Mapping the Imprints of China's Energy Sector Investments on Pakistan's Energy Crisis: Analyzing Pakistan's Transmission Losses and Energy-Mix

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Abstract

The China-Pakistan Economic Corridor (CPEC) is one of the six corridors encompassing China's Belt and Road Initiative (BRI). The commencement of CPEC has led the World Bank to brush-up its economic forecasts for Pakistan; from 5.4% to 5.8%. The improved forecasts are below par, owing chiefly to the energy crisis; the crisis roughly shaves off 2% annually from Pakistan's Gross Domestic Product (GDP) growth. 60% of CPEC investments are targeting the power sector of Pakistan, accounting for roughly 20% of Pakistan's GDP; Thus, making it prudent to study the impact of these hefty investments on the energy quagmire of Pakistan. Since all the energy projects are in the development phase, thus limiting possibilities of impact-forecasting to theoretical means. The study reviews three major areas using the Generalized Methods of Moments (GMM) and Auto-Regressive Distributed Lag (ARDL) techniques for mapping; energy-economic growth nexus, economic impact of power transmission losses and calculating Balance of Payments (BOP) Constrain growth, using Thirlwall's-law to economically measure the impact of CPEC on the energy crisis of Pakistan. The statistical results have been further substantiated with projected results achieved through the Long-range Energy Planning LEAP system and the results indicate positive impacts for economic growth, reduction of energy shortfall and the development of a sustainable energy-mix but highlight a leaky power system owing to obsolete technology.

Keywords: CPEC; FDI; Power Crisis; Transmission Losses; Thirlwall's Law.

Introduction

China's aspirations to realize its trade and infrastructure plan, known commonly as the Belt and Road Initiative (BRI) has already delivered benefits well beyond its borders. The roadmap aims to augment international supply chains chiefly through debt-financed infrastructure projects, through more than 60 countries.

China predicts annual trade with these countries to be worth US$2.5 trillion within a decade. More than 100 countries and international companies have given positive responses to the initiative, with the signing of about 50 inter-governmental agreements of cooperation. Chinese companies have invested more than US$50 billion and built 56 economic and trade cooperation zones in 20 countries along the BRI

routes, generating nearly $1.1 billion in tax revenue, creating 180,000 local jobs and spurring economic development within these countries.

The China-Pakistan Economic Corridor (CPEC), a flagship project of the BRI, has already started to produce economic gains for Pakistan. Funding being received by Pakistan under the umbrella of CPEC is classified as Foreign Direct Investment (FDI). Recently, the World Bank revamped the GDP growth figures it had forecasted for Pakistan. The World Bank had earlier forecasted growth figures of 5% for fiscal year 2016-17 and a growth rate of 5.4% for the fiscal year 2018, as the influx of FDI from China has started to materialize the revised growth rates are 5.2% and 5.8% respectively. Giving clear indications of the fact that, CPEC is playing a positive role in boosting Pakistan's economic growth, which was otherwise stagnant. The funding which Pakistan is receiving within the ambit of the CPEC is the biggest investment as it is the largest among all the BRI economic corridors. Pakistan's GDP is forecasted to be US$ 300 billion for the year 2018 and the funding so far announced and approved for CPEC is US$62 billion which accounts for a little over 20% of Pakistan's economy. Almost 60% or the funding for CPEC so far is being invested in energy projects. Thus it makes it prudent to study and try to predict the outcome of these Chinese investments.

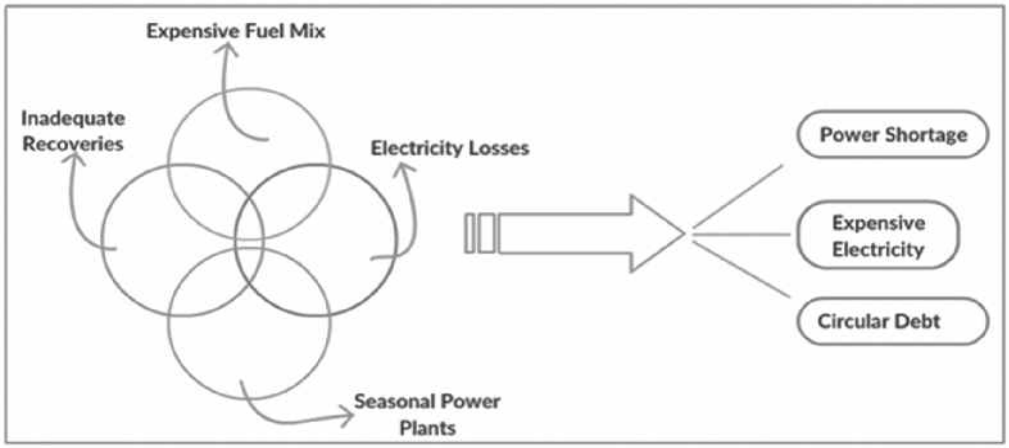
The Power Crisis of Pakistan

Pakistan has been facing power shortages regularly across the nation for the past 10 years, this shortage is overlapped with growing demand in the tune of 2.55%-5% each year (Vats R. , 2016), electricity shortage is something the government of Pakistan cannot take lightly as it is definitely one of the major issues the economy of Pakistan suffers from today (Khalid Mustafa, 2016). This is why the planners in China and Pakistan have given priority to the development of energy projects in the initial phase of the CPEC. The electricity shortage in Pakistan is calculated at 2,500-3,000 Megawatts. Due to the shortage, the government has to resort to power cuts or in other words load shedding; worth 5 to 8 hours daily across the country (Khalid Mustafa, 2016).

As it has been highlighted that CPEC investments are targeting the energy sector of Pakistan on a priority basis that is why roughly US$34 billion have been allotted so far for the power sector, the goal of these investments within the power sector is to deliver power projects with the capability of generating 16,400Megawatts of power which is assumed to resolve the energy crisis (Houreld, 2015). The reality of Pakistan's energy crisis is that, it isn't merely a problem of shortage of production capacity. The problem is multifaceted as Pakistan's current installed capacity for electricity production is 22,797 Megawatts and the country's total demand amounts to 17000 Megawatts but due to a number reasons like bad governance, poor resource management, and obsolete installed technology a circular debt is created within the supply chain, coupled with lack of recoveries and the dependence upon an expensive fuel mix for power generation the electricity produced within the country fluctuates between 12-13000 Megawatts (Shafei Moiz Hali S. I., 2017).

The energy crisis of Pakistan is a result of 4 major problems. Once these are coupled, their ramifications are compounded. The 4 major problems are; utilization of an expensive fuel mix, Electricity losses, installation of seasonal power plants and lastly inadequate recoveries. These four problem areas resulting in to a crisis for the power sector are visually explained in the figure-1 below.

