Electricity Infrastructure in Pakistan: an Overview

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Abstract

Electricity infrastructure in Pakistan has passed through several stages since independence in 1947. The production capacity has increased significantly but not relative to the shooting demand in residential, industrial, commercial and agriculture sectors. Transmission and distribution sectors lagged behind equally. This paper explains the overall value chain of electricity infrastructure from production to consumption. Sector wise, existing potential in each segment of the value chain is explained. It highlights the existing problems and need for future investments to overcome the system's incapacity. The paper concludes that the system faces problems such as investment shortage, governance issues, policy failure, incomplete implementation of reforms and others. Finally, the paper opens avenues for further research to dig into the problems from the theory of New Institutional Economics.

Keywords*: Electricity infrastructure, restructuring, Inefficiency, Pakistan*

1. Introduction

Pakistan with area of 796,095 Sq KM is second most populous country in South Asia after India and sixth in the World with population of 177.1 million according to official estimates. Population projections show that with current growth rate of 2.07% per annum, population will reach up to 210.1 million by 2020 and the country will become third most populous country in the world by 2050. Since independence in 1947, population has increased from 32.5 million to 177.1 million in 2011; thereby adding 144.6 million people in 64 years. Population growth rate in Pakistan has been amongst highest in the world. Although it has shown deceleration trend in recent years by sliding down from 3.06 % in 1981 to 2.07 % in 2011; however this population growth rate is still among highest in the world and unmatchable with Pakistani resources [1]. According to Economic Survey, workforce comprises of 33 % of total population in Pakistan which is 54.92 million. Official estimates show that unemployment stands around 5.7% of total workforce which is quite doubtful due to level of ever rising poverty that stands between 35-40% according to different national and international organizations. Ministry of Planning predicted that job creation for current working class and huge influx of young generation in the pipeline needs annual economic growth rate of 7 % [1] and to attain that level of economic growth rate, energy sector should grow at almost 8 % annually which has been hovering between 3 and 4 % in recent years [2]. Even for average economic growth rate of 5 percent since 1992, energy demand has grown at average rate of approximately 5 % since then [3]. Such persistence of energy deficit has grown into severe energy crisis which has not only risked the future economic growth but has also endangered the poverty reduction efforts through

enhanced unemployment and SMEs'[1] closure which are considered very important for employment generation in the country. According to a statistic, Pakistan's GDP has contracted between 3-4 % due to electricity crisis annually since 2011 which has crippled the industry badly and also enhanced unemployment and poverty level in the country.

Electricity sector in Pakistan has remained under-performing and inefficient since independence. Various drawbacks emanating from the malfunctioning of economic, political, institutional, technological and organizational machinery have remained dominant to keep this sector below the mark as they did with other sectors. There has remained a mismatch between supply and demand, prices and affordability, efficiency and sustainability of electric power in Pakistan. Currently, the country is facing severe electricity crisis which has resulted in severe black-outs in urban and rural areas. This has been impacting economy and society in quite harsh manner. In order to provide a reliable, efficient and affordable electricity service to end-customers so that an impetus for sustainable economic growth and poverty reduction might be provided in Pakistan, the whole value chain of electricity system should be well integrated, receptive and efficient in such a way that system logic arises among different components of the value chain. To understand the level of efficiency and competitiveness of electricity network in Pakistan, it is important to dig into the whole value chain of electricity from production to consumption. This is what we will look into during the course of this paper.

This paper will give an overview of existing state of affairs of electricity sector in Pakistan. Main purpose for writing this paper is to look into the main features of electricity value chain in Pakistan. First part being an introduction has opened up the discussion, second part will explain the existing state of affairs in the whole value chain from production to consumption. This section will end with major problems in the sector. Section three will conclude the paper.

2. Features of Electricity Industry in Pakistan

Electricity infrastructure is made up of a "*complex technical system*" where a strong relationship exists among different segments of the network from production to consumption which work together specifically to ensure the production of certain services such as provision of electricity [4]. Technical functioning of different elements of the network of electricity system also requires certain modes of organization. Lack of complementarities between electricity infrastructure and institutions has resulted in severe failure of functioning of the technical systems in the provision of electricity in various parts of the world [5].

In this section, different aspects of technology and organization of core segments of the electricity infrastructure in Pakistan in a post liberalization period are revealed.

2.1 Organization of electricity industry

Restructuring of electricity sector has been accelerated in the world in recent years due to burgeoning electricity shortfall and financial crisis at the same time. Driving forces for restructuring process vary among developed and developing countries depending upon their particular political and economic conditions. In Pakistan, aspects such as lack of efficiency and under-investment drove the restructuring of vertically integrated electricity industry. All the segments of value chain were concentrated in a single public sector entity

[1] Small and Medium Enterprises

known as WAPDA[2]. The restructuring of electricity industry was greatly motivated by international development partners such as Asian Development Bank (ADB), International Monetary Fund (IMF) and World Bank at a time when Pakistan became unable to finance the maintenance and development of electricity related *"critical infrastructure"* [6] that was key to successfully perform the technical functions of different components of electricity value chain due to intense financial burden on national exchequer [7].

