Analysis of the Power Generation Energy Sources in Pakistan

Conference Paper · November 2006

CITATION
1

READS
8,393

3 authors:

Hafeez Ur Rahman Memon
Mehran University of Engineering and Technology
44 PUBLICATIONS **176** CITATIONS
SEE PROFILE

Mohammad Aslam Uqaili
Mehran University of Engineering and Technology
129 PUBLICATIONS **1,065** CITATIONS
SEE PROFILE

Gordhan Valasai
Quaid-e-Awam University of Engineering, Science and Technology
40 PUBLICATIONS **325** CITATIONS
SEE PROFILE

ANALYSI OF THE POWER GENERATION SOURCES IN PAKISTAN

DR. HAFEEZ UR RAHMAN MEMON [a], GORDHAN DAS VALASAI*, DR. MUHAMMAD ASLAM UQAILI [b], and DR. MUHAMMAD IBRAHIM PANHWAR [c]

[a] Professor, Institute of Petroleum and Natural Gas Engineering
* Ph D Scholar and [c] Professor, Department of Mechanical Engineering
[b] Professor, Department of Electrical Engineering

Mehran University of Engineering and Technology, Jamshoro, Pakistan
([*]Corresponding author: Tel (92) 333 2743180, Fax (92) 22 2772196, Email: valasai@gmail.com)

ABSTRACT

The continued economic growth and human development depends upon energy. Energy is so vital in today's life that one cannot even imagine life without it. All of our actions are dependants of energy.

Pakistan is an energy deficit country and heavily depends on imported energy. Most of its rural population has no access to commercial energy sources. The electricity demand in Pakistan is increasing at a fast rate each year. Pakistan's total energy requirement would increase by about 48 per cent to 80 million tons of oil equivalent (MTOE) in 2010 from about 54 MTOE currently.

The paper concludes that the current state of the power generation sources in Pakistan is not satisfactory. The demand of energy is increasing at the exponential rate. The indigenous oil and gas, the major share contributors in meeting the energy demands in the country; reserves are to last for only 2 and 21 years respectively, according to current reserves to production ratio.

This paper suggests that the renewable energy sources are the best option for meeting the future energy demands. Also the oil and gas exploration activities to be further increased along with import of oil and gas from neighboring countries.

Keywords: Pakistan, Power Generation Energy Sources, Oil and Gas Reserves, Renewable Energy

1. INTRODUCTION

The continued economic growth and human development depends upon energy. Energy is so vital in today's life that one cannot even imagine life without it. All of our actions are dependants of energy. The complexity of energy system can be observed that the demand of energy depends upon economic structure, economic activity, income levels, geography, climatic conditions, technology, natural resources availability, and access to indigenous energy resources, life styles, policy factors, laws and regulations. The demand of energy has always been increasing; the growth rate in developing countries is higher than in developed countries. Developing countries meet their energy demands through import. They face difficulty in security of energy supply and energy prices. Energy price is the major influential factor that affects the economic development and growth; past few years have shown a rapid growth in energy prices. Population, living standards, and rapid urbanization also affect the energy demand.

Energy absorbs a large share of available foreign exchange and capital investments. The inability to supply the needed energy can frustrate the economic and social development, due to lack of financial resources in the developing countries. More than two thirds of the developing world population lives in rural areas, with low standards of living. This population has little access to commercial fuels and relies heavily on traditional sources of energy having very low efficiencies. Energy security can be greatly enhanced by energy conservation and efficiency measures, because reducing energy intensity will reduce the dependence of the economy on energy conservation and imports.

2. POWER GENERATION AND DEMAND IN PAKISTAN

Pakistan is an energy deficient developing country, which meets most of its energy demands through import. The economic growth requires adequate energy supply. The energy consumption in the country reached 55.5 MTOE during 2004-05 as compared to 50.8 MTOE in 2003-04. (1) Oil, gas, hydro, coal, nuclear are the conventional and traditional fuels (fuel wood, agricultural and animal wastes), solar and wind energy are the non-conventional electricity generation energy sources in Pakistan. It is clear from figure 1 that oil contributes a 29.4 % share in meeting primary energy demands, gas as 50.3 %, coal 7.6 % and hydro and nuclear contribute 12.2 % share. (1)

