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Impact of Climate Change on Electricity Consumption: A Case Study of Pakistan

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ABSTRACT

Climate changes may have serious consequences worldwide and may affect many communities across the globe. Pakistan is one of the countries which has been severely affected by variations in climate. These climate changes have hit all sectors of the economy especially the energy. In this background, the object of the present analysis was to find the effect of "climate change" on "electricity consumption" in Pakistan. To analyze the results, researchers collected annually data of Pakistan from 1971-2017. The study reviewed the trend of climate variation for the last few decades. For estimation, the data have been taken from World Development Indicators (WDI), Water and Power Development Authority (WAPDA) and Climate Knowledge Portal World Bank Group. By using ARDL model, and taking data on annual basis, the nexuses between dependent and independent variables has been found. The study revealed significant results and recognized that climate have a substantial impact on nation's energy demand. According to the results it is suggested that the government should take measures to overcome the crises and make strategic policies which can turn the crises into opportunities for bringing around structural changes in long run in the economy and in the society.

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Introduction

Background of the study

Climate refers to the average weather of a region or area over an extended period of time. It is affected by many biotic and abiotic factors. Biotic factors are transpiration, photosynthesis, decomposition and abiotic factors are factors such as latitude, altitude, ocean currents, evaporation, humidity, temperature, topography, air pressure, volcanic activities. Climate has four-dimensional and time centered components which contains many different sorts of weather seasons, their cyclicities, concentrations, and nature of vitality.

As indicated by "Working Group II of the Intergovernmental Panel on Climate Change" ("IPCC"); Climate change imply that any adjustment in the atmosphere over the long haul, regardless of whether because of characteristic inconstancy or because of human movement. Impacts of climate variation are intense droughts, rising sea levels, storm, melting glaciers, floods, earthquake, cyclones etc. Climate shift is an immense challenge facing mankind today. Increase in emission of carbon dioxide, deforestation, global warming, ozone layer depletion etc. leads to huge climatic disasters. These ozone depleting

substance discharges have expanded the nursery impact causing ascend in temperature of earth's surface. It is the natural phenomenon and undeniable, which is the single largest environmental hazard facing the planet. Now the key purpose is to understand the nexus between climate change and electricity consumption. There are some variables which affect both the electricity consumption and climate change.

Like take the example of precipitation level and rainfall, triggered by climate instabilities are positively correlated with electricity generation. Global warming has a very little consequence on the production of hydroelectricity directly. It affects the hydrogeneration slowly by drawing changes in climate over a long period. Generation from hydroelectric plants is affected by climate and climate variation. Heavy rainfall or inversely intense drought and precipitation expressively affect the hydroelectric generation. Many qualitative and quantitative analysis have been done regarding the climate change and its impacts on electricity generation. It is generally known that the electricity generation and precipitation are directly correlated to each other and vary in similar pattern. Change in streamflow and hydrogeneration can be preceded by very little change in precipitation level. Precipitation level changes due to change in runoff water which is the reason of climate variation (Munoz & Sailor 1997). Pakistan being a climatically diverse country is mostly subjected to the various types of events like floods, air pressures, precipitation, droughts etc. Being a low carbon emitter country, ranked 135th while considered among the top 10 nation that are affected by climate changes. Pakistan is faced with an unprecedented level of climate changes and its effects on its economy (German Watch, 2015). According to Wheeler (2015), natural phenomenon, human behaviors, discharge of ozone harming substances, for example, methane, CO2 and alteration in land use can cause climate change. Variations in climate, bring changes in weather conditions and durations by creating warmer temperatures, change in rainfall pattern, rise in sea levels and increased frequency and severity. High variability in precipitation may result in floods. Pakistan faced many devastating floods in 2011,2014 and 2015. Even If Pakistan himself contributes incredibly a bit to total emanations of "greenhouse gasses", however it stays one of the highly harshly struck countries of the world due to "global warming". Table 1 presents the extreme weather events in Pakistan.

Table 1: *Extreme weather events in Pakistan during last two decades*

Year	**Weather Condition**
1992	Most exceedingly terrible flood in Jhelum stream over a century ago.
1996	Wettest month of Lahore was August 1996 during the time of 1961-2000, it got 640 millimeters of downpour (rain). Heaviest metropolitan flooding in Lahore, 437.4-millimeter precipitation happened during 23-25 August.
1999	Extreme tornado in the waterfront territories of Pakistan and India.
1998-2001	Most noticeably awful dry spell in southern pieces of nation.
2001	Flooding in Lai Nullah, Islamabad because of weighty precipitation of 620 millimeters during 10 hours on 23rd July
2003	i) Flooding in Baluchistan in February because of hefty downpour caused numerous passing's and washed away streets and thruways. ii) A warmth wave made greatest temperature arrive at 520C in Jacobabad on the fifth June. At any rate 1,000,000 individuals were influenced because of weighty occasional Monsoon downpours in Southern Pakistan
2005	i) Flooding in pieces of Baluchistan, NWFP and Afghanistan during March because of substantial downpours. ii) Extensive flooding along the Kabul, Swat, Kunar streams because of quickened snowmelt in the sloping regions of the northern part during June.
2006	Rainstorm precipitation flooding brought about in excess of 185 passing's during July and August.
2007	Two super tornadoes Gomi of Cat - 5 and Yemyin of Cat - 1 created in the Arabian ocean in June and hit Makran coast.
2009	Karachi got record 205 millimeters downpour at Masoor Airbase and 143

	millimeters at Airport on 18 and 19 July.
2010	i) Hottest temperature ever recorded in Pakistan in Mohenjo-Daro, Sindh on 26th May. which is fourth most smoking temperature recorded on the planet in the known history ii) Worst floods in Pakistan in 80 years
2011	Record rains in normally dry regions. Floods caused 360 deaths and 1.2 million houses damaged
2012	Intense rainfall battered KP, Punjab and Upper Sindh. More than 100 people died, thousands of houses destroyed, and millions of acres of land affected.
2013	Heavy rain at scattered location of western Karakoram, Punjab and Sindh during august.
2014	Massive rain in Kashmir and Punjab
2015	Heat waves in Karachi

