Power Crises Study for Restructuring China's Energy Regulation Using Equilibrium Theory

Chen Wang, Qing-ping Yang and Yong-Hua Song

***Abstract*—China is the largest electricity consumer after the United States of America (USA). China is also the largest coal producer and consumer in the world. The importance of these developments has been clearly recognized by the International Energy Agency（IEA）. With the fast growing energy demand, China has to reflect and think of strategies to achieve energy demand objectives with increasing environmental concerns and an improvement of energy efficiency. Meanwhile, the targets for safeguarding the environment and improving energy efficiency can be achieved provided there is sensible consideration of power market design, energy regulation framework reform and related international energy policies. In addition, from the experience of global power crises, this paper identifies lessons for restructuring China's energy market regulation. The regulatory body, framework and functions are built in a recommended Equilibrium Energy Market Regulation Model. Comparison and analysis of power crises, including internal and external causes, are presented along with technology, regulation, and politics in related countries.**

***Index Terms*—Energy Market; Natural Monopoly; Power Crises; Regulator.**

I. Introduction

Power crises send shock waves to every corner of the world. Power crises have negative both public services and companies. For example, in 2003 there were power crises in the Eastern US and Canada, London which affected 500,000 people, and all of Italy except Sardinia which affected 56 million people, and China which affected 22 provinces (autonomous and municipalities). In addition china had power cuts in 24 provinces in 2004, 26 provinces in 2005, and 8 provinces in 2006, 19 provinces in 2008[1-3]. They caused serious financial and other problems to the country. This should serve as a wake-up call for every country.

Initial research was conducted by reviewing the current literature on 28 historical large-scale blackouts in 15 countries since 1965, with analysis of their internal and external causes [4-8], as can be seen in [9].

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Classification of Countries by EREC

The Elasticity Ratio of Energy Consumption (EREC) is an indicator to describe the relationship between the growth rate of energy consumption and the growth rate of the national economy.

The EREC can be a good criterion to classify countries because normally the generation power using multi-energy in every country, as coal and gas, and petroleum, expand.

A deep analysis using EREC of power crises in three groups of countries and four cases from these three groups were used. Group 1 (EREC: 0.20~0.29), group 2 (EREC: 0.30~0.39) and group 3 (EREC: 0.40 and over). Analysis focused on seven aspects: 1. PTCTE (place, time, cause, type and effects), 2.country's profile, 3.installed capacity, 4.power generation capacity, 5.generation structure, 6.policy and regulation, 7.electrical interconnected power grids. In this paper, every power crisis described occurred in 2003, as can be seen in [9].

The analysis showed that for china. China's average of EREC was 0.44 (during 1981-2002) and USA was 0.25, and UK was 0.29, as can be seen in [9]. Facing the current state of electrical power market design, energy regulation model and the related technological level of electricity and energy development in China, and the UK currently implements strategies similar to the 3S Energy Regulation Strategies, which 3S is proposed, as can be seen in [9].

What has caused this state of power crises and with high economic growth rate in China? How can strategies be found to address this?

II. Evaluation And Analysis Of Feasibility In China

After researching various regulatory models from different case countries (see [9]), we found power crises are caused both by technological (external) causes and regulatory (internal) causes, and that the UK has an appropriate models for Electrical Power Market (EPM) System design, regulation and regulatory agency.

A. Regulator Ofgem

The effectiveness of energy regulation in the UK was assessed, through an analysis and comparison of different conditions set out both before and after the establishment of the regulator Ofgem. It was done in two ways: by examining rates of consumers switching electricity suppliers and of consumer satisfaction from 2001 to 2003. As shown below: [10]

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Table 1
THINKING ABOUT THE LAST TIME YOU CHANGED ELECTRICITY SUPPLIER, HOW EASY DID YOU FIND THE WHOLE PROCESS (J.D. Power and Associates)

Percentage (%)	2001	2002	2003
Very easy	60	57	58
Fairly easy	25	28	25
Not very easy	7	8	8
Not at all easy	7	8	9
Do not know	1	0	0

Table 2
HOW WOULD YOU RATE YOUR ELECTRICITY SUPPLIER AS PROIDER OF SERVICES TO YOUR HOME? (J.D. Power and Associates)

Percentage (%)	2001	2002	2003
Highly satisfied	70	74	69
Indifferent	25	16	20
Disappointed	4	10	10
Do not know	1	1	1

Table1 shows that the majority of customers who switch find the procedure very easy or easy. The results of Table2 show high degrees of satisfaction, with a significant majority of customers being highly satisfied in all three years.

