Global Research Review

ISSN: 2737-8551

Review homepage: http://www.grrjournal.org

An Analysis on Existing Energy Policies and future Policy Recommendations for Developing Nations: A case Study of Pakistan

Sabir Ali Kalhoro, Dr. Ghous B Narejo,

Sabir13es66@gmail.com, *ghousnarejo@gmail.com*,

Abstract: The existing energy policy is tilted in the favour of the fossil fuels, which has resulted in an ever-increasing cost and consumption graph. The paper discusses the supply and demand obtained from the existing data and future trends. The installation cost and overall cost associated with the renewable energy is analysed as an alternative to existing fossil fuel base. Finally, the policy implications and the analysis of the existing and future energy supply and demand are discussed in the paper.

Keywords: Energy Policy; Energy cost; Future Policy. ,

1. Introduction

The energy demand in Pakistan is exceeding with the passage of time. The increasing reliance on fossil fuels imported from Middle East is causing a gap between the supply and demand of power. This gap between the supply and demand is widening at considerable pace. The gap is also causing damage to the existing power infrastructure [1]. The energy demand in Pakistan is increasing speedily whereas the generation is expanding at a snail's pace. Pakistan is facing a severe energy crisis and the crisis is increasingly hurting the social, economic and environmental sectors [2].

Most of the developed countries had shifted their focus from imports of fossil fuels to indigenous energy resources that are typically economic, environmental friendly and competitive. The existing ailing power network is forcing the country further into an unending crisis [3].

Pakistan is facing severe power shortages which resulted in forced power outages of 8 to 12h on a daily basis in urban areas and up to 18 h in rural areas during last decade. The main causes behind the increasing energy shortages are gap between the generation and consumption that will primarily increase the electricity demand.

At present, therefore, the country is not solely facing a significant challenge of meeting the electricity demand but the challenge of energy security as well. This situation, in addition, has serious repercussions on global climate [4].

The role of policy makers, at this stage, is crucial in not solely assessing and reviewing the ways to minimize the electricity supply and demand gap but additionally addressing the necessity to develop future ways as well, ensuring affordable electricity with economic power generation, transmission and distribution [5].

This paper provides analysis of the cost involved in fossil fuel import and installation cost of the renewable energy sources, namely, wind and solar. The paper also recommends the policy measures for policy makers to narrow the gap between the supply and demand of electrical power for the country [6].

The energy shortage is damaging the investment as well as socioeconomic conditions of the country [7]. The gap between demand and supply is also linked to gross domestic product (GDP) and energy consumption. The slow growth in power generation is due to the poor energy infrastructure, immense capital demands, and delayed policies at the implementation level.

The electrical power demand will never be fully addressed by fossil fuel, coal, and liquefied petroleum gas (LPG). The total energy consumption in 2010–2011 was reported at 38.8 million ton of oil equivalent (MTOE). The demand rose to 68.8 MTOE in 2014-2015. The calculable per capita accessibility of energy was reported as 0.36 TOE [8].

The shift in the energy policy was visualized by introducing the share of renewables in the power generation in 2006; however, there are no effective implementations of the policy. In 2013, the renewable energy policy was further extended for next 5 years (AEDB, 2016) [9, 10].

Pakistan have unlimited potential of renewable energy (RE). There is a potential of 2,900,000MW of solar, 346000 MW of wind, 3000MW of biogas, 2000MW of tiny hydropower and 1000MW from waste [11]. The country has so much exploitable RE potential and a couple of 9 million MW of total alternative energy potential but it still relies on the pricy imported fossil fuel. Moreover, large areas of the country are still deprived from the electricity due to the energy shortage [12]. Apart from energy shortage problems, there is a dire need to adopt the emission-free technologies for the power generation.

The solar energy is optimum energy system in Pakistan due to geographical location. Pakistan is located within the region of high solar insolation in the world. The potential of solar power resources may be adapted to generate the electricity in the off-grid areas within western deserts and northern regions [13]. Additionally, the solar power can also be utilized in other applications such as solar cookers, solar water heaters and solar boilers for industrial usage. The renewable energies such as: solar, wind, and biomass are the only solutions left to meet the speedy power demand [14].

