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Restructuring Kuwait Electric Power System: Mandatory or Optional?

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***Abstract*—**Kuwait's electric power system is vertically integrated organization owned and operated by the government. For more than five decades, the government of Kuwait has provided relatively reliable electric services to consumers with subsidized electric service fees. Given the country's rapid socio-economical development and consequently the increase of electricity demand, a question that inflicts itself: Is it necessary to reform the power system to face the fast growing demand? This paper recommends that the government should consider the private sector as a partner in operating the power system. Therefore, power system restructuring is needed to allow such partnership. There are challenges that prevent such restructuring. Abstract recommendations toward resolving these challenges are proposed.

***Keywords*—**Deregulation, electricity market, ISO, private sector.

I. Introduction

THE State of Kuwait is located on the northern west coast of the Arabian (Persian) Gulf and has an area of 17,818 km^2. In year 2007, Kuwait's population was 3.1 million. It had gross domestic product (GDP) of USD 138.6 billion with GDP growth rate of 5.7% and it is relatively stable. Kuwait holds 10% of the world's oil reserve. The oil industry accounts for 80% of country's revenue and 95% of export revenues [1].

Kuwait's electric power system (KEPS) is vertically integrated utility that is owned and operated by the Ministry of Electricity and Water (MEW), which is a government organization. KEPS is solely dependent on fossil fuel to generate electricity. Table I presents the fuel types and total consumption to satisfy the electricity demand in the year 2005 [2].

TABLE I
Total Fuel Consumption for Electricity Generation in Year 2005

Fuel Type	Total Consumption
Heavy Oil	46,349,361 Barrels
Crude Oil	19,323,394 Barrels
Gas Oil	782,700 Barrels
Natural Gas	90,656 M ft^3

Kuwait's demand for electricity has annual growth rate of 6 – 8% for the last decade and it is expected to stay within the range of 5 - 6% for the next decade. Thus, the figures given in Table I have increased at least 10% since 2005. The fuel consumption increase pace will stay the same for the coming years.

Oil is the major (if not the only) factor that has a significant role in the country's economical, social and political affairs. Unfortunately, oil is a non-renewable resource, and hence, adopting alternative strategies to generate electricity has become the concern of the government of Kuwait. This bearing is perceived from His Highness the Amir of Kuwait (Sheik Sabah Al-Ahmed Al-Sabah) announcement in November 2007 OPEC meeting support of USD 150 million that will be granted to energy research and development (R&D). Moreover, Kuwait's Council of Ministers General Secretariat has called for initiatives involving alternative energy R&D and implementation.

However, adopting alternative energy resources, such as, solar, wind, hydrogen and nuclear, for electric generation is only part of the solution. Reforming any conventional public power system (for the purpose of enhancing its reliability and sustainability) involves the implementation of the following procedures:

- Adopting various energy resources for electric generation.
- Applying demand side management (DSM) policies.
- Restructuring power system from vertical to vertical-horizontal hierarchy organizations.

Several studies have addressed the first two procedures that are related to Kuwait, e.g., [3] – [6]. Only pilot small scale systems that utilize alternative energy sources (solar and wind) have been implemented. However, DSM policies (which include tariff increase) have not been applied due to bureaucratic administrative routines and parliament majority opponents. There has not been any work done that addresses the restructuring of KEPS.

This paper discusses the importance restructuring of KEPS. Several related issues including technical, administrative and legal concerns will be raised. The purpose of this exercise is to identify the feasibility of restructuring KEPS in the middle (10 to 15 years) or long (more than 20 years) term to face the rapid electricity demand.

Section II reviews the present KEPS structure. Section III provides a background on power system restructuring and electricity market modeling. Based on the given aspects presented in sections II and III, challenges facing the restructuring of KEPS will be identified in Section IV. Section V provides concluding remarks.

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II. Present KEPS Structure

The present installed generating active capacity of KEPS is 10,300 MW. There are five electricity generating plants that are distributed along the Arabian Gulf coast. The distant between the far most two power plants (i.e., Sabiya in the north and Az-Zour in the south) is approximately 160 Km.

