Research on Multi-Transaction Concurrent Electricity Transaction Operation Simulation Technology

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Abstract. The spot market is an important part of the electricity market system. It plays a fundamental supporting role in the orderly operation of the open, competitive electricity market, and is also the key to coordinating market transaction and power system operation. In China, the differences of power grid structure, power supply structure, and economic level in various provinces are large. How to choose the local spot market model and market rule can’t be answered through manual experience. At the same time, the electricity market operation is a long-term dynamic evolution process. It is affected by various factors such as power grid structure, supply and demand situation, and external environment. The bidding behaviour of market members is constantly adjusted with the market participation time. It is difficult to predict the market operating effect only through theoretical analysis. Therefore, it is necessary to study the multi-transaction concurrent operation energy trading simulation software that is suitable for the above-mentioned problems in order to solve the above problems, and provide technical support for simulation verification and comparison analysis for the relevant models and rules design of future sales participation in the electricity market. Before the official operation, the experimental simulation was carried out for the continuous operation effect of the market rules.

1. Introduction
Electricity market simulation is an important research method in the field of electricity market, and many countries in the electricity market reform have carried out related research. The British electricity market has established a simple market simulator for studying market trading rules, and construct an agent model based on electricity market information for simple reasoning with the goal of generator profit and unit utilization [1]. Cornell University has developed a network-based test platform which is known as Power Web system to construct agent decision rules based on random quotation and other methods, mainly used to simulate day-ahead electricity market [2]. In order to research the wholesale electricity market rules, The University of Iowa developed an agent-based electricity market simulation system (Ames) that uses RE-learning algorithm as the core of decision-making, which focus on research on the US wholesale electricity market, and this market clearing mechanism is based on the node price method considering network constraints [3-4]. The US Agone National Laboratory has developed EMCAS, a complex adaptive market system for electricity market application that uses electricity price forecasting and greedy algorithms as agent decision-making functions, which uses agents with decision-making and learning capabilities to simulate market participants such as power users, generation companies, and transmission companies. EMCAS can simulate power system
operation and calculate the electricity price per hour and location of the grid, and study the day-ahead electricity market in the US. The market clearing mechanism is a node price method that considers network constraints [5].

With the gradual deepening of theoretical and technical research in the field of electricity market, domestic electricity market simulation technology research and application system development have become hot spots. Wang Xiaoping and Qi Huan of Huazhong University of Science and Technology have proposed an electricity market simulation platform design framework based on HLA standard, which is based on the existing Internet network, build the electricity market simulation platform from the software, and the electricity market adopts the real-time bidding transaction mode under the single buyer mode [6]. The electricity market simulation and training system developed by Southeast University can simulate the operation process of different power networks under different market trading rules, achieve the purpose of training and guiding the participants in the electricity market, and have certain reference value for the design and evaluation of the electricity market mechanism [7]. The “Northwest Electricity Market Integrated Simulation System” jointly developed by Northwest Power Grid Corporation and Xi’an Jiaotong University and South China University of Technology has achieved configurability in terms of market model, which can be carried out in terms of unit constraint type, network constraint type, and financial contract. The configuration realizes the inter-provincial flow section constraint in the time-sharing and segment bidding mode, and can automatically divide the price zone according to the constraint condition, the system uses the combination of artificial simulation and intelligent agent to simulate the market operation. The China Electric Power Research Institute and South China University of Technology jointly developed the “National Power Market Simulation System”, which uses the agent technology based on learning strategies to simulate the generation, and realizes multi-market simulation including annual market, monthly market and day-ahead market. Various constraints such as unit constraints and network constraints can be used to simulate various market types, such as China's Northeast Power Market and East China Power Market [8]. Yang Zhenglin and Zheng Yaxian of China Electric Power Research Institute proposed to use the electricity trading operation simulator to realize the market organization, clearing and settlement of power dispatching trading institutions, to realize the evolution of market members' decision behaviors by market member behavior simulator, and to realize grid operation simulation by grid running simulator, deriving the market evolution process under the set market model, which can be used for multi-electricity commodities, multi-transaction period, multi-transaction mode of electricity market operation simulation and evaluation, operation technology verification, operator training and Operational system functional testing [9].

