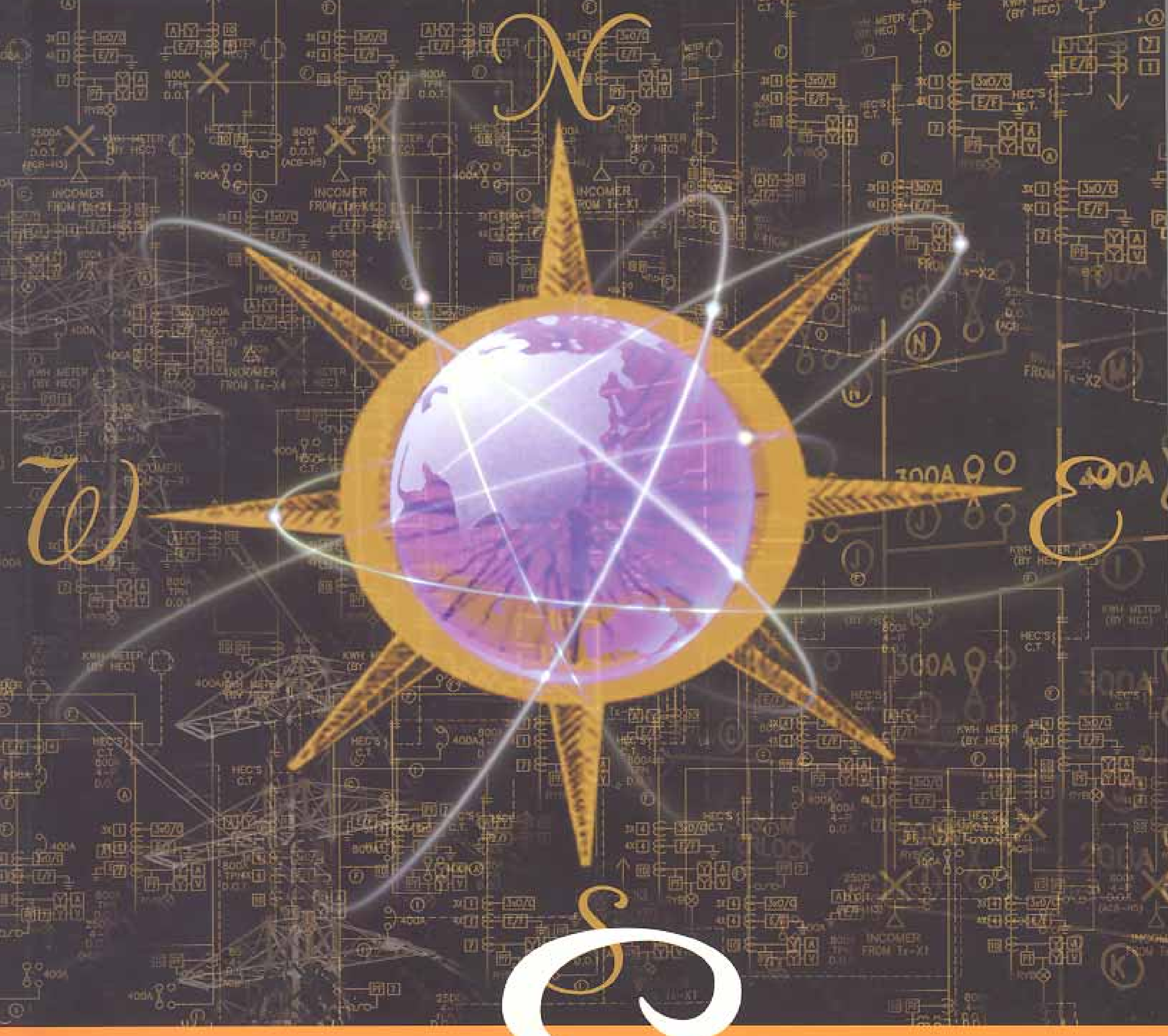


Globalization of Electrical Industry

The Hong Kong Institution of Engineers - Electrical Division

The Nineteenth Annual Symposium

23rd October 2001

THE HONG KONG
INSTITUTION OF ENGINEERS
ELECTRICAL DIVISION

The Nineteenth Annual Symposium

Tuesday

23rd October 2001

GLOBALIZATION OF ELECTRICAL INDUSTRY

at

Ballroom

Sheraton Hotel

Nathan Road

Kowloon

Hong Kong

SYMPOSIUM PROGRAMME

08.30 Registration and Coffee

09.00 Welcome Address

- Ir Dr F.C. Chan
  Chairman, Electrical Division, The HKIE

09.05 Opening Address

- Ir Joseph M.K. Chow, JP
  President, The HKIE

09.10 Keynote Speech

- Mr Lawrence K.M. Fok
  Deputy Chief Operating Officer
  Hong Kong Exchanges and Clearing Ltd.

1. Transmission and Distribution

09.40 Sending Power from West to East: What and How

- Mr Y.H. Yin, Director, Power System Department
- Mr J.B. Guo, Director, Science & Technology Department
- Dr R.M. Li, Chief Engineer, Science & Technology Department
  Electric Power Research Institute, Beijing

10.00 The Challenges, Constraints and Solutions for Electricity Distribution in Hong Kong Island

- Mr Y.F. Leung, Distribution Planning Engineer
- Mr S.C. Chan, Distribution Planning Engineer
  Distribution Planning Department
- Ir T.F. Chan, Area Engineer
  Construction and Maintenance Department
  The Hongkong Electric Co. Ltd.

10.20 Discussion

10.40 Coffee Break

2. System Development

11.10 **The German Super Speed Maglev Technology - System Characteristics and Market Potential**

- Mr Manfred Wackers
  Director of Sales and Marketing
  Transrapid International GmbH & Co. KG
  Germany

11.30 **The Interconnection of Regional Electric Power Systems in China and its Technical Feasibility Studies**

- Mr J.B. Guo, Director, Science & Technology Department
- Mr Y.H. Yin, Director, Power System Department
- Mr Z.X. Xu, Senior Engineer, Power System Department
- Mr G.C. Yao, Senior Engineer, Power System Department
  Electric Power Research Institute, Beijing

11.50 **Industrial IT-Solution for the Global Power Market Place**

- Mr M.Y. Ng
  General Manager, Export Markets
  ABB Utilities AB
  Sweden

12.10 **Discussion**

12.30 **Lunch**

3. Trade Practices

14.00 **Globalization of Safety Certification Industry**

- Mr Raymond C.K. Kong
  Chief Executive
  Intertek Testing Services Hong Kong Ltd.

14.20 **Future Market Trends for Asset Management in the Electricity Industry**

- Mr Anthony Seipolt
  Manager
  PB Associates Australia
  Australia

14.40 Business Improvement Through Greater Development of Purchasing

- Mr Richard Hawtin
  Head of Contracts and Purchasing
  CLP Power Hong Kong Ltd.

15.00 Discussion

15.20 Coffee Break

4. System Restructuring

15.50 Deregulation of Electricity Industry - the California Experience

- Mr C.P. Ng
  Business Systems Application Manager
  Independent System Operator, California
  U.S.A.

16.10 Opportunities, Benefits, Problems and Experience on Power Utility Deregulation

- Dr L L Lai
  Head of Energy Systems Group and
  Reader in Electrical Engineering
  City University, London
  U.K.

16.30 Discussion

17.00 Summing Up

- Ir Leonard C.P. Lee
  Symposium Chairman
  Electrical Division, The HKIE

Closing Address

- Ir Roger S.H. Lai, JP
  Director
  Electrical & Mechanical Services Department
  The Government of The Hong Kong SAR

Acknowledgement

The Electrical Division of The Hong Kong Institution of Engineers would like to express its sincere appreciation and gratitude to the following persons and organizations for their contributions to the Symposium :

Speakers / Authors

Mr Lawrence K.M. Fok
Ir Roger S.H. Lai, JP
Ir Joseph M.K. Chow, JP
Mr J.B. Guo
Dr R.M. Li
Mr Y.H. Yin
Mr Y.F. Leung
Mr S.C. Chan
Ir T.F. Chan
Mr Manfred Wackers
Mr. Z.X. Xu
Mr G.C. Yao
Mr M.Y. Ng
Mr Raymond C.K. Kong
Mr Anthony Seipolt
Mr Richard Hawtin
Mr C. P. Ng
Dr L.L. Lai

Sponsors

Yook Tong Electric Co. Ltd.
Analogue Group
CLP Power Hong Kong Ltd.
The Hongkong Electric Co., Ltd.
Schneider Swire Ltd.
MK Electric (China) Ltd.
Clipsal Asia Ltd.
Junefair Engineering Co. Ltd.
Kum Shing Engineering Co. Ltd.
Siemens Ltd.
ABB Industrial and Building Systems Ltd.
ABB Transmission and Distribution Ltd.
Raychem (HK) Ltd.
Alstom T & D Ltd.
Rickson Engineering Ltd.
Mitsubishi Electric (HK) Ltd.
Wenden Engineering Service Co., Ltd.
Au Chow Electrical Co., Ltd.
Greenland Engineering Co., Ltd.
Metrix Engineering Co., Ltd.
Chat Horn Engineering Ltd.
Thorn Lighting (Hong Kong) Ltd.
Tridant Engineering Co. Ltd.
Supremetech Engineering Co. Ltd.
Hong Kong & Kowloon Electric Trade Association
Hong Kong Electrical Contractors' Association Ltd.

Cover Design of this Booklet by Mr. Graham Tong, Mars Communication

19TH ANNUAL SYMPOSIUM ORGANIZING COMMITTEE

Symposium Chairman	**:**	**Ir Leonard C.P. Lee**
Members	**:**	**Ir Dr F.C. Chan**
		Ir T.P. Uy
		Ir K.K. Fung
		Ir Frank K.L. Ng
		Ir Michael Waye
		Ir S.K. Ho
		Ir C.L. Wong
Hon. Secretary and Treasurer	**:**	**Ir Y.K. Chu**

Paper No. 1

SENDING POWER FROM WEST TO EAST: WHAT AND HOW

Speakers : Mr Y.H. Yin, Director, Power System Department
Mr J.B. Guo, Director, Science & Technology Department
Dr R.M. Li, Chief Engineer, Science & Technology Department
Electric Power Research Institute, Beijing

SENDING POWER FROM WEST TO EAST: WHAT AND HOW

Mr Y.H. Yin, Director, Power System Department
Mr J.B. Guo, Director, Science & Technology Department
Dr R.M. Li, Chief Engineer, Science & Technology Department
Electric Power Research Institute, Beijing

ABSTRACT

This paper describes the project of "Sending power from west to east" in China and deals with basic feature, key projects and transmission technology to be used. It focuses on the year of 2005 and looks into the future.

1. INTRODUCTION

By the end of 2000, the total installed electrical power capacity of China hit 319 GW and the annual generation amounted to 1368TWh. When the new century comes, China starts a grand project in power industry, "sending power from west to east" and nationwide interconnection. Hongjiadu, Yinzidu and Wujiangdu (extension) three hydropower projects, and the third circuit Tianshenqiao-Guangzhou and Yunnan Baofeng-Luoping 500kV transmission and substation projects have been started to construct, symbolizing the beginning of "Sending power from west to east". In May of 2001, a 500kV tie-line between North China Power Network (NCPN) and Northeast Power Network (NEPN) has been put in operation and the process of the nationwide interconnection is in a faster pace in China.

According to "The Tenth Five-year Plan" approved by the National People's Congress of China, "To build three great corridors, i.e. the north corridor, the middle corridor and the south corridor, for sending power from west to east and enhance national network interconnection" is a strategic plan for development of Chinese power industry. "Sending power from west to east" is an indicative project in the large scale development in West China, an optimal way to solve the unequal distribution contradiction between power resource and load centers, being of great importance in realizing strategic restructure of power mix.

In the project of "Sending power from west to east", there are obvious differences in transmitting capacity, distance and schemes among the three corridors of north, middle and south. To improve the transmitting capability, HVDC and some advanced transmission technologies are to be used, such as series compensation including thyristor controlled series compensation, compact transmission line, dynamic reactive power compensation, etc. Also, the project of "Sending Power from West to East" will push forward the applications of advanced transmission technology faster in China.

2. THE NECESSITY FOR POWER INDUSTRY DEVELOPMENT

China is a developing country and relatively poor in reserves of oil and natural gas. In order to achieve a sustainable development in China, we'll follow the policy of "Developing hydropower energetically, thermal power optimally, nuclear power appropriately, renewable energy suiting to local conditions and expanding power networks synchronously, as well as equally stressing exploiting and conservation, placing priority on environmental protection.". Under the conditions of today's economic and technology, electric generation will mainly rely on coal and hydro resources in a relatively long period to meet the rapidly increasing power demand in the country.

In China, energy resources are distributed unevenly. The proven coal deposits are about 900 billion tons, 82% of coal deposits are scattered in the north and southwest. The exploitable hydropower capacity is 378,000MW and average annual electricity is 1920TWh, 67% of hydropower is concentrated in the southwest. The distribution of hydropower and coal resource in China is shown in Figure 1. Unfortunately, 70% of energy consumption concentrates in the central and coastal areas of the country. Therefore the direction of energy flow is mainly from west to east and from north to south. So it is necessary sending power from west to east to make up the deficits of energy in the central and coastal areas.

In addition, China is vast in territory. Besides transmitting power, "Sending power from west to east" can bring out a lot of the interconnection benefits, such as saving spinning reserve, shifting load, improving reliability, etc. Moreover, "sending power from west to east" can accelerate economic development in West China, mitigate the pressure of coal transportation, optimize resources disposition on even large scope and improve environment.

Based on the distribution of energy resources and demand, considering the regional interrelations in economy, geography, etc., the nationwide interconnected grid will likely be consisted of three interconnected sections: the north section, the central section and the south section. Correspondingly, three great corridors of the north, middle and south for sending power from west to east will be built respectively in the north section, the central section and the south section.

3. THE NORTH CORRIDOR

The north corridor is being gradually formed with establishment of thermal power base in Shanxi and Inner Mongolia, which will provide power to JingjinTang Power Grid (the abbreviation of the power grid covered over Beijing, Tianjin and Tangshan cities) and South Hebei Province as well as Shangdong Province. With development of step hydropower stations in upper-middle reaches of the Yellow River and thermal power plants in the north Shaanxi Province, North China Power Network (NCPN) and Northwest Power Network (NWPN) will be interconnected. In that time, the north section of nationwide interconnected grid will be formed, which will be composed of North China Power Network, Northeast Power Network and Northwest Power Network as well as Shandong provincial grid. Then the beginning point of north power transmission corridor will extend to the hydropower stations in the upper reaches of the Yellow River.

About 69.2% of coal deposits in China are located in the juncture of Shanxi, Shaanxi and Inner Mongolia. In this area, large power plants will be built near the mines. About 6,000~7,000MW produced by those plants will be transmitted through the north corridor to the south in 2005 and 17,000~18,000MW in 2020.

During the period of "the Tenth Five-year Plan (2001~2005)", the transmission capability through the north corridor is being enhanced with the construction of thermal power bases in the west Inner Mongolia and Shanxi Province. In the end of 2005, the scale of power transmission will hit about 6000MW with the distance of 300~540km. The number of lines will be up to 7 from the thermal bases to Beijing and south Hebei Province. New 500kV transmission lines will be built. These are the second circuits of Yongshengyu – Fengzhen – Zhangjiafang – Shunyi, double circuits of Tuoketuo-Yinxian-Anding, a circuit of Shentou-Xushui.

At the same time, series compensation (SC) and compact transmission line have been taken into account to improve the transmitting capability and power system stability. Dafang 500kV series compensation substation was put in operation in May of 2001. It is located in the middle of the 500kV double circuits from Datong Plant to Fangshan substation with the length of 290km. The stability limitation increases from 1800MW to 2200MW by 35% series compensation with capacity of 2 x 375MVAr. Also series compensation will be applied in Tuoketuo project. In today's planning, 12 x 600 generation will be finally installed in the group of Tuoketuo plants and provide power to Beijing and south Hebei Province about 480~510km far away. With application of SC, only 4 transmission lines should be needed, that is 2 lines less than without SC. In Nov. 18th, 1999, the first 500kV compact transmission line was put in operation in NCPN. It is nearby Beijing from Changping Substation to Fangshan Substation with a length of 83km. As compared with conventional 500kV line, its Surge Impedance Load (SIL) increases by 34%, the width for right of way (ROW) is restricted to 13.4m and the cost per unit SIL reduces by 22%. The parameters of this compact line are shown in Table 1.

Table 1 Main Parameters of the Changfang Compact Line

Length	83km
Surge Impedance Load (SIL)	1340MW(+34%)
Width of ROW	13.4m(-17.9m)
Conductors	6 x LGJ-240/30
The clearance of phase to phase	6.7m
The bundle diameter	750mm
Investment increase than convention line	+7%
Commission time	Nov. 18th, 1999

By the way, the preliminary feasibility study for applying series compensation and compact lines in Tuoketuo project is being undertaken.

In Northwest Power Network (NWPN), a higher voltage, 750kV, will appear during the period of "the Tenth Five-year Plan". At present, only NWPN takes 330kV as the highest voltage for main framework and others take 500kV. By the end of 2000, total length of 330kV lines is 8669km in NWPN. Because of long distance transmission and heavy power exchange between provincial grids, it is not economic to build new 330kV cross-provincial transmission lines. Six step-hydropower stations is planned to construct by stages with the total capacity of 10,000MW in the upper reaches of the Yellow River, and delivery distance is more than 800km. The available corridors are tight for 330kV lines to transmit this great power flow from the hydropower stations. In NWPN, the distance is also about 800km from thermal power plants in north Shaanxi Province to the load center in Guanzhong. 750kV is determined after a long period study has been done. The construction of the first 750kV transmission line will start in 2002.

With exploitation of hydropower stations in the Yellow River, NWPN will be interconnected with NCPN by HVDC to exchange power and Shandong Provincial Grid will receive power from "Sanxi" thermal base as well. The north corridor will be enhanced further.

4. THE MIDDLE CORRIDOR

With the construction of the Three Gorges Project, the middle corridor basically forms and will be enhanced with exploitation of step-hydropower stations in the Jinsha River. In this way, the central section of nationwide interconnected grid will be established and composed of Central China Power Network (CCPN), East China Power Network (ECPN) and Sichuan and Chengdu Provincial Grids (CYPG) as well as Fujian Provincial Grid. HVDC will play a main role in the middle corridor because a great amount of electric power will be transmitted between regions and in a long distance. In the end of 2005, the capacity sending power to ECPN will be 4,200MW. Around the year of 2020, the capacity to ECPN and Fujian will probably reach 16,000~2,0000MW.

As a part of the middle corridor, the first ±500kV HVDC line of 1,200MW was put in operation in 1989 from Gezhouba hydropower station to Nanqiao Substation with the length of 1045km, which is also the first cross-regional tie-line.

The Three Gorges Project plays a positive role in establishment of the middle corridor. The

Three Gorges Hydroelectric Station (TGHS) will be installed with 26 generating units of 700 MW rating capacity (especially maximal capacity of 840 MVA) and its total generation capacity of 18,200MW, with average annual energy output of 84.7 TWh, will be transferred by fifteen 500kV lines. Then three HVDC lines of bipole, ±500kV, 3000MW will be built to delivery electric power to ECPN and Guangdong Provincial Grid. The first one is from the Left Bank Converter Substation to Changzhou Inverter Substation with the length of 1067km, which will be put in operation in 2002. The second one is from the Right Bank Converter Substation to Shanghai Inverter Substation with the length of 1155km. The third one is from Jingzhou Substation in Hubei Province to Huibei Inverter Substation in Guangdong Province with the length of 1028km, which is called as Sanguang DC Project and will be commissioned in 2004 to realize the requirement of sending 10,000MW power to Guangdong. In 2005, the power from the Three Gorges Hydropower Station and Gezhouba Hydropower Station to ECPN will be 4200MW through the middle corridor.

As a part of the middle corridor, a 500kV line, with the length of 313km, is being constructed from Wanxian to the Left Bank Converter Substation and takes as AC tie-line between CYPG and CCPN. In summer, it will transfer power from CYPG to CCPN and then to ECPN. Based on the digital simulation, it is found that there is a local negative damping in Sichuan grid with about 0.8Hz and a regional weak damping with about 0.2Hz between CYPG and CCPN. The low frequency oscillation can be mitigated by installation of PSS in the relative generators. But in this case it is relatively sensitive to the PSS parameters, which must be coordinated. TCSC has been studied. It is effective in damping low frequency oscillation between CYPG and CCPN, simplifying PSS arrangement and increasing stability. Only 5%~10% TCSC is needed with capacity of 65-130MVAr.

According to the planning, Xiluodu and Xiangjiaba two large step-hydropower stations in Jinsha River will start construction when the first generating unit in TGHS is commissioned in August 2003. The total generation capacity of Xiluodu is 12,000MW and Xiangjiaba is 6,000MW. These two large hydropower stations will be taken into account in planning together. The total 18,000MW will be sent nearly equally to CCPN and ECPN (ECPN maybe little more). The transmission distance to ECPN is about 1750~2200km and three ±600kV HVDC lines are being studied. When the two hydropower stations are completed, the transmitting capacity to ECPN will probably hit 16000~19000MW. There will be six inverters in ECPN and five of them may be scattered in the area of Shanghai-Changzhou-Hangzhou, which is similar to a delta with the length of 150~200km. The detailed planning and measures are being studied to prevent problems caused by multi feeders, such as reasonably arranging the capacity and location of inverter stations to keep certain electrical distance, dropping the DC power in emergency, allocating SVC, etc. The transmission distance to CCPN is about 1000~1140km. The transmission schemes under study are HVDC and AC with series compensation. As exploitation of hydropower stations, maybe nine HVDC lines will appear in the middle corridor around 2020.

5. THE SOUTH CORRIDOR

The south corridor links up with four provincial power grids, those are Yunnan, Guizhou, Guangxi and Guangdong, which forms the south section of nationwide interconnected grid. The HVDC project from Tianshenqiao to Guangzhou was put in operation in June of 2001. In order to realize requirement of sending 10,000MW to Guangdong during "the Tenth Five-year Period", the construction of the south corridor is being speeded up. On the schedule, the some key projects are:

- The third Tianguang 500kV transmission line will be completed in 2003 from Mawo Substation in Tianshenqiao to Maoming Substation in Guangdong with the total length of 735km.

- Guiguang 500kV transmission passageway is scheduled to operate in 2003 from Huishui Substation in Guizhou to Luodong Substation in Guangzhou with the total length of 910km.
- Guiguang DC transmission line will be put in operation in 2005 with bipole, ±500kV, 3000MW in the length of 980km.
- The tie-line from Luoping Substation in Yunan to Mawo Substation in Guangxi is planned to step up to 500kV around 2003.

Meanwhile, a thyristor controlled series compensation (TCSC) project has been lunched and will be completed in the end of 2002. The 500kV double circuits from Tianshenqiao to Pingguo will be compensated by 40% fixed series compensation (FSC) and 10% TCSC with total capacity of 1086MVAr and the transferring capacity to Guangdong can be increased by more than 200MW. In this demonstration project, TCSC is employed to improve the transient stability, damp low frequency oscillation and mitigate the line overload in the N-1 condition. Another FSC is to be put in commission in 2003. It is located in Hechi Substation of Guiguang 500kV transmission passageway. The 500kV double circuits from Huishui to Hechi will be compensated by 50% FSC with total capacity of 1540MVAr and the transmission capacity to Guangdong can increase by 90~560MW. In future, more series compensation will be used in the south corridor to improve transmission capacity. In this way, the south corridor will be composed of HVDC and AC transmission lines with series compensation.

In addition, two HVDC projects are in planning. One is from Xiaowan Hydropower Station (installed capacity of 4.2GW) to Guangdong about 1500km, and another is Nuozhadu Hydropower Station (installed capacity of 5.0GW) to Maoming in Guangdong about 1400km.

6. CONCLUSION

As mentioned above, there are obvious differences among the three transmission corridors in 2005. It is compared in Table 2.

Table 2 Comparison Among Three Transmission Corridors

Corridors	Transferring capacity (MW)	Distance (km)	Transmission schemes	Cross region
North	6000~7000	300~800	7 AC line with SC	No
Middle	4200	About 1000	2 DC lines	Yes
South	7000	About 1000	2DC+4AC lines with SC	No

Note: SC means series compensation.

6.1 Before 2005, the north corridor is composed of AC transmission lines with no cross-regional tie-line. In NCPN, the north corridor is a passageway of AC lines and transmitting thermal power. Series compensation and compact line are used to improve transmitting capability. In future, the north corridor will be enhanced by HVDC between NWPN and NCPN as well as long distance transmission.

6.2 The middle corridor is composed of cross-regional tie-lines. HVDC plays an important role in the middle corridor. Therefore, the middle corridor is a passageway of transmitting DC and hydropower. With the exploitation of hydropower in Jinsha River, it will become the largest power path among the three corridors.

6.3 The south corridor is located in the interconnected network of 4 southern provincial power grids and composed of cross-provincial tie-lines. And it is a hybrid passageway of AC and DC transmission schemes. It sends hydro and thermal power to Guangdong. Series compensation will be used to improve transmitting capability in AC passageway.

6.4 With the development of nationwide interconnected grid, the three corridors will be enhanced and probably connected to each other.

