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Assessment of electricity demand at domestic level in Balochistan, Pakistan

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Abstract. Electricity is basic need for country development. But at the present time proper planning and policy is require at high pace for power generation network extension due to the increasing population growth rate. Present study aimed to analyze the present and future demand for electricity at household level in Province of Balochistan of Pakistan via simulation modeling. Data of year 2004-2005 was used as baseline data for electricity consumption to predict future demand of electricity at both rural and urban domestic level up to subsequent 30 years, with help of LEAP software. Basically three scenarios were created to run software. One scenario was Business-As-Usual and other two were green scenarios i.e., solar and wind energy scenarios. Results predicted that by using alternative energy sources, demand for electricity will be fulfill and will also reduce burden on non-renewable energy sources due to the greater potential for solar and wind energy present in Balochistan.

Keywords: demand and supply; electricity; households; LEAP; solar energy; wind energy

1. Introduction

Globally, opportunity cost for making civilization and development is increasing amount of energy consumption per capita per annum (Shoaib 2013). For building development and progress, any country needs energy power and resources because of its consideration to be the lifeline. With the passage of time, population growth is exceeding at fastest speed, so it is need of time to establish equilibrium between demand and supply of energy. Increasing demand for energy globally has rose up many questions about energy safety and resource allocation. Only way out to this problem is in providing and promoting renewable energy sources. Alternative sources are still being explored and verified by tests and boosted to enhance energy sources. Pakistan is a developing country, however Allah has blessed Pakistan with many natural resources like coal, gas etc. Moreover, due to its geographical position Pakistan has potential to generate energy from solar and wind power. Electricity is secondary source of energy generate from other physical environmental sources. According to Pakistan Energy Book in 2010 Pakistan has potential to generate energy from solar power about 2.9 million Megawatt and 346,000 Megawatt from wind

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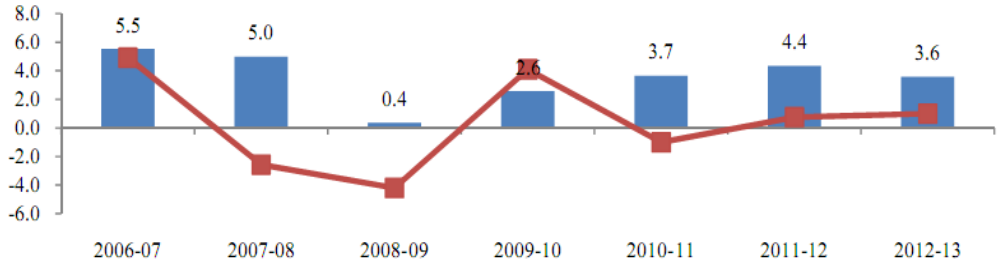

Fig. 1 Relationship between electricity generation and GDP growth rate (Source: HDIP 2010)

(HDIP 2010). Currently, three main natural sources are used for generating electricity in Pakistan like Nuclear power, Thermal power, and Hydel sources. Since 2010, Pakistan is suffering from electricity shortage. Energy outages in Pakistan leaded difficulties in development sectors, during 2010-2011. Primary cause of these difficulties in development and production sector was shortage of electricity. Approximately thirty eight billion rupees per annum which is 2 percent of GDP was the measured cost of energy power crises to the economy (Shoaib 2012). Although for preceding four years from 2008-2012, the given subsidies cost to the power sector was 2.5 percent of GDP, but the electricity consumption has much more than before at an average of 4.8 percent per year for last ten years (Raja 2011). Series of challenges are being faced by electric power generating sector. Although few improvements were observed at generating level but remain fruitless to meet the demand. Many technical along financial problems are involved in solving these crises. In this regard international donor agencies have been providing financial as well as technical aid and sustenance but estimated betterment and outcomes will be established when these under way projects are accomplished.

In Fig. 1, a correlation among electricity generation and GDP growth in Pakistan has been observed. It is shown in figure that there is low GDP growth rate with low period of electricity generation, while higher GDP growth rate where is electricity generation growth has rose up. Electricity generation in Pakistan is extremely dependent upon imported oil, for instance, oil imported every year in Pakistan of nearly $15 billion cost and significant quantity is used for electricity generation. WAPDA is contributing continuously with 48% in electricity generation while Independent Power Producers is contributing nearly 25% (HDIP 2010). The gap between supply and demand is getting wide and wide by each and every passing day and year. Demand for energy according to energy experts, is increasing about 8 to 10% per annum. If this trend carries on then electricity demand will rise up to 36,000 MW in 2015, 54,000 MW in 2020 and 119,000 MW in year of 2030 (NTDC 2013). Another component in picture of electricity shortage and crisis is increasing number of consumers and rapid development of electric network to non-electrified villages. In 2012-2013, number of electricity consumers were 21.7 million out of which 18.5 million were domestic consumers. Share of domestic consumers in 2012 year was 85.5% greater than commercial, industrial, and agricultural sectors which were having 11.68%, 1.35% and 1.3% share, respectively (AEDB 2013). Short fall in electricity started since 2008 and now it has greater than before up to 6000 MV. After that conditions became worst and worst and public suffered from worst load shedding all the time. In last year it has been reported that summer season was the worst period for the Pakistani people when they experienced 16-18 hr load shedding.