The coastal regions of Sindh and Baluchistan provinces have got huge potential of the wind power for generating the electricity [15]. The coastal belt of Sindh and Baluchistan has over

50,000MW wind potential. The wind potential may effectively be used to perform the processes in textile and agro-industries as well [16, 17].

2. Energy Policy Model

2.1 Fossil fuel Based Policy Model

The linear equation expresses the estimated as the best fit on the fossil fuel demand and supply. The general linear model, represented as,

$$y = m.x + c \quad \text{.....Eq.12}$$

Where m is slope, the slope change in Y over the change in X and C is constant.

The data on the fossil fuel demand and supply can also be fitted by using the polynomial function,

$$y = a.x^n + b.x^{(n-1)} + c.x^{(n-2)} + \dots + m \quad \text{.....Eq.13}$$

Or

$$y = a.x^5 + b.x^4 + c.x^3 + d.x^2 + e.x + m \quad \text{.....Eq.13}$$

Where, a, b, c are variable and y represent the polynomial model

The Fig.1 Show the year wise data of fossil fuel energy consumption in the Pakistan. The data can be fitted with the variety of the models. We have fitted the data with the linear and polynomial regression models. The data is the best fitted with the polynomial of 6th degree with the regression model,

$$y = -0.0001x6 + 1.2111x5 - 6024.1x4 + 2E+07x3 - 2E+10x2 + 2E+13x - 6E+15 \quad \text{.....Eq.14}$$

Where, coefficient, x and y values are obtained using the model.

The quality of the best fit on the available data is determined by the value of R^2 being close by 1. In this case, $R^2 = 0.9914$. With the application of the linear regression the best fit was

$$y = 693.94x - 1E+06$$

while $R^2 = 0.9172$ for the linear fit. Therefore, the polynomial to 6th degree seems to be the best fit on the available data.

The Fig.2 shows the year wise data of crude oil imports in the Pakistan. We have the data fitted with the linear and polynomial regression. The polynomial regression of 6 degree as,

$$y = 6E-05x6 - 0.715x5 + 3571x4 - 1E+07x3 + 1E+10x2 - 1E+13x + 4E+15 \quad \text{.....Eq.15}$$

The quality of the best fit with the solar irradiation data is determined by value of R^2 being close by 1. The polynomial with $R^2 = 0.9572$. The application of linear regression the best fit was

$$y = 4.1905x - 8261.3$$

while $R^2 = 0.7124$ for the linear fit. Therefore, the polynomial to 6th degree seems to be the best fit on the available data. The Fig.3 show the year wise data of gasoline prize in the Pakistan can also be fitted with the variety of the models. We have selected the data with the linear and polynomial regression. The polynomial regression of 6 degree as,

$$y = -9E-07x6 + 0.0107x5 - 53.716x4 + 143640x3 - 2E+08x2 + 2E+11x - 6E+13 \quad \text{..... Eq.16}$$

The quality of the best fit with the irradiation data is determined by value of R2 being close by 1. In this case the polynomial $R^2 = 0.8501$. With the application of linear regression the best fit was $y = 0.0277x - 54.848$

While for the linear fit $R^2 = 0.6346$. Therefore, the polynomial to 6th degree seems to be the best fit on the available data. The Fig.4 show the year wise diesel prize in Pakistan data can also be fitted with the variety of the models. We have selected the data with the linear and polynomial regression. The polynomial regression of 6 degree as,

$$y = 5E-07x6 - 0.0055x5 + 27.458x4 - 73471x3 + 1E+08x2 - 9E+10x + 3E+13$$

……..…Eq.17

The quality of the best fit with the irradiation data is determined by value of R2 being close to 1. In this case $R^2 = 0.9854$ with the application of linear regression the best fit was y = 0.0446x - 88.81 while $R^2 = 0.7592$ for the linear fit. Therefore, the polynomial to 6th degree seems to be the best fit on the available data.