REFERENCES

[1] Guo Jianbo, Yao Guocan, Xu Zhengxiong et al "Technical Investigation of the Future Chinese Interconnected Power Systems and Higher AC Voltage (Phase 1)–Some Technical Problems Concerned with the Future Chinese Interconnected Power Systems" Power System Technology Vol.22 No.6 Jun. 1998 (in Chinese)

[2] Guo Jianbo, Yao Guocan, Xu Zhengxiong et al "Technical Investigation of the Future Chinese Interconnected Power Systems and Higher AC Voltage (Phase 2)–Prospective Application of Higher AC Voltage over 500kV in the Future Chinese Power Systems" Power System Technology Vol.22 No.7 Jun. 1998 (in Chinese)

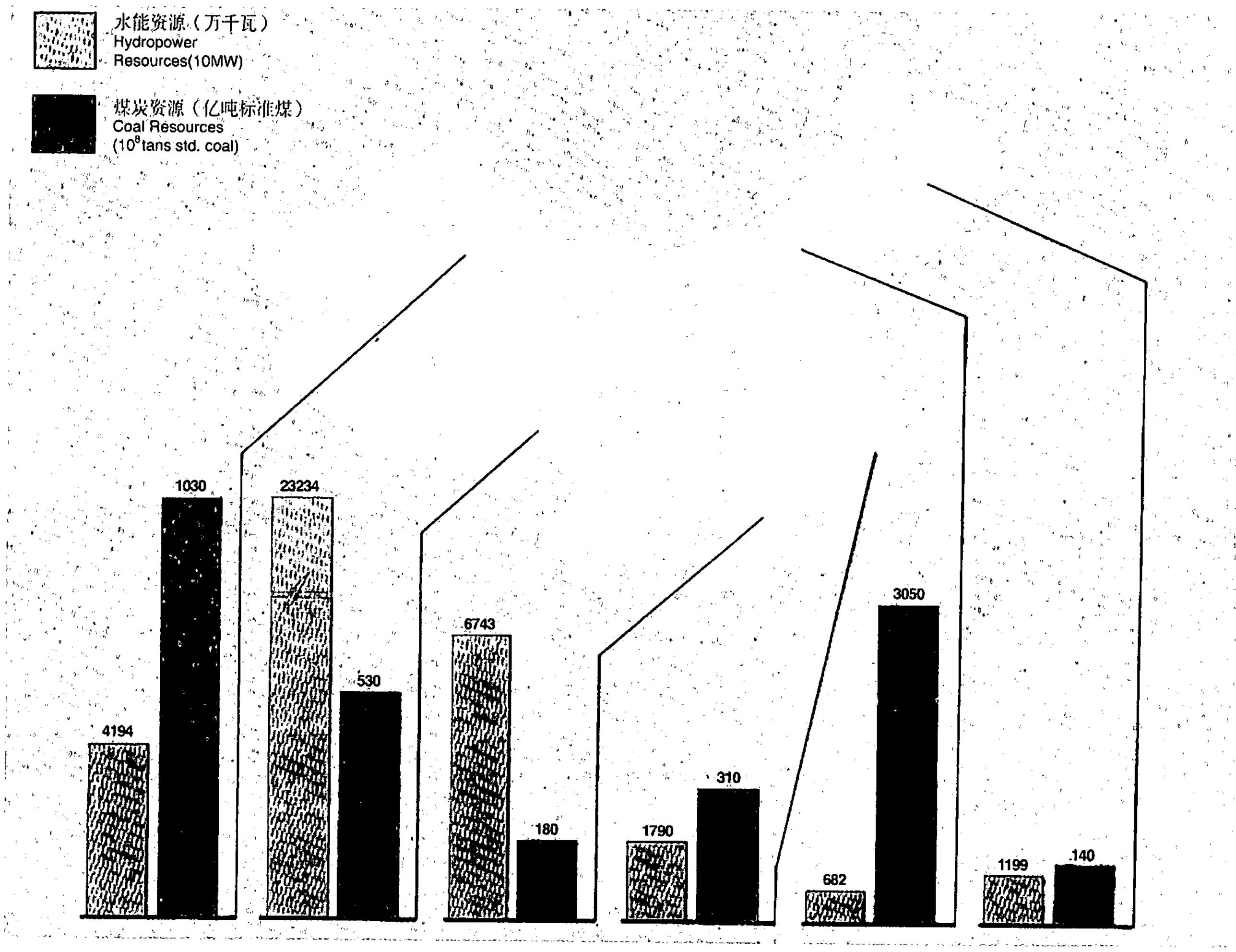
[3] Guo Jianbo, Yao Guocan, Xu Zhengxiong et al "Technical Investigation of the Future Chinese Interconnected Power Systems and Higher AC Voltage (Phase 3)–Inference and Proposals for Power System Interconnected and Higher AC Voltage Levels in Future" Power System Technology Vol.22 No.7 Jun. 1998 (in Chinese)

Names of Places (地方名稱)

Anding：安定
Baofeng：寶豐
Beijing：北京
Changfang：昌房
Changping：昌平
Changzhou：常州
Chengdu：成都
Dafang：大房
Datong：大同
Fangshan：房山
Fengzhen：豐鎮
Fujian：福建
Gezhouba：葛洲壩
Guangdong：廣東
Guangxi：廣西
Guangzhou：廣州
Guanzhong：關中
Guiguang：貴廣
Guizhou：貴州
Hebei：河北
Hechi：河池
Hongjiadu：洪家渡
Hubei：湖北
Huibei：惠北
Huishui：惠水
Inner Mongolia：內蒙古
JingjinTang：京津唐
Jingzhou：荊洲
Jinsha：金沙
Luodong：羅洞
Luoping：羅坪
Maoming：茂名
Mawo：馬窩
Nanqiao：南橋
Nuozhadu：糯紮渡
Sanguang：三廣
Sanxi：三西
Shaanxi：陝西
Shangdong：山東
Shanghai-Changzhou-Hangzhou：上海一常州一杭州
Shanxi：山西
Shentou：神頭
Shunyi：順義
Sichuan：四川
Tangshan：唐山
Tianjin：天津
Tianshenqiao：天生橋
Tuoketuo：托克托
Wanxian：萬縣
Wujiangdu：烏江渡
Xiangjiaba：向家壩
Xiaowan：小灣
Xiluodu：溪洛渡
Xushui：徐水
Yinxian：鄞（圻）縣
Yinzidu：引子渡
Yongshengyu：永聖域
Yunnan：雲南
Zhangjiafang：張家房

Paper No. 1

Figure 1 Distribution of Hydropower and Coal Resource in China



Paper No. 2

THE CHALLENGES, CONSTRAINTS AND SOLUTIONS FOR ELECTRICITY DISTRIBUTION IN HONG KONG ISLAND

Speakers : Mr Y.F. Leung, Distribution Planning Engineer
Mr S.C. Chan, Distribution Planning Engineer
Distribution Planning Department
Ir T.F. Chan, Area Engineer
Construction and Maintenance Department
The Hongkong Electric Co. Ltd.

THE CHALLENGES, CONSTRAINTS AND SOLUTIONS FOR ELECTRICITY DISTRIBUTION IN HONG KONG ISLAND

Mr Y.F. Leung, Distribution Planning Engineer
Mr S.C. Chan, Distribution Planning Engineer
Distribution Planning Department
Ir T.F. Chan, Area Engineer
Construction and Maintenance Department
The Hongkong Electric Co. Ltd.

Pape
No.

ABSTRACT

The Hongkong Electric Company Limited (HEC) has been supplying electricity to the Hong Kong Island, where the financial and commercial centre is located, for more than 100 years. Today, through her 11kV fully automated open ring distribution network, Hongkong Electric has achieved a distribution reliability rating above 99.998%, which is among the best in the world. The paper will describe the major initiatives undertaken by the Company on the 11kV network to achieve such reliability rating.

However there are limitations in the 11kV distribution network in supplying very high load density areas. The number of cables required is numerous and problems with cable outlet and mutual heating among cables are encountered. After detailed considerations, the Company has decided to introduce 22kV distribution system in selected areas in the coming years. The paper will describe the considerations behind to choose the 22kV closed ring distribution network and the benefits that it brings.

1. INTRODUCTION

The distribution voltage of the Hongkong Electric Company Limited is 11kV and basic network topology is open ring. This was first introduced in 1961when the system peak demand was just 114MW. In 2000, system peak demand had increased by more than 20 times to 2417 MW with energy distribution using the same 11kV distribution system. Over the past 40 years, HEC has undertaken major improvements in the distribution equipment and its supervisory and control system. These enhancements aimed to increase plant availability, reduce failure rate of equipment, and speed up fault restoration and resulted in substantial improvement in electricity supply reliability rating to over 99.998%, which was among the best in the world. First part of this paper will describe the major initiatives undertaken by HEC on the 11kV distribution system to achieve this reliability rating.

However, there are limitations in the open ring 11kV distribution system in supplying the very high load density areas in Hong Kong Island. With load density as high as 250MVA/km^2 and above in Central Business Districts (CBD), the area that an 11kV cable can serve shrinks substantially. Large number of distribution cables need to be laid from primary substations having firm capacity of 180MVA (i.e. more than 9000A at 11kV level). Mutual heating among multiple distribution cables installed side-by-side and crossing over transmission cables had resulted in cable de-rating problem in highly congested areas.

On the other hand, despite the high reliability rating achieved today, demand for better 'quality' electricity continues to grow and it has become obvious that the existing 11kV network has very little room to cater for further enhancement and system growth. After detailed considerations, the Company has decided to introduce a completely new 22kV closed ring distribution system in selected areas in Hong Kong. Second part of this paper expands on the considerations behind to choose 22kV closed ring distribution system, its topology and the benefits that it will bring.

2. MAJOR IMPROVEMENTS IN DISTRIBUTION SYSTEM

In the past decades, there were various improvement works being implemented in HEC's distribution system. Generally speaking, the improvement works can be classified into two categories, viz. at equipment level and at equipment control / supervisory level. Objectives of equipment improvement works are enhancement of safety in the operation of the network, upgrading of the equipment reliability, reduction in maintenance and increase in plant availability. Nevertheless, even if the most reliable equipment were installed in the network, there would be failures due to various internal and external factors. Accurate identification of faulty equipment and speedy restoration of the healthy part of the system is of equal importance to overall system reliability. This is the fundamental objective of the distribution supervisory and control improvement works.

Some of the key improvement works that have been successfully implemented in the distribution system are given in the following paragraphs.

2.1 EQUIPMENT LEVEL IMPROVEMENTS

2.1.1 SWITCHGEAR AND TRANSFORMER

In 1961, all distribution apparatus used mineral oil as the principal insulation media. Although mineral oil is a good dielectric material, electrical failure in oil insulated switchgear and transformer could have disastrous consequences to the operator and the network. Any resulting fire may damage not only the faulty equipment but its adjacent apparatus. Fault restoration time could be very extensive.

The Company introduced non-oil insulated distribution switchgear using either air or SF_6 as insulation medium together with vacuum circuit breakers in late 1970's. Use of non-oil insulated switchgear was adopted in mid 1980. Progressive replacement of oil insulated switchgear was carried out since 1987. Added benefit of the replacement programs is that modern remotely controllable switchgear is in place of the aged manually operated oil insulated switchgear. Together with the installation of Remote Terminal Units (RTU) in primary and secondary substations, remote operation of 11kV switchgear was achieved.

HEC started to look for non-flammable distribution transformers that could be installed in secondary substations both below and above ground level. After trying a number of alternatives, SF_6 gas insulated transformers were adopted in bulk since 1983. The gas transformers are designed to withstand normal system voltage even when the SF_6 gas is down to atmospheric pressure. With gas pressure low alarm monitored remotely and with stringent quality control in manufacturing and site installation, performance of the gas distribution transformers has been excellent.

Both the air/SF_6 insulated switchgear and SF_6 transformer require minimal maintenance efforts to up-keep their electrical performance. Interval between two preventive maintenance outages, which is condition based, can be extended without sacrificing safety and reliability. Extended maintenance interval had also increased the availability of the equipment to keep the network intact most of the time to cater for contingencies in the system.

2.1.2 DISTRIBUTION CIRCUITS

Unlike cities such as New York and Tokyo, direct burial system is the only available installation method for underground cable in most parts of Hong Kong. External disturbance and damages to cable and joints causing their immediate or subsequent failures continue to be the major source of failures in the distribution network. Improvements to cable and joints were therefore worked out over the year together with the suppliers to withstand the hostile installation condition here in Hong Kong.

At the beginning of 11kV network development, paper insulated lead sheath cable (PILC) was used. Bituminous fluid filled cast iron joint box were used together with PILC cable. 11kV XLPE cable was later introduced as this technology had matured. Non-compound filled jointing technique started to replace the more time consuming and skill dependent bitumous filled cable boxes. Jointing of conductor had also gradually changed from soldering to compression to the current shear-head bolted connectors. All these developments help to facilitate the prompt installation as well as quick repair of large capacity distribution cable and joints in the congested space beneath the streets of Hong Kong.

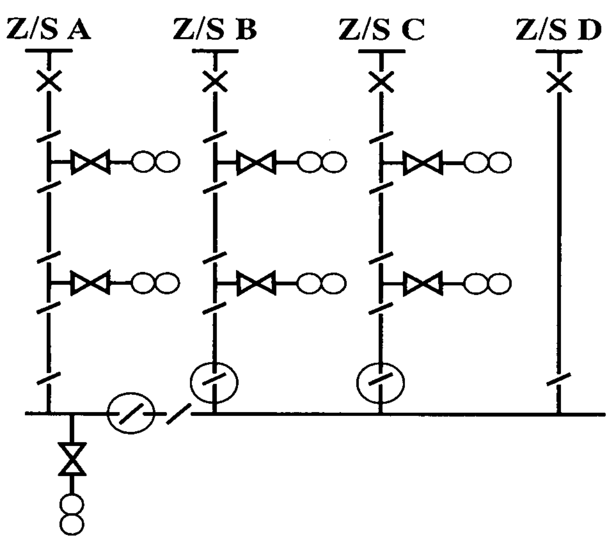
Failure statistics for all types of cable and joints were closely monitored and proactive replacement of aged and weak cable and joints identified were also carried out to reduce the overall faults rates.

2.2 SUPERVISORY AND CONTROL LEVEL IMPROVEMENT

Typical 11kV network in HEC is shown in figure 1.

From switchgear panels at primary (zone) substation, cables are laid to secondary (distribution) substations where ring main units (RMU) and transformers are installed. These secondary substations are interconnected in the form of a feeder group. Normal open points are placed at load break switches of the feeder group and this forms an open ring network. Circuit breakers are installed at the primary substation which will trip when fault occurs in the feeder leg, causing loss of supply to customers. Identification of the faulty element and its isolation is required before supply to the healthy part of the network can be restored.

Figure 1. Typical 11kV Network



2.2.1 FROM MANUAL TO REMOTE OPERATION

When the 11kV network was first introduced, only the primary substations were manned. Identification and isolation of faulty section was by trial and error by sending operators out to various secondary substations. Earth fault indicators were later introduced to aid fault identification and reduce the number of close-onto-faults. Reset of these earth fault indicators was done manually when first introduced.

Supervisory Control and Data Acquisition (SCADA) system for primary substation was introduced in 1969 and it covered all HEC primary substations. The concept of remote control and monitoring was applied to secondary substations in 1980. After the first batch of 112 substations in Central District were successfully connected to the distribution system computer, large scale retrofitting of RTU in secondary substations commenced in 1983 and fully completed in 1996. To date all 3400+ secondary substations in HEC 11kV distribution network, including those at remote areas, are fully remotely controllable and monitored.

2.2.2 RELIABLE INFORMATION GATHERING

To accurately identify the faulty section in the network, reliable and accurate fault indicators are required. Initially only earth fault indicators were installed which can cover about 80% of all fault conditions. To cover the remaining 20% of fault conditions, phase fault indicators were introduced in the mid 80's in new type of switchgear. The long term reliability of the fault indicators is also very critical. Different types of fault indicators had been tried. It was found that fault indicators with only passive element (i.e. without built-in battery) and driven by round CT (hence high noise immunity) were best suit for the job. With all efforts put in, pin-pointing of faulty section had approached 100% accuracy and average fault identification and isolation time of less than 5 minutes was achieved in recent years.

The added benefit of installing RTU to all secondary substations is the precise

Paper No. 2

information gathered on loading and temperature profile of switchgear and transformers inside the substation. Together with a good load management system, system overload and equipment overheating can be basically avoided, which in return contribute to the reliability of the plant being monitored.

3. LIMITATION OF EXISTING 11KV SYSTEM

The major limitation of the existing 11kV network is its open ring design. Despite the efforts put in to reduce fault rate and fast restoration of supply, short time interruption of supply for a few minutes is inevitable. Supply interruptions, though infrequent and short, have become less acceptable by the customers in recent years.

On the other hand, with increase in load density, in built up areas like Sheung Wan, Central, Wanchai and Causeway Bay, large number of 11kV distribution cables have to be laid along the roads to support the concentrated load. Mutual heating among these 11kV cables had resulted in significant derating and restricted the maximum number of cable to be laid in parallel. In many of the trunk routes, new 11kV cables can only be laid in carriageway to avoid unacceptable derating to existing installations. The valuable underground space is used up quickly and becomes more and more difficult to find. Under the constraint of mutual heating and limited space, any network improvement that will increase the number of cable to be installed for the same load demand should be avoided. As the utilization factor of cable is lower for closed ring as compared with open ring, large scale introduction of 11kV closed ring to overcome the inherent drawback of open ring network has been ruled out.

The only option left to facilitate further load density growth and improve quality of electricity supply for HEC customers will be the introduction of a higher distribution voltage. After careful consideration, the Company decided to introduce 22kV as the new distribution voltage.

4. THE NEW 22KV SYSTEM

4.1 CONSIDERATIONS IN CHOOSING 22KV

A number of factors affected the choice of the next higher distribution voltage in Hong Kong. These covered technical, operational and economic aspects.

On technical side, 22kV and 11kV equipment have very small difference in terms of size and weight. It was found that some switchgear suppliers even supply identical model for both voltages with minor adaptations. The same 11kV jointing techniques can be applied to 22kV using slightly thicker insulation. The 22kV/380V transformers are not much bigger and heavier. The same is not true for 33kV equipment, especially the size and weight of 33kV/380V transformer. The choice for 22kV equipment is much more abundant than the 33kV ones and direct 33kV/380V transformer appears to be a brand new product for most manufacturers.

Operational experiences of overseas utilities were also studied. The use of 22kV as distribution voltage was adopted in places like Taipei, Osaka, Singapore and Paris and no major problem in operation and maintenance was encountered. One observation during our study was that no major utility ever uses 33kV as the distribution voltage for direct transformation from 33kV to service voltage.

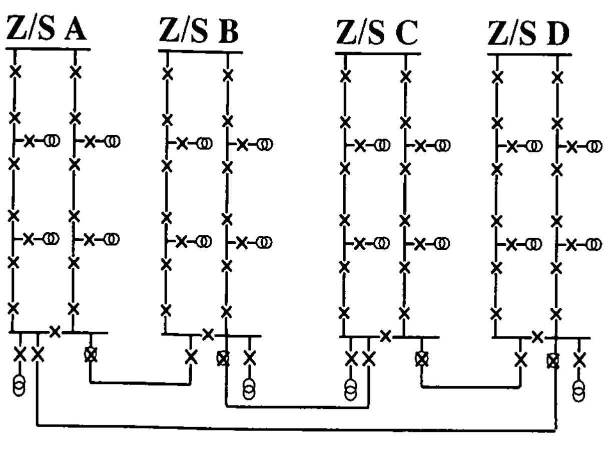
It was further concluded that the skill and techniques for the production, erection and maintenance of 22kV system are quite similar to that of 11kV. Training costs to bring in 22kV can be minimal and most of the training can be done in-house. Taking into account of about two folds increase in distribution capacity (in closed ring configuration) of the same conductor size of 22kV cable, the overall costs of ownership of the new 22kV system are found to be of the same order as that of equivalent 11kV system of the same capacity.

4.2 NETWORK TOPOLOGY

In the new 22kV system, it was decided to use simple closed ring configuration feeding from two separate circuit breakers on the same single busbar of a zone substation. At most four numbers of simple closed ring can be interconnected to one another using radial interconnectors. This topology is preferred due to its simplicity, cost effectiveness and high security. Load on each simple closed ring will be designed to enable full backfeed through the interconnectors to other closed ring. All existing features of 11kV open ring are retained, such as installation of RTU for control and monitoring, dual feeder arrangement in substations with two or more transformers and the remarkable load transfer capability among neighboring zone substations.

To cater for cable faults in the ring, pilot wire protection will be adopted for each cable section between two substations. Backup protection will be provided by feeder overcurrent and earth fault scheme at the circuit breaker of primary substation. Typical fault clearance time in the 22kV feeder will be about 120ms and more importantly, there will be no interruption of supply to customers for single cable faults / damages.

Figure 2 22kV Closed Ring Network



4.3 SWITCHGEAR AND TRANSFORMER

Specification of 22kV switchgear and transformer are prepared with due consideration to the reliability of the 22kV system.

To cope with humid and dusty condition in Hong Kong, all 22kV current carrying parts are either of fully screened solid insulation or sealed design. 22kV switchgear with vacuum interrupter and isolation and earthing switch are housed inside compressed dry air chambers. The switchgear is internal arc fault test for 1 second to ensure safety of the operational staff. Design fault level is 25kA.

SF_6 gas insulated transformer will be used. Protection of transformer is by means of OCEF relays at both HV and LV sides. This enables quick isolation of customer terminal fault, which may not be able to trigger the protection scheme on the HV side of the transformer.

4.4 CABLE AND ACCESSORIES

300mm^2 copper conductor cable 3-core screen type single steel wire armour MDPE oversheath cable is selected for the 22kV system. Tree retardant XLPE cable is specified to reduce the chance of having water tree even when the oversheath is damaged and water gets in. Internal / external stress cone screen type termination are adopted to reduce space requirement of the cable box and eliminate chances of phase-to-phase fault in the cable box.

Similar to 11kV joint currently used in the distribution network, the new 22kV joint adopts heat shrinkable design with mastic filled. Water blocked mechanical connector will be used. Each phase of the joint will be screened to eliminate any possible phase-to-phase fault developed in the joint.

5. THE WAY FORWARD

Over the past 40 years, HEC had been using 11kV as the distribution voltage to all our customers. Knowing the limitations of the present network that cannot be greatly enhanced without fundamental change in network design, 22kV is introduced as the new distribution voltage for the 21st Century.

According to present schedule, the first 22kV network will be commissioned in 2002. To cater for load growth of existing 11kV network in the built-up area, new zone substations will comprise of hybrid configuration to have both 11kV and 22kV panels. Demand from new development can be supplied through either existing 11kV or future 22kV network. However, for development in virgin areas, zone substation with only 22kV panels will be installed. In view of extensive coverage of the 11kV network, the new 22kV system will co-exist with the 11kV system for the years to come.

6. ACKNOWLEDGEMENT

The authors would like to express their sincere thanks to the Management of the Hongkong Electric Co. Ltd. for the permission to publish this paper.

REFERENCES

[1] L. Chan, P.K. Chan, 'Transmission and Distribution of Electricity in Hongkong Electric – Past, Present and Future', HKIE Symposium 1997.

[2] K.T.Yeung, 'Hongkong Electric's Distribution Network Reliability Enhancement – A Total Approach', HKIE Symposium 1998.

Paper No. 3

THE GERMAN SUPER SPEED MAGLEV TECHNOLOGY - SYSTEM CHARACTERISTICS AND MARKET POTENTIAL

Speaker : Mr Manfred Wackers
Director of Sales and Marketing
Transrapid International GmbH & Co. KG
Germany

THE GERMAN SUPER SPEED MAGLEV TECHNOLOGY - SYSTEM CHARACTERISTICS AND MARKET POTENTIAL

Mr Manfred Wackers
Director of Sales and Marketing
Transrapid International GmbH & Co. KG
Germany

Paper No. 3

ABSTRACT

It is widely recognized in industrialized nations that only modern, fast, attractive, track–bound transportation is capable of alleviating the pressure on existing transportation networks. Ever increasing globalization and urbanization tendencies demand transportation solutions that are capable both of relieving traffic density between metropolitan areas and of reducing existing and potential environmental damage. The Magnetic Levitation rail technology developed by Transrapid International offers a solution to the manifold challenges presented by urban development and population sprawl.

This paper describes several aspects of the Marketing of the Transrapid Maglev system

- The Transrapid Maglev system and its technical and economic characteristics
- Implementation parameters and fields of application for the Transrapid
- Strategies for specific international markets under development to introduce the Transrapid Maglev
- Status reports on the projects in the US, China, Australia and in Europe

Mobility is the pulse of civilization. The foundation of this mobility is a satisfactory transportation system. In fact, an acceptable infrastructure is a prerequisite of economic growth. This is pertinent both for established industrialized nations and for those nations experiencing rapid economic and population growth such as in the Asian Pacific nations. The predicted population growth rate in Asia, for example, of 30% over 25 years will strain the existing infrastructure to breaking point. It is well documented that the present economic growth rate of up to 10% and more in these regions cannot be supported when the required levels of mobility demanded by such an economy is inhibited by oversubscribed road and rail networks. The steady increase in road and rail traffic is choking current global networks. Roads, bridges, highways - even the air is overloaded.

Developed to fill the transportation niche between conventional wheel-on-rail trains and airplanes, Maglev System Transrapid easily can be operated at speeds of more than 300 km/h without increasing maintenance efforts. Levitating with a top speed of about 550 km/h Transrapid can successfully compete with air traffic at medium distances of 200 to 1000 kilometers.

As an airport-to-city shuttle, an intercity link or for other regional transportation needs the maglev system can help to connect the outskirts of a metropolitan area to the city center by a dynamic and convenient commuter service.

1. SITUATION OF TRANSPORTATION MARKETS IN THE FUTURE

1.1 ROAD TRAFFIC

One only needs to look at the population figures to understand that an environmentally friendly solution to road traffic congestion must be found. It is estimated that by 2025 the population of the earth will have reached an unprecedented 8 billion. Looking at the level of pollution and congestion which is currently the norm in some eastern countries, it is obvious that an increase in population by 2 billion people would lead to a disaster in many parts of the world as energy resources are increasingly drained and pollution levels soar.

1.2 AIR TRAFFIC

In the past 40 years, air travel has replaced ground-based travel as the most convenient and comfortable means of covering both mid and long distances. Air travel has gained huge popularity among commuters as the fastest and most reliable means of travel. However with the numbers of travelers growing yearly and with airports reaching breaking point, it has to be widely recognized that only modern, fast and attractive track bound transportation is capable of taking up the strain of competing with the airplane. This has already been acknowledged in Europe, where a veritable renaissance in the rail sector has been experienced, exemplified by the wide range of advances in technological system development being implemented in the various European countries.

Transportation experts and an increasing proportion of the general public concur: the imminent crisis in personal mobility can only be averted with the development and implementation of attractive high-speed mass transportation. It is doubtful that conventional, existing railway systems can be categorized as attractive enough for long distance travel in the public eye. In order to catch a substantial share of the market, to divert car traffic and air traffic to rail, the systems offered must be very fast and convenient. This, at least, has been the European experience.

In other areas of the world, the USA, Australia, China and Asia in general, distances tend to be much larger than in Western Europe, with the effect that speeds must further increase in order to go head to head with airlines. Transrapid Super Speed Maglev Technology is the answer to this challenge. Transrapid Technology offers a fast, attractive, comfortable, innovative solution to the transportation problems of the new era. However, like all original technological advances, Transrapid technology must meet certain economic criteria in order to succeed. Engineers may be enthusiastic about the potential of this new product, but the marketplace is still dominated by cars and other means of transportation, all of which are established products vying with each other for a share of the spoils.

2. SYSTEM CHARACTERISTICS

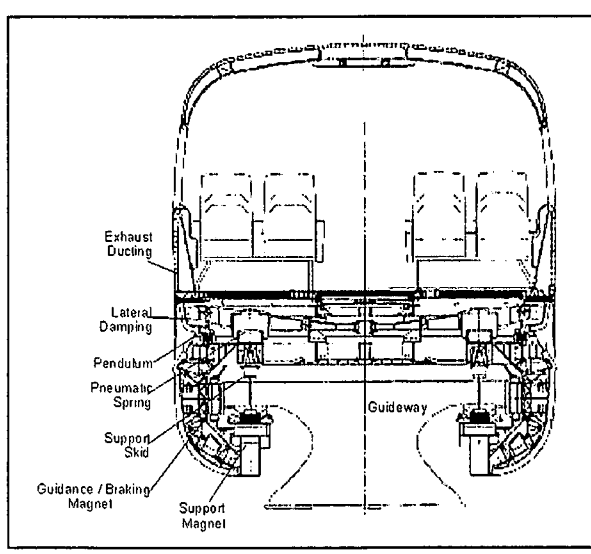
2.1 VEHICLE

Like any other maglev system in the world magnetic forces are used for levitation of the train. With Transrapid they are produced by individually controlled electromagnets, 32 half-magnets per middle car (30 per end car) provide redundant levitation function.Using exactly the same principle of attractive forces, guidance of the vehicle is provided by 12 cross-flux magnets per car.

Each magnet is attached to a levitation frame; two of them build a levitation chassis, which are connected to the car body via suspension systems.

A primary suspension system consisting of rubber elements between the magnets and the levitation frames to dampen vibrations and a secondary one using pneumatic springs (four of each) between a levitation chassis and the car body.

Figure 1 Cross Sectional View of Vehicle



After more than 10 years of operation with the TRANRAPID 07 vehicle testing and demonstrating the system at the Transrapid

Test Facility in Emsland (TVE), Germany, a new vehicle generation appeared to be best suited for superspeed application projects. The pre-series vehicle TRANSRAPID 08 consists of three cars. Significant improvements have been done with TR 08 especially for

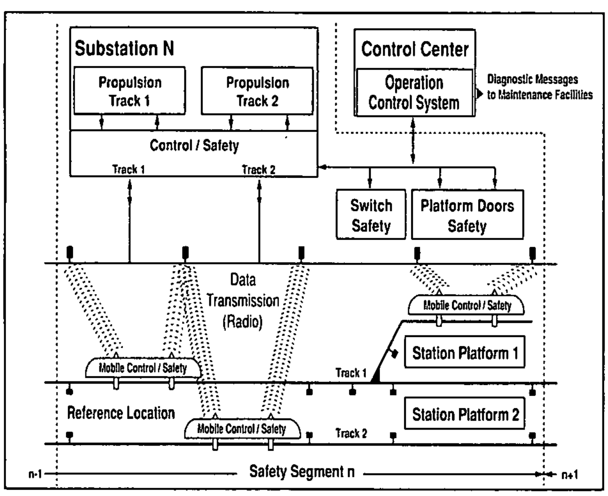
- Riding comfort (track centered guidance)
- Seat capacity (high density)
- Safety (crash worthiness)
- Coverings for the undercarriage

2.2 CONTROL SYSTEM

The operation of the maglev system is carried out automatically and technically safeguarded. A control center handles all communications, information, control and operating tasks for the entire maglev system.

