Panel Session: Power Markets of Asian Countries in the International Markets Environment

(Nikolai Voropai and Tom Hammons)

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Topic: Critical Infrastructure of the Power System

INTRODUCTION

This Panel Session deals with the current state and problems of power markets in Asian countries in the international market environment. The process of restructuring the electric power industry and forming power markets in the world has almost a twenty-year history. Certain experience has been gained that reflects both the positive effects of market transformations in the electric power industry and some problems. Power markets in Asian countries are formed on the basis of world experience. However, in different countries this process progresses at different paces. Generalization of the experience in market transformations in the electric power industries of Asian countries, analysis of the benefits, and risks that may occur as a result of such transformations will help specialists solve the problems encountered in their countries.

The Panelists and Titles of their Presentations are:

1. Subrata Mukhopadhyay, Central Electricity, New Delhi, India; Sudhindra K. Dube, Power Trading Corporation Ltd., New Dehli, India; and Sushil K. Soonee, Northern Regional Load Dispatch Centre, Power Grid Corporation of India. Development of Power Market in India (paper 06GM0336).
2. Serguey Palamarchuk, and Nikolai Voropai. Energy Systems Institute, Irkutsk, Russia. Russia's Power Industry Restructuring: Current State and Problems (paper 06GM0153)
3. Marcel A. Lamoureux, Consultant, Power System Management and Economics, Newport, Vermont, USA. Economic Convergence Points of Russian, CIS and Asian Power Markets (paper 06GM0204).
4. Temur P. Salikhov, Director of the Institute of Energy and Automation, Tashkent, Uzbekistan. Uzbekistan Energy Strategy (paper 06GM0506)
5. Jin Zhong and Yixin Ni, The University of Hong Kong, Hong Kong. Power Industry Restructuring in China (paper 06GM0327)

[#] Document prepared and edited by T J Hammons

6. Fushuan Wen, South China University of Technology, Guangzhou, China. State-of-the-Art and Prospect of Power Industry Restructuring in China (Invited Discussion)
7. Jae-young YOON, Head of Power System Group, Dongwook PARK and Hoyong KIM, KERI, Korea. Feasible Power Exchange Model between Russia, the DPRK and the ROK (paper 06GM0590)
8. Ahmed F. Zobaa, Cairo University, Egypt and Wei-Jen Lee, Energy Systems Research Center, The University of Texas at Arlington, USA. The Globalization of Energy Markets in Asia (paper 06GM0051).
9. Ikuo Kurihara, Central Institute of Electric Power Industry, Tokyo, Japan. Restructuring of the Electric Power Industry and the Current State of the Power Market in Japan (paper 06GM0078)
10. H S Jeong, Korean Electro-technology Research Institute; D Hur, Department of Electrical Engineering, Kwangwoon University, Korea; C K Han and Jong-Keun Park, Seoul National University, Seoul, Korea. Pricing Transmission Services in Korean Electricity Markets (paper 06GM0287)
11. Xingwang Ma, AREVA T&D Corporation, Bellevue, Washington, USA. Key Features of Successful Market Design and its Relevance to Asian Countries (Invited Discussion)
12. Invited Discussers.

Each Panelist will speak for approximately 20 minutes. Each presentation will be discussed immediately following the respective presentation. There will be a further opportunity for discussion of the presentations following the final presentation.

The Panel Session is organized by Tom Hammons (Chair of International Practices for Energy Development and Power Generation, University of Glasgow, UK) and Nikolai Voropai (Director, Energy Systems Institute, Irkutsk, Russia).

Nikolai Voropai and Tom Hammons will moderate the Panel Session.

1. Development of Power Market in India

Subrata Mukhopadhyay, *Senior Member, IEEE*
Sudhindra K. Dube,
Sushil K. Soonee, *Senior Member, IEEE*

Abstract- This paper presents the status of development of power market in India with the creation of opportunities consequent to restructuring of the sector through unbundling, opening up for private sector participation, positioning of regulatory mechanism through commissions at state and central level and appellate tribunal, allowing open access, etc. Starting with the background, it aims at giving a clear picture of achievement till to date and issues to be resolved to reach the goal. In this context opportunities that exist for power and energy trading with neighboring countries too are highlighted.

Index Terms — open access, power market, power exchange, inter-state generating station, free governing mode operation, unscheduled interchange, regional energy accounting, environment impact assessment.

I. INTRODUCTION

At the time of independence in 1947, Indian power sector was merely concentrated in and around few towns and urban areas to meet the need. In the following decade it saw development of massive river-valley projects that lead to some form of limited interconnected system to provide power to population along particular belts as side by side benefit to the effort made for irrigation for the agricultural need and flood control. However, sixties gave proper status to the development of power sector both in terms of generating unit sizes, transmission voltage due to the requirement of rapid industrial development, calling for integration and evolution of state grids. Attempt to join these grids to form the five regional grids, however, became successful by seventies and eighties with unit sizes going from 210 to 500 MW and transmission voltage from 220 to 400 kV as a consequence of haulage of large amount of power from coal pit-head (mine-mouth) thermal power stations to urban conglomeration. Subsequent scenario of power sector in nineties and beyond of course has been quite bright from the point of view of development of HVDC systems, incorporated both for bulk power supply over a large distance as high as about 1370 km, be it within a large state or region or for inter-regional transfer of power, and also for inter-regional back-to-back connection for limited transfer of power. Side by side to this, sector was unbundled with the recognition of generation, transmission and distribution as separate and distinct activities so far as power supply system is concerned. Both at state level and central level regulatory commissions were gradually formed to decide tariff, grid code, etc. With the opening up, sector experienced participation of private sector entities, mainly in generation and then in distribution to some extent. Transmission still remains monopoly with public holding terming it as State Transmission Utility (STU) or Central Transmission Utility (CTU) depending upon whether it belongs to any state or center. With Central Electricity Regulation Commission (CERC) permitting open access to inter-state transmission facility from November 2003 [1], opened vistas of power trading by state-owned Companies or private traders or joint sector venture. It was an important step after the promulgation of Electricity Act 2003 [2]. Activities that followed and aimed at, influencing scheduling and real time grid operation with pseudo Power Exchange [3] in place definitely pave the way for healthy trading in

power that unlike other commodities in market cannot be stored in its form and hence calling for supply-demand matching at every instant of time. As it proceeds paper gives the status of such trading prevalent in India considering the market related to energy, generation capacity, transmission capacity and ancillary services one by one. Also, with the development in neighboring countries, possibility of power and energy trading is explored.

II. ENERGY MARKET

For the Indian power sector bilateral energy market may be on the basis of long term, short-term, day-ahead or intra-day commitments. With measurements logged at 15-minute intervals weekly cycle of settlement of energy is carried out. This is based on before the fact commitments at mutually agreed terms, but taking into care deviations settled at frequency actuated dynamic rate known as Unscheduled Interchange (UI) rate [3]. However, the process has excessive reliance on UI mechanism, though the rate is restricted by regulatory caps. The trend of course is encouraging with consensus being built for an organized market in this respect in the form of Power Exchange (PEX).

III. GENERATION CAPACITY MARKET

As one goes back to history, typically under Central Government regional power stations, may be termed as Inter-State Generating Stations (ISGS) (be it thermal – fossil fired or gas-based, hydro or nuclear) established at different times have a common basis of sharing of power amongst the beneficiary states of the concerned region. Totally an allocation of 85% is made of the installed capacity of the station by that procedure. Hence the capacity may be thought of as locked up in long-term bilateral contract between the producer and consuming states. Remaining 15 % floating capacity is highly sought after during peak demand season and it keeps changing hands subject to negotiating skill and political networking of the beneficiary causing considerable amount of heartburning for the losers. What started as a flexibility margin to accommodate seasonal demand pattern has degenerated into a discretionary instrument.

On the other hand, lackluster participation of private players in capacity addition (generation & transmission) could be attributed to lack of an organized capacity market. However, rays of hope exist due to stray examples of capacity trade. One such case is with Power Trading Corporation (PTC) brokering the sale of royalty share of Himachal Pradesh State Electricity Board (HPSEB) in Nathpa-Jhakri Hydro-Electric Project to Punjab State Electricity Board (PSEB) for the summer months.

IV. TRANSMISSION CAPACITY MARKET

Perspective planning as a whole is carried out by the Central Electricity Authority, an apex technical body of Government of India in power sector. With the data collected through load survey by its regional units in collaboration with the state electric utilities, long term load forecasting is done. Based on the same matching generation is formulated through integrated resource planning approach identifying generation location and possible corridor for transmission of power from source to load. Thereafter studies are carried out to configure in details the network for evacuation of power from generating stations and consequent strengthening of existing network, if required, with level of

voltage chosen with a view to have adequate margin for future expansion. Transmission capacity expansion so planned is then deliberated in the Standing Committees region-wise through a consultative procedure to identify utilities to build, own and operate the relevant expansions.

Accordingly with transmission system still being totally need-based and enjoying natural monopoly, has the pricing tightly aligned to long-term capacity allocations. Though open access is in vogue, in reality it has not been segregated yet as an independent facility under the fear of jeopardizing the existing setup. On the other hand lack of addition may result in congestion sometime at some pockets during grid operation, Consequently its management is totally based on the discretion of concerned Regional Load Dispatching Center (RLDC). The long-term transactions have a priority over short-term transactions. The RLDCs have discretionary powers over interstate dispatch and load regulation. Inter-regional (Pool to Pool) unscheduled interchange transactions are then used for easing congestion.

V. ANCILLARY SERVICES MARKET

Ancillary Services are defined as those services that are necessary to maintain reliable operation of the interconnected / integrated transmission system. These services are required to effect a transaction. It includes reactive power and voltage control, loss compensation, scheduling, dispatch and settlement, load following, system protection, energy imbalance and black start facilities. In India a lot of work needs to be done in this area till now as described below.

A. Load Following-Primary Response

- Free Governing Mode Operation (FGMO) is mandatory as per grid code.
- Issue is diluted / scuttled under the garb of technical jargon / issues put forth by generators.
- Services are basically not priced and implicitly paid through capacity charges. Therefore, there is no incentive for Independent Power Producers (IPP).
- Frequency linked dispatch guidelines are for secondary response.

B. Voltage Control

- Reactive drawl and injection at interstate exchange points are priced.
- It is a simple mechanism. Issues in treatment are virtually of residual amount.
- Generators are not paid and very often they take refuge under a conservative machine capability curve.

C. Loss Apportionment

- Losses are shared by long-term customers in ratio of their subscriptions in ISGS.
- All energy transactions are discounted by estimated losses during scheduling.
- There is regulatory intent of moving towards the concept of incremental losses.

D. Scheduling and Dispatch

- RLDC coordinates as well as implements inter-utility contracts.
- Decentralized resource scheduling is in vogue with state load serving utilities having full operation autonomy of dispatching their generation resources.
- Though as per grid code there is a provision for 5% spinning reserve, due to perpetual shortage in reality implementation has not been possible yet.
- Well-defined timeline exists for declaration of availability and requisitioning of energy up to capacity subscriptions of the shareholders.
- Expenses clubbed under RLDC Operation and Maintenance (O&M) head are paid by long term constituents only.
- At present a sum of Indian Rupees (INR)3,000 / day/ transaction is charged for scheduling open access transactions.
- Inter utility settlement statement (Regional Energy Accounting taking care of UI and Reactive Accounting) is issued by Central Pool Administrator. Capacity and energy charges are settled mutually while the unscheduled and reactive energy settlement is routed through a pool.

E. System Protection

- Equipment protection coordination is decided at the regional level by Protection Coordination Committee (PCC).
- System monitoring and supervision is carried out by RLDC.

F. Energy Imbalance

- It is addressed through unscheduled interchange mechanism.
- Weekly settlement cycle based on above is in vogue.
- It is the discretion of concerned RLDCs for arbitrage across asynchronous (HVDC) links.

G. Black Start

- It is purely voluntary.
- It is well-documented under Regional Black Start Procedures.
- UI mechanism is suspended during period of disturbance and actual transaction is treated as schedule.

VI. POSSIBLE POWER AND ENERGY TRADING WITH NEIGHBORING COUNTRIES

India surrounded by countries of Nepal, Bhutan, Bangladesh, Srilanka, Pakistan creates major prospect in South Asia for trading in power and energy due to disposition of natural resources of different kinds for mutual benefits of all. Nepal and Bhutan are rich in Hydro resources, Bangladesh is rich in gas reserves and India is rich in coal resources, thus providing promising option for cooperation among countries. India can emerge as the

main potential power / gas export market for the neighboring countries. Generation can be at source and trading through electrical interconnection. India can supply coal to the neighboring countries and can import gas from Bangladesh.

Issues to be addressed in the process of development are investment capabilities, lack of market information, viability of buyers, inadequacies in institutional mechanism, environment and social concerns. Cross border trading in electricity has technical considerations as well as political and economic ones. Pricing should be such that both sides benefit. For example, if one party has a lot of inexpensive hydro power, during monsoon seasons then it may benefit from selling it at lower price to a neighbor rather than having the water spill. There is necessity of larger perspective while planning, obviously through integrated approach for the entire SAARC (South Asian Association for Regional Cooperation) region. Both Generation capacity and Transmission interconnection capacity are to be enhanced. To be adopted is common principle / methodology for tariff determination, operational protocol, security / reliability and regulation. To be evolved also is the Contractual Agreement that addresses principal obligations that are equitable, risk sharing, issues related to financial and payment, commercial and legal, dispute resolution and arbitration.

Therefore, prerequisites for Regional Power Pool (RPP) may be summarized as –

- Technical solutions not difficult but Political will of the member countries important
- A cooperative mindset
  - Willingness to reconnect the subcontinent
  - Efforts to build trust / sensitize
  - Greater sensitivities to issues
- A commitment from the member countries for
  - Resources / manpower
  - Reciprocal measures
- Success of Bilateral exchange will create the ground for multi-lateral exchange
- Regional economic prosperity should take precedence over political compulsion

VII. CONCLUSIONS

Though it is in the nascent stage, there are lot of promises in power trading in India with the participation of a number of players from public or private or joint holding companies. Permission for open access really has created opportunities for improving supply system through competition in terms of overall economy as well as ultimate efficiency. With the typical characteristic of the commodity (power) in the market that in its normal form cannot be stored and at every instant supply-demand matching is called for, inherent risk dictates necessity of well-laid principles of practices to be followed for short-term, mid-term and long-term contracts.

So far as power and energy trading with neighboring countries is concerned presently power trading is based on bilateral agreements and although Energy Ring is high in SAARC agenda, the progress has remained slow. The strategies for promotion of trading can be through carrying out sector reforms, setting up suitable institutional arrangements, joint investment in project including Environment Impact Assessment (EIA), private sector participation, long term transmission planning and free exchange of information.

VIII. ACKNOWLEDGEMENT

The authors are indebted to their respective organizations, Central Electricity Authority, Power Trading Corporation of India and Power Grid Corporation of India of Ministry of Power, Government of India for making valuable inputs in the form of published documents. However, the opinions expressed in the text of paper are no way concerned with the views of the concerned organizations or the Government. The authors gratefully acknowledge also contribution of their co-professionals in these organizations during the preparation of this presentation.

IX. REFERENCES

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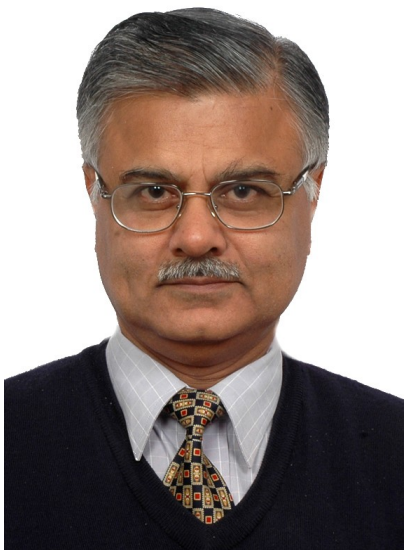
X. BIOGRAPHIES



Subrata Mukhopadhyay (S'70, M'70, SM'80) was born in Asansol, India in 1947. He graduated in Electrical Engineering from Jadavpur University, Calcutta in 1968 and had his Master's and Doctorate Degrees from Indian Institute of Technology, Kharagpur and Roorkee in 1970 and 1979 respectively. His employment experience of 35 years includes teaching and research in Roorkee and power system planning, design and operation with the Central Electricity Authority of Government of India. He has authored two books and twenty-eight papers, won IEEE Third Millennium Medal in 2000, PES Delhi Chapter Outstanding Engineer Award & PES Asia-Pacific Regional Outstanding Engineer Award for 2001, RAB Leadership & Achievement Awards in 2002 and 2004 respectively. He is also a Fellow of the Institution of Engineers (India) and the Institution of Electronics and Telecommunication Engineers, India.

Sudhindra K Dube is presently working for PTC India Ltd. (PTC) as Director (Operations) since December, 2002. Prior to joining PTC he was working as Executive Director (Northern Region) in POWERGRID. He is a Graduate in Electrical Engineering (1969) from Jadavpur University, Calcutta. Before joining PTC he served SAIL, MECON, NTPC and POWERGRID in various capacities. He served also Private Sector for over six years out of his total about 36 years of experience in industry covering the area of Design, Project Management, O&M, Commercial, Power Trading and Regulatory Issues. During his tenure in NTPC he made significant contribution in the commissioning of 200 MW and 500 MW units of Farakka Super Thermal Power Project. In POWERGRID he handled very crucial assignments like *Erection and Commissioning* of 400 KV URI-Transmission system in Kashmir Valley, the first 800 KV Kishenpore-Moga Transmission System in India and development of O&M manuals of Transmission equipment. In his current assignment in PTC he is responsible for Marketing, Operation and Commercial activities, formulation of Power Purchase Agreements with domestic / foreign Developers of Power Projects and Cross-Border transactions with Bhutan and Nepal. He has also extensive experience in Tariff mechanism and Regulatory issues. Dube has presented number of papers in the International conferences, particularly in the areas of Condition Monitoring of EHV equipment and trading mechanisms. He has also traveled widely abroad as part of his assignment. He visited Pakistan as a member in the Indian delegation for Power purchase negotiations. He is a Fellow of the Institution of Engineers (India) and Member, CIGRE.

Sushil K Soonee (M'99, SM'01) born in 1946 and currently heading Northern Regional Load Dispatching Center of Power Grid Corporation of India Ltd. as Executive Director, had his graduation in Electrical Engineering from the Indian Institute of Technology (IIT), Kharagpur, India in 1977. After a brief stint in private sector joined Central Electricity Authority and worked extensively in integration of State Grid to form a Regional Grid in Eastern and North-Eastern Region, carried out Research and Literature Survey in Power System Operation and Control at IIT Kharagpur in 1981, traveled extensively Europe, USA and SAARC countries. He had first hand experience of Power System Operation of Eastern, Southern and Northern Grids, and also Commercial, Settlement, Restoration and entire gamut of Power Pooling and System. Frequency maintenance within permissible limits, voltage control etc. achieved to a great extent during his tenure in Southern Region. Persuaded constituents to rejuvenate Inter-State Transmission lines, hitherto dormant. Worked for implementation of Availability Based Tariff (ABT) and on implementation, the scheme is recognized not only in India but worldwide. At present implementing the Intra-State ABT scheme also, and Free Governor Mode of Operation. Streamlined Open Access in Inter-State Transmission System. Authored 24 technical articles and presented in various forums, chaired many technical sessions in seminars / workshops, acted as Member of various committees for Regional

Power System on disturbance and restoration. He is a Fellow of the Institution of Engineers (India) also.

2. RUSSIA'S POWER INDUSTRY RESTRUCTURING: CURRENT STATE AND PROBLEMS

S.I. Palamarchuk, *Senior Member, IEEE,* and N.I. Voropai, *Senior Member, IEEE*

Abstract -- The Russian power industry is on the way to radical structural and managerial reformations. The paper gives an overview of the present state of power industry restructuring in Russia. The current technical characteristics of the industry and main features of the new round of restructuring are described. New steps to electricity market development and the regulating system improvement are discussed. The restructuring policy in Russia may be useful for countries where industry is on the way of reforms.

Index Terms--power industry restructuring, industry development, electricity markets, electricity prices.

I. INTRODUCTION

Russia's power industry is on the way to radical structural and managerial reformations. Reduction in electricity demand in the early 1990s provided good conditions for structural and managerial changes in the industry. However, the country is facing new industrial growth and the favorable period of excessive generation is coming to an end. The industry needs fast and effective reforms for economic efficiency improvements and investment attraction. The paper reviews the restructuring policy and describes the current state and development of a competitive environment in the Russian power industry. The aim of the paper is the analysis of expected consequences of reforms for the national economy and customers.

II. TECHNICAL CHRACTERISTICS OF THE RUSSIAN POWER INDUSTRY

The main distinctions of the industry are long-distant electricity transmission, unevenly allocated energy resources as well as electricity generation and consumption over vast territory.

The Unified Electric System (UES) in Russia is still operating as a single complex. There are 77 local utilities combined into 7 regional interconnected power systems [1], [2], Fig 1. Six of them (excluding the Far East) operate synchronously. The transmission network covers six time zones, which helps reduce the peak demand by 6%.

The Russian power industry had 204.5 GW of installed capacity up to the beginning of 2001 [3], including 192.2 GW running synchronously within UES. 12.3 GW ran separately from UES in the Russian Far East and in the Arctic regions of the country.

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Taking into account dismantling units the industry had a slight growth of generating capacities in 1999 and a slight decrease in 2000.

All power plants in Russia generated 862,800.0 GWh of electricity in 2000 including 820,800.0 GWh within UES [3]. Thermal power plants on organic fuels generated 542,300.0 GWh or 66% of total production. Hydro power plants generated 149,800 GWh (18.33%) and nuclear power plants produced 128,700.0 GWh (15.7%).

The peak of electricity demand in 2000 in UES was registered on January 26 at 6 p.m. and reached 128.7 GW. The total excess of generating capacity in UES was 63.5 GW or 33% of installed amount. However, not all installed capacity could be used at peak hours. In winter 2000-2001 only 170 GW of generating capacity was available for operation [3]. Taking into account a necessary capacity reserve of 21.4 GW (16.6% of maximum demand) the actual excess of capacity in Russia is 19,9 GW or 9,7% of available amount.

Domestic consumers in Russia bought 676,700.0 GWh of electricity in 2000, and 14,200.0 GWh was sold abroad. UES of Russia supplied electricity to ten countries in Europe and Asia. Two countries (Estonia and Azerbaijan) provided Russia with power flows, Fig. 2.

12.5% of total generation was lost in the transmission and distribution networks. The annual electricity consumption grew up to 4% in 2000 and 2.5% in 2001-2004.

Fig. 1. Interconnected power systems in UES of Russia

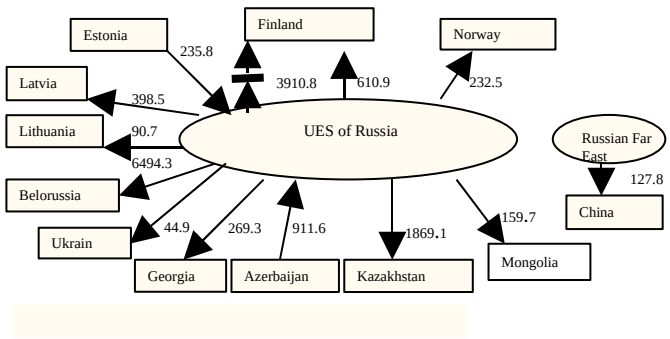

Fig. 2. Export and import of electricity in 2000

III. FIRST STEPS OF RESTRUCTURING

The restructuring process was launched in 1992 [1]. The ownership pattern was changed and the existing State-owned local utilities were rearranged into joint stock companies. Nuclear power plants with a total installed capacity of 21 GW were left under the State control.

The joint stock company RAO "UES of Russia" was established in 1992 as a new managerial holding. 34 large power plants with a capacity of 57 GW (approximately 27% of total generating capacity) were withdrawn from local utilities to reduce the monopoly in power generation and became the property of RAO "UES of Russia". Also, the decision was made to concentrate the transmission network in RAO "UES of Russia" as well as Central and Regional Dispatching Offices. It was supposed that each new local utility had to delegate no less than 49% of its shares to the holding. The RAO was commissioned to set up and operate a wholesale market both technologically and commercially. Actually, not all the utilities delegated this percentage of their shares to the RAO. Nevertheless, RAO "UES of Russia" acquired too much property and authority.

