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An Econometric Analysis of Energy Consumption in Pakistan

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Abstract- The ratio of energy generation and consumption plays a key role in economic growth of a country. In Pakistan, main sources of energy generation are primarily contingent on traditional fuels; substantial proportion of which is imported. Not only its import is linked with GDP, but it also affects the nation indirectly by causing unexpected inflation. By having knowledge of energy consumption, imported conventional fuels must gradually be replaced with locally available alternate preferably from non-conventional domain of energy resources in order to maintain economic growth. This present work is therefore compares the relationship between energy consumption and economic growth. Energy model Long-Range Energy Alternatives Planning System (LEAP) has been used in various scenarios to find out energy demand for 2013 and has predicted the demand till year 2040. The analysis thus uncovers new postulates for think tanks to find out best alternates headway of energy sector to overcome energy deficiency in coming years.

Keywords-Energy Outlook, Energy Planning, Modeling, Scenario Analysis, LEAP

I. INTRODUCTION

Energy sector plays a key role on the progress of any nation and depends extremely on its utilization. It was prominently identified during the embargo oil crisis in 1970's. Reports generated on World crisis.net clearly indicate that oil importing countries could face high inflation in situation of oil supply deficit [1]. In results, it would have great impact on their economy. The energy sector is related to energy demand, supply, technologies market potential, technological progress, society and the environment. All variables and parameters are considered for efficient energy planning. No doubt, energy plays a key role in commercial, residential, transportation, agriculture as well as for industrial use in industry. It plays a key role as a final product to meet power needs and demands i.e. for consumption of refrigeration, transportation, cooking, etc. [2]. The amount of energy required for producing a unit depends on technology which is adopted by end-user [3].

Consumers usually select technical and economic feasibility for the utilization of energy, based on energy planning research [4]. They are affected by different policies in place based on energy planning research. Renewable energy development must be encouraged in energy development program. Theoretically all the natural resources with different time scales are said to be renewable. But if the time period is very small then they are called renewable energy resources as bio gas and bio mass. Naves and Leal have studied and examined three important sustainable development standards: social, economic as well as environment [2]. For clean environment, the important criteria is the reduction in emission of greenhouse gasses (GHG), decreasing in air pollution and more concerns for continuous depletion of natural resources in world. On the other hand, economic standards considers mainly the reduction of fossil fuels because of huge demand and giving more emphasis on needs to work on sustainable energy by promoting local investments and energy efficiency projects which would reduce inflation as well as promote businesses on small scales. Indirectly, it would reduce burden on state to meet the energy requirements on small as well as on large scales. Most importantly, social criterion demands the health improvement and the job criteria.

The world's trend is entirely now towards the globalization. There are many issues which need to be addressed but scholars focus more on energy. Most countries are facing energy crisis and their economy is affected remarkably due to energy shortage. In this era, countries are hunting for sustainable as well as other alternative energy resources. The concept of Macro-economic growth focuses more on labor as well as capital.

Character of energy resources did not be considered which are devouring momentous role on economic growth in addition to production [5], [6].

Pakistan has been gifted with lot of energy resources like coal, natural gas, sunshine, water, wind and geothermal resources. Unfortunately these natural resources are never consumed, as most of them are still not in useful stage. According to Alternative Energy Development Board (AEDB) of Pakistan, up to 2003, these sustainable energy resources were not utilized [7]. Pakistan could control over energy crisis by owing to humble investment in energy sector. Poor energy facilities in Pakistan are major resistance to economic growth as well as to

development. Now Pakistan has more focus on national energy resources to facilitate nation with cheap energy. The objective is to increase per capita of energy consumption as well as to enhance the GDP of country.

