Quantifying the Present Challenges and Future Perspectives of Energy Crisis in Pakistan

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ABSTRACT

Long-term forecasting of energy demand and supply is extremely important for sustainable development. This study provides a general overview of energy consumption in different sectors because domestic, transportation and industrial sectors are the major contributors of GHG emission. Future energy forecasting helps in the development of sustainable energy scenarios and energy policies. Taking base year 2007, Long-range Energy Alternatives Planning System (LEAP) model is used for the projections of future energy demand, supply as well as for greenhouse gas emissions in different sectors for coming decades. Three scenarios Business-as-usual (BAU), Biomass conversion (BC) and Cleaner technology were constructed. The results showed rapid increases in energy demand and GHG emissions until 2030. In 2030 increase in energy demand and GHG emission predicted upto 41.3% and 315.4% respectively. In order to sustain this energy demand biomass conversion (BC) scenario proved to be better as Pakistan has a huge potential of renewable resources.

Key words: Energy demand, GHG Emissions Reduction, Renewable Energy, Pakistan

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INTRODUCTION

Energy is the most important tool for development as well as for industrialized economy. For continued human development supply of adequate, secure and inexpensive energy is necessary. Pakistan is facing serious energy shortage problems over the last few decades. The energy system which is composed of demand and supply system is highly interdependent and complex. With the growing energy demands the energy supply is not increasing and as a result every year, the gaps between the energy demand and supply increases. This Gap results in an increase in oil price, ultimately leading to a global recession [1]. The dominant energy resources of Pakistan are oil and gas while renewable energy and coal are the next important resources. Energy sustainability is becoming a global necessity and energy resources are obtained from the environment [2]. The consumption of enormous amount of energy is directly linked to environmental degradation that affects all the life forms on planet earth.

Total energy supply by different sources is given in table 1. In Pakistan for the fiscal year 2007-2008 the total energy supplies were 62.8 MTOE (Million Tons of Oil Equivalent). The share of (29 MTOE) gas accounts for 47.5% of energy supplies, followed by oil at 30%, hydel and

nuclear at 12.10% and coal at 9.20%. Currently indigenous resources provide only 20% of the oil demand [3].

Table 1. Primary Energy Supply by Source [3]

Source	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	ACGR% Share
Oil	29.90%	29.40%	28.30%	30.00%	30.50%	32.10%	5.70%
Gas	49.70%	50.30%	50.30%	48.40%	47.50%	48.30%	3.70%
LPG	0.40%	0.50%	0.70%	0.80%	0.70%	60.00%	14.30%
Coal	6.50%	7.60%	7%	7.30%	9.20%	7.60%	7.50%
Hydro Electricity	12.60%	11%	12.70%	12.60%	10.90%	10.60%	0.60%
Nuclear Electricity	0.80%	1.20%	1%	0.90%	1.20%	0.60%	-1.70%
Imported Electricity	0%	0%	0.10%	0.10%	0.10%	0.10%	25.50%
Total Annual growth	8.06%	9.31%	4.39%	4.44%	3.80%	-0.56%	4.20%

Table 2. Final Energy Consumption by Source [3]

Source	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	ACGR % Share
Oil	38.50%	36.50%	32.00%	29.40%	29.30%	29.00%	-0.50%
Gas	34.70%	36.20%	39.30%	40.80%	40.30%	43.70%	10.10%
Coal	9.30%	10.30%	11%	11.50%	13.70%	10.40%	7.60%
Electricity	16.20%	16%	16.20%	16.40%	15.20%	15.30%	4.10%
LPG	1.30%	1.40%	2%	1.80%	1.60%	1.50%	8.40%
Total Annual growth	10.15%	10.78%	5.74%	6.07%	9.46%	-5.25%	5.20%

Table 3. Sectoral Energy Consumption [3]

Sector	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	ACGR % Share
Domestic	6,278,918	6,812,535	7,054,587	7,605,145	8,046,294	8,092,132	5.20%
Commercial	927,633	1,080,235	1,247,992	1,377,247	1,455,527	1,459,817	9.50%
Industrial	11,096,624	12,759,957	14,654,360	15,729,049	16,804,303	14,845,670	6.0%
Agriculture	734,202	717,151	732,699	767,266	803,837	798,008	1.50%
Transport	9,281,160	10,071,427	9,493,667	9,721,183	11,567,394	11,371,869	4.10%
Other Govt.	658,393	662,631	762,384	742,364	735,712	786,045	3.60%

