The Egyptian Electricity Market: Designing a Prudent Peak Load Pricing System

by

Dina Mohamed Yousri
The Egyptian Electricity Market: Designing a Prudent Peak Load Pricing Model

by
Dina Mohamed Yousri

December 2011

Abstract

Electricity prices in Egypt have been set significantly lower than the real economic cost of its production and supply. These subsidies encourage the waste of energy and increase the fluctuation in demand, triggering a huge need of additional power generation capacity in Egypt. This dialectical paper addresses this problem by first theoretically analyzing the Egyptian electricity market and then discussing a possible peak load pricing system. According to the results, especially low income households will shift their demand from the peak period to the off peak period. A properly implemented peak load pricing system could reduce the need for power capacity expansion by significant 2000-3000 MW, accompanied by additional savings in the network transmission capacity.

JEL classification
L51, L94, Q40

Keywords
Energy, electricity, peak load pricing, peak demand, off-peak demand
1 Introduction

The theory of Peak Load Pricing has been a theme of wide discussion amongst economists for many decades. It is considered a topic of great interest and controversial. The need for applying different pricing strategy as PLP basically emerged in response to problems that face most public utility, for instance non-storability, stochastic instability of demand and demand time varying where capacity in public utilities is not uniformly utilised. Amongst economists, Peak Load Pricing is known to be the golden solution for dealing with such problems (Main 1981:139). As it provides public utilities with an indirect load management mechanism that meets the double objectives; which is reducing growth in peak load or in other words peak clipping, and lessening the need for capacity expansion, through charging customers in peak time a higher peak price, and hence shifting part of the load from the peak to the base load plants which called valley filling and charging off peak customer a lower off-peak price, thus having some savings in used fuels during peak time (Crew et al 1995:215; Seeto et al, 1997: 169-171; Castell and Tanchuco 2002:1-2; Pillai 2003: 5-8; Viscusi 2005:453).

The main motive behind writing this paper is the actual increasing demand for new power generation capacity that has been witnessed by the government in the last few years; given that the average annual growth rate in electricity demand recorded a 10.3 percent increase in year 2007. Moreover, a greater increase is expected to occur in the coming years. Many recent statistics have actually corroborated these facts, for instance peak load is expected to reach about 57 GW by the year 2027. It should be considered that the current total installed capacity is only 23,530 MW with a Peak Load of 21, 250 MW while total installed capacity is expected to reach 73 GW by the year 2027. However, not free of charge as it entails high cost of operation, installation and expansion, not counting increasing consumption for the non-renewable sources. It is additionally important to bring to light that almost 85% of electricity generated in 2007 is generated mainly by Oil and Natural gas (El-Shehawy 2008: 3-4). These are considered non-renewable sources and of a very high price, thus sustainable growth cannot be assured. In fact, different studies have shown that the primary energy supply will not be sufficient to meet demand starting from 2015 (Beshara 2008:2).

In addition to these serious potential problem, electricity prices in Egypt had been set significantly lower than the real economic cost of its production and supply which encourages more energy misuse by different customers and further fluctuation in demand. Therefore, the energy sector in Egypt especially electricity is in a bad need for introducing new pricing system and accounting reforms, which will enable the utility to enjoy a healthier financial situation and better economic performance (Mehta 2005: 6). Accordingly, this research seeks such a solution, especially in the context of electricity efficient pricing in Egypt. In addition it addresses one of the most successful pricing theories; the Peak Load Pricing theory, which will be constructive in this case, as it would decrease the utility costs and increase its efficiency and profit.
The literature on the problem of Peak-Load Pricing has been quite extensive, as for example Hirshleifer (1959), Williamson (1966) and Turvey (1968). Subsequent contributions in the studies of Bailey (1972), Waverman (1975), Webb (1977), Kay (1979), Saving and Vany (1981), Craven (1985), and Kleindorfer and Fernando (1993) have extended the theory to deal with various forms of rationing and with a profit-maximizing framework. Chao (1983) generalized earlier work to encompass both supply as well as demand uncertainty. These theoretical results have found their way into the practice of ratemaking in different public utility sectors, especially in electricity market of USA, UK, India and Canada like Manning, Mitchell and Acton (1979), Slater and Yarrow (1983), Benders (1996), Karki et al. (2005) and Mehta (2005). It is ironical that the Egyptian electricity market, especially its pricing system, has not received any attention from researchers, while on the other hand, the European electricity market has hundreds of theoretical refinements. Thus the aim of this research is to fill the gap found in the literature and to redress the imbalance by presenting the theoretical foundations for analyzing the Egyptian electricity market and the possibility of maximum demand charges.

This is the first research to tackle such a problem in Egyptian electricity market; it is considered a conceptual or dialectical paper as it studies the Egyptian electricity market condition thoroughly from the official market statistics and data available. Into the bargain, reviewing different literature about the theory of Peak Load Pricing, its technicality and advantage along with its potential problem. In an attempt to find answers for questions as: a) What are the characteristics of an efficient price structure? (b) Can Peak Load Pricing be efficient? (c)What obliges producers to impose a single price despite the periodicity of demand? (d) Can Peak Load Pricing be applied successfully for the Egyptian electricity market? Answering these questions is very challenging, since pricing the electricity in Egypt incorporates many different problematical social, political and economic factors. Additionally, only few researches about electricity market are available.