There are four voltage levels in the electrical network [2], which are:

- 275 kV is the system backbone which the main generating units are connected to it. The total length of this level underground and overhead line is 854 km. The number of its substations is 18.
- 132 kV is the link between the transmission voltage level (i.e., 275 kV) and the distribution voltage level (33 and 11 kV). The total length of this level underground and overhead line is 4,014 km. The number of its substations is 246.
- 33 kV is the sub-transmission level that feeds the 11 kV sub-network. The total length of this level underground and overhead line is 3,129 km. The number of its substations is 116 and the spur substations number is 171.
- 11 kV is the level that is dedicated to distribution (low tension 415 V). The total length of this level lines is 7,279 km. Length of low tension lines is 19,903 km. Length of overhead 11 kV/415 V is 3,724 km.

KEPS has a very high degree of reliability, as a consequence of the high level of interconnection and the accurate management of components and plants, in terms of inspection, operation, and maintenance. However, having such level of interconnectivity within small area develops some challenges in transmitting and distributing the power.

About 5% of Kuwait is inhabited, consequently, the electric network approximately covers 5% of Kuwait's area, i.e., it covers about 891 km^2. An apparent feature of KEPS is the large number of links within small area. Such feature leads to small impedance network. This configuration causes high level of short circuit current. Furthermore, the transmission network is low loaded (in the average); however, there exist some congestion nodes at which substations (few of the 275 and 132 kV substations) and links are heavily loaded. This feature of the network will be considered in later section.

III. Restructuring Electric Power System: Review

A typical monopoly, vertically integrated and publicly owned electric utility (such as KEPS) is shown in Fig. 1. In this case, the generation, transmission, distribution systems are owned and managed by one organization. The ideal goals of restructuring, which will also be referred to as deregulation, are to maximize consumer choice, promote completion and improve the quality and variety of services and to enhance efficiency of the electric enterprises.

The general mechanism of deregulation is to divide the power system into several smaller enterprises. The purpose of this scheme is to make operations simpler. Generator units are dispatched to minimize the cost of operation while satisfying the demand and without violating network flow limits and generators capabilities. In this environment, producers and consumers sell and buy electricity though transactions in a market. An independent system operator (ISO) directs selling/buying transactions and insures that the access to the transmission system is nondiscriminatory. The term "independent" is meant to reflect the fact that the ISO must not have ownership interests in any generation, transmission or distribution company. A typical deregulated power system is depicted in Fig. 2.

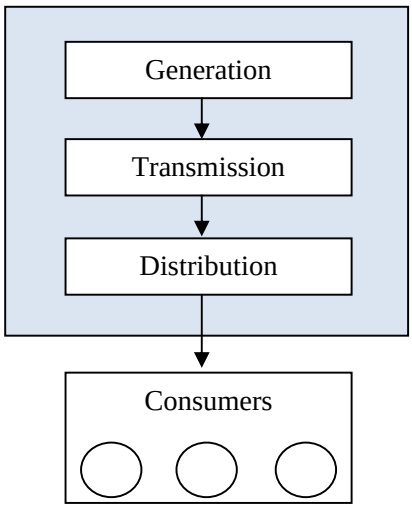

Fig. 1 Vertically integrated power system unit

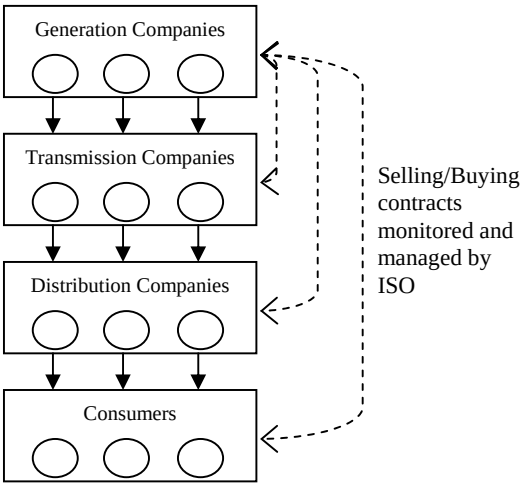

Fig. 2 Typical deregulated electric power system of various option structures

As a result of power system deregulation, electricity market emerges to handle buying/selling wholesale and retails of the electricity transactions. Several models have been presented discussing the deregulation and electricity markets that are established in developed countries [7] – [9]. Among these deregulated or market structures, there are two main types, namely, power pools (centralized market) and bilateral contracts (decentralized market) [8].