Fossil fuels and biomass based fuels contribute to 60% and 36% respectively to the primary energy supply mix. Total electricity supply provided by hydropower and nuclear power is 33% and 2.4% respectively. The largest consumer of electricity is domestic sector accounting for 44.2% followed by consumption of industrial and agricultural sector [4]. The energy consumption by different sectors is given in table 3. During the last four fiscal years (FY04-08), the energy grew by 8 percent, whereas with significant shift in energy supply mix from gas to oil the energy supplies have risen by 5 percent [5]. Consumption of energy in different sectors as seen from table 3, generates a considerable amount of greenhouse gases (GHGs) along with other air pollutants. According to IPCC report in 2007 global warming potentials for CH_4, N_2O, CO and NMVOC are taken as 25, 298, 1.9 and 3.4% respectively from energy and non-energy related activities in Pakistan with the increase in 3.2% growth rate of CO_2. In order

to combat the harmful impacts of climate change it becomes extremely important to reduce the emissions of GHGs [6].

The role of renewable energy for the sustainable energy future of Pakistan is very crucial. Its estimated hydropower potential is more than 42 GWout of which only 6.5 GW has been utilized so far [7]. The available potential of micro/mini hydropower in northern parts of the country is 1000MW of which less than 1% is being developed [8]. Pakistan is amongst the richest countries in the world in terms of its solar energy potential, having an annual global irradiance value of 1900–2200 kWh/m^2 .The wind power has not been exploited so far, however there are plans to produced energy in future. Currently unsustainable energy use is directly linked with the electricity shortage. Now there is need to develop a strategy which will decrease the dependence on vulnerable energy supply sources and explore the secure and sustainable use of renewable energy resources. Effective utilization of renewable energy resources enables Pakistan to meet its present and future energy needs as well as produces zero or almost nil greenhouse gas emissions and other air pollutants [9].

LEAP model is used worldwide for energy projections. LEAP model was used to analysis the future energy demand of power sector scenarios of Bangladesh [10]. In Thailand energy demand and energy saving potential in transport sector was studied using LEAP [11]. In a similar study LEAP was used to estimate the energy demand and monitoring of vehicular emission in Rawalpindi and Islamabad [12]. Keeping in view the importance of energy for economic growth of Pakistan the present study was aimed to document the future energy requirements of Pakistan in various sectors. LEAP model was used for energy forecasting. Analysis of energy supply and demand, future challenges and prospects was done under the current energy scenario. In order to sustain with current situation and future energy demand as well as for the reduction of greenhouse gases renewable energy resources have been explored.

MATERIALS AND METHODS

LEAP model

In this research LEAP model was used to analyze and forecast the future energy demand and greenhouse gas emissions from 2007 to 2030 under alternative scenarios in various sectors of Pakistan. LEAP is an energy-planning system developed by the Stockholm Environment Institute, Boston [13]. For running the LEAP model at least the data of base year and any of the future years is required. The future energy demand and emissions are estimated for the other years using the function such as interpolation or extrapolation or the growth rate method. To develop a scenario a bottom-up, end-use approach was applied. The energy demand profiles and scenarios were assembled using spreadsheets and a flexible, computerized framework (LEAP).

Scenario Construction

Forecasting the future energy demand and supply analysis is a challenging task. The widely used method for this purpose consists of creating a baseline, usually a business-as-usual scenario, and then evaluating alternative scenarios by comparing them to that baseline. In this study three scenarios were constructed to evaluate the use of renewable resources and cleaner technologies in order to meet future energy demand and reduction of GHG emissions. Three scenarios are as follows.