The paper structure is as follows: Chapter two entitled “The Egyptian Electricity Market” gives a brief overview about the historical background of the industry, the diverse sources of energy used to generate electricity, and the specific conditions of Egyptian electricity market. This includes market characteristics like size or structure, technology aspects, potential market entry, consumers and main suppliers, and regulations imposed over the market. These vital characteristics of the electricity market, especially the current pricing system and its weaknesses, will facilitate the further discussion. Chapter three discusses the potential design of a prudent pricing system for the electricity market in Egypt. This discussion includes the identification of potential target groups and the system requirements. Chapter five summarizes the findings.
2 The Egyptian Electricity Market

2.1 Historical Development of the Egyptian Electricity Industry

In the last decade, the role of electricity all over the world has significantly increased due to the increased use of electricity in production and consumption of goods and services. This increasing demand was over many other key indicators, but it was to some extent, at the expense of other energy carriers such as natural gas and coal. Many scientists and scholars have noticed the growth of a few general parameters throughout the last three decades; such as population growth that is amounted by 25%, GDP and TPES by almost 160% to 180% and electricity production, which surpass the other parameters with an increase exceeding 300% (Benders 1996:1). In 1893, the electricity was first launched in Egypt; at that time it was owned and controlled by private companies. In 1962, all these private companies had been nationalized, and since then the government became the electricity owner and the sole operator. With a mission of supplying electricity to all types of consumers while considering international performance standards, in addition to economic, social and environmental determinants.

EEHC has undertaken major restructuring steps started by the separation of the generation, transmission and distribution activities and a serious of unbundling continues to occur because of the increasing number of consumers, demand and the allied increase in the number of power plants and network expansion. The peak demand for instance, has grown rapidly till it reached 19738 MW, with energy generated of 125 TWH and a growth rate of 8.4%, which was a great challenge for the EEHC. Since it has to meet this high demand and maintain system reliability and efficiency of supply. In fact, the EEHC has recently succeeded in achieving a very high rate of availability of power plants of 89% that properly meet the international standards. The EEHC has also prepared its 6th plan that last for 5 years expected from (2007/2008-2011/2012) in order to meet the expected average annual growth of demand of 6.35%. As Egypt’s installed generating capacity in year 2005 stood at 18.5 giga-watts (GW), and it plans to expand capacity to 32,000 megawatts (MW). This implies adding a generation capacity of 7750MW with making the best use of Combined Cycle to reach 37% of the total installed capacity in 2011/2012. Due to the noticeable growth of its customers since, it increased from 4.5 million in early eighties to 23.8 million in 2007/2008 (EEUCPRA 2009). After presenting a brief overview about the Egyptian electricity market it is essential to understand how electricity is generated or produced.

2.2 Main Characteristics of the Supply Structure

It is plausible to say that a general analysis of efficiency for year 2010 and even earlier using meaningful indicator is not possible due to the lack of comprehensive data on the various sectors’ consumption in relation to sector output. In general energy productivity assumed to be improving for some extent, given the expansion, modernization and replacement investment in the industry. Also transport and buildings are using newer processes and equipment set at international standards. Thus figures and general impression should be indicating improvements and high energy efficiency, yet, different figures and general impression points in the other direction. As energy efficiency in industry is still considered low (Suding 2011: 4439-4440).

According to recent statistics, Egypt has successfully managed to secure supply of electricity to approximately 99.3% of its total population (Osman 2008: 2). As mentioned
before, Egypt had actually planed in its 6th plan by the Egyptian Electricity Holding Company. To enlarge its electricity capacity to 32,000 megawatts (MW) over the coming five years, to meet the expected average annual growth of demand of 6.35%. This implies adding a generation capacity of 7750MW with making the best use of Combined Cycle to reach 37% of the total installed capacity in 2011/2012. Hassan Yunis the electricity minister has declared that the additional capacity needed will be provided mainly from 11 new thermal plants and expansions: Kureimat 2 and 3, Talkha, Tabbin, Nuberiya 3, Cairo West, Sidi Krier, el-Atf, Abu Qir, Ain Sokhna and Sharm el-Sheik.

This increase in capacity requires improvements in service provided, as there is a noticeable growth in the number of its customers. Since, they increased from 4.5 million in early eighties to 23.8 million in 2007/2008 (EEHC 2008: 25). In addition to the increase in number of consumer, peak load demand has significantly increased in the last two fiscal years (6.3% and 8.1%) and it is considered one of the most crucial issues for the electricity sector as it requires system expansion investment. For instance, the considerable increase in peak load demand in August 2010, has forced the power companies to ration supply, since available power was not ample to cover peak load. (Suding 2011:4439-4440)