The restructuring of electricity industry which basically means institutional changes, is believed to usher efficiency and improvement in the quality of service through the introduction of competitive electricity markets and institutional regimes mainly dominated by private sector [8]. A complete surgery of electricity industry was required in this regard where vertical integration of electricity monopolies should have been unbundled in such a way that segments of value chain which are predominantly natural monopolies such as transmission sector are separated from those with potential of competitive markets such as generation, wholesale and retail supply [9]. Such surgery does not complete in shorter period and needs reasonable time for separating the activities which remained integrated into a single entity for a longer period. The period can be different for different countries depending on specific political, economic and legal situations. This is a transition period where markets may not work as efficient as perceived; however with more and more experimentation with new strategies to cope with challenges regarding the functioning of different components of a restructured system, the market may move towards efficiency and quality improvement.

Electricity infrastructure in Pakistan consisted of two vertically integrated public utilities prior to restructuring. WAPDA controlled all electricity related technical functions and transactions in Pakistan except Karachi which was under KESC. As a result of restructuring, WAPDA was unbundled by separating inherently monopolistic segments from an easily controllable market segment. Only generation sector was opened to market competition according to model and rest of the components of the value chain such as transmission and distribution were separated from WAPDA into publicly owned companies to infuse corporate culture among them but remained under monopoly. For restructuring the KESC system, the ownership of whole system has been transferred to private sector without unbundling.

Unbundling of WAPDA into generation, transmission and distribution sectors resulted in the creation of nine distribution companies (DISCOs)[3]; four generation companies (GENCOs)[4] and a transmission company. To coordinate the functions and transactions among all unbundled segments of electricity infrastructure and strengthen the organizational setup of newly formed public entities, an agency i.e. PEPCO was formed. The whole infrastructure remained heavily under public monopoly. Market segment could only be created in thermal generation where private investors got attracted partially despite lucrative incentives. Therefore to regulate the monopolistic nature of overall infrastructure, a regulatory authority was highly needed before starting the unbundling process. National Electric Power and Regulatory Authority (NEPRA) was created to regulate the public sector monopolies in 1997, whereas to look after the matters of private sector, Private

[2] Water and Power Development Authority

3 DISCOs include Lahore Electric Supply Co. (LESCO), Faisalabad Electric Supply Co. (FESCO), Gujranwala Electric Supply Co. (GEPCO), Hyderabad Electric Supply Co. (HESCO), Islamabad Electric Supply Co. (IESCO), Multan Electric Supply Co. (MEPCO), Peshawar Electric Supply Co. (PESCO), Quetta Electric Supply Co. (QESCO) and Tribal Electric Supply Co. (TESCO).

[4] GENCOs include Northern Power Generation Company, Central Power Generation Company, Jamshoro Power Generation Company and Lakhra Power Generation Company.

Power Infrastructure Board (PPIB) was formed. Figure 1 explains the shape of electricity infrastructure and interaction among its different segments in Pakistan in a post restructuring period.

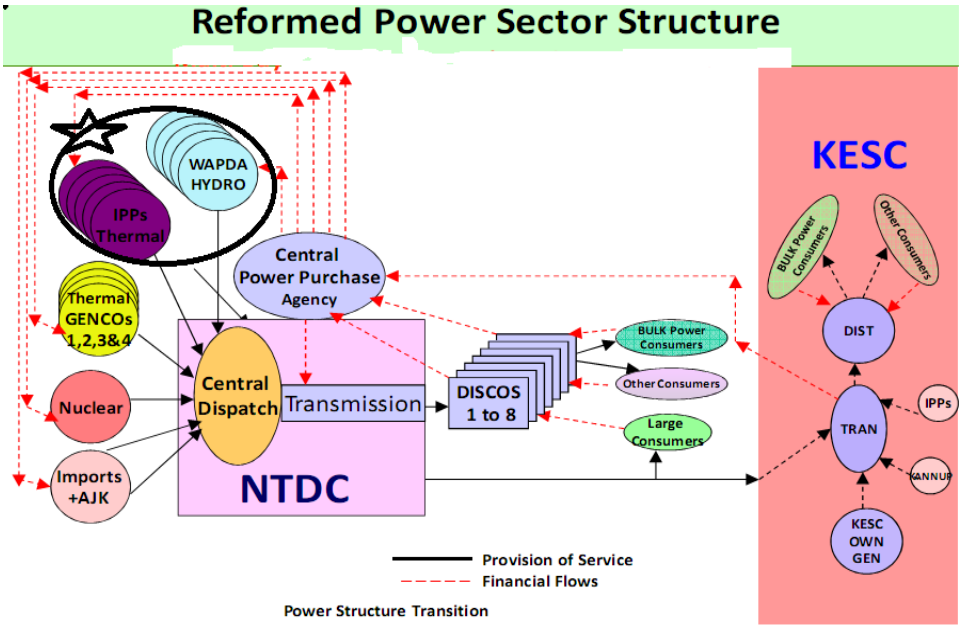


Figure 1. Reformed power structure, source: [10]

Figure 1 shows two parallel systems in Pakistan. The government has transferred the KESC system to private sector without unbundling which is linked to the rest of the infrastructure only for purchasing electricity. Infrastructure under WAPDA was unbundled into generation, transmission and distribution sectors. The left part of the figure 1 mentions the restructured electricity infrastructure under NTDC system or ex-WAPDA. Black arrows mention services provided by different segments of the infrastructure and red dotted arrows depict the financial payback of those services. Another important aspect of the restructured industrial organization is that the NTDC system is under strict government monopoly except thermal generation sector and hydro projects as mentioned in black oval shape at the top of the left side. Private sector has only been attracted to thermal generation which is still far from market competition due to several restrictions regarding investment promoting institutions such pricing regulation. Hydro projects which are under WAPDA's control have been opened for private sector but remained unattractive to them and are still dependent mainly on government finances. Despite initiation of reforms for more than a decade, the reform process remains highly shaky and slow. Public sector companies in all segments of the power sector remain highly inefficient and under-performing, dependent heavily on government support and far from the adoption of corporate culture.

