The Analysis and Design of Unified Data Model for Electricity Market under the Background of Deepening Design

Liu Dong1,2, Zhang Qian1,2, *, Ye Fei1,2, Li Lei3, Chen Chunyi3 and Qiu Shuxian4
1 Nari Group Corporation/State Grid Electric Power Research Institute Nanjing China
2 Beijing Kedong Electric Power Control System Co., Ltd. Beijing China
3 Shanghai Electric Power Trading Center Co., Ltd. Shanghai China
4 Beijing Zhonghe World Management Consulting Co. LTD. Nanjing Branch. Beijing China

* E-mail: hbkjd2009@126.com

Abstract. With the deepening of market-oriented reform in China, the types of market entity are increasing. The existing data model of market entity in China's power trading platform has been unable to meet the needs of registration and multidimensional statistical analysis under the new situation. Based on the design concept of the international standard IEC62325, this paper constructs the unified data mode with the wide range of adaptability including the market model and physical model, combining with the current registration needs of new market entity in China's power market. The model takes into account the market registration of non-enterprise market entities (individuals or organizations) for the first time, and meets the registration needs of multi-identity market entity, realizing data sharing and market collaborative operation between two levels of platforms.

1 Introduction

The electricity market reform is the inevitable trend of power industrial development. The construction of electricity market in various countries is gradually being improved, and a large amount of electricity market data is being generated. The normalization and interoperability of data information model have become the key to data management in the electricity market. On the basis of IEC61970 [1-2] and IEC61968, the International Electrotechnical Commission (IEC) released the CIM standard for electricity market, IEC 62325-301[3], in May 2011, and proposed a systematic and complete electricity market operating standard system. The scholar of China has transformed IEC 62325-301 into the industry standard and applied it to the power trading platform [4].

At present, with the deepening of market-oriented reform in China, the types of market entity are increasing. In addition to traditional market entity such as power producer, electrical customers, and electricity sales companies, virtual power plant and energy storage companies continue to enter the electricity market. In addition, the demand for a single social entity to register as multiple types of market entity has gradually increased. The existing data model of market entity in China's power trading platform[5] has been unable to meet the needs of registration and multidimensional statistical analysis under the new situation. Based on the current new situation of market-oriented reform, it is urgent to build a data model framework for the electricity market under the new situation to support the development of diversified market entity in the future.

Based on the Deepening Design Plan of National Unified Electricity Market and the development situation of China's electricity market, the information of enterprises, individuals and organizations is firstly included in the scope of the market model and the unified data mode of electricity market including the market model, the physical model and its relationship is built in the paper, realizing the standardized design of data model, and effectively supporting the data sharing and coordinated
operation of the two-level platform. Secondly, based on the analysis results of unified data mode, the conceptual data model of the electricity market is designed according to the design specifications of conceptual data model, and the key attributes of its key entities are sorted out.

2 The analysis of unified data mode
This paper comprehensively sorts out the types of market entities that may appear in the current and future market development, and builds the data model based on the difference between market attributes and physical attributes of different market entities. Secondly, it is proposed to establish a relationship between the market model and the physical model through the ownership relationship to support the orderly participation of market entities in the market-oriented transaction business.

2.1 The construction of market model
The market entities of different types and different regions all have a common feature before entering the electricity market, that is, they are a social entity, which may be a profit-oriented enterprise that self-paying profit and loss, and independent accounting. The social entity may also be a collective or group composed of many elements cooperating with each other in a certain way, or it may be a citizen with business ability and registered with the industry and commerce administration department according to the Regulations of Individual Industrial and Commercial Households, engaged in industrial and commercial operations. The social entity may also be a social individual.

With electricity market reform is developing and modifying quickly, social entities entering the electricity market will be multi-typed. In order to meet the needs of different social entities, the paper builds the market model based on the social entities, including company, individual, and group organization. At the same time, the paper sorts out the business roles of market entities in the electricity market and divides them into three categories: power generation, power sale and power consumption.

Secondly, according to the current business habits of market entity in the electricity market, market entity can be divided into seven categories: power producer, electricity sales company, electricity customer, distributed power producer, virtual power plant, energy storage company, and grid company, which can carry out different electricity market business according to their actual situation. For example, power producer can operate power generation and power sale, electricity sales company can operate power sale and power consumption, electricity customer can operate power consumption, and local grid company can operate power sale and power consumption.