EEHC and its joined companies constantly develop, improve and modernize the services offered. As figure 1 shows, the electric generating capacity is mainly powered by natural gas (75%), by petroleum products (14%), and hydroelectric power (12%). This capacity structure is considered a very expensive one, as it depends on mainly a non-renewable sources to generate electricity - which is natural gas and petroleum products- thus its marginal costs is very high unlike solar and wind energy which has almost zero marginal cost and only high fixed costs. Even though the use of NG and petroleum product is attributed by a very high marginal cost, yet the government in its different policies is encouraging its uses, because the Egyptian reserve of N.G is increasing, and, it has an obvious less harmful effect from both economical and environmental point of view. This also supports the idea of promoting the use of NG instead of liquid fuel (H.F.O & L.F.O) and it justifies the large use of N.G in thermal power plants including private sector connected to the gas grid which -has reached 82% - in year 2007/2008 representing 79.3% of total fuel consumption in the power plants (EEHC 2008: 25). Governments are trying to overcome the disadvantage of natural gas by equipping most of the generation plants with dual firing system that alleviate the use of natural gas that helped lower the cost of generation (Mehta 2005: 5-6). Yet even with this successful and substantial increase in the use of NG and number of customers that estimated to be 500,000 annually, others are opposing this substitution policy that encourages the extensive use of NG in electricity production and they are considering it not optimal approach from the economic point of view (Suding 2011: 4440).
After reviewing different energy sources used by government to generate electricity, it is vital to study the economic structure of the electricity market considering firms responsible for generation, transmission, and distribution. The Egyptian Electric Utility includes government owned companies, which consists of generation, transmission and distribution and private owned that include generation and distribution. First government owned generation companies: Cairo, East Delta, West Delta, Upper Egypt, Hydro-plants, and developing and utilizing the new and renewal energy authority. Second, transmission that is only done by the government through the Egyptian Electricity Transmission Company, and distribution is done by nine distribution companies, which are under the Egyptian Electricity Holding Company. Private sector companies are responsible for generation, distribution, or both, and it is either a BOOT projects or independent companies. Thus, it is obvious that generation and distribution are distributed amongst private and governmental firms, whereas transmission is monopolized by government (EEUCPRA, 2009).

2.3 Main Characteristics of the Demand Structure

The production and demand of electricity have formed a complex system of various interrelated components, which are continuously changeable, since they are stimulated by changing trends like technology in addition to their application. An example of this is the technological improvements that helped in reducing electricity demand using appliances with better efficiencies or shifting to other production process. Nevertheless electricity turned out to be a necessity and crucial element in modern society and it has also contributed to the use and growth of unsustainable elements group in Western community (Benders 1996:1-3).

The demand of electricity in general and especially the peak demand has increased tremendously in the recent years. For instance, peak electricity demand in Egypt was increasing by a yearly average of 7-10% over the period 2005-2007 (figure 2). In the year 2007, peak demand has reached 19,300MW. Only one year later, it reached 19738 MW, which means that there is 8.4 percent growth rate. This is considered a great challenge for the EEHC. Since it has to meet this high demand with system reliability and efficiency of supply, but the EEHC has actually succeeded in achieving this task along with realizing a very high rate of availability of power plants of 89% that well meet the international standards. (Osman2008: 2).

The reason behind the increasing need for additional capacity is the escalating demand of different types of consumer such as domestic, commercial, agricultural, housing and
services (restaurant, bakeries). Knowing that the number of subscribers who receive electricity reached 22.6 million in 2006-2007, in which 70.3 percent of them are domestic consumers and for such demand to be covered. Egypt produced 115,407 Gega-watts of electricity in year 2007, with an increase of 6.2% given that the maximum load also increased to become 18,500 megawatts (Elyan 2008).

Figure 2: The Expected Evolution of the Peak Demand till 2027

![Figure 2: The Expected Evolution of the Peak Demand till 2027](image)

Source: Osman (2008: 3)

Needless to say that in order to meet the expected serious increase in peak demands over the coming 20 years. There should be an average annual expansion in generation and transmission as well as distribution of 2000-3000 MW as shown in figure (3). It is planned to add 55 GW by the year 2027, which will actually be done on stages. First by the year 2012 the capacity will be enlarged by approximately 10 GW, and then 12 GW will be added starting from 2012 till 2017. This would be of a very high cost since the possibility of adding more hydro-generation is limited. In addition to that in 2006-2007 installed renewable sources (wind) represented only 1.1 percent of the total installed capacity. The energy that was generated from these sources represented only 0.3 percent of total electrical energy generated. Yet is planned to increase the share of renewable energy, including the hydro energy to 20% by 2020, while the electricity purchased from the self generation and co-generation units in 2006-2007, represented only 0.07% of the total electrical energy generated (Osman 2008: 2; El-Shehawy 2008:7).
2.4 Governmental Regulations over the Market

The electric power industry is currently a government-owned monopoly under the Egyptian Electricity Holding Company (PCSU 2001: 57), whereas the two sources of natural monopoly are economies of scale and economies of scope. In case of Electricity production; a generation plant is needed in order to produce the first kilowatt-hour, yet many KWH can be produced in the same plant (Train 1991: 5-6). The Egyptian Electricity network has grown to serve 99% of the Egyptian population. At the beginning the electricity market was totally in private hands. Later in the sixties of the last century it was nationalized. At the present time the sector is going through a major restructuring in an attempt to make it a more competitive one. The electricity sector activities’ were separated into generation, transmission and distribution activities. Nevertheless, the market is currently organized in a single buyer form, since all the generation companies, together with the three BOOT projects, a wind farm, and four industrial plants sell their production to a transmission company which is owned by government. The transmission company sells this electricity to large customers and also nine distribution companies. This single buyer structure does not allow for having free competition amongst current generation companies, but after considering other countries’ experience such as Southeast Europe in addition to the current Egyptian electricity market needs as well as constraints. This structure is considered an intermediate and a major step towards the establishment of a real laissez-faire electricity market, bearing in mind that, the first step in liberalizing the market is to attract large industrial consumers as potential consumers to have the right to choose their supplier.