2.2 Renewable Energy Based Policy Model

The year wise data of solar installation cost in the Pakistan can also be fitted with the variety of the models. We have selected the data with the linear and polynomial regression. The polynomial regression of 6 degree as,

$$y = 0.0083x6 - 99.685x5 + 496809x4 - 1E+09x3 + 2E+12x2 - 2E+15x + 5E+17$$

…….Eq.18

The quality of the best fit with the irradiation data is determined by value of R2 being close by 1. In this case $R^2 = 0.9973$. With the application of linear regression the best fit y = -428.07x + 864474 while $R^2 = 0.9501$. Therefore, the polynomial to 6th degree seems to be the best fit on the available data.

The year wise data of decreasing cost of solar energy sources in the Pakistan can also be fitted with the variety of the models. We have selected the data with the linear and polynomial regression. The polynomial regression of 6 degree as,

$$y = 1.275x5 - 12824x4 + 5E+07x3 - 1E+11x2 + 1E+14x - 4E+16$$

..……..……Eq.19

The quality of the best fit with the irradiation data is determined by value of R2 being close by 1. In this case $R^2 = 1$. With the application of linear regression the best fit was **y = -15.429x + 31123** while **$R^2 = 0.8866$**. Therefore, the polynomial to 6th degree seems to be the best fit on the available data.

The year wise data of decreasing cost of wind energy sources in the Pakistan can also be fitted with the variety of the models. We have selected the data with the linear and polynomial regression. The polynomial regression of 6 degree as,

$$y = 1.6375x5 - 16471x4 + 7E+07x3 - 1E+11x2 + 1E+14x - 5E+16$$

……..……Eq.20

The quality of the best fit with the irradiation data is determined by value of R2 being close by 1. In this case $R^2 = 1$. With the application of linear regression the best fit was $y = -15.429x + 31123$

while $R^2 = 0.8019$. Therefore, the polynomial to 6th degree seems to be the best fit on the available data.

3. Experiment

In Pakistan, the existing thrust on the fossil fuels based power generation is a clear manifestation of the existing energy policies. The models in the paper are based upon the existing data on import, consumption and cost of the fossil fuels and the RE. The real time data is found from [18-20]. The data obtained is curve fitted with the polynomial and linear models and the best fitted models are then taken forward to presume the existing energy policies of the country.

The Fig.1 shows the year wise fossil fuel energy consumption in the Pakistan. The data is fitted with the linear and polynomials of degree 6 in order to know the trend in the yearly consumption. The data is modelled with the best of the fitted models. The Fig.2 shows the year wise crude oil import in the Pakistan. The data is fitted with the linear and polynomial regression of degree 6 in order to know the trend in the yearly import. The data is modelled with the best of the fitted models.

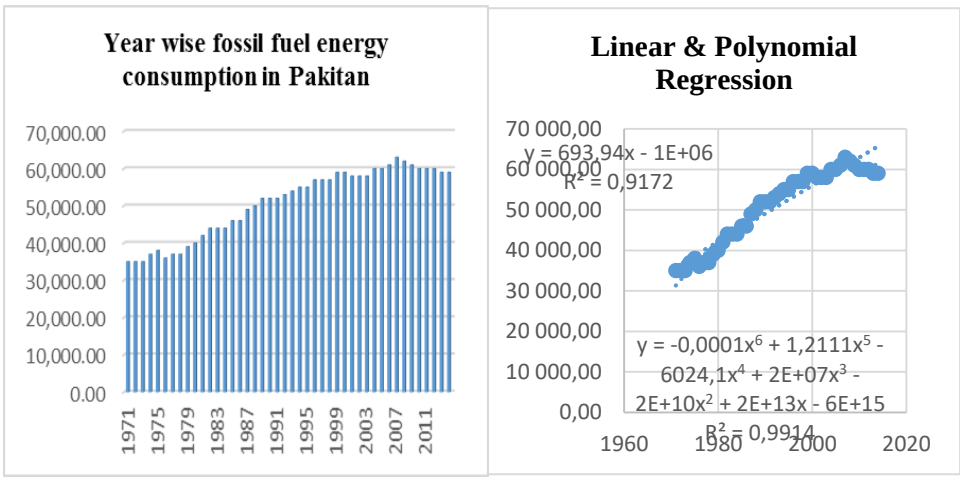

Fig.1 The fossil fuel energy consumption in the Pakistan with the linear and polynomial regression that show the future trend of the fossil fuel consumption. Data Source: The Index Mundi