II. ENERGY CONSUMPTION AND ECONOMIC GROWTH

Since with industrial revolution, energy has been spread exponentially. At present time, by studying the energy consumption per capita, economic growth of any state can be explored. Still energy distribution is not uniform. In the developed countries energy consumption per capita is much larger as compared to developing or under developed countries especially African countries. Therefore, relationship between the economic development and energy consumption vary from country to country and nation to nation. In some countries relation between two variables is constant and in some state relation is not in same rhythm. Much written and discussed on the relationship between energy consumption and economic development in 21st century due to the rapid depletion of energy resources. Energy policy makers provided significant role to understand energy consumption and economy of the country. Historic trend facilitate an important role. In general, configuration of historic energy consumption performs the future energy structure. Forecasting of energy consumption of any nation or state's plans and policies can be developed. In early decades economic progress of any country rely on growth ratio of energetic consumption which should be superior of GDP. But owing to technical variation and structural modification, GDP is preferred as compared to energy consumption growth ratio of economic development of any nation.

Cumulating the consequences from various source of research, energy consumption and economic constraints are categorized into three types which are: (i) No causality (ii) Unidirectional causality (iii) Bidirectional causality [8]. Unidirectional causality is divided into two sub types, one explore that income is outcome of energy consumption second manifests that energy's consumption effects on income [9],[10]. According to numerous schools of thoughts connection between energy consumption and economic are classified into four hypotheses [11]. Growth hypothesis suggests that energy consumption has predominant role on economic uplift. It advocates capital and labor as input factor of production. If energy consumption is slowdown, ultimately it will reduce GDP growth [12], [13]. Contrary to this, conservative hypothesis delivers that policies of low energy usage have no harsh impacts on economy. In addition to this, energy consumption should be excluded from economic growth so that economic growth may not suffer extremely [14], [15]. This hypothesis shows that GDP of the nation state is independent of energy consumption. But there exists a little relationship where a country attains a smooth development. Moreover, Neutral hypothesis suggests that there is no relation between energy consumption and economic parameters. It further clarifies that energy cost is small as compared to GDP, so it doesn't significant on GDP. Bidirectional hypothesis, also known as "feedback", states that economic growth rate and energetic consumption effects on each other which has influence on energy related policies [15], [16]. Bidirectional relation manifests that improvement of energy efficiency measures, scaling down of energy from conventional energy resources and enhances usage of traditional (renewable) energy resources to keep the environment favorable. Resultantly, it would reduce the greenhouse gasses (GHG). Conventional energy fuels (oil and gas) fulfill 80% of world energy consumption. In Pakistan, fossil fuels cover approximately 65% of the total economic energy demand during 2012. It is expected that if this energy carry on, total world energy demand will be increased by over 50% before 2030. In the end of 20th century (1995), oil prices were near to $10 per barrel and now comparatively it has been increased practically 100 times i.e. about $110 per barrel at the end of May 2014 [17]. The import of crude oil in Pakistan was 40.9 million barrel in March 2013 and in March 2014 was 44.9 million barrel. In this situation environment protection is much crucial for livings on the earth. Due to increase in cost and environment concerns, world is shifted towards traditional energy. Less cost is required for this sustainable clean energy. This energy is linked with regional areas development, social community progress, as this renewable energy is available in less developed regions. This can bring down the poverty level in under developed regions. So, economic growth of the country boost up.

III. ECONOMIC STRUCTURE OF PAKISTAN

The economy of Pakistan has been facing abundant exterior and national shocks since 2007 which influence on each sector of society. The economic growth has been critically affected by the devastation caused by the rains and floods, the security hazards in the country and the growing energy demand. The economy of Pakistan, however, has shown bit growing trend at the rate of 2.9% per annum normally as shown in Fig.1.