Currently, Egypt has 81 consumers fed on both the H.V. and E.H.V. levels who consume about 30% of the total electrical energy produced nationwide. Thus, the plan is to gradually direct large consumers into a liberal market where they are given the freedom to choose their own supplier. This will provide a space for competition among current electrical energy generation units. Later on, other participants could join the market and thus competition grows (El-Salmawy et al 2008:1). After reviewing the power sector structure and the market regulation, it is essential to study the current Egyptian electricity pricing system.
2.5 Current Pricing System and its Economic Efficiency

One view may say that in the last few years' extensive efforts has been made by the government to adjust energy prices, not with the aim of managing demand or stifling supply, but, regarding subsidies policy. Accordingly the allocation function of energy pricing appears to be continuously disregarded and mispricing continue to exist (Suding, 2011; 4437). Yet others may say that government has undertook major steps toward pricing restructuring, since the Ministry of Electricity and Energy has announced an increase in electricity prices for all segments including domestic, commercial, agricultural and services consumption to be effective in November for the October bills. The increase in prices has reached more than 18% in some segments. But the prices in some categories remained unchanged. This increase is part of the government's plan to increase prices by 5% annually for five years. They started by raising the prices by 7.5% plus 2.5% due to the increase in oil prices. This serious increase was perfectly justified by them as in fact one kilowatt of electricity costs more than 19 piaster; which mean that they bear LE 3.2 billion in form of subsidies to support primary categories, who can't afford paying the real cost (Elyan 2008; Osman 2008: 2).

The full cost of any service, such as electricity or transportation, doesn't include only explicit costs, but also implicit costs. That's why developing an effective policy to address the impacts of any service utilization, like increasing electricity consumption may require users to pay the full costs of utilization without getting any subsidies. Up till now, most analysis of transportation subsidies or service subsidies in general have focused on the explicit costs, ignoring the more subtle implicit costs. Thus, subsidies may create market bends that will lead to reduced economic efficiency and equity (Lawrence and Kornfield, 1998: 137).

Moreover, from 1992 to 2004 there was no increase in energy prices especially in electricity. Nevertheless Electricity tariff does not reflect the real service price, besides fuel is also subsidized. Thus, both wholesale and end users tariffs are based on cross subsidy scheme. Actually, the majority of goods and services increase in Egypt by more than 5% a year. Since Egypt produced 115,407 Gega-watts of electricity in 2006/2007 with an increase of 6.2%; and maximum load increased to become 18,500 megawatts. what's more the number of subscribers who receive electricity reached 22.6 million in 2006/2007, in which 70.3 percent of them are domestic consumers (Elyan 2008; Osman 2008: 2). That is why government in Egypt needs to sustain its strategy of increasing electricity prices to ensure economic efficiency, good quality of service and equity.

Table 1: Classification of domestic consumers' by electricity prices

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first Category (less than 50 KW) per month, mainly composed of low-income families</td>
<td>Remained unchanged at 5 piaster per KW.</td>
</tr>
<tr>
<td>The second category (51-200 KW)</td>
<td>increased from 10.7 to 11 piaster</td>
</tr>
<tr>
<td>The third category (201-350 KW)</td>
<td>increased from 14.9 to 16 piaster</td>
</tr>
<tr>
<td>The fourth (351-650 KW)</td>
<td>increased from 21.6 to 24 piaster</td>
</tr>
<tr>
<td>The fifth (651-1000 KW)</td>
<td>increased from 31.1 to 39 piaster</td>
</tr>
<tr>
<td>The category exceeding more than 1000 KW</td>
<td>increased from 38 to 48 piaster</td>
</tr>
</tbody>
</table>

Source: Elyan (2008)
According to the different prices shown in the above table (1), government subsidizes first category by 14 piaster for every kilowatt per hour which is more than double the price that they actually pay. Thus, real cost will only be covered and the government will start realizing profit, starting from the fourth category. If first category is subsidized because they are not capable of paying the real price, applying new pricing system – Peak Load Pricing- will encourage them to shift their time of consumption. If not they will have to pay a higher price for utilizing the service in the peak period.

**Table 2: Classification of commercial usage electricity prices**

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first category (less than 100 KW)</td>
<td>Increased from 22.9 to 24 piaster per KW</td>
</tr>
<tr>
<td>The second category (101-250 KW)</td>
<td>Increases from 23.5 to 36 piaster</td>
</tr>
<tr>
<td>The third category (251-600 KW)</td>
<td>Increased from 42.5 to 46 piaster</td>
</tr>
<tr>
<td>The fourth category (601-1000 KW)</td>
<td>Increased from 52.5 to 58 piaster</td>
</tr>
<tr>
<td>who consume more than 1000 KW</td>
<td>will pay 60 piaster instead of 55</td>
</tr>
</tbody>
</table>

**Table 3: Services’ (bakeries and restaurants) electricity prices**

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per KWh</td>
<td>25 instead of 23.1 piaster.</td>
</tr>
</tbody>
</table>

The willingness of services and commercial sector to shift their demand will be much lower than any other sector, as their time of operation is mainly based on the customers themselves, as for instance in case of café the owner will not have a full control over the customer time of visit, or in case of bakeries, since this will affect the quality of good produced. They might even lose their customer due to unavailability of supply at its’ needed time.