On the basis of research on the bidding behavior simulation technology of the sales side market members and the electricity clearing technology of the node marginal price, this paper aims to further study the energy trading operation simulation software technology, and then design and develop a set to adapt to the sale side. The multi-transaction concurrent operation energy trading simulation software is used for simulating the operation process of the provincial electricity market, providing verification simulation means for the electricity market operation mode and corresponding operational effect evaluation released by the sales side. This platform can provide a real-life training environment for the electricity market participant, help the market participant to understand the trading rules, familiar with the trading process, and analyze the bidding strategy.

2. Experimental case management technology research

According to the design of the experimental simulation process, in the electricity market operation simulation based on the experimental platform, the data environment required for the experimental simulation must be prepared first. After that, the market parameter configuration must be carried out, including the Multi-market joint operation, the corresponding trading mode, the market operation simulation time scale, the trading rules, and the clearing rules, etc. These parameters will be applied to the whole market operation simulation process. At the same time, in different market operation, even the same simulation data scenario will result in different process data and operational simulation results.
due to different market configuration parameters and different simulation time intervals. Therefore, it is necessary to manage the configuration parameters and process data of the market operation simulation based on experimental cases to achieve data isolation between different simulation processes.

The experimental case is used for the simulation process management, such as a simulation process from July 1, 2016 to August 31, 2016 for the Jiangsu electricity market. The market simulation type may include forward electricity market, day-ahead electricity market, Auxiliary service market, etc. After creating the experimental case scenario, the market parameters can be set for the experimental case. The market parameters storage is directly related to the simulation case. These parameters directly affect the market simulation operation process.

After completing the experimental case parameter configuration, the continuous market simulation can be realized by two methods: manual triggering or automatic triggering. In the experimental case, the multiple markets operation simulation will be carried out in turn, subsequently, creating the corresponding transactions, declaring and clearing the transaction, and finally the entire market will be cleared and operationally analyzed. All of these links are based on experimental cases. Related operational simulation data are stored based on experimental cases. For example, if this experimental case number is 450, a number of transactions are created during the market simulation process, then the experimental case number information is recorded in the transaction sequence information, and the transaction declaration, clearing, and data such as billing will also be subordinate to the experimental case. Similarly, process status information during the experimental case simulation process and simulation operation records performed by the experimental personnel participating in the experimental case are also subordinate to the experimental case. The data management method based on the experimental case is shown in Figure 1.

3. Transaction operation simulation timing configuration technology
The experimental platform transaction simulation process includes transaction creation, transaction release, transaction declaration, transaction clearing and other aspects. In the experiment simulation process, it is necessary to control the startup sequence and start condition of each link according to the simulation need. The control of the experimental simulation process includes two types: manual control and automatic control. The actual trading operation technical support system mainly uses manual control to control the trading operation process, and can also be used in the test simulation process. Manual control is divided into two methods based on process control and button-based triggering. The experimental process control based on process control has been explained in the platform technology part. The button triggering mode is used to manually control the starting condition and starting sequence of each link. When the transaction creation, declaration, clearing, security check and other links are carried out, click the button to start the corresponding link. This method is relatively simple to implement, and will not be described in detail here.
The process of trading operation simulation involves multiple trading operations and multiple types of transactions. The market products composition and order, transaction types and trading links may be inconsistent under different market modes. Therefore, in order to improve the adaptability of the automatic control of the simulation process, the experimental simulation process is divided into the experimental simulation control program and the independent transaction operation execution links. The transaction operation execution links correspond to the various transaction operation steps, and the experimental simulation total control procedures are in the market simulation process. It is responsible for passing in the corresponding parameters according to the market model and trading rules and starting the corresponding trading links. The automatic simulation control program is started after the start of the experimental simulation. According to a certain frequency, it is judged whether each transaction operation link satisfies the time trigger condition or the event trigger condition. If it is satisfied, the corresponding transaction link is executed until the experimental simulation case is finally completed. The execution process of the experimental master control program is shown in Figure 2.

