Ilkogretim Online - Elementary Education Online, 2020; Vol 19 (Issue 4): pp. 3486-3504
http://ilkogretim-online.org
doi: : 10.17051/ilkonline.2020.04.764735

"Efficiency of Power Generation Companies in Pakistan: Application of Non-Parametric Approach"

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Abstract

Power generation has a central role in the economic growth of every country specifically, in developing countries like Pakistan where, there is scarcity of electricity. Efficient and cheap generation of electricity can assure continuous country's economic growth and development. Therefore, the objective of current study is to investigate the efficiency of Power Generation (PGs) firms in Pakistan for the tenure of 2014 to 2018. These PG firms are also known as Independent Power Producers (IPPs) in the country. This study has applied Data Envelopment Analysis (DEA) and the value added approach is followed over the study for selection of the input and output variables. Sales and power generation is selected as output variables while the selected input variables are gross capacity, fuel cost and labor. The findings of study states on average level the Technical Efficiency (TE) of these PG firm is founded at the level of 72% while Pure Technical Efficiency (PTE) is 86% and Scale Efficiency (SE) is 85%, respectively. Moreover, it was also found that there is an increasing trend in the efficiency of these PGs firms for the tenure of five years. Furthermore, the Tobit regression results suggest as that age is negatively pertained with efficiency whereas, liquidity is found as positively pertained with the efficiency of PGs. Size is found as positively pertained with TE and SE whereas, negatively pertained with PTE in contrast, debt is found positively pertained with PTE and negatively pertained with SE.

Keywords: Technical Efficiency, Power Generation Firms, Data Envelopment Analysis, Pakistan

1. Introduction

The impact of electric power produced is directly related to economic growth of the country. Power is a crucial part for the development of economy.If agriculture and industrial activities increase, the demand of power similarly increases.In developing countries the generated power is participating greater part in growth of the economy and improves the lives of people. PG firms are the main source that provides the electricity for individuals, firms and government.It also motivated by financial and humanistic favor as human right. PGfirms canparticipatea key role in economic development.

Electricity generation and distribution has a share of 1.78 percent in the total GDP of Pakistan. The perceived efficiency in private sector of PG firms motivates the federal government to initially restructure and privatized the power generation industry. In 1947Pakistan become established it got 60MW of power generation twenty years later when WAPDA was established that generation capacity had increased to 119MW (see table 1 for details).Due to the installation of new thermal and hydro power plants in 1970's the capacity raised up to 1331 MW. Now power generation in Pakistan is 22700 MW in 2019.

Table 1.1: Power Generation in Pakistan(Rafique & Rehman, 2017)

Year	Power Generation
1947	60 MW
1965	636 MW
1970	1331 MW
1980	3000 MW
1991	7000MW
2018	18900 MW
2019	22700 MW

Pakistan has faced energy crises in the year of 2008; the shortfall goes up to4000MW. Year 2014started with shortfall, load shedding, and ending with that worst situation. In 2018 Pakistan faces a shortfall between 6000MW while thepower generation was 18900MW.Due to interrupted power traffic the economy of Pakistan badly affected and Pakistan faced energy crises. Pakistan is also working onalternative energy sources like; wind, solar, coal, thermal, hydro and nuclear power. Asian development bank and World Bank also passed financing packages for the power generation of the Pakistan that also helped to generate more electricity.

When a country produced electricity efficiently than it should also be sold at lower price which should meet the living standard of the people and also contribute to the value of economy. Efficiency is the process of using lower input and produce maximum output. It is also the ability to do things successfully well and control wastage. The people and the infrastructure can also be improved when country produces the electricity efficiently.

Current study analyzed the efficiency ofPGs firms in the sector of energy producing at industrylevel are listed at Pakistan Stock Exchange (PSX). The main purpose of this

current study is to examine the overall efficiency of PG firms about the study period prescribed and also to analyzeefficiency trend in the PGs of Pakistan. Moreover this study has thoroughly investigated the determinants of efficiencies in PG sector.

2. Literature Review

Efficiency of PGs has been extensively investigated in empirical literature and there are studies e.g.(Vaninsky, 2006)measured efficiency of electric power generation with DEA in the regions of United States of America(USA) for the tenure of 1991-2004. Net summer capacity, operating expense and revenue were taken as input variables whereas; net power generation and retail sales were selected as output variables. It was found that there was relatively stability in efficiency from 1994 to 2000 between 99 to 100%, thereafter, a sharp decline was found in 2014 to 94.61%. Another study by (Ziaee & Falahati, 2017)applied DEA techniqueto examined the performance of eight major electric power based producing firms. Labor hours, value of raw material, electricity consumption used as input variable whereas,the value of sales is used as the proxy variable for the output of the firms. DEA & Inverse Data Envelopment Analysis (IDEA) approach was used in estimation. It was a research on eight power based producing firms wasused for estimatethe efficiency. Production cost in this varied between the 6708.818 and 16446.59 (Rial/kWh). Rial is used in the country as the unit of Iranian currency. Use of IDEA does not required a time series data on input and output of individual electric power producers and relative efficiency of every firm is possible to be examined. Result shows that five firms are efficient while three are inefficient.