Figure-1 Energy Crisis of Pakistan

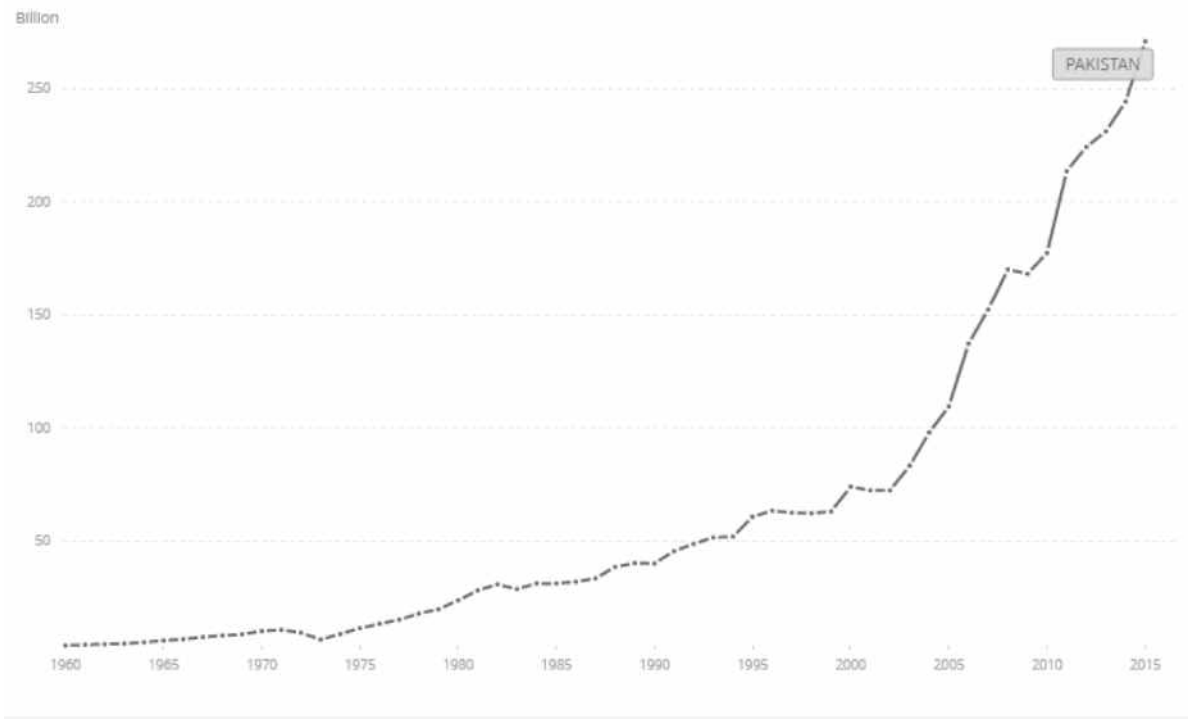


Source: (Shafei Moiz Hali S. I., 2017)

Historical Background of the Power Crisis

Pakistan has been suffering from power outages for many years, before the 1990's the scheduled power outages did not exceed more than 2 to 3 hours a day with in urban areas but as the new millennium began Pakistan started to experience extensive economic growth and annual GDP growth figures reached 7.66% (World Bank, 2017), this sharp incline can be seen in figure-2 below. With this sharp incline exhibited by the economic growth of Pakistan, the demand for electricity also went up significantly and the population of Pakistan also grew rapidly during this time, thus electricity needs became higher and in order to meet this high demand for electricity the measures taken by the government of Pakistan were not adequate and did not involve long-term planning

Figure-2 Economic Growth of Pakistan



Source: (World Bank, 2017)

In order to understand the electricity crisis it is paramount to comprehend why and how the economy of Pakistan experienced rapid economic growth and then the slowdown of the same growth, as it is postulated in this research that, electricity consumption is highly linked with the economy of the country the liquidity in the country. As liquidity is important because without it; the government has very little room for any infrastructure projects. This rise in economic growth experienced at the turn of the new millennium was owed much to foreign investment and also due to the fact that Pakistan received hefty sums as payments through the coalition support fund as part of the Global War on Terror (GWOT), table-1 below provides with the details of these payments.

Table-1 Breakdown of International Affairs Spending and military in Pakistan, 2002-2010 (in millions of dollars)

Pakistan	2002-2010
Economic Support Fund	$4,585.0
Foreign Military Financing	2,160.0
International Narcotics Control and Law Enforcement	528.0
International Disaster Assistance	388.0
Food Aid	380.0
Development Assistance	286.0
Child Survival and Health	220.0
Migration and Refugee Assistance	144.0
Nonproliferation, Anti-Terrorism, Demining and Related	87.0
International Military Education and Training	18.0
Human Rights and Democracy Funds	17.0
Counter narcotics Funds (Military)	225.0
Coalition Support Funds	8,881.0
Pakistan Frontier Corp Training and Equipment	312.0
Pakistan Counter Insurgency Fund	1,100.0
TOTAL	**$19,531.0**

Source: (Dancs, 2011)

With money pouring in to the country, Pakistan's economic growth started to surge but with this increase in economic activity, little investments were made in enhancing the sustainable electricity generation capacity, transmission and distribution base, also little money was spent on enhancing the technologies employed in the existing system, this lead to the brewing of the energy crisis which Pakistan faces today. The country started losing foreign investments and economic progress started to slow down, partly owing to the global financial crisis and partly due to the worsening security conditions in Pakistan, which was caused due to the spillover effect from Pakistan's role in the GWOT. As time progressed the economic costs of GWOT for Pakistan started to outweigh the funds it was receiving for its role in the same war. The economic growth of the country stood at 2.0% in 2009 (Ali A. , 2010) which is a very damaging figure for a developing country as Pakistan falls under the bracket of middle-income countries and the average annual growth for this bracket is 4.2% ('WorldBank', 2016). A developing country like Pakistan with such a high population requires a minimum of 6-6.5% growth to cater for unemployment. This dire scenario created by the war on terror, fleeting foreign direct investment from Pakistan and the global financial crisis of 2008 became overwhelming for the policy makers in Pakistan, who were at one moment trying to manage the high economic growth rates and at the next were faced with such dire economic conditions that they had to resort to policies of renting power plants in-order to meet electricity demands (Bahree, 2009).

Pakistan's policy makers have a track record of being pegged as reactionary policy makers. This can be seen throughout Pakistan's history. Pakistan's government decided to invest in Mangla and Terbela dam once electricity was cut by India to Lahore, which is the second biggest city of Pakistan. The infamous energy policy of 1994 which tilted Pakistan's energy mix in favor of thermal power utilizing oil as a fuel source, was approved once Pakistan experienced massive growth during the 1980's and demand for electricity overshot the supply and the government had to resort to scheduled and unscheduled power outages. The power policy of 2002 was approved once again at time when Pakistan started to receive massive funds as a result of its contributions in the GWOT. The Rental Power Plants policy was adopted in 2009 which was a measure taken to quickly resolve the problem of the electricity demand and supply gap (ICCI, 2010). This

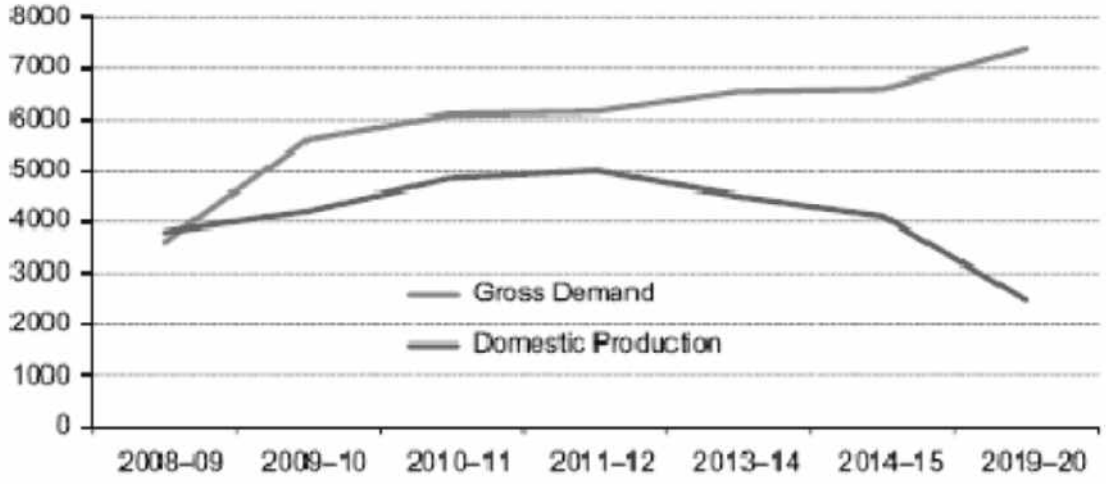
measure resolved the problem but only for a short time span as these power plants utilized thermal fuels and with the government already facing economic turmoil, it was not able to make timely payments to these plants as well as to the Independent Power plants. This resulted in high power outages especially in 2013 and 2014. During the summer season of 2013 alone, frequent power outages crippled the lives of people when the gap between demand and supply was constantly increasing and the shortfall reached between 6,000 and 8,000 megawatts with 18-hour long power outages. (Khan, 2013) Due to this under investment in the infrastructure and power plants, Pakistan now faces about a deficit of 1/3 of the peak demand in the country (NTDC, 2015).