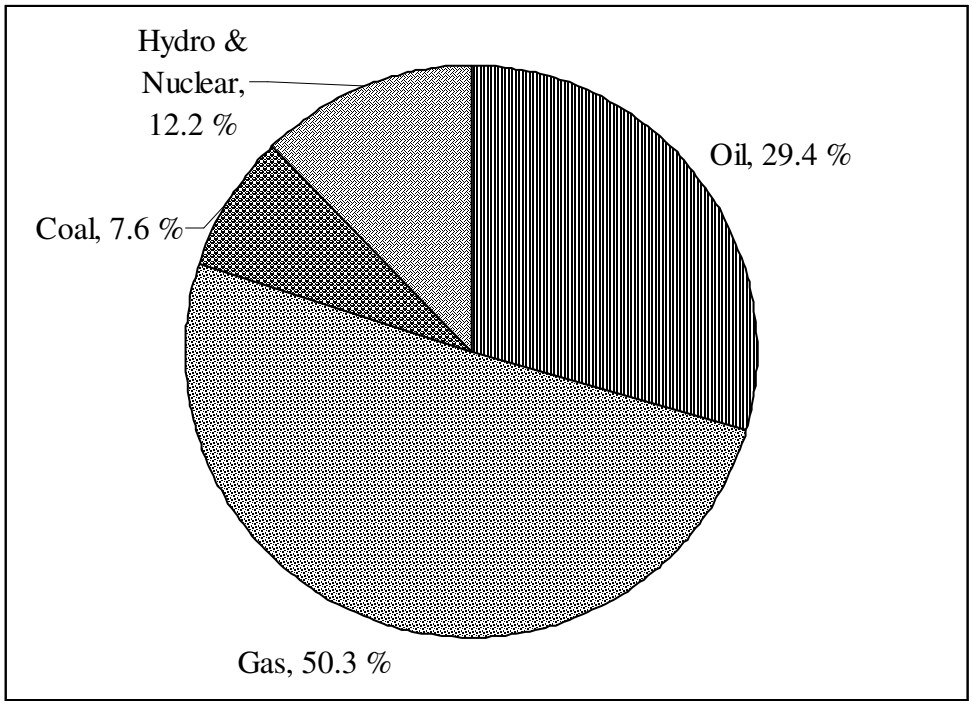

Fig. 1: Share of different energy sources in power generation in year 2004-05

Despite the fact that electricity sector consumes large amounts of economic, social and environmental resources, still it plays a major role in promoting economic and social development in any nation. The total installed generation capacity in Pakistan stands at 19379 MW in 2004-05, against 11526 MW a decade ago. (2) The per capita electricity consumption in Pakistan is about 492 kWh, as compared with US figure of 13228 kWh per capita (3). About 66 % of the total population resides in rural areas; they have no access to electricity. (4) The number of electrified villages has reached 99595 in March 2006; the government has planned to electrify all the villages by year 2007. (5, 7)

Figure 2 shows the share of different energy sources in power generation in Pakistan and shows that natural gas contributes a major share, 50.8 % in power generation in the country, followed by oil 15.8 %, hydro 30%, nuclear 2.3 %, and coal only 1.2 %. (1)