Reference or Business-as-usual Scenario

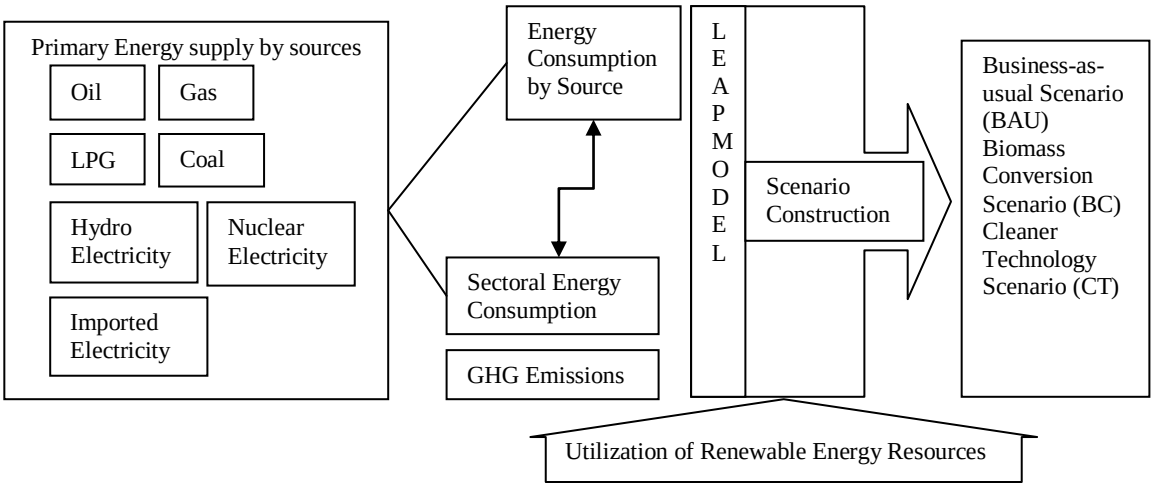
Year 2007 was selected as the base year in reference or business-as-usual scenario. The data of energy supply and consumption by different sources, sectors and greenhouse gas emissions was put in model. The values of energy supply and demand were projected to 2030.

Biomass Conversion Scenario

Renewable energy resources have a huge potential to sustain to future energy demand as well as for nil or zero GHG emissions. In biomass conversion scenario the total energy consumption was replaced at growth rate of 5% by biomass.

Cleaner Technology Scenario

The use of cleaner technologies increasing day by day to meet the global energy demand and to reduce the GHG emission. In this scenario introduction of cleaner technologies at rate of 8% was assumed.



RESULTS AND DISCUSSION

LEAP model was used to forecast the future energy supply and demand in Pakistan for year 2007 and 2030 under the comparison alternative scenarios. It also estimated the GHG emissions for BAU and alternative scenarios. Total energy reservoirs projections were also made along with the estimated share of different sources in energy supply and demand. Year 2007 was taken as base year and time period was projected from 2010 to 2030 to forecast future increase in energy supply and consumption in different sectors and total GHG emissions.

Comparison of BAU and Alternatives Scenarios

The BAU was taken as a reference and compared with alternative scenarios in order to investigate the potential of alternative scenarios to sustain the future energy supply and demand in different sectors and to reduce the GHG emissions form energy and non energy related sources. This comparison enables the sustainable use of energy sources as well as to check the GHG mission reduction in alternative strategies.

The total energy reservoirs of Pakistan in 2007 were 47, 605 and 1527 million tonnes of oil, gas and coal respectively with the growth rates 0.25%, 5.1% and 3.2%. Fig. 2 depicts that in 2010 and 2030 the total energy reservoirs of Pakistan increased upto 2428.1 and 5100.4 million tonnes respectively. A significant increase of coal reservoir was observed in coming years.

Comparison of all three scenarios in Fig. 1 clearly suggests the use of biomass conversion and cleaner technologies for wise use of fossils fuels as these reservoirs were already at decline. In case of alternative scenarios the values were found to be 13794.5 and 13788.2 million tones for BC and CT as compared to the total energy reservoirs of Pakistan in BAU was found to be 18167.3 million tones.