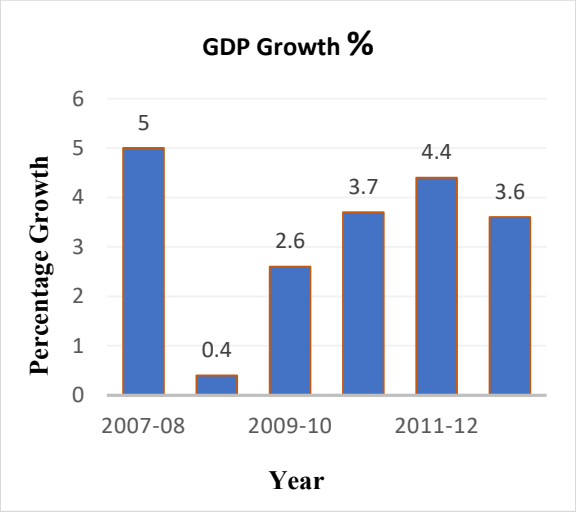

Fig. 1. % GDP Growth Rate of Pakistan from 2007-08 to 2012-13

Energy disasters have been found most deterioration element for economic growth. In fact this does not let us to realize our true economic potential. Power outages have resulted in decrease of annual GDP by 2%. GDP is not progressing any more, which is half of Pakistan's real economic potential of about 6.5% per annum but growth is less than the requirement for constant increase in employment rate and for tumbling poverty. In 2012-13, GDP was estimated 3.6% which encompasses 2.8% in Large Scale Manufacturing (LSM), 3.7% in service and 3.3% in agriculture. Comparing with GDP in previous year 2011-12, GDP of agriculture has fallen 3.5 to 3.3 percent, services 5.3 to 3.7% owing to continuous rains and flood victims. But Large Scale Manufacturing (LSM) growth has increased from 1.2% to 2.8% in current year [18].

In 20th century, 1960, the GDP in Pakistan was $3710 million and now in calendar year 2013, the worth of GDP was 236620 million USD which contributes 0.38% towards the world economy. Average GDP of Pakistan is $56300 million since 1960. On the other hand, in 2013 GNP of Pakistan was smaller than GDP of Pakistan which is 11175600 million PKR.

IV. ENERGY FORECASTING MODELS

Energy models are designed and produced considering the demand of nation. Energy models are categorized in different ways. (i) Univariate against multivariate (ii) Static against dynamic model (iii) Time series techniques ranging verses hybrid models. Energy software models are used to observe the factor of integrating sustainable energy in several systems of energies. Chen and Kung have manifested a model which has features to improve forecasting accuracy using quantitative and qualitative experiences [19]. Energy software models are developed definite to nation liable on market situation and economic. Procedural and economic forecasting model, the integrated Energy planning model, works on alteration sectors and interruption of energy consumption. The core purpose of model is stable energy demand with energy supply and variable used in models are GDP, rural and urbanization rate, growth rate of population, industrial product share as well as number of house hold. For residential energy consumption, Conditional demand analysis (CDA) was analyzed and accurate results obtained by with engineering and network based model [20].

From last two eras, energy consumption is increasing regularly. Worldwide, May energy policy maker and management are trying to overcome shortage of electricity and improving infrastructure, where numerous techniques have been used which anticipate the electricity demand. In Hong Kong, Yuk Yee Yan studied a model, residential consumption model, which is based on climatic variable [21]. In New Zealand, Mohamed and Bodger presented an electricity forecasting model using multiple linear regression model which depend on demographic and economic variables [22]. Al-Ghandoor et al. studied a time series Multivariate linear regression model to isolate basic factor of electricity consumption of Jordanian industrial sector [23]. Liu, Shahbaz and Lean suggested a multivariate model which describes short run as well as long run correlation between urbanization and energy consumption [24]. Similarly, for Srilanka, projection of electricity demand was presented based on time series analysis and this time series model presented forecasting of electricity consumption which makes estimate on the basis of key income and price elasticity [25].