2.2 Electricity production

Total installed capacity of electricity in Pakistan has risen from 60 MW at the time of independence in 1947 to 21593 MW in 2010 [11]. This shows a considerable growth over a period of 63 years which was replete with political, economic and social upheavals in the country; however production remained way behind the actual demand and so the shortfall

between supply and demand of electricity remained a major obstacle in the sustainable economic development of Pakistan.

Since the electricity sector was a public sector monopoly until 1990's and so the installation of generation capacity also depended upon public sector investment. With the introduction of reforms, the sector started to attract private investment which has become a major contributor to the capacity enhancement in recent years (see Table 1).

Table 1. Installed generation capacity (in MW) and actual production (in GW) by type

Type	Installed Capacity (MW) with 5 Years CAGR (%)	Generation (GWh) with 5 Years CAGR (%)
Total	20,921 / 1.8	95,358 / 0.5
Public sector-hydro	6481 / -0.1	28,093 / -2.3
Public sector-thermal	4900 / NA	19,593 / -3.4
KESC (Private entity)	1955 /2.7	7,964 / -3.4
Private sector-IPPs	7123 / 5.1	36816 / 6.5
Public sector-nuclear	462 /NA	2894 / 3.9

Source: Hydrocarbon Development Institute of Pakistan. [12]

Most of the private investment poured into thermal generation sector and long term projects such as hydro remained unattractive to private investors despite lucrative incentives. Table 1 show that the only sector which has shown considerable growth rate over last five years has been thermal generation under International Power Projects (IPPs). Installed generation capacity under thermal IPPs has shown cumulative annual growth rate of 5.1 % and second to it has been KESC which is also run by private sector, and showed growth rate of 2.7%. Installed capacity from the sectors under public control have either shown negative growth over last five years such as hydro projects under WAPDA system or remained unaffected such as from nuclear and GENCOs. The similar case is with actual production where IPPs have shown positive growth of 6.5 % over the years whereas the utilities under public sector have shown negative growth rate except nuclear which has given a continuous production.

Various reports from NEPRA, Planning Commission and State Bank of Pakistan have shown that under-performance of state owned utilities in electricity infrastructure has been due to the result of under-investment, mismanagement and technology barriers.

Thermal sector has become major contributor to overall electricity production which is comprised of around 70 % of the total electricity production in Pakistan [11]. Production from long term projects such as hydro which remained significant in overall electricity production in past has been contracting in recent years. Thermal generation under private sector such as IPPs have been growing at such a scale that it has surpassed the production from all other sources (Table 1). Inside thermal production, production based on imported fuels such as diesel and furnace oil has shown maximum growth in recent years as shown in Figure 2. Currently, production based on furnace oil and diesel is comprised of almost 57 % of total thermal production in Pakistan and the trend has been rising due to worsening situation of natural gas in the country.

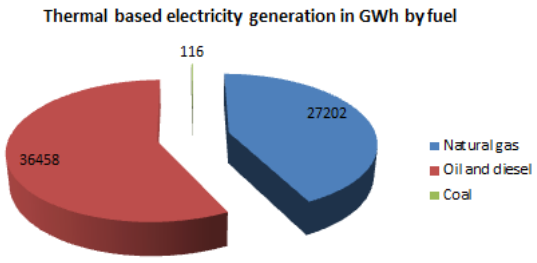


Figure 2. Thermal generation from different sources in 2010

At one side dependence of electricity production over imported fuels has been rising continuously and on other hand there has been tremendous gap between electricity demand and supply. According to NEPRA, Peak load management has touched 6500 MW which is approximately 35 % of total demand during peak seasons. Peak demand during peak seasons of summer (May-Sep) and winter (December-February) have reached up to 19000 MW. Electricity production oscillates between 12000 MW to 14500 MW depending upon demand variations, fluctuations in prices of oil and availability of natural gas, efficiency level of technology and seasonal variations in hydel projects [11, 13]. This situation has badly affected the policy of "least cost generation expansion" to contain the electricity prices within affordable limits.

The production sector has become highly unreliable and inefficient. Despite the fact that installed capacity is more than the peak demand but still it is much lower than actual requirement. One of the factors used to measure the reliability of a supply system is "reserve margin" which is excess capacity than peak demand in percentage over a period of time[5][14]. Various experts mention that RM should be between 18-25% of the installed capacity to ensure an efficient and well-coordinated supply system.