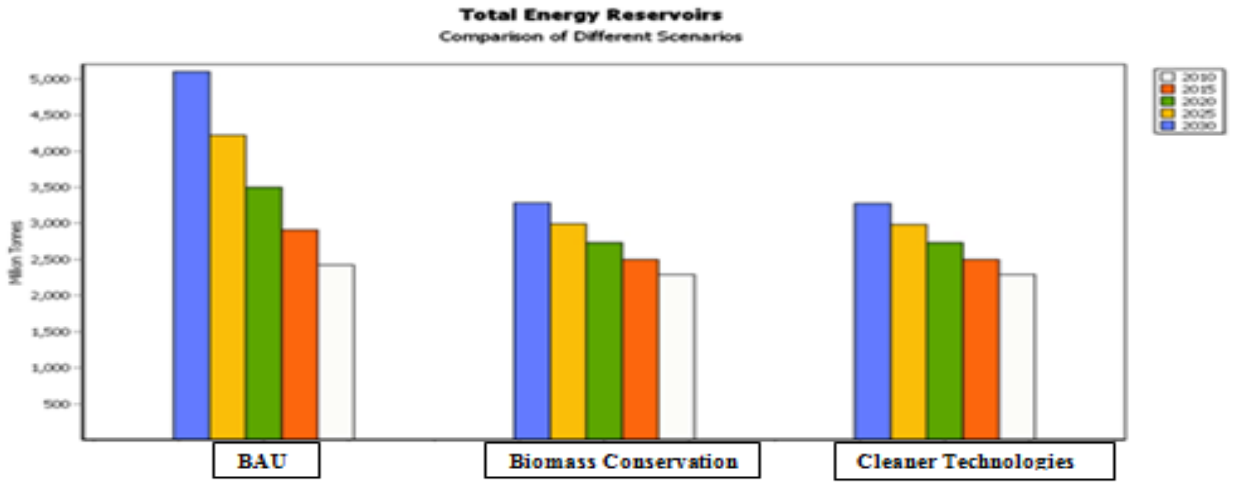


Figure 1. Comparison of scenarios for total energy reservoirs

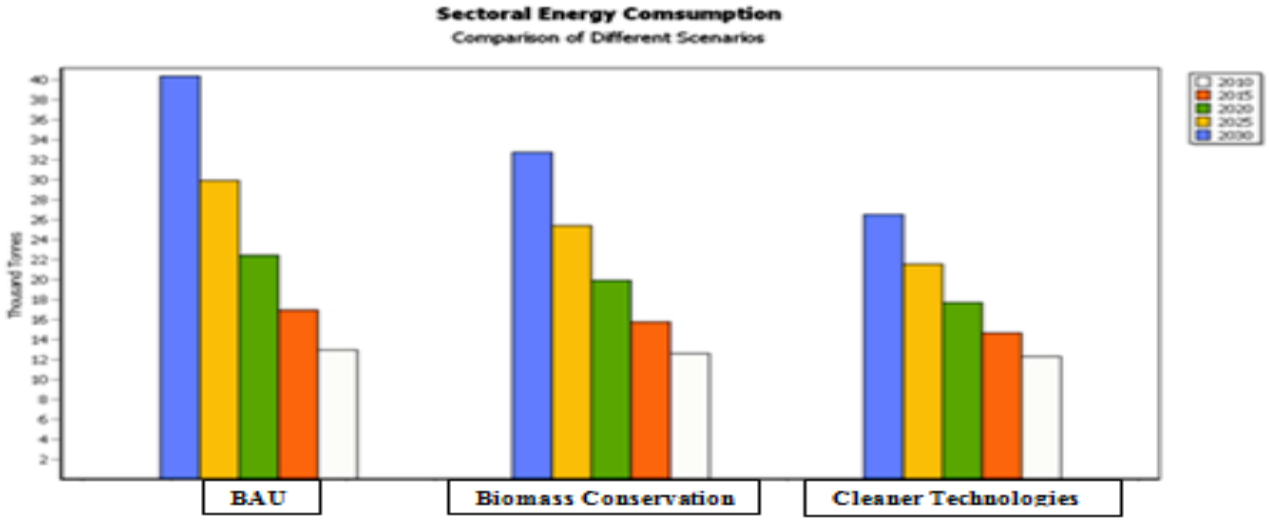


Figure 2. Comparison of scenarios for Sectoral energy consumption

In 2007 the energy consumption by different sources of Pakistan was 39,413,069 thousand tones (table 2). The estimated consumption of same sources increased by 13.7% and 41.3% in 2010 and 2030 respectively. While the total energy supply by different sources were values found to be 15.6% and 56.8% by the year 2010 and 2030 respectively. It is clear that the consumption of natural gas was much higher as compared to other fuels. There was limited supply of other fuels to meet the future energy demands. In BAU the total energy supply by different sources was calculated to be 155 thousand tonnes, which decreased in BC and CT scenarios and their values were calculated to be 131.2 and 118.9 thousand tonnes respectively. Similar trend were observed in the values of total energy consumption like supply by sources decreased in alternative scenario as compared to BAU. In BC and CT the value found to be 108.8 and 96.9 thousand tonnes respectively suggesting the use of alternative technologies.