Since Pakistan's energy mix is now heavily thermal energy dependent thus the cost of producing this electricity has also risen sharply and the government has to resort to subsidies to make the electricity affordable for the public. National Electric Power Regulatory Authority (NEPRA, 2013), requires large subsidies from the budget, because the policy of 2013 was consumer centric, but these policies in reality didn't translate for the betterment of the consumers or the producers. The government was always faced with delays in the disbursement of these subsidies which resulted debts that not only burdened the producers but also tarnished the credit worthiness of the state owned and private power companies alike. Forcing them to lower production levels and this generated a cycle of debt, as these producers owed money to the fuel suppliers and refineries who also suffered due to delayed payments; this cycle is now notoriously known in Pakistan as the circular debt. (Ghumman, 2014).

An important thing to understand here is that a heavily thermal energy dependent energy-mix is not necessarily a bad thing, but the irony of Pakistan's thermal energy dependent energy mix is that; Pakistan's energy mix is among the few national energy mixes in the world which has oil occupying the second largest share for electricity production. Mostly this high share associated with oil is present in those countries belonging to the Organization of Petroleum Exporting Countries (OPEC).

Pakistan's current energy crisis is not merely a problem of demand and supply as mentioned before; this problem is multifaceted and requires serious attention and time, before recovery can be achieved. Within the crisis firstly there is the physical shortage of electricity, which is lack of sustainable supply as this has not been increased to meet the demand. Then the second issue is on the financial side, because of the subsidies in place, line losses, and electricity theft. The government is not left with enough resources to invest in the sustainable supply needed to meet the demand of the consumers. Thirdly there is also an issue of governance. The government is unable to tackle the problems of electricity theft for which many of the government owned electricity institutions are involved in, this electricity theft and the lack of commercial discipline is also a major factor in significantly lowering the productivity of these state-owned electricity companies and organizations. The performance of these state-owned electricity organizations is extremely dismal as compared to those of other countries, Pakistan is ranked 23rd out of 24 countries ranked for efficiency in converting inputs to outputs. (BR Research, 2014). It can be seen below in figure-3 that it is because of the above-mentioned reasons that the gap between electricity supply and demand is constantly widening.

Figure-3 Electricity Demand and Supply Gap



Source: (Abid A. Khan, 2014)

Figure-3 showcases a gap between 7,500 to 8,500Megawatts as the figure above was drawn before CPEC energy investments came in. Currently this gap hovers between 3000-4000 Megawatts. Despite the reduction in the gap there exist many structural problems, and these structural problems have been adequately highlighted in the section explaining the energy crisis of Pakistan. The persisting problems which haunt the energy policy planners are that, despite several endeavors to reign in the issue of circular debt, the problem persists. At the end of the fiscal year 2015-16 the account receivables hiked to PKR.684.06 billion in contrast the payables summed up to PKR.299.06 billion (Khalid Mustafa, 2016). Which is why, it becomes important to study and predict the impact of the investments from CPEC on the energy crisis of Pakistan.

Research Question:

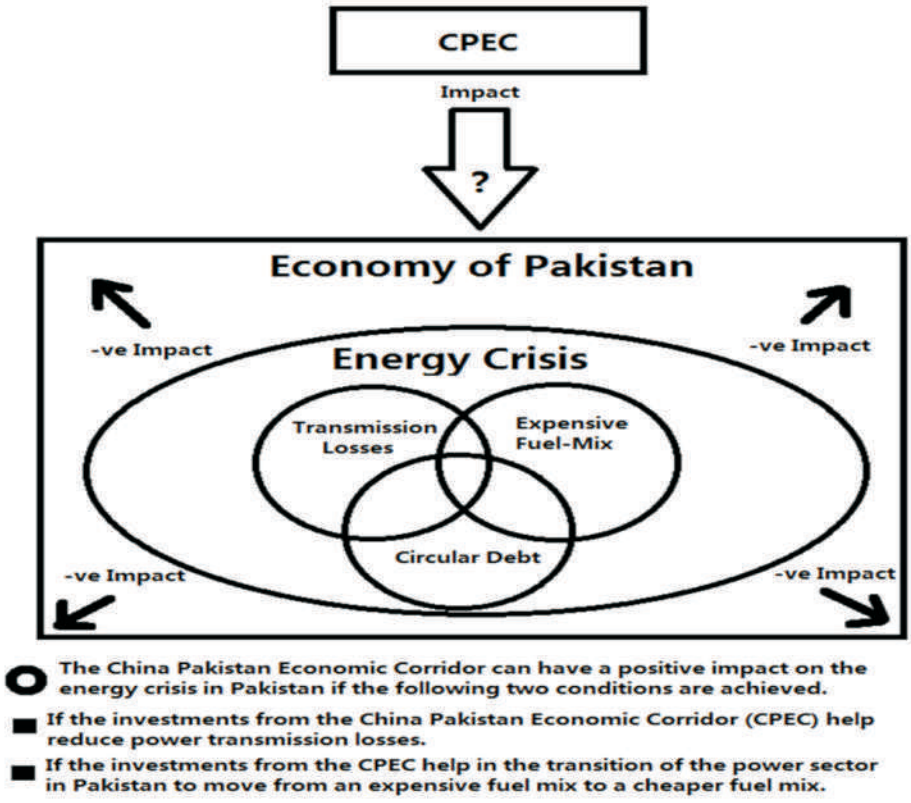
"What will be the impact of the investments from the CPEC on the energy crisis in Pakistan?"

In order to answer this question we need to answer a few more questions. A review of the literature has highlighted that, the energy crisis has three main components. 1. High power transmission losses and electricity theft in Pakistan. Expensive Electricity production fuel-mix. 3. Circular debt.

For this study keeping in view constraints, two of the three major components of the energy crisis number 1 and 2 will be incorporated within the framework of the research. Since all the projects of the CPEC are not operational thus due to the lack of availability of data; an indirect approach will be adopted. The literature reveals that Pakistan's expensive fuel mix is dominated by the importation of furnace oil and the literature also reveals that the CPEC funded power generation projects aim to lessen this burden. Thus if we are able to measure how much BOP constrained Pakistan's economy is? We will be able to answer the question if the CPEC funded electricity generation projects will have a positive impact on the electricity crisis or not.

For the second component, again due to lack of availability of data of the CPEC funded electricity projects, it will be measured how much of an impact do the electricity line losses and electricity theft have on the overall economy of Pakistan. This will help us answer the question of how much of an impact will CPEC funded power/electricity generation projects will have on the overall energy crisis of Pakistan. This framework is visually highlighted in figure-4 below.