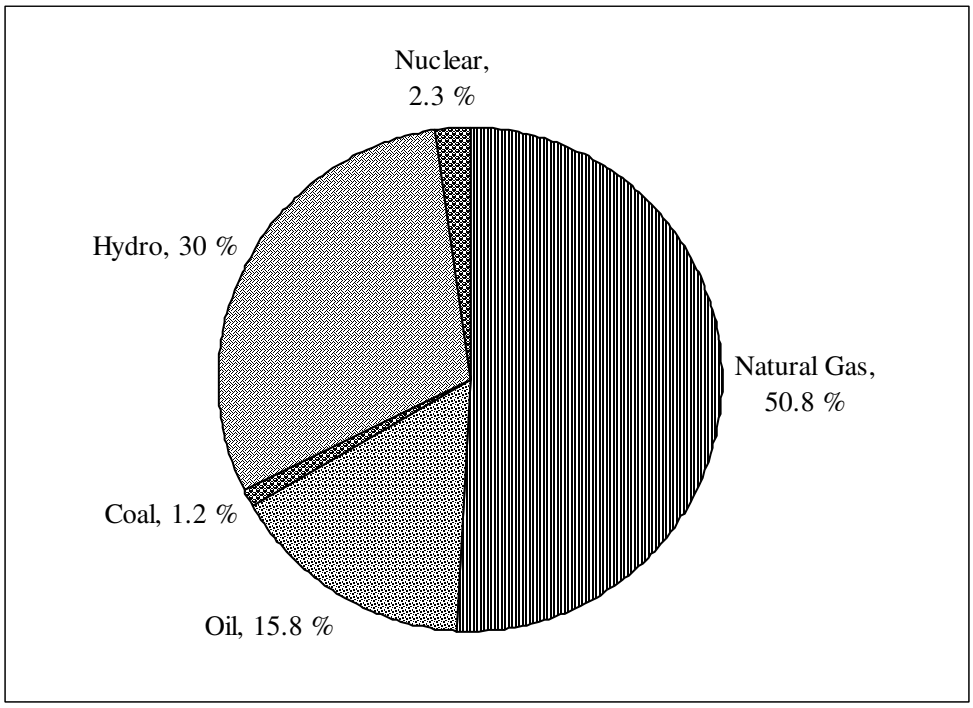

Fig. 2: Share of different energy sources in power generation

3. CONVENTIONAL POWER GENERATION ENERGY SOURCES

3.1 Oil

Pakistan is an oil importing developing country, more than US $ 5.5 billion were spent on oil import in year 2005 alone, due to rapid increase in demand and prices. (7) Pakistan has very limited oil reserves, according to Pakistan Energy Yearbook, 2005; there was a total of 113 MTOE of original recoverable reserves available. After a cumulative production of 71 MTOE, now balance recoverable reserves are 41.4 MTOE. (1) According to current reserves to production ratio, these reserves will last for 2.5 years only, unless new reserves are not explored. (15)

According to the Ministry of Petroleum and Natural Resources, indigenous crude oil meets 18 percent of total demand; the remaining 82 percent of demand is met through imports of crude oil, high-speed diesel, and fuel oil. In fiscal 2005, 8.3 million tons of crude oil, 4.2 million tons of HSD, and 1.5 million tons of fuel oil were imported, at a total cost of $4.5 billion. (6)

Oil contributes about 38.3 % of the primary commercial energy supply in the country. Transport and power sectors are the major consumers of oil. These two sectors consume more than 85 % of total oil consumption, industrial 10.5 %, domestic 1.3 %, agricultural 1 %, and government 2.2 %. Pakistan is currently producing 66079 barrels per day in 2004-05. Despite continuous increase in price, and government's policy to switch over natural gas for power generation, the demand of oil is increasing.

3.2 Natural Gas

The demand of natural gas will continue to increase more rapidly as compared with other fuels due to improvements in the technologies for exploration and production, natural gas releases less harmful combustion products per unit of energy produced, number of new applications of natural gas such as motor fuel for transportation that increase the demand and it is also less costly than other fuels.

Natural gas was discovered at Sui in 1952 for the first time in Pakistan. It is the largest gas reservoir in the country. The balance recoverable natural gas reserves in the country are 16.25 MTOE, out of 42.67 MTOE original recoverable reserves, 26.43 MTOE have already been produced. Pakistan is ranked 29th in natural gas recoverable reserves in the world. (8) According to current reserves to production of natural gas in the country, these reserves will last for only 22 years only, unless new reserves are not explored. Power is the largest natural gas consuming sector of Pakistan. In year 2004-05, 43.7 % natural gas was consumed by power sector followed by general industry 19.5 %, domestic 14.8 %, fertilizer (as feedstock) 12.9 %, fertilizer (as fuel) 3.5 %, commercial 2.3%, transport (CNG) 2.1 % and cement industry 1.2%. (1, 4) The share of different sector in consumption of natural gas in year 2004-05 is shown in figure 3.