Sectoral energy demand in 2007 was given in table 3. The total energy demand in various sectors was 39,413,069 thousand tones. Is was analyzed from Fig.2 that energy consumption in 2010 and 2030 increased up to 13.7% and 41.3% respectively. The demand of energy in domestic sector was greater than in all other sectors. It was observed that the energy consumption by sectors can be controlled by using alternative measurements. In BAU its value was 122.6 thousand tones whereas in BC and CT the values were found to be 106.4 and 92.7 million tonnes respectively.
During 2007 the amount of CO_2 emission was 149,518 thousand tonnes which was greater than CH_4 and other pollutants. An increase of 169 and 315.4 million tonnes in greenhouse gas emission was observed in 2010 and 2030 respectively (Fig. 3). The CO_2 was major contributor in greenhouse gas emissions.

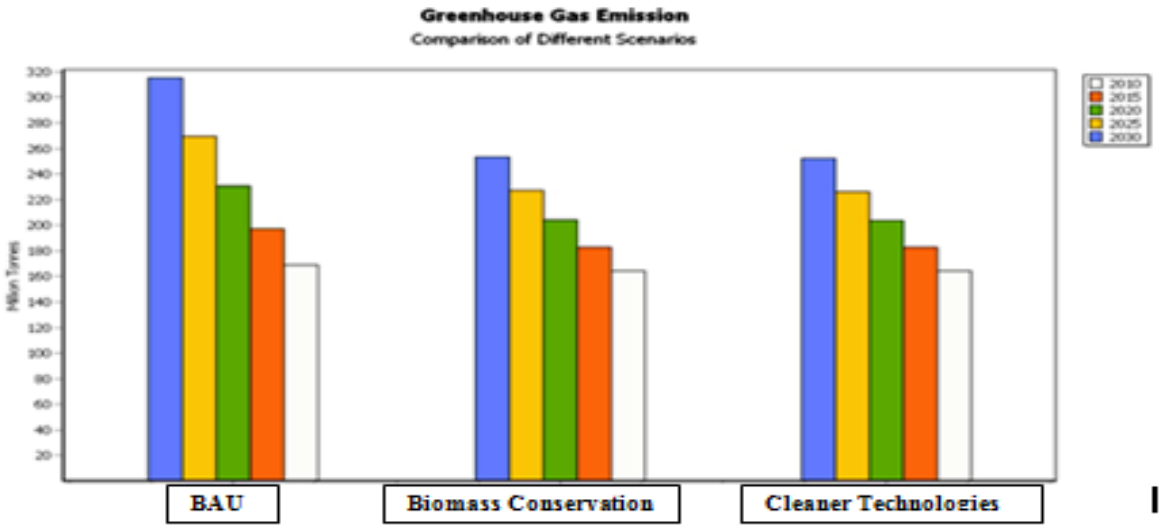


Figure 3. Comparison of scenarios Greenhouse Gas Emissions

In Fig.3the total greenhouse gas emission in BAU were found to be 1182.4 million tones whereas its amount decreased in alternative scenarios. A significant decreased was observed in case of CT and the amount of emissions in BC was 1031.9 million tones and in CT 1028.7 was million tones.
By the use of alternative techniques, the climate change mitigation is possible. For the sustainable energy future of Pakistan it is necessary that energy sector must be at high priority. Exploitation of renewable energy sources be encouraged in order to reduce the dependence on fossil fuels as primary energy source.

CONCLUSION

In present study LEAP model forecasted the future energy supply and demand of Pakistan. It generates convincing results as Pakistan needs to diversify its primary energy supply mix in order to provide a secure sustainable energy future. Renewable energy has a very important role to play in order reduces the gap between energy supply and demand and diminishing indigenous fossil fuel reserves. In this study both the scenarios give better results but the BC scenario gives significant results as compared to BAU. Pakistan having a huge potential of renewable energy and must generate at least 10% of its energy demand through these resources in order to cope with current energy crises. Environmental pollution can be controlled by the use of innovative cleaner technologies and switching to biomass. However there are still barriers in the

development of renewable energy resources in Pakistan, which can be overcome by proper planning and financing programs.

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