There are some research papers which have examined the effectiveness of PGs in European countries e.g. '(Day, 2005) worked on DEA model for the period of 1996 to 2007 on 24 European Union (EU) member state's public power plants. Electricity generation from plant was taken as output variable whereas, labor, fuel and installed electrical capacity wereselected as input variables. In this study it is found that the efficiency scores vary among the countries of EU. It reflects the country vise fuel mix (Gas vs Coal) is used for electric power production. For instance for the year of 2007 the average efficiency about gas based (in fuel mix the part of gas is greater than 50% in 2007) power production is founded double as more as the performance of coal based power production (share of sold fuels in fuel mix is more than 50% in 2007). The average performance of plants basedon gas has been increasing since 1996 that manifest improved in the year of first EU financial trading period while the other is true for coal-based electric power generation industries. It was observed that on average the efficiency of coal base power generating industries with the net long position of EU as (10 out of 14 coal based power industries) deteriorated in the year of 2005, 2006 and 2007.Efficiency of remaining four coal based countries with net short position for EU somewhere improved but most of improvements based on SO2 emission rather that CO2. On average 2005 to 2007 did not improve but it is observed that the improvement occurring in 2007 and a slight deterioration also found in the year of 2006.

The statements further explained that production based on finite sample, environmental efficiency and productivity measures subject to sampling variation. Moreover in the results CO2 and SO2 emissions is also showed as output in the shape of

heat and gases. It is investigated that environmental efficiency is explained the emissions factor which influence the climate change.

There are some research papers in the region of Asia which have explained the effectiveness of PGs e.g.(Jin et al., 2018)evaluated the competence of Chinese Coal Fired electric power production plants using DEA technique. In this research study some research sample used to covers 221 plants over the study period of 2002 to 2006. Annual electricity generation is used as traditional output variable and installed capacity, labor and fuel is taken as input variables. It was found that smaller units were less efficient then larger units because of low fuel consumptions.

(Golany et al., 1994)measuredthe efficiency of electric power plants in Israel by using DEA. This study reports that real data was obtained by power plants operated by Israel Electric Corporation (IEC). Seven years actual data used in study from 1981 to 1987. Power generation was used as output variable and installed capacity, fuel consumption and man power were used as input variables.Using DEA model in the study a set of 91 DMU's (87 observed and 4 standard points) examined about an average 1% decline in efficiency scores of compared DMU's. Likewise a decline in proportion of efficient DMU'S from (45% to 31%) was calculated and most efforts occurred in small site units where efficiency score fall by 1% to 5%. The scores of large site units were hardly affected by adding standards to analysis. Over the study it is also explained that Fuel consumption is highly correlated with power generation and man power is weekly correlated with output. Man power is efficiency gap which is associated with the input.

There are few number of research studies in Pakistan which have analyzed the effectiveness of PG firms. For example; (Saleem, 2003) worked regarding technical efficiency of 21 private and public power plants in electricity generating industry of Pakistan over the period of 1998 to 2003.In the DEA approach fuel consumption and installed capacity was taken as inputs and unit of power generated used for out variable. It was founded that technical efficiency of private operated plant was better the public plant. Private plants used quite new technology therefore,publicplants showed less efficiency as compared to private power plants.

With the passage of time world is facing new challenges. Advance technology change mind of people and lifestyle. Due to globalization the world becomes more informative. Methods of working and techniques are changed rapidly due to competitions among nations. New latest plants are installed by IPP's and have more capacity to generate power with low fuel consumption. Efficiency of new plants is different despite of old one. There is a big change in technology and efficiency. The efficiency of electric power plants is necessary and important to measure that plant operators are using new methods and technology to generate power in Pakistan. Research done in previous century does not match with newly installed power plants. This study is better than old one and has new information for a reader to get better knowledge. Latest and very useful information regarding efficiency measurement is provided by using DEA approach.There is so far no significant research study to the best of authors' knowledge that find the output via DEA of PG firms for Pakistan over the period of 2014 to 2018.To

fulfill this gap this study is done to obtainlatest know how about the power plants working in new era.

3. Methodology

Efficiency of PG firms has been calculated by non-parametric (Programming) techniques.Charnes et al. (1978-1981)(Moesen & Persoon, 2002) who invented the term DEA apply the same work on multi input and output models. It is mostly used to find the efficiency in all fields of study. To find out the efficiency it works on Decision Making Units (DMU) and selects the best one from all of these decision making units DMUs. The finding of DEA lies between one and zero because it uses the maximum ratio of weighted input and output if the results are one it means the unit is efficient but on the other hand if results are zero or less than one then the unit is inefficient. Most of the researchers considered it to be the best for the small size of observation. In (Zhou et al., 2008) and (Jaraiźe & Di Maria, 2012) also used DEA in their study. We follow the same model which was applied in the study of (Afza & Asghar, 2012).

The value added approach followed under this research study and selectedvariable of sales and power generation is considered as two output variables.Sale has very importance in any industry because it explains the firm overall output. Sale is the foundation of a firm's profitability and good image for public. Growth in sales of generation of a commodity plays a key role to build trust and loyalty among business and customers.Value of the sales is derived by the total sales of firm in a financial year.

In Iran (Fathollah Bayati & Sadjadi, 2017) and (Samson & Terziovski, 1999) used total number electricity sales (MW) as output variable in Robust Network Data Envelopment Analysis(RNDEA).Sales also depend upon the power generation of firm. If generation is more so salesis more and if the generation during a year is at lower levelthem obviously sales will be at lower level.