Reserve margin (RM) = installed capacity-peak demand/ Installed capacity

Calculation of reserve margin in electricity system of Pakistan gives following result,

RM=21500-19000/215006= 11.63%

Lower value of reserve margin shows un-reliability of supply side in Pakistan. The reserve margin is of intense importance to balance sudden variations in power market because it can support the overall infrastructure (1) to cover plant breakdowns and also to cover supply shortfall in case of water shortage (2) to overcome peak demand variations attached with weather (3) to cover the supply lag due to plant maintenance (4) to cover the forecasting errors by supply-demand regulating authority [15]. Contracting reserve margin

[5] Time can be a year, month or a day
[6] Data for installed capacity and peak demand in MW is from latest report of NEPRA 2010.

that currently stands at 11.63 % in Pakistan exposes poor situation of installed capacity for establishing a sustainable and efficient power supply.

According to Integrated Energy Plan 2022, Pakistan needs immediate induction of 6500 MW of electricity into national grid by 2012 and will need to induct 3000-4000 MW annually until 2022 when total demand will reach up to 55,000 MW. Thermal generation based on oil has been envisaged to contribute largely to fulfill future demand in wake of contracting national resources and lesser interest by private sector in long term projects. Another reason of increased production of electricity from oil could be worsening gas crisis in the country which has been equally affecting the people's life as is electricity. NEPRA has stopped issuing licenses for gas based generation units due to shortage of natural gas reserves nationally; therefore many of the gas-based units have been shifting over to oil thus augmenting the dependence over imported fuels. These measures are considered as short term and unsustainable because they have no link with "Least Cost Generation Expansion Plan" due to unexpected and sudden changes in petroleum products internationally. Such a situation cannot continue for longer because this has increased the electricity blackouts and prices at an unbearable level and the results have been appearing in form of destructive protests across the country.

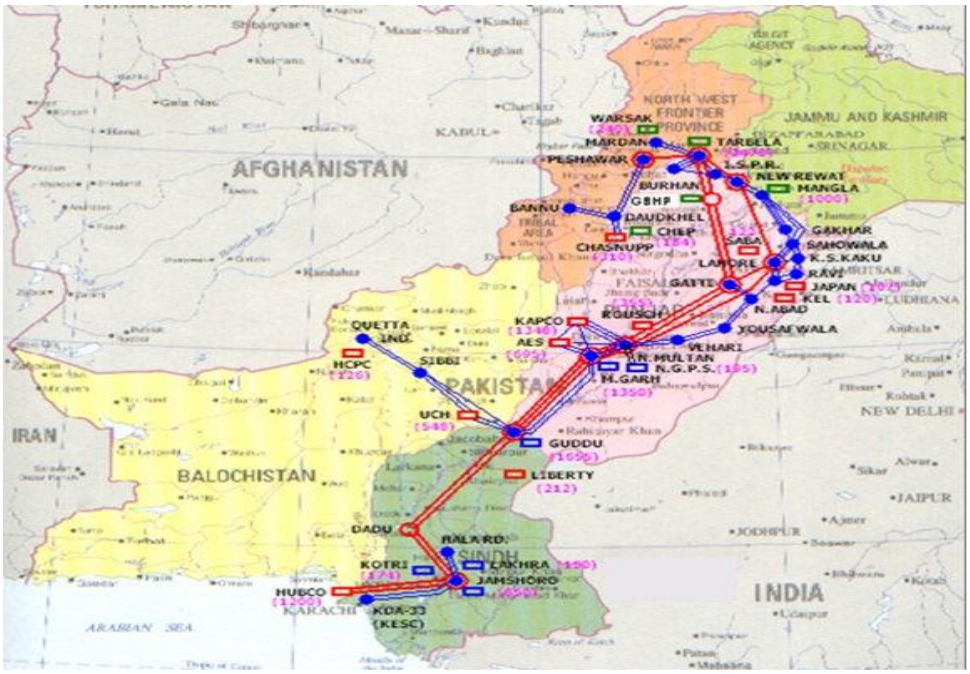
The problem seems to prevail unless enough investment is not attracted into long term projects based on indigenous resources such as hydro and coal. Dependence of long term projects on public sector and contracting public investment has been severing the crisis. Private sector remains aloof from making heavy sunk investments in long term projects due to various institutional, economic and political reasons which will be discussed in another paper. Energy expert group in Integrated Energy Plan 2022 has highlighted 8 hydel projects with overall capacity of 17392 MW and with overall costs of US$ 35 billion. Government has failed to secure funding for any of these projects at a time when private sector seems disinterested in long term electricity projects [3].

2.3 Transmission and distribution

The high voltage grid of the country goes from south to north following the Indus River Valley, where also the majority of the population lives. However, the grid coverage is not nationwide, about one third of the population (about 60 million people) has no access to the electricity grid [16]. One of the major causes is the scale of the country and the remote locations of many settlements. Figure 3 gives an impression of Pakistan's high voltage grid under NTDC system. The figure does not display the electricity grid in the Karachi area.

Figure 3 depicts the transmission system between production centers and main grid stations and then from main grid centers of 500 KV to medium grid centers of 220 KV under National Transmission and Dispatch Company. There are 39 grid stations in overall, with 27 grid stations of 220 KV and 12 grid stations of 500 KV, whereas the length of high voltage and medium voltage transmission lines is 12, 436 km with 7,359 km of 220 KV and 5,077 km of 500 KV[17]. In addition to that Karachi area has a network of 59 grid stations and 1117 km of transmission lines of 220, 132 and 66 KV[7].The transmission of electricity from medium grid to lower grid and then to consumption centers is controlled by respective distribution companies in their respective regions.