Source: *Planning Commission, Government of Pakistan, task force on climate change*

Temperature is also an upsetting variable which immensely alter the electricity consumption while rise and fall in temperature patterns also leads to climate variations. Pakistan is a country which is suffering in a scarcity of resources and crippled by global warming in the World, because Pakistan located in the area where the fluxes in temperature caused by climate changes is above the world average temperature referred as a warm climate (Rasul & Ahmad 2012). In every aspect human life can be influenced by variations in temperature. Temperature is measured in term of CDD and HDD. CDD refers to "cooling degree days" and HDD means "heating degree days". In hot summer days, the cooling electrical device like air conditions, refrigerator etc. require energy for operations so in this way the consumption level of electricity raises too (Prado et al, 2002). Because of climate change, not only rise in average temperature comes about but the ranges of temperature are also expended. Toward the century's end, about 3.3 degree centigrade normal rise in temperature for the region of South Asia has been caused annually (IPCC).

Energy consumption would rise in future under immense climatic changes. Morrison & Mendelsohn 1998 estimated that due to 2-degree centigrade average temperature rise in climate in US, energy costs would increase almost by $6 billion in 2060. The study evaluated that US electricity sector could require investment of $200-300 billion under the climatic change scenarios in order to increase the capacity accumulation requirement through 14 to 23% as compared to "non-climate change scenarios" in the time period of 2010-2055 (Linder 1990). An increase of 1 degree centigrade in temperature, increases the energy consumption for cooling requirements by 28% whereas decreasing the energy use for heating requirements by 10% (Cartalis *et al*, 2001). There will be a considerable drop in heating requirements as the range and average temperature extended throughout the world while the needs for cooling stuff will increased (Howden & Crimp 2001). Due to industrialization, massive urbanization, rural electrification, growth in agriculture sector, rising per capita income and rapid growth in domestic consumption will expend the demand of electricity. Because of poor future planning and forecasting, upgrading the existing generation plants and set up new electricity generation units failed to meet the need of electricity (Kessides 2013). Widening in temperature range boosted the electricity demand. Study examined that average summer peak loads increased by 10% with up rise in temperature about 4%, in Israel (Segal *et al.*, 1992). Due to climatic variations, in Massachusetts, US, increased in energy demand may go up to 40% due to climate change over the year 2030 (Amato et al. 2005). Energy area is one of those areas which is highly affected by weather patterns. These variations affect both the demand and supply sides. Supply side mostly concern with the area which is dependent to hydropower plants. Imbalances in supply and demand of electricity can be produced by long-term change in weather variations. Study forecasted that due to climatic variations, load on energy requirements will increases from 65_75 "MW in year 2020" to 85_95 MW (shows 9-10% upsurge per annum). in year 2030 in Cyprus (Zachariadis 2010).

Pakistan is facing problem of severe energy calamities in the form of electricity shortage. There was an immense gap in the year of 2011 between demand of electricity and supply. Pakistan fell short of supply ranging between 5000 MW to 7000 MW (Malik 2012). In the course of the most recent couple of years,

Pakistan power deficiency has been increasing day by day. In June 2013, electricity produced was 12150MW while electricity gap arrives at 4250 "MW" with the "demand standing" at 16400MW (PEPCO). Table 2 below shows a "gap between supply and demand of electricity" in Pakistan. Further, this gap is also represented in figure 1.

Table 2: *Gap between firm supply and peak demand for Pakistan 2002-2020*

S. No.	**"Year"**	**"Firm Supply"(MW)**	**"Peak Demand"(MW)**	**"Surplus/Deficit"**
1	2002-2003	14336	13071	1265
2	2003-2004	15046	13831	1215
3	2004-2005	15082	14642	440
4	2005-2006	15072	15483	411
5	2006-2007	15091	16548	1457
6	2007-2008	15055	17689	2634
7	2008-2009	15056	19080	4042
8	2009-2010	15055	20584	5529
9	2010-2011	15430	21086	5656
10	2011-2012	14483	21536	7053
11	2012-2013	16846	21605	4759
12	2013-2014	18121	23505	5384
13	2014-2015	18482	24757	6275
14	2015-2016	20303	25666	5363
15	2016-2017	23445	27185	3740
16	2017-2018	28751	28678	73
17	2018-2019	33545	30154	3391
18	2019-2020	35590	31625	3965

Source: *PPIP, "Ministry of Water and Power National Electric Power Regulatory Authority" (NEPRA) 2016.*