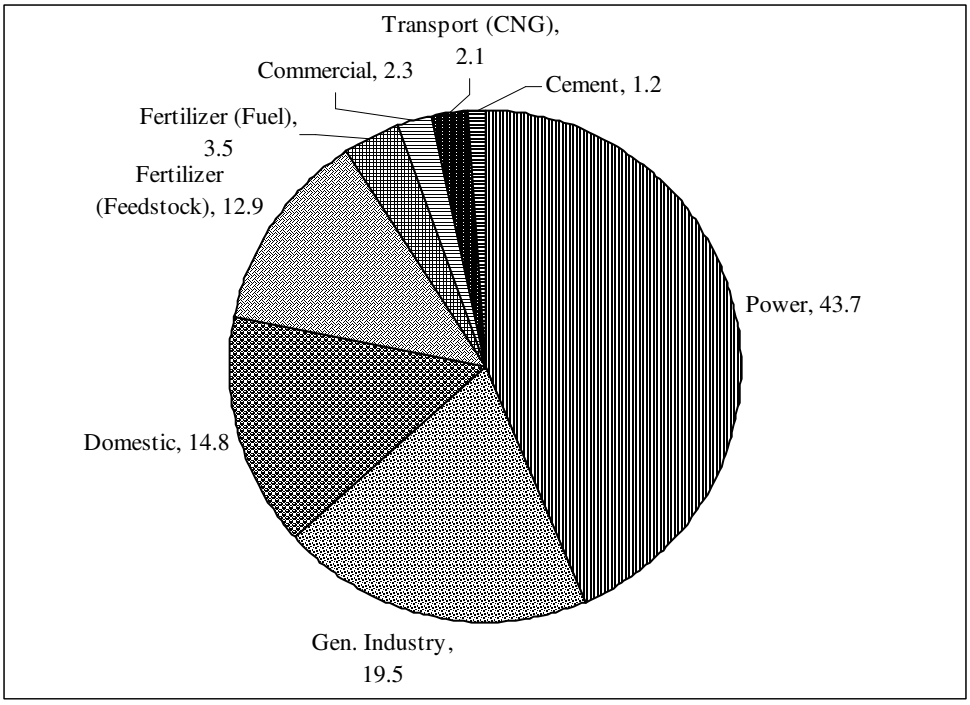

Fig. 3: Share of different sectors in consumption of natural gas in year 2004-05

The demand of natural gas has increased by annual average rate of 10.3 % since 1999-2000, it is also expected that this demand will continue to increase, as government plans to build more natural gas based power plants, increasing supply to domestic sector.

This will also lead to increase in import bill, as government also plans to import natural gas from neighboring countries. Talks are being held on a gas pipeline project, extending from Iran to India via Pakistan. Other options are also available to Pakistan like Qatar and Turkmenistan.

3.3 Coal

Coal is the most abundant fossil fuel and is available in many parts of the world. (10) Three countries United States, China and former USSR together, account for roughly two-thirds of the world reserves. In past few years increases in coal production and consumption have been most rapid in China and India, the fast growing developing countries. China, already world's largest consumer of coal, might triple its consumption by year 2030. (9) The fact remains, that coal emits more carbon per unit of energy than any other fuel. There is not cheap and acceptable way of removing and disposing of the large amounts of CO2 generated through coal consumption.

Share of coal in primary energy supplies in the country is only 7.6 %, despite availability of huge coal reserves. The total coal reserves in the country are 185 billion tones, ranging from sub bituminous to lignite, heating value ranging from 5500 to 14300 Btu/lb. More than 175 billion tones are located in southeastern district Tharparkar. (1) Thar coal is low in ash and sulphur content, but high moisture ranging from 26 to 55 %. There is only one coal fired power plant in Pakistan; Lakhra Power Station at capacity of 150 MW now this power station is not working at its rated capacity. (7, 16)

The coal production in the country has increased by annual average rate of 7.7 % since 1999-2000. 49.5 % coal is consumed by brick kilns, 32.1 % by cement industry, 16.1 % as coke use, and only 2.3 % in power generation sector. (1)

3.4 Hydroelectric

Hydro electricity is a mature technology and has been developed all around the world. It remains the most developed renewable resource worldwide but is now constrained due to societal and environmental barriers. (18) Hydropower plants provide inexpensive electricity and produce no pollution. And, unlike other energy sources such as fossil fuels, water is not destroyed during the production of electricity; it can be reused for other purposes as well.