[7]http://www.kesc.com.pk/en/article/ourcompany/factsfigures.html



Description: = *hydro project,* = *thermal projects in public sector,* = *thermal projects under IPPs,* = *grid stations,* = *Transmission lines of 500 KV,* = *transmission lines of 220 KV.*

Figure 3. Pakistan's high voltage grid under National Transmission and Dispatch Company (NTDC)

National Transmission and Dispatch Company also coordinates supply and demand of electricity on daily basis as a System Operator (SO). And Independent System Operator (ISO) is regarded highly important to enhance competition at generation end by reducing information asymmetries, transaction costs and market power [18]. The system operator, an independent entity is principally responsible for dispatch control and execution of "*complex network interactions*" in electric grid regarding balancing of electricity demand and supply in short period. National Transmission and Dispatch Company (NTDC) has been licensed by NEPRA, to perform dispatch operations in the national grid of Pakistan. NTDC, a public limited company, which is presented as an independent entity for dispatch services is massively controlled by government. It is replete with various shortcomings such as operational mismanagement, capacity insufficiency to balance supply with demand and market imperfections resulting from various internal and external factors. Such imperfections give rise to problems such as high transaction costs and market power which ultimately worsen the market competitiveness. Poor dispatch interactions are also one of the reasons for sustaining gap between power supply and demand in Pakistan.

Transmission network in Pakistan is quite unreliable. An important indicator explaining the unreliability of the system is number and duration of forced and planned outages in the transmission network. In NTDC system, total planned outages in 500 KV and 220 KV lines were 140 and 657 respectively in 2006, whereas forced outages were 29 and 351 [11]. In 2007, number of planned and forced outages increased. In 2010, total number of planned and forced outages stood almost at the same level as they were in 2006; however the duration of outages increased many folds which have further exposed the inefficiency

and unreliability of transmission network. Similar situation prevails in KESC system. Such inefficiency in transmission system has also increased system losses which stand at 3.10 % in NTDC system and 3 % in KESC system according to official sources of NEPRA[8] (Ibid).

Transmission system needs overhauling to increase efficiency and reliability. The efficiency and reliability of the transmission system has been eroded due to various reasons. Lack of capacity in meeting the increasing requirements of electricity induction into the national grid on sustainable basis is one of the reasons along with poor system management and dispatch services by NTDC. Such capacity problem has also given rise to the congestion problem in the system which has resulted in the failure of system on various occasions. A plan of estimated costs of US$ 6-7 billion up to 2022 has been proposed in Integrated Energy Plan 2022 for uplifting the transmission network so to enhance its capacity for carrying out future electricity transmission operations [11, 19].

Distribution sector consists of two vertically integrated systems in Pakistan; under PEPCO or NTDC system, nine distribution companies cater to the domestic, commercial, agricultural and industrial needs, whereas KESC provide services to Karachi and its neighboring areas. The distribution system is responsible for operating, maintaining and developing the grid stations and transmission network of 132 KV and below to provide electricity to consumers located in their geographical areas. The companies are responsible to enhance efficient utilization of purchased electricity from NTDC and generation companies. Area under nine distribution companies is given in Figure 4.

(Map explanation: TESCO= Tribal Electric Supply Co., PESCO=Peshawar Electric Supply Co., IESCO= Islamabad Electric Supply CO., GEPCO= Gujranwala Electric Supply Co., LESCO= Lahore Electric Supply Co., FESCO= Faisalabad Electric Supply Co., MEPCO= Multan Electric Supply Co., HESCO= Hyderabad Electric Supply Co., QESCO= Quetta Electric Supply Co., KESC= Karachi Electric Supply Co.)

Figure 4. Area covered by eight ex-WAPDA distribution companies, Souce: NEPRA

Distribution companies of Pakistan face range of challenges which inhibit their performance. Some of those challenges consist of line losses, inability to recover electricity

[8] The reliability of data is questionable due to its origin from government controlled organizations which may hide the correct information.

charges from consumers, electricity theft, poor management and governance [13]. As a result, DISCOs face financial Losses which vary widely amongst different distribution companies. For example according to NEPRA (2010), PESCO (Peshawar Electric Supply Co.), HESCO (Hyderabad Electric Supply Co.), QESCO (Quetta Electric Supply Co.) and KESC have average annual losses of 60%, 35%, 20% and 40% of their annual revenue collection respectively whereas IESCO, GEPCO and LESCO have average annual losses in last five years around 11%, 12% and 13 % respectively which shows that DISCOs of upper Punjab province have lesser losses than DISCOs of other provinces. The overall distribution and transmission losses in the country exist at 22 %.

Besides financial losses incurred by distribution companies due to financial mismanagement and poor governance, continuity of electricity supply is another important factor to measure the performance of DISCOs. Three indices SAIFI (System Average Interruption Frequency Index), SAIDI (System Average Interruption Duration Index) and CAIDI (Customer Average Interruption Duration Index)[9] are highly important to measure reliability of distribution system. According to NEPRA Distribution Rules 2005, every DISCO should ensure that SAIFI and SAIDI values[10] are contained up to 13 and 14 respectively; however data regarding SAIFI and SAIDI values for different DISCOs presents bleak picture where some DISCOs such as Peshawar Electricity Supply Company (PESCO) has SAIFI value at 193 in 2010 and above 50,000 in previous years, the SAIDI value for PESCO in 2010 was 15787. Other DISCOs present similar pictures regarding frequency and duration of power supply outage; however the real data regarding such values is not reported to hide their performance loopholes from NEPRA and relevant public as well as private organizations [11].