Software (LEAP, MARKAL and TIMES) are used for energy modeling as well as in forecasting. At Boston, institute of Stockholm Environment developed software tool, bottom-up-type, Long range Energy Alternatives Planning System (LEAP). LEAP energy model is adopted in forecasting of energy at national, state, regional and global level. Window based LEAP model is used for energy outlooks, integrating resource planning, strategic analysis of sustainable energy futures, climate change (GHG) mitigation strategies, energy balance and environment inventories. Depending on data of national energy balance, both energy supply and demand are planned for various Mexican end use zones. Energy demand transformation program in LEAP model simulates oil refining, charcoal production, coal mining, natural gas, electricity generation, transmission and distribution, etc.

LEAP integrated energy model has been applied for planning, forecasting and analysis of energy at national and international level Iran [26], China [27], Korea [28], Thailand [29], Rawalpindi and Islamabad [30].

In Taiwan, for long range energy demand and supply, environment change (GHG) emissions analysis, LEAP system software is used. For different type of conditions, various scenarios have been developed [31]. In India LEAP energy model is developed, which is used for modeling the total energy consumption from household of Delhi and accompanying emissions. Various technologies and policies have been analyzed [32]. In Mexico LEAP system model is applied to analyze feasibility of transportation using biogas and electricity generation zone. Different scenarios relaying on moderate and high uses are analyzed. Efficient use of biogas especially in rural sectors is concentrated [33]. In Pakistan (2010), Shabbir and Ahmad worked on LEAP system for Rawalpindi and Islamabad to calculate supply and demand associated transportation emissions [30].

Energy technology systems Analysis Program, an International Energy Agency, developed dynamic technique, bottom up MARKAL model as a least cost linear programming model. Fishbone and Abilock developed numerous equations for Initial MARKAL energy model and several developments have been made on advance level for depth analysis [34]. For different policy changing, Scenarios using 'What if' context and carbon mitigation analysis, MARKAL model can be adapted.

Shanghai used MARKAL system model to develop scenarios under several policy situations [35]. MARKAL model helps in studying how to control pollutant emissions while considering different energy policies.

Planning commission of Pakistan found integrated energy model by using TIMES encompasses the entire energy system which includes resource supplies, power plants and refineries, transmission and distribution systems for fuel and electricity.

V. METHODOLOGY AND DATA USED

LEAP software is adopted to attain main manifests of this research. The key value of LEAP software is that low initial data input is required. The main objective of implement of LEAP in this research is to evaluate and forecast of energy consumption in Pakistan for the duration of 2013 to 2040 because this software relies on simpler accounting principle. In LEAP software, the first depletion year and monetary year in basic parameters of LEAP are taken 2014. In LEAP model only two year values are required one is base year values and other is future year values. For this purpose, different scenarios are constructed. In this research two scenarios were built, one is called current account scenario and second is called business as usual scenario. All such scenarios show the evolvement of energy systems. Most of the researches manipulate forecasting period of twenty to fifty years.

Primarily and also the secondary data has been collected from Pakistan energy year book 2013, economic survey of Pakistan 2012-13, World Bank national statistical report and Pakistan integrated energy model prepared by International resources group for Asian development bank.

In the LEAP, on tree the first notable class is key assumption. Under this class demographic, time series, microeconomic exogenous variables are applied that impact on energy forecasting. These exogenous variables not considered anywhere else in the LEAP resources, transformation and demand tree. Key assumptions used in this study for Pakistan are:

Population 184.30 million people and growth rate is 3.5%. GDP 236.62 billion US$ and growth rate is 4.14%. GNP 110 billion US$ and its growth rate is 6.2%.

In Base Case (Current Scenario) demand analysis is developed. Demand analysis in tree of the LEAP software is distributed into several sectors like household, commercial, industrial, transportation and agriculture. Table 1 shows energy consumption in tons of oil equivalent, TOE, of five sectors and their annual cumulative growth rate (ACGR). ACGR is used in business as usual (BAU) scenario, which is also called modified case, in order to forecast energy consumption in future years.