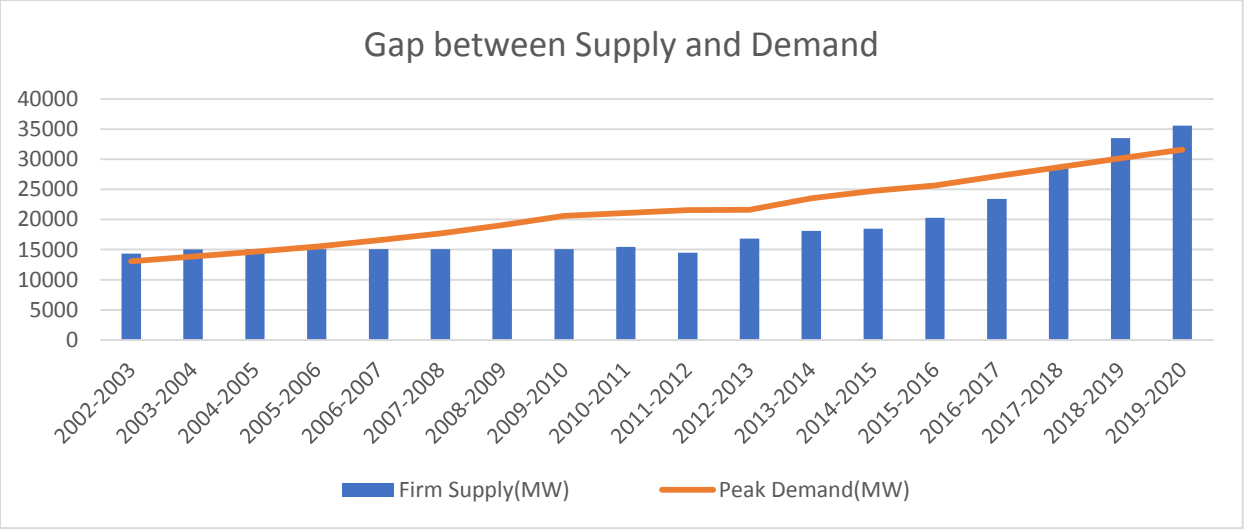


Figure 1. *"Gap between Electricity Supply and Demand in Pakistan"*

Pakistan power system is characterized by huge "gap between supply and demand". In the event that we think about the power creation and utilization levels it can undoubtedly be seen that in Pakistan power creation consistently stayed short to adapt the necessary interest. Figure 1 expand that from 2002 this hole exists which enlarged with the progression of time and consumed further until 2019.

"Electricity demand" is elastic to income and price level. A substantial upsurge in electricity demand in Pakistan has been noticed due to industrial development, urbanization and rural electrification. Chaudhry (2010) found that electricity consumption at both national and household level rises with expansion in "real per capita income" in Pakistan. An productivity role analysis showed that price elasticities affect the energy utilization and cost of production. To measure the income level, GDP per capita is taken as an indicator. Many studies (e.g, Jamil Ahmad, 2010; Javid and Qayyum, 2013) revealed that income and electricity consumption positively related with each other. Previous studies indicated a strong connection among price and consumption of electricity (e.g., Inglesi Lotz; Jamil and Ahmad etc.). These studies emphasized that price and electricity consumption are negatively correlated. As the prices increases there will be persistent decrease in consumption pattern. However, there are restricted and no alternatives for buyers to change from power to different wellsprings of energy like oil, gas and so on because of power costs (Javed & Qayyum, 2013).

GDP is the most important measure of economic performance. Strong positive nexus has been depicted between Gross domestic product development and development pace of power age. During the time of low development pace of power age, GDP development rate stays low. Development pace of power age has declined from 11.8% to 1.5% when GDP rate falls from 5.8% in 2006 to 3.6% in 2013. Economic growth badly affected by power shutdowns and load shedding. It is assessed that around 2% loss in GDP occur due to these blackouts (Abbasi 2007). Chen *et al.*, (2007) and Gosh (2002) claim that electricity consumption is affected by economic growth. Economic growth indicates development in commercial and industrial sector, growth in urbanization and innovation where power has been exceptionally utilized. Electricity utilization in vehicle and agribusiness area has likewise speeded up to stay up with monetary development of the nation. Therefore, direct relation has been revealed between "economic growth and electricity consumption" because energy utilization is straightforwardly connected with mechanical creation, financial development and way of life in Pakistan. A continuous increase in "economic growth" results in increasing the consumption pattern in conventional and electricity in certain.

Electricity has been considered as the backbone for financial thriving and progress subsequently it assumes crucial job in financial turn of events. With the progression of time as quick turn of events and mechanical developments has occurred, the use of energy has additionally mounted. Consequently, interest for energy expanded over the long run. Study confirmed that the financial development of the nation has exhibited to be one of the fundamental jumpers of power utilization. (Inglesi & Blingnaut, 2011). Economic growth is highly influenced by load shedding and power shutdowns. Power calamities and load shedding act as a main damage to the economic growth by causing poverty, unemployment, inflation and trade due to which economic development is affected (Kessides, 2013).

In most of the studies, only temperature has been taken as an explanatory variable to check the relation between "climate change" and the "energy consumption". However, some analyses have been showed to find the "impacts of climate change on electricity consumption" for Pakistan Ali, *et al.* (2013).

Problem Statement

As per preceding discussions, it is concluded that electricity consumption and weather variations are commonly related with each other, but consumption is badly affected by many climatic factors which will upset the Pakistan's economy. In Pakistan there are many factors like carbon dioxide emission, precipitation, temperature, floods, droughts, air pressure and so on which has a negative impact on economy, industrial, commercial, and residential sectors in Pakistan. All these issues are the main hurdles in order to meet the need of electricity.

Research Objectives

The aim of the present study is to discover the impact of "climate change" on "electricity consumption" and what will be the upcoming demand regarding electricity.