There is about 700 GW of hydro capacity in operation worldwide, generating 2600 TWh per annum (approximately 19% of the world's electricity production). (11) About half of this capacity and generation is in Europe and North America, but the proportion is declining as Asia and Latin America commission large amounts of new hydro capacity. Hydropower also plays an important role in reducing emissions of GHGs, by an estimated 10%, through displacement of thermal generation. Small, mini- and micro-hydro plants (usually defined as plants less than 10 MW, 2 MW and 100 kW, respectively) play a key role in many countries, often being the mainstay of rural electrification. An estimated 300 million people in China, for example, depend on small

hydro. Only 18% of the world's technically feasible hydro potential and 28% of the economic potential have been developed so far. Around 6400 TWh per annum economic potential therefore remains to be exploited. (11, 13)

Hydropower generation has been and will continue to be an integral part of the generation mix for Pakistan. The share of hydropower in the total electricity production was 70 % in 1960 reduced to only 30 % in year 2004-05. (1) The approximated potential of hydro power in Pakistan is about 40000 MW, out of which only 6494 MW (only 16 % of the total) has been developed so far. (13)

3.5 Nuclear

In 1965 Pakistani officials contracted with the Canadian government for the supply of a 125-megawatt pressurized, heavy water nuclear reactor, which in 1972 became operational near Karachi. Currently there are only two nuclear power plants in Pakistan Karachi Nuclear Power Plant (KANUPP) producing 137 MW of power and Chashma Nuclear Power Plant (CHASHNUPP) with an installed capacity of 325 MW. The total nuclear power capacity is 462 MW, which is only 2.9% of the total generation. KANUPP has completed its 30 years life and is now producing only 70 MW against its installed capacity of 137 MW. Of the total power produced, KANUPP consumes 10 MW for its own operations. (1, 4, 7)

Nuclear power has always had a great potential in Pakistan, but this potential has remained largely untapped due to financial difficulties and a lack of adequate technical capabilities. If technical and financial support is available, nuclear power can play a more significant role in the coming decades.

4. NON-CONVENTIONAL POWER GENERATION ENERGY SOURCES

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but they are depleting at fast pace and at the same time damaging to the environment and to human health. The potential of renewable energy sources is enormous as they can in principle meet many times the world's energy demand. Renewable energy offers important benefits as compared to conventional energy sources. Renewable-energy resources are abundant; worldwide, many times more energy reaches the surface of the earth from the sun than is released today by all fossil fuels consumed. Like fossil fuels, renewable-energy resources are unevenly distributed throughout the world. (17)

Technological advances offer new opportunities and declining costs for renewable energy technologies which, in the longer term, could meet a greater share of the rapidly growing world energy demand. The cost of solar and wind power systems have dropped substantially over the past 30 years and continue to decline, while the prices of oil and gas continue to fluctuate.

Renewable energy sources currently supply about 14 percent of world's total energy demand. (9) The supply is dominated by traditional biomass, mostly fuel wood

used for cooking and heating, especially in developing countries in Africa, Asia and Latin America. (12) A major contribution is also obtained from the use of large hydropower; with nearly 20 percent of the global electricity supplies being provided by this source. New renewable energy sources (solar energy, wind energy, modern bio-energy, geothermal energy, and small hydropower) are currently contributing about two percent.

Renewable energy sources are likely to play a key role in world's future energy supply scenarios, and particularly in the developing countries like Pakistan. Like other developing countries, Pakistan is also facing a serious challenge of energy deficit. Pakistan is endowed with renewable energy sources, like micro-hydel in the Northern Areas of the country, wind in the southwestern areas, especially coastal areas and solar energy.

4.1 Wind

Wind energy has the advantage that it can be utilized independently, and deployed locally in the rural and remote areas. Thus the location far away from the main grid finds wind suitable for generating electricity and pumping water for irrigation purpose.

Pakistan has also taken initiatives for the development of grid connected wind farms in the costal areas. A wind farm of 100 MW is expected to be completed at the end of June 2006 at Gharo, Sindh. Once the initial target of generating 100 MW through wind energy is achieved, it will be upgraded to 700 MW by the year 2010 and 9700 MW by the year 2030 (19).

According to survey conducted by Pakistan Meteorological Department, the gross potential of wind power in the coastal areas of Sindh and Baluchistan is estimated about 43000 MW, keeping in view the area utilization constrains etc. the exploitable electric power generation potential of this area is estimated to be about 11000 MW. About 30 windmills for pumping water have been installed for experimental purposes in different parts of Sindh and Baluchistan. (1) The experiment suffered due to low quality mills and lack of proper infrastructure for maintenance.