Directional radio data transmission is employed for data transmission and communication between the stationary control equipment along the route and the mobile installations in the vehicles. A pair of neighboring stationary transceiver units mounted on masts ensures a built-in redundancy for the radio contact with every vehicle by covering both tracks. The masts are located alongside the guideway every 1-3 km. Data transmission between the control center, terminals, substations, switches and radio masts is realized by means of fiber-optic cables.

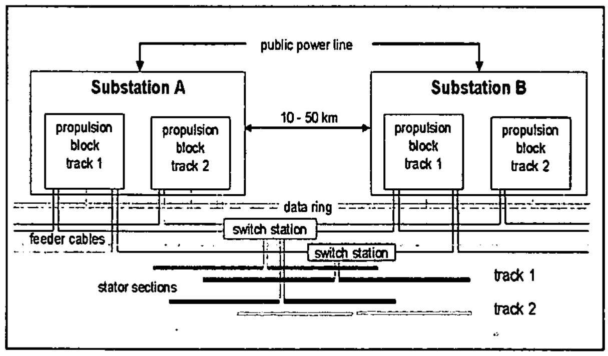
Figure 2 Control System



2.3 PROPULSION

The substations will ensure the supply of propulsion energy for the trains and serve all the electrical equipment along the route. Low-power-type substations with an average energy requirement of 2 MW will be located at the ends of the line in order to supply energy to the propulsion segments at the terminals, parking facilities and at the central maintenance facility.

Figure 3 Propulsion System



The high-power-type substations, with an average energy requirement of 7-12 MW, will supply energy to the propulsion segments, which range from 10 to 50 km long, via section feeder cable systems and electrical switch stations.

2.4 ENERGY SUPPLY

The substations for the Transrapid Maglev System are connected to the public grid via dead-end feeders. The connection is normally set at high-voltage level by means of high-voltage switching systems in the substations. The electrical consumers along the route will be fed from the substations via medium-voltage cables and transformer substations (1 kV/20 kV).

The facilities and installations for the maglev system, which are situated along the route, e.g. stopping areas, transformer substations, electrical switching stations, radio masts are also fed via these medium-voltage lines.

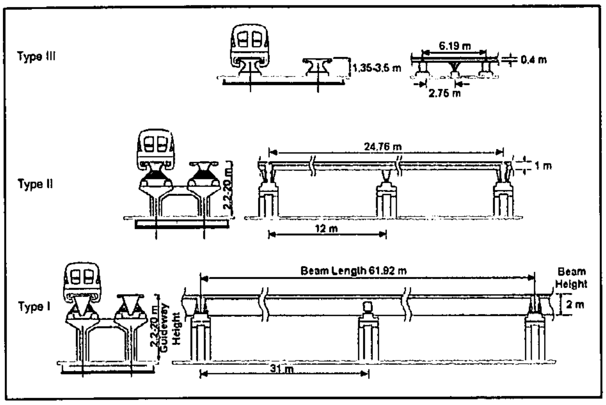
2.5 GUIDEWAY

Everybody here today realizes that the creation

Paper No. 3

of the infrastructure of high-speed trains is the most decisive cost factor. The development of the Transrapid Maglev system has not been confined to the theoretical. Particular attention has been paid to the practical viability of the system.

Figure 4 Guidway



The guideway, although very cost intensive, with its equipment of stator packs and long stator cabling, was designed with specific cost reduction technologies in mind, including fully automatic production lines and assembly processes.

The prefabricated guideway beams can be expediently erected onto the concrete substructures, thereby minimizing construction time and disturbances to the local economies long the route. Flexible alignment parameters mean fewer earthworks, fewer civil structures and allow the Transrapid guideway to travel around existing impediments instead of through them as with less flexible transportation systems.

These corrections have proved to be most important in completely new, so called intra - regional transportation applications in larger urban agglomerations which suffer more and more from daily traffic gridlock (L.A.): Transrapid's flexible, high performance alignment parameters with small curve radii, superb gradient climbing ability, at-grade and elevated guideway design allowing guideway heights of up to 20m without bridge structures give the flexibility to pass through urban and rural landscapes with minimal disturbance of the existing scenery. Where desired, this also allows for unrestricted animal migration, does not impede natural water flows and existing roads and paths can be maintained, so farming is not restricted.

2.6 TRANSRAPID SYSTEM ADVANTAGES

- High cruising speeds of 300-500 km/h to cover long distances quickly
- Cruising speeds of up to 250km/h in congested urban areas combined with very low noise levels
- Unbeatable overall trip times for distances up to 1000km
- Unbeatable overall trip times for short haul shuttle operation between outlying airports and city centres or as a superimposed train system to give relief in large, densely populated urban agglomerations as an inter-regional mass transit system.
- Light and flexible guideway designs / parameters
- Low maintenance due to completely contact free operation and low energy consumption.

These characteristics clearly demonstrate that the Transrapid Maglev concept and the design of all its major subsystems and components was completed with economic parameters in mind and with continuous critical review of all technical solutions.

The following addresses those international markets outside Europe, which Transrapid International is focusing on.

3. PROJECTS FOR THE TRANSRAPID SUPERSPEED MAGLEV

3.1 PEOPLE'S REPUBLIC OF CHINA

The People's Republic of China is planning a high-speed ground transportation network of approx. 8000 km. As well as the Shanghai Project, various routes are under consideration in and connecting with Beijing, Shanghai, and Hong Kong.

3.1.1 SHANGHAI - PUDONG INTERNATIONAL AIRPORT

The contract for the first application of Transrapid technology worldwide was signed on January 23, 2001. The new Pudong International Airport is located 30 km outside the center of Shanghai and is not yet connected by any public transportation means. Construction began immediately after signing and the first demonstration runs are scheduled for January 2003. Commercial operation is scheduled to begin in 2004.

Potential extensions are foreseen from the Pudong Airport station to the city of Hangzhou, a distance of 240 km. From the Longyang Road station, the potential extension is to the city of Nanjing, a distance of 300 km. This latter extension would be the first segment of the high-speed line Beijing – Shanghai.

Route length	30 km
Trip time	7 minutes
Headway	10 minutes
Stations	2
Vehicles	3 (5 sections each)
Ridership volume (Year 2005 – 2020)	10–36 million/year
Commercial operation	2004

3.2 GERMANY

After the cancellation of the Berlin – Hamburg Project in February 2000, the Federal Government selected 5 regional applications for use with the Transrapid. After initial investigation, two projects were chosen in October 2000 for detailed planning within a feasibility study. These feasibility studies are scheduled for completion in early 2002 and will form the basis for the realization of one or both projects. Both projects have the goal of initial operation in time for the World Soccer Championships in Germany in Summer 2006.

3.2.1 METRORAPID

In North-Rhine Westphalia (NRW), the route alignment of the first phase (initial route) connects the cities of Dortmund, Bochum, Essen, Duisburg, the Dusseldorf Airport, and the city of Dusseldorf. Later, the initial route could be extended from Dusseldorf via the cities of Wuppertal, Hagen, the Dortmund Airport, and back to Dortmund. The initial route with extension would encircle the Ruhr area with its population of approx. 12 million people. Another extension is considered from Dusseldorf via the Cologne Airport to the city of Cologne.

	Project	Corridor
Route length	78 km	212 km / 132 miles
Trip time (approx.)	34 minutes	
Stations	6	11
Operating speed (max.)	300 km/h	

Paper No. 3

3.2.2 MUNICH – MUNICH INTERNATIONAL AIRPORT

The Munich International Airport is the second largest airport in Germany with today over 20 million passengers per year. Although the airport is well connected to Munich by two suburban train lines and also a highway, these are at capacity and the trip time to the airport is not satisfying. The State of Bavaria, the city of Munich, and the airport desire a high-speed connection to the airport to ease congestion on the existing modes. The short trip time of the Transrapid connection is not foreseen to hamper the economics of the suburban train lines, due to the strong growth rates of the Munich Airport.

Route length	37 km
Trip time (approx.)	13 minutes
Stations	3

3.3 THE NETHERLANDS

3.3.1 RONDJE RANDSTAD

A high-speed ring connection between the cities of Amsterdam, Utrecht, Rotterdam, Den Haag, and Schiphol Airport is being investigated. The goal of this initiative is to reduce automobile traffic with intermodal stations in each city/airport. The distribution of the passengers at the stations would be handled by the existing taxi, suburban rail, and subway services.

Route length	164 km

3.3.2 AMSTERDAM - GRONINGEN

This route is foreseen to the northern portions of the Netherlands with the Amsterdam ring connection (see 3.1). Furthermore, this would allow airline passengers from northern Germany easy access to Schiphol Airport. With the Transrapid technology option, an extension of the route on to Bremen and Hamburg is also under consideration.

Route length	184 km

3.4 UNITED STATES OF AMERICA

3.4.1 MAGLEV DEPLOYMENT PROGRAM

Included in the Transportation Equity Act for the 21st Century (TEA-21) is the Maglev Deployment Program (MDP) that provides public funds for "Pre-construction Planning Activities" for several projects as well as for "Final Design, Engineering, and Construction Activities" for a single project chosen from those planned.

A total of US$ 55 million is available for Fiscal Years 1999 - 2001. Additional funding (up to US$ 950 million) for construction of a single maglev project will then be applied for as part of a public/private partnership financing concept patterned after the Transrapid Berlin-Hamburg Project.

A total of 11 organizations submitted maglev planning applications to the Federal Railroad Administration (FRA) in February 1999 for funding under the Program. Seven of these projects were selected for funding in May 1999. Six of the seven projects have selected the Transrapid as the technology of choice (these projects are described in more detail below).

The initial phase of planning activities extended from August 1999 – June 2000 and included system definition, environmental assessment, and financial viability. Two projects, Baltimore-Washington and Pennsylvania, were chosen in January 2001 for the next phase with increased funding for more detailed planning work (short list). This phase includes more detailed planning and engineering work and preparation of the Draft Environmental Impact Statement for each respective project.

All project activities in the US are conducted through TRI's US subsidiary, Transrapid International-USA, Inc. (TRI-USA), located in Washington DC. In addition to project management and liaison work, TRI-USA actively lobbies and works with the public and private sectors at the national, regional, and local levels.

The MDP Projects in which TRI is involved are listed in the following sections. Where both Project and Corridor data are given, the Project is the initial segment funded through the MDP and the Corridor is the potential extension(s) to the Project.

3.4.2 SHORT-LISTED PROJECTS

Baltimore – Washington Maglev Project

This route travels from downtown Baltimore to the Baltimore-Washington International Airport and on to downtown Washington DC. It would carry commuters and allow BWI Airport to serve as a third airport for Washington DC. Long term, corridor extensions are foreseen to the north to Boston, MA and to the south to Charlotte, NC.

	Project	Corridor
Route length (approx.)	60 km	1280 km/800 miles
Trip time (approx.)	20 minutes	
Operating frequency	12 minutes	
Stations	3	
Vehicles	5 x 3 sections	
Annual ridership	12.9 million	
Investment cost (approx.)	$ 3.3 billion	

Pennsylvania High Speed Maglev Project (Pittsburgh Airport - Pittsburgh – Greensburg)

This route would serve Pittsburgh commuters and help alleviate congestion on the bridges leading into Pittsburgh. The "Magport" terminal at the Pittsburgh Airport would be truly intermodal with airplanes, maglev trains, buses, taxis, and cars as well as a shopping mall and passenger/commuter services. The route is the proposed initial segment of the Cleveland – Pittsburgh – Harrisburg – Philadelphia network.

Route length (approx.)	76 km
Trip time (approx.)	28 minutes
Operating frequency (peak)	7.5 minutes
Stations	4
Vehicles	8 x 5 sections
Annual ridership	33.5 million
Investment cost (approx.)	$ 2.7 billion

3.4.3 REMAINING MDP PROJECTS

Atlanta – Chattanooga Maglev Deployment Project (Atlanta – Cartersville – Dalton – Chattanooga)

This route will connect Hartsfield Airport with Atlanta, Chartersville, Dalton, and the recently improved airport in Chattanooga, Tennessee. Hartsfield Airport is at capacity and further expansion would be difficult. A high-speed connection to the Chattanooga airport would allow sharing of traffic and services.

	Project	Corridor
Route length (approx.)	52 km	188 km/118 miles
Trip time (approx.)	23 minutes	59 minutes
Operating frequency	15 minutes	30 minutes
Stations	4	5
Vehicles	5 x 3 sections	
Annual ridership	3.6 million	

California Maglev Deployment Project (Greater Los Angeles)

The California High-Speed Rail Authority, the Southern California Association of Governments (SCAG), and the State of California Business, Transportation and Housing Agency have proposed a regional high-speed rail network for greater Los Angeles, which will connect the major regional activity centers and significant inter/multi-modal transportation facilities in Los Angeles, Orange, Riverside, and San Bernardino Counties. This system as envisioned would also provide connection to the San Diego Region, interline with the proposed California North/South corridor and provide for further corridor expansion into the high desert portion of Los Angeles and San Bernardino Counties as the region grows.

An initial segment, Los Angeles Airport – Union Station – Ontario Airport – March, has been selected for funding within the TEA-21 Maglev Deployment Program.

	Project	Corridor
Route length (approx.)	133 km	440 km/275 miles
Trip time (approx.)	58 minutes	
Operating frequency	20 minutes	
Stations	6	
Vehicles	8 x 8 sections	
Annual ridership	22.5 million	

Paper No. 3

California-Nevada Interstate Maglev Project (Las Vegas – Southern California)

Ultimately, this project is foreseen to connect Las Vegas with the southern California basin (Ontario County) as well as to the California North/South route. The project is foreseen to be completed in phases, LV Airport - Primm (state border), LV Airport – LV Downtown, Primm – Barstow, CA, and Barstow – Southern California.

	Project	Corridor
Route length (approx.)	56 km	433 km / 270 miles
Trip time (approx.)	11 minutes	
Operating frequency	20 minutes	
Stations	2	
Vehicles	3 x 8 sections	
Annual ridership	11.8 million	

Gulf Coast Magnetic Levitation Deployment Project (New Orleans)

This route will connect the New Orleans airport with the New Orleans Union Passenger Terminal (downtown) and then cross Lake Pontchartrain to provide commuter service to the fast growing suburbs on the northern shore.

Route length (approx.)	79 km
Trip time (approx.)	27 minutes
Operating frequency (peak)	10 minutes
Stations	4
Vehicles	7 x 5 sections
Annual ridership	5.1 million

3.5 AUSTRALIA

3.5.1 SYDNEY - WOLLONGONG

The necessity for a fast connection between these cities has been acknowledged by the New South Wales (NSW) government and evolved in 1998 into an "Action for Transport 2010" plan where this corridor has been addressed.

For the investigation of the Transrapid technology in this corridor, the NSW government conducted a detailed feasibility study in conjunction with the Transrapid Consortium of Australia.

Route length 75 km

3.5.2 MELBOURNE – MELBOURNE INTERNATIONAL AIRPORT

For the improvement of the regional traffic situation between the center of Melbourne and the Tullamarine Airport, the Victoria government conducted a transportation study in conjunction with the Transrapid Consortium of Australia.

Route length 29 km

4. SUMMARY OF MARKETING OBJECTIVES AND STRATEGIES

Timing and choice of marketing strategies must be carefully harmonized with the particular features of the respective markets. This is normally only possible by bringing in local consultants who are familiar with the political and economic situation as well as the approach to doing business in the particular region. The broad approaches to the international marketing of Maglev technology are based on the following key elements:

- International market survey and analyses with the purpose of better matching Maglev technology to the individual needs of the various markets and for allowing market trends to influence development work from the early stages.
- Ascertaining and evaluating potential application projects at an international level, completion of feasibility studies, including financial viability evaluations.
- Branding of Transrapid Maglev technology in the market place – positioning the technology as a high speed, reliable, high quality means of transportation.
- Initiation of the product adaptation process to satisfy country specific licensing conditions and other requirements of the project country.
- Putting Transrapid International in a position to tender directly for international projects and / or to participate in local consortia tendering for high-speed projects.

Paper No. 4

THE INTERCONNECTION OF REGIONAL ELECTRIC POWER SYSTEMS IN CHINA AND ITS TECHNICAL FEASIBILITY STUDIES

Speakers : Mr J.B. Guo, Director, Science & Technology Department
Mr Y.H. Yin, Director, Power System Department
Mr Z.X. Xu, Senior Engineer, Power System Department
Mr G.C. Yao, Senior Engineer, Power System Department
Electric Power Research Institute, Beijing

THE INTERCONNECTION OF REGIONAL ELECTRIC POWER SYSTEMS IN CHINA AND ITS TECHNICAL FEASIBILITY STUDIES

Mr J.B. Guo, Director, Science & Technology Department
Mr Y.H. Yin, Director, Power System Department
Mr Z.X. Xu, Senior Engineer, Power System Department
Mr G.C. Yao, Senior Engineer, Power System Department
Electric Power Research Institute, Beijing

Paper No. 4

ABSTRACT

This paper describes the schemes of regional interconnected grid in China. Based on the results of digital and analog simulations, some technical problems of the interconnected grid are also discussed. The regional interconnected grid will be basically established in 2020 and become one of largest power systems in the world.

Key Words: Regional Interconnected Grid China

1. INTRODUCTION

Electric power industry plays a significant role in the modernization of China. By the end of 2000, the total installed capacity reached 319 GW and the annual generation amounted to 1304.38TWh. Since the beginning of the new century, the interconnection of regional electric power systems has progressed faster in China. In May 2001, the 500kV AC tie-line between North China Power Network (NCPN) and Northeast Power Network (NEPN) was put into operation. There are also other interconnection projects currently under construction or in investigation stage.

In China, the distribution of energy resources is quite uneven geographically. 82% of coal deposit is scattered in the north and southwest. 67% of hydropower is concentrated in the southwest. Therefore the north and west are called as the energy bases in China. Unfortunately, 70% of energy consumption concentrates in the central and coastal areas of the country.

So transmitting electric power from the energy bases is one of the ways making up the deficits of energy in the central and coastal and it is imperative to develop regional power systems interconnection. In addition, China is vast in territory and the interconnection benefits, e.g., the benefit of shifting load can be obtained because of differences in the seasonal and daily load curves between regions.

In order to make the regional power network interconnection grows perfectly, preliminary studies have been carried out. This paper is a brief description about the studies. Further study is being carried out by means of digital and analog simulations.

2. GENERAL DESCRIPTION OF THE INTERCONNECTED GRID IN 2005

The period from 2001 to 2005 is an important stage in the development of regional power systems interconnection in China. The Left Bank Station of Three Gorges Project will be completed in 2005. The supply area of the Three Gorges Hydroelectric Station will probably include Central China, East China, South China and North China. So the projects of regional grid interconnection will be speeded up. Some key interconnection projects, which will be available in this period, are as follows:

- 500kV AC tie line between North China Power Network (NCPN) and Northeast Power Network (NEPN).
- 500kV AC tie line between North China Power Network (NCPN) and Shandong Provincial Grid(SDPG).
- HVDC line of ± 500kV, 3000MW from the left bank of Three Gorges to East China Power Network (ECPN). Considering the HVDC line of ± 500kV, 1200MW from Gezhouba to Shanghai, which has been available since 1989, there will be two HVDC lines between Central China Power Network (CCPN) and East China Power Network (ECPN).
- AC tie line between East China Power Network (ECPN) and Fujian Provincial Grid (FJPG).
- HVDC line of ± 500kV, 3000MW from Hubei province in Central China Power Network (CCPN) to Guangdong province in South China Power Network (SCPN).
- 500kV AC tie line from the left bank of Three Gorges to Sichuan and Chongqing Power Grid (SCPG). Therefore, CCPN and SCPG will be interconnected.

3. GENERAL DESCRIPTION OF THE INTERCONNECTED GRID IN 2020

By the year of 2020, the regional interconnected grid will be basically established. It will include most of the existing regional and provincial networks in China, which are: NEPN (Northeast Power Network), NCPN (North China Power Network), NWPN (Northwest Power Network), CCPN(Central China Power Network), ECPN(East China Power Network),SCPN(Southern China Power Network), SCPG (Sichuan Provincial Grid and Chongqing Power Grid), Shandong Provincial Grid (SDPG), Fujian Provincial Grid (FJPG), Hong Kong Special Administrative Region and Macao Special Administrative Region.

In the beginning stage, the main purpose of interconnection of regional power grids will be transmitting electric power. It will be gradually changed into obtaining comprehensive interconnection benefits, such as load leveling, emergency back-up, peak load savings, improving operation performance of power systems.

According to the distribution of energy resources, regional relations and interconnections, the regional interconnected electric power systems will be divided into three interconnected parts: the north section, the central section and the south section.

3.1 THE NORTH SECTION

The North section will be composed of NEPN, NCPN, NWPN and SDPG. The deficiency of electric power in NEPN will be mainly filled up by the Humeng's thermal base in Inner Mongolia. NEPN is to be connected with NCPN to obtain interconnection benefits. NCPN and NWPN will be probably interconnected along with the development of "Sanxi" thermal power base in the juncture of Shanxi, Shaanxi and Inner Mongolia (called as "Sanxi" for short). Also, it may be possible that NEPN or NCPN will be connected with Russia Power system.

3.2 THE CENTRAL SECTION

The Central section will be mainly composed of CCPN, ECPN(including FJPG) and SCPG. After the Three Gorges project is completed, there will be a corridor for transmitting electric power from west to east. CCPN, ECPN, SCPG will be interconnected by this passageway.

3.3 THE SOUTH SECTION

The south section will be composed of Guangdong, Guangxi, Guizhou, Yunnan, Hong Kong and Macao. In the South section, large amount of electric power will be transmitted to Guangdong from west area by HVDC and HVAC transmission lines.

3.4 THE INTERCONNECTION BETWEEN SECTIONS

There will be some interconnections among North, Central and South sections. According to the preliminary studies, North, Central and South sections will be interconnected mainly by HVDC lines or back-to-back DC. The main projects are as follows:

3.4.1. THE INTERCONNECTION BETWEEN NORTH AND CENTRAL SECTIONS

There are four connecting points between North and Central sections:

- DC back-to-back (in the first stage, 500kV AC link may be used, then it will be changed to DC back-to-back in the second stage) between North China Power Network (NCPN) and Central China Power Network (CCPN).
- DC back-to-back between East China Power Network (ECPN) and Shandong Provincial Grid (SDPG).
- DC back-to- back between Northwest Power Network (NWPN) and Central China Power Network (CCPN).
- HVDC line or DC back-to- back between Northwest Power Network (NWPN) and Sichuan - Chongqing Power Grid (SCPG).

The main purpose of the above interconnection projects is exchanging electric power to obtain interconnection benefits.

3.4.2 THE INTERCONNECTION BETWEEN CENTRAL AND SOUTH SECTIONS

There may be two connecting points between Central and South sections:

- HVDC line of ± 500kV, 3000MW from Hubei province in Central China Power Network (CCPN) to Guangdong province in South China Power Network (SCPN). The main purpose of this interconnection is transmitting electric power from Three Gorges to Guangdong province. Also,it can obtain trans valley compensation benefit between the Yangtze River and the Lanchang River as well as Honghe River.
- DC back-to-back (in the first stage, 500kV AC link may be used, then it will be changed to DC back-to-back in the second stage) between Sichuan - Chongqing Power Grid (SCPG) and Guizhou Province Power Grid. The main purpose of this interconnection is to exchange electricity between thermal and hydroelectric power.

At present, some of the mentioned interconnection projects are already available, whereas some are under construction or in the investigation stage. The main Interconnection and Transmission Projects by 2020 are shown in Table 1.

4. DIGITAL SIMULATION STUDIES FOR THE SCHEMES OF REGIONAL POWER SYSTEM INTERCONNECTIONS

For evaluating the technical feasibility of regional power system interconnection schemes, preliminary digital and analog simulations, such as load flow and stability studies, have been carried out. The results of the simulations have shown that the interconnection schemes are technically feasible and able to meet the technical requirement of "The Criteria of Power System Security and Stability". But the following problems have been identified whereby countermeasures should be taken.

4.1 For the synchronous interconnection, power system stability would be improved or reduced. More attentions should be given to the relatively weak sections in an interconnected grid. Enhancing the voltage support and grid in the relatively weak sections are useful to improve stability after interconnection.

4.2 When multi-regional grids are interconnected in different points, a big loop network structure should be avoided to prevent loop flow and cascading in severe faults.

4.3 When the synchronous power system is extended with interconnection, more attentions should be paid to the problems of low frequency power oscillation and inadvertent power fluctuation on tie lines. PSS and TCSC are useful to damp low frequency oscillation.

4.4 When several HVDC inverters are concentrated in a narrow area of receiving system, the following problems and measures must be carefully considered:

(a) Simultaneous commutation failure of several HVDC links and its influence to the receiving end.

(b) Voltage instability problem of the receiving end related to the HVDC links.

(c) Mutual impacts between AC and DC system both in sending and receiving ends.

(d) The measures, such as reasonably arranging the capacity and location distance of inverter stations, allocating SVC, optimizing the controller of HVDC system, should be considered.

5. CONCLUSION

5.1 The first decade of the twenty-first century will be the key time for establishing a nationwide interconnected grid in China. This interconnection will strive to carrying forward with the Three Gorges Project as the center. By

Table 1 The Main Interconnection and Transmission Projects by 2020

Interconnection Project		Capacity(GW) /distance(km)	Transmission Candidates
NEPN√NCPN		About 1GW/159	AC 500kV
Hu League(Inner Mongolia)}Liaoning		4.7~10GW/1100	AC 500kV up to 1200kV or HVDC
The west of Inner Mongolia }NCPN		Up to 10GW/400~800	AC 500kV with SC
NWPN}NCPN		1.2GW or more/500~1100	HVDC or AC 500kV or AC 750kV
South Shanxi (Yangcheng)}North Jiangsu		3~4/700	AC 500 kV with SC
NCPN√CCPN		-	at first AC 500kV link, then will be changed to DC back-to-back
SDPG√ECPN			DC back-to-back
Shaanxi√Sichuan			HVDC line or DC back-to- back
NWPN√CCPN			DC back-to-back
The Three Gorges	} CCPN	12GW/up to 500	AC 500 kV
	} ECPN	7.2GW/about 1000	HVDC ±500 kV
	} CYPG	Up to 2GW/335	AC 500 kV
ECPN√FJPG		-	AC500kV
CCPN } SCPN		3.0GW/ about 1000	HVDC
SCPG√Guizhou Province.			at first AC 500kV link, then will be changed to DC back-to-back
Xiluodu, Xiangjiaba	} CCPN	6GW/1200	HVDC or HVAC with SC
	}ECPN	10GW/2300	HVDC or UHVAC
TSQ,Yunnan & Guizhou}Guangdong		7.0GW/ about 900	Hybrid of 500 kV AC& ±500 kV DC
Step stations in Lancang River (Xiaowan, Dacaoshan, Nuozhadu, etc.) } Guangdong		7GW~8GW/1100~1400	HVDCDC
Northeast China–Russia		-	Further studies are needed
Yunnan Provincial Grid–Thailand		-	Further studies are needed

"}" means the direction of power flow, and "√"means power exchange between two systems.

the year of 2020, the regional interconnected grid will be basically established in China.

5.2 In the beginning stage, the main purpose of the interconnection of regional power grids will be transmitting electric power. It will be gradually changed into obtaining comprehensive interconnection benefits, such as load leveling, emergency back-up, peak load savings, improving operation performance of different power systems.

5.3 The results of the digital and analog simulations have shown that the interconnection schemes are technically feasible and able to meet the technical requirement of " The Criteria of Power System Security and Stability ", but some technical problems have been found and countermeasures should be taken.