Therefore, the market model constructed in this paper is a two-tier structure including social entity and market entity. The market model framework is shown in the Figure 1:

![Figure 1. The diagram of market model architecture](image)

The market model framework in the paper can support different types of social entities to enter the market, and also support the same social entity to participate in transaction with different market roles, meeting the expanded definition needs of market entity types market entity.

2.2 The construction of physical model
The design of physical model focuses on the smallest physical unit of different market entities, which is mainly constructed according to the physical characteristics of the market entity. The smallest physical unit mainly includes unit(unit groups), user metering point, energy storage unit, etc.

In addition, the physical model also contains the basic information of the grid model such as cross section, tie line, gate, node, and line involved in power grid transmission.
The specific description of the physical model constructed in the paper is shown in the Figure 2:

![Figure 2. The diagram of physical model architecture](image)

2.3 Mapping relationship between the market model and the physical model

In order to associate the market model with the physics model and support the market entity to participate the market-oriented transactions orderly, the paper establishes the association between the market model and the physical model through equity attributes.

(1) Mapping relationship between grid model and market model. The mapping relationship between cross section, tie line, gate, node, line and grid company in the market model is mainly reflected in the asset ownership.

(2) Mapping relationship between unit and market model. The mapping relationship between the unit in the physical model and the market entity operating power generation in the market model is mainly reflected in the difference in the share of different market entities in the same unit. At the same time, different unit will be affiliated with a certain grid company to complete the grid-connected power generation, that is, the dispatch unit corresponding to the unit.

(3) The mapping relationship between user metering point unit and the market model. The mapping relationship between the user metering point in the physical model and the market entity operating power consumption in the market model is mainly reflected in each user metering point needs to belong to a market entity in order to complete the power consumption.

3 The design of unified data model

3.1 The design of conceptual data model

Firstly, a market entity in the electricity market is first a social entity with the social characteristics of companies, individuals, and group organizations, which has been drawn in the analysis of unified data model. The information of companies, individuals, and group organizations is included in the scope of the market model for the first time in the paper. In the construction of the conceptual data model, this paper first constructs three entities: company, individual, and group organization, to store basic information of different social entities, and can register multiple types to support a single social entity.

Secondly, the paper constructs seven entities including power producer, electricity sales company, electricity customer, distributed power producer, virtual power plant, energy storage company, and grid company to store differentiated information for different types of market entity. The paper constructs a public entity to store the same information for different types of market entity. The paper establishes the association relationship between the social entity and the market entity, meeting the needs of a single social entity to register different types of market entity.

Thirdly, according to the smallest physical unit of different types of market entity in the analysis of unified data model, the paper constructs four entities including unit/unit groups), user metering point, energy storage unit, to store basic information of different physical entities. Among them, the unit (unit group) are divided into thermal power unit, hydropower unit, solar power unit, wind power unit, nuclear power unit, other unit, according to their different power sources for power generation. The paper constructs a public unit entity to store the same information for different types of unit to meet the needs of high-efficiency queries. For the electricity sales company without the smallest physical unit, the paper sorts out the information items required for its registration, and designs the employee entity, distribution network entity, and shareholder entity.

Finally, based on the mapping relationship between the market model and the physical model, the relationship between the entity corresponding to the market model and the entity corresponding to the physical model are established. For example, the user metering point belongs to a electricity customer, and the distributed power generation project belongs to a distributed power producer. The asset relationship of a single tie line belongs to a certain grid company. A single power producer can occupy
multiple unit (unit group), and a unit (unit groups) set can belong to multiple power producers, so the relationship entity between the power producer entity and the unit entity is constructed.

The conceptual model of the market model constructed in the paper is shown in the Figure 3:

![Figure 3. The diagram of conceptual model](image)

3.2 The design of entity attribute

It is necessary to further refine the design attributes contained in each entity. Such as the such as enterprises information including the name, unified social credit code, legal representative, etc., and individual information including the name and address of the owner, and the organization information including the organization code, and the information of power producer including the type of power purchase, dispatch abbreviation, and the information of electricity customer including the type, voltage level, and the information of electricity sales company including the total assets, and unit (unit group) information including the generation type, rated capacity. Therefore, based on the differentiated characteristic information of different entities, the paper designs the corresponding attributes. The attributes of key entities in the data model are now listed and explained.