Key characteristics of Ofgem are that it is a unitary regulator, has authority and is independent.

a) Unitary

Ofgem authority was created in 2000 through the merger of the previous UK regulators of gas (OFGAS) and electricity (OFFER).

b) Authority

- Ofgem controls prices transmission and distribution of electricity by using incentive regulation.
- Ofgem initiates legislation.

c) Independent

Ofgem is an independent agency, in compares with regulatory agencies in China, as it is not directly supervised by government.

B. EPM System Design

The UK also has an advantageous EPM system design according to our research [9]. The reform process for the UK's EPM is shown in figure 1:

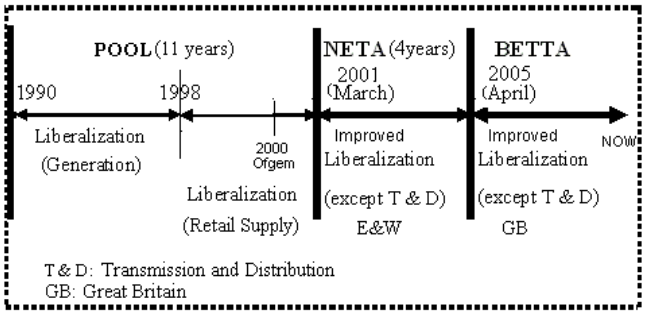

Fig.1. STAGE OF REFRORM IN THE UK'S ELECTRIC POWER MARKET.

From 1990 to 2001 an Electricity Pool market was used in England and Wales, and in 1998 the completion was introduced to the UK's retail supply market. The Electricity Pool had shortcomings and stopped operating in 2000. The British government was frustration by the Pool's inability to deliver lower electricity prices and the perception that its trading rules facilitated anti-competitive behavior by the generating companies. In 2000 the independent regulator-Ofgem was created and in 2001 called the 'New Electricity Trading Arrangements' (NETA) was established with Ofgem having the power to fine companies or remove their operating licences for breaches of the law. In 2005'British Electricity Trading and Transmission Arrangements' (BETTA) was established to create a fully competitive, British-wide wholesale market for the trading of electricity generation, and draw Scotland fully into the scheme.

III. RECMMENDATIONS

A. EPM System design

According to our research, China does not have an appropriate market design, for example China regulation of energy policy has caused coal price disputes between China Electrical Power Industry (CEPI) and China Coal Industry in China (CCI). But the UK's experience of EPM system design reform provides important suggestions for China.

China has to introduce completion into its retail supply of Electricity Pool market. Then China's EPM can be modified by a different system, BETTA, to create a fully competitive in china's energy industries.

B. Equilibrium Energy Regulation Model

It can be said based upon our research that China does not have an appropriate energy regulation model. Therefore, China needs to set up an adaptive new energy regulatory model and framework. Also, it needs to set up an appropriate regulator.

There is an important revelation from the UK energy regulation model. Based on the equilibrium theory, Figure 2 depicts an Equilibrium Energy Regulation Model.

Equilibrium theory is important to economic analysis. "It is at the foundation of both the logical consistency of economic models and of their relevance to the understanding of socio-economic phenomena [11]." There are important aspects. On one hand, one should go to the liberalization competitive market to get balance in generation and power supply. On the other hand, the natural monopoly needs a regulation by an effective regulator, for example, part of transmission and distribution. This model can develop the society objective which ensures safety of supply, sustainable development, and to safeguard the environment (3S).

Energy Regulation Framework

China should continue with electricity sector reform. Its power market framework should separate the power supply sector, and build on an authoritative, independent and uniform regulator to regulate a competition and cooperation with every energy sector. The National Energy Policy Group (NEPG), the State Development and Reform Commission (SDRC), The Energy Office (EO), the Energy Bureau (EB), the State Electricity Regulatory Commission People's Republic of China (SERC), and the China National Coal Association (CNCA) have not organized and implement of appropriate policies. They also did not administer proper cooperation between the China Electrical Power Industry (CEPI) and the China Coal Industry (CCI) in China. Therefore it is important to look at energy experiences and also perhaps more towards a unified model.