Table 1: Energy Consumption of Various Sectors in Toe [Xxxvi]

Sector	**2012-13 (TOE)**	**ACGR**
Household	10119014	4.7%
Commercial	1644845	2.5%
Industrial	14256099	-3.2%
Transportation	12713300	1.9%
Agriculture	659986	-3.9%

In 2012-13, total electricity generation in Pakistan was 96122 GWH. The share of hydro is 31.1%, nuclear 4.7%, gas 28.2%, coal 0.1% and oil is 35.9 percent of total electricity generation of Pakistan. These data set is used in electricity generation subsector of transformation in the tree of the LEAP in current account scenario. Total gross electricity generation from nuclear is 750 MW, Hydro 6773 MW and from thermal is 15289 MW.

In BAU scenario, estimated energy produced from different energy sources till the end of 2040 year is given in table 2. For long time future developments in energy sectors, these assumptions are also included in energy policies of Pakistan.

Table 2: Modified Case Assumptions Used In Bau Scenario [Xxxvii]

Energy Resources	Assumed Install Capacity in 2040 (Mega Watt)
Coal	20000 MW
Wind	6000 MW
Solar	2500 MW
Nuclear	15000 MW
Hydro	20000 MW
Biogas	1500 MW

VI. RESULTS AND DISCUSSION

This studied model has been instigated on settlement of two scenarios which consist of transformation, demand analysis and key assumptions. In various scenarios energy demand was evaluated for the current as well as for any future year at any particular technology branch as product of energy intensity and activity level equation discussed in LEAP software help.

$$D(b,s,t) = EI \times TA \quad \text{---------- (I)}$$

Where D is the demand and B stand for technology branch, s for scenario and t represent from base year to any future year. EI represent energy intensity and TA stands for activity level.

DEMAND - As discussed that 2013 was taken as a base year and 2040 as end year forecast of energy consumption in Pakistan. Table 3 depicts the energy consumption in subsector of demand analysis which are household, commercial, industrial, transportation and agriculture developed by LEAP. These subsectors are further divided into various fuel branches and end uses. The fuel branches involve natural gas, liquefied petroleum gas (LPG), electricity, coal, diesel, kerosene, biomass, biogas, wood and agriculture residues.

Table 3: Demand Analysis of Energy Consumption in Million Giga Joules Using Leap

Branches	2015	2040	Total
Household	20.9	115.1	345.1
Commercial	1.4	5.7	18.9
Industrial	66.8	16.3	214.6
Transportation	68.6	669.6	1530.8
Agriculture	0.4	0.4	2.5
Total	158.0	807.1	2111.8

HOUSEHOLD - Energy demand of household is fragmented into two categories urban and rural and further divided into two parts electrified and non-electrified. Fig. 2 describes complete data of urban as well as rural energy demand till forecasted year 2040. Urban population consists of 38.56 million people and remainder belongs to rural areas. It is rough estimated that 100 % of rural and urban population use natural gas for cooking.

94% of urban population are electrified that use electricity for refrigeration, lighting and other appliances. Rural population consists of fraction it is electrified. Percentage for air conditioning and refrigeration for urban and rural household is 60 and 15 percent and increase steadily till the end forecasted year 2040. In some urban household LPG, wood and biomass is used, but their percentage is not much considerable.
While in rural household LPG, wood, agriculture residues and animal dung is used however their share in cooking percentage is almost negligible.

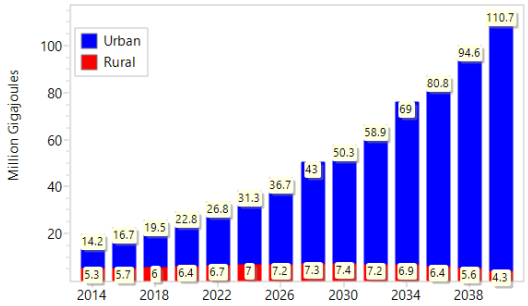

Fig. 2. Household Energy Demand

COMMERCIAL SECTOR - Commercial sector consumes 4.1 percent of total energy for year 2012-13 which is almost equal to the last year's energy consumption that is 4 percent. Its annual compound growth rate has been slowed down from 2.9 percent to 2.5 percent as compared to fiscal year. Fig. 3 is developed by LEAP software which shows that for 2040, energy consumption is three times more than that of energy utilized in 2015. Energy demand will bring the consumption high for water heating, cooking, air conditioning and other appliances.