Figure -4 Theoretical Framework of the Study



Literature Review

For the purpose of reviewing the literature a meta-analytic review of existing studies on the topic was conducted as this method helps to highlight the causal concerns and variables regarding the phenomenon in question. Later these causal concerns can be doubled checked through statistical analyses. Inclusion and exclusion criteria was utilized to shortlist 17 recent studies within the time period between 2015-2018 as it marks the time period after the agreement for CPEC was signed. The selected studies enabled us to collect data for the current study and these studies were selected from the Google Scholar database by setting the search parameters for keywords consisting of 'CPEC', 'Pakistan', 'Energy Crisis', 'Solutions', 'Causes', and 'future outcomes'. The keywords were entered in diverse groupings to get a different blend of studies covering the same topic.

Inclusion and Exclusion Criteria

The studies included in the meta-analysis meet the following criteria:

- Published studies between 2015 and 2018 to ensure the capture of modern trends.
- Identifiable relevance was strictly considered.
- Studies with clear deductions with regards to their hypotheses or research questions.
- Researches which provide conclusions regarding the outcome of CPEC investments in Pakistan.

Meta-Analysis

The collected data from the reviewed studies is analyzed quantitatively. Initially, simple descriptive statistics have been employed for the demonstration of the highlighted barriers and influencers. Once the findings are compiled, Spearman's Rank Correlation has been employed to extract conceivable correlations. IBM SPSS 22.0 software is operated to compute Spearman's rho Correlation Coefficients.

Results from the Meta-Analytic Literature Review

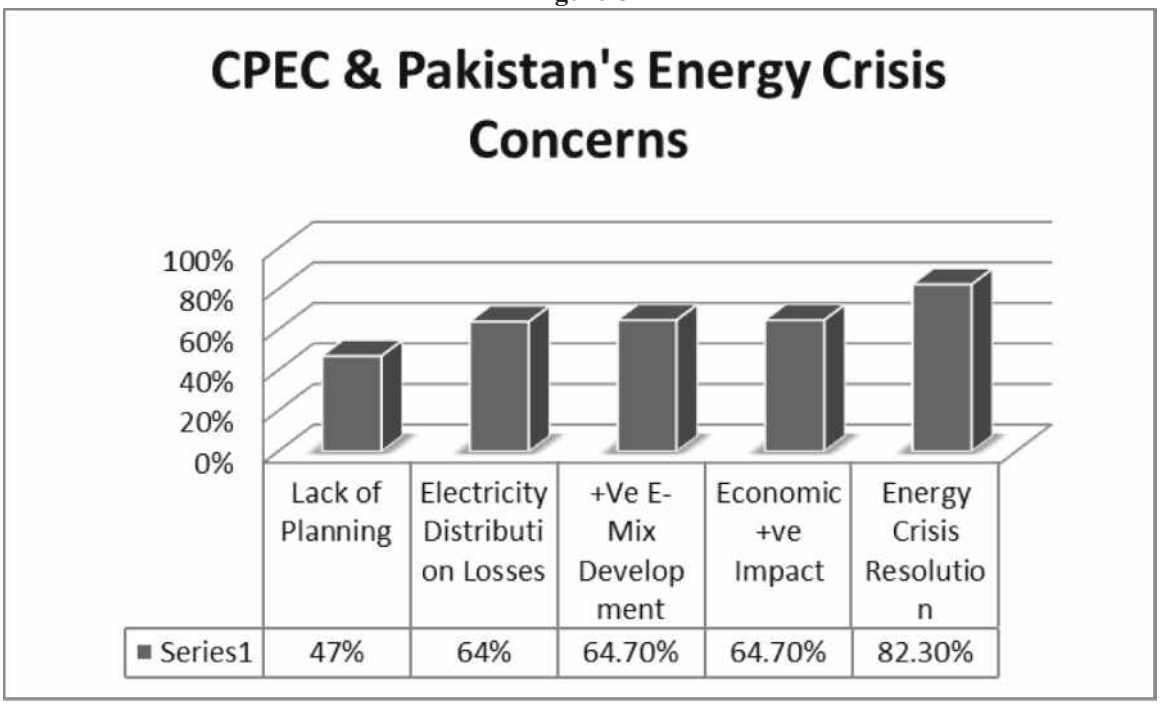
A total of 17 research studies have been carefully chosen for the examination. The analysis was conducted in an absolute method. Each research article has been examined cautiously to ensure significance.

Table 2 presents a concise summary of the salient features debated in the reviewed article.

S.No	Article Details	Inadequate Planning for Project Selection (Lack of Planning)	Inadequate Infrastructure Up-gradation (Electricity Distribution Losses)	Sustainable Energy-Mix Development (+Ve E-Mix Development)	Economic +ve Impact	Energy Crisis Resolution
1.	(S.R.Dadwal, 2017)	✓		✓	✓	✓
2.	Vats 2016	✓	✓	✓		✓
3.	(Kugelman, 2015)		✓	✓	✓	✓
4.	(YAli, 2015)	✓	✓	✓	✓	✓
5.	(Ali, 2016)				✓	✓
6.	(S. Twangar, 2016)				✓	✓
7.	(Cadley Reynolds, 2015)			✓	✓	✓
8.	(M.A.Shoukat, 2017)		✓		✓	✓
9.	(Rana, 2015)			✓		✓
10.	(Javaid Akhtar, 2015)	✓	✓	✓	✓	✓
11.	(Arif, 2015)	✓	✓			
12.	(Muzaffar, 2017)					✓
13.	(Muhammad Irfan, 2017)	✓	✓	✓		
14.	(S.M.Hali, 2017)		✓	✓	✓	✓
15.	(Gordhan Das Valasais, 2017)	✓	✓	✓		✓
16.	(Ali Rana, 2017)		✓		✓	✓
17.	(Shahid Zulfiqar, 2017)	✓	✓	✓	✓	

The above table-2 highlights five issues which can also be termed as the selected variables. The table above presents 17 recent studies covering various impacts regarding the energy crisis and investments coming in to Pakistan, under the umbrella of CPEC. These five variables are; inadequate planning for project selection (Lack of Planning), inadequate infrastructure up-gradation (Electricity Distribution Losses), sustainable energy-mix development (+Ve E-Mix Development), positive economic impact and energy crisis resolution. Table-1 highlights that, 8 out of 17 studies (47%) conclude that, though various energy projects are being developed in Pakistan under the CPEC energy infrastructure development program, but the criteria for selecting these projects leads analysts to believe not a lot of planning tools have been used for selecting these projects. 11 out of 17 studies (64.7%) highlight that, despite the influx of Chinese energy infrastructure investments in Pakistan, more attention is needed towards the up-gradation of power distribution network and power grid stations within Pakistan's power sector. The meta-analysis of the 17 studies shows that 11 out of 17 studies (64.7%) show that, the CPEC energy sector investments will lead to a more sustainable energy-mix in Pakistan. 11 out of 17 studies (64.7%) envision that, these energy infrastructure investments under the account of CPEC will help in appreciating Pakistan's economic performance. The last variable highlights the predictions for an easing energy crisis in Pakistan as a result of these energy sector investments, and 14 out of the 17 studies (82.30%) emphasize this point. The outcomes of table-2 above are graphically exhibited below in Figure 5.

Figure-5



The descriptive meta-analysis is further characterized by level of intensity by which the researchers have associated these variables in their respective studies ("1,2,3" signifying "none", "mild", "major"). This characterized data is then evaluated using Spearman's rank correlation and the findings of these correlations are presented in the table-3 below.