A "New China Energy Regulatory Framework" can be developed for the CEPI and CCI, as can be seen in [9].New Regulator A new regulatory body was proposed for China's energy regulation. This new regulator will need to regulate

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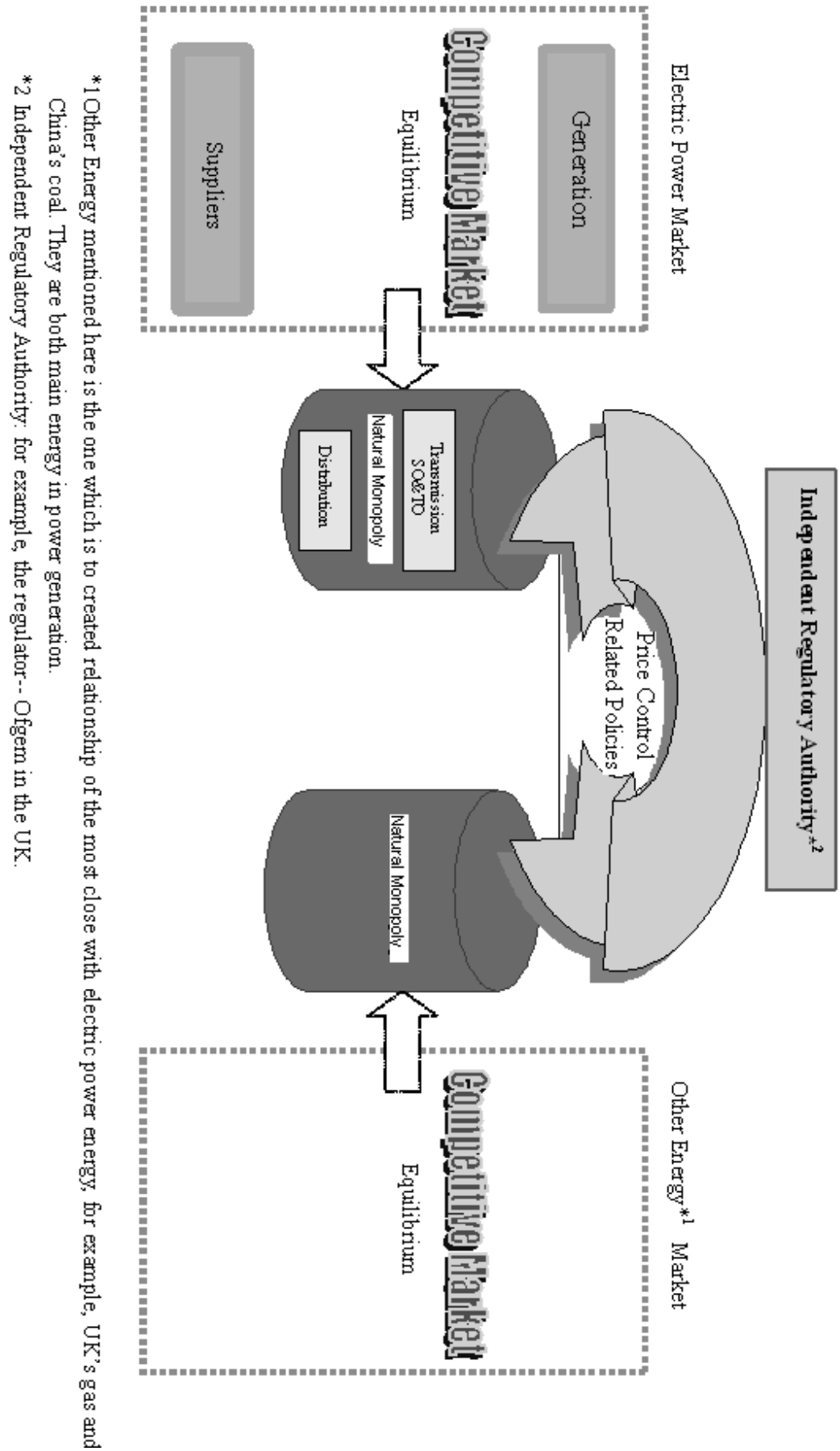

*1 Other Energy mentioned here is the one which is to created relationship of the most close with electric power energy, for example, UK's gas and China's coal. They are both main energy in power generation.

*2 Independent Regulatory Authority: for example, the regulator-- Ofgem in the UK.

Fig.2. EQUILIBRIUM ENERGY REGULATION MODEL.