REFERENCE

(1) Guo Jianbo, Yao Guocan, Xu Zhengxiong, Yin Yonghua "Technical Investigation of the Future Chinese Interconnected Power Systems and Higher AC Voltage (Phase 1)¢wSome Technical Problems Concerned with the Future Chinese Interconnected Power Systems", Power System Technology Vol.22, No.6

(2) Guo Jianbo, etc. "Technical Investigation of the Future Chinese Interconnected Power Systems and Higher AC Voltage (Phase 2)¢w Prospective Application of Higher AC Voltage over 500kV in the Future Chinese Power Systems", Power System Technology Vol.22, No.7

(3) Guo Jianbo, etc. "Technical Investigation of the Future Chinese Interconnected Power Systems and Higher AC Voltage (Phase 3)¢w Inference and Proposals for Power System Interconnection and Higher AC Voltage Levels in Future", Power System Technology Vol.22, No.8

Names of Places (地方名稱)

Anding：安定
Baofeng：寶豐
Beijing：北京
Changfang：昌房
Changping：昌平
Changzhou：常州
Chengdu：成都
Dafang：大房
Datong：大同
Fangshan：房山
Fengzhen：豐鎮
Fujian：福建
Gezhouba：葛洲壩
Guangdong：廣東
Guangxi：廣西
Guangzhou：廣州
Guanzhong：關中
Guiguang：貴廣
Guizhou：貴州
Hebei：河北
Hechi：河池
Hongjiadu：洪家渡
Hubei：湖北
Huibei：惠北
Huishui：惠水
Inner Mongolia：內蒙古
JingjinTang：京津唐
Jingzhou：荊洲
Jinsha：金沙
Luodong：羅洞
Luoping：羅坪
Maoming：茂名
Mawo：馬窩
Nanqiao：南橋
Nuozhadu：糯紮渡
Sanguang：三廣
Sanxi：三西
Shaanxi：陝西
Shangdong：山東
Shanghai-Changzhou-Hangzhou：上海一常州一杭州
Shanxi：山西
Shentou：神頭
Shunyi：順義
Sichuan：四川
Tangshan：唐山
Tianjin：天津
Tianshenqiao：天生橋
Tuoketuo：托克托
Wanxian：萬縣
Wujiangdu：烏江渡
Xiangjiaba：向家壩
Xiaowan：小灣
Xiluodu：溪洛渡
Xushui：徐水
Yinxian：鄞（圻）縣
Yinzidu：引子渡
Yongshengyu：永聖域
Yunnan：雲南
Zhangjiafang：張家房

Paper No. 5

INDUSTRIAL IT-SOLUTION FOR THE GLOBAL POWER MARKET PLACE

Speaker : Mr M.Y. Ng
General Manager, Export Markets
ABB Utilities AB
Sweden

INDUSTRIAL IT-SOLUTION FOR THE GLOBAL POWER MARKET PLACE

Mr M.Y. Ng
General Manager, Export Markets
ABB Utilities AB
Sweden

ABSTRACT

The power industry is in a phase of transition - openness, competition and deregulation are being introduced at breakneck speed in many parts of the world. As a result, the use of information is taking on a new role, bridging technical, administrative and economical aspects. The operational focus has moved to fulfilment of business objectives and increasing of customer services. The importance of an Information Technology (IT) strategy which takes account of all company objectives is growing.

Many vendors to the power utilities have since decades been operating globally, not only the sales and service operations but also engineering as well as R & D. What is new to us is the facts that many power utilities have become global players in the last few years through acquisitions outside the utilities' national base. This process is just in its beginning. The globalization of the utilities has created and will continue to create new challenges both to the vendors and the utilities themselves.

We can foresee that more global partnering is on the way, i.e. global alliances between global equipment suppliers and global utilities. The infrastructure for globalization, from GSM mobile phone to Internet, is widely available. Industrial IT-solution offering accessibility to global know-how and global support is a must. The critical issues for the global utilities can be the availability of human resources fit for global operation.

1. IT IN THE POWER INDUSTRY

The power industry is in a phase of transition - openness, competition and deregulation are being introduced at breakneck speed in many parts of the world. As a result, the use of information is taking on a new role, bridging technical, administrative and economic aspects. The operational focus has moved to fulfilment of business objectives and increasing of customer services. The importance of an Information Technology (IT) strategy which takes account of all company objectives is growing.

Traditionally, there has been a strong belief that centralized control provides the most efficient solution to any nation's energy supply. Generators and network operators worked closely together to find an optimum for the minute-to-minute operation, while developing resource scheduling programs that optimize generation in a medium-term to long-term perspective. This has been fulfilled in a large number of advanced Network Management Systems.

The new electricity markets are characterized by open access networks, competition in power generation and trading and establishing an energy market place for trading of energy. Electricity consumers become customers signing contracts with the producers. Network operation is still regarded as a "natural" monopoly with its services paid by transfer tariffs. Operators continue to focus on security, i.e. reliability of supply, while minimizing transfer losses.

The development of new IT-systems to meet with the new markets also offers a completely new opportunity to avoid the "island-of-operation" position that was common only a few years ago. To be successful in this market, the cooperation between operation, trading and risk management is the key. A need for

Paper No. 5

information applies also to network operations, on all voltage levels. The competitive electricity market with its more dynamic energy contracts, requires more efficient support for scheduling of network resources, detection of bottlenecks etc.

The development is specially dramatic for distribution companies with new demands on keeping up with services while consumers/ customers are free to change suppliers. The need for integration of new systems for customer information all the way to automatic meter readings and billing systems is there. The integration of graphical information systems with network management and outage trouble call systems is rapidly gaining progress, while maintenance and expansion planning systems for distribution networks are also there.

During this period of transition global vendors have to establish itself as a supplier of Information Technology products and services for electricity markets throughout the world. For example, ABB systems are essential to the operation of competitive markets in England & Wales, North and South America, Scandinavia, Singapore, South Africa and Australia. Its systems installed at the Power Exchanges are used for scheduling the market, determining prices, and settlement of payments.

2. DEREGULATION CHANGES CONDITIONS FOR OPERATION OF NETWORKS

The traditional electricity market is characterized by national, regional and local monopolies for power distribution. For generation as well as for distribution companies there have been structural changes in the past and this is expected to continue in the future. In the past, companies that were in possession of concession of a distribution network more or less owned the customers. In reality, there was no alternative supplier of electricity to a customer. Still there were some mergers taken place to improve efficiency and economy. In the future more mergers on the global basis and a more distinct separation between network companies and power producers/retailers are expected to come. Also new actors are entering the market, e.g. some oil companies becoming energy companies.

The new electricity market is characterized by three main issues:

a. Open access networks - Customers are free to sign contracts with electricity service suppliers (Generators, Traders and/or Retail Suppliers). Network operators focus on selling transfer services to the suppliers, while maintaining security of supply and an efficient continual power balance.

b. Competition in power generation and trading - The aim is to increase the total operational efficiency of each company, not forgetting investments, maintenance and organizational costs.

c. A free market place - Customers and suppliers meet in the market to establish the "right" price of electricity. This could be divided into a commercial market for physical energy contracts and a balance market to meet the hourly balance needs.

Electricity consumers (or loads) become customers. They may comprise large industrial consumers or groups of consumers, as well as individuals. A consumer may have one supply contract with many geographically dispersed load points. New constellations of customers are expected to show up. Producers or generators sign bilateral contacts with customers. Bilateral contracts might cover a majority of the supply while a market place handles the remaining portion. New suppliers and traders appear on the market. The energy supply itself of power distributors can be legally separated from the distribution network operator and become a retail supplier.

The energy market focuses its activities on competition. Suppliers operate on cost minimization and profit maximizing. Customer orientation is seen in increased services and in the search for product differentiation (e.g. additional services and products) to meet customer demand. Contract negotiations and a free market place invent new types of supply schemes adapted to customer needs. Each supplier provides daily transfer needs to network operators and receives consumption information for his accounting and billing.

Network operation is a "natural" monopoly under the control of a network authority. Transfer services are paid by transfer tariffs. Tariff structures need to cover operational costs, as well as giving incentives to investments for improving network reliability. Network operators appear on three levels:

a. Main grid, where a national grid company or an independent system operator is assigned overall responsibility for the interconnected power system.
b. Regional network, with operators responsible for subtransmission in their corresponding area.
c. Distribution network.

Network operators continue to focus on security, i.e. reliability of supply, while minimizing transfer losses. Quality, in terms of voltage and frequency, as well as overall effectiveness, are key factors. A network authority specifies, supervises and keeps control of these measures.

3. POWER SYSTEM CONSTRAINTS ON ELECTRICITY TRADING

Over the past decade electricity markets around the world have become increasingly competitive. An electricity market place for generators, traders and retail suppliers, is now in operation in many regions across the globe in the form of a Power Exchange. At the same time Independent Systems Operators (ISOs) are in operation in many countries and regions across the globe. Competition between retail suppliers has intensified, and customers, who are able to change suppliers, demand lower prices and better service.

The electricity trading supports the generator/ trader marketing/bidding on an open marketplace. It is always tuned to the specifications of each trading/pool structure and related contractual agreements. The energy trading supports large scale agreements on the wholesale electricity market, including marketing and bidding through electronic transaction posting and negotiations between utilities and customers. In some countries the electricity network has an open access all the way to distribution and end-consumer levels. To properly act in bidding on such, a marketplace needs retail sales functions that offers support for such activities, either in bilateral agreements, in standard contracts or in a pool arrangement.

The electricity trading is not quite so straightforward as the normal everyday commodity. E.g. it is impossible to say which generator is supplying energy to which load. Furthermore, in a typical power system there exists no electric storage capacity, and the generation has to simultaneously match with the demand. Electricity markets have one attribute that makes them different from other commodity markets - the quantity actually delivered and consumed may be different from the quantity contracted for. The energy consumer cannot predict how much energy will be utilized a day, or even an hour ahead. Thus, electricity has to provide not only for basic energy contracts on a forecasted basis, but also have to provide for balancing power which is required to make up the differences between forecasts and demand.

Furthermore, all generators in an interconnected power system must run in synchronism with one another. The integrity of the power system depends upon keeping the frequency of supply very close to nominal. Since frequency deviation is a near-instantaneous measure of the difference between supply and demand, there then arises another requirement, which is for regulation of plant outputs up and down to maintain frequency

The transportation of electrical energy is a complicated task. It appears like a pool - electric energy is produced and put into the pool, and taken out by consumers. However, many transmission systems have bottlenecks, or congestions, when various lines in the grid are at risk of being overloaded by the patterns of production and demand that exist. The only way to control transmission flows on individual lines today is to adjust the production (and possibly demand) at the grid nodes or substations so that the physics of grid behavior give the desired outcome. Ways of modeling this vary from the extremely complex - full AC analysis and modeling of the entire grid and all its nodes. And electric transmission lines consume energy as they operate, i.e. they create - losses. The magnitude of the losses depends upon the particulars of the transmission equipment and the operating pattern of production and demand. Basically, when a producer sells output from a plant that is far away from the intended consumer, more losses are incurred than if the transfer is short. These incremental losses can be calculated and allowed for.

Keeping the balance between supply and demand and the quality of the power transmitted requires services to the network. The fact that energy effectively flows into a pool (the network) and then flows out to the end users through many conduits produces a new problem of ensuring that fairness prevails in settlement of payments for its production and use. The solution of all these problems and provision of an environment in which competition can thrive is the goal of the electricity markets.

4. MARKET STRUCTURE

Some 10 years ago two rather distinct approaches were seen in setting up an electricity market, and they really did not appear to have very much in common. The refinements, that have been seen over the years, have, however, brought forward the best from both. Common to each of the market developments has been the establishment of competition amongst generators and suppliers of energy. Choice for the end consumer has been a goal of each. Services to maintain quality of supply over the networks (known as Ancillary Services) have been handled quite differently in each of the models to date. Motivations have differed between markets such that some key differences can be seen in their structure.

The elements that differentiate the market models are raised from the above discussion and the following questions:

- How is the market for energy and ancillary services operated on a day ahead, hour ahead and real-time basis?
- Who schedules and controls the power production resources - the owners or the grid operators?
- How is the market for balancing energy developed and operated?
- Who is responsible for demand forecasting and what are the consequences of deviations?
- How can buyers and sellers interact in the different market models: only via the exchange; via side contracts, or directly in bilateral contracts?
- How is the settlement function between actual and scheduled deliveries done? How many settlements are there?
- How are the ancillary services (reserves, regulation, and others) provided for and who provides them?
- To what extent are external market participants able to play in a defined market or pool?
- How are transmission losses paid for and who pays them?
- How are transmission tariffs collected and paid to the transmission owners?
- How is transmission congestion handled - via zones, via locational pricing, via an auction of re-dispatch; or via a rights market and/or auction?

Existing markets around the world have approached these problems from different starting points. The majority of benefits to the actors involved come from the introduction of competition in generation. If the establishment of the market is linked strongly to a privatization of government owned assets, or where the power infrastructure remains in development, then the simplest model will tend to prevail. If, on the other hand, the market is aimed at increasing de-regulation in an already privatized and well-developed industry then more complex models tend to be adopted even though they may or may not maintain the status quo of the control and ownership of generation and transmission assets.

Whilst an increased access to competition tends to be the one which is adopted, the growing interest and participation of financial markets in energy is also driving towards more open (and complex) market models. The financial markets desire price transparency, liquidity, standard delivery definitions that can enable futures and derivatives products to be created and traded, and as much transparency of ancillary services associated with delivery as the market participants can handle.

4.1 THE UK POOL

The original establishment of the Pool model for electricity trading acknowledged that much of the trade in energy would be through bilateral contracts between market participants. The objective of the pool was to ascertain how much of each of the contracts was satisfied by each party and where either was outside contract cover and therefore buying or selling power through the spot market. This model scheduled generation against predicted demand. It then scheduled contracts against the available generation. For each of the contracts where supply was fulfilled by generation from the contract party no payments through the marketplace were made. For the differences payments were made to or from the market based on the spot price. This spot price was taken as the highest priced qualifying generator scheduled to operate in each $^1/_2$ hour. A method of compensation was introduced to take account of reality on the day.

The market ignored the concept of network constraints and simply assumed that all power contracted could be delivered without problems to the contract party. The impact of both network constraints and the provision of ancillary services popped up as an uplift payment to all purchasers of power from the market. This model suffered difficulties due to the complexity in understanding the scheduling of contracts. This was a kind of new concept which did not fall easily with the city and made it very difficult to evaluate the trading risk of the UK companies being privatized with a resulting sell off by the UK government.

The pool model was rapidly followed by a simplified single pool model, which ignored energy contracts and forced all power to be traded through the pool. Bilateral contracts were then still possible but not an absolute requirement with a single clearing price forming the basis for market payments (in and out). In order to have a bilateral contract, however, this represented more the flow of cash than of energy.

Transmission constraints were ignored in this model with all costs associated therewith being bundled into an uplift payment added to the purchase price of energy from the pool. Ancillary services were contracted by the grid operator (with the exception of spinning reserve which was paid through the market) and again paid for through uplift on the pool price. This model was hugely successful in achieving setup of the market and sell off of the government assets. The single pool model additionally proved very attractive to new developers who were able to ultimately make speculative investments in modern efficient power plant (knowing that at least they were guaranteed to sell all of their output at the market price if they were prepared not to try and influence it).

The UK model takes bids from generators and load managers. A unit commitment model optimizes the scheduling process using this against the demand forecast for the day following. The grid operator uses an ABB supplied generator optimization and loading algorithm (unit commitment) which incorporates transportation models for transmission constraints. Thus an active constraint results in a higher clearing price for everyone. This provides efficiency incentives and some benefits from improving the quality of the transmission grid infrastructure.

The UK pool settles on each business day. Settlement takes place some one month after the trading day in question. In the run up to that a number of versions of settlement reports are issued. This is done in order to give market participants the opportunity to resolve any disputes they may have over payments to or from the pool before money actually changes hands. On the due day, however, money is exchanged electronically between pool member bank accounts and it is the members responsibility to ensure enough funds are in the pool transfer account at the appointed time. In the UK pool all money are settled through the market so quite large cash flows take place on each trading day. Most of the generator income is based on the day ahead scheduled generation output.

The benefits of this market model are:

- It is simple to set up and operate.
- It supports security and quality of supply.
- It provides a high degree of transparency.
- It encourages development of new efficient generation
- It fits naturally when there is only one transmission owner; when the bulk of the participants will be in the pool, and is an easy transition for an existing industry pool to make.

Some of the disadvantages are:

- The Forecast model encourages gaming in constraints.
- There are no clear signals as to the value of improving the Transmission Grid.
- Congestion costs and losses are smeared in the uplift.
- There is no choice of whether to trade in the market (everyone must play).
- Transmission bottlenecks make for increased cost to all market customers and not just to the ones responsible therefore.
- Commitment of plant and the cost therefore is managed by the market and not the plant owner.
- The availability of marginal price for all keeps power prices high in favor of the generating companies.

4.2 THE NORDPOOL IN NORWAY, SWEDEN AND FINLAND

NordPool solved the problems of bilateral contracts and fairness by taking a radically different approach to the power pool of the UK. The grid operator who handles ancillary services and energy balancing runs a power exchange. Bilateral contracts are then handled outside the physical market with the exception that contract parties are charged with imbalance in proportion to their imbalance caused. The NordPool in Norway has a simplified model of network constraints, which results in zonal prices. This is somewhat constrained in comparison with Sweden which is considered as fully unconstrained. Finland later became a partner in NordPool with a phase of merging and adapting to the market rules.

There are three operational markets: The futures market – an over the counter forward trade in energy; The day ahead market – operated by the power exchange (NordPool) – a contract trading model with price matching for residual trades, and the balancing market – a single buyer model for purchase of network frequency support.

Ancillary services are provided by the network operator and recharged to suppliers in the region. Trading in the balancing market is non-mandatory. The same is true for the day ahead market where the purchase and sale are in the same market region. Where contract trades go across the zonal boundaries then the generation and load must be bid in the day ahead market at zero prices up to the contract levels. Any day ahead trade in uncontracted power results in price matching between the generator price of production and the buyer price to buy. The matching price sets a single marginal price in each hour, which is the market-clearing price. Constraints are simulated in the day ahead market by price differences between the market zones. This is designed to encourage trade within the transportation capability of the market. The balancing market buys power or demand reduction on the day as required. The ISO operator buys this on a single buyer basis. This is then re-charged to the market participants as a capacity fee.

Generators schedule and dispatch their own energy in this model such that the grid operator is responsible for balancing supply and demand and maintaining quality of supply only.

The benefits of this market model are:

- It supports direct bilateral trades.
- Trading in the market is optional.
- Bids are for energy trades only and do not necessarily relate to individual physical generation units.
- Imbalance on the day is levied to the perpetrator.
- Plant management and dispatch is the responsibility of the owner.

Some disadvantages are:

- It is complex and costly to set up.
- It does not ensure security or quality of supply.
- Transparency is limited to trades, which occur in the day ahead market (optional to participants).
- There are no clear signals as to the value of improving the Transmission Grid.
- Provides few incentives for new independent generation.

4.3 THE SINGAPORE POWER POOL

The Singapore Power Pool adopted a modified model of the UK pool model but with some interesting enhancements. Attempts were made to encourage fair-trading and share more risk between generators and supply companies selling into and buying from the pool respectively. Demand is bid by the pool purchasers. Additional enhancements were made to move the cost of some ancillary services closer to the source of the requirement. This is a dual price market (day ahead forecast and on the day spot) with settlement based on both. The cost of reserve is recharged back to the generating companies in order of their size (largest unit first).

The Singapore Pool settles on each business day. Settlement takes place about a week after the trading day in question. This is done in order to give market participants the opportunity to resolve any disputes they may have over payments to or from the pool before money actually changes hands. On the due day, however, money is exchanged electronically between pool member bank accounts and it is the member's responsibility to ensure enough funds are in the pool transfer account at the appointed time. All money is settled through the market so quite large cash flows take place on each trading day. Generator income is based on a combination of the day ahead and on the day prices. Lack of compensation for constrained off plant encourages the plant operator to bid their costs fairly honestly. Increased demand on the day encourages plants to come on line since this will recover the marginal price.

Ancillary services are handled either through the pool or by requirement on the generator as part of the connection agreement with the grid operator.

The benefits of this market model are:

- It is simple to set up and operate.
- It supports security and quality of supply.
- It provides a high degree of transparency.
- It encourages development of new efficient generation.

The disadvantages are:

- There are no clear signals as to the value of improving the Transmission Grid.
- There is no choice of whether to trade in the market (everyone must play).
- Bids are from individual generation units reducing the flexibility available to the generation plant owner.
- Transmission bottlenecks make for increased cost to all market customers and not just to the ones responsible therefore.

4.4 THE NATIONAL ENERGY MARKET OF AUSTRALIA

The Australian Power Exchange again

followed loosely the UK pool model of all power traded but added interesting features to provide for management of bilateral contracts in the form of re-allocation agreements. It introduced the concept of zonal pricing, which results in different market prices in different transmission constrained zones. Intra regional constraints are taken account of by dispatch from the generating plant. This is a 5-minute marketplace, which is as close to real time. Although bids are submitted in advance, re-bids have significant flexibility and can be made at any time. The addition of Ancillary services contracts and bids results in these being dispatched through the market. The resulting costs are paid for by the participants as a sort of capacity fee but this is fully transparent and not levied as uplift.

Some characteristics of the Australian market are:

- Generation and Supply are Competitive
- Generation and Load Management are treated equivalent
- Inter and Intra-Region constraints are considered.
- Regional and Connection point Pricing is used.
- Bilateral Contacts are enabled through re-allocation
- Spot Market considers Energy and Network Services in real time
- 1/2 hourly settlements.
- System Security and medium term assessment included.

The Australian National Market settles against a schedule, for energy trades only. NEMMCO is responsible for the economic purchase and dispatch of ancillary services (including reserve). These services are re-charged through service charges. Settlements are fairly simple and based on actual generation or consumption as modified by any losses in the system. There are no compensation schemes for generators or consumers disadvantaged by active transmission constraints. This shows in the difference between locational prices. In times of emergency or perceived supply shortage NEMMCO may declare that the market is to be administered. This will normally result in some imposed limits allowing for inter-regional constraints being charged. It is hoped, however, that the need for such administration will be minimal and this is not seen as the normal mode of operation of the market.

The total payments to and from the market are adjusted by any registered re-allocation agreement. Such an agreement can be registered by any two market participants. This is registered as either a profile of demand or money. If it is registered as a profile of demand then any payments/costs against the demand registered are moved from one participant to the other. If the agreement is money then simply the sum of money is re-allocated.

The benefits of this market model are:

- It supports security and quality of supply.
- It provides a high degree of transparency.
- It encourages development of new efficient generation.
- The 5-minute model discourages gaming in constraints.
- The plant owner manages commitment of plant and the cost.
- Bids are flexible from individual or aggregate generator or loads.
- Transmission bottlenecks are reflected in regional prices encouraging traders to reduce them accordingly.

The disadvantages are:

- It is complex to set up and operate.
- There is no choice of whether to trade in the market (everyone must play).

4.5 THE CALIFORNIAN MARKET POWER EXCHANGE

California has taken a different approach to the market as compared with other markets reviewed. The centerpiece of the California market is the ISO. Other major components are the Power Exchange (PX) and Scheduling Co-ordinators (SC). The Power Exchange is regarded as another Scheduling Co-ordinator. For the first four years of operation, all generation owned by the three main Investor Owned Utilities (IOUs) in the state have to be bid through the PX.

Three separate markets are defined: Day-Ahead, Hour-Ahead, and Balancing (real-time). Market commodities include: Energy, Supplemental Energy and Ancillary Services. Included in the Ancillary Services are: Spinning Reserves, Non-Spinning Reserves, Replacement Reserves, Regulation, Reactive Power/Voltage Support, and Black Start Capability.

The PX creates a spot market for energy, and determines the day-ahead and hour-ahead clearing prices for energy. It may also procure ancillary services in support of its energy schedules. The ISO, on the other hand, is responsible for the reliability and security of the grid, schedules all power through the grid, and balances the grid operation in the real-time. The ISO also manages both inter-zone and intra-zone transmission congestion and creates a spot market for all ancillary services.

The PX and Scheduling Coordinators submit balanced portfolios to the ISO. A portfolio for energy includes bids and schedules for generation, load, import, export, and energy trades with other Scheduling Coordinators. All losses associated with the transmission of energy are accounted for in the portfolio. The schedules may be provided down to individual generation unit or load entity basis.

Generation Schedules are assumed to be self-committed. An iterative bid submittal scenario is used. Initial schedules, as submitted by the PX or the SCs, are analyzed by the ISO to determine congestion in the system. In the event that congestion exists, the ISO will perform a detailed bus level analysis to determine the optimum adjustment to the schedules to relieve congestion. These adjustments, in the form of advisory schedules, are communicated to the market participants. The market participants will then submit their revised schedules to the ISO for implementation.

The benefits of this market model are:

- It supports security and quality of supply.
- It supports bilateral contracts.
- Centralized generation dispatch and control would minimize the total operating costs.
- There are clear signals as to the value of improving the transmission grid.
- It encourages development of new and efficient generation.
- Transmission congestion charges are levied on responsible parties only.
- Commitment of the unit and plant is the responsibility of the owner and not the market.

Some of the disadvantages are:

- It is complex to setup and operate.
- All supply and demand resources must participate in this market.
- The adjustment to schedules determined by the ISO to alleviate congestion may conflict with unit commitment constraints.
- The communication of schedule adjustment in the balancing market to generating units may be difficult.

5. OPERATIONAL SUPPORT SYSTEMS FOR NETWORK MANAGEMENT

Network Management includes the traditional power applications needed to support business decisions in the new electricity market. They include network operational capacity calculations and assistance in determining the most cost-efficient power generation, both short-term and long-term. The set of functions being used depend entirely on the role each company has on the electricity market. A few examples are given below.

Load forecasts and its coupling to scheduling are crucial for business decisions and need to be seen in relation to other market analysis activities. These forecasts need to include present as well as potential customers for any supplier. For longer periods, neural network forecasting programs offer significant benefits over traditional regression-based techniques, reducing modeling efforts.

The physical limitations for transporting power within acceptable levels of security are of prime importance in determining the feasibility of simultaneous bulk power transactions. This becomes an even greater concern in open access power networks, and in a market where accurate capacity evaluation is needed for decisions on short-term business transactions. The ability to evaluate power transfer capability is, therefore, invaluable for decisions on short-term energy transactions and planning.

An open, inter-connected transmission network substantially increases the volume of wheeling transactions. These and other transactions significantly impact on the cost and reliability of the operation of the power system. To evaluate the feasibility of any such wheeling transaction is a difficult task without the help of application software. The module permits the analysis of simultaneous transfer in a model with full non-linear accuracy. It can analyze multi-area problems and obtain a maximum security in MW transfers between any number of companies, power pools or even individual buses.

The new market requires tools for each of the generators seeking their own optimal solutions. This function is designed to assist utility operational planners in making mid-range decision related to fuels, emissions, thermal and hydro generation as well as power/energy transactions.

5.1 STATNETT ISO/TSO, NORWAY

Statnett is the power grid company in Norway acting as the ISO in the country. At the same time Statnett is the part-owner of the NordPool market arrangements in the electricity market. Statnett is responsible for keeping the Norwegian main grid at its goals and at the same time cooperating with Svenska Kraftnat of Sweden and FinGrid, Finland to keep the grid ready for a seamless open transmission access to the actors in the market.

Statnetts ISO-system (or as they call themselves TSO - transmission system operator) comprises four control centers, one national and three regional. In total 110 substations will be monitored. Communications will be done with 54 control centers, exchanging both operational data and schedules. The system is highly distributed around a wide area network under the ownership of Statnett. This is true for data processing, the man-machine interface as well as operator training and system development. In addition the ISO-system will be interconnected to existing Statnett systems, e.g. for forecasting and for maintaining a record of power system split and interchange between regions and to Sweden.