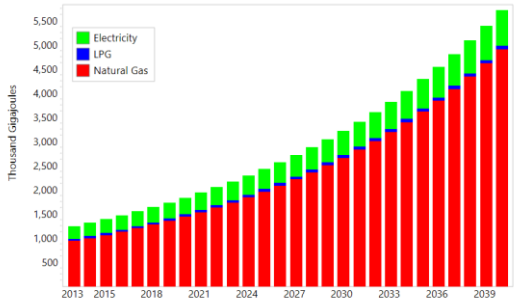

Fig. 3. Energy Demand for Commercial Sector by LEAP

INDUSTRIAL SECTOR - For economic development of any country, industrial sector plays primary role. Since 2006, woefully, energy deterioration results hitting badly on industrial sector's performance of Pakistan. Especially CNG is supplied to transportation sector. Energy consumption in industrial sector of Pakistan relay on oil, natural gas, electricity and coal but mostly industrial output of Pakistan depends on natural gas. Therefore, most of industry in Pakistan is shifting into other Asian countries owing to acute shortage of natural gas. Energy consumption in industrial sector has been declined from 16804.303 thousand TOE in 2007-08 to 14256.099 thousand TOE in 2012-13. According to energy year book 2013, annual cumulative growth rate (ACGR) of industrial sector energy consumption is -3.2 percent containing oil ACGR 5 percent, gas ACGR -3 %, electricity 1.5 % and coal ACGR -7.5 percent. Fig. 4 represents energy demand of various fuels in industrial sector.

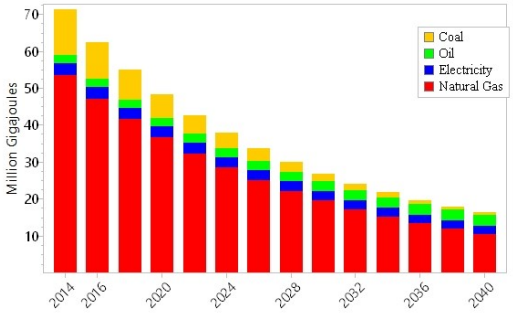

Fig. 4. Energy demand of industrial sector

TRANSPORTATION - Economy of Pakistan also relies on subsector transport which plays a vital role and overall it contributes about 23.74 percent share in services area.

Table 4: Various Fuels Consumption in Transportation Sector [Xxxvi]

Fuel	Energy Consumption (TOE)	%	Growth Rate
Electricity	0	-	-
Natural Gas	2345331	18.447	6.8%
Kerosene	185	0.001	-1.8%
Non Energy	4006604	31.515	12%
Diesel	6361181	50.035	-4.3%
Total	12713301	-	-

Table 4 illustrates the various fuels consumptions that are being used in transport sector as a base year (2013) values. In BAU scenario, the growth rate of these fuels is used as a forecast of energy consumption in transport section. The growth rate of category non-energy, which encloses aviation fuel, motor spirit, High Speed Blending Component (HOBC) and E-10, is 12% which is alarming situation for divesting the natural resources. Diesel in the primarily constituent that is used in transport sector. Diesel contains furnace oil, light diesel oil and high speed diesel. Fig. 5 shows various fuel consumptions by transportation for 2013 to 2040.