In a power pool, the generating companies offer price/quantity figure for the electricity supply. The offered priced can be based on variable costs or the companies can be

free to offer any price. On the demand side, the market operator, which can be the ISO, may forecast the demand and dispatch generating units against forecasted quantity. This procedure is referred to as one-sided pool (Fig. 3a). An alternative procedure, the market operator may dispatch on the basis of a demand curve that is created from price/quantity bids by buyers on the market. Such buyers can be distribution companies or eligible consumers (Fig. 3b).

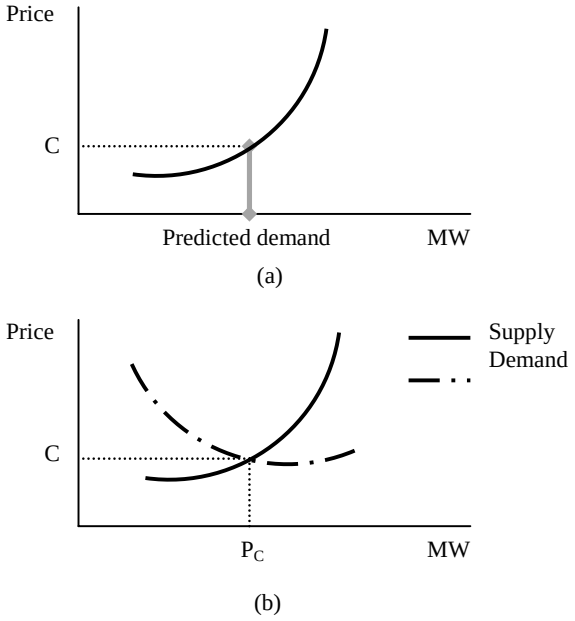

Fig. 3 Power price setting: (a) Supply predicted demand, (b) Intersection of supply and demand at (P_c , C)

In a bilateral contracts model, power sellers and buyers freely enter into bilateral contracts. Sellers are normally the generator companies and buyers are distribution companies and eligible consumers. Generators companies could be buyers (in case of generation shortages). Likewise, consumers could become sellers. Contracts between sellers and buyers can be accomplished by intermediaters. The role of the ISO is to balance the contracted volumes and the actual metered volumes and settle them.

Since power system deregulation, and consequently, electricity market highly depend on the country's social, economical and political systems, power system restructuring schemes of the developed countries cannot successfully be applied in the developing countries.

Several works considered power system restructuring in developing countries, e.g., [10] – [12]. In most of the models applied in developing countries, the ISO is associated with a public (governmental) organization that owns and operates the transmission network to insist preventing favoritism toward particular companies.

Restructuring KEPS is expected to bring the following benefits:

- Lessen the burden of operating and maintaining the power system off the government.
- Promoting reliable electricity production and quality consumer services.
- Encouraging the use alternative means of electricity generation by adopting renewable power generation systems by consumers and generation companies. Hence, reducing dependency on fossil fuel which is the nation's most critical and valuable strategic resource.
- Creating business opportunities and therefore, creating job opportunities.

Not all restructuring reforms that took place worldwide ended as was planned for. Examples of malfunctions of restructuring and electricity markets were in Brazil (2001), California (2000) and Chile (1998) [14], where electricity markets severely collapsed. However, those events do not imply abandoning restructuring and electricity markets. Those are considered to be valuable experiences that many countries have leaned from them for the construction of healthy and robust organizations. A significant lesson to be learned is that electricity market has dynamic nature and requires independent and flexible organizations that are capable of reacting fast and efficiently to face different market conditions.

IV. Feasibility of Restructuring KEPS

The restructuring of an electric power system does not necessarily involve institutional privatization. Privatization is one option among either introducing new competitive procedures or applying new forms of regulation [14]. The Build-Operate-Transfer (B.O.T) policy cannot be considered within the systematical deregulation procedure since the ownership at the end will be transferred to the government. Thus, in this work, B.O.T is not considered to be toward power system liberation and electricity market. The viability of restructuring KEPS depends on several issues that will be evaluated in the below subsections.