Table-3 Summary of Spearman's rho Coefficients of all the Variables Considered

Spearman's rho		Lack of Planning	Electricity Distribution Losses	+VeE-Mix Development	Economic +ve Impact	Energy Crisis Resolution
Lack of Planning	Correlation Coefficient	1.000	-0.1527	-0.0430	0.5443	-0.4884
	Sig (2-t)	.	0.7436	0.9270	0.4556	0.0466
	N	17	17	17	17	17
Electricity Distribution Losses	Correlation Coefficient	-0.1527	1.000	-0.5773	-0.0316	-0.3253
	Sig (2-t)	0.7436	.	0.1339	0.9463	0.4317
	N	17	17	17	17	17
+VeE-Mix Development	Correlation Coefficient	-0.0430	-0.5773	1.000	0.0382	-0.1446
	Sig (2-t)	0.9270	0.1339	.	0.9283	0.5795
	N	17	17	17	17	17
Economic +ve Impact	Correlation Coefficient	0.5443	-0.0316	0.0382	1.000	0.5436
	Sig (2-t)	0.4556	0.9463	0.9283	.	0.0240
	N	17	17	17	17	17
Energy Crisis Resolution	Correlation Coefficient	-0.4884	-0.3253	-0.1446	0.5436	1.000
		0.0466	0.4317	0.5795	0.0240	.

In terms of Chinese energy sector investments in Pakistan contributing towards easing the energy crisis in Pakistan, it can be observed from the above table-3 that; the biggest positive contributor is the overall economic impact as, the Spearman's rho correlation coefficient (rρ) value is 0.5436 which establishes a significance level of 98% with a p-value of 0.024 which shows that Pakistan's economic performance is getting better due to the Chinese infrastructure investments and thus helping in easing Pakistan's energy crisis. The above table also shows that electricity distribution losses and dearth of up-gradation of Pakistan's power distribution network cause a significant amount of hindrance towards easing the energy crisis in Pakistan, with a rρ value of -0.325. The literature review suggests that Pakistan's energy policies need to be upgraded and the table above also supports this argument with a rρ value of -0.4884 which establishes a significance level of over 95% with a p-value of 0.0466. Since the Chinese energy infrastructure investments in Pakistan aim at helping Pakistan's power sector achieve a more sustainable energy mix, it can be assumed that in the future as a cheaper and sustainable energy-mix will reduce the burden of oil imports on Pakistan's economy. The table-3 above also supports this argument as the rρ for a sustainable energy mix and economic appreciation is positive 0.0382.

Methodology:

After a careful and thorough meta-analytic literature review the variables for conducting analyses were selected, which are listed in table-6 below.

Table -4 Selected Variables for the study

• Volumes of Imports of Pakistan
• Real GDP of Pakistan
• GDP of Pakistan
• Real effective exchange rate
• Demand for Imports
• Electricity Consumption (GWh)
• Electricity Production (Gwh)
• Electricity Short Fall (GWh)
• Line Losses (GWh)
• Electricity Produced through Oil (GWh)

The current research utilizes two types of data analyses to measure how deep rooted the problems of transmission losses and an unsustainable energy-mix are for Pakistan and how CPEC will impact these two major issues of the energy crisis. The first analysis is based upon utilizing the GMM technique to gauge the impact of the energy crisis, power transmission losses, and the impact of electricity production through furnace oil on the economy of Pakistan. With this analysis, we will be able to ascertain 3 facts; firstly, just how deep rooted the energy crisis is within the economy of Pakistan. Secondly, how significant are the power transmission losses in Pakistan and how much they impact the economy and how much they contribute towards the energy crisis. Thirdly, we will also be able to gauge how much electricity production through furnace oil negatively or positively impacts the economy thus helping us gauge its resultant impact on the Balance of Payments of Pakistan.

The second type of data analysis deals with gauging whether Pakistan's economy is BOP constrained or not this will be conducted through the application of Thirlwall's Law in which a weak test was conducted. The weak test deals with the imports. This will help in identifying if Pakistan's BOP is constrained or not.

Model for Calculating BOP Constraint Economy of Pakistan

Weak test of Thirlwall's Law

The specific ARDL model for aggregate imports takes the following form:

$$\Delta lnM = \beta_0 + \varphi_1 \Delta lnY_{-1} + \varphi_3 \Delta lnY_{-3} + \sigma_3 \Delta lnREER_{-3} + \delta_1 lnM_{-1} + \delta_2 lnY_{-1} + \delta_3 lnREER_{-1} + vdum$$

Source: (Felipe, McCombie, & Kaukab, 2009)

Within in the above given equation "M" denotes the volume of imports of Pakistan, "Y" denotes the GDP of Pakistan and "REER" represents the real effective exchange rate of Pakistan. The variable "dum" is a dummy/mock variable representing the structural break encompassing the time Pakistan's economy opened up in the year 2001. The values for the dummy variable are measured in (1, 0), where '1' corresponds to the time series data after 2001 and "0" elsewhere (Wacziarg. R, 2003). The equation above tests the hypothesis $\delta 1 = \delta 2 = \delta 3 = 0$ employing the F-statistic (Pesaran. M. H, 2001), and the ARDL modeling technique to check for co- integration. There are various approaches which can appraise for co-integration but ARDL has been adopted for this study because of the benefit of circumventing the classification of variables into I(1) or I(0). Other advantages of this technique include, its inherent capacity to take a number of lags which helps in visualizing the course of data creation which enables the research to move from a general-to-specific modeling research structure, The ARDL approach also enables the researcher to circumvent against the pretesting concerns accompanying other techniques checking for co-integration. The most important reason for choosing the ARDL approach is because it is fit to study small sample sizes as-well as large sample sizes whereas other data analysis techniques usually require large sample sizes.

The second model for analyzing the economic impressions of power production through furnace oil and transmission losses on the economy of Pakistan, for this GMM technique was utilized and the following equation was followed.

$$\ln GDP = \beta 0 + \beta 1\ Shortfall + \beta 2\ \ln Population + \beta 3\ TotalProduction + \beta 4\ Linelossess + \beta 5\ IPP\_Production + \mu$$

On the left hand side we have "ln GDP" which is the real GDP, and on the right hand side we have "β1 Shortfall" which is electricity short-fall caused by excessive demand and shortage of supply, "β2 ln Population" is the Population of Pakistan, "β3 Total Production" is the total production of electricity, "β4 Linelossess" represents line losses from electricity transmission, "β5 IPP_Production" represents electricity production through independent power producers (IPPs) using furnace oil as a fuel source and " μ" is stochastic error term. Both models will be run on the software Eviews.

Results from the analysis of economic impressions of power production through furnace oil and transmission losses, on the economy of Pakistan:

GMM Estimates

The results from table-5 given below show us that the overall model is fit for the test. It is seen that population is estimated to be 2.38, Electricity short-fall "SHORT-FALL" estimated to be 0.21, total production of electricity "TOTAL_PROD" estimated to be 1.5, Line losses "LINE_LOSS" estimated to be 3.26, and production through IPPs "PROD_IPP" estimated at 0.4; all are significantly different than zero at P-values of less than 2%. The J-statistic that is distributed as $\chi 2$ with one degree of freedom is 4.5 with a P-value of 0.207. Which proves that the moment restrictions applied by the model and the rational expectations are not rejected.

Results:

GMM estimations accept the null hypothesis that electricity short fall seriously hinders the economic development of Pakistan.