Today RAO "UES of Russia" is the monopoly in the field of energy supply and is the financial and industrial holding, which consists of a number of regional power utilities, large federal power stations and intersystem electric grid. The State owns the controlling stake of the RAO. The Government appoints both the Board of Directors and the Chief Executive of the RAO. It regulates all activities of the energy holding and regulates the prices of its services and production.

Two kinds of electricity markets were established in the 1990s - the nationwide wholesale market and local retail ones. Electricity prices for power producers on the wholesale and retail markets were fully regulated and set on "cost plus" principle.

Large power plants, which were withdrawn from the utilities, nuclear power plants and local utilities with generation surplus could sell their electricity to utilities with deficient generation on the wholesale market. A few large industrial customers got the right to participate on the wholesale market. Each local utility had a choice either to generate power locally or to buy it on the wholesale market. The retail markets were established primarily within the territories under service of the local utilities and had to supply their end customers. The responsibility for the wholesale market operation was delegated to RAO "UES of Russia". The responsibility for retail market operation was imposed on the local utilities that provided distribution and customer services.

Wholesale electricity prices in Russia were based on generation and transmission costs. The Federal Energy Commission regulated the costs and profits of producers on the wholesale market under control of the Federal Government. The costs of utilities and prices on the retail markets were subject to regulation by Local Energy Commissions under control of local Governments. Electricity prices for the wholesale and retail customers were set as a blanket (weighted average) prices calculated as a ratio of electricity cost to volume of electricity to be purchased. The prices on both the wholesale and retail markets were adjusted on a quarterly basis.

RAO "UES of Russia" was an operator on the wholesale market. It bought, as a single trade agent, electricity from producers using the pay-as-cost principle and sold electricity to the utilities at a blanket (average) price. The electricity price, additionally to the generation expenses, included transportation, operation and investment components. The same approach was used on local retail markets. The prices on the wholesale market were

differentiated with respect to price zones according to the transportation and congestion costs. The prices on the retail markets were differentiated with respect to consumer groups, such as large industrial, small industrial, agricultural, residential and others.

Average retail prices for different regions of the country and for different groups of consumers are shown in Table 1 for September 2001.

Table 1. Average retail prices for different groups of consumers, september 2001

Region	Prices, US cents/kWh			
	Industrial	Railway transport	Urban residential	Rural residential
Center	2.1	1.9	1.9	1.2
North-West	2.0	1.8	2.0	1.4
South	2,5	2.1	2.1	1.5
Volga	2.1	1.6	1.3	1.2
Ural	1.8	1.8	1.4	1.0
Siberia	1.0	1.3	1.3	1.4
Far East	3.2	2.9	1.8	1.3

Prices in US cents/kWh are calculated using official currency rate estublished by the Central Bank of Russia, equal to 30.5 Rub/USD for September, 2001.

Up to the middle of 2003 prices increased by 1.5-1.7 times [2]. Average prices greatly differ in the Siberian and Far-Eastern regions. There are cross subsidies between different groups of consumers. In most regions (except Urals and Siberia) industrial consumers pay above the average price, while rural residential consumers (except Siberia) pay less.

The funds for generation and transmission expansion were mostly filled up through the regulated investment component of wholesale prices. The funds for development of power plants and distribution networks that belong to local utilities were filled up through the regulated component of retail prices.

After the first steps of restructuring the situation in the power industry remained very tense [1]. First of all, the UPS badly needed new investments. Financial injections into the industry were 5-6 times less than was required. This resulted in dangerous aging of generating and transmitting facilities. Nearly half the existing infrastructure exceeded its intended service life [4].

The efficiency of electricity and heat production decreased. Auxiliary electricity consumption in power plants together with electricity losses in networks increased to 23% in 1998 in comparison with 17% in 1991. The fuel component of electricity cost increased by 11% in the 1990s. The relative annual profit of the industry fell down from 25.5% in 1993 to 11.3% in 1999. This led to a hard and unstable financial condition for most of the local power utilities.

A huge debt of customers (more than $4.3 billion) was accumulated in the 1990s. The debt was comparable with the annual income of RAO "UES of Russia". For years, the industry subsidized the Russian economy by supplying the electricity and heat to non-paying customers. A large portion of payments were accepted in barter and mutual debt write-offs. The situation with non-payment was improved considerably in 1998-99 as payments in money rose to 90%. But the accumulated debts pulled the industry down and did not allow local utilities to develop their generating and network facilities.

Wholesale and retail markets in Russia were highly regulated. However, the system of the State regulation was not effective. The pricing mechanism on the wholesale market was obsolete and did not encourage cost reduction. The regulation on local retail markets fell hostage to local governments and politicians. Electricity prices were too low (see Table 2) and did not often compensate even for the production costs. It led to generation reduction and consumer cut-offs. The legislation in the industry remained far behind the current needs.

Unreliable fuel supply was an urgent problem for the industry. Coal miners and natural gas suppliers did not provide power plants with enough fuel because the power plants and utilities often failed to pay for the fuel in time. This resulted in dangerous situations on some territories of Siberia and the Far East of Russia, particularly in the severe winter of 2001 when electricity and heat supply was interruptible. Unreliable fuel provision led to ineffective generating unit commitment.

Most experts considered the situation in the Russian power industry dangerous. In any case, the industry needed radical and wide-scale reforms based on the interests of different parties in the society.

IV. A NEW STAGE OF RESTRUCTURING

A new stage of restructuring started in 2001 after the Governmental resolution validation. The main goal of the stage is to provide stable work of the industry on the basis of competitive market development. The following measures are needed to succeed.

Development of a new legislative framework for the industry. A new State Law "About Power Industry" was enacted by the Parliament and the President in March 2003. The Law declared the market relationships in the industry as a main instrument for efficient and stable electricity supply.

Two existing Laws, namely "State tariff regulation in the industry" and "State monopolies in Russian Federation", were changed. Additionally the Government issued several new Resolutions on pricing of electric and heat energy, the wholesale market rules and boundaries of pricing zones.

The new Laws and Governmental Resolutions form a power policy that provides broad guidelines for coming reforms and enact the legislation necessary for implementing this policy. It helps to provide a transparent regulatory framework and to establish a market encouraging efficiency improvement.

Restructuring local power utilities. Local power utilities are under restructuring now. They separate "non-profile" businesses and create new entities for power generation, distribution and supply. They introduce new systems for bookkeeping and financial planning.

Small and combined electricity and heat production plants form local generating companies (GenCos). Later, the local GenCos will be combined into 18-20 regional GenCos to improve their maintenance and to make cheaper financial credits for development and reconstruction. Local distribution companies (DistCos) are to provide an

open access to the electric networks for end customers. Later, the local DistCos will be combined into 7 regional DistCos.

Several supply (energy-sales) companies are under creation in each region.

They will compete for the end consumers by lowering the price of its services and by offering more profitable and convenient conditions of energy supply. One of the supply companies is Guaranteeing Supplier (GS). GS is a company, which continues the obligation to provide supply service to all customers on the GS's service territory who request such a service.

Competition can be introduced in the generation and supply spheres, but is not feasible for transmission, distribution, and system control businesses because these are the functions of natural monopolies.

The process of utility restructuring will continue 1-1.5 years.

Restructuring the holding RAO "UES of Russia". It is evident that RAO "UES of Russia" dominates the industry and must be promptly and substantially restructured to improve efficiency and attract necessary investment. The following steps were made in 2002. Some of them are expected in the nearest future.

The Federal Transmission Company (FTC) was created to operate, maintain and expand the national transmission network. Lines and substations with voltage 220 kV and higher are combined under control of the new company. FTC will remain the sister company of JSC "UES of Russia" for two or three years. Later, 75% of FTC's shares will belong to the State.

New company called "System Operator" (SO) was established to operate UES. SO is targeted to provide reliable electricity supply and non-discriminatory access to the networks. SO combined the Central Dispatching Board in Moscow and seven regional Dispatching Centers. Later the dispatching divisions of the local power utilities will join SO. The ownership of the State in the capital of SO should be more than 75% from mid-2005.

Administrator of the Trading System (ATS) was established as a non-profit entity for the wholesale market design and operation. ATS registers amounts of bilateral electricity trade, sets prices on the spot market for different buses of consumption, and supervises trading agreements and payments for electricity on the wholesale market.

Seven Wholesale Generating companies (GenCos) are being designed currently and will be created this year with private property. The Wholesale GenCos will have approximately equal installed capacities of 8.5-9 GW. Six of them will combine thermal power plants. One GenCo will consist of hydro power stations. Additionally, there is an independent GenCo consisting of 8 nuclear power plants. This company is supervised by the Ministry of Nuclear Energy and belongs to the State. Unbundled generating companies are established under dispersed ownership. Private investors are expected to bring financial resources to update running units and construct new ones.

Reforming the electricity markets. Significant developments are expected on the wholesale market. Two challenges will be available for electricity producers and customers. They may participate on the spot market or arrange bilateral forward contracts for electricity delivery. New companies such as the wholesale and local GenCos, local electricity suppliers, Federal Transmission Company and large end customers will participate on the wholesale market instead of vertically integrated utilities. System Operator will be responsible for safety and reliable operating conditions in UES.

A new pricing mechanism will be introduced in the wholesale market. Instead of blanket average prices a new market will introduce local marginal prices. The wholesale

customers will pay at the margin what it costs to produce and supply electricity to them. On the one hand, it will encourage the power producers to improve the efficiency of production. On the other hand, it will result in price growth.

The spot market organization needs the development of sophisticated measurement system. Considering vast territory of the country this is a complicated technical problem.

Improvements in the State regulation. The State regulation of the industry should be concentrated on price regulation in the spheres of natural monopolies. On the wholesale market the focus of regulation is to prevent anticompetitive abuses and the market power exercises. On the retail markets regulation should be focused on balancing the interests of suppliers and customers. The prices in the natural monopoly spheres remain regulated including transmission tariffs, expenses of System Operator and ATS.

Prices in the competitive spheres are not regulated, but the Federal Energy Commission as the State Regulator can set price caps on the wholesale market. Also the State Regulator endorses the rules for customer's access to the networks and the procedures for tariff calculation. Local Energy Commissions regulate the tariffs for heat supply and electricity distribution as well.

Any cross subsidies between territories, groups of customers, different kinds of products (electricity and heat energy) and services should be eliminated step by step.

V. INVESTMENT ATTRACTION INTO RUSSIA'S POWER INDUSTRY

The volumes of new equipment commissioned in the last decade have been extremely small. The average annual input of generating capacities in the years 1991-2000 was 0.6-1.5 GW per year, while in 1976-1985 construction of new capacities was 6-7 GW. In China this rate was 17000 MW annually during the last 15 years [5]. Financial injections into the industry were 5-6 times less than was required. This resulted in dangerous aging of generating and transmitting facilities [4], [5].

Therefore attraction of investments into Russia's electric power industry is a key problem. The solution to this problem will somewhat differ for privately owned generating companies and for network companies that are regulated natural monopolies.

Attraction of external investors is important for generation expansion and calls for:

- Essential increase in the investment attractiveness of GenCos by providing financial transparency, economic stability, predictability of management actions and other corporate measures;
- Considerable increase in the reliability of State guarantees to the investor by clear legislature, predictability and stability of State policies in electric power industry, etc.
- Effective system of investment risk insurance.

The above measures can considerably decrease financial risks for investors, which will not require high electricity tariffs to compensate for these risks.

At the same time the world experience shows that in a free market environment the short-term purposes of power companies prevail over the long-term ones which, with time, may lead to an inadmissible drop in the reserves of generating capacities, formation of generation shortage and as a result growth of electricity tariffs [4], [6].

The new Law on the electric power industry envisages prompt and long-term measures not to allow such situations. The prompt measures imply introduction of price caps and then regulation on the markets in the event that there are no conditions for competition due to the shortage of generating capacities. A basic long-term measure is development of a State Program for generation expansion that would provide permanent availability of surplus capacities on the wholesale markets. This can be based, for example, on nuclear power industry that belongs entirely to the State. Distributed generation can also play and an important role here. The Program should form economic incentives for GenCos and external investors to invest the capital in construction of new power plants.

As to the regulated network companies, their development can mainly be provided by the investment component included in the tariffs for power transmission service. At the same time, due to insufficient transfer capability of the electric network, and the need of its essential increase to expand the conditions for electricity market operation, it may turn out to be necessary to attract additional investments both governmental and private. The volumes, conditions and mechanisms of attracting such additional investments require additional thorough scrutiny.

VI. A TRANSITION PERIOD IN THE RESTRUCTURING PROCESS

A transition period has started since March 2003 after the new Federal laws are enacted. There are two sectors on the wholesale market during the transition period.

The first one is a competitive spot market with bids/offers submission on a per hour basis and with local marginal price setting. The other one is a fully regulated sector with "cost plus" principle of pricing for producers and average prices for customers within tariff zones.

Until 2006 the regulated sector will work with the single purchase agency. After January, 2006 the sector will be organized in the form of long-term bilateral contracts. The State Regulator will consider the prices of producers and define the set of suppliers for each wholesale customer. Prices within the bilateral contracts will be set for three or five years. Every customer will be able to dissolve the whole package of bilateral contracts once a year and joint the competitive spot market.

Currently each producer can sell up to 15% of its generation in the competitive sector. Year by year the share of sales in the competitive sector will grow. In the end of transition period all electricity trade will be competitive. The Government defines duration of the transition period.

VII. REGIONAL PROBLEMS OF THE MARKET DEVELOPMENT

The wholesale market of electricity in Russia has been established as the nationwide market. Nevertheless, the unity of the market exists only «de-jure» [6]. The wholesale market is divided in fact into several large regions due to the high cost of electricity transmission and limitations in the transmission capabilities.

The European part of Russia including Ural, Siberia and the Russian Far East are three large regions. The structure of the economy, electricity consumption and climatic conditions in these regions are quite different. These circumstances bring additional troubles for using a nationwide model of the wholesale market. The Federal wholesale market in Russia should have distinctions at least in three large regions.

The European region of Russia has 72% of total installed capacity and 74% of total electricity consumption. Fossil fuel power plants in the region burn mainly natural gas. There are nuclear and peak (semi-peak) hydro power plants among producers. Generation is relatively equally spread over the territory. Transmission network is well developed and provides alternative ways for power supply. The European section of UES has the surplus generation and transmission reserves.

It seems reasonable to have the following model of the wholesale market:

a) the independent Administrator of the Trading System (ATS) in the region organizes and operates the day-ahead wholesale spot market. ATS works as a «flexible» entity arranging transactions as a brokerage system in the power exchange. The bilateral trade for a year and a quarter is permitted in addition to the centralized spot market;

b) large fossil-fired power plants and hydro power plants are combined into private generating companies. Nuclear power plants are combined into the State concern "Rosenergoatom", which plays as an independent producer on the wholesale market. Customers on the market are local supply companies and large power consumers;

c) ATS calculates the local marginal prices for electricity based on free bids/offers on the spot market. Contract partners define prices within the bilateral contract. The State Regulator sets tariffs for electricity transmission and the System Operator's services for a year. It sets the price caps for the spot market as well.

The Siberian region has 22% of the Russian generating capacity and 21% of total consumption. More than 50% of electricity is produced by large hydro power plants. These plants generate very cheap energy and have a strong influence on the economy and ecology of different territories. Almost 30% of total amount of electricity is generated in cities at cogeneration plants. Electricity generation at these plants greatly depends on heat consumption. Almost all fossil-fired power plants burn Siberian coals.

The transmission network has weak ties with the European sections of UES and is isolated from the Far-Eastern one. Power grid in the region is spread on a vast territory and has limitations on power flows in some cut-sets. That is why it is difficult to provide an open access to the transmission network for all market participants.

Electricity generation and consumption in Siberia are subject to unstable natural impacts due to variations in river inflows and long droughty periods. The climate is severe with annual and seasonal temperature variations.

Considering specific conditions of the Siberian region the following market organization can be proposed as rational:

a) establishment of the Siberian branch of ATS with the same main principles of work as the ATS in the European part. Proportions between bilateral trade and spot market sales may differ from other sections of UES. Regional Dispatching Center, which is the sister-company of System Operator, supervises reliable operation of the power grid in Siberia;

b) electricity transactions should be provided among the market participants located in Siberia;

c) introduction of a technique for long-term generation scheduling and pricing for hydro power plants. The technique will take into account the availability of water in the reservoirs, ecological impacts and interests of water users;

d) introduction of a procedure for price setting on the spot market based on competitive prices of electricity and regulated prices of generating capacities. The procedure should reduce the "jump up" of the wholesale prices due transition from the average to the marginal principle of pricing;

The Far Eastern region has less than 10% of electricity generation and consumption. There are a few relatively large power plants combined with a weak and extended network. Electricity supply of many territories is separated from UES. There are no sufficient conditions yet for the effective competition among producers and suppliers. It seems reasonable to save the State regulation for electricity producers for the nearest future. Considering the importance of the Far East for the interests of Russia the power industry in this region needs special governmental support.

VIII. EXPECTED EFFECTS OF THE MARKET REFORM

New markets may result in:

1. Introduction of non-discriminatory relationships among market participants. It follows from unbundling the generation, transmission and supply businesses and from the new legislation enacting;
2. Removal of the cross subsidies among businesses, territories and customers. It will provide proper economic signals for electric power systems operation and development;
3. Encouragement of the electricity producers to reduce their production cost due to marginal pricing introduction;
4. Improvement in financial conditions for generation, transmission and distribution companies due to electricity price growth;
5. Attraction of domestic and external investments.

At the same time there can be some negative impacts including:

a. Increase in the wholesale and retail electricity prices due to introduction of marginal principle of price setting instead of average regulated approach;
b. Decrease in electricity supply reliability for the nearest future due to lack of experience in operation and control of new unbundled companies.

IX. CONCLUSIONS

1. The Russian power industry does need an improvement in efficiency of operation and new investment inflows. The industry and the Government see the main way out from current problems in restructuring of the holding “EES of Russia” and local power utilities. The market rules and market infrastructure should be improved for competition introduction.
2. The new State Law opens good perspectives for further progress in the restructuring process. The industry has entered a practical stage of restructuring. Power utilities are unbundling for separation of generation, transmission, and supply services. New market rules have been developed to improve the wholesale and retail markets.
3. Two challenges will be available for electricity producers and customers. They may participate in the spot market and arrange bilateral forward contracts for electricity delivery. There will be competitive and regulated sectors in the wholesale spot market during the transition period. Up to 15% of generated electricity is selling in the competitive sector now. Year by year the share of the competitive sector will increase.

4. The restructuring of the industry is accompanied by apprehension of significant increase in electricity prices and possible decrease in supply reliability. The restructuring process should be well prepared and staged over time. Any new reforming decisions have to be made after detail analysis of consequences and based on available potentialities. Different regions of the country may choose their own restructuring models and determine the terms and rates of restructuring.
5. Attraction of investments into Russia's power industry is a key problem. The new legislation in the power industry envisages prompt and long-term measures to develop generating facilities and electric networks. The long-term measure stipulates creation of the State Program of expansion planning that would provide permanent availability of surplus capacities in the wholesale markets. The Program should form economic incentives for GenCos and investors to invest the capital in power plants. Development of the market infrastructure can mainly be provided by the investment component in the tariffs for power transmission service.

   Russia has unique conditions for the competitive environment development. Its restructuring policy may be useful for big countries where power industry is on the way of reforms.

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XI. BIOGRAPHIES

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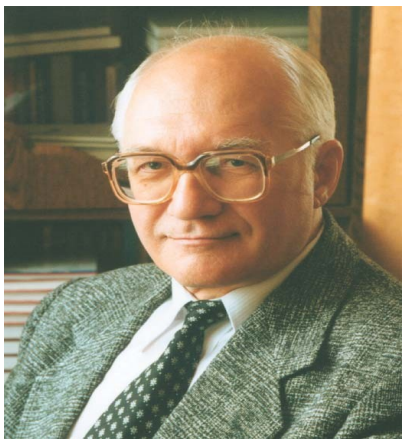

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3. Economic Convergence Points of Russian, CIS and Asian Power Markets

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Abstract - The convergence of power markets is, by definition, emerging from strictly technical reliability concerns to economic reliability concerns. Commonalities of Russian and the Commonwealth of Independent States' power sectors includes structural reforms, power system integration, legislation and price liberalization. Other Asian countries divide reform incentives along macroeconomic lines, however, they share the primary aim which is to improve overall economic efficiency. Based upon experiential research, each country in Asia should nationally *and* regionally contextualize a reform program designed on one or many models.

Index Terms - power industry, power industry restructuring, power industry development, electricity markets, electricity prices, power systems, interconnected power systems, power system economics.

I. INTRODUCTION

The convergence of Asian power markets crosses political and geographical boundaries. This paper provides an analysis of the technical and economic commonalities involved. The two primary goals of power sector reforms have been liberalization and the establishment of a competitive power market.

Section II discusses the fundamentals of cooperation, and the primary goals of power sector reforms. The main reform priorities and primary strategic areas are discussed in the context of the developing power market in Russia.

Section III makes the point that despite the large geographical area, and economic disparity of Asian countries, there are commonalities to be considered in power sector reform. Each country should create a reform methodology in a national and regional contextualization.

It is explained that there are five common steps which this can be based upon. Additionally, when determining the correct model to apply to an economy to bring about the desired efficiencies, it is important to consider 13 transitional issues.

II. ECONOMIC ANALYSIS OF RUSSIAN AND COMMONWEALTH OF INDEPENDENT STATES POWER SECTOR INTERCONNECTIONS AND MARKETS

The Commonwealth of Independent States[1], (CIS) power sector has been characterized by cooperation, liberalization, privatization, investment, and cross border integration of electricity markets [1]. The fundamentals of cooperation have been stated in the CIS agreement entitled “On coordination of interstate relations in the field of electricity of the Commonwealth of Independent States” signed in February, 1992. Arising from this agreement, cooperation has been implemented in the areas of structural reforms, power system integration, legislation and price liberalization. This is in response to serious power sector problems experienced by CIS countries in financial, technical, operational, and investment areas. As a group, the CIS countries faced additional crises because of the 12 members, only four, Azerbaijan, Kazakhstan, Russia, and Turkmenistan have enough fuel and energy resources to cover internal demand.

The primary goals of power sector reforms in the CIS have been liberalization and the establishment of a competitive power market. This has been conceived, since 1996, as a complex process, based upon relevant technological, structural and legislative foundations [1]. Many of the CIS countries have phased-in the process of power sector reforms. These reforms have followed previous global experiences by de-integrating

[1] The CIS is composed of: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. In October, 2000, the heads of five countries (Belarus, Kazakhstan, Kyrgyzstan, Russia, and Tajikistan) signed an agreement on the creation of the Eurasian Economic Community. Armenia, Moldova and Ukraine have observer status under EAEC. In October, 2005, Uzbekistan agreed to join this organization. In September, 2003, four countries (Belarus, Kazakhstan, Russia and Ukraine) signed an agreement on the Formation of CES (Common Economic Space).

vertically integrated monopolies into distinct distribution, transmission, and generation companies. This has established the foundational single-buyer model of market reform, in preparation for more liberalization. The single-buyer model was introduced in developing countries in the 1990s. It provides exclusive rights for a single transmission and dispatch company to purchase all electricity from generators and then sell it to distributors [2].

The single-buyer model became popular in the CIS countries and elsewhere because of technical, economic, and institutional reasons. These include:

- Balancing of electricity input and output is facilitated by a single dispatch method in real-time.
- The "contract path" problem is avoided.
- The single-buyer model is usually responsive to the sector ministry in the areas of generation capacity investment and state-owned company's financial affairs. This is favoured by the most influential stakeholders.
- Price regulation is simplified, maintaining a unified wholesale price.
- The single-buyer model is favoured by politicians who do not agree with a complete withdrawal of the state from wholesale electricity trading [2].

