Send Orders for Reprints to reprints@benthamscience.ae

The Open Electrical & Electronic Engineering Journal, **2015**, *9*, 175-178

Strategic Research on China Domestic Power System Modeling

Wang Ye*

College of Business, Sichuan University, Chengdu, China, 610065, P.R. China

Abstract: Power system modeling is a software management tool for managing electricity demand, power system trading electricity and power system generation expansion planning purposes, through the combination of various models and their comparison, which can be used by the Government for its policy support and by the power enterprises for their business development planning decision support, and ensure that power enterprises can provide sufficient and safe quality power supplies at the lowest economic and environmental costs. Based on the study of existing power system models of advanced western countries as well as the current domestic power system modeling status, this article puts forward some proposals and ideas on building domestic power system models.

Keywords: Electricity system modeling, strategic research, technical economy.

1. INTRODUCTION

With the continuous development of modern communications, computing, networking and control technology, global resources and environmental issues have become increasingly prominent, constructing smart grid, securing energy safety, promoting energy-saving reduction emission and developing low-carbon energy, has become more and more of great significance especially for developing countries like China [1]. Electricity systems modeling is a high level complicated system engineering, which covers all circles of power generation, transmission, consumption, *etc.* To simulate the constraint conditions of the electricity systems through the electricity systems modeling, includes production and operation capabilities of power plants, environment constraints, fuel costs, transmission constraints, *etc.* and finally achieve solving contradictions, finding uncertainties, and optimizing electricity system resources, *etc.* In this paper, we analyzed the development and application of electricity systems modeling of western developed countries, deeply digging the large gap between China domestic electricity systems and those of foreign developed countries, and finally give some advice on developing China domestic electricity systems modeling from strategic points of view.

2. FOREIGN ELECTRICITY SYSTEMS MODELING

At present, foreign grid modeling mainly includes two kinds of methods, i.e. stochastic methods and dynamic methods [2].

Stochastic method mainly adopts statistical principles, using original history data of electricity systems or generated concerned system parameters through random data generator for simulation, combined with the corresponding algorithms of linear, nonlinear, or both, the latest research also use much artificial intelligence algorithms, for grid-related constraints research and optimization; dynamic method is mainly used to solve those much more complicated problems, i.e. to split the complex problem into relatively simple subproblems, through hierarchical layer by layer and using a bottom-up or top-down recursive solution , dynamic method usually contains more major constraints, and eventually conclude the optimal model through the massive large data recursive algorithm. The typical dynamic methods include Agent-based automation model solution, time-based model solution, and cost-based model solution, *etc.*

Because a high degree of openness of foreign electricity systems, the information resources and historical data of their electricity systems are complete, which can be accessed from Internet and even traced back to earlier than1980s like USA, England, Canada, Australia, New Zealand, *etc.* [3-6], undoubtedly which has provided the first hand massive data for the electricity systems modeling research of these countries; meanwhile, the academic research also brings cheap and high quality achievements to the development and optimization of electricity systems of these countries.

2.1. General Foreign Electricity Systems Models

Typical foreign electricity system models include IBM smart grid model, DOE smart grid model by the department of energy of America, EPRI smart grid model by Electric Power Research Institute of America, and EU smart grid model by European Union, *etc.* [7]. IBM smart grid model was put forward by IBM company, APQC (American Productivity and Quality Center) organization and the global smart grid colleague, which covers the smart grid planning, its production, operation and maintenance, which establishes detailed evaluation systems on eight sections on two areas of personnel and technology, and operation workflows; whose

*Address correspondence to this author at the College of Business, Sichuan University, Chengdu, China, 610065, P.R. China; Tel: +86 13985420991; 13808033367; E-mails: 251063746@QQ.com, 550593760@QQ.com

1874-1290/15

purposes are to evaluate the reliability and maturity of electricity systems, and provide detailed technical specifications for the electricity systems optimization. DOE smart grid model focuses on improving electricity server quality on areas of information and new services, improving the electricity resources utility efficiency, which is designed with the end user participation mode, facing new type electricity consumption markets like electric motorcycles, achieving the interaction between electricity generation and consumption, which can achieve a dynamic pricing mode of smart grid. EPRI smart grid model focuses on the research of investment and output model of electricity projects, based on the whole lifecycle management of electricity systems, to increase the electricity resources efficiency and operation efficiency through flexible design of electricity systems on auto precaution and auto fault self-recovery technologies, *etc.* EU smart grid model focuses more on marketing security, electricity quality and environment restrictions, especially defined detailed evaluation indicators on low-carbon and energy-saving emission reduction, which provides an advanced prerequisite for building a more rational, high efficient, and green EU electricity system, *etc.*