GMM estimations accept the null hypothesis that increase in total electricity production/Consumption has a positive impact on GDP.

GMM estimations accept the null hypothesis that line-losses through transmission have a negative impact on real GDP of Pakistan.

GMM estimations accept the null hypothesis that electricity production through IPPs using oil as a fuel source has negative impacts on the real GDP of Pakistan.

The above mentioned null hypotheses have been accepted because:

From table-5 we can see that:

The elasticity of coefficient of electricity short-fall shows that 1% change triggers a -0.21% change in real GDP.

The elasticity of coefficient of electricity production/consumption shows that 1% change triggers a 1.48% change in real GDP.

The elasticity of coefficient of line losses through electricity transmission shows that 1% change triggers a -3.27% change in real GDP.

The elasticity of coefficient of electricity production through IPPs using oil as a fuel source shows that 1% change triggers a -0.4% change in real GDP.

Table-5 Generalized Method of Moments

Dependent Variable: GDP Method: Generalized Method of Moments Sample : 1980- 2014				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-12.81614	4.198340	-3.052668	0.0100
POPU (Population)	2.378392	0.600574	3.960197	0.0019
S.F (Electricity Shortfall)	-0.216019	0.082085	-2.631652	0.0219
Total Electricity PROD	1.480031	0.451101	3.280928	0.0066
LINE_LOSS	-3.269220	2.500759	-1.307291	0.2156
PROD_IPP (Oil)	-0.402194	0.101388	-3.966890	0.0019
R-squared	0.989898			
Durbin-Watson stat	2.193804			

Identification of BOP Constraint within the Economy of Pakistan:

Pakistan's economic appreciation rate has grown at an average of 5.2 percent since 1960, and it has the productivity of the country has appreciated at an average rate of 2.5 percent. Though these growth rates seem decent enough as compared to global trends but for a developing country in Asia these seem dismal especially as compared to other Asian neighbors like those of the Asian tigers. Experts suggest that these dismal growth rates are owed to dreary growth in exports which translates in to problems of managing BOP (Felipe, McCombie, & Kaukab, 2009). Felipe, McCombie and Kaukab calculated that Pakistan's economy suffers from BOP constrain but the study by Felipe, McCombie and Kaukab calculated this constrain until the year 2008 and their study has not been updated since. The current study utilizes the same model prescribed by Felipe, McCombie and Kaukab and endeavors to update the weak-test of Thirlwall's law using the software Eviews-9 to provide evidence of short term BOP constrain during the current time period.

Results from the ARDL model:

In order to find prove BOP constrain within the Pakistan's economy Felipe, McCombie and Kaukab's 2009 study has been updated and the equation derived by them has been employed. Table-8 presents the bound test.

$$\Delta lnM = \beta_0 + \varphi_1 \Delta lnY_{-1} + \varphi_3 \Delta lnY_{-3} + \sigma_3 \Delta lnREER_{-3} + \delta_1 lnM_{-1} + \delta_2 lnY_{-1} + \delta_3 lnREER_{-1} + vdum$$

Source: (Felipe, McCombie, & Kaukab, 2009)

Table-8 F-Bound Test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.73	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.7
		1%	3.06	4.15

The above results in table-8 have been derived after running the data analysis technique through the ARDL approach and the model hypothesizes that $\delta 1 = \delta 2 = \delta 3 = 0$ and the hypothesis was tested using Pesaran et al (2001). as we can see from table 10 above that the F-statistic. The results show that the calculated F-statistics at 4.73 exceeds the intermission of critical values (2.08 – 3) at the 90% significance level; this signifies that; the null hypothesis of no long-run relationship can be rejected. It is also clear that co-integration among the variables is present and long-run estimates have been derived. The results for the ARDL approach for Pakistan's aggregate imports are given below in table-9.

Table – 9 ARDL Model for Pakistan's Imports and their Demand (Dependent Variable ΔlnM)

Coefficient	Estimate	t-ratio
β_0	-2.86	-1.44
φ_1	1.69	5.13
φ_3	0.17	0.24
σ_3	0.06	1.51
δ_1	-0.26	-2.15
δ_2	0.57	2.16
δ_3	-0.75	-3.33
V	0.15	3.38
No. of Observations: 36		
R^2 = 0.97		
Wald F-Statistic: 4.73		
Interval of Critical Values(2.08 - 3)		

After running the ARDL model for cumulative imports on Eviews 9, the long-run elasticities of Pakistan's Income on Imports and Pakistan Import Price w.r.t Pakistan's GDP were gauged. The Income on imports elasticity is calculated as 2.1 (calculated as – [0.57/ (-0.26)]) and the price elasticity as –0.81 (calculated as – [(–0.21) / (–0.26)]). The error correction term $\delta 1$ is weighty because it exhibits a high degree of adjustment of (–0.26).

Table 10 below reports parameters of the equations derived by Felipe, McCombie and Kaukab (2009). The BOP equilibrium growth rate for 1980–2016 is calculated at 4.65% per annum which is a touch lower than Pakistan's actual growth rate of 4.87% per annum during the considered time period. This advocates that, between 1980 and 2016 Pakistan's economy grew at a rate close to its BOP equilibrium growth rate. The approximations of the price elasticity exhibit the demand for Pakistani exports is price-inelastic. When each of the price elasticity controlled within the Theirlwall's equations and put as (-0.5) is The BOP equilibrium growth rate turns to 3.6%. From table-10 we can see that the figure for growth of the real effective exchange rate is close to that of the rate of change of the terms of trade, then according to Felipe, McCombie and Kaukab (2009) there is a constraint which is implied from the Marshall-Lerner condition. Which prescribes that, change in the exchange rate will have little or no influence on the balance of payments, as long as the current account is in equilibrium. Thus proving Thirwall's law and the clear existence of a BOP-constrained economic growth scenario in Pakistan, where the advancements of exports cannot be augmented through real exchange rate depreciations.

Table-10 Balance-of-Payments Equilibrium Growth Rate: Growth Rates and Parameter Values, 1980–2016

Variable		Value
Y_A	Growth of GDP	4.87% p.a.
Z	Weighted Growth of Trading Partner	3% p.a.
X	Growth of Exports	7.7% p.a.
$r-P_X$	Growth of Real Remittance	9.32% p.a.
P_X-P_M	Growth of Terms of Trade	-4.28% p.a.
reer	Rate of Change of Real Effective Exchange Rate	-6.46% p.a.
π	Import Income Elasticity	2.1
η	Import Price Elasticity	-0.81
ε	Export Income Elasticity	1.69
Ψ	Export Price Elasticity	-0.49
Θ_X	Average Export Share in Foreign Currency Receipts	0.428
Θ_R	Average Remittance Share in Foreign Currency Receipts	0.572
BOP equilibrium growth rate for 1980–2016 (YBP) $=\frac{\Theta_X X+ \eta(reer)+ \Theta_R(r-P_X)+ (P_X-P_M)}{\pi}$ $YBP=\frac{0.428x0.077+(-0.81x-0.0646)+0.572(0.0932)+(-0.0428)}{2.1}$		YBP= 4.65 (3.6)%
BOP equilibrium growth rate for 1980–2016 (YBP)= $\frac{\Theta_X \varepsilon Z+(\eta+\Theta_X\psi)(reer)+ \Theta_R(r-P_X)+(P_X -P_M)}{\pi}$ $YBP=0.428x1.69x0.03+(-0.81+(0.428)(-0.49)(-0.0646))+0.572x0.0932+(-0.0428)/2.1$		YBP=4.61 (3.7)%