There is evidence, however, that it is more efficacious to adopt a market model that has multiple buyers formed immediately after unbundling, in areas such as the CIS. The single-buyer model is criticised because it tends to place generation capacity expansion decisions in government officials' hands, who do not assume the financial consequences. This model also makes the state ultimately responsible for poor power purchase agreements that cannot be honoured. This is regularly part of the contract agreement. This model also does not respond well to reductions in electricity demand. Wholesale electricity prices will rise in response to demand reduction because of fixed capacity charges, which must be applied to a reduced volume of electricity purchases. Another drawback is the under-development of cross-border power trade. This is because the state-owned single-buyer has very little profit motive. This can cause long-term problems when a neighbouring country or region develops a more liberalized power market model. Incentives for distributors to collect payments from customers is also reduced. Again, politically unpopular decisions are difficult for a state-owned entity. This is important because in the single-buyer model, delinquent payments from distributors are assumed by the aggregated cash proceeds of the single-buyer. Paying and non-paying distributors are treated basically the same, weakening the resolve of distributors to enhance the collection of payments. Another political intervention in this model has been experienced in the Ukraine and Poland. In these countries, groups have lobbied on behalf of coal miners to provide special treatment for coal-fired power plants. Interestingly, because of the political advantages of the single-buyer model, some governments have significantly delayed the next "phase" of fully liberalized markets [2].

The CIS has experienced advances in the privatization of the power sector. For example, Armenia, Azerbaijan, Georgia, Kazakhstan, Moldova and the Ukraine have either contracted the management of electric companies, or sold generation companies and distribution electric grids [1]. Modernization through the construction of energy facilities has been facilitated by the creation of a legal basis. This has attracted direct investments in improvement projects from internal and external sources. For example, Armenia, Azerbaijan, Georgia, Kyrgyzstan, Tajikistan and Uzbekistan have received

investments in projects ranging from hydro power plants, steam gas turbine units to electricity grid restoration [1].

There has been on-going integration, and re-integration of the CIS power systems. For example, in June, 2000, the power system connections of Russia and Kazakhstan were restored. Since the autumn of 2001, 11 of the 12 CIS countries have re-synchronized their power systems as an interconnected power system of the Commonwealth of Independent States (IPSCIS) [1]. Additionally, the CIS is involved with power exchanges and trade with the neighbouring countries of Afghanistan, China, Finland, Hungary, Iran, Norway, Poland, and Slovakia. The CIS power authorities believe that cross-border synchronization is beneficial because it places better use of existing generation capacity, provides emergency assistance options, and harmonizes standards in the areas of safety, ecology, and technology.

As part of an economic analysis of eastern Europe and CIS transitional development from centralized planning to free market forces, a framework is used to evaluate the impact of infrastructure upgrades [3]. Research has indicated that "The potential for developing competitive markets in transition economies had been inhibited by the inadequacy of both the institutional and physical infrastructure inherited from the socialist era [3]." Although the following are general recommendations for transition economies, the following economic contributions of market-enabling infrastructure can be applied to the power sector:

- *Market Selection*: By increasing market competition, infrastructure investments that reduce transaction costs reduces the market share of higher-cost firms. This raises the average production efficiency of the economy.
- *Infrastructure Investments*: If these investments increase product market competition, incentives for firms should change to help reduce their costs by engaging in a restructuring plan.
- *Increasing Market Share*: If lower cost firms enter the market, they have probably been attracted by an infrastructure that lowers transaction costs (European Bank, 2000).

Therefore, each investment project in the CIS power sector can be evaluated in terms of the contributions of direct market selection, restructuring and entry.

The primary problem with the power sector in Russia, in the context of the CIS, has been inadequate investment [4]. Reasons for this are found historically, primarily being a lack of investment in generation capacity, and increased industrial activity and subsequent higher demand. A main goal has been to attract internal and external large-scale investments to the potentially competitive elements of the power sector. Although Russia has formed a plan, crafted in 2001, to eventually liberalize wholesale and retail electricity tariffs and to privatise segments of the sector, other contiguous CIS members have taken a lead in reformation. Kazakhstan was a reform leader by unbundling transmission, distribution and generation [4]. Most generation and distribution assets have been privatised, but transmission networks are still owned by the government. In April, 1999, the government of Kazakhstan approved a program to develop the electric power sector, with a view to 2030 [5]. The main priorities are:

- To have economic and population self-reliance in electric power, and to have energy independence as part of national security.
- To create competitive resources for electric power export to supply energy markets of contiguous and third countries.
- To develop a competitive electric power market on the basis of electric power transport and distribution networks accessible for generators – and a system to control power flow.

The primary strategic areas are:

- To create a Kazakhstan unified energy system (UES).
- To restore the synchronous network with Russia, and other energy networks of central Asia.
- To further develop an open and competitive market for electric power.
- To commission new generation capacity to offset power imports.

Assuming these priorities, it is useful to view Kazakhstan as a precursor to significant, similar changes in Russia. In 1990, the electricity shortage in Kazakhstan reached a level of 17.3 billion kWh [5]. This shortage was made up by power imported from Kyrgyzstan, Russia and Uzbekistan. In 1996, the state generation and power grid monopoly was the object of reform, with the aim to create a competitive power market. That year, the government initiated a program to privatise and restructure the power sector formalized by Decision No. 663 of May, 1996. Because of this decision, large generators were sold to investors, and a grid company was created to own and maintain the high voltage grid assets, including voltage levels of 1150, 500 and 220 KV. Additional decisions (1188 of September, 1996 and 1193 of July, 1997) provided a model for Kazakhstan to follow for the creation of an electricity market [5]. Designed for competition, the single electricity market would have two levels, wholesale and retail. The trade of electricity would be based upon fixed date bilateral purchases and transactions, and agreements on grid capacity. The competitive model would be brought about by pro-active changes in the electricity sector:

- Restructuring to create an effective, competitive market based on forwards contracts under the supervisory control of a centralized dispatch.
- A testing period for competitive market principles and enhanced quality indicators, especially regarding current frequency.
- The creation of a pool of reserves – comprising a market of electricity reserves.

As of 2003, the wholesale power market is functioning on the basis of bilateral contracts. The electricity exchange for day in advance power purchases was established in February, 2002. The total volume of sales at the exchange is considered to be 7 % to 10 % of the total supply of electricity for Kazakhstan [6].

Hirschhausen and Waelde, [7] have posited that an economic transition period from socialistic to capitalistic markets, especially in energy, no longer exists. Interestingly, the authors make the critical point that experience with emulating institutional models has shown that they often work very differently for the emulator than the emulated [7]. Utilizing an institutional interpretation of energy sector reform in the CIS, the authors

contend that the transition from socialistic to market based economies has led to diverse outcomes. These differing outcomes are based primarily upon the pre-existing formal and informal institutions which dominate the particular country. The CIS countries have looked to Western market economies as models for the restructuring of their power sectors. Two diametric cases [7] that have been studied are the Anglo-Saxon and French approach. The authors qualify this statement by suggesting that there is no theoretically or empirically discernable best practice to structure and regulate the global energy sector. The CIS, including Russia, however, have overwhelmingly chosen the Anglo-Saxon (British) approach which has been reproduced in Australia, Canada, New Zealand, Scandinavia, and several U.S. states. This approach has been marked by very direct privatisation, corporatization, and competition. The French system, in contrast, has essentially maintained integrated monopolies protected from competition. Despite the similarities found in the French and formerly Soviet approaches, linked by a dominating public service obligation and a close relationship between management and politics, the French system has not been the model of choice for the CIS. The initial elements of the approaches found in most CIS countries have been to:

- Identify appropriate reform models from international experiences,
- Attempt to re-produce those models in an effective way domestically,
- Allow the domestic model to emerge and evolve with contextualized principles [7].

Interestingly, after surveying international examples, some countries such as Russia and the Ukraine have crafted early proposals that have included additional competitive elements. This enthusiasm for the Anglo-Saxon approach can be tied to what is perceived as superior wealth generation, technological innovation and swiftness of economic response to the needs of the market. Possibly most importantly to consider, Hirschhausen and Waelde, [7] indicate that the AC connection of Poland and other east European countries to the West European grid was an external impetus to modernization. This is an important recognition of the relation between the physical connection of electricity grids of distinct systems, and the subsequent need to reform such areas as security, technical requirements, quality and communication.

Indeed, this is demonstrated by the relationship of technical and economic needs of the Japanese power grid interconnection (PGI) considered with Eurasia. Arakawa [8] suggests that a major issue concerning Japan's PGI is the "eventual interconnection of the Japanese power system with the Eurasian mainland [which] will be achieved with restructuring of Japan's electric power market to be freely competitive. In addition, the relationship between Japan and Russia must be improved to a point that the neighbouring nations will be able to cooperate, for example, in mutual development of Siberian natural resources. Apart from political and economic concerns, no major technical difficulties in PGI are anticipated [8]."

Projects such as the potential Japanese-Eurasian interconnection can be financed through three main approaches, (1) public ownership, (2) public-private partnership, and (3) private ownership. Though not the primary focus of this paper, more rigorous analyses of potential Asian interconnections should be carried out before assuming the existence of financial, capacity, or reserve capacity incentives. For instance, if the potential interconnections are between two monopolies, then analyses can be carried out using bilateral monopoly trade theory. This would be particularly useful with a

monopsony – monopoly power market scenario. However, in this scenario, the Nash equilibrium theorem cannot be used because the asymmetry found between distinct systems discounts the determination of a unique price.

III. CONVERGENCE OF ASIAN POWER MARKETS

Asia-Pacific Economic Cooperation[2], (APEC), created in 1989 to continue to stimulate regional economic growth, has remained a consensus-based entity, without binding agreements [9]. APEC, although a non-treaty based organization, is having a significant impact on the reform of the Russian economy, including the Russian power sector. The primary purposes of APEC have been to encourage economic growth, trade, investment and cooperation in the Asia-Pacific region. APEC is a 21 member organization, each called a Member Economy, representing 47% of global trade. The APEC Member Economies include the Russian Federation as an integral participant. Particular themes can be found in APEC interests, including:

- Reduction of tariffs.
- Efficient domestic economies.
- Increased exports [9].

Other APEC activities include policy creation and economic cooperation to facilitate the exchange of products across regional borders [9].

Established, and ongoing studies of the APEC economic area electricity supply industry have indicated that reform in the developed economy members has been designed to improve efficiency in the sector. In contrast, the developing economy members have sought reform because of partial access to electricity supply, low infrastructural investment, uneconomic pricing of electricity, and inability to manage high demand growth [10]. The progress of microeconomic reform of the APEC electricity sector has been steady across both developed and developing member economies. Despite the large geographical area, and economic disparity of member economies, an APEC energy working group has concluded that there are commonalities to be considered in electric sector reform:

- Governments remain responsible for the outcome of reform, even after industry restructuring takes place.
- If governments cannot demonstrate the success of reform programs, there may be political consequences.
- Reform needs to be contextualized to each member economy based on needs, circumstances, and resources.
- Despite advances in a competitive electric market, electric security and stability of the entire system must always take precedence.

[2] APEC's 21 Member Economies are: Australia, Brunei Darussalam, Canada, Chile, People's Republic of China, (Hong Kong, China), Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, The Republic of the Philippines, The Russian Federation, Singapore, Chinese Taipei, Thailand, United States of America and Viet Nam.

- Restructuring has been defined as a “break-up” of generation and supply, which are contestable, and mostly non-competitive elements of transmission and distribution.
- The introduction of a competitive electricity market will create high risk for consumers if supply is unreliable, or becomes unreliable. High levels of competition are not appropriate for developing economies in the early stages of electric sector reform.
- If the impetus is to keep the electricity market at a marginally competitive level, other aspects of the system can be made more competitive. The separation of the transmission system and the creation of a competitive system to acquire primary and secondary energy are examples.
- The historical emergence of competitive electricity markets has arisen “naturally” from trade between distinct power systems via sub-national and national power system interconnections.
- Under pricing of electricity removes much of the incentive to invest in infrastructure.
- There is no “reform standard”. This being the case, it is important to create an objective-setting, monitoring and measuring system to manage reform.
- Highly valuable empirical reform experience can be lost. It is important to retain talented experience for on-going institution building [10].

Importantly, it can be maintained that each member economy should create a reform methodology in a regional and national contextualization. However, there are five common steps which this can be based upon:

- Create national policy objectives.
- Identify reform risks.
- Assume and implement reform strategies which are realistic.
- Project-manage the reforms.
- Create an institutional unit to consistently monitor the progress of reforms [10].

Interestingly, the research methodology used by the APEC energy working group was composed of a literature review, interviews of reform participants in APEC economies, cross-sectional assessments of the current status of reform, and applications of practical experience in case studies of developed and developing economies in APEC [10]. Overall reform of the electricity sector has been divided into eight primary sections:

- Policy objectives
- Management
- Structure
- Framework for law and regulation
- Mechanisms for wholesale market
- Transmission and distribution
- Retail tariffs
- Privatisation [11]

By utilizing mixed research methodologies to provide analyses, each of these eight sections has strategic principles designed to provide common points of reference for reform, and to also provide the basis for a contextualized approach. Interestingly, Principle 35, under *Wholesale Market Mechanisms,* states: "The establishment of a competitive wholesale market should only be considered in the context of overall market structure and design [11]." Wholesale market mechanisms should be able to interface with regulatory frameworks, transmission and distribution planning, and access. This should account for the need to provide cost effective supply from generation to the distribution connecting points. Competitive wholesale market mechanisms are integral to overall power system reform planning and implementation. The primary aim of power system reform should be to improve economic efficiency. This can be divided into three areas:

- *Productive efficiency*, which is the relationship between production input and output, and the implementation of best practice concepts.
- *Allocated efficiency*, which is the way resources are utilized, in the light of appropriate signals for investment and consumption.
- *Dynamic efficiency*, which is the extent that innovation and productivity increases are encouraged over a specific duration [11].

Critically, when determining the correct model to apply to an economy to bring about the desired efficiencies, it is important to consider transitional issues. These transitional issues include:

- ***Ownership***

  If the current model of the power sector is a state-owned monopoly, full privatisation should be delayed until it can be determined that the new companies will be viable, and after new markets have been tested.

- ***Incumbents***

  If competition is introduced, incumbent utilities are under an obligation to reduce operating costs, and to develop new strategies and new markets to supply power to. The restructuring of the industry creates new risks for incumbent utilities. This includes the areas of finance, regulation and politics. As an example, generators have can have competition amongst local power suppliers. Additionally, as the electricity grid becomes more interconnected, with more room for capacity, interstate and international generators then add to the competitive marketplace.

- ***Stranded costs***

  Stranded costs are the historical costs, mainly through generation plant construction, that may not be recoverable in the new prices charged in a competitive market. Generally, there are four types of stranded costs:

1) New generating plants could out-compete old plants, necessitating the decommissioning of older plants.
2) Competition can provide lower cost, long-term fuel or power purchasing contracts. Utilities bound to uneconomic contracts have higher input costs, and consequently a loss in earnings, making recovery difficult.
3) Utilities that have been obligated to invest in "regulatory assets" can find that the regulatory regime can change under a competitive environment, reducing their protective "extended payment plans" by deregulated, lower prices.
4) Other public policy programs such as Demand Side Management (DSM) programs can be stranded, as their cost recovery will become impossible in a deregulated system [11].

Although full recovery of stranded costs are rare, most experts in the field agree that governments should pay utilities for stranded costs, on a case by case basis, based upon specific attributes of the utilities in question.

- ***Security of supply***

  Two primary aspects of security of supply must be considered when planning and implementing a transition to competitive markets. They are the securing of long duration sources of generation fuels and the reliability of the power system.

- ***Investment***

  It has been found that competition in generation can reduce incentives to invest, and lower operating costs. In building the reform of the power system, it is important to create a system for signalling the need for generation capacity and power grid improvement.

- ***Reliability***

  Interestingly, reliability, by definition, is moving from strictly technical reliability to economic reliability. Economic reliability is composed of a contractual arrangement between generators, distributors, and consumers, reflecting a certain level of reliability.

- ***Transparency***

  Pricing mechanisms in a monopolistic system often are subsidised to appease social policy requirements. However, in a deregulated market, consumers should eventually be able to choose their own retail supplier. In this arrangement, consumers need accurate and transparent information regarding price and service.

- ***Social policy***

Although government is responsible for social policy, it is recommended that energy policy not be an element of social policy. A newly designed regulatory system can be crafted to synchronize public and private interests.

- ***Equity***

  Universal service obligations may no longer be maintained by the government as a consequence of deregulation. Low income customers may need to be assisted by direct government funding.

- ***Consumer protection***

  It is possible that industrial customers will benefit more from deregulation than residential ones. Regulation will need to be applied to enforce appropriate competition laws.

- ***Pricing issues***

  It is important to manage prices as a country transitions from one power market model to another. Two areas are commonly found: price increases and reduction of employment levels. Price increases may be made more gradual, especially by utilizing subsidies, efficiency improvements, enhanced competition and disbursement of consumer information.

- ***Reform and the environment***

  Interestingly, as a wholesale power market develops to be more competitive, there is more pressure to run plants that have a lower cost of production. It is possible that these lower cost of production plants emit the most harmful contaminants into the environment. Though not intrinsic to the reform process, it is recommended that environmental policy evolve at the same time as economic and social policy.

- ***Regulation***

  Market power is a central issue in deregulation, and requires a regulatory regime to constrain non-competitive manipulation of the market.

Reflecting the theme which suggests that each country, including the APEC members, should contextualize a reform program designed on one or many models, the APEC energy working group states, “The circumstances of each APEC economy present unique issues and problems in designing regulatory aspects of market reforms. What has succeeded in other economies may not be appropriate in a particular economy in Asia [11].” This is substantiated by the prominence that Russia holds as a case study when looking at APEC area electricity sector deregulation [12].

Indeed, Belyaev, et al, [13], foreshadowing Arakawa, [8], indicates that the interconnection of electric power systems, to broaden power markets, is expanding internationally. The North-East Asia region, composed of China, Japan, North and South

Korea, and the Far East area of Russia hold the highest potential to design and implement interstate interconnections. The east Siberian area, including the Krasnoyarsk and Irkutsk electric power systems, has a surplus of capacity. This extra capacity is because of reduced exports to the European and Ural part of Russia as the industrial economy has been in decline. Consequently, and for example, energy experts at the Irkutsk, Russia electric utility have concluded that it is possible for an economically efficient interconnection between Irkutsk and China, exporting, respectively, up to 3 Gigawatts [13]. Plans such as this are supported by published policies of APEC [14]. Cross-border transmission networks, as planned in APEC, are perceived to strengthen the security, quality and flexibility of energy supply.

IV. CONCLUSION

It is important to adopt a market model that has multiple buyers formed immediately after unbundling, in areas such as the CIS. CIS cross-border synchronization is beneficial because it places better use of existing generation capacity, provides emergency assistance options, and harmonizes standards in the areas of safety, ecology, and technology.

It is thought that the economic transition period from socialistic to capitalistic markets, especially in energy, no longer exists. Experience with utilizing institutional models has shown that they often work very differently for the emulator than the emulated.

Wholesale market mechanisms should be able to interface with regulatory frameworks, transmission and distribution planning, and access. This should account for the need to provide cost effective supply from generation to the distribution connecting points.

The primary aim of power system reform should be to improve economic efficiency. The economic milieu of each economy presents unique issues and problems when designing regulatory aspects of market reforms. What has succeeded in other economies may not be appropriate in a particular economy in Asia.

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VI. BIOGRAPHY

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4. UZBEKISTAN ENERGY STRATEGY

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Abstract: Analysis of Uzbekistan energy policy on the base of system approach has been performed. It has been shown that the energy policy can be presented in the form of various components of the policy such as geopolitical, economic, technical and social ones and the step by step principle of reforming has been used in its realization. Due to correct and balanced implementation of the energy policy Uzbekistan has been able over a relatively short time to ensure the stable advancement of its vast fuel and power complex.

Index terms - Energy efficiency, energy fuel sector, energy strategy, gas and oil industry, market, power, reforms

I. INTRODUCTION

The objective of the present work is to analyze the Uzbekistan energy policy during its independence. It will be shown, that it can be presented in the form of various components of the policy such as geopolitical, economic, technical and social ones. In realization of the energy policy the step by step principle of reforming has been used. This process would be considered as follows.

The first stage of the energy policy was implemented in 1991-1997 and consists of the following components:

- Geopolitical component- achievement of energy independence;
- Social component - supply of large-scale access of the population to energy carriers;
- Economic-social component - restraint of the low prices for energy carriers for supporting the local manufacturers and the population;
- Technical component - uninterrupted and reliable energy supply of the consumers and the population.

The second stage of the energy policy has been realized since 1998:

The economic component of this second stage consists in step-by-step reforming the fuel energy complex of the country:

1. Reforming the oil-and-gas branch since 1998
2. Reforming the power branch since 2001
3. Reforming the coal branch since 2002

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It is to be noted that investment component of the energy policy was actively developing during the second stage of the energy policy in realization reforms of the fuel energy sector. Favorable investment climate for attraction of domestic and foreign investments to fuel energy sector of the country was created on this stage.

The third stage of the energy policy has been realized since 2002. The task of this period is to increase efficiency of use of energy resources and to create

necessary conditions for realization of energy saving measures providing preservation of energy independence and export potential of the country.

Now on the basis of the presented structure of energy policy we will illustrate its course and results.

The Republic of Uzbekistan is located in the middle of Central Asia, mostly in the interfluve area between the rivers Amudarya and Syrdarya. Uzbekistan economy is a combination of both industry and agriculture. Gross Domestic Product during 2000-2003 grew at an average annual rate of 4.3%. Industry is responsible for 15% of GDP. The principal sectors include the electric power, fuel, chemical, light, and food industries, and ferrous and non-ferrous metallurgy. The fuel and power sectors account for 25% of gross industrial production. The share of agriculture in GDP amounts to 28.8%. The principal crop is cotton. Uzbekistan holds the 5th place in the world for cotton output and is 2nd for cotton exports. Apart from the latter products, its exports are dominated by gold, gas, oil products, copper, motor vehicles, and farming produce.

Uzbekistan boasts substantial proven reserves of organic fuel and a robust hydroelectric potential. It accounts for more than 40% of the entire Central Asia's natural gas and some 20% of its oil. For its natural gas output, Uzbekistan comes 3rd in the Commonwealth of Independent States (CIS) and is among the top ten producers in the world.

II. ENERGY STRATEGY

The principal task facing the Uzbek fuel and power sector is to ensure the security of energy supplies to all other sectors of the national economy, as well as to the population, by bringing about drastic improvements to energy efficiency.

Structural policies in the fuel and power sector during 1991-2003 were pursued amid accelerating economic reform and aimed to achieve the priority objectives of the energy strategy designed:

- to create a reliable resource base, and to support strategic economic sectors;
- to increase the efficiency of energy uses, and to furnish essential conditions for the implementation of energy saving measures as required in order to preserve the nation's energy independence and its export potential; and
- to sustain the energy sector's financial stability, to attract additional investments in its development, to revamp the legal and regulatory environment and upgrade the fiscal system with due regard for the special aspects of pricing in the energy sector and its relations with related sectors, to consistently cultivate a competitive environment in the energy sector by creating full-blooded market players and an adequate market infrastructure.

With a view to tackling the above tasks in line with the strategy for transition to a market economy the relevant energy policies in Uzbekistan have been implemented step by step. The primary tasks at the 1st stage of Uzbekistan's energy policies during the period of transition have included:

a) ensuring energy independence;
b) ensuring that natural gas supplies become accessible to the entire population; and
c) keeping energy prices low so as to maintain living standards and the competitiveness of local producers at creditable levels.

Rich in primary energy resources, Uzbekistan has successfully coped with the above tasks at the initial phase in its energy policies. Over the years of independence, it has trebled its crude oil output from 2.8 million tons in 1991 to 7.5 million in 2001, the natural gas production has gone 50% up - from 41.9 billion cubic meters in 1991 to 53.1 billion in 2003. Uzbekistan turned into a net exporter of natural gas as early as in 1995, while its imports of crude oil, which had amounted, in monetary terms, to USD 485 million that year, dwindled to zero in 1996-97.

That period also witnessed the construction of a state-of-the-art oil refinery in Bukhara, built to take advantage of the latest oil processing technologies. The first stage of the facility, capable of recycling 25 million tons of gas condensate per annum, was put into operation in 1997. Also in 1997, the construction of a compressor station was completed with the involvement of foreign companies at the Kokdumalak field to flood it with dried gas at a pressure of 50 MPa (in a cycling process).

The first stage of the energy policies has also been characterized by the continued extension of Uzbekistan's gas piping system. A 350-kilometer gas main between Gazli and Nukus went into operation in 1997 to ensure both natural gas exports and gas supplies to the population in the Khorezm Region and the Karakalpakistan Republic. The 300-km Pakhtakor-Yangiyer-Tashkent gas pipeline with an offshoot to a seven-unit compressor station at Yangiyer joined service in 1998 to make for secure gas supplies to households in the Tashkent Region and the Fergana Valley.