The ISO functionality comprises of course an extensive set of SCADA -functionality for monitoring and control of all own and some adjacent substations. With the distributed man-machine interface it is possible to view any information point according to defined authorities and priorities.

The Historical Information Server (HIS) represents a data warehouse where operational statistics data are stored for reporting and analysis purposes according a legal framework in the marketplace. The ISO-system also integrates functions for maintenance scheduling and personnel resource scheduling.

The set of Power Applications shows naturally the standard set for network monitoring of today including state estimation, dispatcher's power flow, contingency analysis, short circuit calculations etc. All these maintain the security in the network. Additional functions included are dynamic security analysis, voltage collapse analysis in real-time as well as in study mode and other mid-term transient stability calculations. All these are needed to both offer the grid open to every actor in the NordPool market and also to maintain the interconnected Norwegian - Swedish main grid.

5.2 CALIFORNIA ISO, USA

The California ISO responsibility is to observe and also to control the market as well as the main grid operation by all the actors on the California open electricity market. The IT-systems which were built up consist of among others:

a. Power Exchange system providing an interface to all trading participants

b. Power Management system similar to a standard Network Management System, concentrating on network security applications and transmission capacity applications, as well as providing for the ancillary services.

c. Scheduling Coordinator system that handles details of the bilateral trade that exist and also has a market information interface.

d. Settlement system involving all metering, settlements to the billing & credits functions.

All the systems were developed with a very tight timeschedule to the needs at that time. They were fully integrated and communicated with other systems. And they have been gradually updated and changed according to changing/developing rules in the California Electricity Market.

5.3 GÖTEBORG ENERGI, SWEDEN

Göteborg Energi is a community owned distributor for the second largest city in Sweden. The energy service comprises electricity and gas as well as district heating.

With a turnover of US$200M in the electricity branch, with 240 000 customers and 4200 Gwh of delivery it is one of the largest actors in the electricity market.

In the mid -90s, it became obvious to the management of Göteborg Energi to focus the customer even more than before, due to the deregulation in Sweden.

The systems integration for maintenance planning, customer information and the documentation systems of the distribution networks forms the basis to improve customer service. By combining information from these systems one quickly can identify those customers that are affected by an interruption of supply and their importance. This information is used to prioritise repair and supply restoration activities accordingly. Similarly one can produce mailing lists of customers whom to inform, when performing such planned maintenance that will interrupt the supply.

The IT-concept decided upon was grouped into a number of applications areas:

a. Customer Information - A customer information system (CIS) for large customers and a CIS for ordinary customers. An accounts receivable system and a sales support system. All of these systems are common for electricity, gas and district heating.

b. Bulk trading systems - For electronic trading on the NordPool market of bulk power and for computerised forecasting of the load have been installed.

c. Energy Metering - At major customer premises, and at customers that have selected to buy electricity from other suppliers, electronic meter terminals are installed. A metering administration system has been installed, where results are stored and processed according to the legal rules. The system also maintains and creates the relations between delivery points, metering devices, metering values, customers and suppliers. The reports are sent to the customer information, to the suppliers and to Svenska.

d. Asset and Maintenance Management - The Asset and Management System (AMS) is common for electricity, gas and district heating and comprises the distribution network as well as the production units. The AMS will comprise more than 1 million objects when fully implemented. A Geographical Information System (GIS) is common for the networks of electricity, gas and district heating.

e. Energy Management - The distribution systems for electricity and district heating are monitored and controlled by separate SCADA systems. In the future the district heating system is planned to also accommodate the gas distribution network. These systems perform monitoring and control functions for respective process. The SCADA systems will also be integrated with the asset management system. Data about assets usage and malfunctions is forwarded from the SCADA to the AMS system as input for the planning of maintenance works. Status about planned and ongoing work orders is forwarded to the SCADA systems to form a basis for coordination between operation and maintenance.

6. GLOBALIZATION OF UTILITIES

The open and competitive power market is not limited in one nation, but is international. For example, European Union has defined a schedule for the creation of a single open and competitive market within EU. Another driving force for the globalization of the utilities is to strengthen their competitiveness by business of scale. Mergers and acquisition of utilities have been taken place and will continue to take place. Utilities in the industrialized world have put such measures into their strategic agenda.

Many vendors to the power utilities have since decades been operating globally, not only the sales and service operations but also engineering as well as R & D. What is new to us is the facts that many power utilities have become global players. This process is just in its beginning. The globalization of the utilities has created and will continue to create new challenges both to the vendors and the utilities themselves.

We can foresee that more global partnering is also on the way, i.e. global alliances between global equipment suppliers and global utilities. The infrastructure for globalization, from GSM mobile phone to Internet, is widely available. Industrial IT-solution offering accessibility to global know-how and global support is a must. The critical issues for the global utilities can be the availability of human resources fit for international operation around the globe.

Paper No. 6

GLOBALIZATION OF SAFETY CERTIFICATION INDUSTRY

Speaker: Mr Raymond C.K. Kong
Chief Executive
Intertek Testing Services Hong Kong Ltd.

GLOBALIZATION OF SAFETY CERTIFICATION INDUSTRY

Mr Raymond C.K. Kong
Chief Executive
Intertek Testing Services Hong Kong Ltd.

ABSTRACT

Product safety certification services used to be nationally based many years ago in the product consuming / utilizing countries. Starting the late 80's and the early 90's, the trend has gone towards globalization. The safety certification companies today have taken globalization as one of the basic requirement for survival and growth.

The most important factor of this trend is due to changes in the trading process. All countries are now relying on products supplied from outside but at the same time also supplying products to other countries. This phenomenon has laid down the need of globalization for the safety certification industry.

The retailers are also going towards global in terms of both product sourcing and retailing. Walmart, Home Depot, Toys R Us, Carrefour are good examples. These global retailers do require the safety certification services to be supplied everywhere in the world. The one-stop-shop and total solutions are needed.

On the other hand, we can also find the giant manufacturers moving towards regionalisation and globalization. Ericsson, Hitachi, Samsung, Hasbro, together with other reputable brands are clear examples of manufacturing going global. Traditionally, the manufacturers are major users of safety certification services and therefore the international service supplying one-stop-shop and total solutions are also essential.

The global economy has gone regionalised in the last ten years. Headed by USA, the North American countries have formed NAFTA to protect the benefits of members. The development of single economy in Europe, with ASEAN, and the loosely organized APEC, are all examples of regionalisation of economics. This movement has created tredmenous impact on changing the trading process as well.

The safety certification servicing companies have to follow different regulations and standards of different countries. At present, the trend is for these different standards to be harmonization. The World Trade Organization is encouraging standards harmonization to minimize possibility of technical barriers. In a way, harmonization of standards also affects the development of safety certification.

All the above has led to globalization of safety certification services. Acquisition and merger are occurring in the safety certification industries. These changes are creating tremendous impact to future development.

Paper No. 6

1. THE PRODUCT SAFETY CERTIFICATION INDUSTRY

Product safety and performance certification emerged from the industrialized nations in the early 20th Century. Initiative was primarily taken by the government agencies due to the need of health and safety protection of consumers. With the widespread of consumer protectionism, rapid development was seen in 1960's and 1970's. During the course of development, there are various level to reflect the status of testing organizations – National Certification Bodies (NCB), Certification Bodies (CB or CB Testing Laboratories, CBTL) and Testing Organizations (TO). The product safety certification industry has evolved reacting to the changing needs of the trading system as well as continuous evolvement of safety standards. Whilst most of the product safety certification services are performed by commercial organizations, the government remains as an active player, especially in the developing countries.

Product safety certification was first applied on the electrical and electronic products due to higher occurrence of safety issues. This was rapidly expanded to cover food, drugs and consumer products such as toys, which were creating public concerns of safety and health issues. The servicing scope today is further extended to product performance and environmental protection.

Following the rapid development of product certification needs, people realize the importance of reliability and technical competence of testing data produced. National laboratory accreditation schemes were implemented half a century ago. Today these accreditation authorities have developed into regional and global forums. Many of them are now working on mutual and multi organization recognition agreements. The same phenomenon is also being developed amongst certification bodies regarding testing data.

All the above changes are primarily reacting to enormous changes in product movement around the world.

2. EVOLUTION OF MANUFACTURING, TRADING AND RETAILING INDUSTRY

Traditionally, manufacturing, trading and final product distribution used to concentrate within one country until Marco Polo landed on the China land. Enormous changes occurred to each sector in the last 100 years. All the three sectors are closely connected with the certification laboratories and influencing the trend of development.

Consumers' demand and increasing competition have lead to more sophisticated product designs and materials used. Keen competition to lower final product price has led manufacturers to identify cheaper sourcing for raw material, labour, and related services. Very few big manufacturers nowadays can survive without going international. A lot of reputable brands in the US, Europe, Japan and Korea are forced to relocate their manufacturing plants to foreign lands to lower the cost base. Manufacturers today have to internationalize their operating system or else they will be left out. It has become normal practice for a Japanese branded product to have product design in Japan, sourcing components and raw materials from a few foreign countries, manufacture the products in another country and finally deliver the products to the international markets. Although there are still manufacturers centralizing the quality assurance function in the headquarters, more others are decentralizing this function. The manufacturing segment is a traditional user of the certification services. With manufacturing being globalized, certification services of course also needed to be globalized.

The trading sector has been an important client to certification laboratories, especially in Asia. The trend of traders dealing directly with manufacturers in the past 20 years has eroded a large portion of rooms for growth. However, the roles of the traders are so versatile that can never be totally eliminated. The traders are now identifying their value added by getting closer either to manufacturing or retailing. Some of these companies also tried to include product quality certification as part of their service scope. Perhaps the biggest values added by traders is to provide data of international product sourcing to serve the buyers' need on one hand and helping the manufacturers to gain access into the international market on the other hand. The trading segment is acting as catalyst to internationalize the various industries.

The retailing segment has now become the major party attracting focus of all kinds of product and service providers. Retailers are dealing with the final consumers in the front line. To capitalize their position, the retailing industry has gone through a lot of merging. Bigger retailers are now able to deal with all vendors and service providers in a most beneficial way. Definitely the merged and bigger retailers are internationalized in every aspect. They are sourcing product globally and also selling to consumers globally. A lot of the retailers are still keeping a centralized quality assurance and product testing development but more retailers realize it is uneconomical to keep their own quality assurance facilities and leaving that function outsourced.

3. STANDARD INSTITUTION

In the early days, standards writing bodies were having heavy involvement in product certification services. A lot of the organizations today such as British Standards Institute (BSi), Underwriters Laboratories (UL), Canadian Standard Association (CSA) and many other renowned names have built up their status through their connection with standards writing. Due to the conflict of interest and the risk of liabilities, most of these organizations have separated the certification operations from standard writing function. There are different practices of writing standards in different countries. Some countries have adopted the practice of more integration between the governments and the commercial sectors whilst others are still dominated by the government.

Although there are lots of movement and discussion about internationalization of writing standards for product safety and quality, final decision and enforcement of product standards are still rested with national governments. A good example is Europe where the single market movement started ten years ago. Harmonization of standards has started for years and people today are still unsure whether the harmonization would be completed in the next ten or twenty years. There are also continuous dialogues between standards writing bodies of Europe and Northern America but progress is slow.

Although there are different barriers, the world is definitely going towards direction of global harmonization of standards.

4. LABORATORY ACCREDITATION

Laboratory accreditation authorities in different parts of the world are having concerns with international testing organizations. The first issue being appropriateness of national accreditation applying to operations outside their country. Assessment and surveillance of technical competence and quality management systems has become much more complicated. Secondly, there are conflict of interest amongst different national accreditation bodies. The writer has a strong feeling that communications amongst these accreditation authorities are by far inadequate. People would like to see much faster and much more communication amongst international organizations such as IEC, IAF and ILAC. Ultimately, accrediators have to care for betterment of trade and consumers.

5. GLOBALIZATION OF THE CERTIFICATION INDUSTRY

To conclude the above, the certification industry has to strive for globalization in the following areas:

5.1 SERVICING NETWORK

The manufacturing plants have a tendency of shifting the production base from one place to another due to benefit of material, labour, transportation and management costs. Certification bodies are therefore required to cope with the trend. Moreover, manufacturing sites keep shifting and all laboratories have to made adjustment of resource accordingly.

5.2 PROMOTION NETWORK

Decisions of selecting certification service suppliers could be made by manufacturers, traders, importers/exporters and retailers. Sales and marketing resources of certification bodies are therefore needed almost everywhere.

5.3 BUSINESS PROCESS

It is common practice, especially in the high tech products, that product design, components, final product production/ assembly, and product consumption countries are spreading in several parts of the world. In many cases, certification bodies are required to evaluate product design in Taiwan, coordinate component testing datas from China, conduct the follow up audit for production in Malaysia and award compliance product labels for goods shipping to the United States.

5.4 PRODUCT STANDARDS & TRADING PROCESS

Certification bodies are also required to have global know-how and expertise of standards & regulations trading process and distribution of products in all the product destined countries.

5.5 TECHNICAL RESOURCES MANAGEMENT

Engineers have to be transferred around to cover shortage of professional resources. A lot of companies adopted the localized policy but technical and professional resources are always in shortage worldwide.

5.6 CERTIFICATION BODY SCHEME (CB SCHEME)

The CB Scheme is currently the real system participated by different laboratory certification bodies globally. The CB Scheme is a cost effective way bridging compliance regulations in different parts of the world. This scheme is now widely used by the manufacturing sector and is an important tool to facilitate international trade.

6. CHALLENGES FACED BY CERTIFICATION INDUSTRY

Certification industry has been growing rapidly in the past 40 years due to increasing demand. However, this trend is changing due to the following:

6.1 A lot of the big names, especially those involved in standard writing, has been commercialized. These institutions have been part of government agencies before (or subsidized by governments) and virtually very difficult to change their culture to meet the commercial management demands. A lot of the certification bodies of this type are right now going through restructuring to improve productivity, efficiency and customer service. The writer is expecting some names to be faded out in a few years time.

6.2 SERVICING PRICE

There were different scales of financial turmoil happening in different parts of the world. Most certification laboratories were not able to make service price adjustment due to unfavorable climate in the manufacturing, trading and retailing sectors. Many international certification companies are not able to cope with these challenges and to sustain growth.

6.3 STANDARDS HARMONIZATION TREND

The trend of standards harmonization will be reducing the required amount of testing and certification. Although the process of harmonization is slow, the progressive effect would undermine the certification industry.

6.4 MULTI RECOGNITION AGREEMENTS

Multi recognition agreements are happening amongst different accreditation schemes and certification bodies. The manufacturing sectors will be benefited at the cost of less revenue for certification sector.

6.5 ONE STOP SHOP AND TOTAL SOLUTION SERVICES

Apart from servicing price, international certification bodies are competing extremely keen on value added service. The one stop shop and total solution servicing trend will add a lot of costs to every certification body. It is impossible for people to offer service purely at their own choice. Laboratories have to offer all kinds of product and services so long the clients are having the needs.

All the above has explained why the smaller players are selling their companies to be bigger players. There will be few players and difficult to have new players in the field.

International Safety Marks

Country	Mark	Country	Mark
Canada & USA	ETL c us LISTED	Germany	ITS Testing & Certification GS geprüfte Sicherheit
Sweden	S	Canada & USA	Warnock Hersey c WH us
International	emc ITS	UK	BEAB
International	NSF	International	GS3
Australia		Argentina	IRAM

Paper No. 6

International Marks

Country	Cert. Body	Mark	Country	Cert. Body	Mark
Argentina	OAA		Norway	NEMKO	
China	CCIB/ CCEE		Poland	PCBC	
The Czech Republic	EZU		Russia	ROSTEST	
Denmark	DEMKO		Singapore	PSB	
Europe	—		Slovakia	EVPU	
Europe	CEN		Solvenia	SIQ	
Finland	FIMKO		South Africa	SABS	
Hungary	MEEI		Switzerland	ESTI	
Japan	METI		Taiwan	BSMI	
Korea	KETI/ KTL		Uzbekistan	Uzgosstandart	
Mexico	NOM		USA	FCC	

Paper No. 7

FUTURE MARKET TRENDS FOR ASSET MANAGEMENT IN THE ELECTRICITY INDUSTRY

Speaker : Mr Anthony Seipolt
Manager
PB Associates Australia
Australia

FUTURE MARKET TRENDS FOR ASSET MANAGEMENT IN THE ELECTRICITY INDUSTRY

Mr Anthony Seipolt
Manager
PB Associates Australia
Australia

ABSTRACT

The Electricity industry in the UK and Australia has undergone dramatic change due to privatisation and deregulation. While the UK and Australian models have been successful in reducing prices and maintaining service levels, what is likely to happen in the future?

What can we learn from the history of the UK and Australian markets and where are these markets now heading?

Asset management is a world-wide trend in the utility industry, yet almost every utility has a differing interpretation of what Asset Management actually is. This presentation looks into the new business focus on asset management and considers where the next steps in business improvement will come from.

1. BACKGROUND AND HISTORY

1.1 PRIVATISATION

This section deals with the factors leading to the privatisation and deregulation of the electrical industry in Australia and particularly Victoria. It is useful to note the similarities with the industry in the UK and Argentina.

The Victorian model has been chosen as it represents a deregulation process that was undertaken with benefit of learnings from the UK experience. By using the Victorian process and relating to the UK model, this paper seeks to provide some real examples and likely future trends for the electric industry worldwide.

1.1.1 THE STATE ELECTRICITY COMMISSION OF VICTORIA

The State Electricity Commission of Victoria (SECV) was formed by the State Government in the early 1900's and lead by Sir John Monash for many years. During the early years the SECV focussed on the electrification of the State of Victoria building networks firstly in the major towns and then extending into more rural areas.

The electrification programs slowed down in the 60's and 70's and the SECV entered a relatively stable period of consolidation and moderate growth.

Many of the systems and processes utilised by the SECV were similar, if not duplications, of those employed by the UK industry.

In the late 1980s and early 1990s rumblings of discontent began to emerge. Labour disputes became more prevalent with a number causing serious disruption to electricity supplies across the state.

In this period the State Government recognised that the local industry was not performing well. In particular...

- Over supply of generation due to conservative planning
- Low generator availability due to poor processes and systems
- Gold-plating of transmission and distribution systems
- High level of industrial disputes and low productivity
- Significant cross-subsidies and high costs in some areas.

Paper No. 7

Recognition of these issues did deliver an easy solution. The significant risk of industrial disputes, formidable labour union strength and entrenched processes and practices meant that industrial reform would be a very difficult task for any government to tackle.

A management report for the financial year 1991/92 highlighted the concerns that were now being voiced both internally and externally...

- % employees above estimated requirements – 101%
- Wage increases above national average – 13%
- Overtime as a % of ordinary hours – 8.3%
- Production lost due to disputes – $11,230,000

1.1.2 THE GOVERNMENT SOLUTION

The process of industry deregulation was already taking shape in the UK. This must have provided an opportunity to the State Government that was too good to miss.

Privatisation provided the Government with the opportunity to receive a massive cash injection at the same time as placing the costs and "hard-work" of reform in the hands of private industry.

For a State Government to tackle the industrial issues that were being faced by the SECV would have been an extremely difficult task as well as risking the loss of the next election.

Industry working groups were established and consultants brought in from the UK to aid in the process of determining the optimal privatisation process and structure.

1.1.3 THE SELL

Upon announcing the intent to sell the electrical distribution, transmission, generation and retail assets of Victoria the government commenced a program designed to increase the level of investor interest in the assets.

The State treasurer and premier made presentations to local and international investment groups while the local electricity businesses readied themselves for privatisation.

The regulatory framework was established to provide healthy incentives for companies to inject efficiencies into the companies – at least for the first 5 years.

Upon commencement of the bidding process it became apparent that there were many more bidders than assets. The end result was a sellers-market where investing companies were willing to pay high prices for the Victorian assets. In addition, asset privatisation was being assessed by a number of Australian States and the Victorian assets were seen as a foothold into the wider Australian market.

The resultant purchase prices were considerably greater than the value of the regulated asset bases, often nearing twice this value.

1.2 PRIVATE OWNERSHIP

1.2.1 EFFICIENCIES AND THE ROLE OF ASSET MANAGEMENT

American interests were the major investors in many of the Victorian electricity assets and many of these businesses imported American management staff into the key business roles.

Many of the companies then undertook fairly aggressive restructuring and downsizing activities to capture the maximum savings. Under the new regulatory framework, the earlier in the period that a saving could be achieved, the greater the total return to the business. For that reason the majority of cost cutting activities took place early on in the 5-year regulatory period, followed by a period of relative quiet and consolidation.

The restructuring and downsizing had a dramatic impact upon the industry with some companies reducing permanent staffing levels by up to and exceeding 50%. As a result, operating costs were dramatically reduced as well as capital expenditure.

During this time every distribution and transmission company in Victoria was the implementing some form of asset management model. The model differed in detail between companies but was essentially the same with a split of the decision-making processes from the "doing" or operational areas of the businesses.

Some companies pursued the separation of Decision from Action to the extreme of almost completely outsourcing the construction and maintenance activities of the business. (Two companies in New Zealand have completely outsourced construction and maintenance – WEL Group and Orion Group.)

The focus on Asset Management allowed the businesses to drive operational costs out of the business and improve the efficiency of the work teams through competitive tendering. This was not done without some industrial disputes and CitiPower in central Melbourne was part of a bitter 13-week dispute during which management undertook emergency works while work crews picketed the businesses depots.

The other key improvement delivered by the Asset Management restructuring was the focus on risk management. As the companies developed increasingly detailed knowledge of the failure rates and performance of the assets, they were able to extract greater output while maintaining a consistent level of reliability.

Asset Management allowed the businesses to ensure the expenditure was focussed on those parts of the networks that contributed most to performance. This allowed significant reductions in both capital and operating expenditure.

Public information on the levels of returns achieved by the Victorian businesses is not available. While the regulatory return levels (Referred to as the WACC or Weighted Average Cost of Capital) for this period varied for each business and were in the order of 10%, estimates of the actual returns achieved by the companies range from 15% to 20%. This level of returns seemed to fully justify the high purchase prices paid for the Victoria assets.

1.2.2 PRICE REVIEW

As the end of the first price review period drew to a close the companies and regulators prepared to enter into a review of the allowed returns and expected service levels for the next period.

Inflation and the cost of capital had reduced significantly during the last 5 years. In addition, the perspective of many Australian regulators had grown to view distribution assets as low risk assets. Commensurate with a low risk investment is a relatively low level of return. Distribution assets in particular were equated to government bonds in terms of their level of security and returns.

The WACC (Weighted Average Cost of Capital) for the period of 2001 to 2005 was reset to figures in the order of 6.7%. While this represented a reduction from WACC of the previous period, it was a dramatic reduction in terms of the actual revenues.

1.2.3 US AND UK EXPERIENCE

A similar experience was also had in the UK. With many of the "obvious" cost savings already accomplished the electricity business owners had less and less opportunity to cut costs further and extract higher profits.

The UK market has been through two price review processes both of which have further reduced the allowed business returns.

Indications from the US are that they are currently experiencing a similar pattern amongst utility investors. The increased return expectations generated through deregulation have peaked and investors are now expecting a return to more typical level of return.

2. ASSET MANAGEMENT

The combination of intense downward pressure on costs and the restructuring of the businesses following privatisation coincided with an international move towards Asset

Management structures within the electricity industry.

Within a very short timeframe everyone of the Victorian Distribution Businesses had established some specific asset management group or division within their business.

2.1 FORMS OF ASSET MANAGEMENT

If you ask 10 people for their definition of asset management, my guess would be that you would receive 10 different answers. Much the same occurred within the Victorian industry. Although each company now had a group that was charged with the function of Asset Management, each company's description of the roles was, and still is, quite different.

2.1.1 MINIMALIST

The minimalist Asset Management approach deems that Asset Management is a strategic or high-level function. Typically this means that the Asset Management groups consist of strategic planners and forecasters as well as including a standards group.

The typical roles undertaken by this group have almost nothing to do with the day-to-day operations of the system. The minimalist approach may even include financial and economic planners to provide the businesses with forecasts and projections of revenues and expenditure.

In a typical electric network business this group would represent less than 10% of the total workforce.

2.1.2 MODERATE

The moderate Asset Management approach will typically extend the functions of the Asset Management group to include the tactical side of the business. This would include the project design group, contract management, construction and operations management.

In a typical electric network business the Moderate Asset Management group would represent between 10% and 20% of the total workforce.

2.1.3 EXTENDED

The extended Asset Management group takes the typical functions of the other groups and includes the operations, dispatch, stores, procurements, resourcing and project management functions.

In a typical electric network business the extended Asset Management group would represent between 20% and 35% of the total workforce. The remaining workforce would typically be those employees directly involved in physical construction and maintenance activities.

2.2 CONTESTABILITY

The push for deregulation into Australia was championed by the concept of contestability. Competition for services was deemed to provide the most effective means of minimising prices and improving efficiency.

Retail competition was one of the earliest forms of competition to enter the market. In Victoria, retail competition began for very large consumers and was gradually introduced at ever decreasing levels. Full retail competition is due to be introduced to Victorian and New South Wales on 1 January 2002.

By now most electric industries around the world have plans in place for competition in retail and energy services.

From a network perspective, it was originally considered that contestability could only be easily applied to large construction activities. The construction of zone substations and similar projects were routinely tendered to the most competitive provider.

The next areas to come up for competition were the civil and "low-value" works. Examples of these works were trench digging, reinstatement, cable boring and street lighting.

Early successes in these areas soon lead to enforced competition for almost all customer-based distribution construction activities[1].

For a period of time competition remained at this level. However, a change was occurring within some companies lead by the Asset Management groups. These groups recognised that a construction or maintenance business will always seek to do more work and grow the businesses. This meant that the construction and maintenance divisions of a Distribution Business were most likely seeking to undertake more work than may was absolutely necessary.

The aim of the Asset Management groups was to reduce expenditure and this was directly in conflict with the construction and maintenance incentives.

The answer for these businesses was to outsource the construction and maintenance activities completely. This left the Asset Management group responsible for determining workload and managing the outsourced workforces.

Contestability for these works was intense and significant savings are reported based on the outsourcing of these activities.

2.3 ASSET OWNERSHIP

Contestability does not necessarily end once all of the construction and maintenance activities are competitive. Much to the surprise of the Asset Management groups they found that even Asset Management was considered ripe for competition.

This move has been facilitated by the actions of the regulators. In Victoria and the UK, distribution assets are considered to be a low risk investment. Much the same as investing in government bonds or secure stocks.

The level of returns for government bonds is quite low and this has lead many current distribution asset owners to seek other areas to invest their capital.

If low risk equates to low returns, who would be interested in owning electrical assets? The answer may be the superannuation and secure investment community. Companies that are seeking to place their investors capital in a portfolio of safe and secure investments may see distribution assets as providing that security.

Of course, superannuation companies are probably not interested in running the day-to-day activities of a network business. Therefore a company that is purely focussed on providing Asset Management services could find a role.

2.4 ASSET MANAGEMENT FOR HIRE

The concept of seeking alternate providers of Asset Management services is not a new one. The hotel industry has been following this model for many years now.

Hotel buildings are often owned by one group of investors who are not involved in the hotel operations.

Hotel management is a thriving industry in itself. Groups like Hilton and Radisson are professional hotel managers with a suite of tools to brand, market and managed their hotel chains. Contract services (e.g. cleaning, maintenance) are commonly provided by separate local businesses.

Each hotel management group has a different style and marketing philosophy. For this reason, some hotel buildings will change name and pass from one group to another as their age and marketability dictates.

3. GROWING ASSET MANAGEMENT

3.1 HORIZONTAL INTEGRATION

Looking back at the last 10 years in Victoria it would appear that the industry keeps being carved into smaller and smaller pieces.

The familiar vertically integrated business that included generation, transmission, distribution and retail has now been splintered into a multitude of competing businesses.

The recombination of the industry is not likely to occur along vertical lines for some time as regulators have put barriers to such reintegration in place. This leave horizontal integration as the obvious business growth area.