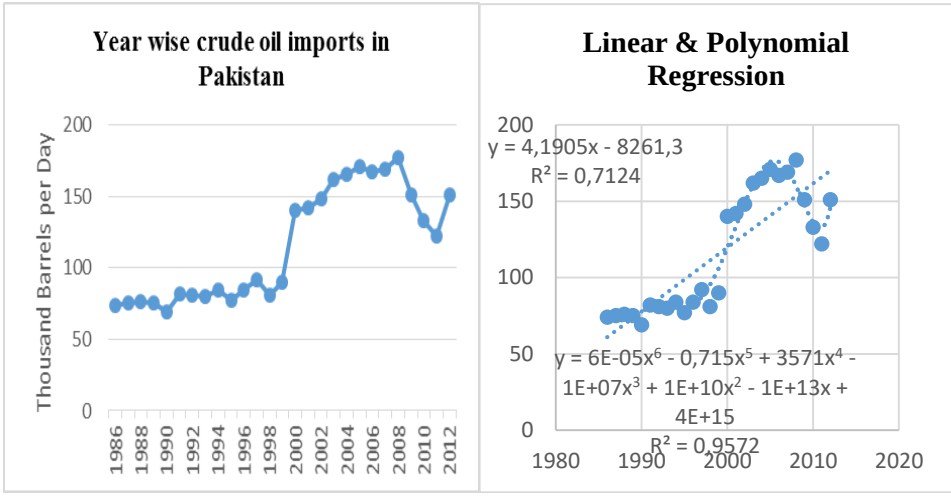

Fig.2 The crude oil imports in the Pakistan with the linear and polynomial regression that show the future trend of crude oil import. Data Source: The Index Mundi

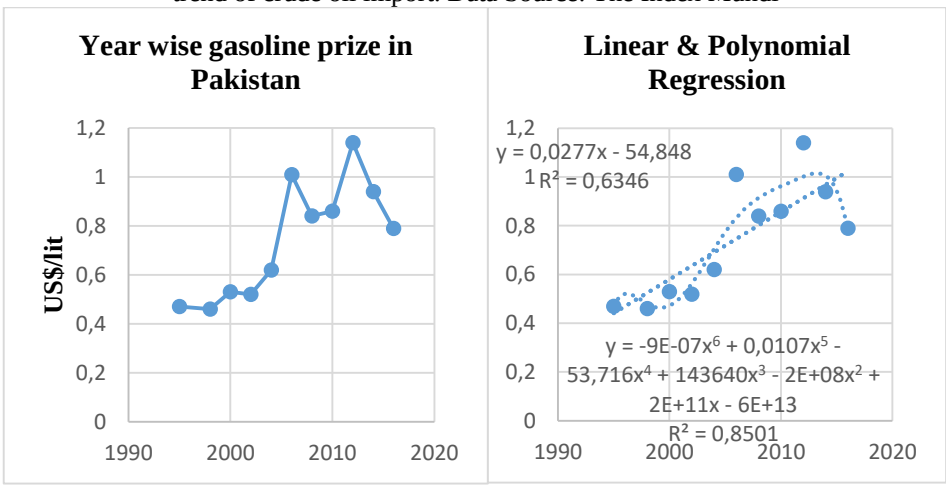

Fig.3. The Year wise pump Price for the gasoline in the Pakistan with the linear and polynomial regression that show the future trend of gasoline prices. Data Source: Knoema World Data Atlas

The Fig.3 shows the year wise gasoline prize in the Pakistan. The data is fitted with the linear and polynomials of degree 6 in order to know the trend in the yearly increasing prize. The data is modelled with the best of the fitted models. The Fig.4 shows the year wise diesel prize in the Pakistan. The data is fitted with the linear and polynomials of degree 6 in order to know the trend in the yearly increasing prizes. The data is modelled with the best of the fitted models. The Fig.5 shows the year wise solar installation cost in the Pakistan. The data is fitted with the linear and polynomials of degree 6 in order to know the trend in the yearly solar installation cost. The data is modelled with the best of the fitted models.