The same stage has seen *the privatization process in the Uzbek fuel and power sector gradually take off*. The Cabinet of Ministers in those years, for example, issued Resolution No. 290, "On the Experimental Privatization of Particular Petrol Stations Selling Petrol to the Population in the City of Tashkent for Cash", dated July 9, 1994, and Resolution No. 107, "On the Privatization of Petrol Stations in the Republic, Selling Petrol to the Population for Cash", dated March 20, 1996.

Both the annual generation of and demand for electricity have been on the increase since 1996. Table 1 shows the development of electric power supply and demand between 1995-2001.

As can be seen from the above, Uzbekistan achieved self-sufficiency in fuel in 1995 and became fully self-sufficient in energy over 1996-97.

As far as the task of making natural gas supplies more readily accessible to the population is concerned, it should be said that a really great deal has been done towards this end over the years of independence, with more than 3.5 million households, or *95%* of the

TABLE 1

ELECTRIC POWER GENERATION AND CONSUMPTION IN UZBEKISTAN

	1990	1995	1999	2000	2001
Electric power consumption, GWh	-	42020	43015	44017	45011
Electric power production, GWh	-	47453	45300	46840	47927

Source: Energy Balances of non-OECD countries 2000-2001, IEA Statistics, 2003 Edition

population**,** now enjoying access to the natural gas distribution network and an extra 720,000 households using liquefied gas these days as a result of those efforts. The Uzbek Government intends to get the remaining 5% of the population connected to the gas distribution network as well within the next three years.

Efforts to keep energy prices low were required at the 1st stage in the nation's energy policies, because Uzbekistan has decided against any shock therapy during its transition to a market-based economy. Its Government has opted instead for the evolutionary path of economic reforming, the result being that the reform drive in the energy sector as a basic national industry has proceeded gradually, on a phased basis. It is planned that energy prices will rise as it makes further headway not only in the energy sector, but in the economy as a whole.

The 2nd stage in Uzbekistan's energy policies has seen a plan-based reforming of the various branches of the energy sector with a gradual implementation of market-based mechanisms there. The reform in the oil and gas industries started in 1998, in the power industry in 2001, and in coal mining in 2002. The economic reform in the sector has been accompanied by institutional change and the provision of the required legal and regulatory framework.

The institutional change started with the establishment of Uzbekneftegaz National Holding Company in 1998, which was made responsible under Presidential Decree No. 2154 dated November 11, 1998 for managing the country's entire oil and gas sector. The organization and operations of Uzbekneftegaz were defined in Cabinet of Ministers Resolution No. 523 dated December 15, 1998. The company has eight subsidiaries.

The commencement of that kind of institutional change was accompanied in the same year of 1998 by the launch of building work on the Shurtan plant to produce polyethylene and liquefied gas, Central Asia's largest facility of this kind. The factory, which went on stream recently, is capable of annually producing 125,000 tons of polyethylene, 137,000 tons of liquefied gas, and 37,000 tons of light gas condensate. Likewise in 1998, reconstruction work went ahead in cooperation with the Japanese Mitsui on the Fergana oil refinery, which manufactures gasoline, diesel fuel, and jet fuel to world standards.

In order to ensure full and reliable supplies of natural gas to industrial centers, an underground storage for 1,800 million cubic meters of gas was built at Khodzhaabad in the Fergana Valley in Uzbekistan in 1999.

Therefore, the years between 1991-2000 saw the Uzbek oil and gas industries fulfill the following three paramount tasks:

1) The nation's self-sufficiency in fuel was achieved;
2) A marked increase in the output of export-oriented products of gas processing and oil refining operations and in natural gas exports as a result of the sector's restructuring; and
3) A legislative basis put in place as required to attract foreign investments in the oil and gas sector.

The Uzbek power grid has an installed capacity of 11.2 million kilowatts, and comprises 9 thermal power stations having a total generating capacity of 9.8 million kilowatts (or 87.5% of the total), and 28 hydroelectric power stations having a total generating capacity of 1.4 million kilowatts (12.5%), as well as three departmental electric power stations with a total generating capacity of 319,000 kilowatts.

Since developing a socially oriented economy is a priority objective of the ongoing reforming, the projected reform of the existing smooth running, but centralized power sector requires a balanced, consistent, and prudent approach. Before 2001, the sector was called upon to provide steady, uninterrupted supplies of electricity to all other branches of the national economy by making use of its advantages as a vertically integrated monopoly. However, with the reforming of all spheres of social and economic life, the unduly centralized system for managing the generation, transportation, and distribution of electric energy no longer makes it possible to cope with the tasks of making such operations more efficient and cost-effective. This is why economic reform went under way also in the power sector in real earnest in 2001 in line with Presidential Decree No. UP-2812, "On Furthering Reform in the Electric Energy Industry in the Republic of Uzbekistan," dated February 22, 2001.

The Decree has set the following goals:

- advancement of market-geared reform in the sector;
- its demonopolization;
- higher economic efficiency of enterprises operating in the industry;
- wider-scale privatization with the involvement of domestic and foreign investors; and
- improvement of quality and security of electricity supplies to consumers.

The reform drive in the sector is to prioritize the following:

- consistent demonopolization of energy enterprises;
- looser government regulation, and better conditions for competition among different electricity distributors;
- progressive fostering of wholesale and retail markets of electric and thermal energy;
- equal opportunities for all competitors, including equal access to power transmission lines;
- implementation of efficient arrangements and methods for developing coal fields, and broader reliance on coal as fuel in power generation;
- extensive attraction of domestic and foreign capital in the modernization and re-equipment of energy facilities;

- stage-by-stage transformation of thermal power stations, combined heat and power plants, and regional power networks into joint stock companies with the continued controlling equity participation of the state-owned Uzbekenergo; and
- transformation of construction, installation, and repair enterprises into joint stock companies which will continue to be at least 25% controlled by the state.

The Decree has also effected some institutional change by way of demonopolizing and improving the management system in the sector. The Uzbek Ministry of Energy and Electrification has been abolished, with the state-owned Uzbekenergo public joint stock holding concern organized on its basis to incorporate also the Ugol joint stock coal-mining company. Other entities resulting from the measure have included a high-voltage network subsidiary (Uzelektroset) to transmit, and regional distributors to allocate, Uzbekenergo's electricity.

The Uzgosenergonadzor state agency for supervision over the electric power sector under the Uzbek Cabinet of Ministers, initially established as the government regulator for the electric and thermal energy industries and coal mining, has been converted into the Uzgosenergonadzor state inspectorate under the Uzbek Cabinet of Ministers in accordance with the latter's Resolution No. 96 dated March 1, 2004.

An immediate follow-up on the above presidential decree, the Cabinet of Ministers' Resolution No. 93 of February 24, 2001, "On Measures to Organize the Operations of Uzbekenergo State Joint Stock Company," has detailed practical measures to implement that Resolution on power sector reform and presented further steps to refurbish and privatize Uzbekenergo. They have included the following:

1) Phased corporization of thermal power stations and regional power distribution networks with 40% interests to be offered to investors;
2) Sale of more than 75% of the shares to investors during the privatization of design, construction, installation, and repair enterprises;
3) Transfer of state-owned equities and shareholdings in thermal power companies to appropriate utility and maintenance associations for trust management; and
4) Privatization of Uzbekenergo social infrastructure facilities.

Step-by-step reforming is the leading principle of the nation's energy policies. This is why the fulfillment of the overriding task – that of becoming independent in the energy field – should be followed by the attainment of national energy security. As already noted above, the share of gas in the country's fuel budget is exceedingly large and this fact detracts from its energy security. Therefore, fuel diversification is among the key aspects of the energy security issue. It would be sensible for Uzbekistan, which boasts ample reserves of brown coal, to expand the share of that resource in the national fuel budget. For this reason, coal sector reform has come as the natural next phase in the country's energy policies.

Total coal production at initial stages in the reform process tended to decline, but the subsequent implementation of measures towards greater energy diversification has made for further and steady gains in coal output. The share of the power sector, namely: electric power stations, in the combined consumption of coal as fuel has reached 80%, with other users accounting for the remaining 20%.

The table 2 offers information about the production and use of coal in Uzbekistan.

TABLE 2. COAL PRODUCTION AND CONSUMPTION IN UZBEKISTAN OVER 1992-2000

	1992	1995	1996	1997	1998	1999	2000
Production, Mtoe	1.66	1.08	1.00	1.04	1.03	1.05	0.91
Consumption, Mtoe	2.18	1.07	1.20	0.98	1.03	1.02	0.88

Sources: Energy Balances of non-OECD countries 2000-2001, IEA Statistics, 2003 Edition

The reform drive in coal mining commenced in 2002 with the issue of Cabinet of Ministers Resolution No. 196 dated June 2002, which has set out the Development Program for the Coal Industry in Uzbekistan for the Years 2002-10. The Programme provides for stage increase in coal output from 2.7 million tons in 2001 to 9.4 million in 2010 and in the share of coal used for power generation in the national energy balance from 4.7% in 2001 to 15% in 2010.

Uzbekistan has been able over a relatively short time to ensure the stable advancement of its vast fuel and power complex. However, in order to sustain the country's self-sufficiency in energy and its export potential, it is extremely important to improve the efficiency of energy uses and set the necessary conditions for implementing the energy conservation policy formulated by the Uzbek Government in 2002.

III. CONCLUSION

The energy policy of the country can be presented in the form of various components of the policy such as geopolitical, economic, technical and social ones and the step by step principle of reforming has been used in its realization. Due to correct and balanced implementation of energy policy Uzbekistan has been able over a relatively short time to ensure the stable advancement of its vast fuel and power complex.

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V. BIOGRAPHY

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5. POWER INDUSTRY RESTRUCTURING IN CHINA (PAPER 06GM0327)

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***Abstract*—** China power industry is on the way to a deregulated electricity market since the industry restructuring in 2002. The integrated generation and transmission has been regrouped into five independent generation companies and two grid companies. The regional grid companies act as the system operators and exchange centers for the regional electricity markets. The customer side is still regulated by the government. In this paper, we will introduce the situation of China power industry restructuring. Some issues will be discussed for the current regional electricity markets, such as, electricity price policy, renewable energy policy, investment and planning issues.

***Index Terms*—** electricity market, electricity price, planning, renewable energy, power industry restructuring.

I. Introduction

Restructuring and reform of the traditional integrated power industry has been started all over the world for more than 10 years. In various deregulated power systems, the market structures, the degree of privatization and the sequence of reform stages are different. China has started the process of power industry restructuring since the late 1990s. In this paper, we will introduce the current situation of China power industry reform and will focus on the following issues: market structure, electricity price policy, investment and planning, renewable energy in the new market.

II. China Power Industry Structure and its Restructuring

China has been experiencing significant economic growth since 1980s. The electricity consumption increased more than three times due to the booming market and manufacture industry. At the end of 2004, the installed capacity in China has reached 440GW, and the annual generation has reached 2180TWh. Both installed capacity and generation are ranked the second highest in the world. Within the 440GW, the proportions of thermal units, hydro station, nuclear and wind power are 73.7%, 24.5%, 1.6% and 0.17 %, respectively [1]..

A. Power Industry Restructuring

In February 2002, the State Department issued the Power Industry Structure Reformation Program. The program includes three main points: 1) Restructure state-owned generation assets, and establish several independent generation companies; 2) Restructure transmission assets, and establish two grid companies; 3) Establish State Electricity Regulatory Commission (SERC) to monitor and regulate the electricity markets.

On the 29th of December 2002, two grid companies, State Grid Company and South

China Grid Company were established. The State Grid Company has five subsidiary regional grid companies. They are North China Regional Grid, North East China Regional Grid, Central China Regional Grid, East China Regional Grid and North West China Regional Grid. The geographical areas of the regional grids are shown in Figure 1.

Fig. 1. China Regional Grids

On the same day, five independent generation companies were established. They are:

- China Huaneng Group,
- China Datang Corporation,
- China Huadian Corporation,
- China Guodian Corporation, and
- China Power Investment Corporation.

The installed capacities of the five generation companies are given in Table I. Each of the five generation groups have a certain amount of share of any local market [2]. After the restructuring of generation assets, the State Grid and South China Grid own 24.5GW generation capacity, of which, 15.9GW capacity is used for frequency regulation and load following to ensure the reliable system operation [1]..

The installed capacities owned directly by the two grid companies and all regional grid companies in 2004 are given in Table II. The total generations of all grids in February 2005 are given in Table III [3].

Table I. Installed Capacities of the Five Generation Companies in 2002

	Capacity (Gwh)
China Huaneng Group	40.98
China Datang Co.	4.95

China Huadian Co.	8.64
China Guodian Co.	29.30
China Power Investment Co.	27.96

Table II. Installed Capacity in Each Grid Company at the End of 2004

		Thermal Capacity (GW)	Hydro Capacity (GW)	Total Installed Capacity (GW)
State Grid	Own by State Grid	9.8	2.1	7.7
	North China Grid	77	74.5	2.5
	North East Grid	41.5	35.9	5.6
	East China Grid	78	64.4	11.6
	Central China Grid	65.4	41.9	23.5
	North West Grid	27.1	18.8	8.3
South China Grid				80.3

Table III. Generations of All Grid Companies in February of 2005

	Generation (Twh)	Increase Rate (%)
North China Regional Grid	32.6	5.67
North East Regional Grid	15.4	2.21
East China Regional Grid	30.3	1.62
Central China Regional Grid	22.9	6.45
North West Regional Grid	10.2	13.7
South China Grid	17.5	1.16

B. Regional Electricity Markets

The structure of China electricity market is a regional electricity market based on regional grids. The first regional market, North East electricity market, started generation auctions in January 2004. Four months later, East China regional market started its market operation [4]. The market participants of a regional electricity market are power system operation and exchange center, grid company, the five generation companies and local provincial generation companies. The regional regulator commissions monitor and regulate the operation of regional markets. At the current stage, the system operation and exchange center is the single buyer of the market. The market settlement mode is Pay-as-bid. Single buyer model has been used in many countries as a transition stage toward competitive market.

In the energy markets, generators provide long-term offers and short-term offers in the auction market. Long-term offers include annual transaction offers and monthly transaction offers. Short-term day-ahead spot market will be established in the next stage of the regional markets.

Ancillary services, such as reserve, frequency regulation and voltage support, are provided by some hydro plants owned by the grid companies. Some compensation mechanisms have been applied for the ancillary services provided by the units owned by the generation companies.

The mid-term goals of China regional electricity markets are: establish ancillary service markets; run day-ahead spot markets; consider unit emission criteria in the auction markets; start bilateral contract markets and generation right markets. The long-term goals are: open customer-side markets, establish financial markets, such as, futures, forward and option markets.

III. Electricity Price Policy

The electricity price policy plays an important role in China power industry reformation. In May 2005, the National Development and Reformation Commission (NDRC) issued three regulations about electricity prices, Generation Price Regulation, Transmission and Distribution Price Regulation, and Customer Electricity Price Regulation [5].

A. Generation Price

Generation price is composed by capacity price and energy price. Energy price represents the variable costs of a power plant. The price is obtained by competition through regional auction markets. It is the price for a certain amount of power during a time period. Generators can submit 3-segment offers or 5-segment offers depending on the market regulations. In some regional markets, the regional grid company provides a reference energy price for each provincial generation company.

Capacity price represents the fixed costs of a power plant. It can be calculated as following:

capacity price = capacity payment / installed capacity.

Capacity price is determined by the installed capacity of the plant and the capacity payment, which is decided by the NDRC from time to time according to the power supply and demand of the time. The purpose of utilizing capacity price is to guarantee the basic benefits for power plants. The ratio of capacity price and energy price can reflect the degree of competition in a market. The higher percentage the energy price in a generation price, the higher competitive level the market is. In one of the regional markets, the capacity price vs. energy price can roughly be 1: [2~3].

Electricity price reformation in one of the core parts of power system deregulation. Price reformation will be accomplished gradually in a longer term in China. The current two-part generation price is a transition pricing mechanism towards completely competitive electricity market.

B. Transmission and Distribution Price

In the Transmission and Distribution Price Regulation issued by NDRC, the T&D price is composed by transmission price, ancillary service price, and special service price. Transmission price covers the network expansion and maintenance costs. Ancillary

service fee is paid for the regional grid companies for their provision of ancillary services, such as, reserve, frequency control, voltage control, black start, *etc*. Grid companies use grid-owned units to provide such ancillary services. The special service prices are charged to market participants that require special services from the grid company. Such as, connect to the network, build a transmission line for a special project, etc. The transmission and distribution prices are decided by the government and NDRC.

C. Customer Price

Electricity price for customer is regulated and decided by NDRC. Customer prices can be classified into three categories: residential customer price, industry customer price and agriculture customer price.

D. Electricity Price Interlink with Coal Price

Most areas of China have experienced a high increase of electricity consumption in 2003, and one third of the provinces are suffering power shortages [2]. In some areas, electricity demands are higher than power supplies. System operators sometimes have to shed load to balance the power demands. On the other hand, the fossil-fuel price goes up dramatically at the time. Around 74% of installed capacities in China are fossil-fuel thermal plants. The high coal price limited the profits of power plants to the maximum extend.

In April 2005, NDRC announced a scheme to interlink electricity prices with coal prices. According to NDRC, customer side electricity prices can be adjusted with the change of coal prices. A few months later, the customer electricity prices in all provinces have increased from 0.95 to 3.99 cents (Chinese Cent) per kWh. The average electricity price of the whole country has increased 2.52 Cents per kWh [6]. This price increase is around 5%.

On the other hand, generation prices all over the country are also adjusted with the increased coal price. The generation prices of all provincial power companies increased from 0.33 to 3.1 cents per kWh. Other Independent Power Producers (IPPs) followed provincial power companies and increased their generation prices to keep up with the coal price increase [7].

At the current stage of power system restructuring, government and NDRC are on a leading position regulating electricity prices. Both transmission & distribution price and customer side electricity price are determined by the government and NDRC. Only generation prices can be partly decided by auction market.

IV. Renewable Energy Policy

In China power system, coal-fired thermal power plants dominate the electric power generations (around 74%). The generation costs and the electricity prices rely on coal prices to a certain extent. With the coal prices continuously going up in 2004 and 2005, the profits of most generation companies drop down. On the other hand, hydro generations are around 24% of the total generations. Renewable energy generation sources are not more than 1% of the total generations. The current renewable energy sources are mostly

small-scale wind turbines. The slow development of renewable energy was due to the lack of market regulations and pricing mechanisms for high-cost renewable energy entering electricity markets.

In February 2005, the Renewable Energy Act was issued by NDRC. The Act indicates that the renewable energy generation is encouraged by the government. The detailed regulations of the Act will be forced in January 2006. A proper renewable energy policy and a reasonable pricing mechanism would facilitate the development of renewable energy sources in China power system.

The renewable energy generations currently used in China are mainly solar energy and wind energy. The solar energy generation production has reached 230MW in 2005. Some of the solar energy generations are installed at the remote areas. In Shenzhen, a photovoltaic power station of 860kW has been interconnected to the transmission grid. It is estimated that the total solar generation production could reach 500MW in 2010.

The total installed capacity of wind power in 2005 is 500MW. Besides this, the wind turbine capacity is going up at an annual increase rate of 40%. The capacity is expected to reach 100GW in 2020, which will be around 10% of the total installed capacity of that year. Wind power and solar energy generations are the potential new generation sources in the future China power industry.

One of the factors that limit the development of renewable energy is the high production cost. The cost of renewable energy is much higher than that of the regular coal-fired generation. In China, the cost of small hydro generation is around 1.2 times of the cost of thermal generation; the cost of biomass generation is about 1.5 times, the cost of wind power is about 1.7 times, and the cost of photovoltaic generation is about 11-18 times [8]. The average generation price for traditional thermal sources is around ¥0.5/kWh, the cost of wind power is usually around ¥0.8/kWh and the cost of solar energy could me more than ¥5/kWh. Besides the high cost of renewable energy, the uncertainty of the renewable energy pricing mechanisms and the unclear of renewable energy policy also raised the investment risk. Investors are hesitated to invest in renewable energy generation unless they can see the benefits.

The Renewable Energy Act and its regulations provide detailed rules about interconnecting renewable energy units to the grids and the detailed generation prices for various types of renewable energy.

In the new regulations, renewable energy generation price is composed by two parts: government regulating price plus market auction price. The wind power generation price decided by the government is expected to be the fossil-fuel generation price plus ¥0.25 per kWh. The generation prices for photovoltaic might be classified into two categories: ¥3.2/kWh for those located at open areas and ¥3.4/kWh for those located in buildings. The prices for other renewable energies, such as biomass energy, are also stated in the regulations [1]. The government authorized renewable energy generation prices will insure the companies recover their generation costs and the return rate of investment.

To facilitate renewable energy generations, the government authorized some regulations as well as the regulating prices. In the Act, it has been explicitly stated that the future renewable energy policy will be a quota system. The grid companies must sign purchase contracts with renewable generation companies and buy all the contracted renewable energy generations in their grids as well as providing transmission services. On the customer side, the large customers are compulsory to pay for the shares of the renewable

energy allocated to them. The future regulations might fix a required proportion of the renewable energy in a grid. On the other hand, some preferential policies will be issued to encourage generation companies developing renewable energy sources. For examples, some perquisites might be provided for renewable energy, some funds are founded especially for renewable energy, providing tax reduction or low interest loan, etc.

In Shanghai, the government has started to execute the regulations on special generation prices and purchase prices for Green Power. The residential customers are required to buy Green Power at least 120kWh per year.

V. Investment and Planning

The electricity consumption in China is keeping on increasing in recent years. The total consumption in 2004 is 2.17PWh, which is a 15% increase of 2003. In 2005, the consumption increases for another 10% and reaches 2.4PWh. On the generation supply side, 50GW new generation capacity is installed in 2004, and 70GW new generation capacity is installed in 2005. However, it is still not easy for all investors to enter the market of generation investment. The five independent generation companies and local government owned generation companies play the dominant roles in generation investment, although the individual investors and overseas investors hope can hold a share in the investment market.

A. Investment

After the power industry restructuring, transmission and distribution are regulated by government. The generation side is deregulated, and independent power companies are able to participant generation side markets. Each generation investment project will be examined and discussed by the government before it is approved.

Currently, the state-owned generation assets are around 90%, and the other 10% are owned by private investors and overseas investors. Of the 90% state-owned assents, 35% are owned by the five generation companies (including the 40GW approved in 2004), and the other 65% are owned by the local government generation companies [9].

The generation investors in China are mainly in five categories:

- The former state-owned five generation companies.
- Some other state-owned companies.
- Local government owned generation companies. They own around 55GW capacities in total.
- Overseas investors. They own 37GW in total.
- Other private investors.

In the new generation investment projects, the state-owned generation companies still occupy a large share. For example, the 40GW generation capacities approved in 2004 are mostly invested by the five generation companies.

Overseas investment

At the end of 1980s, electrical consumption demands increase dramatically. To attract oversea capital investments to China generation market, China government has provided very high rate of return for overseas generation investments. The annual rate of return was as high as 15% - 20%. In some provinces, the local governments sign long-term contracts with investors. The contracts guarantee the generators can get fixed generation prices for a number of years. More than 30 overseas companies invested power plants in China. In 1997, their total capacity ever reached 14.5% of the total installed capacity of the country. In 1999, the government started to abolish the fixed high rate of return. Some of the investors don't see the high profits any more and withdrawed their investment from the market. The overseas generation investment reduced from 14.5% of 1997 to 7.5% of 2002.

B. Power System Planning

In the traditional integrated power system, planning is performed centrally. For some years, the power system planning has been under a situation that generation planning always leads transmission planning.

After the restructuring of power industry, the integrated power system has been separated into some generation companies, and some grid companies. Who will perform power system planning is still not clear. State Grid Company has the most possibility being authorized by the government to perform transmission network planning for the whole country grid. Each regional grid company is responsible for its' own regional gird expansion and planning. Generation companies are responsible for generation expansions. Where and what size to invest new generations are decided by the government and the State Grid Company. Generation companies bid for building new generation capacities. The government and NDRC examine and approve all the expansion projects.

VI. CHALLENGES

There are some issues need to be emphasized in the development of China power industry after the system restructuring [10].

- The structure of generation sources is not yet fully optimized. The proportion of fossil-fired generation sources is much higher compare to other clean renewable energy generation sources.
- The high proportion of generations relying on coals makes the electricity prices affected by coal prices significantly.
- The transmission network expansion and planning are lagging the generation expansion. How to perform generation planning and transmission planning after unbundled generation and transmission is an emerging issue.