4.2 Solar

Pakistan has a very good overall solar-energy potential. The average daily insolation rate amounts to approximately 5.3 kWh/m2. Especially the southwestern province of Baluchistan offers excellent conditions for harnessing solar energy. There, the sun shines between 8 and 8.5 hours daily, or approximately 3,000 hours per annum. (20)

Solar energy is a much economical choice for Pakistan as compared to wind energy-respective costs for solar and wind energy are (US cents/kWh) 20 and 77. (21) Availability of solar energy is quite adequate and responsive to the varying energy demand over the year.

4.3 Biomass

The biomass fuel is a renewable source of energy consisting primarily of agricultural residues, tree residues, fuel wood, and dung. In Pakistan, approximately two out of three people live in rural areas; people rely heavily on biomass in the form of fuel wood or charcoal for cooking and heating. Invasion of the forest areas by housing and the demand for wood fuels and other products in different sectors have combined to generate scarcity, and the price of wood for fuel is increasing. (22)

Consequently, the women of these households have to spend a longer period of time to gather lower grade biomass fuels in the form of agricultural and animal residues. The use of lower grade fuel is related to health problems, as exposure to smoke during cooking can cause acute respiratory infection, chronic obstructive lung diseases, low birth weights, lung cancer, and eye problems (22).

5. FUTURE ELECTRICITY DEMAND

The future electricity demand has been forecasted by various researchers show that the demand will increase more rapidly, as country's economic growth is increasing, along with population. Uqaili M.A. et al 1996, has forecasted the electricity demand under four different scenarios, under Heightened Environmental Concerns (HEC) the demand of electricity is projected to reach 13 MTOE by year 2018, in case of Low Oil Price (LOP) the growth is fastest; the demand is projected to reach 17 MTOE. Under High Oil Price (HOP) scenario it increases to 12 MTOE, and under Business As Usual (BAU), the demand of electricity reaches 15 MTOE. Figure 4 shows the demand of electricity by year 2018, under different scenarios, as forecasted by Uqaili M.A. et al 1996. (23)

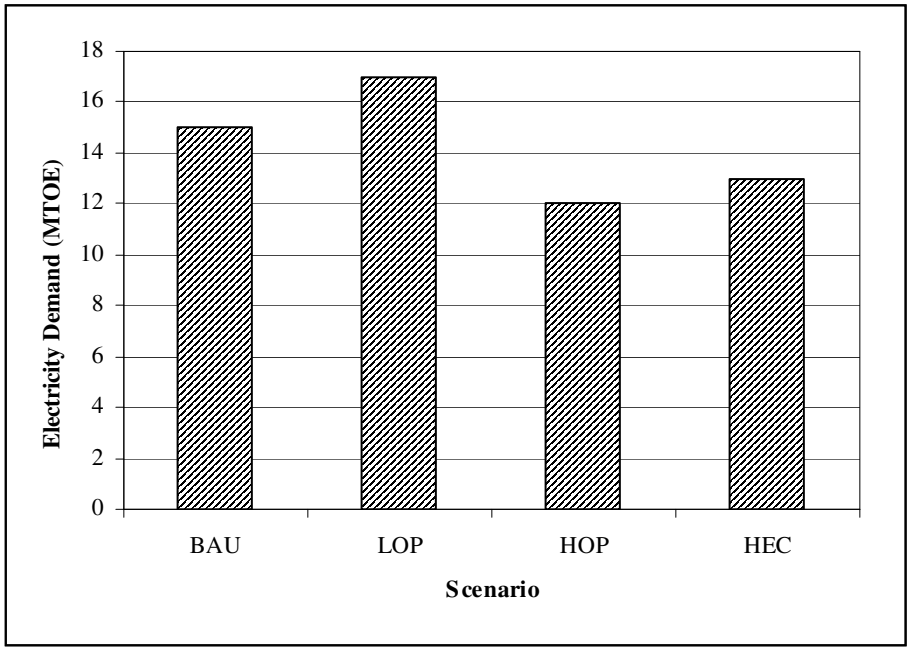

Fig. 4: Electricity demand in year 2018, as forecasted by Uqaili M.A. et al 1994

Harijan, K. et al 2006, has also forecasted future electricity demand under three different scenarios; figure shows the increase in annual total final demand from 2004 to 2030. Under Business As Usual (BAU), scenario electricity demand is projected to 41.77 MTOE in 2030, under Low Economic Growth (LEG), 16.46 MTOE, and under High Economic Growth (HEG) 96.06 MTOE. Figure 5 gives the demand of electricity by year 2030 under different scenarios, as forecasted by Harijan K. et al 2006. (24)