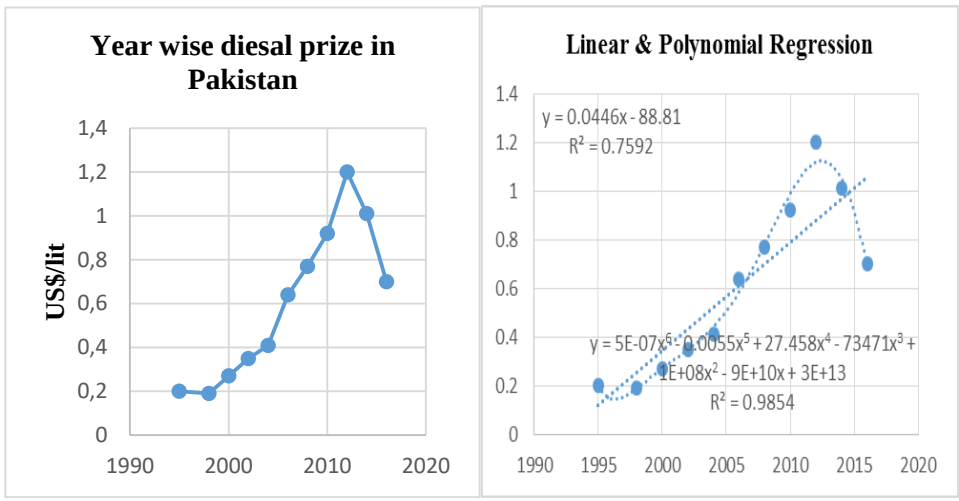

Fig.4. The year wise pump price for the diesel fuel in Pakistan with the linear and polynomial regression that show the future trend of the diesel fuel prices. Data Source: Knoema World Data Atlas

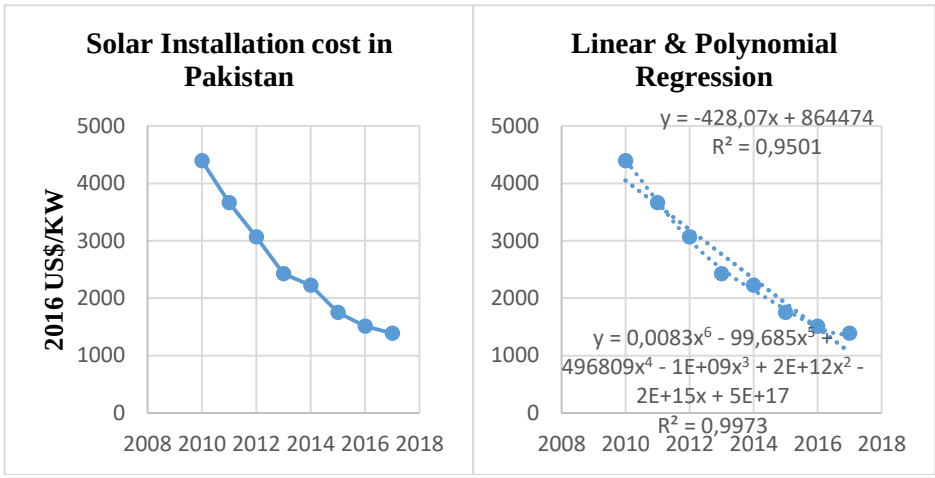

Fig.5 The year wise decreasing solar installation cost of renewable energy with the linear and polynomial regression that show the future trend of decreasing solar installation cost. Data Source: IRENA BNEF, UNEP, WHO, OECD, National Renewable Energy Lab, National Academy of Sciences