**Table 4: Agricultural usage electricity prices**

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per KW</td>
<td>increased from 10.4 to 11.2 piaster</td>
</tr>
</tbody>
</table>

**Table 5: Housing companies electricity prices**

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per KW</td>
<td>remained unchanged at 13.9 piaster</td>
</tr>
</tbody>
</table>

Source: Elyan (2008)

For the three categories, agriculture, housing, and services, the price paid is still considered very low compared to the service provided and its actual cost. The current pricing system is based on the amount of electricity consumed, as customers are divided into categories according to their level of consumption (KWH) and their type, for instance commercial industrial or household. The more the customer consumes the more he pays, as
the higher the level of consumption the higher the willingness and ability to pay. It is vital to highlight the fact that generating only one kilowatt of electricity costs more than 19 piaster; given that the primary category of household pays only 5 piaster per KWH which means that the government bears LE 3.2 billion in form of subsidies to support mainly primary category. It also support second and third categories but with a lower rate. Although these entire pricing system is considered an active tool to support, Egyptian citizen financially from the social perspective but it is still considered from the economic perspective inefficient especially that household consumers constitute 70.3% of the total electricity subscribers.

This pricing system encourage the misuse of electricity and cause a continues increase and fluctuation in demand, which in turn will increase the demand on the primary energy that is considered economically scarce and there is always an opportunity cost for using primary energy in generating electricity, thus electricity must be priced according to its real cost. There are many other instruments to support the poor rather than subsidies the electricity as it is usually considered inefficient policy to mix both social and economic perspectives together. Even though the current pricing system is not the best one, but still it could be applied along with other pricing strategies that overcome the deficiency of the current pricing system, which mean that prices shouldn’t only be based on level of consumption but also consumption time. Thus, the consumer who uses electricity on the off peak period should be charged a lower price including only marginal cost, while consumer who uses electricity on the peak time should pay a higher price, which include marginal plus fixed costs. Moreover, what really needs to be considered while pricing, is that electricity cost as it is not the same in all sectors.

In addition to the challenges facing the electricity ministry with regard to efficient pricing more challenges are facing them with regard to production capacity and expansion in the future. Egypt had actually planed to enlarge its electricity capacity to 32,000 MW over the coming five years. The additional capacity needed will come mainly from 11 new thermal plants and expansions to the current plants (EIA 2008). Although, expansion plans are important and needed but still it is not enough, as it must be backed by efficient pricing system. The Peak Load Pricing will be presented as new pricing system that can reduce the need for extra capacity that will be unutilized most of the time.
3 Designing a Prudent Peak Load Pricing System for the Egyptian Power Market

3.1 Shortcomings of the Current Pricing System

As previously mentioned electricity is unlike any other commodities in fundamental ways, electricity is in fact problematic, when it comes to supply-demand imbalances, since storage costs are too expensive and interconnected because switching costs are unaffordable. That could explain the need for capacity requirements. Hence, when only one supplier fails to satisfy his customers' demands, all customers who are sharing the distribution grid will lose power, not only those customers that were not served. Thus, the need to preserve the so called- balanced loads over an interconnected grid- will cause blackout externality (Brennan 2003:1-3; Moss 2005: 4-5). For that reason, public in general will benefit from investment decision that attempt at maintaining reliability and avoid demand from exceeding capacity.

Electricity prices in Egypt had been set significantly lower than the real economic cost of its supply and production. Needless to say, the energy sector in Egypt especially electricity is in a bad need for introducing new pricing system and accounting reforms, which will enable the utility to enjoy a healthier financial situation. Few years ago the government had started a major reform program allover Egypt in an attempt to enhance the overall economic and social conditions. The government was also working on the electricity sector to make it more attractive for private sector in particular in power generation. Yet, less attention has been paid to the pricing system, ever since 1994 there had been many problems in price reforms. Besides, the low prices of electricity and the devaluation of the EGP Pound have played a major role in lowering the net income for both the Egyptian Electricity Authority and Egyptian Electricity Holding Company.

According to the actual pricing scheme followed by the electricity authority, the different categorize of customers such as -Very High Voltage users, small agriculture landholders plus low-income domestic consumers- have been paying far below the real cost of supply. Over and above, the utilities have also neglected the Long run Marginal Cost approach for setting the service price. Thus, it is possible to say that; the Government and the official of electricity ministry are in fact responsible for a significant part of the existing financial problem facing the utilities. Unsurprisingly, the high receivables along with the low prices have led to a poor short-term liquidity position for EEA and EEHC. Accordingly, the financial capability of the utilities is expected to be fatally at risk (Mehta 2005: 6).

