Electrical Energy Crisis in Pakistan and Their Possible Solutions

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Abstract:

This work presents the dilemma of shortfall in the supply of electrical energy that is currently faced by Pakistan. The root cause of this shortage in the supply of energy is mentioned in this work. An abridged history as well as the present situation of the electricity production and its consumption in the country is discussed. The electricity generation potential of Pakistan in different sectors to produce energy is viewed. The importance of utilization of coal resources and water resources for the production of electric power is discussed. Pakistan has been blessed with rich and vast renewable energy (RE) resources. These renewable energy resources can play effective and considerable role in contributing towards energy security and energy independence of the country. Some predictions are made on the basis of empirical data and preliminary observations. An estimated forecast of demand and supply of electricity for the next twenty years is also projected in this article.

Key Words: *Electrical Power energy, energy crisis, electricity generation, renewable energy resources*

1. ITRODUCTION

The electricity Pakistan is presently facing a serious energy crisis. Despite strong economic growth during the past decade and consequent rising demand for energy, no worthwhile steps have been taken to install new capacity for generation of the required energy sources. Now, the demand exceeds supply and hence “load-shedding” is a common phenomenon through frequent power shutdowns. Pakistan needs about 14000-15000MW electricity per day, and the demand is likely to rise to approximately 20,000 MW per day by 2010. Presently, it can produce about 11, 500 MW per day and thus there is a shortfall of about 3000-4000MW per day. This shortage is badly affecting industry, commerce and daily life of people.

All possible measures need to be adopted, i.e., to conserve energy at all levels, and use all available sources to enhance production of energy. It seems that the government is considering importing energy from Iran and Central Asian Republics and using indigenous sources, such as, hydel, coal, waste, wind, and solar power, as well as other alternate and renewable energy sources, besides nuclear power plants for production of energy. Needless to say that if the country wishes to continue its

economic development and improve the quality of life of its people, it has to make serious efforts towards framing a coherent energy policy.

Energy crisis is the most burning issue that is facing by the whole world now a days. It is the one of the basic requirement of economic development and an adequate standard for living. The demand in the electrical energy demands in a country is proportional to the growth in the population. If this demand is not met with the supply, energy crisis is produced.Pakistan has been facing an unprecedented energy crisis since last many years. This problem becomes more severe in summer and as a result shortage of electricity is faced 8 to 10 houres in urban areas while 16 to 18 hours in rural areas. The above mentioned circumstances are due to lake of management and planning. Any power system has three major parts- generation system, Transmission System and Distribution System.

The main technical causes of the shortfall in the ability of energy crisis in Pakistan are

1. Insufficient installed generating capacity
2. Transmission system unable to transmit the load imposed
3. Grid stations and related equipment unable to carry the load imposed
4. Substantial distribution system of power supply

The major management related causes of the crisis are:

1. Faulty management information system
2 Failure of forecast and future planning
3 No new transmission / distribution networks and grid stations

2.1 HISTORICAL BACHGROUND

At the time of independence in 1947, Pakistan inherited 60MW of power generation capability for a population of 31.5 million, yielding 4.5 units per capita consumption. The Government of Pakistan in 1952 by acquiring majority shareholding took control of the Karachi Electric Supply Company (KESC) engaged in generation, transmission and distribution of electric energy to the industrial, commercial, agricultural and residential consumers of the metropolitan city of Karachi and its suburbs.

In 1958, Water and Power Development Authority (WAPDA) was created as a semi-autonomous body for the purpose of coordinating and giving a unified direction to the development of schemes in water and power sectors, which were previously being dealt with by the respective electricity and irrigation department of the provinces.

In 1959, the generation capacity had increased to 119 MW and by that time the country had entered the phase of development, which required a dependable and solid infrastructure, electricity being its most significant part. The task of power development was undertaken by WAPDA for executing a number of hydel and thermal generation projects, a transmission network and a distribution system, which could sustain the load of the rapidly increasing demand of electricity.

After the first five years of its operation by 1964-65, the electricity generation capability rose to 636 MW from 119 MW in 1959, and power generation to about 2,500 MKWH from 781 MKWH. At the inception of WAPDA, the number of electrified villages in the country was 609 which were increased to 1882 villages (688,000 consumers) by the year 1965. The rapid progress witnessed a new life to the social, technical and

economic structures of the country. Mechanized agriculture started, industrialization picked up and general living standards improved.

The task of accelerating the pace of power development picked up speed and by the year 1970, the generating capability rose from 636 MW to 1331 MW with installation of a number of thermal and hydel power units. In the year 1980 the system capacity touched 3,000 MW which rapidly rose to over 7,000 MW in 1990-91.