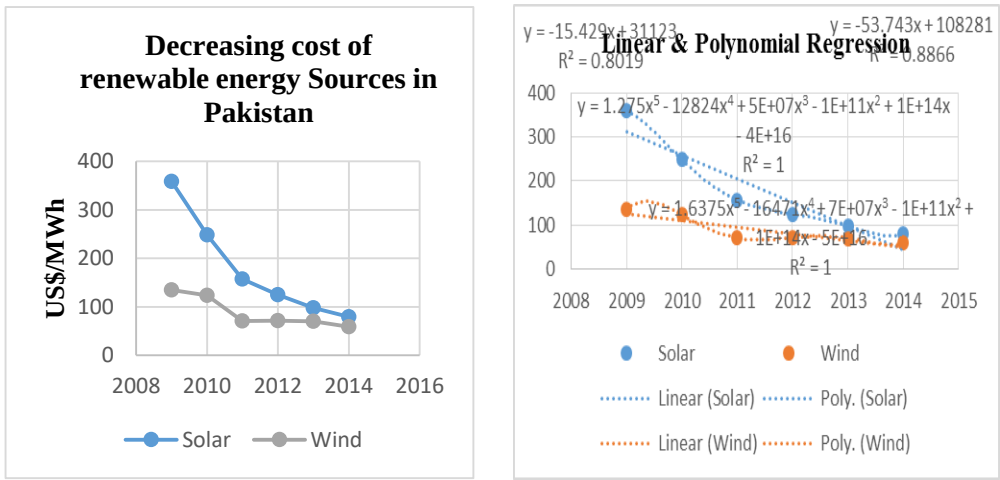

Fig.6. The year wise decreasing cost of renewable energy resources with the linear and polynomial regression that show the future trend of decreasing cost of renewable energy resources. Data Source: IRENA BNEF, UNEP, WHO, OECD, National Renewable Energy Lab, National Academy of Sciences

The Fig.6 shows the year wise decreasing cost of renewable energy resources: wind and solar in the Pakistan. The data is fitted with the linear and polynomials of degree 6 in order to know the trend in the yearly decreasing cost. The data is modelled with the best of the fitted models.

The year wise models and results, obtained as shown in the model sections respectively, point at a data across the different years. While looking at the models as well as the parameters at which these models depend, it may be observed that the data for Pakistan is showing a consistent trend. The consistent trend is in the form of line that predict the future trend of the data hence in the future the fossil fuel consumption as well as prizes will increases in same way the RE resources show the decreasing trend of installation cost as well as prizes. The model is employed to forecast the data trend for each year which predicts consistent trend for each of the selected year.

4. Analysis

The Fig.1 shows the year wise trend of fossil fuel for the year 1971-2014. The data was studied on yearly basis and the trends were observed. From the diagrams based upon the real time data, it can be clearly seen that the trend of the fossil fuel is uniformly increasing. The Fig.2 shows the year wise trend of the crude oil for the year 1986-2012. The data was studied on yearly basis and following trends were observed. From the diagrams based upon the real time data. It can be clearly seen that the trend of the fossil fuel uniformly increasing.

The Fig.3 shows the year wise trend of the gasoline prize for the year 1995-2016. The data was studied on yearly basis and following trends were observed. From the diagrams based upon the real time data. It can be clearly seen that the trend of the gasoline prize uniformly increasing as for as the particular year is increase. The Fig.4 shows the year wise trend of the diesel prize for the year 1995-2016. The data was studied on yearly basis and following trends were observed. From the diagrams based upon the real time data. It can be clearly seen that the trend of the diesel fuel prizes uniformly increasing as for as the particular year is increase. The Fig.5 shows the year wise trend of the solar installation for the year 2010-2017. The data was studied on yearly basis and following trends were observed. From the diagrams based upon the real time data. It can be clearly seen that the trend of the RE uniformly decreasing as for as the particular year is increase.

The Fig.6 shows the year wise trend of the decreasing cost of renewable energy sources including solar and wind in the Pakistan for the year 2009-2014. The data was studied on yearly basis and following trends were observed. From the diagrams based upon the real time data. It can be clearly seen that the trend of the RE uniformly decreasing as for as the particular year is increase. Hence the RE cost will be continuously decreasing with the increase of time period. The present energy shortages within the Pakistan can be overcome by the potential of renewable energy as a viable source to beat the gap. The recent developments in the RE technologies and their applications within the country will overcome the energy shortage [12]. While comparing the fossil fuel cost with that of RE cost, it can be clearly observed that the cost for RE is lower and is yearly decreasing. The import,

consumption and cost data on fossil fuel shows the fact that excessive cost is incurred on the import of fossil fuels. In comparison, the RE installation costs have reduced.

