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Pricing Simulation Platform Based on System Dynamics

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Abstract

By constructing a system dynamics simulation platform of transmission service node pricing, this paper analyzes optimization principles of node pricing for power market engineering operation, and predicts effects of node pricing in Chinese power market. Simulation results show that under node tariff mode, the Chinese electricity market, as a whole, is running well and node price performs well in promoting transmission congestion management, guiding transmission expansion and selecting power and load location.

*Keywords:*Transmission service; Node pricing; System Dynamics; Engineering

1. Introduction

Electricity transmission services mean the process electricity delivered from power generations to users safely, economically and with high quality. Transmission grid is the "competition platform" of electricity transactions. The, grid ,balancing supply and demand of the system, guaranteeing reliability of transmission and applying efficient congestion management, connects power suppliers and users, Not only a kind of business activity, the price of transmission, in a competitive market, offers the most important signals of stimulating production, consumption, investment and technology innovation by affecting return of relative parties.

Pricing for transmission can be sorted into two levels: the conformation of payment amount and distribution of payment. The deciding factor for transmission service is pricing scientifically. Scientific pricing, however, is becoming more difficult due to technology and economic features of transmission grid, such as lumpy investment of transmission, economies of scale leading to difficulty of recovering cost and loop flow causing hardness of distribution of transmission charges.

With deep revolution of power market, "separation of firms and grids" is realized in China. In the government document Electricity transmission and Distribution Price Tentative Procedures in 2005, National Development and Reform Commission stipulates that during the primary stage of revolution of electricity price, transmission fee equals average sales price minus average purchase price and transmission loss, and when bidding is applied, it should transfer to management way of cost plus return. The revolution of pricing of electricity transmission is at the

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former stage and transmission charge is lack of efficient forming and distributing system and it would have great impact on electricity industry in China. Firstly, transmission expansion is short of sustainable motive power. Generation price is increasing and sales price is hard to be adjusted and these two factors could lead to narrow space for transmission price regulation and no compensation for grid establishment. Secondly, grid scheme, power supply plan and load estimation are irrelevant in some areas. The present system cannot release signals to guide location plan of power grid, power supply and load.

In recent years, PJM from the USA, New York, California, New England, Australia and New Zealand is applying a new pricing system named node pricing, which means a node, a price. The difference between node prices is their transmission price. Node pricing is believed to be able to reflect scarcity degree of power in various areas and could offer better signals for power generations, consumers, investors and managers and this could result in short and long term optimal operation for power system.

China has never experienced power market, which could be risky and establishing Chinese power market building by pure practice could become deformed and fall into historical repetition. It is hard to find two exact power markets in the world and it is unreasonable to copy the entire foreign experience. As for the historical risk, experiments should be operated to understand the node pricing theory and estimate its impacts on power market.

Node pricing, however, involves power generations, consumers and transmission service providers and each party concerns complicated mutual influences on others which is a long process. Power system applying node pricing is strongly counter intuitive and the existing model is hardly able to evaluate the process clearly and fully. As a course dealing with non-linear, higher-order, multi-variables, multi-feedbacks, complex time-varying system, system dynamics fits well to do the research.

In this paper, simulation platform, based on ssystem dynamics, is built to investigate the theory of node pricing optimizing power market operation and analyses effects and obstacles of node pricing in China.

2. Literature Review

From model World1 established by Forrester in 1971[1], system dynamics has been used in the field of energy. With wide spread of system dynamics and deep research of energy, system dynamics in power field is becoming independent gradually.

Roger Nail(1977) established the first comprehensive system for national energy production and consumption in America[2]. George Backus and Jeff Amlin(1978) developed Energy 2020 to study comprehensive long-term energy policy and scheme in north America and Europe[3]. Andrew Ford built CPAM(the Conservation Policy Analysis Model) in 1985 to analyse energy-saving policy of every states in America and established RPSM(the Resource Policy Screening Model) in 1990 to simulate non-public power market in America[4]. From the perspective of system dynamics, Christoph Grobbel(1999) studied competition of generation in German and its neighbouring countries[5]. Rafal Weron etc.(2003) constructed a MRJD model conerning immediate prices in power market. Karl Magnus Maribu(2002) built Kraftsim model[6], concentrating on development of renewable energy in liberating power market. There are also applications of system dynamics in Chinese power field. Jianbo Huang(2005) established Two-Part Tariff and generating capacity investment model[7].

3. Model construction

3.1. Overall framework and basic hypotheses for the model

- Overall framework

At present, there are northern, central and southern channels for "power transmission from west to east" with 500 and 220 KV. backbone architectures in China, which realizes grid connection within regions and provinces and cross regions. Power market in China is abstracted to western, northern and southern regional markets and named market 1, 2, 3 respectively.

The simulation platform of transmission node pricing could be divided into three regional power market sub-models and a transmission grid sub-model. Every power market possesses load and generation and every load decides the demands and suppliers determine the supply and investment scheme. Transmission system is the carriers for power transactions and every regional market are connected by network forming a united market and practice