgent to further transform to the joint optimal dispatching with multi-energy complementarity.

As a result, there is a relatively stable output in the operation of thermal power units, which is based on a high coal consumption, resulting in high operating cost of thermal power units, as well as a large amount of carbon dioxide and sulfur pollutants. New energy is a kind of clean energy, with no pollution or emission during the operation of power generation, but it is easy to be affected by external influences and has strong randomness and intermittency. Climate change will greatly affect the stability of its output, and this kind of uncertainty will also have a negative effect on the power system. Relatively speaking, hydropower units have the advantages of stable output, rapid start-up and shutdown, etc. [180], which can cooperate with new energy generation in the power system and eliminate the uncertainty of new energy generation to a certain extent. However, hydropower is usually subject to seasonal variations, which may increase the loss of abandoned water. Therefore, the study on the operation characteristics of the multi-component power system of cascade hydropower
station, thermal power and new energy generation, and the comprehensive consideration of the economic objectives and environmental protection objectives of the power system, can better promote the development of the multi-energy complementary power system.

This chapter makes an in-depth study on the optimal operation of multi-component power systems for cascade hydropower stations, thermal power plants and new energy generation, and discusses their complementary operation characteristics, modeling and solving methods. Combined with the complex constraints of hydropower and thermal power, a multi-objective optimal dispatching model for the water-fire-new energy system was established, which comprehensively considered the economy and environmental protection. Then, a hybrid multi-objective herding algorithm is proposed to solve the model, and a set of multi-objective non-branched-surface optimal scheduling scheme is formulated, which provides effective guidance for the optimal energy allocation and economic and environmental protection operation of the multi-energy complementary power system.

By analyzing the operation rules of hydropower and thermal power systems and considering the economic benefits and environmental impacts of the power system.

5. Conclusion
In this paper, the relevant knowledge and solution methods of the optimal scheduling problem of multi-energy complementary power system are discussed, and some theoretical results for researchers' reference are obtained through the analysis and verification of the model example. Restricted by the author's theoretical level, the completeness of research data and the depth of cognition, there are still some deficiencies in the current research work, which need to be improved in the future research:

(1) For the analysis of the uncertainty of new energy power generation, this paper only discusses the influence brought by the prediction error. However, since new energy generation is very sensitive to environmental changes, there are other objective factors that will affect it, which need to be further studied. At the same time, in order to simplify the model structure, this paper does not consider the cost of new energy generation, so it is necessary to further improve the model.

(2) The unit combination model in this paper is relatively simple, and some safety constraints, such as power flow constraints, fuel constraints and mandatory operation constraints, have not been considered. In future studies, the model should be as close to the reality as possible. The number of thermal power units in the model is relatively small. With the development of the electric power system, pumped storage system plays a good regulating role in it, so the research on the electric power system with pumped storage system and yarns should be accelerated.

(3) The algorithm used in the model still has some shortcomings, such as the rules of parameter selection, the optimization of iteration mechanism and the universality of the problem, so the algorithm still needs to be continuously improved. In the future research, we can learn from the advantages of other algorithms to improve the iterative mechanism or combine different algorithms to get better optimization results.

References
[1] Yang hongxing, lu Lin, ma tao, solar-wind complementary power generation technology and its application [M]. China construction industry press, 2015. [2] Zhou Binbin. On the application of electrical automation technology in power enterprises [J] Science and Technology, 2016, (5): 69-69.doi: 10.3969/j.issn.1004-9207.2016.05.063.
[2] National development and reform commission, development of renewable energy during the 12th five-year plan period [J]. Solar energy, 2012, (16) 6-19.
[3] Fan yuzhen, analysis and research on the influence of wind power generation system on the stability of power grid system [D]; North China electric power university.
[4] Liang Z, Liang J, Li Z, et al. Analysis of multi-scale chaotic characteristics of wind power based on Hilbert-Huang transform and Hurst analysis [J]. Applied Energy, 2015.
[5] Hu yawei, wang xiao, chao qin et al., adopted the method of improving the prediction accuracy of wind power by horizontal and vertical error translation and interpolation correction [J].
[6] Liu fang, pan yi, ding qiang et al., a new wind power prediction error distribution model; Proceedings of the proceedings of the electrical system automation committee of the Chinese society of electrical engineering, 2012, F, 2012.

[7] Liu jizhen, wang haidong, li mingyang, a review on the problem of unit combination in electric power systems with wind power [J]. Electric power construction, 2014, 35 (12): 38-45.

[8] Shi yun, using the scientific development concept to analyze the advantages and disadvantages of China's hydropower development [D]; Chengdu university of technology, 2008.

[9] Sichuan water resources and hydropower survey and design institute, strengthening environmental supervision, taking the road of sustainable development of hydropower projects [J] sichuan hydropower, 2005, 24 (5): 1134.

[10] Liu yuan, he tao, li yanong, environmental impact assessment promoting green hydropower design [J]. Environment and development, 201729 (7): 37-8.

[11] Liu xiangwei, hydrological and meteorological characteristics analysis of the Brahmaputra river basin [D]; tsinghua university, 2015.

[12] Chen lei, hydropower and national energy security strategy [J]. China three gorges, 2010, (3): 5-7.

[13] Zou zuixiang, comprehensive impact analysis on regional economic development of hydropower development in key river basins of sichuan province [D]; sichuan academy of social sciences, 2015.

[14] Liu guohua, gu yi, sun qingfeng et al. Development trend of new energy [J]. Green and low-carbon petroleum & petrochemical, 2018.