The above study determines the price of the fossil fuels based energy is increasing with increasing time and at the same time the renewable price and its installation cost with respect to time is decreasing. According to the World Bank group Pakistan has used only 0.8% of the renewable energy sources up to 2015 as [21]. Currently the Pakistan is far behind in the way of renewable energy. Pakistan's attributed toward the renewable energy is 2% in 2019 where the other leading countries uses 20% [22]. Hence the Pakistan trend toward the renewable energy is inadequate as compare to the other countries. The future trend of the Pakistan toward the renewable energy is clearly shown in the fig.7.

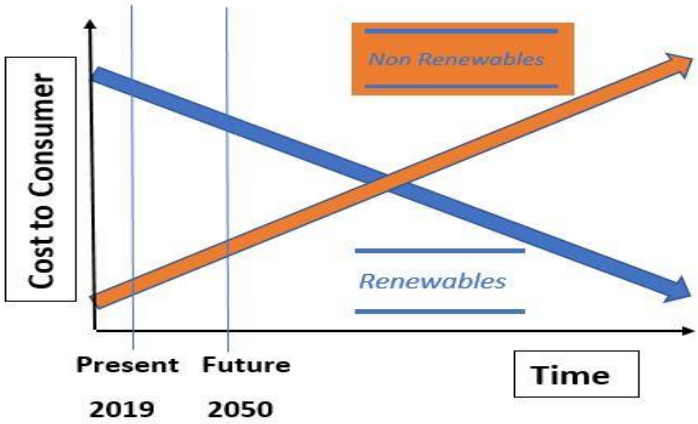

Fig.7. The growing cost to consumer of Non-renewable energy against Renewable energy

4.1 Policy Recommendations for Pakistan

- The proposed energy plans aims to shift the energy policies to the cheap and emission free hydel to renewable energy generation system. This shifting of the energy combine puts an additional burden on the national treasury. The increasing power shortages of Pakistan can be overcome by only the patron of RE. This research suggests the policy manufacturers to move toward the long term energy policies. The environmental and socio-economic gap within the country will only be minimized through the reduced reliance on foreign energy and promoting energy efficiency.
- Developing a policy and preventive framework for promoting RE application in industries of Pakistan
- Encourage the investor to build energy services companies in Pakistan related to the renewable power plant.
- Build domestic, commercial and industrial solar power plant.
- Domestically and commercially promote the use of alternative energy applications to fulfil the consumption
- The solar boilers and solar heater power can be put the supplement necessities of industries. The industrialists are promote the use of solar power to fulfil their energy demands. Solar power for water heating and steam production for the plant etc. This

contribution help solar power rather than fossil fuels to get heat in the form of electricity, and improve overall economic science, scale back the assembly prices, creating heat and electricity accessible as, once it's needed by the entities.

5. Conclusion

The year wise data obtained from Index Mundi and IRENA sites was analyzed. The available data was compared for a yearly in order to find a trend that may be easily predicted or forecasted for the future trend. The same was done for the yearly RE resources for the particular data provided by Index Mundi and IRENA sites. The yearly data points were mapped with the linear and polynomial fit in order to find a trend in the data. On the basis of the data for the particular period, a consistent trend is observed by yearly data. So, it best to advance the renewable resources as an alternative because these sources are environmental friendly. The Pakistan have so much noted areas where there is access of renewable potential for power extraction but we never utilize these noted areas for getting renewable energy [36]. The coverage highlights to the different other countries which make a transition at various steps from non-renewable energy to the renewable energy resources. These resources provide the complete accuracy in the whole system. In this research we will discuss the existing energy scenario and giving the alternative for the economical and reliable future of the Pakistan. Hence from the above discussion Pakistan need to move from the conventional power resources to the non-conventional power resources.

Acknowledgments

The efforts of the department of Electronic Engineering, NED University of Engineering &Technology, Karachi, are acknowledged for its support for research. The efforts of the Index Mundi and IRENA are acknowledged for making the data available for Pakistan.