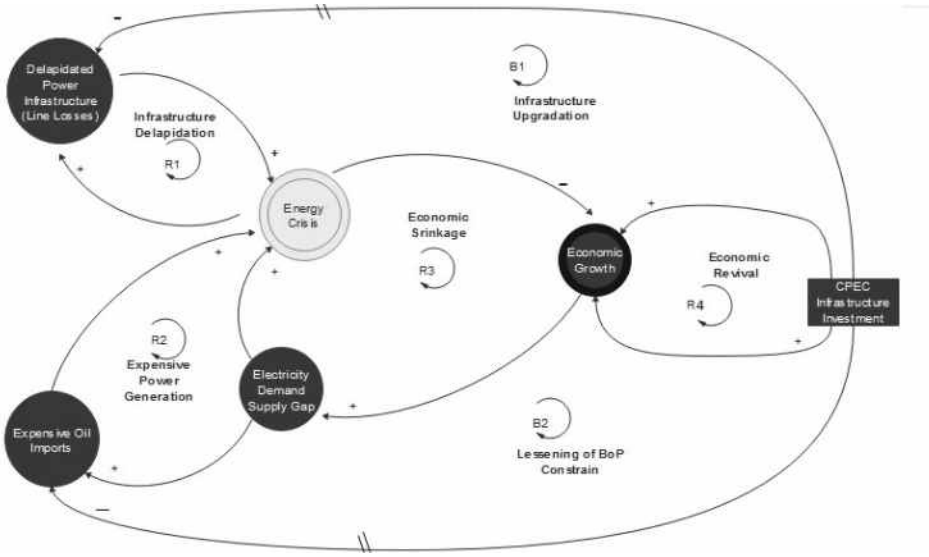
Note: *Figures in parentheses in the last two rows are the balance of payments equilibrium growth rate when η and ψ are each constrained to take a value of -0.5..*

Sources: (Economic Survey of Pakistan1980-2017), Pakistan Federal Bureau of Statistics, ADB sources, Felipe, McCombie and Kaukab (2009) & (G.Ali, 2016).

Findings and Conclusion:

The study had aimed to find out the impact of the CPEC on the energy crisis of Pakistan. As explained earlier, since the energy crisis is also a crisis for Pakistan's economy that is why it was thought to be prudent to gauge the impact of CPEC on Pakistan's economy. For this purpose firstly the economic impact of the energy crisis was gauged through the GMM technique and the results revealed that, power shortfall within the electricity system of Pakistan yields a -0.22% impact on the percentage change in annual economic growth. While the power losses incurring during the power transmission process yield a -3.27% impact on the economic growth of Pakistan and electricity production through furnace oil also negatively impacts the economic growth of the country by-0.40% annually. The second data analysis involving Thirlwall's law reveals that Pakistan's economic growth is BOP-constrained, which implies that any policies or measures which aid in depreciating imports will improve Pakistan's balance of trade and held reduce the economic burden. The following Causal Loop Diagram (CLD) depicts how CPEC's energy infrastructure investments will impact the energy crisis.

Figure-6 CPEC's Energy Sector Investments & Pakistan's Energy Crisis CLD

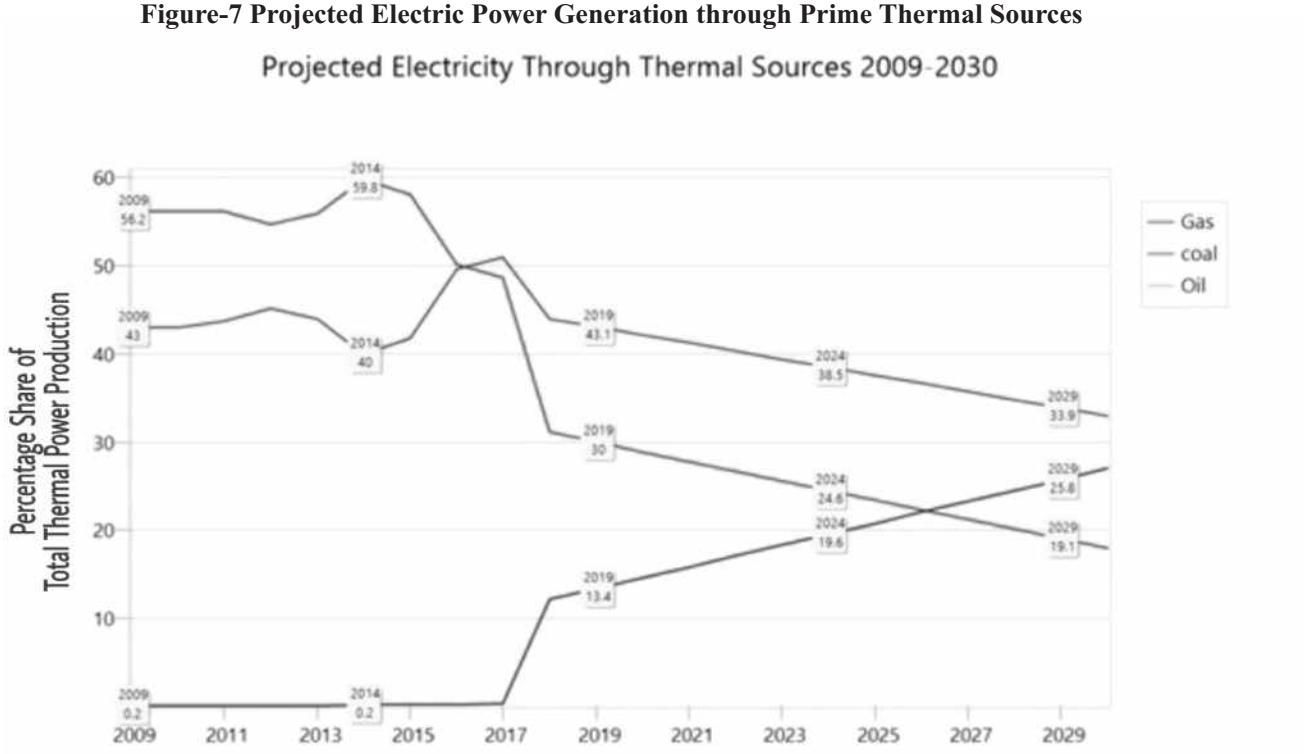


According to figure-6 we can see that if China's energy infrastructure investments are targeted at making Pakistan's energy-mix more sustainable by lessening Pakistan's dependence on generating power through furnace oil, then these investments will definitely have a positive impact on Pakistan's economy and will also help lessen the scale of the energy crisis in Pakistan. Since, it is evident from the list of power sector projects under the umbrella of CPEC; that more focus is being given towards augmenting the focus of power generation on renewable energy sources and cheaper thermal fuels. Resultantly, this focus towards a more sustainable energy-mix is lessening the reliance on power generation through furnace oil which will help in dampening the energy crisis.

China's energy infrastructures investments are targeted at making Pakistan's power generation sector less reliant on furnace oil are as a fuel source. These measures will definitely help curb the import bill as oil's share is the heaviest within the country's total imports, thus bringing about positive compounding economic dividends according to Thirlwall's law.