In order to solve this financial problem and to set a proper pricing system, the customer expenditure behavior and price elasticity of demand needs to be thoroughly studied. First, price elasticity of demand; quantity demanded would decrease if price increase and a decrease in price will cause increase in quantity demanded. In electricity, an elasticity of 1 would mean that a 1% price increase would create a 1% increase in consumption. In Canada for example, energy price elasticity was -0.3 to -0.6 and about -0.7 for petroleum products in year 1984, which indicate that a price increase causes a consumption decrease. Elasticity in Egypt should be similar to those in Canada. Thus raising the price of electricity should endorse reduced use of energy. Many analyses have tackled this point- impact of energy cost on amount of electricity demanded/used. For instance, a study was made in California, which showed that the use growth rate varies from 3.4% to 6.3% and if energy cost is doubled the use growth rates will decrease to 4.7% (Aubrech 2006: 76).
Although, the literature available about the Egyptian household's behavior with regard to consumption and expenditure is very limited, yet, estimation has been obtained for four expenditure categories. To be precise, (1) bread and cereals; (2) meat, fish, seafood, milk, cheese, and eggs; (3) other food; and (4) non-food and this research main concern is the non-food category expenditure which includes; Housing, Water, Electricity, Gas and other Fuel. Fabiosa and Soliman (2008:13)

These data have shown that rural households spend a higher percentage of their income on bread and cereals and other food if compared to urban households. As urban household spends almost the same proportion but on eggs, fish, seafood, meat, milk and cheese, though they spend on non-food category such as water, housing and electricity much lower proportion. Moreover, the percentage of expenditure spent on food items will decline as household income increases, even as the proportion spent on the non-food category will increase. This point supports the pricing system set by government as the higher the income the higher the willingness to pay.

These findings have been further proved through income elasticity estimates table (6); as all food items have less than unit elasticity, whereas the income elasticity of non-food category has exceeded the unit elasticity. Meaning that the higher the income the less would be spend on food comparing to their increase in income, and the more will be spend on non-food category. Yet, the decrease in urban household expenditure will be much higher, if compared to the decline in expenditures of rural households which would be marginal, known that their elasticity’s are almost unitary for all categories with the exception of the other food category. Thus it is noticed that responsiveness of households to changes in income decreases radically when the level of their incomes increases (Fabiosa and Soliman 2008: 10-11).

But if poor people are elastic or spend more on food as a percentage of their income they will be willing to shift their demand to avoid being charged with high peak price.

Table 6: Income elasticity using 2004-2005 HIECS.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Urban</th>
<th>Rural</th>
<th>Egypt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread-cereals</td>
<td>0.711</td>
<td>0.728</td>
<td>0.914</td>
</tr>
<tr>
<td>Meat/fish/dairy</td>
<td>0.864</td>
<td>0.814</td>
<td>0.985</td>
</tr>
<tr>
<td>Other food</td>
<td>0.734</td>
<td>0.736</td>
<td>0.840</td>
</tr>
<tr>
<td>Non-food</td>
<td>1.166</td>
<td>1.164</td>
<td>1.088</td>
</tr>
</tbody>
</table>

Source: Fabiosa and Soliman (2008:19).

Subsequent to, discussing the pricing structure, the Egyptian customer expenditure behavior and the price elasticity of demand in this chapter and the previous ones, it is time to tackle the requirements needed to apply a new pricing system according to the customer elasticity of demand.

3.2 Requirements of a Peak Load Pricing System

As previously mentioned, electricity is too costly or impossible to store, and accordingly enough capacity must always be available to cover demand. In electricity peak demand is used to determine needed capacity. Variation in electricity demand takes daily, weekly, monthly, and seasonally conventional cyclical trend. Before designing
pricing system it is essential to consider some main requirements such as the cost structure of electric power system and reliable information about load curve changes that must exist for many fundamental reasons. First, adapting certain rating structure as in Peak Load Pricing should be based on measuring economic efficiency gains realized by marginal cost pricing in comparison to the next most efficient pricing, including costs metering and billing with a more detailed price and sensitive time consumption counters (Manning et al 1979: 131-132).

Given that the current used pricing might not be the next best pricing, calculation for the changes in the load curve by price-period is needed. Second, it is essential to predict the level of load after applying the new pricing especially during the peak period, since the application of a peak-load price will alter the rate at which the utility’s capacity must be expanded. Lastly, basic changes result from the application of Peak Load Pricing in the shape of the load curve will adjust the optimal mix of generating equipment and accordingly have an impact on the calculation of the marginal costs themselves (Manning et al 1979: 131-132).

Yet, it is vital to highlight the fact that Peak Load Pricing system might not be easily implemented, and producer might even charge all customers the same price during the whole period given that demand is strongly fluctuating and affecting the quality of service provided. Because producer might lack the information that allows differential pricing across periods of consumption, it also might be the high added cost of needed equipment to impose different prices depending on times of consumption which could be an added investment in itself. Third reason might be that there are rules imposed by regulatory authorities (Castell and Tanchuco 2002:1-2).

Furthermore, the two main concern of the Peak Load Pricing of electricity, are calculating marginal costs in a complex supply system along with, the expected quantitative changes in the sequential pattern of the quantity demanded of electricity -the load curve- after applying new tariff. Even though the economic analysis of marginal costs is considered a standard practice in many European utilities, hitherto it is immature in America. Nevertheless, getting most of the information required to calculate marginal costs can be easily derived from the investment planning models, whilst cost-minimizing -procedures are now regularly used by utilities (Manning et al 1979: 131-132).

But what still remain under research sight are the methodological questions, however by applying the European methods to these data an approximated measure for the short-run marginal costs in addition to foundation for calculating peak-load tariffs could be generated. Unlike the marginal costs analysis, no sufficient data base exists that enables the decision maker to predicate the changes in load curves that will result from adoption of peak-load rate structures (Manning et al 1979: 131-132) especially with having different types of customers.