Power generation in used as output variable over the study. A country can move forward if it has good sources to generate power. Electricity is a God blessing that science has given to mankind. It has become basic need now a day'sfurther for better future of public. The electricity is generated by different methods and resources. Generation of electricity is carried out by the power plants also called power stations and supplied to public and all users of the country by transmission lines network and grid system installed all over the country.In recent research in February (2019),(Soh & Parves, 2018)used net generations of power as output of combined cycle power plants in Bangladesh.

Raw material consumed,installed capacity and salaries are used as input.Raw material consumed is considered as the first input variable in the current study because it has main role in the final input. Sale of the firms are mainly depends on the raw material.It is required to boil the water and converted to steam. The steam produced by consuming of raw material is used to rotate turbine that is mechanically connected to rotar of power generator. The rotar rotates and in result electricity is produced. Different typeof raw material can be used to generate electricity as hydro, wind, nuclear, biomass, solar thermal, geothermal, solar pv, natural gas and coal.Chairman of Indian Railway

board(Yadav et al., 2012)used in a study Material as input variable while working on Multi Criteria -Data Envelopment Analysis (MCDEA).

The second input variable of this study is the installed capacity. The value of installed capacity is computed by capacity of power generation by a power plant. Installed capacity described the firm's efficiency that how much a firm can produce over its operation time. The fundamental input factor is installed capacity that explained the power productivity of a plant and it is further represents about the level of highest capacity of a power system is designed to run it. For example for a hydroelectric power plant is refers to the maximum runoff that can be constantly maintained and utilized by the equipment at the plant. For a wind turbine it states that how much electricity production over the turbine in normal wind conditions. As with other forms of power production is typically measured in Mega Watts (MWs). So it is said that a plant of 10 MWs can produce 10 MWs power over the installed capacity of 10 MWs. But in case of wind blow it fluctuates with weather condition changing constantly.(Jin et al., 2018)researched on PM2.5 Emission reduction DEA in electric power industry of China used installed capacity of power plant as input variable.

The third and the last input variable of the current study are the salaries. Salaries are the value that is measured by using salaries over work done in labor hours or man power under administration and operations for running the firms activities. Salaries describe the firm overall production over an accounting period it also describe the efficiency of an individual to the organization as a whole.(Arabi et al., 2014)from Malaysia also used salaries as input factors in DEA approach.

Input variables and output variables used in the study are presented in table 2.

Table 3.1: DEA Input and Output Variables

Symbol	Variable Description	I/O	Measure
y1	Generation	Output	Total MW produced by the firms
y2	Sales	Output	Total sales of the firms
x1	Raw material	Input	Values of raw material& fuel consumed
x2	Installed capacity	Input	Value of installed capacity of a power plant
x3	Salaries	Input	Salaries of administration +operation

Determinants of Efficiency

This research work has further analyzed the form of structure associated of firm characteristics with the quality and efficiency level of the PGs. The firm's characteristics include: size, profitability, assets, performance, liquidity, operating efficiency and age of power plants.

The relationship between the size of the PGs and its efficiency is important for all of the stakeholders. This study is assuming that the size offirm has a positive relationship with the efficiency of the PG firm since old technology. Inthe big size firm setup fuel consumption is low and generation is more therefore size has significant importance in production of electricity rather than small size setup the production of electricity is low and fuel consumption is more. There is a positive association between the increase in minimum capital requirement and efficiency. This is measured as debt to equity. C is expected sign of size is used in equation of efficiency. Capital Structure is measured as debt dividing by equity and multiplied by 100.

H1: There is a positive association between size and efficiency.

Equity is also frequently used as one of the main determinants of efficiency in the empirical literature.Assets means Equipment's and property are the items of value that's the company leases or owns for order to run business routine activities. It can be also describe that the means of producing value in a running business –like for example, intellectual property in a business, customer relations with company and market goodwill.The study is expecting equity to be positively related with power generating firms' efficiency since it strengthens them financially. Equity in the study is measured as taking the natural log of total assets of firm. Regarding the natural log of total assets expected sign is used as$\beta 2LNTA$.

H2: There is a positive association between total assets and efficiency.

A debt relief firm can help a debtor to get rid of the debt, while financial advisors and credit counselors can help in getting individuals or firms to be in control of their finances, debts and financial habits.Mostly power generation firms are not facing various challenges these days which compel them to maintain a provision for advances (loans) to overcome the problem of bad loans. This is because they are using most of their own financial resources. Due to availability of more funds the cash reserve is viewed as a cushion mechanism to confirm about the power generating firms may not unexpectedly lose their outstanding loans. The financial crisis in market has also raised its importance. This study is expecting a positive relationship between provision for debt and the efficiency scores since provision decreases the cost and ultimately increases the profit. Advances are measured as trade credit dividing by total assets and multiplied by 100. Expected sign used for debt is $\beta 3DEBT$.

H3: There is a positive association between debt and efficiency.

For being successful in business profitability is very important and necessary for a firm to remain survive and attractive to investors, stakeholders and analysts. Profitability is necessary for a firm's existence and long-term survival.Revenue is a company's net profit after all the expenses related to the production and selling of services are deducted. Profit is "available fund is shape of deposited money in the bank account." This goes directly to the owners of a company or shareholders or it may be reinvested in the company again for business purpose. Profit is the primary goal of any

company.Stakeholders and Shareholders always try to get the high profit to maximize their wealth. Therefore this is also very important to analyze its relationship with the trends of efficiency. In this paper it is expected a positive relationship of profitability about the efficiency of PG firms. The profitability of PG firm is measured as gross profit dividing total assets multiplying by 100 Return on Assets (ROA). $\beta 4ROA$ is expected sign used in return on asset.