In this study Balochistan was selected as study area where Allah has gifted solar and wind power potential to generate electricity at more pace. Balochistan is largest province by its

geographical area on map of Pakistan. In Balochistan, Nokundi in Chagai district is consider as one of the best corridor for wind where wind speed is virtually constantly at 12.5% greater than average speed necessary for electricity generation. Parallel is instance of Lasbela district in province of Balochistan where wind at fastest speed worthy for generation of electricity is accessible. On other hand Balochistan has availability of sunshine nearly 8 to 10 h/day (Mehboob 2012).

No study has been found till to current date conducted on energy modeling technique for calculating future dependency of Balochistan on electricity production, demand and supply. In this regard present study was aimed to analyze the urban and rural household electricity demand by mean of using computer based model named Long-range Energy Alternative Planning System (LEAP). This study also provided guideline about how can Balochistan reduce the dependency and load on current means of electricity production by presenting future based benefits of green energy scenario. This software based model was not only used for analyzing energy demand in future but also used for emission calculation released by energy sources in environment. More important function which can be used in this modeling is to put forward substitute energy source, with the percentage decrease on main non-renewable energy resources, with its emission calculation.

Present study was carried out with the following objectives:

1. To investigate the present electricity demand at domestic level
2. To predict electricity demand in future time period
3. To calculate and suggest significance of solar and wind energy as alternative energy sources

2. Materials and methods

Present study was directed to predict the possible electric shortfall and electricity demand at domestic level, which the province Balochistan may come across in future time period due to rapid population growth rate and increasing demand for electricity. Calculation for electricity demand was done at urban and rural household's level. For this purpose consumption was categorized and divided on the basis of electrical appliances usage and their share to electricity consumption yearly by each household on average calculation. The most common items for electricity consumption are fans, water motors, bulbs/lights, fridge, and air conditioners.

Model Framework: LEAP model for simulation modeling was used to accomplish the objectives of present study for electricity demand. This model (LEAP) was used to predict and evaluate electricity demand at household level in Balochistan under substitute energy sources for the forecasting period of 2005-2030. The prime concept was creating scenario based analyses in LEAP. For this purpose three scenarios created in model with providing baseline data of two years 2004-2005 for electricity demand supply and installed capacity in Balochistan. By this model electricity demand was extrapolation for subsequent future up to 2030 (Urooj *et al*. 2013).

Data Collection: Energy data collected from Economic Survey of Pakistan of three years 2004, 2011 and 2013. Whereas, reports of World Bank and National Statistical Bureau were also referred. Electricity demand, supply, and consumer information of Balochistan was provided by Quetta Electric Supply Company (QESC). Year 2004 was selected as base in which total population of Balochistan was recorded 7.8 million people, income was $400 US per capita, and GDP was $410 US with growth rate of 2.1%. Recorded households in 2004 were 0.3 million in overall Balochistan. Electricity demand of electrified households was projected and calculated as function of GDP and share of electricity consumption by households at rural and urban level

Table 1 Urban and rural households demand for electricity

Units: Gigawatt-Hours							
Area	2004	2008	2012	2016	2020	2024	2028
Urban	294	609	1018	1544	2212	3053	4106
Rural	84	102	124	150	180	244	323

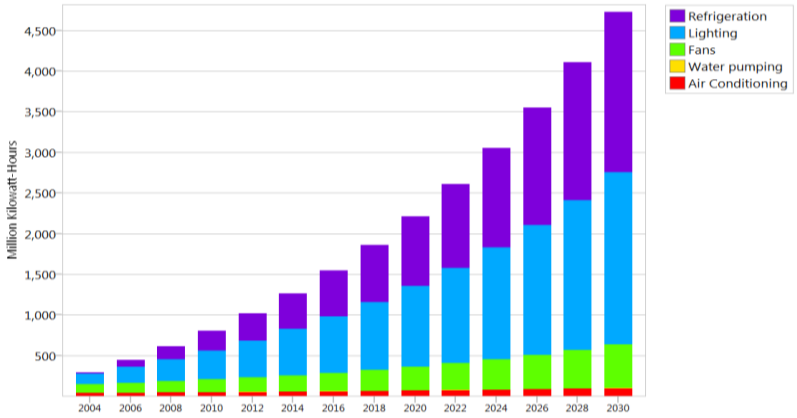

Fig. 3.1 Projection of urban demand for electricity developed by LEAP model

(PEPCO 2010). On the other hand the percentage share of electricity consumption in different appliance at urban and rural household levels was derived from baseline study conducted by Asian Development Bank in 2009 (ADB 2009).