2.2. Other Commercial Foreign Electricity systems Models

There are some other typical commercial electricity system models. 1. AURORAxmp model developed by EPIS Inc. in 1997, the latest version is 9.6, which is designed for wholesale electricity market modeling; currently AURORAxmp system is loaded with both North America and European electricity databases, which can predict short term and long term of electricity marketing prices through real time and situation simulation and analysis, AURORAxmp adopts optimization methods like linear algorithm, genetic algorithm and recursive methods, *etc.* AURORAxmp also applies stochastic treatment on new interrupted type energies, e.g. wind energy management. 2. EMCAS electricity model developed by Argonne national laboratory in 2004, which is based on Agent technology and used for behavior models like marketing bidding between electricity producers and consumers, power plant production, operation and maintenance, decision support, electricity consumption analysis, *etc.* to increase the prediction accurateness on electricity markets, the latest version is 2.6; EMCAS prediction can be applied as per real time, hourly, daily, weekly, monthly, yearly and multi-yearly, while short-term prediction simulation can be used for bidding strategy evaluation and resources utility optimization, and long-term simulation analysis can be used for the investment planning on general marketing environment; agents here can play consumer, requirement demander, distribution company, power plant, transmission company, independent operation and maintenance system, local operation and maintenance system, coordinator unit, *etc.*; EMCAS can also analyze the changes of real electricity markets behaviors through simulation on changing the rules of electricity markets inside the system. 3. PLEXOS electricity market model developed by Glenn Drayton company, which has been adopted by many electricity organizations of US Federal Energy Committee on their research works and which can be used on thermal, hydro, renewable energies, transmission, marketing services, *etc.*, can also be used for marketing analysis, design, planning on power capability extension, and existing capability optimization; PLEXOS adopts typical Monte Carlo method to optimize and maintain existing production capability, predicts based on yearly ahead on capability extension; transmission model inside PLEXOS can give accurate predication on demands based on fixed load, transmission restrictions, security factors, *etc.* 4. GTMax model, another one developed by Argonal national laboratory in 1999 for maximization modeling of power generation and transmission, which has been widely used by world bank, European Union, US International Development Agency, *etc.* for the interconnection analysis of local electricity markets, planning on power generation and transmission research, *etc.* Compared with PLEXOS, GTMax modeling is much more detailed on its simulation optimization, which has covered hourly max/min power generation and transmission, hourly ramp rate, startup and shutdown costs, minimum up/down time, daily change factors, transmission factors, *etc.* 5. UPLAN model developed by LGG consulting energy company in 1983, the latest version is 8.5, the special features of this model is its analysis on security, safe economies of electricity systems, which has been committed by US Federal Energy Coordination Committee, Department of Environment of USA, World Bank and European Bank of Reconstruction and Development; UPLAN can apply real time, hourly, daily, weekly, monthly, yearly, multi-yearly predictions through network buses and non-linear dynamic searching technologies. 6. WASP model developed by Tennessee Valley Authority and Oakridge National Laboratory while maintained by International Atomic Energy Agency in 1973, which is the oldest and widely used power capability extension model, and which has been widely used on many academic research and development projects; WASP is focusing on long-term and intermediate term prediction, which has been adopted as standard by World Bank for testing and validating other new electric marketing models. 7. WILMAR model developed by RISO national laboratory for integrated wind energy markets in 2006, which is designed for short term and intermediate term prediction analysis of wind energy generation integration in liberalized electricity markets, which is now being used for integrated electricity markets resources planning of Denmark, Finland, Germany, Norway and Sweden.

3. CURRENT DOMESTIC ELECTRICITY SYSTEMS MODELING STATUS

In recent years, modeling of domestic electricity systems develops very quickly. However, the gap with western developed countries is still large, e.g. the very initial data access, collection, *etc.* and even data type itself in China domestic electricity systems are not unified, which means we will have a quite long way to go [7]. We can see that more and more scholars, researchers from academic and scientific institutions contributed into this area into changing this backward situation. An agreement has been made by many

researches that many current official research and evaluation systems based on China domestic electricity system have stopped on building evaluation indicators of traditional Chinese electricity systems, such as the typical "two-type" electricity system, which means resource saving type and environment friendly type, whose main purposes are focusing on the security, reliability, economic capability, *etc*. of China electricity systems, one word to building an indicator system for assessing traditional Chinese domestic electricity systems [6]. We understand that there are quite some difficulties on building a modern so-called "Smart Grid" of China domestic electricity system, e.g. smart grid technology, intelligent power generation, intelligent transmission, smart distribution, *etc*. Building a modern smart Chinese electricity modeling and evaluation system is still at its initial stage at present, whose basic purposes will cover but not limited to for improving the safety and reliability of existing Chinese electricity systems, ensuring its network security and the coordination with economic operation, enhancing the capability to accommodate more types of energy, and improving the electricity resources utility efficient and operation efficient, *etc.* [8]. In May of 2009, China put forward a plan for building so-called state smart grid of China electricity system, which is split into three stages and a unified state smart grid will be constructed by 2020. The first target has been achieved last year with the purpose of optimizing existing China electricity maintenance and operation systems. More than 1000 PMUs and more than 10 WAMS central stations have been established during this period of time. At the same time, many high quality domestic research papers have been released on this smart grid area [9].