The challenges to the industry and government in the restructured power system are from some sides. From the investment side, efficient policies would facilitate the investment in renewable energy sources and optimizing the generation source structure.

From the planning side, generation planning and transmission planning coordination is a big challenge for the unbundled system. An authorized body for power system planning might be a good option to solve the problem. From the development side, the current single-buyer regional electricity market is still a transient stage towards the competitive electricity market. Electricity market models in all countries and areas are various. Find the best electricity market model for China power system will be one of the goals for the future China power industry.

VII. Conclusions

In this paper, we introduced the regional electricity markets after the restructuring of China power industry in 2002. Some issues in the new market environment have been raised and discussed. The issues are electricity price, renewable energy, planning issues, *etc*.

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IX. Biographies

Jin Zhong (S'00, M'04) received her B.Sc. degree from Tsinghua University, Beijing, China, in 1995; the M. Sc. degree from EPRI, China, in 1998 and the Ph.D degree from Chalmers University of Technology, Gothenburg, Sweden, in 2003. At present, she is an assistant professor in the Department of Electrical and Electronic Engineering of the University of Hong Kong. Her areas of interest are electricity sector deregulation and ancillary service pricing.

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6. State-of-the-Art and Prospect of Power Industry Restructuring in China (Invited Discussion)

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PENDING

7. Feasible Power Exchange Model between the ROK, the DPRK and Russia

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***Abstract*--**This paper describes the feasible power exchange model on NEAREST(Northeast Asian Electrical System Ties) . It contains the feasible scenario in technical, economical and marketable viewpoints between Russia, the DPRK and the ROK. Power exchange between Russia, the DPRK and the ROK is a part of NEAREST, which is expected to become a reality within the near future, as it offers great economic benefits, and contributes to peace in this region. This paper specifies basic conclusions for feasibility study on power system interconnection between Russia, the DPRK and the ROK, considering future power industry and electricity balances in each country. It will address the technical, economic and marketable study results.

Index Terms -- power system interconnection, power exchange, electricity trading, NEAREST

I. INTRODUCTION

During the past 3-years, KERI performed the 1st NEAREST project on pre-feasibility study for power system interconnections between Northeast Asian countries. This project is sponsored by MOCIE (Ministry Of Commercial, Industry and Energy) and many domestic/foreign institutes take part in this project and discharge their inherent duty. Generally speaking, the ROK, the DPRK and Russia have the most powerful potential on power system interconnection when their status and future prospects are considered. These three countries have different situations and backgrounds on power system interconnection from technical, economic and political viewpoints. The ROK power system is an island, having been isolated from the DPRK network after 1948. Also, the ROK is very poor in natural resources and must import 97.4% of the total primary energy consumed domestically. Also, the ROK has difficulties relating to generation sites. Since the 1980s, the DPRK has suffered from a deficiency of electricity supply and wants to be supported by the ROK and Russia. After the summit between the ROK and the DPRK in 2000, the

DPRK has requested electricity support with a short-term capacity of 500MW, and a long-term of 2,000MW from the ROK government. Conversely, East Russia, FER (Far East Russia) and ES (East Siberia), have plenty of coal, gas and hydro resources and has plenty of power export potential. This paper specifies the reasonable power exchange model between the ROK, the DPRK and Russia based on the study results of 1st NEAREST project. It means the study results of pre-feasibility for power exchange between Russia, the DPRK and the ROK, considering future power industry and electricity balances in each country. It will address the technical, economic and marketable study results. As a conclusion, this paper expects the prospect of power exchange model considering future demand/surplus supply plans and exchangeable power in technical, economic ad marketable aspects.

II. INTERCONNECTION SCENARIOS FOR "RFE – DPRK - ROK"

Many scenarios on NEAREST have been published by various institutes as ESI, KERI, and others.[1-3] These scenarios include estimated rough parameters such as voltage level, capaci1and length. The basic contents and concepts covered by all these scenarios are quite similar with each other. NEAREST scenario draft is established in light of offering investigation subjects for detailed study on technical, economic and marketability assessment. After looking into various scenarios to interconnect between the ROK, the DPRK and Russia, we could propose four scenarios as described in <Table 1> and evaluate the basic characteristics, merits and demerits of each scenario. <Table 1> shows the basic assessment of each scenario. According to the detailed investigation results, factors of these draft scenarios are subject to be amended. The interconnected power system between ROK-SPRK-Russia can have various types according to the following factors and hypothesis:

- Whether or not the new power plants in the DPRK are included in NEAREST.
- DPRK territory only provides the interconnection path between Russia and the ROK or DPRK system or is included in NEAREST.
- Whether or not the "Vladivostok-Chungjin" local AC interconnected power system under discussion based on the separation with the DPRK full system will be realized in future, and the Chungjin load is re-connected to the DPRK system.

Besides these four scenarios, other scenarios, four example, (Scenario-5) which includes KEDO Nuclear Plant into NEAREST has meaningless at this stage as the construction of KEDO Nuclear Plant is stopped. After detailed study on detailed qualitative assessment, we can conclude that (Scenario-1) in <Fig. 1> can be the best reasonable scenario considering the technical, economic and marketable assessment and this could give the power exchange model with equal base in terms of investment, sharing of benefits and risks between 3-countries.

TABLE 1. OVERVIEW OF EACH SCENARIO

Items	(Scenario-1)	(Scenario-2)	(Scenario-3)	(Scenario-4)
	Base Case	DPRK :	Via the	Border BTB

		interconnection path	East Sea	
Power trading countries	RU-NK-SK	RU-SK	RU-SK	RU-NK-SK
No. of C/S	3	2	2	2
investment costs	Medium	Low	Medium	High
System operation	Difficult	Easy	Easy	Difficult
Energy security	Low	Medium	High	Low
ROK-DPRK cooperation	Positive	Negative	Negative	Medium

(RU: Russia, NK: DPRK, SK: ROK)

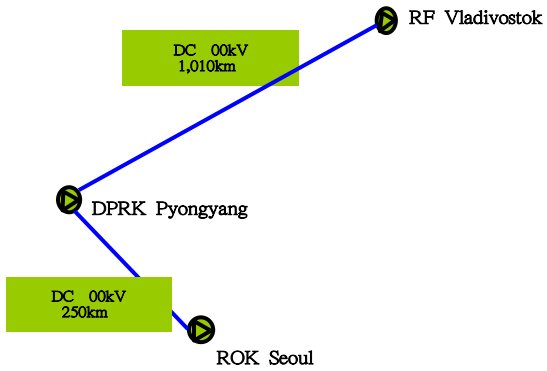

Fig. 1. Concept routes of (Scenario-1)

III. ADMISSIBLE INTERCONNECTED CAPACITY IN ECHNICAL/ECONOMIC VIEWPOINTS

A. Evaluation of maximum exchangeable Power

An evaluation of maximum exchangeable power was studied.[6-7]. It can be evaluated by taking into account the following technical aspects, such as ROW (Right of Way) and system constraints. ROW constraint means the geographical constraints that the interconnected line should pass through. Also, system constraints include technical problems, such as load flow and stability analysis. The study results of technical aspects in (Scenario-1) are as follows.

- ROW constraint: Considering the geographical situation between Russia and the Korean peninsula, a two-bipole system having a capacity of 7GW can be built.
- Load flow analysis: There are no violation of overload and voltage in a steady state up to 7GW of inflow power. However, in (N-1) contingency, some violations happen as the inflow power exceeds 4GW. Therefore, 4GW seems to be the maximum exchangeable power.

- Dynamic analysis: The power system frequency of the ROK can keep the standard when losing 2GW of power. However, loss of more than 3GW of power makes frequency violate the standard. Considering a one-bipole trip, 4GW is the maximum exchangeable power.
- Reliability analysis: We developed the NEAREL program to evaluate the composite system reliability index including generation and transmission system. As the analysis result of this NEAREL program on power system interconnection between ROK-DPRK-Russia, we conclude that in the case of more than 3GW, the reliability index is saturated. This means 3GW is reasonable on reliability viewpoints.

B. Evaluation of minimum exchangeable power

Minimum exchangeable power is evaluated through a comparison of total costs and benefits of the interconnected line during life cycle span of 30 years. The total costs consist of initial investment and operating costs. Initial investment means the construction cost of transmission lines and converter stations and operating costs includes the maintenance costs of transmission lines and converter stations. The benefit of interconnection comes from the electricity tariff difference between the ROK and Russia. The electricity tariff difference in 2000 was $0.0383/kWh, but this difference has been getting decreased because the annual rate of increase for electricity tariffs in Russia will be higher than that of the ROK. <Table 2> describes the total cost and benefits for (Scenario-1). In this table, we have shown that more than 2GW should be necessary in economic sense.

TABLE 2. TOTAL COST AND BENEFITS FOR (SCENARIO-1)

Exchange power	Cost (billion $)	Benefit (billion $)
1GW	4.13	3.16
2GW	6.60	6.33
3GW	7.82	9.49
4GW	10.56	12.65

C. Analysis results for feasible exchange Power

Table 3 describes the study result on maximum and minimum exchange power in technical and economic viewpoints between the ROK, the DPRK and Russia. In this table, we can know that 4GW of power exchange is the maximum exchangeable power from a technical viewpoint between Russia and the ROK at present status, and this result could satisfy the energy security points in Korean power system. Also, the minimum exchangeable power is about 1-3GW. Finally, we can say that the following conclusions considering technical and economic viewpoints, the reasonable exchange power is expected to 3-4GW.

- The range of 3GW to 4GW seems to be a reasonable power exchange level between ROK-DPRK-RF interconnection in 2010.
- To assure economic feasibility, more than 2GW is required
- The maximum exchange power is limited by system constraints and the exchangeable power can be increased through the reinforcements of ROK power system.

TABLE 3. MAX./MIN. EXCHANGE POWER CONSIDERING TECHNICAL/ECONOMIC VIEWPOINTS

Scenarios	Minimum exchange power	Maximum exchange power
Scenario-1	2GW	4GW
Scenario-2	2GW	4GW
Scenario-3	3GW	3GW
Scenario-4	1GW	4GW

IV. CONSIDERATIONS FOR MARKETABILITY ASSESSMENT

Fig. 2 describes the general feasible processing structure on power system interconnection. We have shown that all of the concerned countries related to power system interconnection should have an agreement on governmental level. Joint Venture of Transmission Company for financing, construction and finally operation the interconnected lines should be established by corporative investments of all concerned governments. This company will negotiate for financing with the international lenders, multilateral financial institutions such as WB and ADB. Under the guarantee of each concerned country, the Project Lenders can loan the investment costs on power system interconnection.

Maybe, it is too early to speak to this processing structure on power system interconnection in NEA region. Nevertheless, it is clear that future development of NEAREST project will have a positive influence on regional political peace and economic benefits. The more difficult challenge will be how to solve political issues among countries, especially with the DPRK and how to finance the project. The task for concerned countries will be to make acknowledgement of its importance and mutual benefits, and to create confidence within the nations and with international investors.

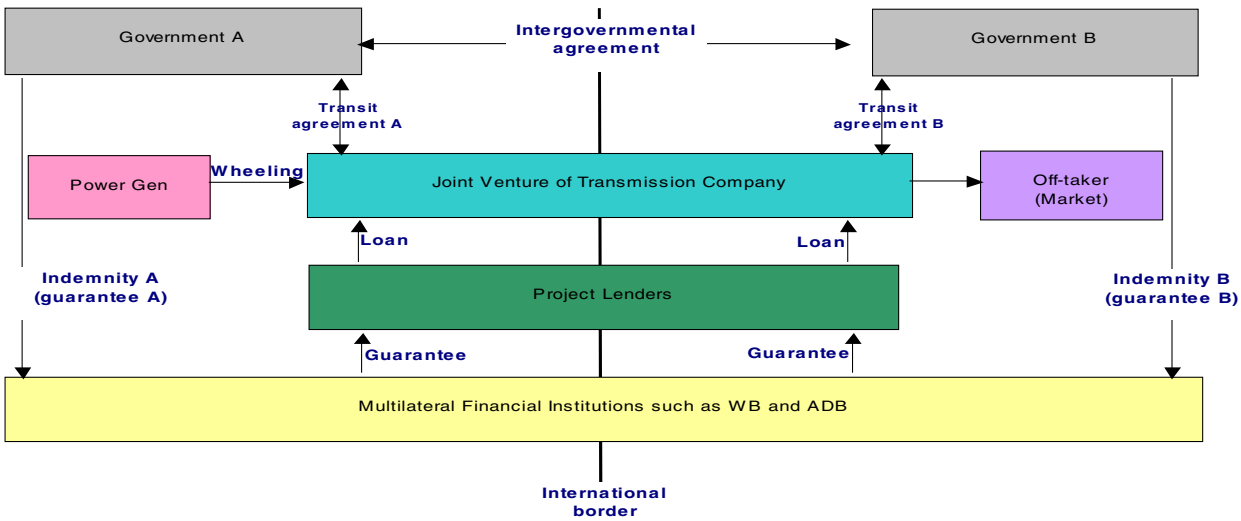

Fig. 2. Feasible Processing Structure for Power System Interconnection

If it turns out to be feasible on NEAREST in technical and economic viewpoints, we should consider the marketable assessment and find the obstacles in implementing the NEAREST project, and suggest the solutions to overcome these obstacles. We developed five issues on NEAREST marketable assessment and the study results at this stage are specified as follows.

1) Status and prospect of the NEA energy markets:

We reviewed the status/prospect of energy and electricity balance and this is specified in [9]. The DPTK now is suffered from serious electricity shortage, but, Russia has surplus energy resources and electricity. China will have very high increase rate in energy sector because of the rapid economic growth. The ROK and the DPRK should have relations and cooperative policy on energy sector, above all, in power industry.

2) Impacts of electric power industry restructuring:

This is to analyze the future directions on power industry of NEA countries and the status of restructuring. As a consequence, power industry restructuring of NEA countries have both positive and negative effects on power system interconnection. However, summing up overall effects, it turns out to be a positive point as it gives more and more competitive surroundings between GENCOs.

3) Legal and institutional issues in NEAREST

Describing the current legal and institutional issues on NEAREST, we have a conclusion various legal problems on power industry in each country exist and should be solved for the realization of NEAREST, especially for the DPRK case. By performing these legal and institutional efforts, we could overcome the obstacles on NEAREST.

4) Aspect of politics and energy security

We examined the mechanism of politics and energy security under the various scenarios depending on the DPRK political status between the ROK and the DPRK and finally concluded that it is beneficially the power system interconnection not only energy sector but also politics in both parties(the ROK and the DPRK).

5) Financing

The more difficult challenge will be how to solve political issues among countries, especially with the DPRK and how to finance the project. International power projects in general entail larger and more risks than domestic projects so that financing for international projects is more complicated and difficult. For securing funds for such project require that all project participants work to reduce/minimize those risks pertaining to each one. Reducing risk will be directly translated into improving the probability of securing finance for the project. In the case of involving the DPRK, we could suggest the corporative financing under the guarantee on governmental base is necessary. Maybe, we guess the general project base financing will be impossible because of the high political risk related to the DPRK.

V. FEASIBLE POWER EXCHANGE MODEL BETWEEN THE ROK, THE DPRK AND USSIA

Based on the above technical, economic and marketable assessments, we have a conclusion the feasible power exchange model between the ROK, the DPRK and RUSSIA.

1) In the case of interconnecting the power system between 3 countries, the necessary generation capacity is reduced and capacity factor is increased for all interconnection scenarios.
2) Feasible scenario on "ROK-DPRK-RF" inter-connection:
   - (Scenario-1) with 3 C/S located in Vladivostok, Pyongyang and Seoul is expected to be the best alternative.
   - 3-Terminal HVDC Interconnection, DC ±500kV
   - Interconnection capacity of 3GW~4GW is reasonable.
   - Average reliability index of all countries is greatly increased. But, ROK is slightly decreased in case of unidirectional supply from the ROK to the DPRK because of the severe electricity deficiency of DPRK. Of course, after DPRK status is stabilized, it is expected that the reliability index of the ROK also increase.
3) Market structure
   - At initial stage, CBT(Cross Boarder Trade) with contract base is reasonable, but, finally market base will be realized.
   - Deregulation of power industry has positive effect on CBT, regardless of the uncertainty of the DPRK.
   - Corporative financing under the guarantee on governmental base is necessary because of the DPRK risk.

VI. CONCLUSION

This paper specifies the future feasible power exchange model between the ROK, the DPRK and Russia from technical, economic and marketable viewpoints. The main results of this paper on this power system interconnection are as follows.

- Performing the power system interconnection between 3 countries, the necessary generation capacity will be reduced and capacity factor increased for all interconnection scenarios.
- (Scenario-1) with 3 C/S located in Vladivostok, Pyongyang and Seoul is expected to be the best alternative. The general design parameter with DC ±500kV and interconnection capacity of 3GW~4GW is reasonable.
- At initial stage, CBT (Cross Boarder Trade) with contract base is reasonable, but, finally market base will be realized. Corporative financing under the guarantee on governmental base is necessary because of the DPRK risk.

This study is based on a hypothesis and only research study results, not on practical engineering projects. Therefore, more detailed engineering work from the technical, economic and marketable viewpoints are required for the realization of NEAREST. Above all, we could not estimate the future prospect for the DPRK power system because we

have a problem to obtain the exact DPRK data and, consequently, the detailed accurate study results to DPRK system.

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8. The Globalization of Energy Markets in Asia

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Abstract— Energy market globalization brings significant benefits for producers and consumers, if the political will can be mustered to implement thoroughgoing, market oriented reforms. Experience in power trade zones in Europe and North America shows that to achieve the benefits of fully fledged trade, the countries in the subregion need to closely coordinate electricity sector policy, operating protocols, and network development. This Note sets out the market development options, reviews sector reforms so far, assesses the obstacles to full power trade, and briefly outlines multilateral efforts to promote an infrastructure that will support international power trade in the subregion. This paper presents the globalization of energy markets in Asia.

Index Terms – Energy markets, power trade, Asia

I. INTRODUCTION

Energy market globalization is deepening and broadening, not only through international trade but also through cross-investments, deregulation of domestic markets, and industrial restructuring that links the older energy industries to the new global political economy. This transformation of energy industries and markets is apparent around the world, and it offers great promise in terms of economic efficiency, technology development, and consumer choice.

The process of energy globalization is uneven, however, and some of its impacts will present new challenges for strategic planners. What new relationships are developing between producers and consumers, and between buyers and sellers? Who are the winners and losers? In a context of opening energy markets, why is there renewed concern about energy security around the world today? What types of security challenges will energy globalization present during the next two decades?

There are varying approaches to energy security in a context of market globalization. The United States supports market-oriented energy policies at home and abroad that open traditionally closed markets to new forms of competition and restructuring. Asia, a region where the United States has vast security stakes and where the most rapid increases in oil and gas imports are projected in the next two decades, deserves special attention. Policymakers in Asia and other countries worry that the market alone will not ensure energy security. The United States has generally pursued energy security on a different track, making Persian Gulf security a high priority.

To promote the cooperation and mutual interdependence that open energy markets require, it will be necessary to explore different approaches to energy security, analyze some of the unintended security risks that globalization of energy markets entails, and draw conclusions about the implications for U.S. security. Although the United States has already made large investments in Asian security, new multilateral approaches will be needed to pre-empt and mitigate the energy-related disruptions that may lie ahead. Defending the sea-lanes, to take an example, will be more important than ever in the future, but ensuring freedom of transit will require new multilateral efforts that cannot be simply subsumed under traditional alliances. Although the United States will have

adequate access to energy supplies, it may be drawn into energy-related disputes, as weak states fragment, and producers and others seek to exert political leverage via energy supplies and infrastructure. Despite the uncertainties and difficulties of multilateral initiatives, it will be necessary to use them to address myriad energy-related security problems that are likely to arise as unintended consequences of energy market globalization.
This paper presents the globalization of energy markets in Asia [1]-[9].

II. Energy Challenges in Northeast Asia

Recent Progress in Energy Integration in Northeast Asia

In the IEA [WJL1] programmes, Northeast Asia, Fig. 1, includes Northeast China (Heilongjiang, Liaoning and Jilin Provinces), East Siberia and the Far East of Russia (mainly Sakhalin Islands and Saha Republic), Mongolia, and Democratic People's Republic of Korea (DPRK). These countries and areas form a unique region in terms of energy supply lines together with Japan and Korea.

Fig. 1 The potential Northeast Asia Power Market

Recently, there has been increasing interest to integrate this area with various cross-border energy development projects and, in fact, several regional and international organisations have begun to put in serious effort to tackle this issue. Since June 2000, the United Nations Development Plan (UNDP) has held the international program called TRADP (Tumen River
Area Development Program) among five Northeast Asian countries - China, Russia, Mongolia, Korea and DPRK- and organized annual meetings among the National Coordinators to discuss the cooperative work in energy, trade and investment, transportation, telecommunication and tourism. The UNDP is providing administrative

and consultancy service for this series of meetings, and the IEA was invited to become a collaborating organization in the energy part of this program.

In June, 2001, an international symposium on Northeast Asian energy cooperation was held in Seoul jointly by UN/ESCAP (United Nations Economic and Social Commission for Asia and the Pacific), KEEI (Korea Energy Economics Institute), and IEEJ (The Institute of Energy Economics, Japan). In this conference, a necessity to build an inter-governmental communication channel was suggested. Based on this discussion, a senior government officials meeting among Russia, Mongolia, Korea and DPRK was held in Vladivostok on 8-10 April 2005?. The IEA was invited as a guest speaker to share the Member countries' experience in energy trade with Russia. A second session of this senior officials meeting is scheduled in November 2005?.

In addition to the internal energy cooperation within the Northeast Asian region, the cooperation between ASEAN and Northeast Asian countries is getting stronger. Since the ten member states of ASEAN have limited resources to nourish their own economic development, the partnerships with Japan, China and Korea have great significance. In this case, a collaborative relationship with ASEAN+3 can even benefit DPRK, Mongolia and Far-East Russia as well. There have been continuous talks and meetings since 1999 among these countries not only on energy cooperation but also all possible economic partnerships. These efforts were accelerated by ASEAN+3 Summits and will have substantial impacts on energy security of Northeast Asian region.

Considering that the Northeast Asian region accounts for more than one fifth of the world's energy consumption and is expected to account for one-third of the world's total energy demand increase over the next 20 years, it is certain that the energy integration of this region will have a significant impact on the world energy security. This is good grounds for IEA Secretariat attention to the energy development in this area.

The On-going Energy Integration Projects in Northeast Asia

One of the distinguishing features of Northeast Asia is that, in spite of both the immense energy demand and abundant energy resources that exist in the region, the region remains segregated. On the demand side, the most critical issue of the three major energy importing countries- Japan, China, and Korea- is their high dependency on imported oil, especially from the Middle East. Therefore, the common denominator for these large energy consuming countries is the diversification of the energy sources, i.e., the need to shift from oil to other energy resources such as natural gas and renewable, and to move from Middle East towards other energy suppliers for their energy imports.

On the supply side, the energy reserves in the eastern region of Russia are crucial to Northeast Asia. To date, most discussions of Russian energy have focused on its exports to Europe, but in the last five years, Russia's interest in developing energy relations with its eastern neighbours and potential energy partners has grown. The main reason for this "Russia East" policy is to exploit the abundant natural gas and oil resources in the east of Russia such as Sakhalin Island, Yakutsk, and Irkutsk near Lake Baikal, which could supply Northeast Asia and even the whole Asia-Pacific market.

Under these circumstances and in order to ensure energy security in the region, there have been many private sector efforts to connect these abundant energy resources with the demanding countries. The following are the major ongoing projects and plans in this region. Some of these initiatives are progressing more actively than others and bear a close review.

III. DEVELOPING INTERNATIONAL POWER MARKETS IN EAST ASIA

The Greater Mekong subregion, Fig. 2, Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Vietnam, and the Yunnan Province of southern China—has significant potential for cross-border power trade. The subregion is well endowed with low-cost hydro resources—the Mekong River Basin is the world's twelfth largest river system—and China, Lao PDR, Thailand and Vietnam have large coal and natural gas reserves. The potential for trade stems from imbalances in costs and in supply and demand between countries in close proximity: the low cost hydro potential is in Lao PDR, Myanmar, and Yunnan Province, but the main markets are Thailand and the more distant Malaysia-Singapore grid about 1,000 kilometers away.