3.3 Potential Customers and Technical Applicability

A wave of reform has been implemented in the Electricity supply industries in both developing and developed countries. In an attempt to reduce electricity costs through enhancing both economic and technical efficiency in developed countries, while in the developing countries the aim was to break the cruel cycle of deprived performance accompanied with low prices, high losses and insufficient electricity supply because of the state ownership for electricity and its political interference. Nevertheless, the main aim of these different electricity reforms in either developed or developing country was to enhance performance, decrease the financial burden on government and maintain a continues and flexible path of electricity sector operation. All these different reform plans have successfully created independent Power Production and competition in generation, in addition to
unbundling of integrated utilities into generation, transmission and distribution. Moreover, the operation of an independent transmission system for either wholesale transactions or retail electricity (Karki et al 2005: 72-73).

After reviewing various literature and government statistics, it was quite obvious that the Egyptian electricity holding company has exerted too much effort, in making the electricity market a more competitive one. Hitherto, an efficient pricing system is still not yet implemented, given that, a manifest growth has been recorded in number of electricity customers’ in Egypt, who increased from 4.5 million in early eighties to 23.8 million in 2007-2008 (EEUCPRA 2009). Egyptian Electricity holding company actually serves many different customers, such as residential, commercial, industry, agriculture, governmental sector and utilities. The major customer based on their consumption level as well as size is; residential customers, who reach 16,968,095 customers (71.3%), followed by commercial 12,17,253 customers, and industry 621,103 customers. Although commercial are larger in number than industrial, industrial are still consuming more electricity (EEHC 2008: 39). Thus, the main focus of this research would be on those three customers as they constitute the largest share in electricity consumption and considered the main cause of peak load problem as illustrated in the figure below (4) also because applying the Peak Load Pricing system on those customers in specific, is quite easy and effective, because of their high elasticity of demand.

Given that, those customers are charged far below the actual cost, for the first 50 KW consumed, they are charged only 5 piaster provided that, the real cost is more than 19 piaster per kilowatt per hour; this implies that the government is subsidizing the primary category that can't afford paying the real cost with, LE 3.2 billion (Elyan 2008; Osman 2008: 2). These low prices have actually caused a decrease in the net income for both the Egyptian Electricity Authority and Egyptian Electricity Holding Company. Besides, it has led to a severe short-term liquidity problem for EEA and EEHC, and encouraged fluctuation in demand. Accordingly, the financial capability of the utilities is expected to be fatally at risk (Mehta 2005: 6)

Since the requirements discussed in previous chapters for applying PLP, can be easily fulfilled by EEHC, it is highly recommended for the EEHC to implement such pricing model. As applying Peak Load Pricing would solve these formerly mentioned problems and it would be technically applicable, if the utility succeeded in obtaining reliable information about load

Figure 4: 24 hour electricity load curve

Source: (Beshara 2008:2)
curve changes which is needed for many fundamental reasons. First, adapting certain rating structure as in Peak Load Pricing should be based on measuring economic efficiency gains realized by marginal cost pricing in comparison to the next most efficient pricing, including costs metering and billing with a more detailed price. Given that the current used pricing might not be the next best pricing, calculation for the changes in the load curve by price-period is needed. Second, it is essential to predict the level of load after applying the new pricing especially during the peak period, since the application of a peak-load price will alter the rate at which the utility’s capacity must be expanded. Lastly, basic change results from the application of Peak Load Pricing in the shape of the load curve will adjust the optimal mix of generating equipment and accordingly have an impact on the calculation of the marginal costs themselves (Manning et al 1979: 131-132).

Furthermore, the PLP will successfully achieve its target, if government, could calculate marginal costs in a complex supply system along with, the expected quantitative changes in the sequential pattern of the quantity demanded of electricity -the load curve- after applying new tariff. Even though this economic analysis of marginal costs is considered a standard practice in many European utilities, yet it is immature in America for example. Nevertheless, getting most of the information required to calculate marginal costs can be easily derived from the investment planning models, whilst cost-minimizing -procedures are now regularly used by utilities. What still remains under research sight are the methodological questions, however by applying the European methods to these data an approximated measure for the short-run marginal costs in addition to foundation for calculating peak-load tariffs could be generated. Unlike the marginal costs analysis, no sufficient data base exists that enables the decision maker to predicate the changes in load curves that will result from adoption of peak-load rate structures (Manning et al 1979: 132). Nevertheless, it is vital to underline the fact that Peak Load Pricing system might not be easily implemented. If utility lack the information for differentiating prices across periods of consumption, or failed to obtain the cost of needed equipment to impose different prices depending on times of consumption because of its high added investment cost. Accordingly, producer might even charge all customers the same price during the whole period given that demand is strongly fluctuating and affecting the quality of service provided(Castell and Tanchuco 2002:1-2).