Mismanagement and financial losses of DISCCOs have affected their ability of reimbursement to generation companies for the purchased electricity. Such an inability to payback has plagued the functioning of whole electricity network in the form of circular debt due to existence of strong complementarities among all the segments of the network. Discos' incapacity for reimbursement complicates the financial transactions among other segments of the network such as generation sector and other networks like oil & gas sector. This has resulted in amassing the circular debt above Pak Rs. 200 Billion [19] which has become one of the important factors responsible for the under-production of thermal electricity than installed capacity and resultantly causing sudden blackouts. Severe blackouts in recent months have created mass-scale demonstration across the country thereby forcing the government to intervene into public sector electricity infrastructure with heavy subsidies. Despite massive subsidies, the system is still shackled in circular debt which is piling up with every day and exposing the flaws in different segments of the infrastructure.

2.4 Electricity consumption

According to NEPRA sources, electricity generation has been hovering between 90,000 and 100,000 GWH for last five years whereas electricity consumption has been trapped between 60,000 and 72,000 GWH (Figure 4).

9 CAIDI= SAIFI/CAIDI, measured in hours per interruption
10 Power supply disruption per customer in hours per annum

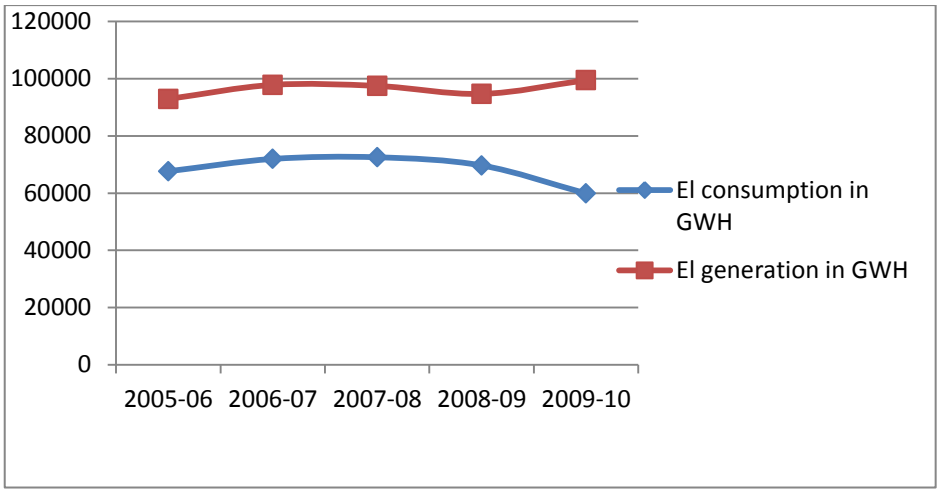


Figure 5. Total electricity generation and consumption in Pakistan[11]

The consumption sector is getting electricity in lesser quantity in recent years despite the fact that generation has been rising. The widening gap between electricity generation and consumption elucidates electricity losses in the form of line losses during transmission and distribution of electric power and unmetered electricity supply i.e. theft.

Electricity consumption increased with GDP increase in Pakistan. Consumption is mostly concentrated in urban centers and those rural areas where people's incomes have increased considerably due to higher industrial and agricultural produce and also because of high inflow of remittances from abroad. Punjab which is most populated province in Pakistan and also enjoys highest per capita income and elite status of making up of around 60 % of total electricity consumption in the country. Other four provinces[12]have lower electricity consumption, lower grid connectivity but higher mismanagement in power sector and higher losses. Total number of electricity consumers in the country has surpassed 20 million figure, of which Punjab province has more than 50 % of the total consumers, Sind is at second, KPK at three, Baluchistan at number four and Gilgit Baltistan is at number five in terms of electricity consumers in the country [11].

Sector-wise breakdown of electricity consumption in Pakistan presents a different picture from many other developing countries. Residential sector has been biggest electricity consumer in the country, making up approximately 46 % of total electricity consumption. Industrial sector has almost 28 % of electricity consumption (detail in Figure 6).

[11] Data for this comparison between electricity generation and consumption has been accessed from NEPRA's official report 2010 on Power sector.

[12] Pakistan has five provinces consisting of Punjab, Sind, Baluchistan, Khyber Pakhtunkhwah (KPK was known as NWFP or North West Frontier Province earlier) and Gilgit Baltistan. Gilgit Baltistan, previously administered by federal government, was given a status of province in 2009. The electricity distribution and transmission matters are overseen jointly by TESCO and PESCO.