Significance of the Study

The significance of this study shows that how this study is different from other studies. Most of the studies used only temperature but in this we have used many other climatic variables. We have used an econometric model which include different variables like temperature, GDP, rainfall, carbon dioxide emission etc. We will find the impact of these variable on "electricity demand" which will affect the Pakistan economy and empirical analysis of income and price elasticities.

Organization of the Study

The study is organized into five chapters. The material is allocated in this research is that the first chapter of the research is allocated to the introduction of this research which includes all the subparts of the introduction. The second important chapter is allocated to the literature review. The third important chapter is allocated to the methodology of this research in which an econometric model is used. This provides best estimates of electricity demand on current climatic predictions. The fourth chapter is allocated to the results and conclusion in which recommendations are given. In the last chapter summarizes the results, conclusions and recommendations are presented.

Literature Review

For researchers, connection among "climate change" and "energy demand" became the area of interest mainly in late 1980's. Under the situation of bending over of corbon emissions, Cohen and Bhartendu (1987) revealed the adjustments in power utilization in Ontario, Canada. The study found positive relation of carbon emissions to cooling requirements while negative relation with heating requirements of households by integrating population weighted "heating and cooling degree days" through regression analysis. According to the IPCC assessment report 5, carbon dioxide emissions from the energy sector will increase from 14.4 giga tones (GtCO2) per year in 2010 to 24-33 GtCO2/year by year 2050. The carbon dioxide discharges in 2014 were around 40% higher than 1800s. This compares a yearly increment of two sections for each million (ppm) in the previous ten years.

Metz *et al.* (2007) stated that global climate change is generally brought about due to increase in GHG concentration in atmosphere. The transcendent wellspring of GHG emanations in environment is fossil fuel combustion which contributes about one third of the total global GHG emissions. CO2 concentration reached about 388 ppm in August 2010, showed an increase by very nearly 100 sections for each million (ppm) by volume as contrast with pre-mechanical levels. Without approaches throughout the following 20 years, worldwide GHG outflows are projected to increment from 25% to 90%.

Sailor and Munoz (1997) deduced the impact of climate variability on hydroelectric generation by regressing the hydrogeneration on climate variables such as snowfall, total precipitation, soil, moisture, and evaporation on the watershed in which the plant is located. This scenario found that shifts in hydroelectricity generation is triggered by climatic unpredictability like global warming, greenhouse effects, temperature rise and fall, precipitation levels etc. The energy sector particularly production area is one of the highly responsive sectors to the weather changes because electricity cannot be stored. It indicates that produced electricity must be instantly used. Further, good quality models are needed to forecast future consumption. Tariq & Athar (2009) examined that weather change is major problem which can affect the life on earth. Weather changes results in temperature rise or fall which may affect the ocean levels. Climate change effect different sectors of the economy, specifically agriculture and energy. The evaluation of study is based on the effect of climate change on energy sector in Pakistan from last two decades. The climate change effect on energy sectors may be in the shape of decreasing the hydro power generation and its efficiency. From General Circulation Climate Models, Hadley, *et al.* (2006) estimated the uncertainty between climate change and energy demand in US. Study revealed that the variability in climate may alter the energy demand and carbon emission increases through electricity generation responsive to climate change. Development in populace and expectations for everyday comforts is

prompting increment in force utilization, transportation which thus expanding the outflow on carbon dioxide and other greenhouse gases (GHG).

Temperature and rainfall are two key meteorological elements which decide the environment of any locale. Any steady change in both or one of them as for long haul mean or ordinary qualities prompts the environmental difference in that locale. Guttman (1983) examined the changeability of populace weighted occasional warming degree days for 48 states in United States. He determined that population demand for cooling increased as compared to heating demand. Results assumed that the estimate of future heating energy demand depend on the variability of climate not only rely on historical averages. Under global warming, Rosenthal, *et al.* (1995) observed a decline in warming and freezing energy wants in US for commercial and residential segments. This study involves two step methods. In first step the sensitivity of electricity demand to temperature rise is estimated while in other step these regarded sensitivities are projected alongside environmental change to gauge future energy interest. Analysis assessed that one degree warming in the US would reduce primary energy use by 0.70% in 2010 relative to non-warming scenario and energy expenditure by $5.5 billion. Valor and Meneu (2001) used statistic models to designate a daily air temperature behavior. The study has been conducted in Spain which disclosed strong seasonal behavior of temperature in terms of heating degree days and cooling degree days. They found that electricity demand is reactive to the temperature change which is considered most substantial weather variable. Electricity demand, price and volumes of electricity are extremely influenced by temperature. Authors found non-linear relation between energy demand and temperature which expressed an increase for electricity demand both for heating degree days and cooling degree days correspond to the cooling requirements in summer and for heating purpose in winter season. This study not only confined to value the weather derivatives but also use these estimations in future for managing economic activity risks like rise in electricity demand, increase in oil and gas prices etc.

Bessec and Fouquau (2008) in the time period 1985 to 2000 via monthly data examined the temperature-electricity demand nexus. They conducted this study for 15 European countries and analyzed the threshold temperature as well as the relationship between the above two variables for those countries by using panel smooth transition regression model (PSTR).