H4: There is a positive association among profitability and efficiency.

A firm required the financial freedom of action during its activities. Its means firm is must capable to meet the all due payments and bills. If a firm cannot pay dues pending it will become an insolvent firm which also can be called bankrupt. To save firm from this type of situation that can be a reason of the ending or demolishing of a firm.To remain solvent in market is to pay dues the flow of funds in form of liquid are very necessary for a firm.Even if a firm growsup economically, the solvent firms are endangered for this. It may be possible about the creditors will always pay off their dues but it's an admitted fact that creditors wait sometime for the last moment or till the lastor due date of payment at ending stage. A firm not having the excess funds available or the luxury to late their due payments, but obliged the dues ofcreditors or suppliers and pay off immediately as early canbear a liquidity hurdles or problems of blockage funds for firm operationsin case of insufficient available funds.

Liquidity measures the ability of a firm to meet its short term obligations. Therefore, it is necessary to find out the relationship of liquidity with different efficiencies. It is expected to be positively related with the efficiency of PG firms since it reduces the risk. Liquidity is the sum of cash available to pay obligations, is measured from current assets divided by total liabilities and multiplied by 100. Sometimes it may be negative due to non-availability of cash.Expected sign for liquidity is$\beta 5LQUDTY.$

H5: There is a positive association between liquidity and efficiency.

Operational efficiency of a firm and its ability to provide the service to user is a special important factor whatever is the organization or firm either in the field supply, production or service type facility. This is the very important part in any firm regarding ongoing operations also are highly concern & their organizational growth at local and regional level the expansion of their businessactivities whether this is a business oriented or for NGO or a nonprofit oriented organizations. Mainly performance and operational efficiency depends on the factors of external environment. In business market the external factors are reasoning thechallenging competition environment and intense among theall players of industrial sector. However future contingency plans, operational strategy and strategically planning are much important and played special role to takeover future new changes. If the firm or organization is not capable to handle thosenew changes that are occurring inside the firm and also outside of the firm direct impact on the operational efficiency of the firm. For handle those new environmental changes need the most prudent plans and strategies to design adjustment at firmlevel pertained to operating plans and strategies. This will reason for help to obtainthe firm corporate objectives as per plan alreadydesigned.

In PG firm operating efficiency measures the quality of a firm to achieve its targets of turn over by the expense occurred during the operation of firm. Therefore, it is necessary to find out the relationship of operating cost with different efficiencies. It is expected as positively related with the efficiency forPG firms since it reduces the risk. Operating efficiency means the functions are going on smooth ways and it is measured from equity divided by total assets and multiplied by hundred. Expected sign used for operating efficiency is $\beta 6OPEF$.

H6: There is a positive association between Operating Efficiency and efficiency.

Age is also very important for a PG Firm. It helps to analyze regarding the efficiency forelectric power plants working within country. From the previous scores obtained and financial recorded data of a firm can show the trends of firm direction towards growth or decline.

According to research every new PG firms operating efficiency is high due to installation of new machinery and use of advance technology in power generation operations. The new firm is associated with positive relationship with efficiency. Over the study it is observed that in the old PG firms after specific time limit plant face deprecation and its performance becomes at low level that shows a negative association in this case. Expected sign for age is $\beta 7AGE$.

H7: There is a negative association between age and efficiency.

Concluding the above discussion, we ended up with the following model.(Afza & Asghar, 2012)

$$\theta i t = \beta 1 + \beta 2LNTA + \beta 3DEBT + \beta 4ROA + \beta 5LQUDTY + \beta 6OPEF + \beta 7AGE + €$$

whereθ : *Profit efficiency or Cost efficiency*

C : *Capital Structure=Debt/Equity (%)*

LNTA : Natural log of Total Assets

DEBT : Trade Debt=Trade Credit/Total Assets (%)

ROA : *Return on Asset= Gross Profit /Total Assets (%)*

LQDTY : *Current Assets /Current Liability (%)*

OPEFF : *Equity / Total Assets (%)*

AGE : *Non-Interest Income / Total Assets (%)*

Current study analysis of the financial data of 11 private PG firms also called independent power producers (IPP's) from the annual financial reports. These firms are listed in (PSE) Pakistan stock exchange. Financial data is obtained from internet using the official websites of the firms. In this study 7 firms are dropped because of the non-availability of firm's financial data. Theavailable financial data is analyzed over the study period of 2014 to 2018. Currentstudy choosesthose years due to the energy crises in the previous years.

Table 3.2: Descriptive Statistic Table

Years ⟹		2014	2015	2016	2017	2018
Variable output ⇩						
Generation	Mean	173039	160461	171347	266846	158670
	S D	2372623	2450452	2501636	4083536	2372909
Sales	Mean	3376.79	2631.6	1814.79	1904.97	1949.96
	S D	49693.3	42413	27043.1	28439.5	30322.6
Input						
Raw material	Mean	1618.89	1193.68	1949.15	1693.25	1411.38
	S D	27834.6	23512.4	28399.8	26488	23354.4
Installed capacity	Mean	36.3099	36.3099	36.3099	36.3099	36.3099
	S D	507.108	507.108	507.108	507.108	507.108
Salaries	Mean	23.1464	27.7288	30.2509	27.7142	23.7825
	S D	354.442	425.431	450.919	462.993	472.029

The Mean and the standard deviation of PG firms are presented in above table.The Mean sales of the current study shows mix trend over the study period of 2014-2018.In 2014 and 2015 the mean sale of PG firms is 3376.79 to 2631. 60 million respectively which shows slight decline in 2016 and reached at 1814.79 million but it shows a rising trend of 1904.97 and 1949.96 million in 2017 & 2018.