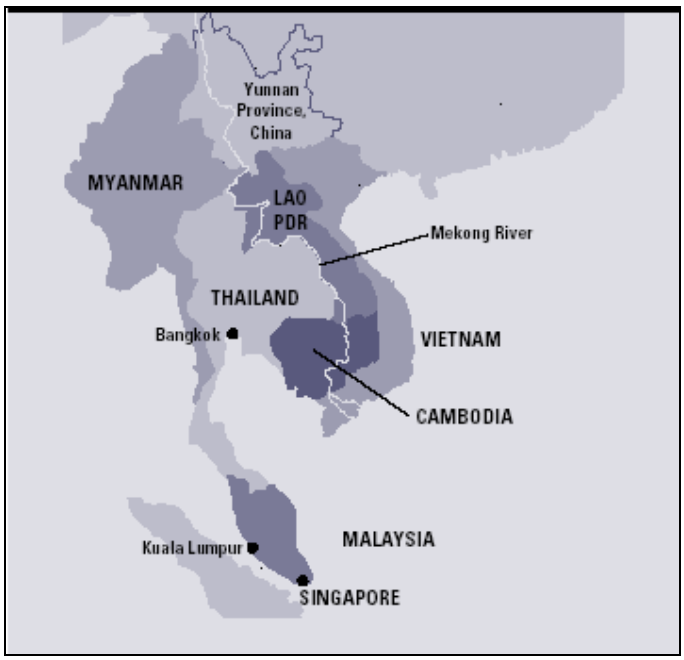

Fig. 2 The potential East Asian Power Market

Recent studies comparing scenarios of electricity self-sufficiency in each country with a full trade scenario show that full trade could yield cost savings of at least US$10.4

billion in 2001–20 and a reduction of airborne pollutants valued at US$160 million a year. (These estimates assume a significant
slowing in power demand over the next few years in Thailand as a result of the current financial crisis.) The savings would arise from:

- Lower operating costs due to economic power exchange, postponed and lower investments in generation due to least-cost development of regional energy resources, and reduced spinning reserve costs.
- Lower coincident peak load (compared with the sum of individual peak loads), mutual access to generation reserves for interconnected systems, a more robust power supply to meet such unexpected events as load growth above forecast or delayed commissioning of generation and transmission projects, and increased system reliability.
- Lower greenhouse gas emissions and other pollutants, largely due to a shift from thermal to hydro generation in the long term.

There is growing interest in cross-border bilateral power trade in the subregion, spearheaded by private developers in Lao PDR selling power to Thailand. The government of Thailand has agreed to buy 3,000 megawatts from these private power developers by 2006, and several independent power producer (IPP) projects are moving ahead. China's Ministry of Electric Power is encouraging studies of the export potential of Yunnan's planned Jing Hong hydropower plant and associated transmission lines to Thailand, through Lao PDR, with the support of the Lao and Thai governments. The Vietnam and Lao governments have signed a memorandum of understanding on purchases of about 2,000 megawatts of power by 2010.

IV. ENERGY MARKET GLOBALIZATION

Does it matter that globalization is unfolding unevenly and that policy priorities for enhancing energy security are defined differently in the United States, Europe, and Asia? Traditionally, analysts have focused on the potential for military conflict over energy resources as the primary threat. Extrapolating 20 years ahead, based on consensus supply-and-demand projections that show sharp increases in Asia's energy requirements, a number of energy-related issues are likely to generate new types of problems and unintended consequences associated with deepening globalization. To the extent that globalized energy markets more deeply integrate economies in the region, of course, investment resources, entrepreneurial skills, and experience in governance will be available to mitigate the downsides. At the same time, U.S. officials responsible for security as well as for economic policy need to anticipate problems—many of them unintended consequences of globalization—that they may be required to address. Focusing on Asia, where there is no overarching, institutionalized security framework and where energy market globalization offers perhaps the biggest uncertainties as well as great promise, brings potential problems into sharper view.

Among the countries of the Asia-Pacific Economic Cooperation (APEC) group, electricity demand is projected to increase 60 percent by 2010, with China's electricity demand likely increasing by almost 6.4 percent annually. In India, the International Energy Agency (IEA) forecasts that electricity consumption will be more than double

between 1995 and 2010. These forecasts (revised after the Asian economic downturn) imply major additions to generating capacity and to grids. Coal will likely continue to play the major role in electric power generation, but substantial increases in gas-fired generation are expected. Asia now has only limited intercountry electricity trade and pipeline systems. A number of countries, China in particular, have substantial energy resources located far from industrial and population centers.

Most of developing Asia is part of the global energy system, but because of inadequate investment in infrastructure as well as weak political leadership, the connections are in some cases tenuous. Rapid population growth and pressures for economic restructuring and deregulation have already produced some wrenching changes. Twenty thousand miners rioted in Northeast China in early 2000 after an announcement that a large mine had gone bankrupt, and workers were offered a one-time severance package equal to $68 per working year. The army was brought in to restore order, but the incident was not reported in the press for weeks. Industrial unrest is rising in China's resources sector, where inefficient plants must be closed in line with government restructuring plans and ambitions to enter the World Trade Organization.

Russia exemplifies another type of political complication associated with market integration. In Russia, the country with the world's largest natural gas reserves, a good portion of which are located in the Far East, there are frequent blackouts. Gazprom cut gas supplies to RAO Unified Energy Systems (UES) recently in response to nonpayment. Gazprom is not investing enough to keep its gas flowing, and UES has warned that its old network of power stations and lines needs $75 billion in investment if Russia is to avoid blackouts. Europeans and Asians hoping to import more Russian gas are rightly concerned about supply security in light of Russia's status as a nonsignatory of the energy charter, which includes transit provisions.

These examples illustrate the potential political fallout when energy market globalization occurs in developing and transitional economies that lack experience with market competition. As markets and infrastructure are connected across national borders, fuel substitution and economic benefits accrue. At the same time, new vulnerabilities are created. Energy infrastructure such as power grids can be the target of terrorists and opposition groups. These concerns are not unique to developing countries, of course. The President's Critical Infrastructure Commission has outlined serious threats to the U.S. energy system from a number of sources—including hostile governments, terrorist groups, and disgruntled employees—as well as accidents.

For some groups in developing economies, the sharp changes in fortune that accompany restructuring and global energy market integration can create a political backlash that threatens the security of neighbors who buy energy from them or import it through their territories. Intense discussions are now under way in Northeast Asia about cooperation in pipelines and high-voltage transmission lines extending from Russia into China. According to some estimates, Eastern Russia could supply half of Northeast Asia's natural gas needs by 2020. These projects offer great promise in meeting energy demand and in hands-on cooperation among countries that have been historical competitors and enemies. The United States and countries in the region need to discuss the security implications of growing and asymmetrical interdependence, however, at an early stage. Joint planning and scenario analysis involving government as well as private sector organizations will be needed to anticipate and mitigate risks. The United States could lend support for discussions involving public officials and private sector representatives from Japan and South Korea, but Russia and China also need to be involved. In addition to

high-level discussions on rules of the road for cooperative energy development, there is a need for joint efforts among environmental experts to assess potential effects, among regulatory authorities to discuss harmonization of equipment and industrial standards, and among legal experts to clarify issues such as transit rights and reciprocal tax treatment.

In developing Asia, where energy market integration is uneven, energy demand will grow sharply; because the infrastructure is inadequate and vulnerable, securityrelated problems are likely to grow. Attacks on energy infrastructure in friendly nations could lead to requests for U.S. assistance—both official and private. U.S. cooperation in the APEC and other regional initiatives to promote common standards and shared infrastructure are, in this light, a good investment. Although U.S. support for APEC energy market liberalization initiatives has been strong, energy security concerns have been treated with less urgency. U.S. industry and government could make this a higher priority and share expertise for assessing and mitigating risks.

A second dimension of uneven globalization—Asia's growing dependence on Middle East oil—also will present new challenges. The United States has made great investments in Persian Gulf security and has gone to war to ensure the stability of the region and its oil production. In the future, the narrow, shallow Straits of Malacca and the sea-lanes between the Middle East and Asia will be more congested with tankers
and other ships carrying fuel and commodities. Today, 90 percent of Japan's oil imports and most of South Korea's and Taiwan's oil imports flow through these waters. More than 200 vessels pass through the Malacca, Sundra, and Lombok Straits and the South China Sea daily. In 1994, more than $1 trillion in international trade passed through these waters, which have seen an increase in serious accidents since the early 1990s. Piracy, kidnapping, and other acts of violence by nonstate actors, such as leftwing rebels in the Philippines, are also on the rise. China has fortified small islets in the South China Sea with fort-like structures, and the number of incidents involving fishing and naval vessels from Southeast Asian countries has increased.

Although some argue that territorial chokepoints such as these narrow water passageways are no longer security concerns in an age of globally integrated electronic markets that permit rerouting of cargo and fuel switching, securing freedom of the sea-lanes may well be more of a security challenge in the future. Competing claims among six claimants to the Spratly Islands, differing interpretations of the United Nations Law of the Sea, and the inability of the International Maritime Organization to establish safety and environmental standards of sufficiently high quality all contribute to a sort of maritime anarchy. At the urging of the Philippines and other Southeast Asian states, the Association of Southeast Asian Nations (ASEAN) Regional Forum has agreed to take up the question of a code of conduct for the South China Sea; however, China opposes legally binding agreements and prefers to deal separately with each country. Other countries favor demilitarization and joint development, with the geographically closest claimant country taking stewardship over disputed areas. In this context, the potential for military conflict remains significant. By supporting efforts of regional states to address these issues, the United States can add momentum and expertise.

In the future, accidents and acts of terrorism and piracy will be even more likely throughout the region. Some have called for a change in the transit passage law enshrined by the Law of the Sea separating commercial and military traffic. The objective would be increased regulation of commercial vessels in the Straits of Malacca to ensure navigation safety without affecting military or government vessels. Such a regime would involve not only the key states but also shipping concerns and user states such as Japan, China, and

the United States. Another approach has been led by a working group on maritime security cooperation of the Council for Security Cooperation in the Asia Pacific, a nonofficial organization that provides input to the ASEAN Regional Forum. The working group has developed guidelines for maritime cooperation and plans to examine the Law of the Sea to identify areas that need clarification in order to ensure maritime security in South Asia. These efforts suggest that addressing maritime security problems in Asia will be a challenging task, but arguably a good investment in preventive diplomacy. Cleaning up after a major oil spill and relief efforts to deal with terrorism or piracy could be much more costly after the fact.

Another way to address vulnerabilities in energy transportation through the sealanes is to develop regional emergency response mechanisms. Japan, Australia, and New Zealand [WJL1] are the only Asian members of the IEA, although South Korea is following IEA activities closely, and programs for nonmember states such as China have recently expanded. Asia lacks a viable regionwide program of emergency response or oil stockpiles. Although the impulse is strong for many of the Asian countries to pursue old-style resource diplomacy to secure supplies of Middle East oil, a more effective approach would be to build cooperative emergency response measures.

Market-oriented approaches can also contribute to solutions. Asian countries could permit cross-investment in downstream facilities so that refinery operations could be streamlined and efficiencies improved, encouraging Middle East countries to consider establishing storage facilities in the region. In addition, government involvement in emergency response and stockpile development is needed. American political support, technical expertise, and approvals to use international development assistance funding would help significantly in addressing energy security concerns in Asia and in bolstering the confidence and mutual trust required to sustain energy market liberalization policies over the long haul.

International corporate linkages in Asian energy markets are most extensive in the upstream resource exploration and development areas. Japanese firms have for years been mining coal in Australia, developing natural gas resources in Indonesia, and purchasing oil from China. With greater openness come new possibilities. Tokyo Electric Power has stakes in new power-generating ventures in Malaysia and Vietnam. Enron has teamed up with ORIX Leasing to compete in Japan's energy services and electric power markets. Marubeni, a Japanese trading company, and Sithe Energies, an independent U.S. power producer, plan to buy power plants and market electricity in Japan. Gas and electric power are the focus of networks of growing international joint ventures that include firms from many Asian countries, as well as from the United States.

These corporate linkages today extend further and deeper into the domestic economies and, in some cases, can stimulate market-oriented corporate restructuring and advanced technology development. They can also lead to new security challenges. In 1996, Japan imported almost one-fifth of its natural gas from Indonesia, a country where violent independence movements have threatened central authority in some regions. Electric power, gas, and steel companies have long-term contracts for liquefied natural gas (LNG) imports from Indonesia that stretch more than a decade ahead in some cases. Two-fifths of Indonesia's LNG exports come from Aceh, at the western end of Sumatra. Aceh is overwhelmingly Islamic; its rural people resent the wealth of the Javanese who run the industrial enclave. Disputes and violence have erupted. The potential fragmentation of energy- and resource-rich regions poses problems not only for central government but also for the importers whose investments become vulnerabilities. The United States, Japan, and

others have an interest in developing multilateral approaches toward assistance that leverage the resources of the international community and address the basic grievances that have led to strife and tension.

Advanced technology is diffusing through energy development, presenting another double-edged sword from a security perspective. Japan, South Korea, Russia, China, Taiwan, India, and Pakistan have commercial nuclear power programs, and four of these states have tested and/or developed nuclear weapons. For Japan, nuclear power has been the central pillar of its energy policy—seen as Japan's only hope for gaining a degree of autonomous control (through technology indigenization) and for meeting environmental commitments. However, the serious criticality accident that took place recently at a fuel fabrication plant shook Japan's energy policy leadership enough for the government to announce a comprehensive review. Japan's ambitious plan to develop the complete fuel cycle has proved to be expensive and technically difficult. Such problems aside, Asia has become the new center of gravity for the
global nuclear industry, as additions to capacity in this region are projected to make up three-quarters or more of the world's total over the next two decades.

For safety, environmental, and nonproliferation reasons, advanced technology cooperation in energy among Asian nations is essential. Working with other nations around the world, the industrial operators and research institutions of Asia need to develop a stronger safety culture. In addition, governments will need to work to strengthen nonproliferation norms (a very difficult task in South Asia) and to build cooperation in material protection, accounting, and export controls. Weapons of mass destruction proliferation is clearly a major threat to the stability of a region where the security framework is weak. Two of the benefits of addressing the North Korea problem have been an expansion of security cooperation between Japan and South Korea and a broadening of dialogue involving China.

Other forms of cooperation are also needed to make the most of new technologies that are coming on stream. They include microturbines and fuel-efficient vehicles that offer promise not only for industrialized countries but also for many developing nations. Regulatory barriers, as well as established business practices, may present obstacles to the application of new equipment and systems. Government leadership in eliminating regulatory obstacles and in supporting international partnerships could speed up penetration and assimilation of technologies—with environmental gains for all concerned.

V. CONCLUSIONS

As energy market globalization proceeds in Asia, the likelihood that the United States will be forced to deal with threats that stem from unintended consequences will increase. Multiple actors will be involved, and solutions will in most cases need to be constructed—at least in the near term—in the absence of established frameworks and institutions.

The potential security risks stem in large part from the unintended consequences of uneven globalization in a context of partial market liberalization. In the current transitional phase, critical choices are being made about financial investments, partnerships, technology development, and fuels that will affect evolving and multidimensional interdependent relations among actors. Addressing energy security concerns, rather than dismissing them, is a requirement for promoting marketoriented policies.

In this fluid context, the United States should take pre-emptive action, investing resources in preventive diplomacy and building security communities on specific issues in order to avoid the need for military force deployment down the road. Despite the uncertainties and inadequacies of multilateral approaches, there is really no alternative. The investments will be costly (not so much in terms of hardware, but in terms of time) and will challenge the skills of strategists trained to deal with more traditional security threats. Security specialists will need to work more closely with economic policymakers and the private sector, bridging the traditional separation between security and economic policy domains.

Asia offers the most striking example of both the potential risks of neglecting these issues and the tremendous gains that can come from devising new ways to address the concrete problem of energy security. China and India, the emerging new energy giants, will need assistance in meeting energy requirements and addressing concerns about energy security—if they are to contribute to, rather than detract from, Asian security. The United States will need to work proactively with them and with other countries in the region, forming new communities to deal with specific energy security concerns. In many cases, doing so will require focused dialogue not only with close allies and friends but also with other countries. Issues that require attention include disputes over energy-rich areas such as the South China Sea, the absence of an emergency response program in Asia to deal with oil supply interruptions, and the need for cooperation in resource development and efficient and environmentally sound energy use in the Russian Far East and China, as well as the potential for expanded energy cooperation involving South and North Korea, if progress continues in building trust and reducing threats on the Korean Peninsula.

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VIII. BIOGRAPHIES

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9. Restructuring of the Electric Power Industry and the Current State of the Power Market in Japan

Ikuo Kurihara, ***Senior Member, IEEE***

***Abstract*--** Restructuring of the Japanese electric power industry has been carried out in stages, and in April 2005 a third-step deregulation measure was implemented to expand the scope of liberalization of electricity retailing, allowing non-utility power producers to supply electricity to all high-voltage service customers in the retail market, excluding residential customers and small factories. At the same time, a neutral body tasked with securing impartiality in the use of utility power grids and an electric power exchange started operations.

Although it is still too early to draw a firm conclusion about the benefits of the restructured electric power industry, electricity rates, one of the important measures of the implications of restructuring, have dropped significantly. Electricity transactions on the electric power exchange have also been growing in volume gradually over time. The results of institutional reforms to date are now being assessed in order to start discussion in 2007 on the complete liberalization of the retail market to include all customers.

Index Terms - Restructuring, Power Industry, Neutral Agency, Power Exchange, Evaluation

I. INTRODUCTION

The restructuring plan for the Japanese electric utility industry has first focused on the major objective of lowering electricity rates, which are rather expensive by international standards, to levels comparable to those prevailing in foreign countries. However, the plan has called for achieving this objective through competition while also addressing public-interest issues such as environmental protection, with due consideration of the conditions specific to Japan, such as the nation's current heavy dependence on imported resources (Figure 1). Institutional reforms have therefore been pushed forward in accordance with the Basic Law on Energy Policy Making. A Japanese-style electricity deregulation model designed to secure fair competition while retaining the integrated power generation/transmission/distribution regime has been created, with the existing electric power companies playing a central role in working to promote the public interest.

The Japanese electric power industry is being restructured in stages as described later. In the stage begun in April 2005, just over 60 percent of the retail electricity market was opened up, while basic mechanisms for the Japanese-style deregulation model, such as a neutral body and an electric power exchange, were put in place. Although it is still too early to judge the results of the restructuring, some appreciable benefits such as lower electricity rates have already been achieved. In fiscal 2007, discussion will commence on progressing toward complete retail deregulation. In order to provide inputs for this discussion, the efforts made so far to restructure the electric power industry are now being

assessed.

This paper reviews the progress of restructuring and discusses the characteristics of the adopted Japanese-style electricity deregulation model. It then assesses and verifies the ongoing power industry restructuring plan and reports on the results of the industry restructuring efforts.

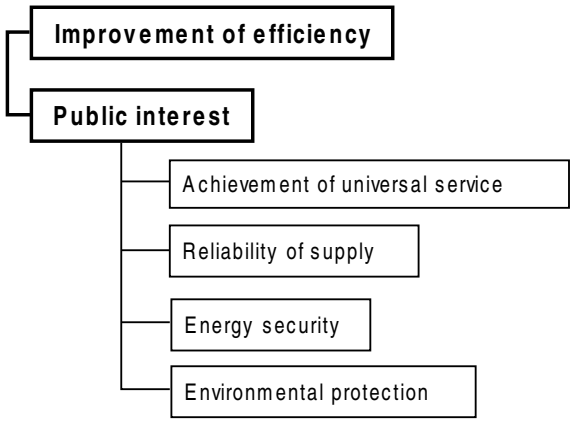

Fig. 1 Basic principle of the restructuring

II. PROGRESS IN THE RESTRUCTURING OF THE JAPANESE ELECTRIC POWER INDUSTRY

The restructuring plan for the Japanese electric power industry has made slow but steady progress through three broadly divided steps. The major milestones in these steps are as follows:

- **1st Step: 1995**
  - Liberalization of access to wholesale electricity industry (entry by IPPs)
  - Introduction of a wholesale power supply bidding system
  - Institutionalization of a retail electricity business at specified points of supply (Special electricity industry).

- **2nd Step: 2000**
  - Liberalization of retail electricity sales to extra high voltage customers (customers receiving electricity at 20 kV and with contract power of 2,000 kW or more). Newcomers with power generating facilities are referred to as *Power Producers and Suppliers* (PPSs)

- **3rd Step: 2005**
  - Liberalization of retail electricity sales to high voltage customers (customers with contract power of 50 kW or more)
  - Establishment of a neutral body, the *Electric Power System Council of Japan* (ESCJ)
  - Establishment of the *Japan Electric Power Exchange* (JEPX)
  - Elimination of pancake rates

- Revision of the balancing rule (the imbalance system)

In Japan, as mentioned earlier, in order to fully consider the characteristics of electricity and perform public welfare tasks, an electricity deregulation model designed to achieve structural reforms within the framework of electric power companies' integrated power generation and transmission system has been adopted, instead of the vertically unbundled electric utility model prevailing in the United States and European countries. The changes made in the third step are described in more detail as these represent the salient features of Japan's structural reforms.

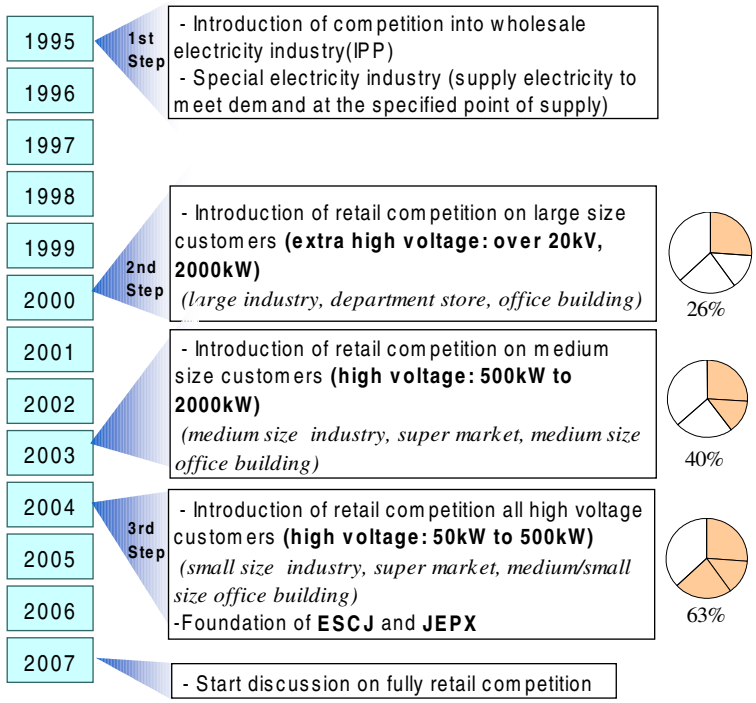

Fig. 2 Steps of the restructuring

III. OUTLINE OF THE INSTITUTIONAL REVISIONS EFFECTIVE IN 2005

Figure 3 outlines the institutional revisions made since April 2005. The main measures implemented include:

1) Establishment of a neutral organization and the enforcement of activity regulations in order to secure fairness and transparency in the network sector within the integrated power generation/transmission framework
2) Creation of the Japan Electric Power Exchange
3) Expansion of the retail electricity deregulation to cover all high voltage customers
4) Elimination of the pancake rate system in order to facilitate the use of power grids across the country

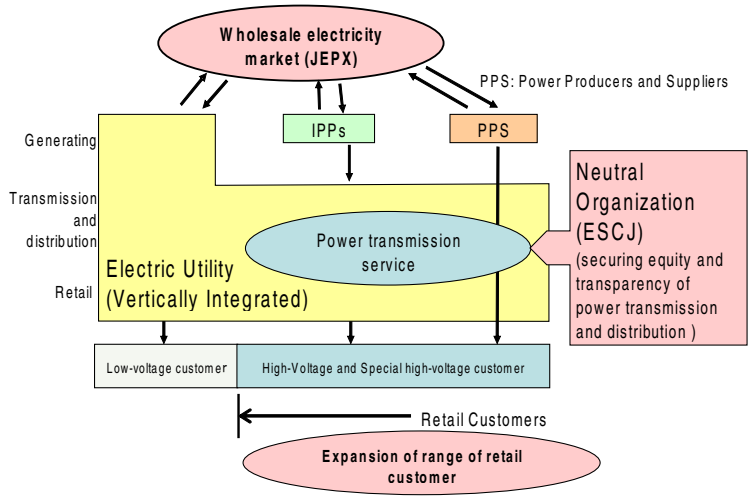

Fig. 3. Institutional revisions made since April 2005.