Amato, et al. (2005) used a procedure to recognize the regional energy demands to climatic deviation in the Federation of Massachusetts by relapsing month to month per capita energy utilization on temperature, HDD, CDD, pattern in CDD and HDD, cost of power and long stretches of light and so forth. From results, positive and huge effects of HDD and CDD on power request was noticed and based on these discoveries future energy requests to climatic alterability was additionally outlined. To anticipate the yearly and pinnacle ascend in power interest from 2005-2099 for California, Franco and Sandstad (2008) utilized the atmosphere projections by utilizing the nexus of hourly power burden and normal every day temperature longer than a year from three General Circulation Models (GCMs). Literature anticipated significant rise in energy demands to the temperature by 3.1 % in the time period of 2005-2034, 8.1% in 2035-2064 and 1.8% in 2065-2099. In order to examine the potential patterns in the temperature reliance of power interest for Netherland, Hekkenberg *et al.* (2009), utilized everyday information throughout the timeframe 1970-2007. Examination outlined that in late spring months generally in month of May, June, September, October and throughout the late spring occasions power request is most noteworthy in Netherland. This critical lift in power interest for summer season drives a sign to raise the future assumptions for extra pinnacle heaps of power utilization affected by environmental change.

“Moral-Carcedo” and “Vicens-Otero” (2005) by utilizing every day information utilized the limit relapse model (TR) and the strategic smooth change relapse (LSTR) model to fabricate the connection among temperature and power interest in Spain for the time frame of 1995-2003. Assessment sorted out that the connection between power interest and temperature is non-direct and the non-linearity is pondered the limit temperatures. By taking month to month time-arrangement information which goes from 1983 to 2012 and using smooth transition regression model (STR), Liao, *et al.* (2018) predicted the electricity

consumption and temperature relationship by building non-linear econometric models in Taiwan. By using this model, the author estimated the six threshold and average temperatures. The value of average temperature was 26.384 degree centigrade while the threshold temperature ranges between 25.364 degree centigrade and 27.156 degree centigrade. All these stuffs provided framework to the policy makers of Taiwan's in order to find the future demand and to meet the demand. This study showed significant results and provide approaches to moderate the impacts of climate fluctuations on consumption of electricity. By mean of key measures of temperature i.e. HDD's and CDD's, all the demand and supply of electricity can be detected which is inclined due to climatic deviations. By HDD's means that entire negative deviations in a given time span from the actual temperature which is measured to the base temperature but CDD's is opposite to HDD's. CDD's refer to the total of positive deviation in a given time frame from the average temperature to the base temperature. Sailor and Munoz (1997) established and related two statistical models based on different sets of monthly independent variables, one with derived variables measuring heating and cooling degree days and one with "primitive" variables, applied to eight US states. Derived variables refer to HDD and CDD while primitive variable means precipitation, snowfall, moisture, rainfall etc. Better results for electricity yielded by using degree day model while the primitive variables were desirable for natural gas.

Iqbal (1983) estimates the elasticities of price and income for residential electricity and natural gas demand. By using OLS and GLS method, findings figured out that electricity demand is only income elastic although in case of natural gas both pay (income) and value (price) flexibilities are measurably critical. As per Khan and Usman (2009), pay and power costs are showed up as significant determinants of power request work which is assessed through Johansen cointegration and ECM through VAR system for the stretch of time 1972-2007. Examination uncovered that power go about as both pay and cost inelastic which reflects power as a need. Because without electricity no one can think his/her life now a days.

Energy assumes an urgent part in upgrading financial turn of events. It has become a motor of financial development at neighborhood and worldwide level. Power is required worldwide for encouraging and supporting improvement measures. "Hu and Lin (2008)" noticed the non-straight "cointegration" among "GDP and disaggregated energy utilization" for "Taiwan". This audit reveal that when an appropriate edge is reached, the change cycle of energy utilization toward balance is profoundly consistent. Shahbaz, et al. (2012) examined that economic development boosts by energy consumption. Electricity is the main input for economic growth. By applying ARDL method, the connection among "GDP and electricity consumption" has been explored over the time period of 1972-2011 by using "Cobb-Douglas production method". Javid and Qayyum (2013) inspected the connection among "electricity consumption", prices of "electricity" and "economic growth" for industrial, residential, agricultural and commercial sectors. The study discovered the electricity consumption function over the time period 1972-2010 for Pakistan by means of time series procedures. Through this study, the authors found a nonlinear, deterministic but stochastic nexus among "electricity consumption" and "GDP". The study disclosed the fact that electricity is vital to mutually the "production" and "consumption" of "goods and services" within the economy. The electricity demand throughout the whole economy raised with the increasing populations, industrial development, massive use of electrical appliances and intensive urbanization.

For Pakistan literature only few studies have been done to find the electricity demand function by taking temperature as an explanatory variable Jameel and Ahmed (2011) while Ali, *et al.* (2013) tried to explore the link between climate variability and its impact on electricity demand and consumption. This study deduced the relationship by using ARIMA model between monthly extreme temperature index in Pakistan and electricity demand and also forecasted the electricity consumption due to rise in temperature in future. The forecast value depicts that electricity demand increases due to rise in temperature with the passage of time. Monthly data exhibited growth in electricity consumption for summer season but decline in winter season.

Being climatically diverse country, the current issue required more consideration because this area remains yet to be explored. However, this study bridges the gap for Pakistan by examining the connection among “electricity demand” and “climate change”.

Table 3 shows some previous studies related to the impact of climate and other socio-economic factors on electricity demand.