A. Electrical Power System

1) Generating Power Plants

Section II presented a summary of the present physical power system in Kuwait. The first concerning issue is the ownership of the power generation plans. The government of Kuwait has profoundly and enormously invested in these plants. Transferring the assets of these plants to the private sectors faces several challenges. Given the present law in Kuwait where foreign companies cannot be established without Kuwaiti partnership of more than 50%. Furthermore, establishment of sole Kuwaiti companies to own these power plants is economically repellent due to the huge required capital versus revenues. Moreover, all existence power plants are over-employed due to the government's policy of "Kuwaiti employment obligations". This over-employment is the most difficult obstacle facing the liberalization of power plants.

Given the above most explicit challenging issues, the question that strongly imposes itself, will the power system, and at least the generating power plants, stay under the government for the long term? Middle, long or even extra long term, KEPS will eventually be liberated into several

enterprises. Hence, it is important to continuously discuss, study and review deregulation policies in order to prepare the infrastructure for such restructuring. Restructuring will not be an option in the long term. The following are suggestions to tackle the challenges facing the liberation of power plants:

- Develop a mechanism to transfer the operation (not the ownership) of the existing power plants to the private sector. In the beginning, the government compensates the generation companies for power production costs including fueling and Kuwaiti manpower staff wages. Gradually, in span of 7 to 15 years, the manpower will be adjusted according to requirements. Furthermore, generation companies could turn to the international market for the fuel. The government may create a subsidy program with consumer directly.
- Once the generating companies fully establish themselves, approximately 10 to 15 years after handling the operation of the power plants, an assessment should be made to review the ability of these companies for transferring the ownership of the power plants. Long term payment installment plan can be designed for the transition.
- Construction of new power plants should be supported by the government by assigning the proper location and required space land.

2) Transmission Network

It is recommended that the transmission network is to be under the management of a governmental organization which can be represented by ISO. ISO needs to be regulated to ensure impartial and efficient use of the assets by providing nondiscriminatory access to promote fair competition among generation and distribution companies and consumers.

ISO controls the transmission network and associated substations via the National Control Center (NCC), and sub-transmission network and associated substations via district control centers (DCCs). ISO acts on the behalf of all consumers and is provided the exclusive rights to buy and sell energy to distribution companies, who in turn sell it to consumers. The consumers are charged for the electricity production, transmission and distribution costs.

The transmission network of KEPS (see Section II) comprises some weakness, which are the high level of short circuit current, and there are some congestion nodes at which substations (few of the 275 and 132 kV substations) and links are heavily loaded. Network reinforcement is required so that the electricity market can make use of the most capacity of the system. It is recommended to adopt the new technologies of substation automation within the transmission network. Cost-benefit analysis should be carried out to illustrate the advantages of the new technologies.

3) Distribution Network

Distribution companies are the last module to emerge once the restructuring of the generation and defining the ISO duties are achieved. Distribution companies can be considered as brokers. They buy electricity from the market (i.e., electricity offered by generating companies) and sell it to consumers. Electricity prices are set depending on the market structure (see Fig. 3).

The competition in the distribution side is not as intense as that in the generation side. However, competition can be created among distribution companies. Having the freedom of selecting a distribution company, companies compete toward attracting more consumers by providing quality services.

There exists a major obstacle that will not only suppress distribution restructuring from emerging but restrains the whole restructuring scheme of KEPS. Fee collection against electricity services is inefficient and almost do not exist. There are two main causes behind this predicament. The first cause comes from the political affairs that have been developed to stop any legal actions toward those who do not pay their electric services dues nor cutting off electricity from them. The second cause is the absence of effective metering system.

The solutions for eliminating this obstacle are clear and yet difficult to implement. The difficulties stem from the society's background toward the use of the country's resources and wealth. Eventually, these difficulties will dissolve through time. However, educational enlightening programs are needed to speed the process of awareness, especially among the political parties. In addition to socio-political solutions, infrastructure of automatic and intelligent meter readers systems should be established in the future construction developments.