Horizontal integration can apply at many levels. Already construction and maintenance companies in Victoria are providing electric, gas, water, sewerage and telecoms services.

Similarly, a number of companies have purchased electric and gas assets to seek economies of scope from these combined operations. It is not difficult to imagine integration with similar industries such as rail, roads, ports and other asset intensive industries.

The UK has experienced similar merging of businesses with a number of consolidations between water and electric businesses.

The growth of an Asset Management business will depend largely upon two things;

1. The establishment of a set of core or foundation skill sets. (e.g. Contract management, risk management, IT systems, etc)
2. A large base of assets under management from which to build scale and provide security to asset owners.

4. CONCLUSION

Asset Owners...

- Regulators WILL continue to drive asset returns down to bond-stock levels (WACC)
- Equity investors WILL NOT be interested in these levels of return
- Fund investors (e.g. superannuation, mutual funds and investments houses) WILL find low risk/low return electrical assets a natural fit with their portfolios.
- Fund investors WILL NOT want to manage these assets. (E.g. Building and hotel industry)

Asset Managers...

- Asset managers would operate in a regulated environment but not be regulated on their returns.
- Higher returns could be achieved through
  - Building Scale:
    - Managing assets for multiple electric utilities
  - Building Scope:
    - Managing assets

Service Provider returns to remain tight...

- Strategies for improving returns include:
  - Joint ventures and alliances with Asset Managers
  - Building scale across multiple electrical authorities
  - Building scope across multiple industries
  - Niche providers

Paper No. 8

BUSINESS IMPROVEMENT THROUGH GREATER DEVELOPMENT OF PURCHASING

Speaker: Mr Richard Hawtin
Head of Contracts and Purchasing
CLP Power Hong Kong Ltd.

BUSINESS IMPROVEMENT THROUGH GREATER DEVELOPMENT OF PURCHASING

Mr Richard Hawtin
Head of Contracts and Purchasing
CLP Power Hong Kong Ltd.

ABSTRACT

As anything from 50 to 60% of the typical organisation's expenditures are spent on equipments and services, the potential for purchasing to yield the single largest immediate contribution to the bottom line is very great. The examination of purchasing therefore is not just to achieve an improvement in expenditures through economies of scales in unit cost, aggressive cost reductions and consequent margin growth. It is also about establishing strong internal links between progressive purchasing professionals as change agents, business strategists and core company professionals such as engineers, as well as between the company and its vendors as strategic allies. Thus, purchasing reengineering can easily demonstrate the function becoming more of a pool for building and developing a business than merely the department that counts dollars and cents.

The modern tools in IT, particularly for e-commerce, are offering greater opportunity to make this reengineering of purchasing possible and encouraging more join/collaborative ways of working, both inside and outside of a company.

NOMENCLATURES

Supply Chain. The complete chain of companies and other organisations which contribute to providing the ultimate user with the equipments and services required by that user. Any supply chain has 2 key process – purchasing for buying the equipments and services, and logistics for moving those equipments throughout the applicable chain..

Purchasing. The process by which an organisation commercially interfaces with others to obtain the goods and services it needs to fulfill its business objectives in the most effective way.

Some parts of the world define "Purchasing" as being the greater subject, "Procurement" being the transactional sub-process within this. Other countries in the world will refer to this the other way around. For the purpose of this paper, the words purchasing and procurement will be used to mean the same.

Logistics. The process of managing the flow of raw materials, goods, and any other equipments, throughout the supply chain. This includes within companies as well as externally.

Materials Management. It is a term often used to describe the logistics activity just within the organisation. It includes stores management. The expression may or may not include purchasing, but as purchasing encompasses both goods and services, and materials management by its very definition is just goods, for the purposes of this paper purchasing is considered to be outside materials management.

Suppliers, Vendors, Contractors, Sub-contractors. The various expressions used to describe those who provide goods and services to a company. For ease of presentation in this paper, ***suppliers*** will be used to generically refer to this group of providers.

1. INTRODUCTION

As we all know, we live in an age of increasing change. The rapid technological developments, particularly those which are exploiting the power of the internet are not only driving new changes in the business world, but are also impacting people in an individual way in their daily lives. This in turn has a knock on effect into their working environment, again forcing examination of the ways time is spent and managed.

There is thus now a two-fold "attack" on business – the need to continue improving business performance in the face of increasing competition, often driven by much more demanding and sophisticated customers, and the need to improve working practices that will satisfy an equally more demanding, better educated and technologically aware workforce. No longer is it acceptable for organisations to assume that their employees will just follow time-honoured routines, where long standing ways of working were faithfully followed without question. Rather, those same employees who would have worked this way a few years ago are now questioning, and in an increasing number of situations demanding, that more effective practices are introduced into the work place to help improve the quality of their lives. Work commitments have to be better balanced with leisure, time with family and other pursuits.

2. THE SUPPLY CHAIN

Improving business performance is not a new issue of course, but the challenges brought about today through movements in the global patterns of business, together with mergers, acquisitions, closures and the emergence of new companies, are causing businesses to develop a much more flexible approach and rapid response to these challenges than would have previously been acceptable.

One of the key business processes at the forefront of this change is the supply chain - the complete activity from first, and often smallest, provider of raw material or service to the final user of a much greater product or service. Supply chain management is no longer a matter for just the operational and functional areas of an organisation. It is a strategic subject demanding top-level management attention, as evidenced by those companies which have moved themselves to being leaders in this area and have reaped the clear business rewards in terms of performance and shareholder return. Initially this was for product manufacturing and retain firms, but increasingly now includes service companies such as banking, insurance, healthcare, entertainment and utilities. Excellence in managing the supply chain for greatest value for more demanding customers is now widely included as one of the key criteria for competitive edge.

Purchasing, the acquisition of the goods and services needed for the business, and logistics, the movement of equipments and other physical goods throughout the supply chain, are the two major processes within the supply chain, but it only purchasing which is considered in this paper.

3. PURCHASING

The role of purchasing is to establish, and then manage on behalf of the purchasing company, the commercial interfaces with other organisations in the supply chain. Historically, this role has been very much transactional, just processing the various decisions made by others onto suppliers through paper based orders. More recently, as companies have recognized the value associated with purchasing goods and services to meet business needs, this role has become more strategic. In addition, it has become evident that many more are involved in this company-wide process than just the full time buyers and others of the purchasing department. (Figures 1 and 2 present a way to look at this process across the whole of a company and who is likely to be involved.) It is no longer acceptable for the well being of the business that supply arrangements, and their accompanying commercial interfaces, are set up as an afterthought and without due consideration of the supply base. Equally, it is also unacceptable that certain areas of spend are considered too specialist or too technical to be handled by a purchasing department and are therefore considered "exempt" from normal purchasing disciplines. Examples of such specialised areas are computer hardware and software, advertising, energy, design services and capital items/ projects. Experience, as well as significantly improved business performance, is increasingly demonstrating that acquisition of all goods and services can greatly benefit

Figure 1 Purchasing is a Company-Wide Process

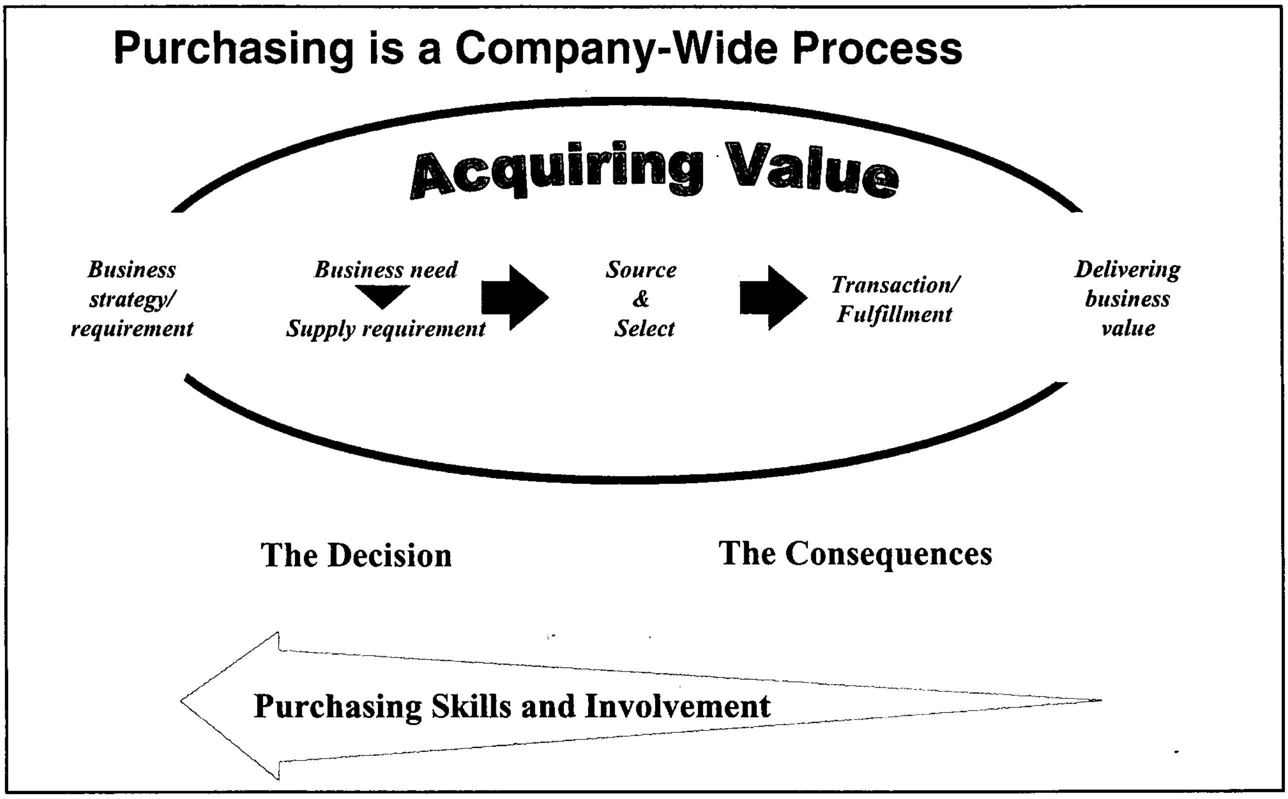
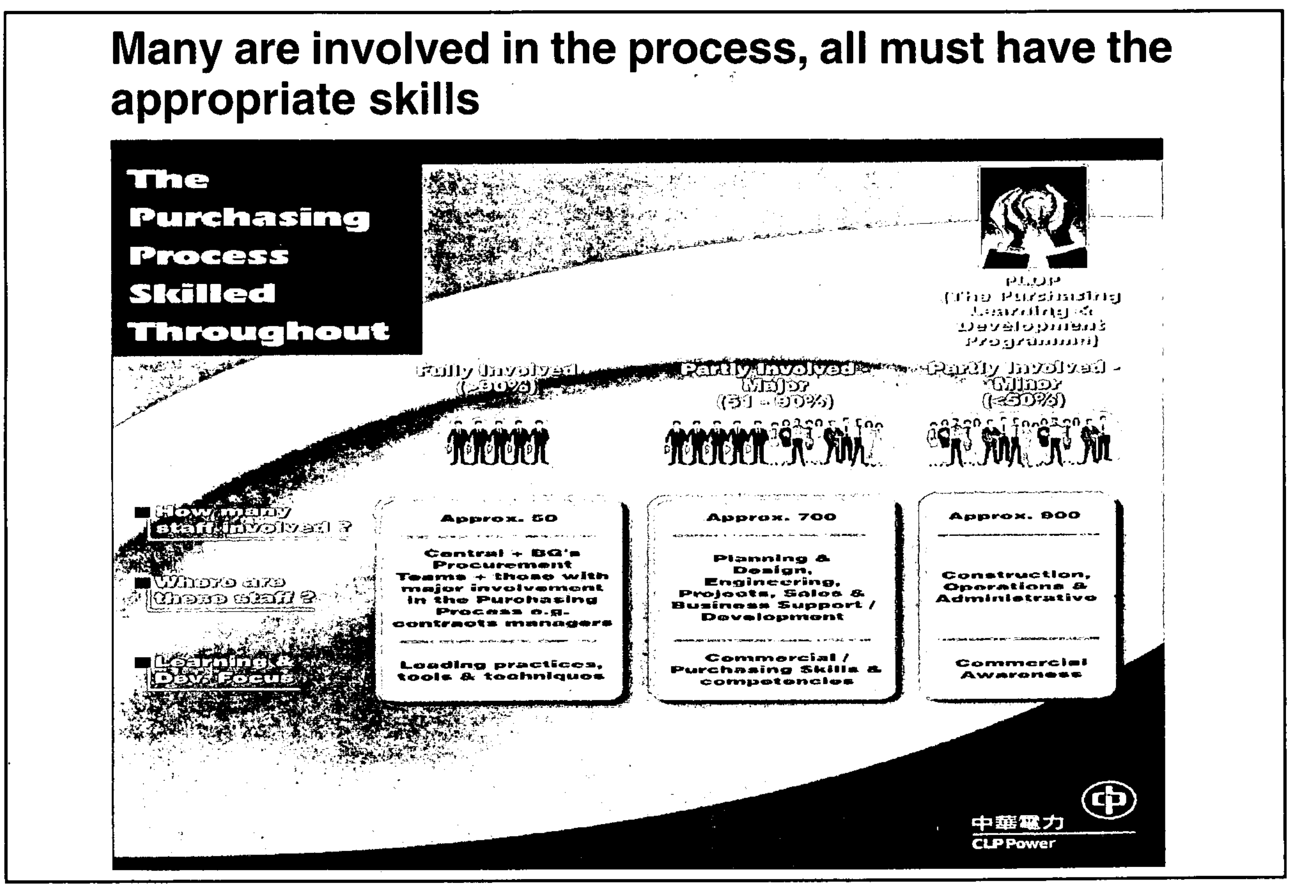


Figure 2 The Purchasing Process Skilled Throughout



Paper No. 8

from a more professional and structured approach to purchasing.

Today's aim with strategic purchasing is to acquire value for money, i.e. the best balance between price and quality over the life of the goods/service to meet the identified business needs. This value for money approach includes:

- the best purchase price commercially available
- the hidden costs of stockholding and purchasing administration
- the costs of poor quality and late delivery
- the loss of interest on early payments
- the costs of subsequent operation and maintenance
- the costs of operational failure
- the consequences of a negligent or incapable supplier
- the costs of final disposal.

From such a list, it becomes clear that for an organization to successfully address all these aspects, no one function or skill, particularly no one individual, can effectively handle all the issues involved. Rather, a team approach to integrate a wide variety of skills and knowledge will produce the best results.

World class purchasing is therefore much more than just placing orders. It is about leading and managing a process which operates across the whole of a company, properly involving other experts at all key stages in this process, and ensuring that real value is delivered for the business performance.

4. E-PROCUREMENT

The internet revolution has presented business with significant opportunities to both improve operational efficiencies as well as increase the effectiveness of the business itself. These opportunities are now typically grouped as being customer facing – B2C, business to customer – or supplier facing – B2B, business to business. This paper is of course only considering B2B.

The biggest breakthrough in prospect for B2B lies in achieving a fully integrated decision support system that links all parties throughout a particular supply chain. We are at the stage where parts of this have been achieved – between the design team and the corresponding teams in some of their suppliers who will provide integral parts and sub-processes, between the ordering organisation and the receiving company for the commercial arrangements, between the production departments of both buyer and supplier for forecast requirements and deliveries, and between the respective finance departments for electronic payments. However, the fully integrated supply chain, allowing the immediate flow of accurate data to help speed up processes as well as improve the quality of decision making, is not yet with us. It is though only a matter of time, not least because of the flexibility of the internet.

The computer solutions of the eighties and nineties were all or nothing, huge systems which required companies to prepare and implement them in a "big bang" way with all the resulting impact on resources and productivity during this time. Now, "small is beautiful", with much smaller packaged solutions capable of being explored, developed and implemented with minimal impact on an organization. This saves time and money, is much less disruptive to the business and minimizes the risks associated with bringing in new technology.

Paper No. 9

DEREGULATION OF ELECTRICITY INDUSTRY - THE CALIFORNIA EXPERIENCE

Speaker : Mr C.P. Ng
Business Systems Application Manager
Independent System Operator, California
U.S.A.

DEREGULATION OF ELECTRICITY INDUSTRY - THE CALIFORNIA EXPERIENCE

Mr C.P. Ng
Business Systems Application Manager
Independent System Operator, California
U.S.A.

ABSTRACT

In April, 1998, California began deregulating its electricity industry. Two new organizations, the California Independent System Operator and California Power Exchange were formed to operate the power grid and the deregulated electricity market. Utilities sold off most of their generation asset and became Transmission Owners and Utility Distribution Companies. New generation companies, power brokers and Scheduling Coordinators also came onto the scene. This paper describes the major players and the new market structure. The road to deregulation has not been smooth. During the last few years, the California Independent System Operator had to overcome major challenges in meeting its charter to operate the power grid in a reliable fashion while facilitating an open and competitive energy market. This paper also reviews some of these challenges and their solutions.

1. INTRODUCTION

On April 1, 1998, California took a giant step in restructuring its electric power industry. A new energy market based on open competition and market based rates was formed. New market players came onto stage. During the last several years, some deficiencies have been identified with the original market model and various improvements have been made over time. This paper describes the history of deregulation in California, the market players, the new market model and the improvements made.

2. ROAD TO DEREGULATION

Before the restructured electricity market began in April 1998, California was served by three Investor Owned Utilities (IOUs) and a number of local municipal utilities. The three IOUs: Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric Company (SDGE), served about 75% of the consumers in California. The IOUs were vertically integrated and provided generation, transmission and distribution services to all the consumers in their territories.

In 1992, the US Federal Government issued the Energy Policy Act, which encouraged the states to foster competition and market mechanisms as the preferred means to develop and deliver energy services. In September, the California Public Utilities Commission (CPUC) directed its Division of Strategic Planning to prepare a report to examine alternative regulatory approaches for the electric utilities in California. This report [1], commonly known as the Yellow Report, was issued in February 1993. It pointed out that the existing regulatory approach in California was established at a time when vertical integration was the only effective mechanism to deliver reliable electricity services, but alternative electricity providers had become available and there were mounting pressures to allow greater choice for consumers. The report concluded that a reform in the industry was necessary to ensure California would be well positioned to

Paper No. 9

benefit from a competitive future. After a series of initial public hearings, CPUC decided to pursue the restructuring dialogue with various stakeholders under certain guiding principles. In April 1994, CPUC issued an Order Instituting Rulemaking and Order Instituting Investigation [2], now commonly known as the Blue Book. The Blue Book proposed that the existing cost-of-service based rates for the utilities would be replaced by a performance-based rate and consumers would gradually be allowed voluntary Direct Access to alternative generation services. It also laid out the guiding principles for the industry reform: no cost shifting between consumer groups, preservation of the utilities' opportunity to earn, continuation of vital public purpose programs and most important of all, the continuation of reliable and reasonably-priced electricity services. The utilities initially opposed the reform, arguing that there was no need to fix something that was not broken. However, over the next year, it became clear that the reform, being favored by the key advocate groups, was inevitable. In May 1995, CPUC issued its Preferred and Alternative Proposed Policy Decisions [3]. The preferred structure was a wholesale power pool and the alternative proposal recommended consumer choice through Direct Access. In September 1995, Southern California Edison, together with a number of consumer groups, filed a Memorandum of Understanding (MOU) [4]. The MOU recommended a market structure that merged CPUC's preferred and alternative proposals. It proposed the formation of two new entities: a Power Exchange (PX) and an Independent System Operator (ISO). PX would operate a forward energy market and ISO would allocate transmission capacity to energy users and operate the power grid to assure reliability. The MOU also suggested a 5-year phase-in of Direct Access. In December 1995, CPUC issued its Preferred Policy Decision [5], which was generally consistent with the MOU. However, the Decision also required the IOUs to divest at least 50% of its fossil generating plants to prevent excess market power from the utilities. IOUs were also required to bid all their generation output into PX and purchase all the energy needed to meet their demand from PX. In September 1996, the California state legislature passed Assembly Bill 1890 [6] embracing the restructuring model in the CPUC Decision. In the 18 months that followed, many teams worked feverishly to set up the PX and ISO. On April 1, 1998, the new deregulated market was born.

3. MARKET PLAYERS

In the restructured market, in addition to PX and ISO, other new players came to the scene. The IOUs also took on new roles. This section examines the key players and their roles.

California Power Exchange (PX) was a new organization that managed the forward energy markets. All IOUs were required to bid all their generation and demand into the PX market. Other market participants may bid into this market on a voluntary basis. Using non-discriminatory and transparent protocols, PX would select the least cost generators to meet the demand and determine resource schedules for every hour of the day. The price of the marginal unit (that provided the last MWh of energy to meet the demand), after certain adjustments to reflect any unrecovered start-up and no load costs, established a Market Clearing Price (MCP) of energy for the hour. PX then submitted its matched generation and demand schedules to ISO. In January 2001, PX stopped operation after the Federal Energy Regulatory Commission (FERC) abolished the IOUs' requirement to bid into the PX market.

California Independent System Operator (ISO) is a new organization that is chartered to operate the power grid to ensure system reliability under the restructured environment. ISO took over the system operator responsibility from the 3 IOUs. It runs the combined power grid as one single Control Area. This independent entity is created to ensure open and non-discriminatory transmission access for all parties. If the power grid operation jurisdiction had resided with the IOUs, they might favor their own resource schedules over the schedules supporting Direct

Access. ISO performs the following functions:

- Receives resource schedules from market participants, identifies any transmission congestions and allocates transmission usage based on non-discriminatory and market based protocols.
- Operates a competitive Ancillary Services (A/S) market. A/S consist of several types of energy reserves used for assuring system reliability.
- Operates the power grid in real time, observing all relevant system reliability standards and balancing supply and demand at all times by dispatching available reserves based on their energy bids.
- Performs financial settlements for all energy services provided to or provided by ISO.
- Provides public market information including Market Clearing Prices, forecast and actual load, system conditions, A/S requirements and procurements. Such information allows the market participants to make informed decisions based on the appropriate price signals.
- Coordinates planned outages for generators and transmission equipment.
- Performs long term transmission planning.

Both PX and ISO are independent and non-profit companies regulated by FERC. They are not allowed to own any financial interests in transmission or generation assets. This independence is necessary to eliminate any potential conflict of interests. The separation of PX from ISO is designed to minimize the possibility of ISO giving preferential treatment to PX schedules over schedules submitted by other market participants.

Investor Owned Utilities (IOUs) have taken on new roles. The **Participating Transmission Owner (PTO)** is the IOU's business unit that owns and maintains the IOU's transmission assets, but the operational jurisdiction of the transmission facilities now lies in the hand of ISO. The Revenue Requirement of the PTO is recovered through transmission access fees collected from all end use consumers. The **Utility Distribution Company (UDC)** is the another business unit that provides distribution services to all end use consumers. For those consumers that have not opted for Direct Access, the UDCs are also the default energy supplier with the obligation to serve. The UDCs continue to be regulated by CPUC.

Scheduling Coordinators (SCs) are clients of ISO. They submit resource schedules to ISO. Each SC is required to balance his schedule portfolio so that his supply and demand are matched in each hour. SCs may self-provide A/S to meet his own reserve requirements. Alternatively, the SC can rely on the A/S procured by ISO. SCs also gather and submit meter data of actual energy consumption to ISO. While some SCs may own generators and market their power to end users, others may only deal with power wholesale, providing the scheduling and market services for generators and retailers. There were about 40 SCs in 1998. They have grown to more than 60 in 2001. From ISO's perspective, PX served as a SC.

Energy Service Providers (ESPs) sell electricity directly to retail consumers. They are regulated by the CPUC. Some of the ESPs are also SCs, but they may also use the service of another SC to schedule power deliveries through ISO.

Generators are power plants. Before restructuring, they were mostly owned by the IOUs. Restructuring required the IOUs to divest at least 50% of their fossil generators. However, most IOUs opted to sell most of their fossil generators because they typically fetched prices that were several times of their book values. Only small portions of the generators, mostly nuclear and hydro units, are still owned by the UDCs.

4. ISO MARKET

The design of the ISO market is influenced by a number of guiding principles:

- Matching of supply and demand schedules is the responsibility of the SCs and PX. ISO does not play any role in forward energy procurement. Each SC (including PX) is required to balance his schedule portfolio in each hour (i.e. Total supply, after adjustment for losses, must match the total demand.). It is expected that at least 95% of the system demand and corresponding supply be scheduled through the forward markets. ISO conducts a real time energy market and serves as the supplier of last resort.

- Energy schedules submitted by the PX and other SCs are treated in the same fashion by ISO. ISO makes no attempt to optimize such schedules economically if there is no transmission constraint violation. In cases when the schedules do cause transmission congestion, ISO will then adjust the schedules based on the bid information provided with the schedules. Adjustments are made to remove the congestion while (1) keeping each SC's portfolio in balance and (2) minimizing the total redispatch cost. The scheme assures that ISO will not force an energy trade between two SCs.

- Each market commodity (energy, A/S or transmission usage) is settled with a single Market Clearing Price (MCP) in each trading period. In a bidding process, amongst all the bids that are selected for services, the most expensive bid sets the MCP. SCs with lower bids also receive the MCP. There are often questions why ISO does not pay the SCs as bid to minimize overall payment. The use of MCP is based on the market theory that bidders will adjust their bid, under a pay-as-bid mechanism, to gravitate towards the perceived MCP. The guesses made by the bidders may escalate and drive the bids even higher than those under a MCP scheme.

As the system and market operator, ISO operates continuously around the clock. For a given operating day, ISO's market activities take place in 3 different time frames: the Day Ahead Market, Hour Ahead Market and Real Time Market.

Day Ahead activities take place between 6 a.m. and 2 p.m. on the day before the operating day. The sequence of key events is described below. Unless noted otherwise, all schedule and bid data are provided by hour and resource location. A resource may be a generator, a load or an intertie transaction.

- All SCs (excluding PX) submit to ISO their advisory load schedules representing their Direct Access loads.

- Based on the advisory load schedules, ISO informs each UDC the total Direct Access load by hour in its service territory. These data allow the UDC to determine the amount of load it needs to serve.

- UDCs, as well as other market participants, bid their generation and load into the PX market. PX matches the load with the cheapest generation available.

- All SCs (including PX) submit their Preferred Schedules to ISO. ISO protocols require the combined energy schedules for each SC be balanced. SC may provide an adjustment bid for each energy schedule. The adjustment bids are used by ISO to allocate transmission usage when multiple schedules compete for the use of limited capacity of a transmission path. A/S self-provision schedules as well as A/S bids may also be submitted in the same time frame. Submitted schedules and bids are validated at the time of submission. SCs are alerted of any errors at once so that they can be corrected.

- At a preset time, ISO evaluates all the Preferred Schedules to determine whether there is any transmission congestion. If none exists, all Preferred Schedules are accepted and become the Final Schedules. If congestion exists, ISO uses the adjustment bids to adjust certain schedules to relieve the congestion. The congestion management scheme also determines a Congestion Usage Price, which is charged to every MWh of energy flowing in the congested path.

- Taking into consideration of the self-provision and forecasted requirements, ISO evaluates the A/S bids and selects the cheapest ones to satisfy its reserve requirements.

- When there is no congestion, ISO returns the Final Schedules (for energy, self-provision and accepted A/S bids) to the SCs. MCPs for A/S are also published. The Day Ahead activities then stop.
- When congestion is identified, ISO returns the Adjusted Schedules (for energy, self-provision and accepted A/S bids) to the SCs. Interim Congestion Usage Prices for the congested paths and A/S MCPs are also published
- SCs may optionally modify their adjustment bids and submit the Revised Schedules back to ISO.
- ISO begins a second iteration of congestion management and A/S evaluation. The Final Schedules are determined and returned to SCs. Final Usage Prices and A/S MCPs are also published at this time.