Table 3: *Some previous studies about electricity consumption*

Author Names	**Data Type, Time Period and Country**	**Dependent Variable**	**Independent Variable**	**Method/ Estimation Technique**	**Results**
Abosedra et al. (2009)	Monthly time series data (1995-2005), Lebanon	"Electricity consumption"	"Real income", "relative humidity", "degree days"	"OLS", "ARIMA" and "Exponential smoothing" technique account for heteroskedasticity problem.	All the explanatory variables are statistically significant at 10% level. In test, forecasts show that the forecast made by "ARIMA" is superior in term of lowest "RMSE", "MSE" and "MAPE" criteria followed by "OLS" and exponential smoothing.
Goel (2014)	(Jan 2005 - march 2013) Delhi, India.	Electricity demand	Temperature, humidity, precipitation.	Multiple regression, ARIMA, Trend seasonality model	Strong correlation between electricity and climate variables such as temperature, mean humidity %age and precipitation has been indicated.
"Bose and Shukla (1999)"	"Annual time series data", (1985-94) "India"	"Electricity consumption per capita"	"Real GDP per capita", "electricity prices", "diesel prices"	"OLS" ("under" slacked model the issue of "multicollinearity" and heteroskedasticity is wiped out in this manner OLS gives predictable assessments.	Power utilization in business and enormous mechanical areas are pay versatile (>1) while private, cultivating and little and medium endeavors are pay inelastic (1<). The short run esteem versatilities change from - 1.35 in cultivation, - 0.65 in private, - 0.45 in immense industry, - 0.26 in business and irrelevant in little and medium industry.
Chaudhry (2010)	Annual panel data (1998-2008) 63 countries	Electricity consumption	Real GDP, electricity price	"Fixed effect model" (to examine the pay and value versatilities for "Pakistan" as "fixed impact model" offices to dissect the individual nation under board information.	To start with, as pay per capita increments in Pakistan, utilization of power per capita will increments. Second, more exorbitant costs will essentially diminish the interest for power in assembling area.
"De vita et al". (2006)	"Quarterly data" of time series from (1980-2002) "Namibia"	"Energy", "diesel", "petrol" and "electricity consumption"	"Real GDP", "own fuel prices", "alternative fuel prices", "temperature"	"Bound test approach" to "cointegration" under "ARDL" framework.	Outcome reveal that "energy" utilization react decidedly "to changes in GDP" and adversely to change in energy costs and air temperature. Be that as it may, didn't locate any huge cross value versatilities between various energy structures.
Erkan (2007)	Quarterly time	"Electricity	"Real GDP per	Engel Granger approach	Study revealed that consumers react to cost and pay

	series data (1984-2004) Turkey	consumption per capita"	capita", "electricity prices"	to cointegration	changes is very restricted the flow official power request projections profoundly overestimates the power interest in Turkey.
Jaunky (2006)	Annual panel data (1971-2002) 16 African countries	"Electricity consumption per capita"	"Real GDP per capita"	Panel dynamic OLS and fully modified OLS technique	Bi-directional causality exists and all tests support a since quite a while ago run connection between the two factors. Thusly, the since quite a while ago run versatilities are registered by utilizing FMOLS and DOLS and are discovered to be underneath the solidarity.
Khan and Qayyum (2008)	Annual time series data (1970-2006) Pakistan	Electricity demand	"Real GDP", "electricity prices", "no. of customers", "temperature at time"	"Johnsen cointegration technique" and "ECM" via "ARDL"	Pay and the quantity of clients apply positive effect on power interest in since quite a while ago run just as short run. The costs of power apply adverse consequence on power interest over the long haul at total just as for subgroups of power clients.
Mahmood et al. (2013)	(July 1998-June 2013) Pakistan	"Monthly demand for electricity in residential and commercial sector of Karachi"	"Heating degree days" (HDD) and "cooling degree days" (CDD)	"OLS" estimation procedure	Outcome reveal that increasing "temperature" will cause an increase in demand for electricity.
Narayan et al. (2007)	"Annual panel" and "time series" data (1978-2003) Group of 7 (G7) countries	"Electricity consumption per capita"	"Real GDP per capita", "electricity prices", "natural gas price"	Panel dynamic OLS,	In "long run", "residential demand" for "electricity" is "price elastic" and "Income" inelastic.
Q. Huaisui *et al.* (2004)	(1953-1999) China	Energy consumption	Temperature in terms of (HDD) and (CDD)	Polynomial method, method of degree days	There exists a good linear relationship between energy consumption and temperature which shows that energy consumption caused by climatic factors changes faster.
Santamouris *et al.* (2014)	Cyprus	Electricity demand and	Ambient temperature	Response functions	Peak electricity demand increases from 0.45% to 4.6% per degree of ambient temperature rise. The actual increase of electricity demand per degree of

		consumption			temperature rise varies between o.5% to 8.5%.
Watson and Majithia (2005)	(1983-95) and (1970s-03) UK (England and Wales)	Electricity demand	Weather related variables, GDP, population growth	Multiple regression model	There is very strong correlation between electricity demand and GDP and with population growth. But there is a strong inverse relation between demand and temperature.
Souza et al.	15min ahead forecasts for next 15 days (3years of quarter-hourly loads) Southeast of Brazil	Short term load	Temperature effects (max, min), Holidays effect	Exponential smoothing model and Holt-Winters approach with double cycle (daily and weekly)	Relationship between electricity consumption and temperature is non-linear and depend on the level of temperature. Moreover, effect also depends on the season of the year. The significance of the variations between regular and holiday periods could be checked at 95%level of confidence.
Zachariadis (2009)	Cyprus	Electricity consumption	Price, income, weather variables	ARDL (auto regressive distributed lad) model	Electricity use in Cyprus is expected to grow much faster than GDP and triple in the upcoming years 20-25.
Akil and Miyauchi (2013)	(2007-2009) Japan	Electricity consumption	Temperature, relative humidity, holidays, non-holidays	Half year and Seasonal model	Humidity has the lowest influence to demand. Demand is lower in holidays than in non-holidays. CDD and HDD are the most significant variables.