A Neutral Agency

The neutral agency is called the Electric Power System Council of Japan (ESCJ), and its main functions are:

1) Rule making for using power grids
2) Rule monitoring (settlement of disputes)
3) Support for the operation of interconnected transmission lines (management of ATC, maintenance work coordination, and congestion management)
4) Provision of information about transmission systems

As shown in Figure 4, the ESCJ is composed of a governing board and various expert committees, such as a rule-making committee and a rule monitoring committee under the control of a general meeting of members who are the general power utilities, PPSs, wholesale electricity suppliers and neutral parties, each having an equal voting right. A consultative board conveys the views of non-members to the Council.

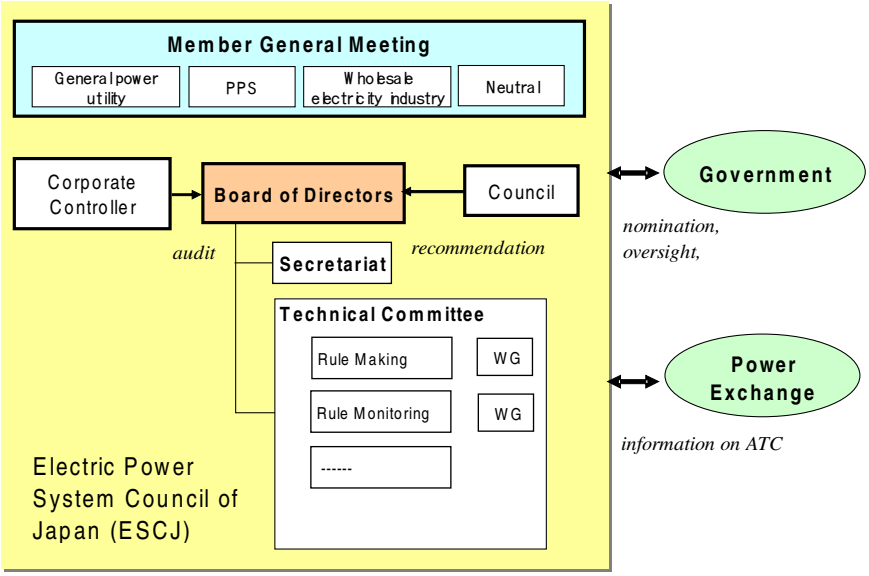

Fig. 4. Structure of the ESCJ

B. The Japan Electric Power Exchange

The Japan Electric Power Exchange (JEPX) is a privately-managed voluntary institution that was founded as Japan's first nationwide power exchange. The JEPX is expected to perform risk management functions, including the formation of a benchmark price, and the provision of selling and procurement means in the event of a mismatch of supply and demand.

Anyone who is capable of handling the generation and has assets worth 10 million yen or more can participate in the trading market. The JEPX deals in the following types of market.

1) Day-ahead market (spot deals):

Spot deals are deals for selling and buying electricity in units of 30 minutes to be used the next day and for 48 different commodities of electricity. Contracts are closed on the single-price auction basis.

2) Forward market:

Forward market deals sell and buy electricity for one year ahead from the following month in one-month units. Contracts for 24-hour delivery and for daytime delivery from 8 a.m. to 10 p.m. on weekdays are traded. Transactions are performed on a continuous session (price-oriented, time-oriented) basis.

Table 1. Assessment of the Macroscopic Policy Objectives

Objectives	Issues	Areas of Assessment	Items of Assessment
Enhanced efficiency of electric power supply service	Retail electricity market	- Changes in electricity rates - Factors contributing to cost reductions and rate cuts - Initiatives other than electricity rates	1) Electricity rates - Changes in the levels of electricity rates - Quantitative analyses of the effects of institutional reforms on electricity rates 2) Factors other than electricity rates - Efforts in terms of services - Initiatives designed to strengthen business bases, including technological innovation and development of overseas business operations 3) Options for customers - Number of suppliers and shares - Customer satisfaction
	Wholesale electricity market	- Robustness of the power generation and wholesale electricity markets - Performance of JEPX's initial purposes	1) Wholesale electricity market - Trading volume by electric power companies and PPSs, and prices - Trade channels (cross trading with JEPX, self-supply and purchase from other companies, etc.) - Correlation among wholesale electricity prices, generation costs and retail prices 2) JEPX - Position of JEPX in the wholesale market - Trading volume and prices in spot market and forward market, and liquidity compared with bilateral trading
Supply Reliability	Construction, maintenance and renewal of facilities	- Facility investment - Maintenance and renewal of facilities - Attainment of suitable generating mix	- Supply reliability - Changes in the amount of facility investment - Facility maintenance levels and measures for extension of life of facilities - A future power generation mix, transmission line construction plans, and electric power development plans by PPSs, etc.
	Interconnected transmission line	- Limitation of line capacity	- Construction of interconnected lines - Maintenance and operation of interconnected lines
	Load dispatching control and system management	- Burden on load dispatchers - Appropriateness of ancillary services	- Changes in electric power companies' load dispatching control and system management activities following institutional reforms - Harmony between protection systems such as special protection schemes and short-circuit relays and newcomers' facilities - Provision and operation of ancillary services
	Safety and disaster restoration	- Changes in the functions of safety and disaster prevention systems	- Response to safety and disaster restoration needs
	Technology development and succession of skills	- Necessity of development of new technologies in the power transmission and distribution sector, etc.	- Implementation of technology development projects in response to institutional reforms
Environmental protection	Choice of power sources	- Orientation toward a generation mix attaching importance to economic efficiency only	- Changes in the generation mix and CO2 emissions in the power sector
	Development of environment-related technologies	- Efforts toward environmental development that have no direct contribution to profits	- Investment in the development of environment-related technologies

Since a study on deregulating retail electricity for all customers is to start in fiscal 2007, the institutional reforms implemented so far are now being assessed and verified. The assessment looks at:

1) How macroeconomic policy objectives, such as enhanced efficiency, stable supply and environmental protection, have been achieved; and
2) What kind of results have the implications of individual institutional reforms, such as the elimination of pancake rates and the establishment of a neutral agency and an electric power exchange brought?

The results of the assessment will be made available by the summer of 2006. This section summarizes the areas of assessment and the items assessed.

Regarding the macroeconomic policy objectives in 1) above, as shown in Table 1, the effects of the current institutional reforms on enhancement of the efficiency of electric power supply

Table 2. Assessment of Individual Institutional Reforms

	Areas of Assessment	Items of Assessment
Wheeling service system	- Elimination of pancake rates and revitalization of wide-area power transaction - Functions of the new imbalance charging system	- Effects on wide-area transactions and on JEPX trade - Recovery of transmission line costs, an appropriate cost reimbursement mechanism, and restrictions on the siting of power sources in remote places - The incidence of imbalances and the shouldering of charges
Activity regulations	- Securing of fairness and transparency in the transmission/distribution segment through activity regulations	(a) Information firewall - Management of information related to wheeling service, and formulation and announcement of internal rules (b) Prohibition of discriminatory treatment - A survey of cases of discriminatory treatment in access to wheeling service for specific power suppliers (c) Prohibition of cross-subsidization (keeping of different account books) - Preparation and disclosure of documents needed to verify an income and expenditure account statement and the process of preparing the statement
Neutral agency	-Securing of fairness and transparency in access to power grids, construction of facilities and disclosure of information	- Establishment of an organization and a mechanism designed to achieve fairness, transparency and neutrality - Rule-making procedures securing fairness, transparency and neutrality - Consistency of load dispatching communication and system information disclosure systems (OASIS) with the neutral agency's rules - Fairness and transparency in the scheme for rule monitoring - Current situation of rule monitoring - Implementation of load dispatching communications - Appropriateness and security of the information disclosure systems (OASIS)

services, supply stability, and environmental protection are verified. Essential points in the assessment include the robustness of the electricity rate and trading market, capital spending, congestion of interconnected transmission lines, investment in the development of technologies, and investment without consideration of the environment.

On the other hand, the effects of individual institutional reforms are assessed in terms of the objectives mentioned in Table 2.

V. EVALUATION OF INSTITUTIONAL REFORMS IN THE EARLY STAGE

Institutional reforms are now being systematically evaluated from the abovementioned perspectives. This section evaluates the institutional reforms in their early stage based on currently available data. Note that some factors, such as electricity rates, can be accurately evaluated as the result of institutional reforms as sufficient time has passed since the early stage of the reforms, while it may be too early to evaluate other factors such as the robustness of transactions on the electric power exchange that were commenced in the third step of the reforms.

A. Electricity Rates

The wide gap between electricity rates in Japan and in foreign countries, which triggered the structural reforms in the Japanese electric power industry, has narrowed compared with before restructuring of this industry was started, as shown in Figure 5.

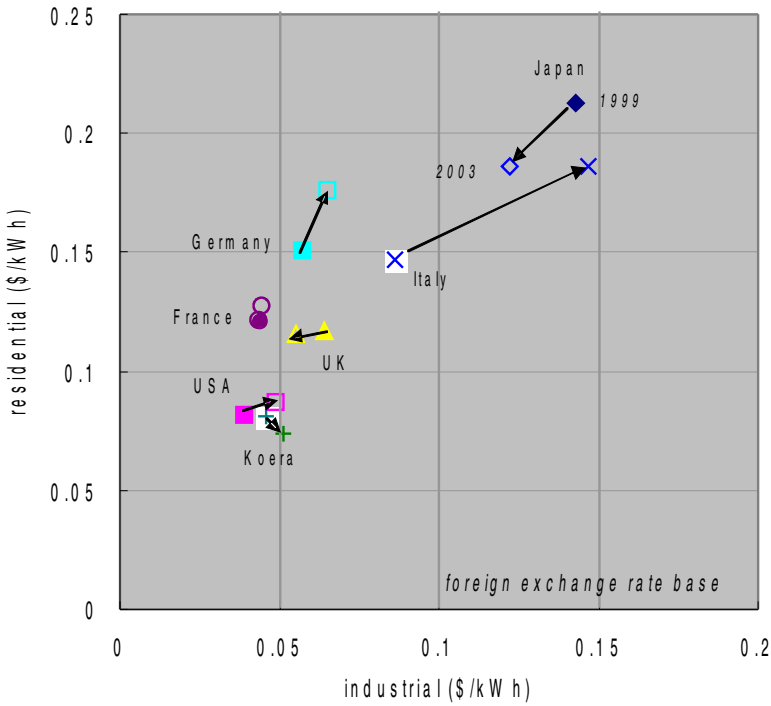

Fig. 5. Comparison of electricity charge before and after the institutional reform

Changes in electricity rates over the past decade are shown in Figure 6:electricity

rates dropped by 1.8% annually on average from fiscal 1994 to fiscal 2004 and a simple comparison between electricity rates in fiscal 1994 and in fiscal 2004 shows a decline of approximately 17%. As the graph shows, residential charges, which are not liberalized, have declined to sufficiently lower levels. In the liberalized segment, a simple comparison between electricity rates in 2000 and in 2004 revealed a significant drop of nearly 26% in electricity rates for commercial customers.

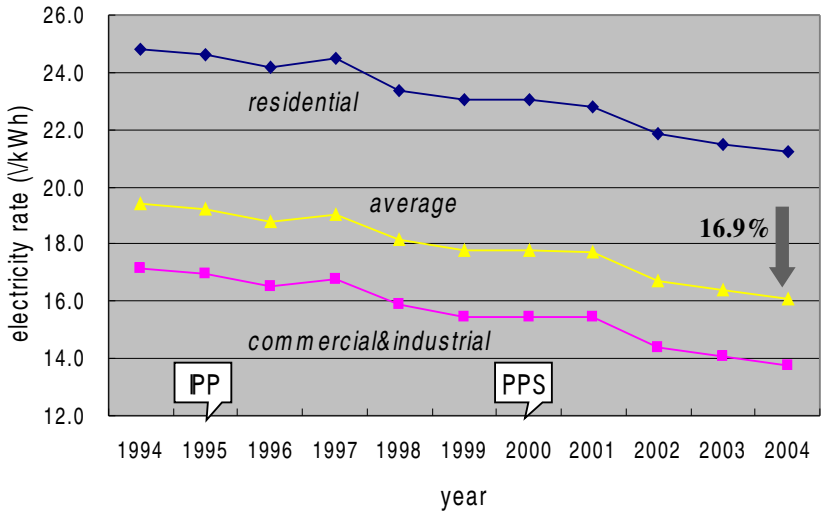

Fig. 6. Changes in electricity rates over the past decade

B. Situation of Newcomers

A look at newcomers (PPSs) in the liberalized sector shows that although their share is still small at around 2%, PPSs have been steadily increasing their power sales (Figure 7). PPSs' shares vary according to electric power companies. In Tokyo Electric Power Company's service area, where the utility meets an immense demand for power, newcomers hold a share of more than 5%, whereas PPSs account for no more than 1% in the service areas of some local electric power companies.

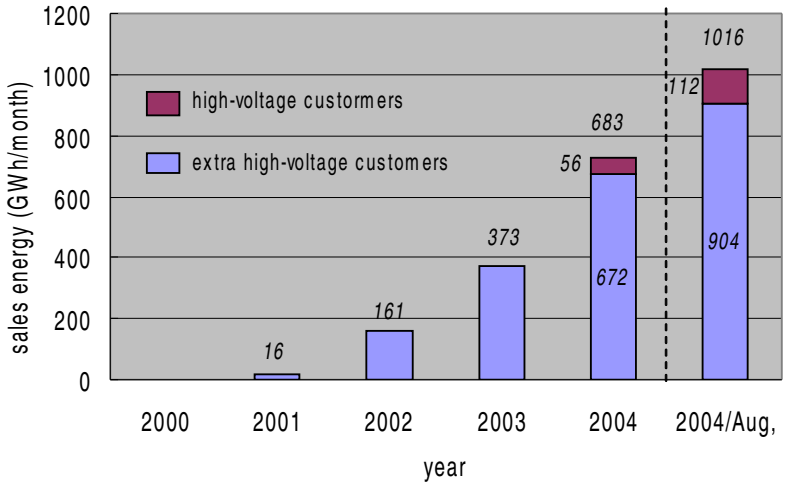

Fig. 7. Share of Power Producers and Suppliers (PPSs)

C. The Japan Electric Power Exchange

The Japan Electric Power Exchange is still immature as it was opened only in April 2005. As shown in Figure 8, over the five months following its opening, the exchange has had thin trading and prices are relatively high in summer, but subsequently transactions have increased gradually and prices have become steady. Reasons for this tendency include the emergence of relatively large sellers, a rise in oil prices, and the suspension of large power sources.

At the time of the exchange's opening, an outlook for trading volume was provided as shown in Figure 9. The actual volume of transactions already surpassed the estimate for the first year in mid November.

Challenges that the exchange must tackle in the years ahead include:

- Measures to increase the trading volume: Increase in the number of exchange members, such as in-house power generation facility owners.
- Introduction of new commodities meeting needs: Introduction of short-term forward delivery contracts.

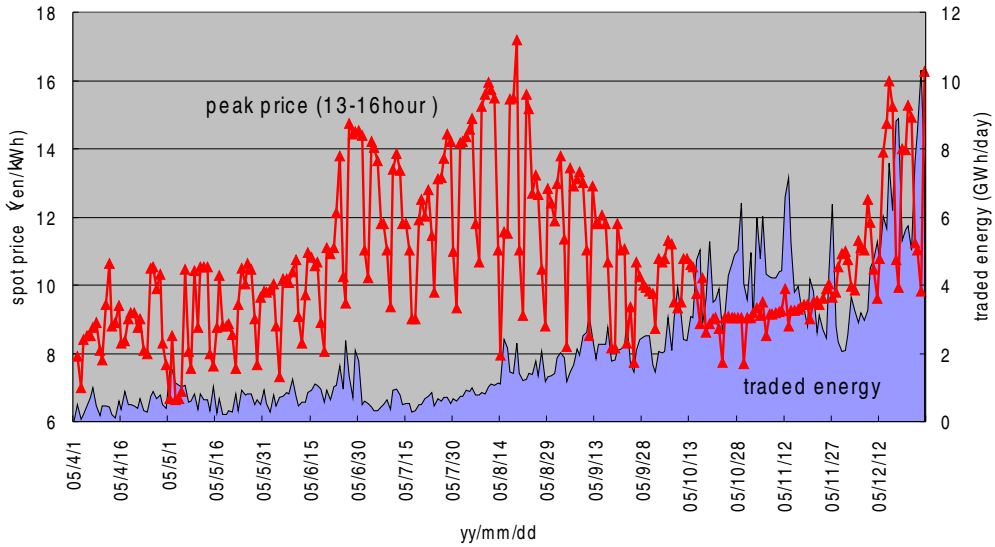

Fig. 8. Price and traded energy in day-ahead market of

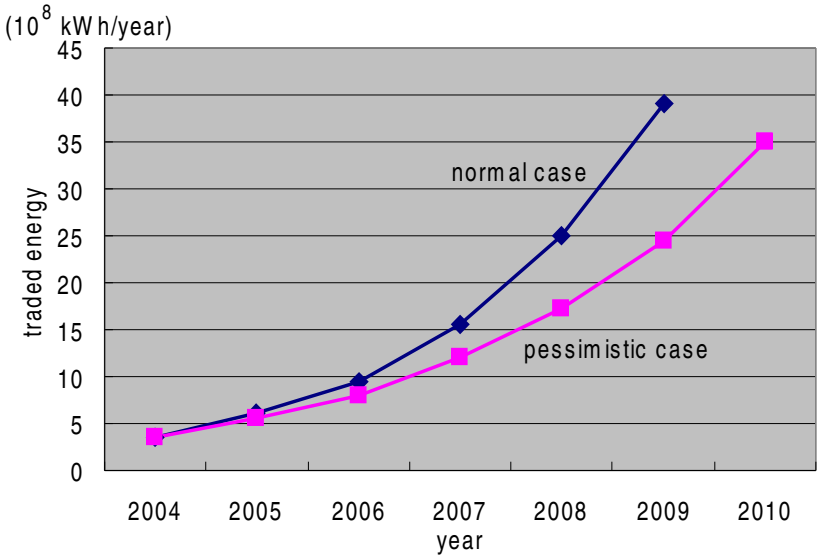

Fig. 9. Prospect of trading volume (at the opening time of JEPX)

D. ATC and Transmission Line Congestion

Available transmission capacity (ATC) for the next ten years in Japan is shown in Figure 10[3]. In Japan, due to the geographical conditions and historical background, interconnections between electric power companies are loosely connected and transmission congestion poses a problem in domestic interconnected lines. ATC is therefore presented for each interconnected line.

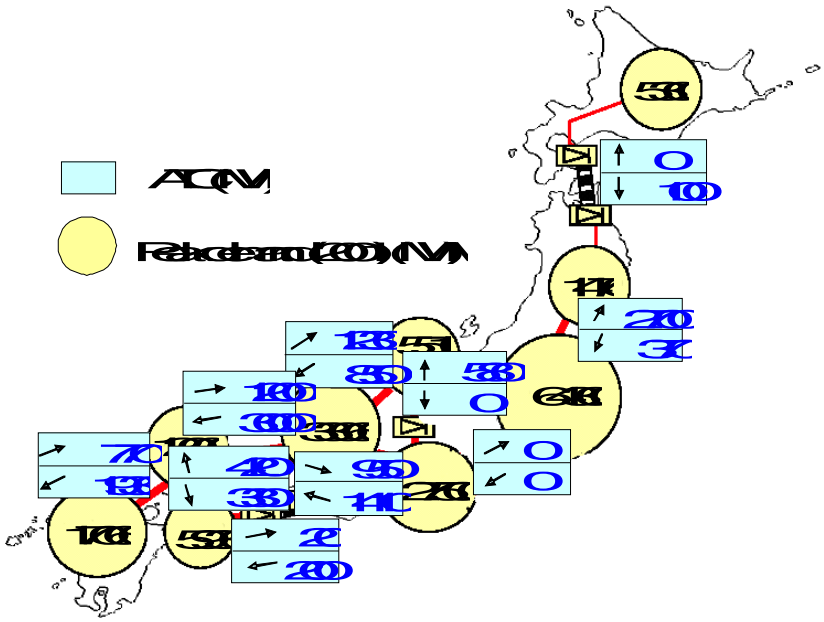

Fig. 10. ATC of the interconnected line (from 2005 to 2014)

The frequency and duration of transmission line congestion are shown in Table 3. Congestion occurs several times a month. In September and October in 2005, transmission

congestion occurred due to a decrease in the counter power flow (a power flow in the opposite direction) resulting from the extended period of repairs on large power sources.

The ESCJ has undertaken a technical study on ways of managing interconnected transmission lines, including reinforcements.

Table 4. Prospect of generation adequacy

	demand/supply balance	
	2009 (August)	2014 (August)
Peak demand	18,200	19,246
Planned capacity	19,838	21,268
Reserve ratio	1.09	1.11

Table 3. Congestion of interconnected lines (2005)

E. Adequacy of Generation Capacity

One of the ESCJ's functions is to assess reliability of power system. An assessment of the adequacy of generation capacity is given in Table 4. The adequacy of power sources is expected to be maintained at an appropriate level for the next ten years or so.

Month	Frequency		Duration	
	Planned	Emergency	Planned	Emergency
April	0	1	0	10.82 h
May	1	0	130 h	0
June	4	2	90 h	26.5 h
July	3	3	123.5 h	56.97 h
August	1	1	80 h	744 h
September	20	2	660 h	257 h
October	31	0	824 h	0
November	3	1	123.5h	39.6h

F. Capital Investment by Electric Power Companies

Capital investment by electric power companies has fallen sharply over the past several years as shown in Figure11. This decline has occurred partly because demand growth has slowed down as shown in figure and partly because electric power companies have virtually completed their bulk power transmission systems through investments made over the years. In fact, reductions in capital spending have released financial resources that have allowed the electric utilities to lower electricity rates.

The population of Japan begins to decline in 2005 much earlier than expected, and so electric power demand cannot be expected to increase significantly in future. Still, the facilities that were constructed during the growth period will have to be renewed by around 2010. How the facilities should be managed within the context of electricity deregulation is an important question that remains to be answered.

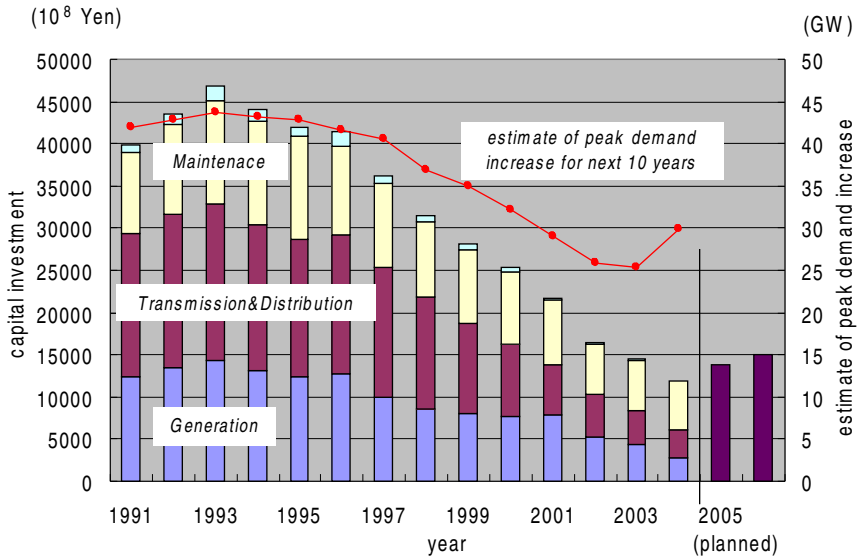

Fig. 11. Trend of capital investment in utilities

VI. CONCLUSION

This paper has outlined the institutional reforms in the Japanese electric power industry and an assessment of the reforms already made. The structural reform of the Japanese electric power industry is characterized by a step-by-step approach as well as by reforms

being implemented within the framework of electric power companies' vertically integrated power generation and transmission structure. Although it is still premature to draw conclusions about the results of the structural reforms, electricity rates have dropped and the differential between electricity rates at home and abroad has narrowed considerably. A national-level assessment of the institutional reforms is under way and the results will be produced in the summer of 2006. Based on these results, discussion will be commenced in order to establish a Japanese-style electricity liberalization system.