However, electricity consumption in Pakistan has been growing at a higher pace compared to economic growth due to the increasing urbanization, industrialization and rural electrification. From 1970 to the early 1990s, the supply of electricity was unable to keep pace with demand that was growing consistently at 9-10% per annum. In the early 1990s, the peak demand exceeded supply capability by about 15-25%, necessitating load shedding of about 1,500 - 2,000 MW. On the demand side, there was a weak link between the electricity price and demand, which failed to manage the demand. On the supply side, the main reason behind this capacity shortage was the inability of the public budget to meet the high investment requirement of the power sector, despite the allocation of a high share to this sector. During the 1990s, the economic growth rate of Pakistan declined to a level of 4-5% per annum from a level of 6% per annum in the 1980s.

In order to eliminate power shortage/load shedding in the minimum possible time, the Government constituted an Energy Task Force in 1993 to devise a consolidated and comprehensive policy for revamping the energy sector. On the recommendations of the Energy Task Force, the Government announced a “Policy Framework and Package of Incentives for Private Sector Power Generation Projects” in March 1994 for a large scale induction of private sector in power development. The said policy offered a fix levelized tariff of USD 5.57/kWh to the prospective investors (USD 6.1/kWh average for 1-10 years) and a number of other incentives to attract foreign investment in the power sector.

The Power Policy 1994 helped in overcoming load shedding in the country. Rather, it resulted in surplus power as the actual load growth was much less than that projected and the projects were contracted beyond requirement. Moreover the Policy attracted only thermal projects resulting in reversal of the hydel / thermal generation mix.

In the year 2000, the vertical disintegration of WAPDA started as part of the country’s new electricity market restructuring and liberalization program. Since then WAPDA has been broken down into fourteen separate units: four thermal power generating companies, nine distribution companies and a transmission and distribution company.

In November 2005, the Government of Pakistan privatized (74.35%) the Karachi Electric supply Company (KESC). At present, KESC and WAPDA operate their own networks and are interconnected through 220 KV double circuit transmission lines and can supply power to each other.

On June 30’ 2008, the total generation capacity from WAPDA’s own hydel and thermal sources plus generation from two nuclear power plants, KESC and Independent Power Procedures (IPPs) stood at 19,420 MW.

2.2 Present Situation of Crisis

At Present, less then 45% of Pakistan's population has no access to electricity. The nation is currently facing a 5000 MW power supply shortage - the most severe energy crisis to ever hit the country [3]. The occurrence of prolonged and frequent power outages has had a negative impact on industry operation, the economy and the livelihood of citizens in general. While the energy shortage continues to grow, abundant indigenous sustainable energy resources such as wind, solar and biomass remain virtually untapped[15]. The government attempted to promote the adoption of renewable energy technologies (RETs) in 2006 by implementing its first renewable energy policy. However, this policy has had limited success and faces a number of challenges. These policy challenges must be clearly identified and addressed in order to pave the way forward for a sustainable energy future in Pakistan.

Currently, approximately 60% of power generation in Pakistan is derived from fossil fuels (primarily oil and gas) followed by hydroelectricity (35%) and nuclear energy (2.84%). Figure 1 illustrates the shares of electricity generation by fuel type in 2011.

As it can be observed from the figure, hydro is the only sustainable energy resource which Pakistan employs for large-scale power generation.

The total generation of electricity by different sectors in Pakistan is given in table1. A forecast of demand and generation for years 2009 –2030 is given in the table 2. a careful examination of table 2& 3 shows that although Pakistan's installed generating capacity will increase, but the shortfall will continue to exist[2]. The government must take serious steps to handle this situation.

3 Electricity Generation

The electricity production sector in Pakistan is a miscellaneous industry of hydro, thermal and nuclear power plants. The country meets its energy requirement around 41% by indigenous gas, 19% by oil, and 37% by hydro electricity. Coal and nuclear contribution to energy supply is limited to 0.16% and 2.84% respectively with a vast potential for growth.

3.1 Hydel Generation

As a effect of partition of the Indo-Pakistan Sub-Continent in 1947, India and Pakistan became two autonomous states. Hydel generation capacity of only 10.7 MW (9.6 MW - Malakand Power Station & 1.1 MW - Renala Power Station) existed in the territory of Pakistan. With the passage of time, new hydel power projects of small and medium capacities were commissioned including the first water storage dam and power house at Warsak due to which country's hydel capability rose to about 267 MW up till 1963.

In the year 1967 & 1977, Mangla Dam on Jhelum River and Tarbela Dam on Indus River having the provision of power generation were commissioned respectively. However, their capacities were subsequently extended in different phases.

Pakistan has a huge potential to produce electric power from hydro-electric power plants. In table 5 presents a view of electric power generation with power plants whose feasibility study has been completed or is under process. Construction of all these plants gives almost 6444 MW. This easily meets the electrical energy requirement of Pakistan for next 20-25 years. The hydro-electric power has a great potential and

these plants can give low cost electricity. As they are run of river plants, they can be easily installed with minimum cost and in short time.