References

[1] M. Mujahid, Rafiquea, S. Rehman. (2017) National energy scenario of Pakistan – Current status, future alternatives, and institutional infrastructure: An overview. Renewable and Sustainable Energy Reviews 69 156–167.

[2] Shahzada M. Naeem Nawaz, Shahzad Alvi. (2018) Energy security for socioeconomic and environmental sustainability in Pakistan. Heliyon 4 e00854. doi: 10.1016/j.heliyon.2018. e00854.

[3] Farooq MK, Kumar S. (2013) An assessment of renewable energy potential for electricity generation in Pakistan. Renew Sustain Energy Rev; 20:240–54.

[4] Nayyar Hussain Mirjat, Mohammad Aslam Uqaili, Khanji Harijanb, Gordhan Das Valasaib, Faheemullah Shaikh, M. (2017) A review of energy and power planning and policies of Pakistan. Renewable and Sustainable Energy Reviews 79 110–127.

[5] Georgios Savvidis, KaisSiala, Christoph Weissbart, Lukas Schmidt, Frieder Borggrefe, , Karen Pittel, Reinhard Madlener, Kai Hufendiek. (2019) The gap between energy policy challenges and model capabilities. Volume 125, February, Pages 503-520.

[6] SarahRoyston, JanSelby, ElizabethShove. (2018) Invisible energy policies: A new agenda for energy demand reduction. Volume 123, December, Pages 127-135.

[7] ShuyangSi, MingjieLyu, CynthiaLin Lawell, SongChen. (2018) The effects of energy-related policies on energy consumption in China. Volume 76, October, Pages 202-227.

[8] M. Mujahid Rafique, Gulzar Ahmad. (2018) Targeting sustainable development in Pakistan through planning of integrated energy resources for electricity generation. https://doi.org/10.1016/j.tej.2018.08.001.

[9] Policy for Development of Renewable Energy for Power Generation, (2006) Government of Pakistan.

[10] Usman Zafar, Tanzeel Ur Rashid, Azhar Abbas Khosa, M. Shahid Khalil, Muhammad Rashid. (2018) An overview of implemented renewable energy policy of Pakistan. Volume 82, Part 1, February 2018, Pages 654-665.

[11] Muhammad Wakeel, Bin Chen, Soomro Jahangir. (2016) Overview of Energy Portfolio in Pakistan". Volume 88, June 2016, Pages 71-75.

[12] AyeshaSadiqa, AshishGulagi, ChristianBreyer. (2018) Energy transition roadmap towards 100% renewable energy and role of storage technologies for Pakistan by 2050. Volume 147, 15 March, Pages 518-533.

[13] Xiao-Chen Yuan, Yan-Jun Lyu, Bing Wang, Qiao-Hong Liu, QingWu. (2018) China's energy transition strategy at the city level: The role of renewable energy. Volume 205, 20, Pages 980-986.

[14] DenyDel Moretto, Teresa AnnunziataBranca, ValentinaColla. (2018) Energy efficiency and reduction of CO2 emissions from campsites management in a protected area". Volume 222, Pages 368-377.

[15] Hanan Ishaque. (2017) Is it wise to compromise renewable energy future for the sake of expediency? An analysis of Pakistan's long-term electricity generation pathways. Energy Strategy Reviews 17 6e18.

[16] Asad Ashfaq, Anton Ianakiev. (2018) Features of fully integrated renewable energy atlas for Pakistan; wind, solar and cooling. Volume 97, December 2018, Pages 14-27.

[17] Muhammad Shoaib, Imran Siddiqui, Yousaf Muhammad Amir, Saif Ur Rehman. (2017) Evaluation of wind power potential in Baburband (Pakistan) using Weibull distribution function Renewable and Sustainable Energy Reviews, Volume 70, April 2017, Pages 1343-1351.

[18] The Index Mundi.

[19] Knoema World Data Atlas. [https://knoema.com/atlas/Pakistan/Diesel-price]

[20] IRENA BNEF, UNEP, WHO, OECD, National Renewable Energy Lab, National Academy of Sciences.

[21] http://wdi.worldbank.org/table/3.7

[22] https://tribune.com.pk/story/1879268/6-pakistans-energy-mix/