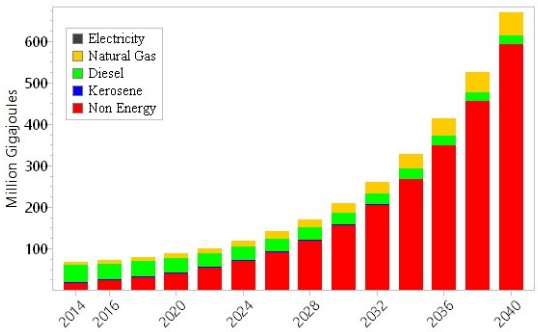

Fig. 5. Energy demand in Transport Sector developed by LEAP

AGRICULTURE - About 61.44 Percent of Pakistan's population belongs to rural areas and depends directly or indirectly on agriculture sector. In economic activity of Pakistan agriculture sector plays a role of back bone and it accounts for nearly 24% of GDP of Pakistan that is largest contribution.

Table 5: Fuels Consumption in Toe of Agriculture Sector [Xxxvi]

Source	2007-08	2012-13
Oil (TOE)	113889	33158
Electricity (TOE)	689948	626827

Table 5 demonstrates major sources of energy in agriculture sector in Pakistan for 2007-08 and 2012-13. It clearly depicts that it depends on electricity and oil. Tube wells and tractors both run by electricity and oil respectively. More over for harvesting, ploughing and other resources, oil is used. On the other hand, according to economic survey of Pakistan, agriculture's growth rate has been fell down to 2.1% in 2013-14 which was .6% more in last year i.e. 2.7%. Fig. 6, developed by LEAP, demonstrates consumption of energy in agriculture between years 2013 to 2040.

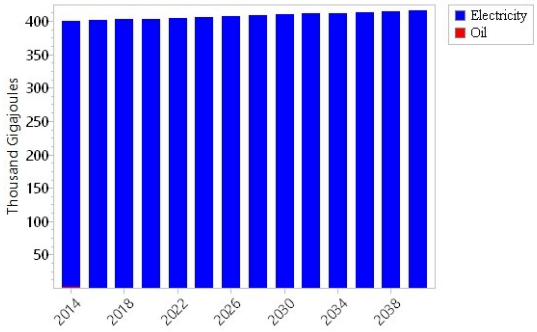

Fig. 6. Energy demand in Agriculture Sector

TRANSFORMATION: ELECTRICITY GENERATION - Fig. 7 depicts of electricity generation variation from base year 2013 to till end forecasted year 2040 developed from LEAP. Fossil fuels play predominant role in Pakistan electricity generation. In current year, share of fossil fuels in electricity generation is 64.1 percent which will be slowed down to 46.8 percent in end year 2040 and will be shifted to nuclear, hydro and some renewable resources such as solar, wind, biogas.

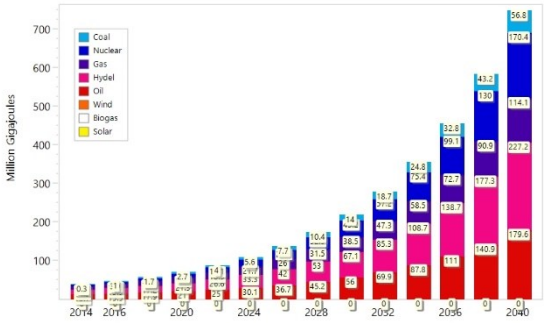

Fig. 7. Electricity Generation Variation from 2013 to 2040.

VII. CONCLUSION

Core upshot of the said research is to discuss the assorted factors which are directly or indirectly involved in planning to pawn the predicament of energy crises. It is hooray to move that consumption of energy is significant, vow economic progress along with the auxiliary components in Pakistan. In future upsurge in energy demand involves factual tenacity of aggregate of energy. As energy is prime need for growing economy, however, economic of Pakistan is devastating owing to scarcity of energy. Pakistan has huge potential of wind and solar energy. Sindh and Baluchistan have wide area which suits best for the utilization of Wind energy in power generation. Its capacity is about 150,000MW all over the country whereas 50,000MW is available at average wind speed of 7 m/s. On the other hand, large area in Pakistan does support for the solar energy generation, but these two green energy sources are not playing significant role in power generation.

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