Scenario Construction: Three scenarios i.e., Baseline scenario and two other alternative scenarios were built in order to predict household electricity demand at urban and rural level in Balochistan province.

Scenario 1: Baseline Scenario

This scenario also named as Business-As-Usual (BAU). BAU built as reference scenario and 2004 was taken as base year. Values in BAU were about electricity demand at rural and urban level from base year up to end year 2030. Values were projected by extrapolating the base year data upto 2030.

Scenario 2: Wind Energy Scenario

Under baseline scenario two more scenarios were created. One of them was wind energy scenario (WES) as alternative scenario. Pakistan finance ministry published a report on integrated energy planning 2009-2022, according to which Pakistan has potential to generate 0.346 million MW energy from wind source and it has been reported that proposed consumption of wind energy is 5 percent currently by installing wind turbine for electricity generation (EAC 2014). So BAU would be reduced by 5% as whole and 1% by each branch of electricity consumption.

Scenario 3: Solar Energy Scenario

Other alternative scenario built under BAU was Solar Energy Scenario (SES). Solar energy is great source for electricity production in Balochistan. Overall in Pakistan and particularly in Balochistan solar energy potential has been reported 2.9 million MV which is much greater than wind energy. Whereas it has been reported in 2010 by Pakistan Energy Year Book that proposed consumption of energy generated by solar power is 2.5% (HDIP 2010).

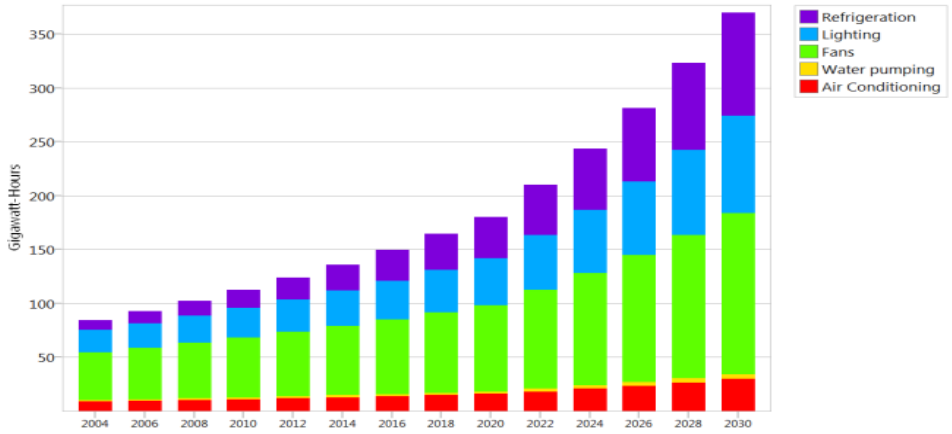

Fig. 3.2 Projection of rural demand for electricity developed by LEAP model

Table 2 Different scenarios comparison for electricity consumption

Units: Million Kilowatt-Hours						
	Years					
Scenarios	2005	2010	2015	2020	2025	2030
BAU	392	468	557	664	791	941
SES	382	402	422	443	465	487
Decrease	10	66	135	221	326	454
% decrease	2.5	14	24	33	41	48
WES	388	440	499	566	640	724
Decrease	4	28	58	98	151	217
% decrease	1	5.9	10	14.7	19	23

*The bold values highlight the percentage change

3. Results

LEAP model of two alternative scenarios under baseline scenario was run in order to evaluate and forecast electricity demand since 2004 base year to end year 2030. Electricity demand on the basis of base years was calculated as product of total activity and energy intensity given in Eq. (1) (Heaps 2012).

$$D = TA \times EI \quad (1)$$

(Whereas D used for Demand, TA for Total Activity and EI for Energy Intensity)

Results of BAU scenario: In order to forecast electricity demand for future time period in Balochistan, 2004 was taken as base year. Results of BAU scenario showed that the total consumption of electricity by households at urban and rural level from 2004 to 2030 was 378 and 5094 million Kilowatt respectively mentioned in Table 1. The demand for electricity in 2030 will be thirteen times more than the energy demand in 2004 in both urban and rural households shown by Figs. 3.1 and 3.2.