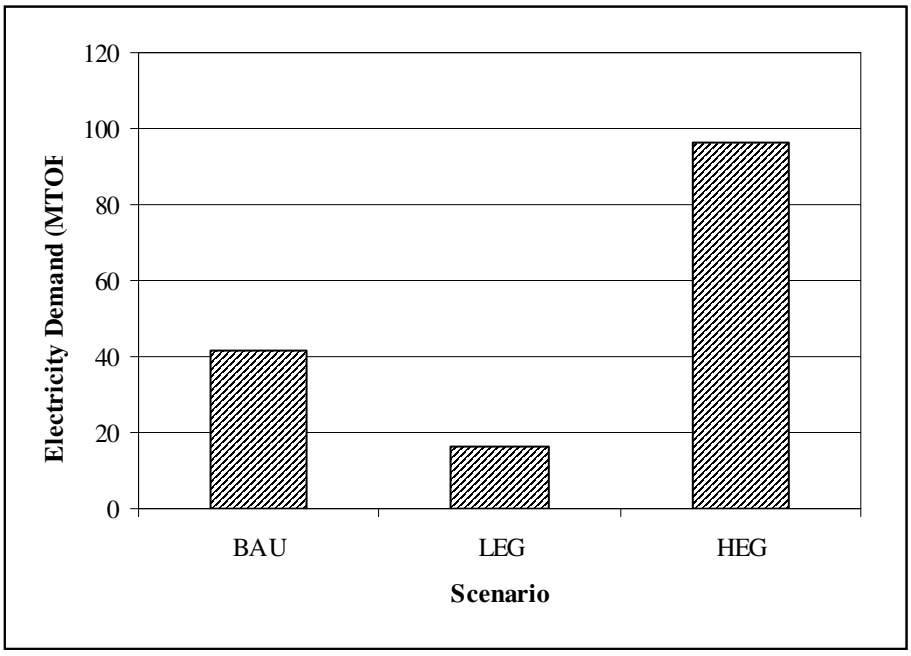

Fig. 5: Electricity demand forecast in year 2030, as forecasted by Khanji Harijan, et al 2006

6. CONCLUSION

Pakistan is fast growing developing country; per capita primary commercial energy (PCE) and electricity supply in the country are only 0.32 TOE and 500 kWh respectively, which are one of the lowest supplies in the world. About 68% of the country's population lives in rural areas and most of them have no access to commercial energy.

The demand of energy is increasing rapidly and the energy sources in the country are depleting very fast. According to current rate of consumption the oil and gas reserves of the country will last for only 2 and 21 years respectively.

Although energy security has been adequate for the past 20 years, and has in fact improved, the potential for conflict, sabotage, disruption of trade, and reduction in strategic reserves cannot be dismissed. The renewable energy source is a good alternate,

to meet the future energy requirements. There is substantial potential of renewable energy sources such as small hydel, solar, wind and biomass energy in the country. The current utilization and future development plans shows that these renewable energy sources alone cannot meet the rapidly growing commercial energy demand in the country.

The indigenous coal resources are the only assured resources available which could meet all current and future commercial energy requirements of the country. By increasing the indigenous exploration and production and also by importing from the neighboring countries, Iran, Qatar, and Turkmenistan, the growing commercial energy demands can be met.

7. ACKNOWLEDGEMENT

The authors acknowledge the Departments of Electrical Engineering and Mechanical Engineering, and Institute of Petroleum & Natural Gas Engineering, Mehran University of Engineering and Technology, Jamshoro, Pakistan for providing the Library, Laboratory and Internet facilities to carry out this research work. The author also greatly acknowledges the Higher Education Commission, Ministry of Science and Technology, Government of Pakistan, for providing financial support.