3.4 Designing a Prudent PLP System for Residential Customers

In order to be more efficient and realistic, government may start applying this new system on household customers only. Given that, the demand for electricity in a typical weekday by household might follow the pattern in figure (5). Whereas, the peak demand occurs between 21:00 to 22:00 o’clock requires the supply of additional 5000 MW (EEHC 2007-2008: 10). For minimalism, let the billing cycle over which electricity is utilized be composed of two different pricing periods that are continual for the duration of the cycle. \( P_1 \) is the price charged for every kWh of electricity consumed in the peak period and a price of \( P_2 \) per kWh in the off-peak period. This is based on the assumption that the consumption of electricity in the peak period is greater than in the off-peak period (Berg and Savvides 1983:259). Provided that, a typical electric power system has a combination of plant types because it helps in lowering the overall cost of supplying the inconsistent pattern of demand. Hydro-plants or renewable sources in general have relatively low variable costs but have relatively high fixed costs. For that reason, they are appropriate for running as many hours per year as possible as the “base load” plants (Viscusi 2005:447-448).
The extent of using nuclear, wind and solar power plant Egypt is limited, so the coal-fired plants are used for providing the base load; and although they have higher marginal cost, they also have lower fixed costs than nuclear plants. The same applies for, combustion turbines that have relatively high running costs but lower fixed costs. Accordingly, they are used to meet peak demands that last for only a small number of hours per year (Viscusi 2005:447-448). Thus, the aim now is to set a price which covers this high cost and cause demand to shift from peak time to off peak. In order to set such price, optimal capacity must first be determined. (Viscusi 2005:453). Also considering that at peak load times capacity is fully utilized and MC includes variable costs and extra cost of capacity. Whilst off-peak time, there is ample of unused capacity and its marginal cost is zero. Hence, if prices should meet marginal costs they should be higher at peak load times to encourage demand shift and accordingly to a more efficient use of capacity (Barbot 2003:5).

In previous chapters the potential problem of the current pricing system has been present, in addition to the advantages of applying Peak Load Pricing system. After reviewing many literatures it was quite obvious that applying such model would solve these problems as it will encourage electricity customer’s especially low income customers’ who are charged only 5 piaster per KWh for the first 50 KWh, and enjoying price subsidies reached LE 3.2 billion in total to shift their time of consumption (Elyan 2008; Osman 2008: 2). What is really important is that their elasticity to change in price would be much higher than high income customers. Yet, this doesn’t mean that Peak Load Pricing will only affect low income people, as even if Peak Load Pricing didn’t shift the consumption of high income customers-fourth to six categories -from the peak period because of their low price elasticity, they will have then to be penalized with paying higher peak price. The power supplier could start implementing such pricing strategy in all newly built communities. Although those are not mainly our targeted customer, yet, it is one step on the road as in all cases sensitive time counter will be installed in all houses allover Egypt. According to Berg and Savvides, applying this Peak Load Pricing can go in parallel with the old pricing system adapted by EEHC as both don’t contradict each other (1983:258). Let’s assume that the household customer who belongs to primary category has consumed electricity from 9:00 to 10:00 in the evening. This will imply that he would be charged as usual 5 piaster per KWH. Yet, an additional capacity cost will be added to this price and it will be specified according to real cost of added capacity, while considering their price elasticity of demand.
4 Conclusion

In Egypt, total energy demand grows considerably faster than energy supply capacities, even in years when the increase in economic growth is moderate. The energy system is approaching its limits. Also, the increase in oil prices is considered a real threat for the Egyptian economy. Egyptian gas and oil reserves are not sufficient when compared to the increase in population and their consequent demand. That’s why in the long run the risk of uncovered demand is unavoidable. As for the specific case of electricity, non-storability and the periodic and stochastic instability of demand are adding to the general energy scarcity. What is more, the demand for electricity, especially peak demand, has significantly increased due to the increasing use of electricity in production and consumption by different types of consumer such as domestic, commercial, agricultural, and industrial. Given that, the number of subscribers who receive electricity reached 22.8 million in 2007/2008, in which 70.3 percent of them are household consumers. For this demand to be covered, an average annual expansion of 2000-3000 MW is needed which is very costly, because the utility depends on natural gas mainly in production. Over and above, the electricity prices in Egypt had been set significantly lower than the real economic cost of its supply and production as it is subsidized by government. Charging customers such low prices encourages fluctuation in demand over the time and energy waste, in addition, lowering the net income for both the EEA and EEHC.

Thus, applying new pricing system will encourage electricity customer’s especially low income household customers who are charged only 5 piaster per KW, and enjoying price subsidies to shift their demand from the PP to off peak period. Since their price elasticity would be much higher than the elasticity of high income customers, yet, this doesn’t mean that PLP will only affect low income people, because, if high income customer kept utilizing the electricity during peak hours, they will have to bear a higher electricity price. Hitherto, it is vital to emphasize that PLP system might not be easily implemented, and producer might even charge all customers the same price during the whole period given that demand is strongly fluctuating and affecting the quality of service provided.

Finally, economists in recent years have made major progress in developing both theoretical and empirical models of electricity demand. Almost all the economic studies presented in this research, nevertheless, have relied on traditional economic and production variables such as income, prices, demographics, and stocks of electricity-using devices for countries like UK, USA, India and Canada. Modest if any attention has been given to the Egyptian electricity market, if at all, its price structure. consequently this research has faced some limitations as few improved data sources about the Egyptian electricity market was available, considering demand which vary over time, income elasticity and amount of electricity consumed by each category. Future research should pay more attention to the Egyptian electricity market, and the potential improvement for the Egyptian electricity pricing structure and the possibility of having a more competitive market.
References