CONCLUSION

We can see that in the developed countries the main features of their electricity systems include but limited to, firstly, the ability to accommodate various new types of power generation and energy storage devices; secondly, the capability to develop new products, new services and new markets; thirdly, high network security and quick response to various disturbances, malicious attacks and natural disasters; fourthly, high electricity system resources utilization rate and operational efficiency; fifthly, providing high quality electrical power and interactive operation mode with end electricity users' participation and so on. Therefore, based on the level of development of China domestic electricity markets, more efforts should be made on the following aspects:

First, China domestic electricity markets information should be more transparent and open national wide so that on one hand experts, researchers, scholars from academic and research institutions, production plants, transmission units, *etc.* can get first-hand data on their daily researches, meanwhile development of our electricity systems can also get direct benefits from their research and contribution; on the other hand, all these foundational researches with various practical application purposes will help to construct and validate a solid framework of China national wide electricity system at last. For example, China electricity market is not a liberalized market so far, building a validated dynamic electricity pricing model with features of China electricity market and meeting marketing rules is still on investigation. The benefits for building such a model, one way is that the China government can guide local residential electricity consumption through pricing leverage especially considering that more and more new types of green energies are connected into China national electricity systems and more and more electric motorcycles are entering into Chinese families, *etc.*; another way is local citizens can positively choose how they will use the electricity resources for their own benefits, *etc.*

Secondly, learn from the successful experiences of foreign advanced countries on their electricity systems development. Based on China's foundational national conditions and different stages of China electricity systems development, various modeling and evaluation systems of China electricity systems with various purposes and Chinese characteristics are deeply researched and developed. At present, China is at the stage of rapidly building its urbanization, industrialization and national electricity systems which are the basic facilities of China's economic and social development. Modeling and building an efficient and accurate assessment system should starts from a view of the whole society and focus on its technical feasibility, economic reasonability and the whole social benefits.

Thirdly, there are quite much research achievements from domestic and foreign scholars on electricity systems construction and intelligent innovative technologies application. Consider to construct and gradually optimize an efficient evaluation system of China electricity systems, e.g. can accommodate much more green and renewable energies, building dynamic electricity systems with more and open participations of consumers, and continuously optimize the resource utility efficiency and operation efficiency of China national electricity systems.

Fourthly, consider to introduce competition system into building China modern electricity systems; one way we could build a research competition system with Chinese characteristics in Chinese academic and research institutes like what western developed countries did in the past, e.g. the world-wide competition EUNITE network [10]; another way is to build a real competition system inside China electricity market, which will bring much benefits to consumers while pushing China electricity market grows quickly in a professional way.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Q. Sun, Y. Zhang, D. Han, and Z. Yan, "Dynamic evaluation method of benefit evaluation for smart grid energy conservation and emission reduction," *Journal of Electric Power Science and Technology*, vol. 27, no. 4, pp. 28-33, 2012.

[2] A.M. Foley, B.P.Ó. Gallachóira, J. Hurc, R. Baldickd, and E.J. McKeogh "A strategic review of electricity systems models," *Energy*, vol. 35, no. 12, pp. 4522-4530, 2010.

[3] ISO, New England Market: http://www.iso-ne.com/

[4] Independent Electricity System Operator, Ontario Market: http://www.ieso.com

[5] PJM Market: http://www.pjm.com/

[6] J. Wang, and S. Ting, "Assessment index system for smart distribution grids," *Journal of North China Power University*, vol. 39, no. 6, 2012.

[7] Q. Sun, X. Ge, G. Xubo, L. Lin, X. Xin, Z. Yibin, N. Ruixin, and Z. Yuan, "Review of Smart Grid Comprehensive Assessment Systems," *Proceedings of the CSU-EPSA*, vol. 23, no. 6, pp. 219-229, 2011.

[8] ISO, New York Market: http://www.nyiso.com/public/index.jsp

[9] J. W. Cao, Y.X. Wan G.Y. Tu, S.Q. Zhang, A.X. Xia, Z. Chen and C. Lu, "Information System Architecture for Smart Grids", *Jisuannji Xuebao* (*Chinese Journal of Computers)*, vol. 36, no. 1, 2013.

[10] World-wide competition within the EUNITE network: http://neuron-ai.tuke.sk/competition/

Received: October 16, 2014 Revised: December 23, 2014 Accepted: December 31, 2014