Mean of generation of firms decrease in 2015 from 173039 to 160461 and show increase trend in next coming years to 2016 and 2017 to 171334 and 266846 and in the year 2018 high decline to 158670. However there is growth potential under the study duration that help businesses to enhance their sales plus also increase the efficiency of the firm but this rising trend does not contribute to the economy of the country.

Raw material consumed describe increases trend as decrease from 1618.89 million in 2014 to 1193.68 million in 2015 and also shows increase of 1949.15 over the study period of 2016 except in 2017and 2018 shows decrease. Installed capacity of the power generation firms is taken as grosscapacity for the period of 2014 to 2018 that remains constant 36.3099 for 11 selected firms.Mean salaries of the PG firm's shows consistent increase as in 2014 2015 and 2016for 23.1464, 27.7288 and 30.2509 million respectively it is 27.7142 and 23.7825 million decrease for the period of 2017 and 2018 to 27.7142 and 23.7825 million.

The standard deviation ofraw material consumed, generation, installed capacity and salaries shows decreasing trend for the study tenureregardless of sales shows increasing trend. Different reasons may be linked with this decrease the short fall problems of Pakistan has been solved to some extend that also contribute to the economy of Pakistan.

4. Empirical Results& Discussions

Efficiency conclusions for PG firms for Pakistan have been presented in table No 4 from 2014 to 2018. On average PGs are 72% technical efficient that indicate about these PGs firms are able to generate the same level of output with 28% less inputs. The level of these firms is improved consistently except 2017 only in this year a little decrease occur. The basic reason behind this increase is the economic growth and infrastructure development which positively contributes towards the growth and development of power generation sector of Pakistan. Due to newly installed plants and use of advance technology firm wise technical efficiency of these PG firms is also increased respectively over the research tenure.

On average stage the pure technical efficiency of these PG firms is 86% which shows increasing trend due to the new Chinese's projects in power sector and other development programs while scale efficiency is 85% which also shows increasing trend over the study period because these firms also use other cheaper sources of power generation like wind, coal, thermal and solar. Current study also found that these efficiencies almost contribute to the overall Technical Efficiency (TE) of these firms. In study two firms showed as best. These are NCPL and NPL are founded at maximum TE level infive years analysis. Two firms perform worst as results in average. These are AEL and PKGN that shows minimum technical efficiency during five years.

In the efficiency scores in firm wise it is observed regarding PKGNand SEL in averageshows lowest Pure Technical Efficiency (PTE)that is bad result and low performanceandtwo firms NCPL &NPL shows highest PTE as average result of five years and founded both good in growth.In five yeartwo firms AEL and KAPCO represent lowest levelScale Efficiency (SE)that shows bad results. NCPL and NPL displayed highest results by analysisfor average five years and showed best performance among other firms.

Table 4.1: Efficiency of PGC

Efficiency in Power Generation Companies of Pakistan (2014 to 2018)

Company Name	2014				2015				2016			
	TE	PTE	SE	RTS	TE	PTE	SE	RTS	TE	PTE	SE	RTS
HUBC	0.911	1.000	0.911	DRS	0.912	1.000	0.912	DRS	0.963	1.000	0.963	DRS
AEL	0.038	1.000	0.038	IRS	0.160	1.000	0.160	IRS	0.342	1.000	0.342	IRS
ALTN	1.000	1.000	1.000	CRS	0.975	1.000	0.975	IRS	1.000	1.000	1.000	CRS
EPQL	0.243	0.249	0.973	DRS	1.000	1.000	1.000	CRS	0.466	1.000	0.466	IRS
KAPCO	0.552	0.914	0.603	DRS	0.613	1.000	0.613	DRS	0.642	1.000	0.642	DRS
KOHE	0.927	0.934	0.992	IRS	0.946	0.969	0.977	IRS	1.000	1.000	1.000	CRS
NCPL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS
NPL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS
PKGN	0.711	0.822	0.865	DRS	0.160	0.168	0.953	DRS	0.690	0.738	0.935	DRS
SEL	0.518	0.539	0.961	IRS	0.469	0.502	0.933	IRS	0.615	0.639	0.963	IRS
SPWL	0.527	0.539	0.977	DRS	0.527	0.539	0.976	DRS	0.649	0.663	0.979	DRS
Mean Efficiency	**0.675**	**0.818**	**0.847**		**0.706**	**0.834**	**0.864**		**0.761**	**0.913**	**0.845**	
Maximum	**1.000**	**1.000**	**1.000**		**1.000**	**1.000**	**1.000**		**1.000**	**1.000**	**1.000**	
Minimun	**0.038**	**0.249**	**0.038**		**0.160**	**0.168**	**0.160**		**0.342**	**0.639**	**0.342**	
S.D	**0.330**	**0.258**	**0.292**		**0.335**	**0.292**	**0.258**		**0.242**	**0.151**	**0.242**	