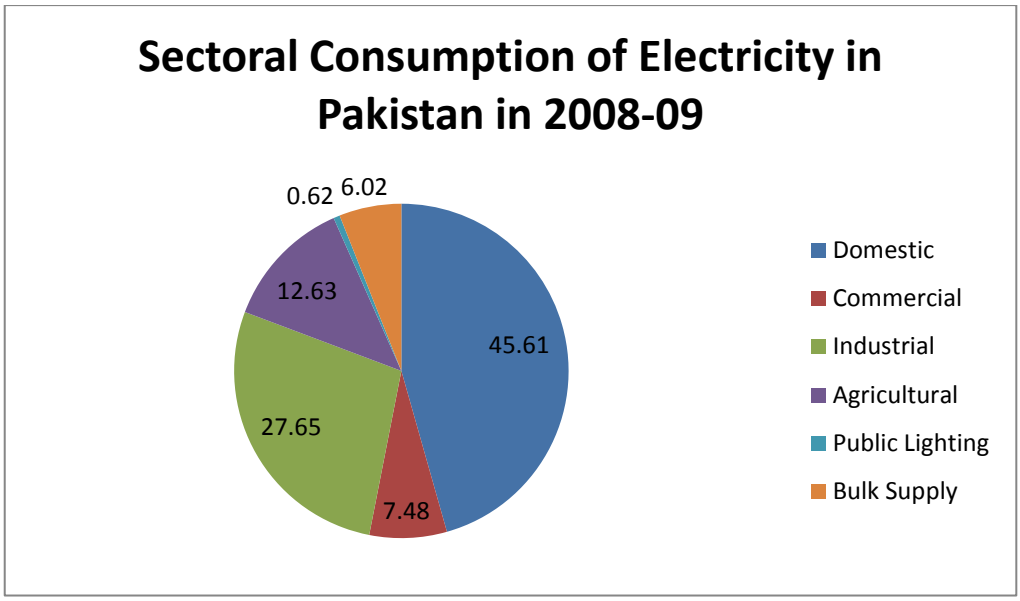


Figure 6. Sector-wise Consumption of Electricity in Pakistan in 2008-09[13]

Domestic consumption, currently at almost 50 %, has gradually increased over years on one side and industrial consumption decreased on other hand. Domestic demand has increased due to increased usage of electrical appliances. High inflows of remittances, rapid urbanization and tremendous rise in consumer financing activities in electrical appliances have helped to raise electricity demand many folds in recent years. Another reason for augmentation in domestic consumption is increased trend of rural electrification among DISCOs belonging to Upper Punjab such as GEPCO, LESCO, FESCO and IESCO [11]. Only 40 % of 45000 villages were electrified in 1991, however the number increased considerably due to extensive electrification programs during late 90's and early 2000. DISCOs in Punjab province, particularly in upper part of the province made incredible accomplishments in village electrification in their premises due to highly integrated and populated areas. Higher rate of village electrification in Punjab also increased electricity consumption in the province which was mostly concentrated in domestic sector. Similar to Punjab, domestic sector also dominated electricity consumption in other provinces despite the fact that village electrification remained quite poor over recent years and so the consumption was mainly concentrated in urban centers and was fuelled by increased usage of electrical appliances. Such an increase in electricity consumption in residential sector which is also subsidized has put the whole power sector and overall economy into financial crisis.

Pakistan is enlisted among countries having lowest electricity consumption per capita in the world, however intensity of electricity is quite higher compared to various developing countries [20, 21]. Utilization of inefficient electricity appliances in domestic, industrial, commercial and agricultural sector has caused higher demand. Demand side management has remained quite poor to meet electricity shortfall. More importance is given in supply enhancement instead of huge potential in electricity savings from demand side management. Inefficient pricing for electricity consumers has also helped to enhance

[13] Data for 2009-10 was incomplete; therefore data for year 2008-09 has been used to break down the electricity consumption sector-wise. Data has been taken from original annual report from NEPRA.

electricity intensity. A better and effective mechanism for electricity pricing may improve electricity efficiency and will also encourage investments in development of efficient electrical appliances.

2.5 Electricity pricing

Efficient mechanism in price setting for different players of the market holds very central position for a competitive power market. It is quite important to transfer the benefits of market competitiveness to all the players including consumers. Failing to establish such an effective pricing system, may entail less responsive consumption and supply variables which are necessary for better functioning of the market competitiveness. Lack of an effective pricing mechanism may also discourage investors from investing in generation, distribution and transmission networks so to coordinate the flourishing market demand with supply [18].

NEPRA has been authorized for tariff setting at every step of supply system including generation, transmission, distribution and retail sales to domestic, industrial, commercial, agricultural consumers and also to industrial consumers requiring bulk supply[22]; however GOP (Government of Pakistan) holds key authority in this regard which finally endorses every price variation by NEPRA so to protect their own interests such as political, economic etc. Although pricing at every step is vital for better performance of overall infrastructure; however pricing at generation and consumption ends are more important for Pakistan case because pricing at those ends affects the generation capacity directly due to existence of markets at both ends. An attractive and flourishing consumption market may have investment incentives at the generation end and failing to produce an attractive consumption market may keep the investors away from investment. A well responsive consumption market could be attractive for investors due to attractive pricing for the generators; otherwise subsidies will have to be inducted to keep the generators in the production sector.