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VIII. BIOGRAPHY

Ikuo Kurihara (M07849276) was born on July 5, 1953. He graduated from the doctoral course of electrical engineering in University of Tokyo in March,1982. He joined Central Research Institute of Electric Power Industry (CRIEPI) in 1982. From 1986 to 1987, he was a visiting researcher of University of Texas at Arlington, Texas, U.S.A. His main research field is planning and operation of power systems. He is a Doctor of Engineering. He won paper prize award in 1992, 1998 and 2005 from Institute of Electrical Engineers of Japan. He is a Senior Member of IEEE.

10. Pricing for Transmission Services in Korean Electricity Market

H. S. Jeong, *Member, IEEE*, D. Hur, *Member, IEEE,* C.K. Han, *Member, IEEE* and J.K. Park, *Senior Member, IEEE*

Abstract: In Korea, the trend of heavier real power flows into densely populated load centers from several vast power plants in remote locations will continue or become profound, leading to our national-interest transmission bottlenecks during some periods of the year. The first step toward increasing the role of market forces in managing transmission system operations is to develop the role of locational price signals to direct the actions of market participants toward outcomes that improve operations when congestion occurs on the bulk power grid. In this overall perspective, we need to thoroughly investigate how best it would be to send an adequately accurate locational price signal with the congestion costs incorporated into the transmission pricing rule when the electricity market is not unduly maintained. This paper attempts to make a supportive and self-explanatory proposal that it could fit the Korean Cost-Based Pool (CBP) that satisfactorily sharpens the locational price signal.
Index Terms-- Access Charge, Cost-Based Pool (CBP), Locational Price Signal, Power Tracing Method, Transmission Usage Charge

1. INTRODUCTION

(1). The evolution of competition in Korean electricity industry

It used to be assumed that electricity generation, transmission, distribution and supply enjoyed significant vertical economies that would be lost if the functions were placed under the control of different companies. Such long-held belief made it possible that the Korea Electric Power Corporation (KEPCO) had monopoly power – supported by legal protection.
Since the 1997 financial crisis, economic policy in Korea has aimed to remove barriers to trade and competition. Network industries like electricity and natural gas, which were historically sheltered from competition and operated within national or regional boundaries, have experienced radical change as a consequence. National pressure to liberalize electricity markets reflected the perceived benefits of introducing market forces into the electricity industry previously viewed as a natural monopoly with substantial vertical economies. In the meantime, the generation sector was split up into six subsidiaries which will be privatized each, after all. Still, the KEPCO is being engaged in monopolistic business activities of the transmission and distribution systems alike. In an attempt to help mitigate potential negative prospects about which the hasty reform drive could bring, a new transitional electricity market, dubbed ‘Cost-Based Pool (CBP)’, was set up in 2001.

(2). The distinctive feature of CBP

The characteristics of the Korean CBP market can be briefly summarized as follows:

- The Korea Electric Power Corporation (KEPCO) is the single purchaser. Exceptionally, large consumers (above 50MVA) and district electricity businesses can either buy electricity directly from the Pool or KEPCO.
- The generators added at peak load are given the short-term marginal price (SMP) and the capacity payment, 7.17 won/kW as the fixed cost, while the base-load power plants receive both the base-load marginal price (BLMP) and the capacity payment, 21.49 won/kW as the fixed cost. When the CBP was first designed, greater portions of the windfall profits from the high SMP for each generation company were envisaged because of the shortage of base generation capacity. Thus, the so-called BLMP was adopted to evade the excessive revenues of the base-load generators.
- As such, there is no locational price signal. If the generators inevitably change their output due to the congestion, they have been paid the uplift to make up for their generation cost.
- The generation cost is a priori known by the committee's actual test. Individual generation companies offer their available capacities alone, not prices. Then the Korea Power Exchange (KPX) performs economic dispatch based on the generation fuel costs.
- Indeed, the transmission price seems to be nominal in that it is published every year but not really applied to the market participants. In the CBP, the KEPCO collects the electricity price from the customers on a regulated tariff and provides the variable costs (SMP and BLMP) plus the capacity payment for the generation companies.

Originally, the futuristic model, namely Two Way Bidding Pool (TWBP) in which the market clearing price would be determined from the bids of customers and the offers of generation companies in the unconstrained dispatch, was supposed to commence in 2004 in order to overcome the shortcomings of the current CBP. However, it is halted by the government and accordingly the CBP is expected to continue for the time being.

II. PRICING FOR TRANSMISSION SERVICES UNDER THE COST-BASED POOL

Now, the main drawback in the CBP is an essential absence of the locational price signal. Though either nodal pricing that recognizes different prices at every location or zonal pricing that creates administrative aggregations to reallocate costs is a nearly dominant answer to the prospective price signal in energy markets [1, 2], it would be really time-consuming to rectify the current uniform pricing regime and, at the same time, redesign the market in terms of future network infrastructure costs. The access charge such as license plate or postage-stamp method is widely accepted to meet revenue expectations. In some European electricity markets, the power tracing method has been introduced for full cost recovery and locational price signal [3].

(1). The basic structure of pricing for transmission services

In general, the overall equipments of transmission system are grouped into connection assets, common and locational components, respectively. The pricing for transmission services in the CBP mainly consists of the access charge and the transmission usage

charge as seen in Fig. 1.

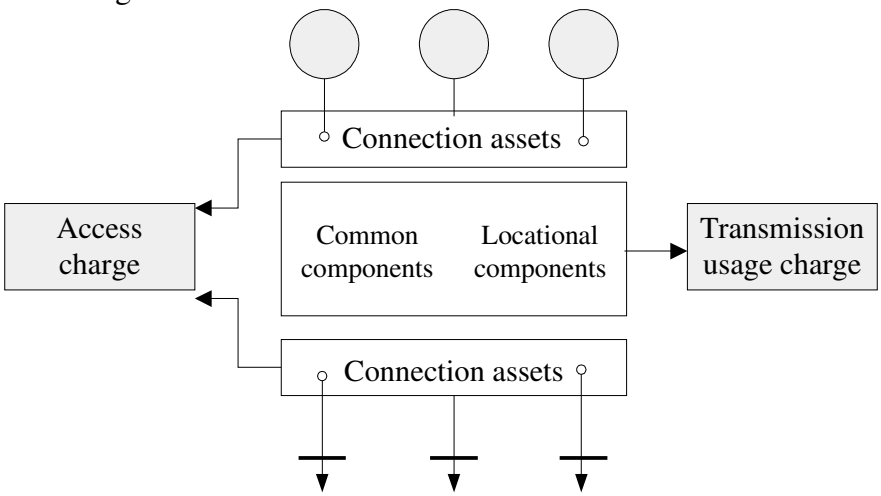

Fig. 1. The basic structure of Korean transmission pricing

- **Access charge:** All the market participants who would likely use the transmission system should pay the charge for the connection assets which directly interconnect them with the substation. As is well known, a 'deep' basis is better rather than a 'shallow' basis in case of the access charge. From a practical standpoint, the CBP comes to have a clear preference for a "shallow" basis since it is a relatively good tool for elaborating the stringent criteria.

- **Transmission usage charge:** The electricity passing the connection assets is transmitted from generators to loads through the core of transmission system. Two components, i.e. the locational and the common service components, are included hereof. In principle, the common component is made up of facilities related to the reactive power, non-operational land holdings, communication equipment, whereas the locational component encompasses transmission lines and circuit breakers, etc. In the CBP of Korea, postage-stamp rate method is traditionally used for the common component, while the power tracing method associated with the locational component is poised to give a locational price signal to the participants. In Fig. 2, the transmission charges in the CBP are represented for better understanding.

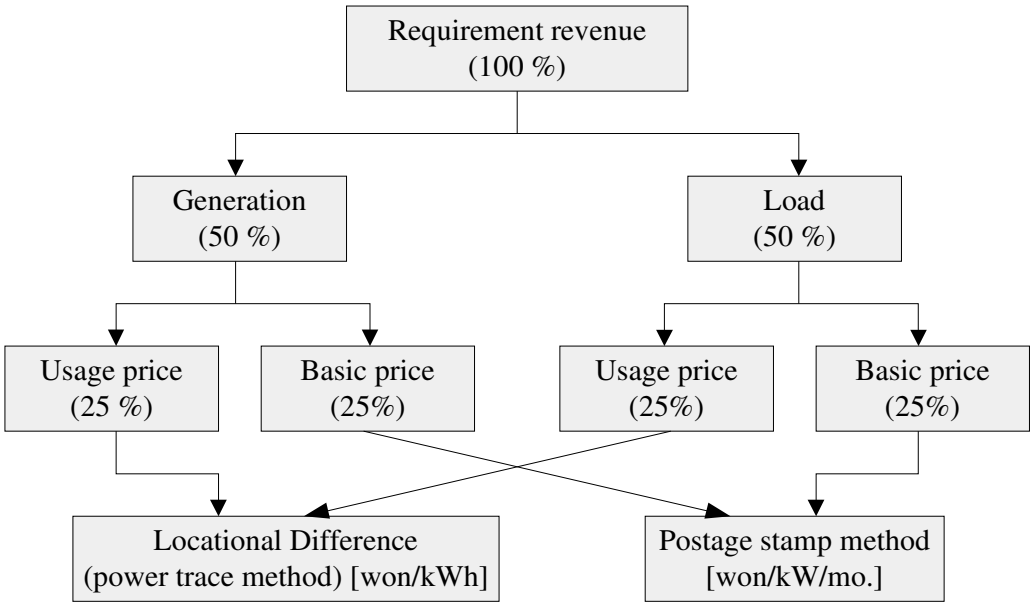

Fig. 2. Illustration of transmission charges in the CBP

(2). Power tracing method

The gist of the tracing method is to evaluate the contribution of transmission users to transmission usage of locational components. This method may be employed to determinine which generators are supplying corresponding loads, how much use each load is making of specific transmission lines and what are the annual costs of individual network elements to be recovered.

Especially, the cost of substation with which several branches are connected is actually divided into each line. In this method, more detailed load flow analysis of the system and its operation at the peak time are usually required to allocate the estimated annual costs of network elements to all the participants who use them. In an early stage, the fault current based power tracing method in the Victoria pool was scrutinized, but at this time, the methodology set forth by Felix Wu is in popular use [4].

A natural implementation of the proposed algorithm is described in the following procedures (see Fig. 3):

1) Choose 5 reference points when each load reaches 100, 90, 80, 70 and 60 % of peak load.
2) The power tracing method is applied for 5 averaged load-demand and generation level at buses, allowing for a whole set of 5 reference points.
3) The cost of each transmission line is calculated using equipment replacement cost which deals with what it will cost to replace the piece of equipment in the future and then converts the future cost into today's pricing.
4) All 5 transmission prices as to each bus are created from a pair of the averaged demand and supply at the respective reference points. A weighted average of 5 transmission prices against the elapsed time is equal to the final transmission price at each bus.
5) The zonal price, or a weighted average of the node price against the corresponding load-demand within the same zone, is derived.

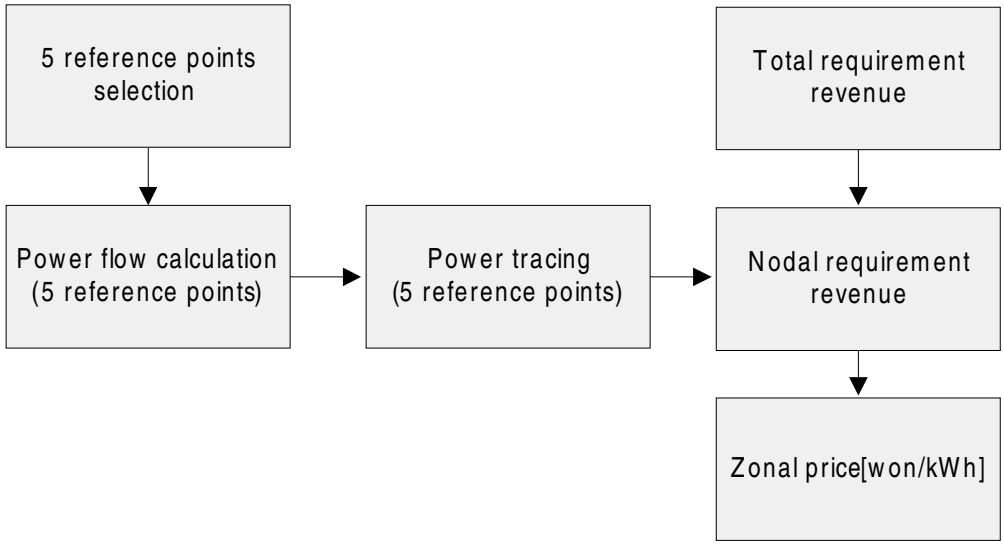

Fig. 3. Procedure of usage price calculation

III. CASE STUDY

Data from Korea electric power system is used to calculate transmission prices. Fig. 4 is a schematic showing locations of major generation and transmission facilities in Korea electric power system. From the geographical point of view, the system can be characterized in the following [5]:

- Island system
- Concentration of load demand in the metropolitan region
- Location of major generation plants in non-metropolitan regions
- Environmental concerns and restrictions on regional transmission siting

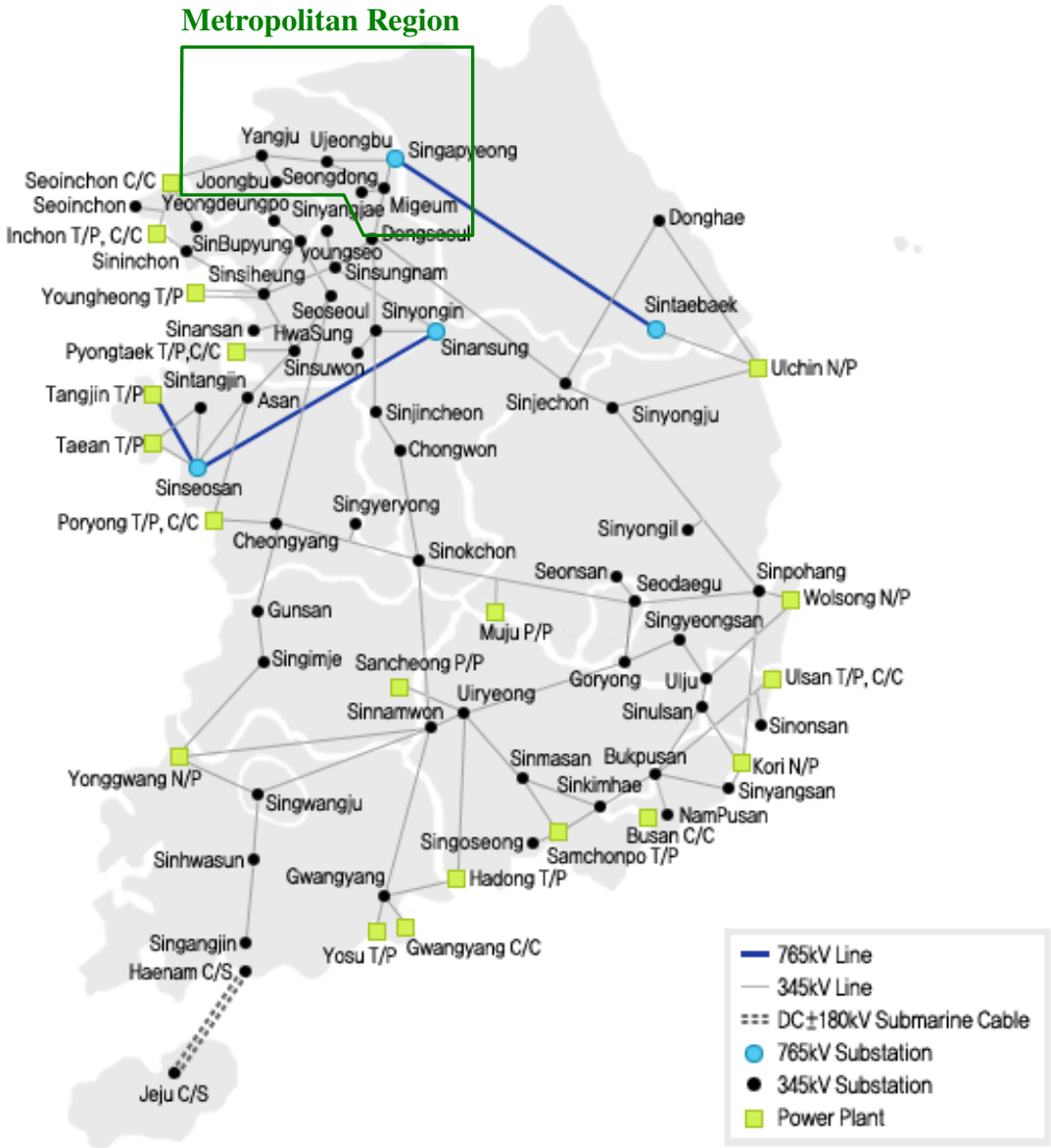

Fig. 4. Schematic of major transmission facilities in Korean electric power system

The transmission price calculation algorithm used in NETA and Ireland is applied to the Korea electric power system for comparison with CBP method. In the results of simulations, it shows that the methods of NETA and Ireland provide stronger locational signal than the CBP's. In Fig. 5, the left side of the horizontal axis indicates the nodes of metropolitan region and the right side indicates the nodes of non-metropolitan region. While there are negative prices in metropolitan region for the methods of NETA and Ireland, there are all positive prices in the CBP's method. Even though providing locational price signals is an important role of pricing transmission services, it is undesirable that these methods should be applied to the Korean pool model. The reasons are as follows:

- The energy markets of NETA and Ireland is run by contracts without locational price signals.
- Most of the electric power markets include capacity market or capacity payment. In

CBP, capacity payment is paid to all generators who submit capacity offers. For example, lower efficient generators in the metropolitan region make an additional profit on negative transmission price.

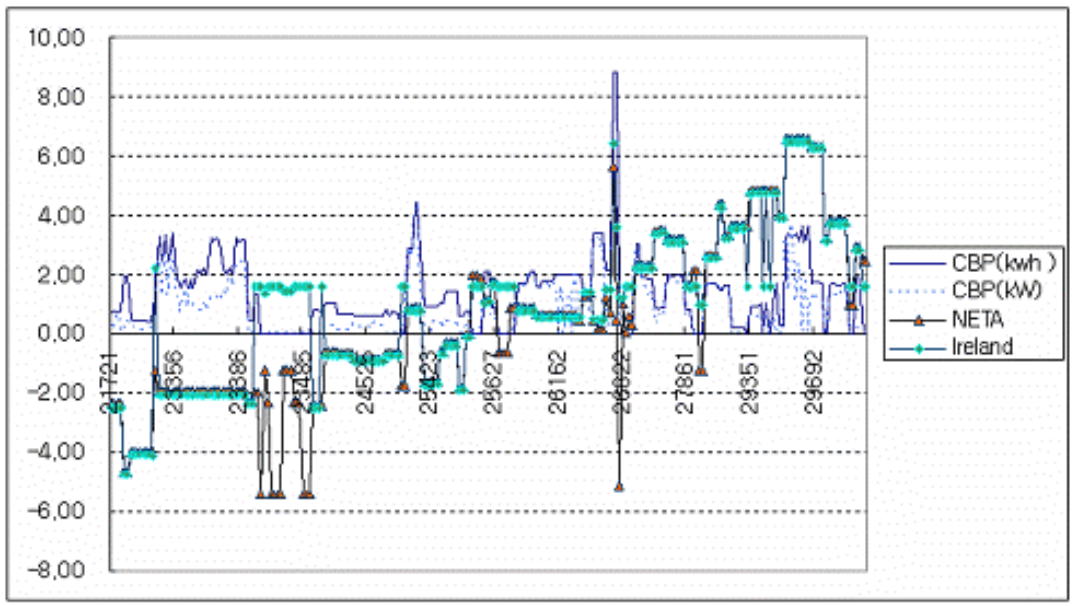

Fig. 5. Comparison with transmission price calculation algorithms

IV. THE CHALLENGES FROM PRICING TRANSMISSION SERVICES IN THE COST-BASED POOL

(1). Access charge

- Though it is clearly stated that the already established generation companies in the CBP should take the responsibility for the access charges, they do not pay for these charges as it is. Conversely, a group of independent power producers with the power plants in course of construction is installing the connection assets as long as their budget allows. That is, new entrants are being outright discriminated from the old ones in the CBP model.
- It is even difficult for the existing generation companies to be imposed on the access charge in the CBP environment. That is why the market should reward those companies with the SMP, CP and infinitesimal reserve-related charge which are earmarked according to the generation fuel costs and installed generation capacity, and hence they can afford no extra payments for access charges, let alone the transmission prices. This critical defect is fairly associated with not only the access charges but also the transmission pricing in itself.
- For some generation companies, they are linked with the common components via the transmission line whose voltage might be as high as 765 kV. Those companies are facing a heavy burden with the enforcement of the capacity investments of the past.
- Today and increasingly in the future, some parts of connection lines may be constructed across quite long-distance routes so as to be utilized for the common components.

(2). Transmission usage charge

In relation to the transmission usage charge, the following questions can be arised:

- Further work will be needed since the allocation rules, with rating the shares of the generation companies and load entities or common and locational components at fifty-fifty, are totally unconvincing forceful standards.
- In fact, the extent or systematic methodology of yielding locational price signal should be discussed in a meticulous way and it should ultimately have a bearing on the energy market. But neither the CBP energy market nor capacity price provides locational price signals between two areas. Therefore the pricing for transmission services to provide different locational price signals between two areas is necessary.
- The appropriateness or usefulness of the power tracing method will be analyzed in detail.

The states of power systems are subject to change, relying solely on the planned maintenance overhauls for generating units, new entry of power plants and the configuration of the infrastructure. Nonetheless, the ongoing method does not capture the changes of conditions in power systems, with the transmission price through the year fixed on a single value. It needs to be identified how much impact each factors have on the transmission price so that the transmission pricing should be able to enhance fairness and efficiency.

V. CONCLUSION

In the face of much complication, the Korean government has been committed to putting the final touches on the public services in the electricity industry, reiterating its willingness to go ahead with the policy. The fruit of these incessant efforts has proved bitter as yet. In these staggering surroundings, it is a brilliant future task to see the inherent limitations of the current Cost-Based Pool and find fundamental solutions without delay. To be sure, it will be allowed with the nation's consent if there are attractive alternatives to the aforementioned tantalizing problems. Apparently, the transmission pricing should be a reasonable economic indicator used by the market to make decisions on resource allocation, system expansion and reinforcement.

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11. Key Features of Successful Market Design and its Relevance to Asian Countries (Invited Discussion)

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ABSTRACT

Economic forces have been driving the dramatic restructuring of the power industry in the United States and throughout the world in the last decade or so. Central to this restructuring process is the specification of detailed market rules governing an electricity market operation that also provide further improvements of physical system operational security. A successful market design covers many aspects from societal cost and benefits, real-time metering of generation and load to the mathematics of pricing methodology for energy and ancillary services. Experiences with electricity markets have shown that getting the price right is crucial to market success; and the right prices mean providing market incentives that encourage market participants to comply with short-term grid security requirements and long-term reliability needs for generation and transmission. In this presentation, key elements of such a successful market design are discussed with reference to several US markets in Mid-Atlantic PJM, New England and Mid West regions.

Several major blackouts in the last several years, in particular the August 14, 2003 blackout in North-eastern US and Canada, caused an intensive debate about competitive markets and grid reliability. Reliability has once again become the focus issue of a global debate. While this incident prompted further market reform in some regions, additional cautions are being exercised in other regions that are concerned with deregulation's potential adverse effect on grid security. It is however worth noting that the final US-Canada task force report on the August 14 blackout pointed out that the need for additional attention to reliability is not necessarily at odds with increasing competition and the improved economic efficiency it brings to bulk power markets. Reliability and economic efficiency can be compatible.

The key to reliability compatible market design is to abide by the laws of physics and the principles of economics. These same principles should apply to the deregulations in Asian countries. It needs however to be recognized that the Asian countries with fast growing economy are facing a unique set of challenges. These unique challenges, among others, include severe power shortage, or even worse, energy (or fuel) shortages, and the multi-tiered control structure, such as the three tier control of national, regional, and provincial tiers in China. While the fundamental economic principles for the market design in the US and other countries are generally applicable in Asia, these local characteristics must be considered and incorporated in their deregulation policies and market design. This presentation will discuss the market mechanisms that are applied to resolve these challenges.

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