Comparison of Scenarios: In this study, potential for solar and wind energy was calculated to

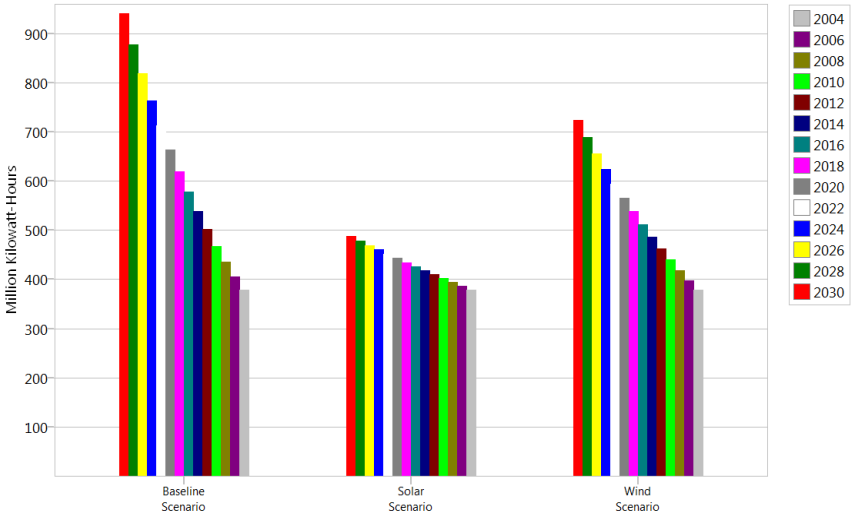

Fig. 3.3 Total Energy Demand (TED) by comparing scenarios

generate electricity in order to meet the future demand of households. By keeping in consideration that proficiency of present-day energy technology retain as unchanged in coming future so BAU was taken as reference scenario. Data of BAU scenario was compared with WES and SES with aim to look over potential capacity of both these alternative scenarios and estimate from calculation that how much WES and SES potential can be generate electricity to fulfill the household demand for future time period up to 2030. In Fig 3.3, it has shown that the TED in Baseline scenario was much greater and will increase with increase population in future years, which it has been projected by interpolation in LEAP model. Contrary, input of alternative energy scenarios have little but significant contribution, because still their percentage brought into being to be decreased from BAU, demonstrating in Table 2.

These results showed that 48% and 23% energy could be saved in future time period by wind and solar energy integration for electricity production. If Government invests and utilizes significant potential of these two renewable energy sources, then Balochistan will not only generate energy to meet the total electricity demand of households at provincial level but will also fulfilled the industrial and commercial demand as well as can export to others.

4. Discussion

From results it has been shown that electricity demand at households level in Balochistan province will be thirteen time higher than the present demand at rural and urban household level. For forthcoming sustainability of this province, energy demand should be optimized by local government management administration. No doubt Balochistan has greater potential of non-renewable resources i.e., coal and natural gas. But these resources can be used with a limitation because these are finite resources. Still households at urban and rural level in Balochistan are facing 2-3 hour load shedding problem especially in summer season. As this study revealed, the potential for renewable energy in Balochistan is much greater and if it is utilized properly then Balochistan can not only become self-dependent in generating electricity to fulfill the future

demand but this province can also export electricity (Mehboob 2012). So government must work on it, move towards for this sustainable energy generation by mean of wind and solar power. By adopting these two green technologies, more lives will be developed in Balochistan. So policies related to the energy in Balochistan should be directed headed for electricity generation by mean of green technology. One study was done on energy demand in Iran at household level by using LEAP model. For this study, base year and end year was 2011 and 2036 respectively in order to project energy demand at household level. Like present study, alternative scenarios were constructed. Total seven scenarios were built and results revealed that Natural gas consumption will be greater up to 2036 and consumption of electricity raised 21 Million KWh till 2036. Outcomes of this study also showed that 23 percent energy could be saved by adopting suggested alternatives form of energy (Abbaspour *et al*. 2013). Similarly present study was designed on simulation modeling for electricity consumption in Balochistan. Comparative to discussed case study of Iran, base year was 2004 and end year was 2030 for electricity demand projection. It has been suggested that Balochistan has great potential of wind and solar energy and there are 8-10 hour of sun light and more than three hundred sunny days per year. So if recommended green energy technologies get integrating by Government of Balochistan in future plan and policies then Balochistan will not only fulfill its raising demand for electricity but also save its energy for future demand. This study directed government administration to make plans for future towards sustainable development.

5. Conclusions

With the passage of time, along with increasing population growth, more households in villages and non-electrified areas will get connection of electricity; TED will increase year by year in coming future as shown by the results. In Balochistan regardless of dam construction or extending the existing capacity of dams and the existing capacity to generate electricity by coal and gas will be diminish because both sources are renewable to fulfill and meet the upcoming increasing demand at household's level or in any other sector. Only solution to this problem and short fall crisis of electricity which the population facing at both rural and urban level, lies in utilizing the great potential of non-renewable energy sources that are present in Balochistan province. It is fact that, yet having great potential for solar and wind energy in this province, no significant input was made by these two alternative sources in energy generation. But in forthcoming with lot of proposed projects and planning by different companies, agencies and local government, Balochistan will produce electricity from these two renewable energy sources at large scale.

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