Company Name	2017				2018				AVERAGE (2014-18)		
	TE	PTE	SE	RTS	TE	PTE	SE	RTS	TE	PTE	SE
HUBC	0.753	1.000	0.753	DRS	0.703	1.000	0.703	DRS	0.848	1.000	0.848
AEL	0.355	1.000	0.355	IRS	0.427	1.000	0.427	IRS	0.264	1.000	0.264
ALTN	0.774	1.000	0.774	IRS	0.928	1.000	0.928	IRS	0.935	1.000	0.935
EPQL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	0.742	0.850	0.888
KAPCO	0.644	1.000	0.644	DRS	0.803	1.000	0.803	DRS	0.651	0.983	0.661
KOHE	0.782	0.801	0.976	IRS	0.843	0.861	0.979	IRS	0.900	0.913	0.985
NCPL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000
NPL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000
PKGN	0.392	0.491	0.798	DRS	0.425	0.508	0.837	DRS	0.476	0.545	0.878
SEL	0.341	0.367	0.930	IRS	0.462	0.485	0.952	IRS	0.481	0.506	0.948
SPWL	0.595	0.635	0.937	DRS	1.000	1.000	1.000	CRS	0.660	0.675	0.974
Mean Efficiency	**0.694**	**0.845**	**0.833**		**0.781**	**0.896**	**0.875**		0.723	0.861	0.853
Maximum	**1.000**	**1.000**	**1.000**		**1.000**	**1.000**	**1.000**		1.000	1.000	1.000
Minimun	**0.341**	**0.367**	**0.355**		**0.425**	**0.485**	**0.427**		0.264	0.506	0.264
S.D	**0.253**	**0.238**	**0.200**		**0.240**	**0.202**	**0.179**		0.23064	0.18442	0.20804

TE	Technical Efficiency
PTE	Pure Technical Efficiency
SE	Scale Efficiency
RTS	Return to Scale
DRS	DRS: Decreasing Return to Scale
IRS	IRS: Increasing Return to Scale
CRS	CRS: Constant Return to Scale
HUBC	Hub Power Company Limited.
AEL	Arshad Energy Limited.
ALTN	Altern Energy Ltd.
EPQL	Engro Powergen Qadirpur Ltd.
KAPCO	Kot Addu Power Company.
KOHE	Kohinoor Energy Ltd.(XD)
NCPL	Nishat Chunian Power Ltd.
NPL	Nishat Power Limited.
PKGN	Pakgen Power Limited.
SEL	Sitara Enengy Ltd.
SPWL	Saif Power Ltd.

Figure
4.1: Technical Efficiency by Asset Size (Chart 1)

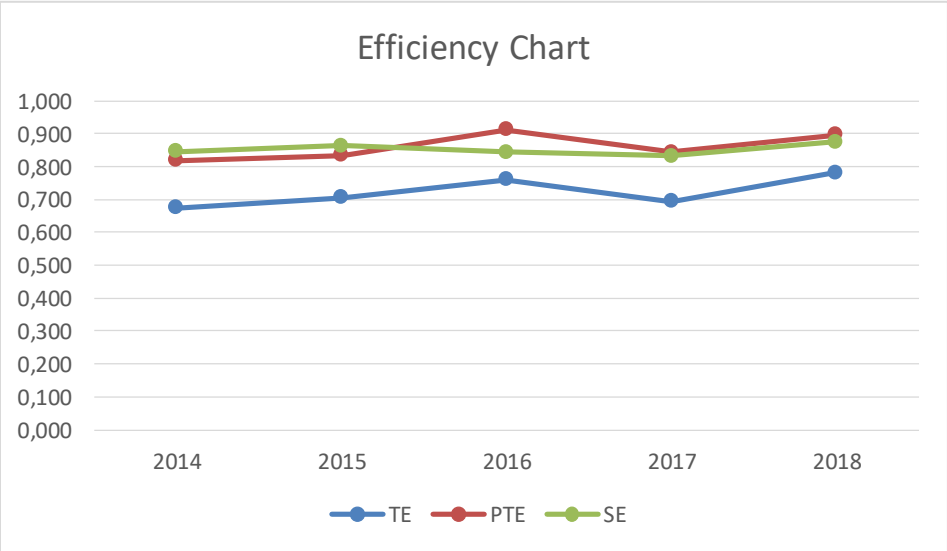

Figure 1 shows that technical efficiency depicts increasing trend over the study period of 2014 to 2018 despite of 2017. PTE also shows increasing trend in the years of 2014 to 2018 while decreasing in 2017. SE shows declining trend in year 2016 to 2017 and increasing trend from 2014-15 & 2018 over the study period. Therefore it's concluded that in the years of 2017 there is a requirement of improvement in operational activities of these PG firms to upgrade the efficiency level. On the other side the inefficiently workingPG firms have to improve or update their operational and managerial practice to make best of their firm operations for the purpose to increase their efficiency.
Almost results are found positively and significantly in the study related with the different variables efficiency which indicates that allover firms are growing. Moreover, it also provides profits. This result suggests that Tobit Model has a positive association with the efficiency scores. LNTA is found positive and significant related with the TE, PTE & SE in the PG firms while DEBT is positive and significantly in PTE & SE. This study also indicates that LQDTY is significant and positive in PTE of doing generation. Age is positive and significantly founded in TE and in SE.