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cooperation between CEPI and CCI, and protect the energy source from declining and environment, namely, to ensure safety of supply, sustainable development, and to safeguard the environment. In addition, the new regulatory body will require the employment of more staff and maintain suitable staffing.

The new regulator is created to deliver a major goal of the government's industrial policy. So the new regulator will have some new functions, it will need to do the following:

1) Promoting effective competition
2) Regulating effectively the monopoly companies which run the electricity wires
3) Helping secure China's energy supplies by promoting competitive coal and electricity markets-and regulating so that there is adequate investment in the networks
4) Helping coal and electricity markets and industry achieve environmental improvements as efficiently as possible
5) Take account of the need of vulnerable customers, particularly older people, those with disabilities and on low incomes

C. Development of Related Policies and Codes

a) Price Controls

Chinese government is hoping to set up a standardized and transparent price mechanism, classifying the electricity prices into the on-grid price, the transmission price, the distribution price and the end-user retail price, and to set aside the on-grid prices and retail prices to be determined through market competition. China's government will keep regulating transmission and distribution prices [12]. Proper institutional measures are necessary to structure a wide-ranging approach to energy regulation in China.

b) Emissions Trading and(ET) Clean Development Mechanism(CDM)

Emissions trading service the environmental protection goals by the Kyoto Protocol [13]. It involves the exchange of emissions certificates. Operators of large energy production plants or energy-intensive industrial companies are assigned a prearranged number of emissions certificates by their governments. These initial certificates are free, and authorize the industries or companies to produce a particular amount of CO2. If the industry or company overruns its allowance, it must buy in extra certificates. This policy can take place at national or international level, or between companies. In Europe it began on January 1, 2005[14].

The CDM is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries [15].

The CDM strategy has supplied a wonderful opportunity for China. Therefore, China needs to develop national strategy in line with climate change responsibilities in three ways. Firstly, it needs to use skills of international energy policy and also needs to improve capacity of international energy strategies research. Secondly, it needs to set out appropriate and effectual regulation mechanism in energy and electricity market. Finally, it needs to improve staffs ability in related departments and organizations for international technology trading.

c) Strengthening capacities of legislation

If China is to have a reform of energy regulation there is much work to do. Several short-term goals stand out as priorities. China needs first to strengthen its institutional acts, including regulations, directives, decisions, legal structures suggestions and ways of reporting within the new governance framework. It should further define the roles of government agencies. The new independent energy regulator's mandate and enforcement powers regarding pricing and oversight of the energy sector also need to be defined. This includes generation, gird of security. The new independent energy regulator should also develop capacity for identifying and monitoring anti-competitive behavior. It should carry out to enhance transparency and enable effective monitoring for the transmission owner.

d) Human resource management

Finally, to carry out these functions which were mentioned in this section, another urgent task is to unbundle every energy sector's accounts all state interests (and specially country's interest) to enhance transparency and enable effective monitoring. The new independent energy regulator's staffing levels and capacities must be strengthened quickly.

And staffing levels and capacities, they from an appropriate human resource management. For example, a new regulator, or a regulatory model, or legislation was set out that all by a work of stuffs of a section. Therefore, China's government must to reform for electrical and energy industries of human resource management.

IV. Discussion

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as μ0H. Use the center dot to separate compound units, e.g., "A·m2."

These implications may assist in the reformation of China's electrical power and energy regulation model through introducing competition into China's power supply market. In addition to this, a new regulator was set up, and some new functions given to this effective regulator which promoting effective competition, regulating effectively the monopoly companies, help secure China's energy supplies by promoting competitive coal and electricity market-and regulating so that there is adequate investment in the networks, and improving environmental protection levels, and consider of the needs of vulnerable customers. It is an independent, uniform and authoritative regulator. The functions concerned with the regulation of CEPI and CCI by using related policoes .For example, Price control. Moreover, the new regulation framework is which assist in the implementation of new functions of the regulator. The Equilibrium Energy Market Regulation Model was created in which cooperation and competition can flourish for the benefit of energy customers. These may also be useful for maintaining safety of supply, creating sustainable development, and safeguarding the environment in China by using some international energy trading strategy, for example,

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ET, CDM and so on.