8. REFERENCES

[1] HDIP. (2005), "Pakistan Energy Year Book 2005", Hydrocarbon Development Institute of Pakistan, Islamabad, Pakistan

[2] WAPDA, Pakistan: "Power System Statistics: Twenty Eighth Issue", 2004

[3] WWW, http://www.iea.org, International Energy Agency, France

[4] GOP, "Economic Survey of Pakistan", 2004, Economic Advisor's Wing, Finance Division, Government of Pakistan, Islamabad

[5] WAPDA, Pakistan: "Load Forecast Update: Forecast period 1998-2018), August, 1998

[6] Ministry of Petroleum & Natural Resources, Government of Pakistan

[7] WWW, http://www.dawn.com Daily Dawn, Karachi, various issues from 2004 to 2006

[8] WWW, http://www.cia.gov

[9] IEA, "World Energy Outlook 2004", International Energy Agency, 2004

[10] "Clean Coal: Building a Future through Technology", World Coal Institute, 2004

[11] Whittington, H. W. "Electricity generation: options for reduction in carbon emissions", The Royal Society, 360, 1653-1668, 2002

[12] Antonia V. Herzog, Timothy E. Lipman, Daniel M. Kammen, "Renewable Energy Sources", Encyclopedia of Life Support Systems (EOLSS), available at http://www.eolss.com

[13] Uqaili, M. A.; Mirani, M.; and Harijan, K. (2004b), "Hydel Power Generation in Pakistan: Past Trends, Current Status and Future Projections", Mehran University Research Journal of Engineering and Technology, Vol. 23, No. 3, pp. 207-216, Jamshoro, Pakistan, July, 2004b

[14] Harijan. K.; Uqaili M. A.; and Memon, M.D. (2005), "Potential of Non

Conventional Power Generation Energy Sources in Pakistan", Proceedings, 5th International R&D Conference, Bangalore, India, 15-18 February, 2005

[15] Gordhan Das Valasai, Dr. Muhammad Aslam Uqaili, and Dr. Hafeez Ur Rahman Memon, "Power Generation Choices for Pakistan in presence of diminishing fuel resources an environmental constraints", presented at International Conference on Environmental Horizons, December 19 – 21, 2005, University of Karachi, Karachi

[16] Gordhan Das Valasai, Dr. Muhammad Aslam Uqaili, and Dr. Hafeez Ur Rahman Memon, "Meeting Electricity Demand through Indigenous Coal based Power Generation in Pakistan", published in proceeding of International Conference on Environmental Management 2005, (ICEM-2005), Jawahar Lal Nehru Technological University, Kukatpally, Hyderabad, Andhra Pradesh, India

[17] Stanley R. Bull and Lynn L. Billman, "Renewable Energy: Ready to Meet Its Promise?", The Washington Quarterly • 23:1 pp. 229–244, WINTER 2000

[18] Ralph E.H. Sims, Hans-Holger Rogner, Ken Gregory, "Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy resources for electricity generation", Energy Policy 31 (2003) 1315–1326, 2003

[19] Mirza, U.K.; Ahmad, N.; Majeed, T.; and Harijan, K. (2006), "Wind Energy Development in Pakistan", Renewable and Sustainable Energy Reviews, DOI:10.1016/j.rser.2006.03.003, May 2006

[20] Mirza, U.K.; Maroto-Valer, M.M.; and Mercedes, M. (2003), "Status and Outlook of Solar Energy Use in Pakistan", Renewable and Sustainable Energy Reviews, Vol. 7, No. 6, pp. 501-514

[21] Muneer, T.; and Asif, M. (2005), "Prospects for Secure and Sustainable Electricity Supply for Pakistan", Renewable and Sustainable Energy Reviews, DOI: 10.1016/j.rser.2005.05.001, June 2005

[22] Wahidul K Biswas, "Bangladesh's Energy Sector: The Past, Present, and Future of Renewable Energy Technologies", University of UNSW 2052, Australia

[23] Uqaili, M.A., "Energy Modelling and Energy Policy in Pakistan". Ph.D. Thesis, Leeds University, U.K. 1996

[24] Harijan, Khanji, "Modelling and Analysis of the Potential Demand for Renewable Sources of Energy in Pakistan". M. Phil Report, Mehran University of Engineering & technology, Jamshoro, Pakistan, 2006