The Hour Ahead Market allows SCs the flexibility to make adjustments to their schedules and bids for a given operating hour. It begins at the close of the Day Ahead Market and completes one hour before the operating hour. All adjustments have to be made before a cutoff time which is two hours before the start of the operating hour. Then, ISO performs its congestion management evaluation for the target hour, making schedule adjustments as necessary if congestion exists. A/S evaluation is also performed using the latest system requirements and bids available. Final schedules are issued to the SCs at least one hour before the start of the operating hour.

The Real Time Market takes place during the operating hour. Once every 10 minutes, ISO evaluates the imbalance between actual supply and demand and dispatches resources to minimize such imbalance. The dispatchable resources available to ISO consist of those providing A/S (through the ISO auction or self-provision) or Supplemental Energy. The amount of energy dispatched in each interval is determined by the following objectives:

- Minimize Area Control Error.
- Mitigate interzonal congestion.
- Restore regulating units to their scheduled operating points.
- Restore Operating Reserves if they are being depleted by previous dispatch.

The dispatchable resources are arranged in a merit order stack according to their energy bids. When ISO needs more energy, resources with the lowest incremental energy prices are dispatched. When there is surplus energy, ISO instructs the resources with the highest decremental energy prices to reduce output. The dispatched bid with the highest price sets the MCP for real time energy. The resources' available capacities and ramp rates are also considered to assure feasible dispatch instructions.

5. ISO CHALLENGES

The California market is the first one in the nation that supports full-scale competition at market based rates. During its short history, it has encountered various market issues that required improvements to the market protocols. Some of the major challenges and their solutions are described in the following.

5.1 FIRM TRANSMISSION RIGHTS

ISO's congestion management method is based on a zonal model. In this model, the ISO power grid is divided into a number of geographic congestion zones. A zone is a geographic area of the grid in which transmission line overload is expected to be rare. On the other hand, congestion may occur frequently on the interzonal paths. ISO has about 25 intertie connections. These are also potential bottlenecks due to their limited capacities. To include the interties as interzonal paths, the remote end of each intertie is defined as an external congestion zone. During its initial operation, ISO has only two active internal zones and 21 external zones. A third internal zone was added subsequently. The zonal

Paper No. 9

approach greatly simplifies the congestion management scheme in which only the power flows in the interzonal paths need to be evaluated. When congestion is identified, ISO allocates the scarce transmission capacity based on the prices that the SCs are willing to pay. This involves adjusting the SCs' schedules utilizing their associated adjustment bids. The marginal price used in the adjustment process establishes the Congestion Usage Price for the path. ISO then collects the Congestion Usage Fee from every MWh of energy flowing in the congested path. The collected fund is forwarded to the Transmission Owner(s) of the path and used to offset its Transmission Revenue Requirement. The Usage Price also serves as a price signal to invite investments for improving transmission or adding new generation in the receiving zone of the congested path.

Some of ISO's interzonal paths are prone to frequent congestion. Many SCs are concerned about their financial exposure due to the fluctuating Usage Prices. Began in 1999, ISO conducts an annual auction to sell Firm Transmission Rights (FTRs) on most of the interzonal transmission paths. The proceeds from these auctions are paid to the Transmission Owners to reduce their Transmission Revenue Requirements. FTRs are sold in MWs of capacity for a specific interzonal path and direction over a given period of time (typically one calendar year). They can also be traded freely in secondary markets. The owners of the FTRs are entitled to receive the Congestion Usage Fees that are collected for the transmission capacity to which the FTRs are associated. SCs may use the FTRs as a vehicle to hedge against fluctuating Usage Prices. For example, a SC owns 100 MW of FTRs on a given path. In a given hour, he schedules 100 MWh of flow over the path. If the Usage Price is $10/MWh, the SC is charged $1000 in Usage Fee, but as a FTR owner, he also receives $1000 in congestion revenues. In addition to being hedging devices, FTRs can also be treated as simple investments that allow the owners to collect revenues.

5.2 ANCILLARY SERVICES REDESIGN

ISO's primary charter is to operate the power grid to assure reliability. ISO observes the reliability and performance criteria established by North American Electric Reliability Council (NERC) and Western Systems Coordinating Council (WSCC). During its initial operation, ISO procured 4 types of reserve commodities through its A/S markets. These included Regulation, Spinning Reserve, Non-Spinning Reserve and Replacement Reserve.

Regulation is the ability of a resource to respond to Automatic Generation Control signals issued by the system operator. To achieve the control performance standards defined by NERC, ISO keeps an amount of regulation that is about 1% – 5% of system load. Spinning Reserve refers to unloaded generation capacity that is synchronized to the power grid and can be converted into energy within 10 minutes. Non-Spinning Reserve may be provided by a generator or an interruptible load. It refers to the capacity that can be converted into energy (by generators) or curtailed (by loads) within 10 minutes. The combined Spinning and Non-Spinning Reserves constitute the Operating Reserves. WSCC guidelines require the system operator to keep sufficient Operating Reserves that amount to 5% of the load that is served by hydro generation plus 7% of the load served by other generation reserves. In addition, at least 50% of the Operating Reserves must be Spinning Reserves. Replacement Reserve is similar to Non-Spinning Reserve, but has a less stringent requirement. It refers to the capacity that be converted or curtailed within 60 minutes. It is used by ISO to restore Operating Reserve that may be depleted as a result of unforecasted increase in demand or loss of generation.

Based on the first year's operating experience, ISO made significant changes to the A/S procurement and allocation schemes in the summer of 1999. The changes included:

- ISO separated Regulation service into two distinct services: Regulation Up and

Regulation Down. ISO had all along treated Regulation Up and Regulation Down as two distinct services, but only one MCP (which was the higher of the two marginal prices) was created. The single MCP did not provide a clear indication of the values of the services and undermined the competitive procurement of the Regulation services.

- The ISO A/S auctions consist a series of sequential procurements beginning with Regulation, followed by Spin, Non-Spin and finally Replacement Reserve. The sequential algorithm uses a fixed A/S requirement for each service and does not optimize the overall procurement cost of all the services. In theory, a higher quality service with a lower bid cost can be used to replace lower quality service with a higher bid. The sequential scheme is not able to identify such opportunities. ISO devised the Rational Buyer scheme which modified ISO's A/S requirements before the sequential auction began. In the scheme, the requirement of a lower quality service may be shifted to that of a higher quality service if such shift lowers the overall A/S procurement cost.
- A/S costs were originally allocated to SCs based on their "non self-provided requirements" which were, in turn, determined using the SCs' final schedules less any self-provisions. SCs might under-schedule their demand in order to reduce their shares of the A/S costs. The new scheme allocates A/S costs based on SCs' true obligations, which are derived using the SCs' actual metered demand less any relevant self-provisions.

5.3 10-MINUTE SETTLEMENT

During its first two years of operation, one of the bigger challenges for ISO was that many resources had significant uninstructed deviations from their Preferred Schedules. To maintain a reasonable level of control performance, ISO had to increase its load following and regulation capability which resulted in a significant increase in the overall A/S costs. The deviation of a resource from its Preferred Schedule can be broken into two components: Instructed Energy and Uninstructed Energy. Instructed Energy referred to the amount of energy dispatched by ISO. Uninstructed Energy referred to the deviation from the instructed operating point (i.e. Preferred Schedule plus Instructed Energy). Instructed Energy was dispatched for a 10-minute interval and settled using MCP established in that interval. Uninstructed Energy, however, was rolled up for the entire hour and settled using a weighted average energy price for the hour. This pricing scheme created incentives for Uninstructed Energy. In one scenario, SCs might increase their resource output without being instructed when the hourly energy price was expected to be high. In another scenario, some SCs might take advantage of the difference between the interval and hourly energy prices. For example, if a SC was instructed to provide 10 MWh at $50/MWh and the hourly average price turned out to be $40. The SC might ignore the instruction. He would still be paid $500 based on the instruction and charged $400 for his Uninstructed Energy. The presence of these deliberate uninstructed deviations required ISO to dispatch larger amounts of balancing energy and heavily strained ISO's real time operation.

To remedy such problems, ISO devised the 10-Minute Settlement scheme that was implemented in the summer of 2000. It consists the following key elements:

- An Automatic Dispatch System (ADS) is established to provide reliable electronic communication between ISO and the SCs who intend to provide A/S or Supplemental Energy. Through ADS, ISO can issue a large number of dispatch instructions quickly. SCs are required to acknowledge the instructions and indicate to ISO the amounts of energy they can deliver. Based on the acknowledged amounts, ISO can determine whether alternative resources need to be dispatched. ADS helps ISO to dispatch resources much more efficiently and effectively.
- The definition of Instructed Energy is modified to reflect the lesser of the ISO

instructed amount, the SC's acknowledged amount and the amount that is ultimately delivered (as confirmed by the meter data). Instead of being rolled up hourly, Uninstructed Energy is settled for each 10-minute interval. An incremental and a decremental MCPs are determined in each interval. The ISO scheme assures that the incremental MCP is higher than or equal to the decremental MCP. Positive (i.e. surplus energy provided to ISO grid) Instructed Energy is paid the incremental MCP while negative (i.e. energy taken from ISO grid) Instructed Energy will be charged the decremental MCP. On the other hand, positive Uninstructed Energy is paid the decremental MCP and negative Uninstructed Energy is charged the incremental MCP. Through the new definition for Instructed Energy, ISO only pays for Instructed Energy that is actually delivered. The less favorable prices for Uninstructed Energy also help to discourage SCs from excessive uninstructed deviations.

- A No Pay scheme is devised to assure the performance of the A/S providers and deter them from turning A/S capacity into Uninstructed Energy. Under this scheme, ISO withholds the capacity payments (and energy payments in certain cases) if one or more of following conditions are detected:
  - A/S capacity is converted by the SC into Uninstructed Energy.
  - SC declines an ISO instruction to convert the resource's A/S into energy.
  - SC fails to deliver the instructed amount.

5.4 CONGESTION MANAGEMENT REFORM

As the transmission operator, ISO's goal is to allocate the finite transmission capacity to SCs based on sound economic principles which should minimize the congestion costs to the users and provide a price signal that properly indicates the scarcity of capacity. In early 2000, based on previous operational experience, ISO came to the conclusion that the existing congestion management scheme would need significant improvements. Several problem areas were identified:

- ISO's zonal model does not reflect intrazonal reliability constraints that may be due to thermal limits of lines and other factors such as local voltage support requirement, system stability and security. A set of schedules that appear to be feasible in the interzonal congestion management scheme may actually violate certain intrazonal constraints. During early market design, such violations were thought to be infrequent, but they turn out to be more pervasive than expected. If the Congestion Usage Price is established by a set of infeasible schedules, it creates an incorrect price signal to the market.
- By deferring the resolution of intrazonal security violations to real time, ISO can only rely on the resources that provide A/S or Supplemental Energy. However, the merit order of the energy bids from these resources does not reflect their effectiveness in solving a local constraint problem. ISO sometimes may have to resort to "out of sequence" or "out of market" transactions. These transactions typically have higher prices. In addition to the added costs, the existence of multiple energy prices does not help to provide a meaningful price signal.
- In areas where there is lack of competitive resources to resolve intrazonal constraints, suppliers may exercise their market power to fetch unreasonably high prices.

In 2000, ISO launched a Congestion Management Reform effort and proposed a new scheme in which the congestion zones would be replaced by Locational Price Areas (LPAs). The basic approach is to devise a congestion management scheme that will consistently take into consideration of all real time operation constraints. The congestion management results from the forward markets shall lead to feasible schedules that can be implemented in real time. LPAs can be visualized as smaller congestion zones whereby all the operation constraints are translated into inter-LPA flow constraints. LPAs are defined such that resources in the same LPA have the same effectiveness in resolving constraint violations. A LPA may also require a certain level of local resources be available to meet any real time reliability needs. The proposed congestion management scheme utilizes a 2-prong approach.

- A Local Reliability Service auction is conducted in a forward market (proposed to be held 2 days ahead of the operating day). Such services assure the necessary level of resources for managing local reliability issues in real time.
- In the Day Ahead and Hour Ahead Markets, ISO continues to use the adjustment bids provided by the SCs to maintain the inter-LPA flows within constraint limits.

Later in 2000, the California energy market was shadowed by another looming crisis (described in the next subsection). ISO had to focus its attention to tackle the new challenge and the proposed congestion management reform was put on hold.

5.5 PRICE MITIGATION

Following several price spikes in July 1998, ISO set up a price cap of $500 which was subsequently lowered to $250. The market seemed to be working fairly well in 1999 and ISO relaxed the price cap to $750 in October 1999. Year 2000 was a turning point for the ISO markets. In May, energy prices started to climb and ISO had to declare system emergency (which is triggered when system reserves fell below 7% of system demand) on a number of occasions. ISO reduced the price cap to $500 in June and further to $250 in August, but the prices continued to stay at a high level. To meet the system demand, ISO frequently had to procure energy out of market at prices far higher than the market cap. This could happen because the price cap could only be enforced on resources bidding into the ISO market. The higher prices hit two of the IOUs (PG&E and SCE) hardest. Since their tariff rates were frozen, they were not able to collect enough revenues to pay their own energy bills. In December, contrary to the general expectation that prices would drop, the prices reached historic highs. Figure A in the Appendix shows the ISO's monthly average real time energy prices during the first few years of operation. FERC intervened and issued an order [7] to institute the following changes to the California energy market:

- Eliminated the IOUs' requirement to bid all their supply and demand into the PX market. In FERC's opinion, the spot markets are too volatile and prone to manipulation. The IOUs need stable prices which can only be achieved if they are allowed to secure their own supply through long term bilateral contracts. (PX went out of business as a result.)
- Replaced the existing ISO Governing Board with a new one consisting of members that are not market stakeholders. The original Board had about 30 members representing various stakeholder groups (e.g. IOUs, municipal utilities, power producers, large industry and agricultural consumers, and consumer advocates). FERC believed that ISO could not be truly independent under the influence of these stakeholders.
- Established a soft price cap of $150 for the ISO markets. The MCPs for energy and A/S would be capped at this value. ISO might accept and award bids that were above the cap, but they would be paid as-bid and might not set the MCP. These higher bids were also subject to review and refund if the rate was found to be unjust or unreasonable.
- Directed ISO to establish an Under-scheduling Penalty which would apply when a SC failed to submit forward market schedules that covered at least 95% of his actual demand. ISO's Real Time Market was designed to handle about 5% of system demand, but ISO frequently experienced unscheduled demand that amounted to 10% to 20%. Last minute procurement of large amounts of energy created opportunity for price manipulation. ISO agreed to the penalty scheme, but requested a postponement for its implementation on the ground that it would further jeopardize the

financial condition of the IOUs.

- Directed ISO to cancel the payments for Replacement Reserve capacity that had been dispatched in the Real Time Market. FERC believes the energy payment alone is sufficient to compensate for the Replacement Reserve service.

The damages were already done by then. Despite these measures, it did not solve the IOUs' financial problems. Prices stayed fairly high and the IOUs were not able to pay their energy bills. Some suppliers threatened to stop selling to the ISO market. The State government was concerned about the grave impact the energy crisis would have on the state's economy. It stepped in and agreed to financially back the ISO energy markets. In addition, the State also began to procure energy (through other spot markets and long term contracts) to minimize the dependence on ISO's Real Time Market. PG&E filed for bankruptcy in April 2001. On April 26, FERC issued another order [8] instituting a new price mitigation scheme in California. The key elements in the order included:

- Strengthened ISO's authority to coordinate and control generator outages.
- Instituted the Must-Offer requirement for all non-hydro generators in California. Regardless of ownership, they must bid their spare capacity into ISO's Real Time Market. Hydro generators are exempted because they have limited fuel and the concept of "spare" capacity becomes vague.
- The soft price cap was removed. In its place, new price mitigation measures were implemented during periods of system emergency. Under this scheme, all gas-fired units are required to file their heat rates and emission rates with ISO. During emergency periods, ISO replaces the units' bids with the proxy bids that are constructed using the units' heat rates, emission rates, prevailing fuel and emission prices. The units may elect to use their own bids instead of the proxy bids, but they are subject to review and refund. Only the proxy bids may set the MCP.

Both the State and ISO believed that price control measures should be extended to cover all the western States around the clock. The interconnected transmission grid makes the western United States effectively a single market. With price control in one state but not the others, the sellers simply sell to the other states. ISO also observed the "MW laundering" phenomenon in which generators tried to bypass the price cap by export their energy out of state and then selling it back to ISO through out of market transactions.

In May 2001, California State announced the establishment of the California Consumer Power & Conservation Financing Authority whose charter was to finance electricity generation projects, natural gas transmission/ storage projects, and energy efficiency programs so that there would be adequate energy reserve in California within 5 years. In June, FERC eventually modified its position. In its order [9] dated June 19, 2001, FERC expanded its price mitigation scheme to cover the entire western United States. The Must-Offer requirement is applied to all non-hydro generation. California resources are required to bid their spare capacity into the ISO market. Resources in other states may choose markets of their choice. During system emergency periods declared by ISO, the same mitigation measures, as defined in FERC's April 26 Order, apply. Outside the emergency periods, a single mitigated price cap will be applied to all spot markets in the western United States. Following each emergency period declared by California ISO, the mitigated price cap is set to the highest energy MCP set by the ISO Real Time Market during the previous stage 1 emergency. This price cap stays in effect until the next system emergency. Emissions related costs are removed from the proxy bids. In its place, ISO will implement a separate recovery mechanism for the generators' start-up and emissions related costs so that these components do not inflate the MCP. FERC also directed ISO to put a 10% adder in the incremental MCP for energy. The adder is used to compensate the suppliers for their credit risk exposure when bidding into the ISO market.

At the time of writing, the energy prices in California have dropped significantly, even to levels well below the mitigated price cap. The cooler summer temperature, new generators coming on line, energy conservation effort, demand relief programs, public scrutiny of high prices sought by suppliers and FERC's recent price mitigation measures have helped.

In retrospect, the deregulated market provided an environment that exacerbated the energy crisis in California, but there were several other contributing factors.

- Growth of demand in electricity out paced that of supply. ISO's annual peak load has grown by 1000 MW every year since 1998, but very little generation was added during the same period. The rapid demand growth was the result of the booming US economy in the 1990's. The demand grew not only in California, but also in the neighboring states. In California where the economy was fueled by the high technology companies, the demand growth was particularly acute. In the mid 1990's, the State's own forecast projected a surplus generation for California in 2001, but the forecast was based on the assumptions that there would be moderate additions of renewable and cogeneration capacity, availability of excess hydro power in the Northwest and Southwest, demand reduction through energy efficiency programs and interruptible services. Few of these assumptions materialized. California has always been relying on a significant amount (close to 20% of demand) of energy import during summer to meet its peak demand. With the demand growth everywhere and the recent dry winters that did not bring enough snow for the hydro-rich states, our neighbors had little to sell. Supply soon fell short of demand in California.

- There was a sharp rise in natural gas prices in California towards the end of year 2000. About 30% of California's demand is served by generators fueled by natural gas, which is produced outside the State. There has never been sufficient pipeline capacity to meet winter demand in California. It was a conventional practice to store gas inside California during the summer months and withdraw in winter. In the deregulated environment, more and more generator owners decided not to pay for gas storage. Gas prices had been rising steadily throughout the summer of 2000 due to the higher demand by electric generation. An explosion at a major gas pipeline feeding southern California reduced its capacity to 85% for several months. With reduced pipeline capacity and insufficient local storage, gas prices rose to an average of $20/MMBtu in December (compared to about $3/MMBtu in January) and electricity prices also went through the roof.

- The California market model, when coupled with a tight supply condition, created opportunities for market manipulation. The IOUs were required to secure their supply through PX's market which was essentially a day to day spot market. Without the ability to negotiate stable prices through long term contracts, the IOUs were subjected to huge price volatility. When supply was tight, the co-existence of PX market and ISO Real Time Market encouraged sellers to withhold their capacity until the last minute to seek higher prices. The IOUs were not able to secure enough supply through the PX market and this caused the huge unscheduled demand experienced by ISO in the Real Time Market.

- There was insufficient price control measures. When demand exceeded supply, it was natural for sellers to seek ever increasing prices. ISO could not implement any price control measures without FERC's approval.. However, FERC believed that tighter price control would violate competitive market principles and would discourage investments in new generation.

- The IOUs did not have sufficient revenues to pay their energy bills. The two largest IOUs: PG&E and SCE, served the majority of the load in California. With fixed retail rates that were capped by CPUC, they could not collect sufficient revenues to pay their bills. Suppliers claimed that they incurred losses due to the outstanding payments and had to increase their prices to account for their risk exposure. Some smaller suppliers simply stopped selling in California. These created a spiraling effect that drove prices even higher.

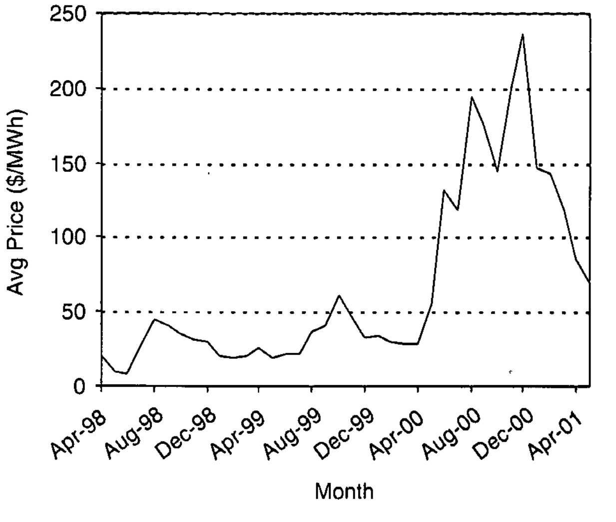
6. CONCLUSION

The road to utility deregulation in California has been rough and heavily influenced by key stakeholders. The initial market model was by no means perfect. During the last several years, significant improvements have already taken place in the energy market, but there are still a lot of remaining issues to be addressed. Consumers have suffered from higher than reasonable prices. On the other hand, the open market has also invited new investments in new generation and transmission facilities. About 1000 MW of additional generation capacity have been put on line this summer and several thousand more is in the construction plan. More than $1 billion of transmission improvements have been approved since 1998. The pace at which new generation and transmission are added is amazing and unlikely to take place under the old regulated regime.

Deregulation is not the miracle solution to foster a competitive environment. It may not lead to lower prices in the short term. Any restructuring effort should be well planned and carefully staged. The market model must be engineered after an in-depth evaluation of various local factors such as amount of surplus generation, transmission constraints, anticipated load growth, potential market power, availability of investments for new generation and transmission, consumer awareness, demand side response, environmental impact, regulatory scheme, among others. Close monitoring of the market conditions by the market operator (or the government) is vital, especially during the transition stage. A truly competitive market may take time to mature. The experience from the deregulated electricity markets in California and around the world provides good lessons for those who contemplate deregulation.

7. APPENDIX

Figure A ISO Real Time Energy Prices



REFERENCES

[1] "California's Electric Services Industry: Perspectives on the Past, Strategies for the Future", CPUC, February 1993.

[2] "Order Instituting Rulemaking and Order Instituting Investigation R.94-04-031/I.04-04-032", CPUC, April 1994.

[3] "Preferred and Alternative Proposed Policy Decision D.95-05-045", CPUC, May 1995

[4] "Memorandum of Understanding", Southern California Edison, California Large Energy Consumers Association, California Manufacturers Association and Independent Energy Producers, September 1995.

[5] "Preferred Policy Decision D.95-12-063", CPUC, December 1995.

[6] "Assembly Bill 1890" , California Legislature, September 1996.

[7] "Market Order Proposing Remedies for California Wholesale Electric Structure", FERC, 12/15/2000.

[8] "Order Establishing Prospective Mitigation and Monitoring Plan for California Wholesale Electric Markets and Establishing an Investigation of Public Utility Rates in Wholesale Western Energy Markets", FERC, 4/26/2001.

[9] "Order on Rehearing of Mitigation and Monitoring Plan for the California Wholesale Electric Markets Establishing West-Wide Mitigation and Establishing Settlement Conference", FERC, 6/19/2001.

[10] "California ISO 1998 Annual Report", California ISO.

[11] "California ISO 1999 Annual Report", California ISO.

[12] "California ISO 2000 Annual Report", California ISO.

Paper No. 10

OPPORTUNITIES, BENEFITS, PROBLEMS AND EXPERIENCE ON POWER UTILITY DEREGULATION

Speaker : Dr L L Lai
Head of Energy Systems Group and
Reader in Electrical Engineering
City University, London
U.K.

OPPORTUNITIES, BENEFITS, PROBLEMS AND EXPERIENCE ON POWER UTILITY DEREGULATION

Dr L L Lai
Head of Energy Systems Group and
Reader in Electrical Engineering
City University, London
U.K.

ABSTRACT

Deregulation leads the electricity industry to focus attention on the costs of generation and provides incentive for generators to reduce their costs and minimise risks. It affects the way existing plant are run and operated. New plants are being built on more short-term cost based decisions. The rules of competition are in conflict with government intervention, which is being reduced. However, governments still intervene in deregulated markets to ensure environmental and security objectives.

Reforms in the electricity sector are progressing at different paces in different countries around the world and in many cases they have not even started yet. There are still many unresolved questions on the long term effects, and the future development of reforms will depend on the experience gathered. New technologies suggest new market applications, imply new possibilities for market structure and so lead to pressures for regulatory reform. Regulatory and institutional changes occurring for other reasons can create opportunities for technologies.

As there is much uncertainty in the environments, due to the structure of the market, planning over a long-term horizon is perceived as a very difficult at present. Yet, without long term planning, it is likely that the electricity power industry would be at great risk, as it might not be able to supply the growing demand, or to maintain the same quality of service as it is currently providing to its consumers. The recent chaos in California is an example.

Since there is a large number of players in the market, it is important to work out the type of bidding, or negotiation strategies that each player can play. It is especially important to work out the information content of the bidding strategies. This paper also covers experience from various countries on power utility restructuring and deregulation. Analytic tools for the modelling and analysis of competitive power markets are discussed.

1. INTRODUCTION

Restructuring of the electricity supply industries is a very complex exercise based on national energy strategies and policies, macroeconomic developments and national conditions, and its application varies from country to country. It is important to point out that there is no single solution applicable to all countries and there is a broad range of diverse trends.

Competition is fundamental to most market reforms and it is introduced in order to reduce costs and increase efficiency. There is considerable variation in the extent of the competition which is introduced. For example, competition could be introduced just for the addition of new generating capacity and referred to as competitive bidding where the existing generating company invites contractors to tender to build, operate and sell electric power to the monopoly at a specified price. Alternatively all licensed generators could be allowed to compete to supply wholesalers or retailers through a short-term market (spot market) or via longer term contracts; this is called competitive generation. The next level is wholesale competition, i.e. competition in the sale of electricity to wholesale companies for resale to a retail level or directly to final customers. This usually allows the large consumers to choose their own suppliers. Competition at final consumer level, including household consumers, is called retail competition. This is usually the very last step of the reforms, as it requires a complex information technology system because of the large number of small users involved. Retail competition is usually introduced gradually starting with the larger industrial consumers, then the medium consumers and finally including smaller consumers.

2. THE ADVANTAGES OF COMPETITIVE GENERATION

Competitive generation provides a market within which independent firms compete on the basis of price to sell electricity directly to large industrial customers, and to supply electricity, via common carrier transmission, to distributors who in turn sell power to final users. Producers may specialise or diversify by load characteristic. For example, some may prefer to compete for long-term base-load contracts. These firms are likely to own hydro and nuclear power plants. On the other hand, firms with fossil fuel plants might seek to supply base and cycling loads. Finally, producers with gas combustion turbines and co-generators could compete to meet peak loads. Other firms may diversify and be ready to compete for base, cycling and peak loads. Prices charged for each type of service (peak and off-peak load, daily to seasonal) could be established by contract, 24 hour advance notice, and in spot markets. Unit prices could vary by the amount of electricity purchased per period. As a result, customers would face more service options and a more complex pricing scheme.

3. THE ROLE OF THE EXISTING POWER INDUSTRY

The nature of the existing generating plants will affect the speed of reforms. In countries where the coal industry has dominated the economy there has been opposition to restructuring the electricity industry, which usually includes a substantial amount of coal-fired capacity. Deregulation of the electricity sector meant loss of a secured market for coal which now has to compete for its share in the market.