In Average Log is founded likelihood at levelin TE in PTE and in SE. While Left Censored observations are Zero in SE PTE & SE. Right Censored observations are 17 in SE, 35 in PTE & 17 again in SE. According to working in the results, number of total observations is 55.Financial scores are found significantly and positively linked with profit efficiency. The study has followed the methodology of many papers which used the Tobit model.

Table 4.2: Determinants of Efficiency in IPP's of Pakistan

Determinants of Efficiency in IPP's of Pakistan (Table 5)

Variables	Expected Sign	TE			PTE			SE		
		β	SE	Sig	β	SE	Sig	β	SE	Sig
C		0.290	0.340	0.394	0.703	0.798	0.379	0.592**	0.263	0.025
LNTA	+	0.066*	0.036	0.067	-0.177*	0.101	0.079	0.103**	0.025	0.000
DEBT	-	-0.357	0.419	0.394	2.343**	1.145	0.041	-0.872***	0.288	0.002
ROA	+	0.007	0.007	0.314	-0.010	0.016	0.522	0.006	0.006	0.254
LQDTY	+/-	0.002	0.001	0.182	0.007*	0.004	0.064	-0.000	0.001	0.979
OPEFF	+	0.002	0.001	0.247	0.003	0.003	0.298	0.001	0.001	0.481
AGE	-	-0.027***	0.008	0.001	-0.016	0.017	0.353	-0.024***	0.006	0.000
Avg. log likelihood		-0.184916			-0.53037			0.075082		
Left censored obs		0			0			0		
Right censored obs		17			35			17		
Total obs		55			55			55		

5.Conclusion

For mankind the Generation of power is one of the biggest technological innovations.Now the use of electric power has become import part of human routine life

and nobody can think to live without usingthe facility of electricity in the modern world.Electric power now becomesvery important necessity of homes appliances &for operating the industries in every country. Overallaround the globe of world all the electronic devices and electrical equipmentused in houses, businesses and factories are acting their functions because the use of facility of available electricity.The basic use of electric power depends on the location where it is consumed and the nature or source of the available power facility.

The power utilities industry is also affected by macroeconomic indicators because electricity production is linked to economic growth. The innovation in economic output is related to the electricity used by the country. The economic output of a country is analyzed by the Gross Domestic Production GDP. GDP of country is veryimportant key macroeconomic indicator for the power industry. The GDP and electricity demand within countrycan be used as indicators for each other. AGDP of a country can be said the sum of its industrial sector, agricultural sector and also for services sector output. Services sectors and agriculture sectorsare less to moderate electricity consumers. While the industrial sector of any country is highly depends on electric power. As a result, the relationship among electric power consumption and GDP is huge for countries having highly exposure for the industrial sector in the GDP.

Industry of electricity production of any country can holds a share of the economy because it overall contribute to manufacturing and infrastructure development, GDP growth rate, foreign exchange reserve and in every industry of the country. Efficiency measurement of power generation sector participate a significant importance for management regulators, analytical experts and policy developers to determine the efficiency, existing position and limitations of each PG firm.Researchers can analysis the efficiency trend and market structure over the study period more accurately. Efficiency grades are often useful for management because they are driven from various input and output variables. Therefore management of PG firm can easily recognize those variables that cause inefficient in a particular PG firm. More ever these grades are also importance for policy planners as they rank the each electric power generating firm on behave of their effectiveness to select the right choice.

Current studyattempts to investigate the efficiency of PG firms over the study period of 2014-2018. There are several conclusions which have been drawn Technical efficiency shows positive scores for each PG firms and also shows increasing trend over the study period. Current study also argued that PTE shown increasing trend except years 2016whether SE also shown increasing trend except 2016 & 2017 in these two years the average efficiency scores shows declining trend over the study period. Current study also found that large size firms has more technical efficient results as compare to small and medium size firms. Fuel consumption in the large scale firm is less then small level firm due to the fuel is more used in small level firms.

Future research can be done by increasing the study period furthermore distribution sector can also be selected for future.Same research work can also be practiced in other

regions of the world. Efficiency analysis of Pakistan power generation sector can also be compared with other states of the world.

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Appendix

Data Envelopment Analysis (DEA) MODEL

Efficiency of PG firms has been calculated by non-parametric (Programming) techniques. Charnes et al. (1978-1981) who invented the term DEA apply the same work on multi input and output models. It is mostly used to find the efficiency in all fields of study. To find out the efficiency it works on Decision Making Units (DMU) and selects the best one from all of these decision making units DMUs. The finding of DEA lies between one and zero because it uses the maximum ratio of weighted input and output if the results are one it means the unit is efficient but on the other hand if results are zero or less than one then the unit is inefficient. Most of the researchers considered it to be the best for the small size of observation. P Zhou and Kim Leng Poh in (2008) and jarite and Maria also used DEA in their study (2010).