(1) The attributes of company entity include COMPANY_ID, MEMBERS_NAME, ALIAS_NAME, REG_ADDRESS, MEMBERS_NAME_OLD, GEOGRREGION_ID, CREDITCODE, LEGAL_REPR_NAME, TAXCODE, DEPOSIT_NAME, ACCOUNT, DEPOSIT_BANK, FOUNDDATE, INDUSTRY, CORPORNNAME, REGCAPITAL, ENTERPRISE_TYPE, ORGANIZECODE, DOUCUMENT_NUMBER, DOUCUMENT_TYPE, ADDRESS, SCOPE, WEBADDRESS, TEL, BUSINESSTERM, POSTALCODE, FAXPHONE.

(2) The attributes of individual entity include COMPANY_ID, GEOGRREGION_ID, SHOP_NAME, FOUNDDATE, ORDER_ID, OPERATOR_ADDRESS, OPERATOR_SCOPE, END_
DATE, START_DATE, OPERATOR_NAME, DOUCUMENT_NUMBER, DOUCUMENT_TYPE.

(3) The attributes of market entity include COMPANY_ID, MEMBERS_ID, MARKET_DATE, MEMBERS_BUSI_TYPE, MEMBERS_TYPE, MEMBERS_CODE, MEMBERS_NAME, MARKET_ID, ORDER_ID, STATE, EXIT_MARKET_DATE.

(4) The attributes of electricity sales company entity include MEMBERS_ID, SALE_TYPE, INSTITUTION_CREDIT_CODE, CREDIT_REPORT_CODE, PAID_ASSET, ATTRIBUTION, LICENCECODE, DMS_TYPE, LICENCE_EXPIRATION_DATE, LICENCE_EFFECTIVE_DATE, TOTAL_ASSET.

(5) The attributes of power producer entity include MEMBERS_ID, MEMBERS_NAME, DISPATCH_NAME, RATING, SCHEDU_RELATION, POWER_PURCHASE_TYPE, ELECTRICITY_UNIT, BUSI_DEPART.

(6) The attributes of unit entity include UNIT_ID, MARKET_ID, GENERATOR_NAME, GENERATOR_STATUS, TYPE, MARKET_DATE, GENERATOR_TYPE, GENERATOR_TYPE_SUB, GENERATOR_TYPE_THIRD, COMMERCIAL_TYPE, GEOGRREGION, GEOG_AREA_ID, ORDER_ID, GENERATOR_MODEL, CONNECT_VOLTAGE_ORDER, IS_OFF, MIN_TECPower, MAX_TECPower, REGISTER_CODE, CURRENT_APPRL_PRICE, CURRENT_APPR_PRICE_DATE, PRICE_APPR_NUMBER, PLAN_PROD_DATE, TRIAL_RUN_DATE, DISPATCHT_DCJZ, DISPATCHT_LEVEL, EXIT_MARKET_DATE, RATED_POWER_FACTOR, GENERATOR_RATED_CAP, OPEBEGIN_DATE, LICENCECODE, ISREMITTED, LICENCE_EFFECTIVE_DATE, LICENCE_EXPIRATION_DATE, ZDKCDMMFTS.

4 Conclusion
This paper studies the current registration needs of new market entity in China's power market, and constructs the unified data mode with the wide range of adaptability including the market model and physical model. This model can satisfy non-enterprise market entities to register, and support the registration business of multi-identity market entities, and provide basic support for the realization of data sharing and market collaborative operation between two levels of platforms.

Acknowledgments
This paper is sponsored by the science and technology project of the State Grid Corporation of China (Research and Application of Key Technologies for Deepening Design of National Unified Power Market).

References
[1] ZHANG Shenming, LIU Guoding. Introduction of standard IEC 61970[J].Automation of Electric Power System,2002.26(14):1-6.
[2] CAO Yang, YAO Jianguo, YANG Shengchun, et al. Latest advancement of smart grid core standard IEC 61970[J]. Automation of Electric Power System,2011.35(17):1-4.
[3] IEC 62325-301-2014 Framework for energy market communications-Part 301; common information model(CIM) extensions for markets[S].2014.
[4] ZHENG Yaxian, YANG Zhenglin, XUE Bike, et al. Latest Development of International Electricity Market Standards IEC 62325[J]. Automation of Electric Power System, 2015.39(15):1:8+81.
[5] SHI Lianjun, SHAO Ping, ZHANG Xian, et al. Discussion on Architecture of New-generation Electricity Trading Platform[J]. Automation of Electric Power System, 2017,41(24):67-76.