4. Experimental scene data management technology
Experimental environment preparation refers to preparing a corresponding data environment for electricity trading operation simulation. According to the overall design of the electricity market panoramic experiment platform, the system data environment includes four parts: global database, experimental simulation work area, case database and case data file, as shown in Figure 3. The model management, basic data maintenance, system parameter setting, grid operation simulation and other functions of the experimental platform work on the global database, while the electricity transaction operation simulation process runs in the experimental simulation work area, and the case database and case data files are used for storage. The data of the secondary electricity trading operation simulation case. Therefore, the experimental environment is prepared to obtain data from the global database, case database, or case data file and load it into the workspace according to the requirements of the experimental data scenario.

When loading the experimental environment from the experimental scenario backup database, you need to first select one of the cases managed in the case database, then find the case data table to be loaded in order and delete the case ID field to create the corresponding work area in the work area. The data table, then obtain the data of the case according to the ID of the selected case and copy it into the work area data table.

When loading the experimental environment from the case data file, you need to select a case file in the case file managed in the case data file system, then find the case data table to be loaded in order and
create the corresponding work area data table in the work area. Then copy the data of the case to the work area data table, as shown in Figure 4.

After the experimental scene data loading is completed, the data acquired by the data access service of the experimental platform is the data after the switching, and the switching of the experimental environment is realized. Of course, if the experimental scene data is loaded into the work area and then the transaction case is simulated, and the experimental scene of the current work area needs to be added to the sample library to be retained, the data management service needs to be called to export the experimental scene data of the current work area. Dump files or E files and store them in the corresponding path of the sample library data file. In this way, the next time the sample data scene is loaded, the scene data will also become one of the alternatives.

5. Multi-case data comparison analysis technique

On the basis of case data management, comparative analysis between multiple cases can be carried out, including comparison of various data in the case and comparison of statistical analysis indicators.

5.1. Case comparison analysis method

Case comparison refers to selecting multiple comparisons from various simulation cases saved by the system. There are a lot of cases in the system. In order to ensure the comparability between cases, in the case of multi-case comparison analysis design, there are two ways to select the case data for comparison:

(1) Two or more case data corresponding to the same time period;

(2) Case data for the same time period in two or more cases.

The case comparison process involves statistical processing of large amounts of data and data comparison and trend change display. Therefore, in order to adapt to different angles of data comparison analysis, the case comparison function is designed as a configuration tool in this project, and can be used according to the configuration of the comparison analysis screen is required.

5.2. Case comparison analysis project setting

(1) Comparison of calculation conditions: refers to the comparison of the transaction operation simulation case input data, including the unit model data participating in the market, load, section, and tie line, equipment maintenance plan arrangement, clearing calculation parameter setting, and load forecasting, tie line plan data, etc.

(2) Comparison of electricity price indicators: refers to comparing the electricity price data in the simulation result of the transaction operation simulation case and the corresponding statistical analysis indicators, including the unit price data and each node, the average region electricity price, and the average electricity price of the group, the daily maximum electricity price of the whole system, the daily minimum electricity price, and the trend of the above-mentioned electricity price data;

6. Conclusion

This paper is mainly engaged in the design and development of electricity transaction operation simulation systems adapted to the electricity sales side release, the electricity transaction operation experimental verification, and the market operation effects evaluation and analysis. First of all, the simulation system functions and the overall software architecture are designed in accordance with the requirements for the electricity transaction operation simulation that are released on the electricity sales side. Based on the design scheme, the simulation system is developed and integrated, and then the non-stop clearance method is developed based on the simulation system. Electricity transaction operation simulation under different transaction pricing periods. Finally, the market operation effect is analysed and evaluated according to the simulation results, which provides decision-making reference for the market models and rules design.
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