According to Asghar and Afza (2010) "The input oriented DEA model is used to estimate technical efficiency pure technical efficiency and scale efficiency which if given in figure (1)

Min	λ0θ0			
s.t.	Σ λ 0j yrj	≥	y r0	(r = 1…….s) (1
	θ 0 xi0 ≥	Σ^{n}J=1λ0j xij		(i = 1…….n) (2
	Σ^{n}J=1 λ 0j	=	1	(3
	λ0j	≥	0	(j = 1…….n)

1) Σ λ 0j y rj ≥ y r0 (1) is the output constraint.
2) θ 0 x i0 ≥ Σ λ j x 0 is the input constraint.

yrj and xio are the output and input of the nth DMU whereas; λ is the weight. 0 is the DMU which is to be measured and by solving the non-parametric model, we can get the minimum θ0 which is the vector of the efficiency score. The index j specifies DMUs for j=1,…,N. yrj is the rth output of the jth firm for r=1,..,R. xij indicates the ith input of the jth DMU for I = 1,…,I (Mahlberg, 2000). The third constraint introduces variable return to scale (VRS) into the model and if third constraint is dropped, the frontier technology

converts from VRS to CRS. Moreover, if ($\Sigma\lambda 0j \leq 1$) is applied instead of third constraint, the new model can even determine the reason of scale inefficiency that could be increasing return to scale (IRS) or decreasing return to scale (DRS)".

Names of PGs Companies

HUBC	Hub Power Company Limited.
AEL	Arshad Energy Limited.
ALTN	Altern Energy Ltd.
EPQL	Engro Powergen Qadirpur Ltd.
KAPCO	Kot Addu Power Company.
KOHE	Kohinoor Energy Ltd.(XD)
NCPL	Nishat Chunian Power Ltd.
NPL	Nishat Power Limited.
PKGN	Pakgen Power Limited.
SEL	Sitara Enengy Ltd.
SPWL	Saif Power Ltd.

TE	Technical Efficiency
PTE	Pure Technical Efficiency
SE	Scale Efficiency
RTS	Return to Scale
DRS	DRS: Decreasing Return to Scale
IRS	IRS: Increasing Return to Scale
CRS	CRS: Constant Return to Scale

Efficiency in Power Generation Companies of Pakistan (2014 to 2018)

	2014				2015				2016			
Company Name	TE	PTE	SE	RTS	TE	PTE	SE	RTS	TE	PTE	SE	RTS
HUBC	0.911	1.000	0.911	DRS	0.912	1.000	0.912	DRS	0.963	1.000	0.963	DRS
AEL	0.038	1.000	0.038	IRS	0.160	1.000	0.160	IRS	0.342	1.000	0.342	IRS
ALTN	1.000	1.000	1.000	CRS	0.975	1.000	0.975	IRS	1.000	1.000	1.000	CRS
EPQL	0.243	0.249	0.973	DRS	1.000	1.000	1.000	CRS	0.466	1.000	0.466	IRS
KAPCO	0.552	0.914	0.603	DRS	0.613	1.000	0.613	DRS	0.642	1.000	0.642	DRS
KOHE	0.927	0.934	0.992	IRS	0.946	0.969	0.977	IRS	1.000	1.000	1.000	CRS
NCPL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS
NPL	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS
PKGN	0.711	0.822	0.865	DRS	0.160	0.168	0.953	DRS	0.690	0.738	0.935	DRS
SEL	0.518	0.539	0.961	IRS	0.469	0.502	0.933	IRS	0.615	0.639	0.963	IRS
SPWL	0.527	0.539	0.977	DRS	0.527	0.539	0.976	DRS	0.649	0.663	0.979	DRS
Mean Efficiency	**0.675**	**0.818**	**0.847**		**0.706**	**0.834**	**0.864**		**0.761**	**0.913**	**0.845**	
Maximum	**1.000**	**1.000**	**1.000**		**1.000**	**1.000**	**1.000**		**1.000**	**1.000**	**1.000**	
Minimum	**0.038**	**0.249**	**0.038**		**0.160**	**0.168**	**0.160**		**0.342**	**0.639**	**0.342**	
S.D	**0.330**	**0.258**	**0.292**		**0.335**	**0.292**	**0.258**		**0.242**	**0.151**	**0.242**	

2017				2018				AVERAGE (2014-18)		
TE	PTE	SE	RTS	TE	PTE	SE	RTS	TE	PTE	SE
0.753	1.000	0.753	DRS	0.703	1.000	0.703	DRS	0.848	1.000	0.848
0.355	1.000	0.355	IRS	0.427	1.000	0.427	IRS	0.264	1.000	0.264
0.774	1.000	0.774	IRS	0.928	1.000	0.928	IRS	0.935	1.000	0.935
1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	0.742	0.850	0.888
0.644	1.000	0.644	DRS	0.803	1.000	0.803	DRS	0.651	0.983	0.661
0.782	0.801	0.976	IRS	0.843	0.861	0.979	IRS	0.900	0.913	0.985
1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000
1.000	1.000	1.000	CRS	1.000	1.000	1.000	CRS	1.000	1.000	1.000
0.392	0.491	0.798	DRS	0.425	0.508	0.837	DRS	0.476	0.545	0.878
0.341	0.367	0.930	IRS	0.462	0.485	0.952	IRS	0.481	0.506	0.948
0.595	0.635	0.937	DRS	1.000	1.000	1.000	CRS	0.660	0.675	0.974
0.694	**0.845**	**0.833**		**0.781**	**0.896**	**0.875**		0.723	0.861	0.853
1.000	**1.000**	**1.000**		**1.000**	**1.000**	**1.000**		1.000	1.000	1.000
0.341	**0.367**	**0.355**		**0.425**	**0.485**	**0.427**		0.264	0.506	0.264
0.253	**0.238**	**0.200**		**0.240**	**0.202**	**0.179**		0.230634	0.184442	0.208084