Data and Methodology

In this study, we study the relationship between climate change and energy consumption. For achieving the objective, we need to develop an econometric model which verifies the relationship between climate variability and electricity consumption. For such purpose we have applied different estimation techniques. In this study electricity consumption is used as dependent variable while the independent variables are temperature, rainfall, carbon dioxide emission, and GDP. Thus, the general electricity demand function is given as follows:

Electricity demand = f (average annual temperature, average annual rainfall, carbon dioxide emission, GDP)

More specifically, an econometrics model is given as follows:

$$EC_t = \beta 0 + \beta 1 Temp_t + \beta 2 Rainfall_t + \beta 3 CO2_t + \beta 4 GDP(PC)_t + \mu t \dots\dots (1)$$

Where;

EC_t = Electricity consumption/demand

T=temperature

R=rainfall

CO_2=carbon dioxide emissions

GDP= GDP per capita

$\mu_{t=}$ error term

In Eq. (1) EC shows the electricity consumption measured in (kWh) per capita which is dependent variable and temperature is measured in ˚C, rainfall is measured in, CO2 shows the carbon dioxide emission, GDPPC stands for GDP per capita at constant price in US dollar. Here in the equation the term t expresses the time period which is from 1971-2017, β_0 is the intercept while $\beta_1,\beta_2,\beta_3,\beta_4$ are the coefficients of temperature, rainfall, CO2 emissions, GDP respectively. Various tests are applied "to examine the relationship between the dependent and independent variables".

Data and Data Source

Different variables are used to investigate the nexus between electricity consumption and climate variability. The statistically estimate is consist of "time series data" and from the duration of 1971-2017 and data is of secondary nature. Data on electricity consumption, GDP per capita (constant US$), CO_2 emission has been taken from "World Development Indicators" (WDI). "For electricity consumption, we have used electric power consumption (kWh) per capita". For country level analysis, annual data on average temperature and rainfall for this time have been taken from Climate Knowledge Portal World Bank Group.

Estimation Techniques

The reliant variable in our model is power utilization in Pakistan, which is relapsed on temperature, GDP, precipitation, GHG to discover the connection between them. As power request doesn't rely just upon temperature yet in addition different factors ought to be remembered for the examination like value, GDP rate, population (Jamil and Ahmad, 2011). It is guaranteed in writing that there is a two-path causality among temperature and power request Lee and Chiu, 2011). An ascent in temperature causes an upsurge in the power interest while on other hand development in power age from numerous sources to satisfy expanded need may achieve climatic impacts like elevate in normal temperatures through ozone harming substance emanations (Climate and Electricity Annual 2011). If there should arise an occurrence of examination on Pakistan in general, 47 years information on power utilization are utilized which is a period sufficiently long to justify thought of climatic impacts on utilization design. The study uses ARDL

estimation technique and EViews statistical software for the computation of empirical results. Since the data are of time series nature, therefore, various data characteristics shall be studied and based on those results econometric estimations employed.

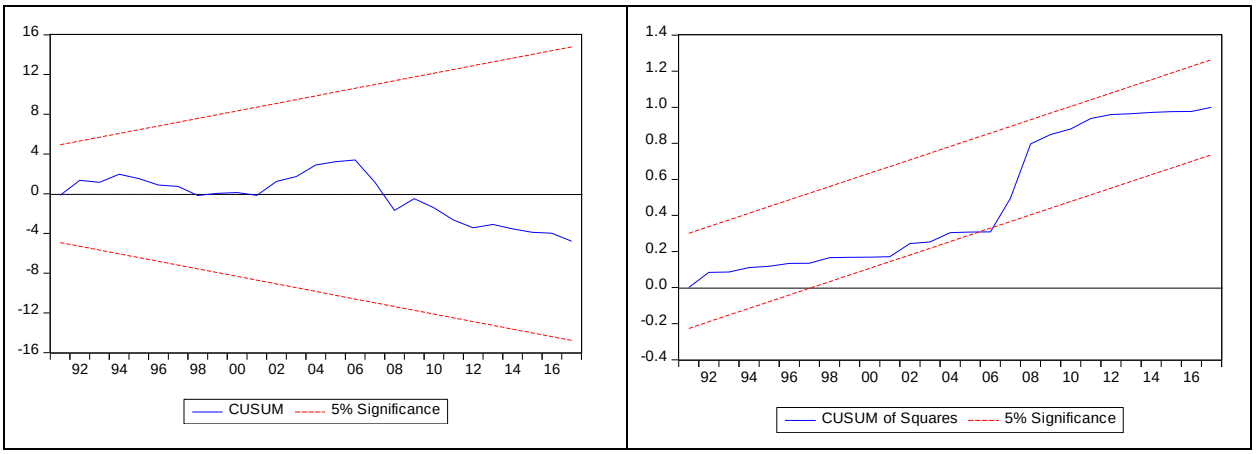
Result and Discussion

The below table show the relationship between effect of "climate change" on "electricity consumption". The estimated result shows that temperature have negatively significant, which means that increase in temperature will lead to reduce electricity consumption in developing countries like Pakistan. The reason behind this is shortage of electricity during summer season. Rainfall have positively significant but after some lags it will be negatively significant. Co2 emission have also negatively significant at 10% level. While GDP per capita have positively significant, which indicates that rise in GDP "per capita income" of individual "will lead to increase" electricity consumption. In terms of the diagnostics, "both the short run" and "the long run" results are stable "in the model". It shows that the models are stable as it converges towards the long run equilibrium which is reflected in the fact that the ECM terms are negative and significant. The Lagrange Multiplier (LM) indicates that the model has no issue of serial correlation problem, while the CUSUM (CSM) and CUSUM of Square (CSM2) indicate the stability of the model. While the value of the adjusted R square is reasonable.