Prices tend to go down as competition is introduced and are expected to fall significantly in the long-term. For example, in the UK prices have fallen since the market opening and they are expected to fall even lower. In 1995 real prices, the price of electricity for industry decreased by almost 13% and the price for households by 6.3% between 1991 and 1995. It is has been observed that industrial prices have decreased more than household prices in most of the countries where reductions have occurred.

One of the consequences of privatisation is the development of the international energy company concept - a company whose focus is becoming more global and more multi-purpose. For example US electricity and gas companies have been purchasing electricity assets in the UK, and Australian and UK companies have been heavily involved in setting up independent power projects in developing countries. Another change with privatisation is the focus on shareholder value. Privately owned companies have to compete for funds in the capital market and it is important to show that they operate efficiently and are expected to do well in the business environment to attract investors. That means a completely new organisational structure and strategies for companies from what were used in the highly regulated power industry.

4. RECONFIGURING THE ELECTRICITY SYSTEM

In the past, power systems were developed to transmit large amounts of power at high voltage from remote generating stations and to distribute power at lower voltage down to millions of small consumers. This was the favoured pattern, allowing ever-larger power stations, mostly coalfired, to be built and achieving economies of scale and high efficiency. The national grid evolved to ensure secure supplies to all consumers and centralised control and supervision was essential. In the present privatised electricity supply industry based on free trading of electricity as a commodity, central control is unwelcome. Wherever possible, electricity generation should be closely integrated with space and process heating in a diverse array of combined heat and power (CHP) systems. Renewable energy sources should be harnessed by large numbers of wind and wave machines, marine tidal-current or small-hydro plant, solar photovoltaic generators on roofs and small generating plant close to farms supplying wood fuel or to sources of combustible waste products. Generating plant will be small and dispersed and since CHP systems must be located close to their heat loads there will be a natural tendency for most electricity generation capacity to lie close to the consumer. There will be little need to transmit large amounts of electric power over long distances. The function of the power system will be to handle the fluctuations in load and in the output from the renewable power generators. High-power, long-distance transmission will be much less important.

In the current energy structure, a central power plant is the key facility providing energy for houses, factories and offices. With decentralised co-generation of heat and power and the deployment of renewables, this situation would change. The new structure would be less centralised and more dispersed. Network stability and frequency regulation would gain in importance and energy storage would become very important. Electricity generation is provided by a large number of small units rather than a small number of large units. Co-generation is the generation, on site, of your own power and at the same time taking advantage of the exhaust heat from your gas turbine or other engine to meet on-site heat needs. Heat can be used to heat buildings, heat dryers, generate steam through an HRSG (heat recovery steam generator), or to provide air-conditioning through an absorption chiller. Power and heat can be generated locally from natural gas or liquid fuel using an efficient, reliable gas turbine.

The uncertainty in the USA today is what will happen to electricity prices. The major competing factors are limited deregulation and lack of new generating stations (particularly large coal or nuclear stations). Estimates range from modest decreases in prices, to the levelling of local inequities, and significant increases driven by demand without supply. Our view is that prices over the long haul will increase slightly with some local inequities being eased. All this means that for many sites cogen (distributed power) will be a viable option for those willing to improve their competitive position through reduced energy costs.

New enabling technologies have now improved transport of electricity in high-voltage DC systems to the point where this may be cheaper, and use less energy, than transporting fossil fuels, for distances of 5000 km and above. This might make it possible to link low-CO_2 power sources where demand is low to distant regions where demand is high.

4.1 ENERGY POLICY AND GOVERNMENT INTERVENTION

There is always going to be some government intervention in energy policy to ensure consumers' interests are protected, demand is met and competition is fair. In some European countries and the USA there are special provisions for electricity generation from renewable energy sources. In Italy, for example, new legislation requires that from 2001 all generators and importers of electricity will have to supply into the system a quota generated by renewable sources. The EU directive allows member states to balance competition with public services where this is necessary in the general interest of the society, provided they comply with Community law. Examples could be an obligation for the customers to purchase a certain percentage of electricity from renewable energy sources or an obligation for distributors to supply all customers in their area at an equal price per kWh.

The political decisions set the economic framework in which the energy industry networks will determine success or failure in meeting the target. Private developers will install the CHP and the renewable energy plant if they see a return for their investment. If the necessary developments are to happen, unpopular measures will be required, such as taxes on emissions, incentives for the development of suitable installations, and the relaxing of restrictions imposed by planning regulations.

Deregulation has led the electricity industry to focus attention on the costs of generation and provides incentives for generators to reduce their costs and minimise their risks, e.g. by investing in smaller scale plants. Capital costs, construction time, fuel costs, operation and maintenance costs will determine the decision on what plants are built.

4.2 CLEAN COAL TECHNOLOGIES

Clean coal technologies is a term used for technologies that achieve a higher efficiency and lower emissions for converting thermal energy to electricity than conventional pulverised coal combustion (PCC) with subcritical steam and without emissions control. The term is also used to include emission control systems such as NO_X control equipment. Clean coal technologies are the way forward for coal as they can ensure compliance with the tightening environmental standards. There has been considerable effort to develop these technologies at competitive costs. Reserves of coal are large and widely distributed and are likely to continue to be widely used, so more efficient and cleaner coal technologies (CCTs) are an important option in a future energy strategy. CCTs will enable the use of coal with higher energy efficiency and minimum environmental impacts. There are four main types of coal technologies applicable to large-scale power generation: supercritical steam PCC technologies with emissions control equipment (SPCC), atmospheric circulating fluidised bed combustion (CFBC); pressurised fluidised bed combustion (PFBC); and integrated gasification combined cycle (IGCC) technologies. Retrofitting pollution control equipment is also important as future and existing coal-fired plant may need to meet increasingly stringent environmental standards.

4.3 ENVIRONMENTAL CONSIDERATIONS

Energy is one of the most critical resources for modern society. At a global level, it is expected that energy consumption will at least double in the next 50 years and grow by a factor of up to five in the next 100 years. At present levels of consumption, our use of energy poses threats to the climate, with potentially severe environmental consequences; given the levels of consumption likely in future, it will be an immense challenge to meet the global demand for energy without unsustainable long-term damage to the environment. This situation has attracted the attention of political leaders across the world, and at the Kyoto meeting of the parties to the UN Framework Convention on Climate Change in December 1997 there was agreement to tackle one aspect - the amount of greenhouse gases emitted to the atmosphere. The levels of atmospheric CO_2, for example, have increased from 285 ppm before the Industrial Revolution to about 350 ppm now. It is now generally accepted that there is a strong case for acting to mitigate the threat of drastic climate change associated with the unrestrained continuation of this trend. The Kyoto meeting produced pledges by the industrialised nations to cut their GHG emissions, by 2012, to an average of 5% below the 1990 levels.

Deregulation could play a positive role by giving flexibility to different plants or even countries to trade emissions. In this way a generator could have a portfolio of plants including some using renewable energy and therefore meet overall environmental requirements. It could also help the development of less costly pollution control technologies. In the single European electricity market, however, where electricity will be traded between member states, it is not yet clear where to allocate emissions. It could be the country where electricity is produced or where it is actually used. This is particularly important in the view of commitments to reduce GHG emissions.

In a deregulated market the environmental image of fuels and technologies is important. It can influence decisions taken by developers and politicians for new projects as well as by consumers. Competition in retail will certainly create more possibilities for electricity consumers to influence developments. Although cost and security of supply remain the main factors affecting customer choice, as environmental concern grows this choice may be influenced by the environmental consideration. In the UK a number of electricity suppliers are planning or have launched environmental tariffs for household consumers, selling electricity from renewable energy projects. An opinion poll in the UK found that 86% of consumers would prefer to buy electricity from renewable sources, but only 21% of those would be prepared to pay more for it. In California an energy supply company has launched a green energy scheme which gives customers the option to buy a part of or all their electricity from renewable energy sources.

4.4 DISTRIBUTED GENERATION

Many studies indicate that distributed generation (DG) might play a significant role in the future power system structure. A study by the Electric Power Research Institute (EPRI), for example, indicates that by 2010, 25 % of the new generation will be distributed [2]. Owing to variations in government regulations, different definitions for DG are used in different countries. In England and Wales, the term 'distributed generation' is predominantly used for power units with less than 100 MW capacity. In Sweden, DG is often defined as generation up to 1500 kW. In Australia DG is often defined as power generation with a capacity of less than 30 MW. In New Zealand, DG is often considered as generation up to 5 MW. There is no special definition of DG in the Californian and Norwegian electricity markets.

A general definition for DG could be an electric energy source connected directly to the distribution network or load centre. Customers benefit from the success of DG because:

- The use of distributed energy will allow improvements in the dispatchability of resources and improve the integrity of the transmission and distribution systems.
- Identification and use of alternatives to power generation, transmission and systems controls will improve load levelling, load management and overall power quality.
- The system will become more robust in its ability to tolerate natural disasters, suffer less damage and minimise the dependence upon the need for immediate restoration of the grid system. Overall system reliability will improve.

4.4.1 MARKET REGULATION

In competitive power markets, DG competes with centralised power generation. Hence, market regulations should ensure that DG can act freely within power markets, similar to centralised generation. It is, however, often argued that most market regulations used worldwide have been designed with large centralised generation in mind and that, therefore, DG often faces significant barriers within the competitive market.

4.4.2 THE POWER POOL

The power pool is used to create an efficient marketplace for trading electricity. The main difference between various approaches for electricity markets is that the trading of electricity through a power pool (or power exchange) is optional in some countries, e.g. in Nord Pool (Scandinavia), and mandatory in others, e.g. England and Wales as well as in the National Electricity Market in Australia.

In the UK, there are three main problems associated with the pool price:

1. Most energy contracts effectively bypass the pool.
2. Since system marginal price is paid to all, it is mathematically impossible for bid prices to be meaningful.

3. Average pool prices bear no relation to any real price parameter. The price of fuel and hence of generation has been falling steadily since 1990. Pool prices, by contrast, rose until about 1994, steadied, and now seem set on an upward path again.

Pool prices are related to centralised generation, but most renewables - and all DG, by definition - are injected into low (33 kV or below) voltage networks. So electricity at the retail level is being valued at wholesale prices, which is wrong. The characteristics of pool pricing are marginal pricing, complexity of bids and pool capacity payments. These lead to slow progress in change and decision making, lack of transparency in contracts for differences, concern over prices and a reduction in consumer confidence. As a result, new electricity trading arrangements (NETA) were proposed [3].

The expected benefits of NETA are:

- Lower prices from more efficient and competitive trading
- Focus on bilateral contracts and firm trades
- More direct demand-side participation
- Sharper incentives to manage risks
- Greater choice of markets
- Increased transparency and price discovery
- More efficient and effective governance.

The government's reforms to the electricity market, of which NETA is an important part, will lead to lower electricity prices - at least 10 % lower at the wholesale level over the medium term. A fundamental change in the market will have a big impact on different buyers and sellers in the electricity market. The reformed market will encourage generators to deliver what they say they will. The introduction of the new arrangements will have different effects for different market participants. Some distributed generators, particularly renewable and CHP generators, are concerned since the arrangements will favour generators with flexible and predictable output and those generators with inflexible and unpredictable output will face exposure to imbalance charges. Therefore, not every CHP scheme will benefit from the NETA reforms. However, the position of renewables and CHP generation needs to be looked at in a wider context.

4.4.3 ANCILLARY SERVICES

The general approach for pricing ancillary services within competitive electricity markets is based on fixed contracts for a certain time period between the independent system operator and market participants that are able to provide the required ancillary services. Thereby, the ancillary services are split up into different services, e.g. active reserves, reactive reserves and system restart. In regard to DG, active reserves and reactive reserves are of particular interest. Many DG approaches aim at participating in the ancillary service market to get an additional income just like 'traditional' generators. However, often DG is not regarded be able to maintain the 'right' level of reliability and quality and at the same time as being cost competitive.

The contracts for different ancillary services in competitive electricity markets are usually awarded in tender processes. However, new technologies, such as DG, usually face significant barriers within specific bidding processes, as the tender is often only open to traditional technologies. This assumption is confirmed by the Norwegian regulated power market, since it is only open to generators with a minimum installed capacity of 40 MW.

4.4.4 TECHNICAL ISSUES

The generation of electricity by distributed generators within distribution networks raises a number of technical issues concerning real and reactive power flows, voltage regulation, fault levels and power quality.

Most small distributed generators, such as the majority of wind generators and small-scale CHP systems, are based on induction machines which have no steady-state reactive power generation capability. There is a need to import reactive power to provide field excitation.

5. LONG-TERM PLANNING

The essential point of long-term planning is to determine how external influences, including growth of new business and changes in the regulatory environment, will affect the development of the network and the levels of investment that will be required.

5.1 CHANGES IN DEMAND

The impact of load growth and new business can be determined by the economic study of demand growth. This is a significant subject in its own right and no attempt will be made to discuss the building of a demand model here. Any such model should address sufficient growth scenarios to allow the planner to assess the sensitivity of their proposals. It is normal to plan against a nominal base case load forecast. The base case forecast would define the most likely growth scenario, but being a long-term prediction it is unlikely to be very accurate in the short (3-5 year) term. Two alternative load growth scenarios should also be considered. These are normally a high-growth scenario and a low-growth scenario. Actual load would be expected to vary between these two predictions, hopefully showing a linear trend similar to the base case forecast.

Developing a long-term plan against such forecasts allows the planner to refine its long-term developments to maximise the flexibility of the network. The current regulatory regime has encouraged a five-year planning cycle. The problem with the five-year plan is that construction of the latter stages of a plan has to begin very shortly after the plan has been defined, limiting the flexibility of the planner to change the proposal to meet changes in demands on the system.

Whilst it is often considered that planning more than five years ahead is of little benefit because of changes in load growth. This will give an improved view of the risk of large capital investments needing to be brought forward or deferred. The planner can therefore continually adapt the long-term development proposals to the changing environment.

In time adopting such a methodology should lead to an improved match between system developments and the demands they must supply. Such techniques have been successfully applied in a number of projects worldwide and are typically standard practice when developing plans for international financing agencies.

The advent of the increased demand for telecoms data and Internet services has also begun to add significant loads to the distribution systems particularly for the associated switching centres. The magnitude of such loads (10-40 MW) and time scales (12-18 months) for such developments are such that the distribution company has to be in a position to respond creatively and flexibly if it is to avoid losing the potential business either to another company in a different location where supply can be afforded quicker or cheaper, or to a competitor who is prepared to establish a separate distribution or private network. The large urban centres such as London are not seeing the predicted reductions in system maximum demand due to more efficient loads as these are being offset by these IT-related increases.

6. WHOLESALE ELECTRICITY MARKET

Wholesale electricity market characteristics include auctions, bidding, pricing, forward and real-time markets, simultaneous and sequential markets, congestion management, bilateral trading, scheduling, gaming, ancillary services, physical and financial markets [4]. In a wholesale electricity market multiple products that may not be very distinctive from one another are being traded over multiple time periods using several different mechanisms.

6.1 CHALLENGES

Electricity markets are highly complex systems that consist of a number of interrelated markets for different commodities (energy, transmission and ancillary services) and different time frames (real-time, hour ahead and day ahead). There are still many unresolved problems in the design and operation of electricity markets. Practical difficulties arise when the pure economic theory is applied to a power system with operational constraints. The economists want the electricity markets to embrace the laws of supply and demand and with simply ideal examples they can show the benefits of such a competitive environment. The real-time nature, physical constraints and reliability issue all act to make the development of an ideal market impossible. It should be noted that it is well accepted that all markets, even those for simple commodities, are not ideal. Therefore the goal should be to develop a market that is a *best fit* to the ideal.

Several wholesale electricity markets have been established around the world and most of these are in a continuous process of change. This evolutionary process is being driven by the need to address some of the outstanding issues in the design and implementation of these markets. Some of these challenges are:

6.1.1 SYSTEM CAPACITY

The issue of planning in generation and transmission must be addressed with a view to maintenance and enhancements to meet increasing demand. On the generation side these functions are generally left to the market, the assumption being that energy prices will signal the best times to maintain units and when to build new plant. A market for generating capacity over a longer time frame (more than one year) may provide the necessary market signals to ensure that the system will expand according to the needs of the consumers. The concept of marginal cost pricing for electricity is based on fundamental microeconomic principles. In an ideal market bidding at incremental cost is an optimal strategy. However, the resulting schedule may be unprofitable because of costs such as no-load costs, startup costs and fixed costs. In the VIU environment with spot pricing Schweppe *et al.* [5] introduced the concept of revenue reconciliation where marginal pricing may not be sufficient to cover all costs and give a reasonable profit. In competitive markets revenue reconciliation should be redundant as it can be argued that marginal cost pricing will in the long run resolve this issue. In the long run if the revenue participants receive is not sufficient to cover their fixed costs plus expected profits then they should not be in business. However, this issue is still a matter of debate [6].

6.1.2 RELIABILITY

While it is desirable to encourage competition in the electricity market to reduce the costs and improve the service quality for consumers, it is also vitally important to maintain the system reliability. In an operational environment, an important reliability measure is system security. Much effort in the past decades has been devoted to the development of computational tools for system security assessment. These tools include state estimation, contingency selection, contingency evaluation, external network equivalents and load forecast. As the power industry evolves into a competitive environment, system security continues to be an important function. Since the environment is market driven, however, there are new technical challenges. For example, the level of uncertainty in the generation pattern has increased significantly. This is due to the fact that the market decides the generation patterns and the market outcome may not be easily predictable. Consequently, a system engineer at the ISO who studies system security may find it difficult to predict the future generation and load conditions for evaluation of system security.

7. DIFFERENT EXPERIENCES

Different market structures and pool systems employed in various countries will be covered in this section. In particular there are detailed subsections on countries like England, Wales and Norway, which are among the pioneers in energy deregulation. These subsections include numerical examples to illustrate the *ex ante* and *ex post* pricing mechanisms in these countries. The relatively new Californian market will also be discussed and analysed. Each of these sections concludes with a discussion on lessons that could be learnt from each country's reforms. There is also a brief description on reforms in other countries like Scotland, New Zealand and Germany, and in the European Union [7].

7.1 ENGLAND AND WALES

The England and Wales Electricity Pool facilitates a competitive bidding process between generators by setting the price of electricity each half-hour of the day and establishing which generators will run to meet forecast demand. It is a mandatory pool that acts like a uniform price single-sided auction (only a very small number of demand side participants are allowed to bid) and adapts *ex ante* pricing combined with *ex post* mechanisms for power imbalances.Since it is a mandatory pool all generators have to offer bids to the pool. Trading outside the Pool is only allowed in the form of hedging contracts such as Contracts for Differences (CFDs). The purpose of CFDs is for participants in the pool to hedge the price fluctuation of the pool prices.

Even though there has been a significant drop in electricity prices in England and Wales since privatisation, this price drop does not fully emulate the cost reduction of generation. These lower prices are not passed on to customers entirely but are partially retained by generation companies in the form of higher profit. Also, there has not yet been a significant decrease of price in the retail market. A possible reason for the inefficiency in the wholesale market is that the three largest generators could game and manipulate the wholesale market. The market lacks small IPPs which could potentially favour competition and reduce the market power of the large generators.

In view of the existing problems of the pool, the director of the Office of Gas and Electricity Markets (Ofgem) published the NETA for England and Wales in 1998. The reforms should commence in 2001 and should lead to significant changes in the existing market. First of all, a discriminatory auction will replace the uniform auction. Secondly, demand-side bidding is allowed so the market will transform into a bilateral market. The reforms are designed in such a way that participants can choose over different ways they participate in the market. In a different time frame before actual delivery participants can choose to trade in the following markets:

Forwards markets: these are optional and are operated by independent organisations. Participants can sign bilateral contracts that are up to several years ahead as desired.

Short-term bilateral market: this is optional and open from 24 to 4 hours ahead of the trading period. All trades will be organised by a market operator (MO).

Balancing market: this is also optional and it is open 4 hours ahead to the end of each trading period. It would engage in trades to ensure that generation and demand are balanced, taking into account and resolving any constraints on the transmission network. Real-time power imbalance charges are imposed on participants whose contracted amount is different from the actual metered amount. The reforms feature full demand-side bidding, firm offers and bids and simple offers and bids, and they aim to provide market participants with higher flexibility over different ways of trading.

7.2 NORWAY

Similar to the England and Wales Pool, the Nord Pool utilises ex ante pricing to set the prices one day prior to delivery and compensates power imbalances using ex post mechanisms. One day ahead of actual delivery, the Nord Pool accepts generator offers and demand bids for each hour of the following day. The system price is the equilibrium point where the aggregate demand curve meets the aggregate supply curve. The Nord Pool facilitates a uniform price auction by paying all generators the last accepted bid. When there are bottlenecks between bidding areas during this process, the whole region is divided into different price areas. In the surplus area, the area price is found by the right shifting of its demand curve by an amount equal to the line capacity, whilst in the deficit area, the area price is found by the right shifting of its supply curve by the same amount. In economic terms, the area price in the surplus area is set up in such a way that it should stimulate an extra demand which has a quantity equal to the capacity of the constrained line. On the other hand, in the deficit area, the area price is set up so that suppliers are encouraged to supply an additional amount equal to the capacity of the line. Congestion management will be costly when congestion becomes more serious. Moreover, the selection of regulating bids using merit order, which is easily comprehensible by participants, does not necessarily result in the lowest cost to alleviate congestion.

7.3 CALIFORNIA

The California Power Exchange (CalPX) is responsible for holding auctions for the competitive forward markets (day-ahead and day of markets). The day-ahead market is similar to its counterpart in Norway and England. Market participants provide hourly supply/demand bids to CalPX one day prior to physical delivery. A market-clearing price (MCP) is actually the equivalent of system price in Norway or system marginal price in England and Wales. Uniform pricing is adopted and all participants are paid or debited the MCP. The day of market provides participants with the chance to make up for system imbalances by holding auctions at various times during the delivery day. Zonal pricing is employed for congestion management. Market participants can submit the so-called schedule adjustment bids (SABs) which are similar in nature to the regulating bids in the Nord Pool. The SAB represents the desire of the participant to adjust its schedule if energy price varies. When there is congestion, the region is divided into zones and the ISO calculates the zonal prices using SABs. The PX uses this information to work out the final prices for participants so that upon settlement the PX remains revenue neutral.

Energy deregulation is in its early stage in California and it is premature to comment on the efficiency and operation of the various markets. However, there is concern over the operation of the spinning and non-spinning reserve markets. Generators have to reserve a certain amount of their capacity in order to bid in the reserve markets. They are not encouraged to do so unless they can make more money in the reserve markets than in the spot market. Because of that reason, generators submit very high bids to the reserve markets, resulting in non-competitive reserve prices. Non-spinning reserve has a relatively higher price than spinning reserve because there are insufficient participants in the non-spinning reserve market.

7.4 NEW ZEALAND

The voluntary wholesale electricity market in New Zealand commenced in 1996, but before that there had already been limited competition in the supply sector. It is operated by the Marketplace Company Ltd (M-co Ltd) which has recently been sold to RMB Australia Ltd. As in the Californian Pool, market participants in New Zealand can trade outside the pool through bilateral contracts, provided that the system operator is informed of the transactions. In New Zealand generation is dominated by hydro power, which is located in the South Island. The load concentrates on the North Island which is connected to the South Island by an HVDC interconnector. Even though the three government-owned generation companies dominate the wholesale market, the market remains transparent through the broadcast of predicted prices and load forecast. Effort was spent only on introducing competition in the retail sector between distributors and the state-owned generation company, but it was soon realised that retail competition alone was not enough to reduce electricity prices and hence the wholesale market was developed subsequently. The New Zealand spot market is an *ex post* market featuring nodal pricing. Nodal pricing is based on the theory of spot pricing. Under nodal pricing, if the market is competitive, the short-term price signals so generated should enhance the efficient operation of the market. However, there have been ongoing discussions on effective economic long-term price signals and the management of the losses and constraint surplus arising from nodal pricing. *Ex post* pricing in the physical spot market is accomplished using the latest supply and demand bids and the actual measured plus losses in the system. Measurement of actual demand is vital and it is one of the main roles of the Metering & Reconciliation Agreement. Final prices are published a few days after the actual dispatch.

7.5 THE EUROPEAN UNION AND GERMANY

After years of negotiation and debate, The Council for the European Union eventually adopted Directive 96/92/EC in December 1996 to liberalise the electricity industry. According to the directive, members of the EU are required to open their markets gradually. By the year 2006 at least one-third of the EU-wide energy market will have been opened. Different European countries can liberalise their markets at their own pace, as long as the requirements set by the directive are met. Apart from introducing competition in the wholesale and retail sectors, the directive also features unbundling. Countries at the forefront of liberalisation include Spain and the Netherlands. In Spain, a pool, similar to the existing one in England and Wales, will be developed to set up pool prices based on hourly supply and demand bids, while in the Netherlands the Electricity Act in 1998 mandates a complete liberalisation of the generation section by the year 2007. However, there are also countries, like France, Italy and Belgium, which keep their liberalisation progress to the minimum level required by the directive because of domestic political reasons.

In April 1998, Germany opened its market to all suppliers and end users. As it is a country with relatively few natural resources, two-thirds of the energy consumed is imported from other countries. Effort in deregulation is therefore focused on the maintenance of security of supply. Under the Energy Law Amendment net owners are required to provide open access to facilitate competition. However, only a few out of about 700 net users have so far published the charges for using their networks. At present, most net owners also operate the grid; therefore the issue of separation of ownership and operation would need to be looked into. Also, practically small customers have not been able to change their suppliers easily under the current legislation.

The German project group on the energy market is drafting a potential project sketch and it is likely that the concept for the potential energy market will be similar to the developed EEX (European Energy Exchange). It is envisaged that the development of the market will be done step by step. The first step will be the development of a futures market where bilateral contracts can be traded ahead of time. Then a spot market will be founded for physical and short-term power trading. Before reaching that step, Germany has to work on the infrastructure and regulations for fast and reliable wheeling which is essential for efficient running of the spot market.

8. CONCLUSIONS

This paper has discussed the opportunities, benefits, problems and experience on power utility deregualtion. It can be foreseen that in this new environment, utilities win because they retain rights over their transmission system and can charge what the market will bear rather than a regulated price. They do not need to surrender control to regulators and can recover stranded costs, limited merely by the right of others to compete. They can also gain the right to invade the territory of others. Consumers win because the grid will develop naturally, since newcomers must demonstrate competence. Grid innovations become necessary and reliability is maximised.

REFERENCES

[1] H. Chao and R. Wilson, 'Priority service: Pricing, investment, and market organization', *American Economic Review,* Vol.77, 1987, pp. 899-916.

[2] Thomas Ackermann, G. Andersson and L. Söder, 'Electricity market regulations and their impact on distributed generation', *Proceedings of the International Conference on Power Utility Deregulation, Restructuring and Power Technologies 2000,* IEEE, April 2000, pp.608-613.

[3] 'New electricity trading arrangements (NETA) program', Office of Gas and Electricity Markets, 2001.

[4] Mark O'Malley and Chen-Ching Liu, Competitive Wholesale Electricity Market, in Loi Lei Lai (Editor), *Power System Restructuring and Deregulation: Trading, Performance and Information Technology,* John Wiley & Sons Ltd, Chichester, UK, 2001.

[5] F.C. Schweppe, M.C. Caraminis, R.D. Tabors and R.E. Bohn, *Spot Pricing of Electricity,* Kluwer Academic Publishers, 1998.

[6] B.H. Kim and M.L. Baughman, 'The economic efficiency impacts of alternatives for revenue reconciliation', *IEEE Transactions on Power Systems,* Vol.12, 1997, pp.1129-1135.

[7] Kwok Lun Lo and Yee Shan Yuen, Deregulation of Electric Utilities, in Loi Lei Lai (Editor), *Power System Restructuring and Deregulation: Trading, Performance and Information Technology,* John Wiley & Sons Ltd, Chichester, UK, 2001.