NEPRA adopts different criteria for price setting at different stages. At generation end as well transmission and distribution, tariffs' setting depends upon rate of return where all the costs incurred by companies in their operations plus a reasonable rate of return are ensured in tariff setting. Tariffs are determined on quarterly basis with monthly reviews based on variations in fuel costs. As the market players in the value chain have substantial weight in setting their costs of production so it may render them power to manipulate. Private companies in generation sector have benefitted greatly from this type of policy on tariff setting in various parts of the world as indicated by World Bank, by documenting higher costs of production than actual ones such as Enron price manipulation in California and from other IPPs in Australia and in ASEAN region [23]. Public sector companies which mostly operate to cover their operating costs may have less incentive to set higher costs of production; however costs of inefficiency, bad governance, T&D losses, power thefts and inability in recovering utility bills may add up to overall operating costs thus increasing their total costs to be transferred to the final customers. Such tariff mechanism may also discourage research and development on efficient and sustainable power projects, because governments may find it difficult to pay higher for the electricity from such projects in early years of their installation due to institutional, organizational and economic constraints. So, tariff regime plays quite important role to diversify the electricity generation from multiple sources, enhance competition at wholesale level, reduce market power, supply cheap and sustainable electricity at consumer end and to infuse efficiency in public as well as private regulated companies.

Tariff setting at retail level is based on Incremental Block Tariff (IBT) structure which involves the price increase with increments in electricity consumption. The main logic behind using IBT system is to protect the lifeline users, using electricity less than 50 KWH per month. All the consumers including lifeline consumers are also charged with minimum of 75 for single phase connections and 150 for a three phase connection. All the consumers have been divided into four blocks with first block consisting of consumers consuming up to 100 KWH with a further division into lifeline consumers consuming less than 50 KWH, second block between 100 to 300 KWH, third between 300-700 and fourth comprising of consumers consuming above 700 KWH per month. In overall, 96 % of total consumers consume less than 300 KWh a month and only 4 percent of consumers including industrial consumers consume above 300 KWh per month. The incremental rate in tariff to cover supply costs is less effective to consumers consuming less than 300 KWh and more effective to consumers consuming above this threshold [22]. This has created huge deficit between costs of supply and retail price which is curtailed by government through subsidies. So, most of the financial burden from variations in fuel's prices and overall increase in costs of electricity supply due to various reasons which have been described previously, remains unshared between supply and demand side due to nature of the tariff regime (Ibid).

A better and efficient tariff mechanism is need of the hour at both ends i.e. production and retail supply to better assimilate the sudden changes in power market. One way forward could be learning from tariff models being implemented in power markets which have faced similar problems during their transition periods of power market restructuring. Real time pricing may enhance efficiency at both ends i.e. wholesale and retail level provided they are coupled with a competitive production sector. It may not only help to reduce consumers' bills [24, 25] but may also add up efficiency and sustainability to overall sector with better use of efficient technologies and an organized way of using power during peak hours.

It has viewed that the power system suffers from a range of problems in the value chain which put the whole system into quagmire of inefficiency. Following problems are important in the value chain.

1. The production capacity is far behind the electricity demand and this will continue to be the case in the coming decades if the investment in new production capacity continues to stay behind. Investment is mainly attracted in technologies dependent over imported thermal fuels for power generation which has dragged the sector towards higher costs of production. Developing cheap and indigenous resources such as coal, hydro, wind etc. for power generation have remained unattractive for investment. This has also resulted in limiting the available capacity from multiple sources so as to balance the high production prices from imported fuels with low prices from local sources.

2. Pricing of electricity at production and retail levels do not correspond with the basic objective of liberalization that is to provide better service at affordable prices.

3. Coordination between different components of the value chain has remained quite poor to provide a sustainable and efficient service from electricity infrastructure. Dispatch operations by system operator i.e. NTDC has not delivered required services to clear demand with sustained supply at every time and place of the grid.

4. The system faces severe financial pressure due to inter-departmental debt i.e. also called circular debt. The problem ensues from poor governance and mismanagement in public sector companies of electricity infrastructure, inability of Discos in tariff collections

from influential politicians, beaurocrats, industrialists and federal and provincial ministries as well as public sector corporations.

5. Despite implementation of reforms, the electricity market is not functioning well. Part of the problem is the inconsistency of industrial organization with the institutional environment of the country, where textbook model has been adopted from outside without considering the institutional requirements of that model. This has resulted in the continuation of sector's inefficiency as it prevailed prior to the implementation of reforms.

3. Conclusion

It appears from the detailed outlook of the electricity sector and main problems being faced by the sector that all the governmental efforts to bring efficiency and reliability in the electricity infrastructure through restructuring have not proved successful. Investment could not be brought into the system despite several incentives such as fixed rate of return, ensured fuel supply, tax free imports of technology, freedom of site selection, long term contracting etc. The transition period attached with the restructuring of infrastructure is taking too longer to end and the results of liberalization in the form of cheap and sustained supply of electricity are not reaching to the final consumers. Rather than getting fruits of liberalization, they have been facing long blackouts and higher rates of electricity.

At first instance, it appears that liberalization process or process of institutional change in the electricity sector of Pakistan has failed to produce required results; however it is necessary to investigate whether the liberalization process was planned and started in right way? Whether the process of institutional change was provided all the necessary ingredients for bringing about the required change? There are important questions to look into the basis of the failure of institutional change in the electricity sector of Pakistan.

The problems being faced by the electricity value chain in Pakistan will be looked from the lens of New Institutional Economics (NIE) in another paper to find out whether the problems have their emergence from dysfunctional characteristics of institutions.

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