B. Fueling System

Fuel provides the basic source of energy that is converted to electric power by generating units. In Kuwait, the primary fuel types used for the production of electric power are given in Table I. A fuel network, which consists of various dimension sizes of pipelines, carries different type of fuel (i.e., gas and liquid) to the five power plants. In the year 2005, the total length of the major liquid and gas fuel pipelines were 562 and 212 Km, respectively, [2]. Recently, the maintenance and operation of the fuel network has transferred from MEW to Kuwait Oil Company (KOC). Fuel purchasing transactions are only made through the Kuwait Petroleum Corporation (KPC). Both, KPC and KOC are state owned entities that are responsible for Kuwait's hydrocarbon products domestically and internationally.

In deregulation environment, in the case of Kuwait, the generating companies will only deal with one fueling source, i.e., KPC. Such situation does not open any margin for fuel price variations. However, when generating companies are allowed to engage either in long-term contracts fixed pricing or on the spot market pricing, generating companies can optimize fueling procurement strategies for their economical benefits. A consideration should be given in establishing several fueling companies. Moreover, foreign fueling companies should be facilitated in Kuwait fueling market for the benefit of competition.

In addition to the consideration of having one fueling source, the generating companies will only deal with one fueling network manager, i.e., KOC. This is another issue that is required to be investigated in technical and economical benefit terms.

C. Business Organizations

One of the advantages of restructuring power systems is taking operation/maintenance burden off the government, beside the provision of quality services to the consumers. Hence, private sector needs to be encouraged in investing in KEPS. Currently, in Kuwait, the investments of the private sector in power systems do not exist. Investment in KEPS is repellent due to various reasons that need to be addressed. Some of these challenges include:

- Regulatory and legislative concerns. The government and parliament (Kuwait National Assembly) should review the current decrees related to the electrical power production and develop regulations that support the existence of a private sector in owning and operating the power system.
- Effective payment and collection system. After developing effective meter reading system, the parliament and government should cooperate in pushing toward fee collection and encouraging payments by developing legislations that legally prosecute those who do not pay.

In the beginning, it is important to create an environment that guarantees the sustainability of private sector participation. Once regulation and laws take their effect, a reliable and credible studies can be performed to provide benefits and risks indices. Such indices will be important for the establishment of companies that will manage the KEPS.

To ensure stability and continuity of the private sector in managing KEPS, it is recommended (in the beginning) to establish companies which most of their shares are owned by the government and the rest are for general public subscription. Through long term plan, the government gradually reduces its share and sells it in the market.

Furthermore, it is recommended that the government subsidizes the production and distribution of electricity in the supply and demand sides for at least 5 to 10 years. In another words, the government should subsidizes the fuel in the supply side, and subsidizes the actual electricity cost in the demand side.

V. Conclusion

This work presented a view on the restructuring of KEPS. Eventually, KEPS restructuring will impose itself as a result of the rapid growing economy of the country and the region. Increase of electricity demand is the natural result of this economical growth. Therefore reforms are required to invite the private sector in investing in KEPS.

After reviewing the current technical, business and regulatory status of the KEPS, it is found that KEPS cannot be restructured in the short and middle term future. The major obstacles preventing such reform include the inefficient system in consumption meter reading and, consequently, fee collection. Moreover, the political philosophy of tolerating nonpaying consumers is another and even more serious issue. There exist some technical bottle-necks in the transmission network, such as the high short circuit level and high load congestion on some of the network nodes. These problems can be handled by stepping up the extra-high-voltage level from 300 to 400 or 500 kV. The congestion can be handled either by redirecting load procedures, or by enforcing the network with new substations. Moreover, new technologies should be adopted, such as, substation automation.

Kuwait and the region is in the track of fast economical growth. Eventually, KEPS restructuring is expected to come out in the long term future (20 to 25 years) due to the rapid increase of electricity demand. Thus, the participation of private sector becomes significant to satisfy the demand. Therefore, it is important to address the present challenges and examined them in advanced.

An vital observation that the government and private sector decision makers should pay attention to is that Kuwait's annual growth of electricity demand is and will be around 6% for many years to come. Such rate implies an excellent opportunity for healthy sustainable electricity business.

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