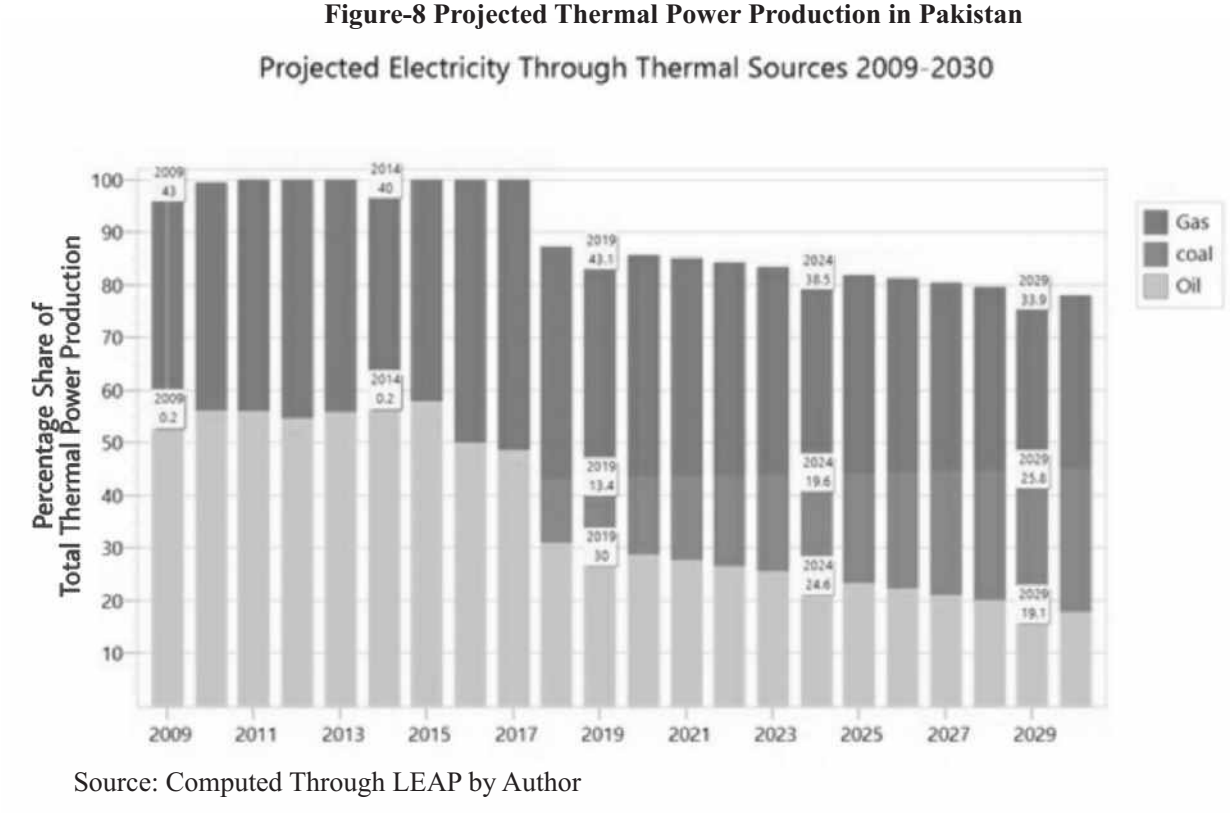
LEAP, the Long-range Energy Alternatives Planning System, is a commonly used software tool for energy policy analysis and chalking out future predictions to verify policy goals. For the current research the software has been utilized to check the results of the meta-analysis. Which highlights that, Chinese electric power sector investments will aid in making Pakistan's electric power generation mix more sustainable. In order to check for this, feedstock data for various thermal electric power sources was computed in LEAP from the year 2009-2018 and LEAP has made projections based upon the input data which is highlighted in the figures below.

Figure-7 Projected Electric Power Generation through Prime Thermal Sources



Source: Computed through LEAP by Author

Figure-8 Projected Thermal Power Production in Pakistan

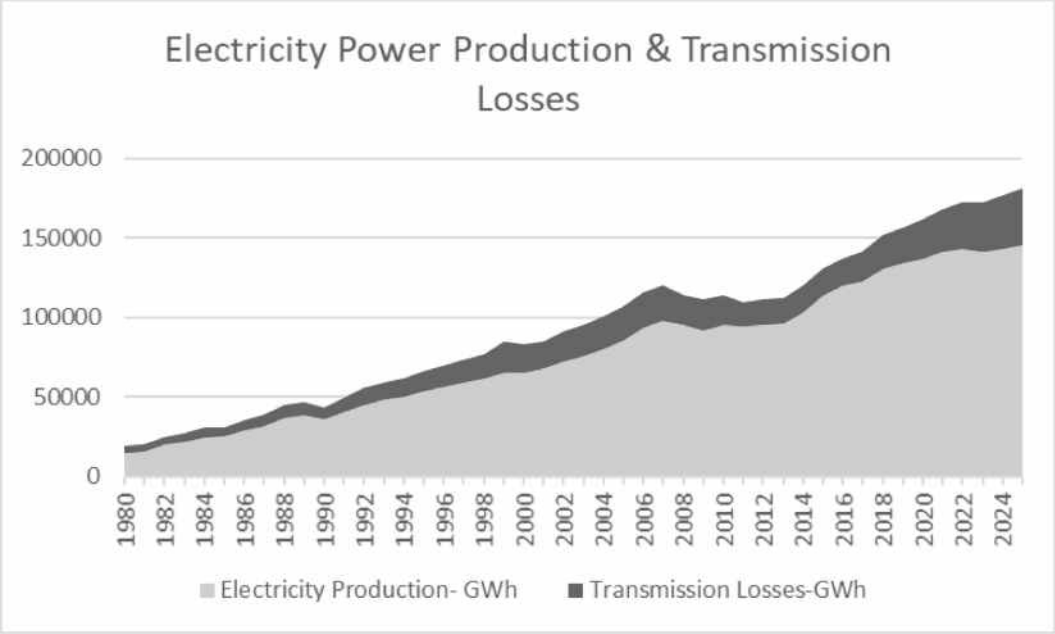


Source: Computed Through LEAP by Author

Above figure-7 and figure 8 both highlight that, as time progresses Pakistan's energy mix will become less dependent upon furnace oil as the major source of electric power generation. In figure-7 and 8 electric power generation through furnace oil is highlighted by the color green and in both graphs it is evident that, share of production from furnace oil is decreasing.

Once the data for total electric power production in Pakistan was computed in the LEAP software along with the historical data for electric power transmission losses, it was revealed that, with the rise in electric power production annually especially after the Chinese funded electric power projects become operational, the transmission losses also witness an incline. This incline is owed to the fact that, limited investments are being made in Pakistan to upgrade the existing transmission networks and grid stations which are obsolete and have a limited load bearing capacity. These results achieved through LEAP are evident in figure-9 below.

Figure-9 Projected Electricity Transmission Losses (1980-2025)



Source: Computed through LEAP by Author

This leads the study to conclude that, this oversight can hinder other efforts towards curtailing Pakistan's energy crisis. Mixed results achieved within this study, should not be a cause for alarm as the CPEC is a mega project and its culmination and delivery will take a long-time and there are annual joint review meetings between the two governments. In joint meetings projects are added and subtracted each year and results from such researches will help recommend plausible policy recommendations which will help steer FDI for the development of CPEC in the right direction.

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Abbreviations

CPEC: China Pakistan Economic Corridor

FDI: Foreign Direct Investment

CLD: Causal Loop Diagram

GMM: Generalized Methods of Moments

BOP: Balance of Payments

ARDL: Auto-Regressive Distributed Lag

GDP: Gross Domestic Product

BRI: Belt and Road Initiative

REER: Real Effective Exchange-Rate

IPP: Independent Power Producer

NEPRA: National Electric Power Regulatory Authority

GWOT: Global War on Terror