V. Conclusions

In this paper, global power crises have been analyzed and important implications drawn out for China. These implications may assist in the reformation of China's EPM system design, regulation model, regulation framework, and regulator. This may also be useful for creating sustainable development maintaining safety of supply and safeguarding the environment in China's energy governance market.

VI. Future Work

The 2008 Sichuan earthquake has taken lives of close to 70,000. From 2006 to2010, the natural disaster was another important factor to cause power outages in China. China had power cuts in 8 provinces in 2006, 19 provinces in 2008. Meanwhile, natural disasters send shock waves to a lot of countries, including USA, UK, France, and so on. Therefore, the energy structure, climate change, environmental protection and policy regulation are important for China in the future. These can be a basis for future research.

Abbreviations And Clossary

CHINA:
CCI China Coal Industry
CCIN China Coal Industry Network
CDT China Datang Corporation
CEPI China Electrical Power Industry
CGAS China Gas Sector
CGC China Guodian Corporation
CGG China Gezhouba Group
CHC China Huadian Corporation
CHCG China Hydropower Construction Group
CHEC China Hydropower Engineering Consultation
CHINA5E It is advocate of Information and Technology (IT) for the Energy Industry in China.
CHNG China Huaneng Group
CHYD China Hydro Sector
CMA The Ministry Agriculture of the People's Republic of China
CMWR Ministry of Water Resources
CNCA China National Coal Association
CNCCUGC China National Coal Comprehensive Utilization Group Corp
CNCG China National Coal Group
CNCGC China National Coal Group CORP.
CNCIEC China National Coal Industry Import and Export (Group) Corporation
CNPC China National Petroleum Corporation
CPEC China Power Engineering Consultation Gp
CPET China Petroleum Sector
CPIC China Power Investment Corporation
CSPG China Southern Power Grid Co Ltd
CZEFC China Zhongneng Electricity Fuel Company
EB The Energy Bureau
EO The Energy Office
NEPG The National Energy Policy Group
SASAC State-owned Assets Supervision and Administration Commission of the State Council
SDRC State Development and Reform Commission
SERC State Electricity Regulatory Commission People's Republic of China
SHGC Shenhua Group Corporation
SG State Grid Corporation of China
UK:
GEMA The Gas and Electrical power markets Authority
Ofgem The Office of Gas and Electrical power markets

References

[1] Hui Ren, University of Wisconsin-Madison, North China Electric Power University, "Electric Power Industry in China", Feb. 6, 2007
[2] M.Y. Huo, "Power Supply in 2007 China". 2005. Available from: http://www.cas.cn [Accessed 16 June 2006].
[3] State Grid Corporation of China (SGCC), "Report of analysis and research for China power market in 2004", Beijing: SGCC, (ISBN 7-5083-2982-1), 2004, pp.14.
[4] P. Hines, J. Apt, S. Talukdar, H.W Liao, "The frequency of large blackouts in the United States electrical transmission system: an empirical study," Second Carnegie Mellon Conference in Electric Power Systems, Pittsburgh, January 2006.
[5] J.W.Bialek, "Recent blackouts in US and continental Europe：is liberalization to blame?" Cambridge Working Papers in Economics CWPE0407., pp.22-23, 2004.
[6] (The Blackout History Project). (2006 August) Great northeast blackout events 1965. Available from: http://blackouts.gmu.edu/events/tl1965.html
[7] S.E. Hrudny, "A Critical Review of Current Issues in Risk Assessment and Management, Environmental Risk Management Working," Paper, ERC96-8, University of Alberta, 1996.
[8] Wikipedia, "List of power outages", 2006.
[9] Chen Wang, "Power Crises Study for Restructuring China's Energy Regulation Using Equilibrium Theory,"2007, pp. 20–149. unpublished.
[10] Office of Gas and Electricity Markets, "Domestic gas and electricity supply competition", 19 June 2004.
[11] IAP-Doctoral Workshop, "Equilibrium Theory and Optimization for Public and Industry Regulation", December 2004.
[12] The International Energy Agency (IEA), "Coal in the energy supply of China Report of the CIAB Asia Committee", 1999.
[13] Department for Environment, Food and Rural Affairs, "UK Emissions Trading Scheme", April 2002.
[14] Congressional Research Service, "Climate Change: The European Union's Emissions Trading System (EU-ETS)", July 31, 2006
[15] The Intergovernmental Panel on Climate Change (IPCC), third assessment report chapter 6.3.2.2, "The Clean Development Mechanism", 2002.

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