Table 4: *Empirical Results for Pakistan: "Linear ARDL model estimates"*

Panel A: "Short run results"						
Lags	0	1	2			
Δ Temp	-1.38(-0.46)	6.09**(1.89)				
Δ Rainfall	1.07*(2.64)	0.52(1.46)	-0.71**(-1.83)			
Δ CO2	117.4(1.40)	-138.6**(-1.83)	-128.09**(-1.98)			
Δ GDP (PC)	0.68*(4.60)	0.34(1.49)	-0.20(-1.44)			
Panel B: Long run results						
Constant	Temp	Rainfall	CO2	GDP (PC)		
-156.62(-0.39)	-32.21(-1.55)	2.61(1.20)	1009.35*(5.54)	0.26*(3.22)		
Panel C: Diagnostic results						
"F"	"LM"	"ECM"	"RESET"	"CSM"	"CSM2"	"Adj R2"
4.94	0.51	-0.20*(-2.83)	1.90	S	US	0.39

*Shows significance at 5% and ** shows significance at 10%. Abbreviation n.e.s refers to not elsewhere specified. *The critical values for upper and lower bond for 5% and 10% are 2.86 to 4.01 and 2.45 and 3.52 respectively. LM is lagrange multiplier test of residual serial correlation. It is chi square distributed with one degree of freedom. Ramsey RESET test for functional form. It is also chi square distributed with one degree of freedom. Its critical values at 5% (1%) significance are 3.84(6.63). number inside the parenthesis is next to the coefficients are the absolute values of t-ratios.*



The above graphs show the stability of the model. In CUSUM it will clearly indicate that model is stable, while in the CUSUM of Squares model is weakly unstable.

In this study the result shows that there is high relation between the dependent variable and independent variables. The independent variables highly explained the dependent variable.

In this study we have developed a methodology for assessing energy demand response to climate change. Results show that energy demand in Pakistan is sensitive to the climatic and other socio-economic factors. These discoveries propose a need to consolidate the effects of environmental change into local energy framework extension intends to guarantee sufficient stockpile of energy both consistently and for times of pinnacle interest.

Conclusions

In this paper we present the changing worldwide climate and its likely effects on power utilization in Pakistan. Environmental change could have significant sway on power interest. We have introduced a basic ARDL model including both atmosphere related and financial components which can be utilized basically by utility organizers to survey long haul power designs utilizing long haul assessments of atmosphere boundaries and GDP. The benefit of our methodology is that it is more evident to comprehend the connection between atmosphere related and financial factors and power interest. The study examines the impact of climate change on electricity consumption in Pakistan for the period of 1971-2017. Moreover, this study implies different econometric tests like ARDL, bound test (F-test), ECM test, short run and long run tests, LM test, and Ramsey reset test. Climate variability is receiving much attention recently because it has significant effects on electricity sector and also on socio-economic activities of the society especially in developing country such as Pakistan. In view of brief writing with respect to Pakistan it very well may be inferred that power utilization and request assume crucial part in approach plan. Subsequently, the significance of interest side of power area gets essential to be examined. In the wake of investigating significant examinations on power request work at both Pakistan and global level it tends to be inferred that there exists enormous broadening in assessment procedures and results. This examination sorts out the significant determinants of power request which assumes an amazing part in power request induction and opening new ideal models for strategy investigation with respect to request the executives. The government will continue to diversify energy supply to meet energy needs in a sustainable and affordable manner. The influence of climate on virtually all human activities implies the need for adaptive strategies in order to minimize disruption to economic, social, technical and other institutions.

Policy Recommendations

Public energy approaches especially sustainable power arrangements incorporate anticipating abundance limit, an express supportive of helpless measurement, the projection to boost the use of environmentally

friendly power sources and the structure of dependable factual information base are should have been made. The expanded utilization of environmentally friendly power ought to be essential for the improvement program, raising political obligation to its advancement. It will require more political will and obligation to accomplish the fruitful executions of these energy plans. Develop an investment attraction strategy to attract foreign and domestic investors and encourage private sector financing. Governments should apply specific policy packages and tax incentives to promote energy efficiency and renewable energy projects. Government should take legislative actions to criminalize the theft of electricity. To be fair, law enforcement must be aligned with the explicit, pro-poor dimension to be included in energy planning. Modernize power plants on a most optimized plan of attack premise to increase supplies and decrease the expense of force age. Follow this with the upgradation and modernization of the current force transmission framework to diminish misfortunes. Endeavors are additionally expected to improve power duty assortment so that assets can be raised for framework activity, support and enhancements of power. There is need to run research projects and improved examinations on biomass applications for power age could be completed at the homegrown level, considering conceivable GHG emanations and agrarian and infrastructural advancement. Creation of biofuel yields ought to be engaged to satisfy the energy need for every single accessible asset. Lobbies for expanding the attention to the populace on energy investment funds and the need for broad utilization of environmentally friendly power sources. Should introduce smart energy bills to make public aware of their electricity consumption.

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Conflict of Interest

Authors have no conflict of interest.

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