The seasonal variations of reservoir levels and consequent reduction in Power outputs of storage type hydel projects in Pakistan are very pronounced. Tarbela with maximum head of 450 feet experiences variation of 230 feet while Mangla has 162 feet variation against the maximum head of 360 feet. The lean flow period of Tarbela reservoir is from November to June when the Capability reduces to as low as about 1,350 MW against the maximum of 3,692 MW during high head period i.e. August to September (15% permissible overloading on Units 1~10). Lean flow period of Mangla reservoir is observed from October to March when the minimum generating capability is 500 MW. The capability rises to as high as 1,150 MW during 'high head' period (15% permissible overloading).

In all, WAPDA's hydel generating capability varies between the two extremities of 2,414 MW and 6,746.0 MW over the cycle of a year. WAPDA is carrying out feasibility studies and engineering designs for various hydropower projects with accumulative generation capacity of more than 25,000 MW. Most of these studies are at an advance stage of completion. After the completion of these projects the installed capacity would rise to around 42,000 MW by the end of the year 2020. Pakistan has been blessed with ample water resources but could store only 13% of the annual flow of its rivers. The statistics warrant construction of number of reservoirs to enhance availability of water which stands at 1,070 cubic meters per capita.The hydropower potential in Pakistan is over 100,000 MW with identified sites of 55,000 MW. Currently, studies under way include Diamer Basha (4,500 MW), Bunji (5,400 MW) and Kohala (1,100 MW) amongst many others. As mentioned previously, hydro is the only sustainable energy resource which Pakistan has been effectively employed for large-scale power generation. Currently, Pakistan has an installed hydropower capacity of approximately 6.6 GW. This figure is only 16% of the total hydropower potential in Pakistan, estimated to be about 41.5 GW [15].

3.2. Thermal Generation

Pakistan with 185 billion tons of coal reserves, the fourth largest in the world, is under utilizing this resource. In the overall energy mix, the share of coal power is only 7% as compared to world average of 40%[3]. Coal is the main source for producing cheaper electricity and the Government has decided to enhance the share of coal in the overall energy mix of upto18% by 2030. The Government is striving hard to minimize the gap between consumption and generation of electricity at affordable rate.Pakistan has the 4th largest coal reserve in the World, amounting to approximatel185.175 billion tones. Thar has largest reserve in the country that is approximatey 75.5 billion tones. Pakistan can generate more than 100,000 MW of electricity for next 30 years if it uses all coal available to it. Bulk of Pakistan’s power generation is based on thermal resources mainly furnace oil and natural gas as fuel; coal is almost non-existent. The total installed capacity of thermal power plants in the country as on June 30’ 2008 was 12,478 MW. It is learnt through the sources of Pakistan Electric Power Company (PEPCO) that an investment of around US$ 2 billion is expected in power sector through Rental Power Projects (RPPs) and an additional electricity of 1,675 MW will be

added in the system by 2009-10 when nine rental power projects will start generation. At present Pakistan generates only 0.79% of its total electricity from coal [3]. Coal contributes approximately 40% of the total global primary energy demand

3.3 Nuclear Power Generation

Pakistan is among the 30 nations in the world, which have reposed confidence in Nuclear Power Plants. The global installed capacity of Nuclear Power Plants stood at 375,000 MW at the end of 2010, based on 442 Nuclear Power Plants. Since the first Nuclear Power Plant was installed in 1950, tremendous progress has been achieved in the field of Nuclear Power Generation. There has been substantial improvement in the efficiency of Nuclear Power Plants and their availability factor has also increased, which means reduced downtime for maintenance. These improvements have encouraged a number of Asian nations to go for Nuclear Energy in a big way. Japan and South Korea were already among the leading nations producing nuclear electricity. In recent years China and India have made huge investments in Nuclear Power Plants. China presently has 11 Nuclear Power Plants of total 9000 MW capacity, while the total installed capacity of 20 Nuclear Power Plants in India has reached 4780 MW. India has also recently commissioned a locally increase the installed capacity of its Nuclear Power Plants to 8800 MW by 2020 by installing 10 new Nuclear Power Plants. Pakistan is presently importing fuel for the developed nuclear power reactor of 220 MW capacity. Pakistan has also drawn up plans to Nuclear Power plants from China. In order to make the country self-sufficient in nuclear fuel,a facility is being developed, which will use locally available Uranium ore to produce 350 tons of nuclear fuel annually starting from 2015. To take care of the nuclear waste generated by the Nuclear Plants, Waste Management Centers are being developed at Karachi and Chashma, and a Repository for low and intermediate level waste is expected to be commissioned by 2015

4. Renewable Energy

Pakistan has abundant available and unlimited renewable energy (RE) resources, which if tapped effectively can play a considerable role in contributing towards energy security and energy independence of the country. In May 2003, Alternative Energy Development Board – AEDB was established to act as a central agency for development, promotion and facilitation of renewable energy technologies, formulation of plans, policies and development of technological base for manufacturing of renewable energy equipment in Pakistan. The Government of Pakistan has tasked the AEDB to ensure 5% of total national power generation capacity to be generated through renewable energy technologies by the year 2030. In addition, under the remote village electrification program, AEDB has been directed to electrify 7,874 remote villages in Sindh and Balochistan provinces through renewable energy technologies. At present, total Renewable Energy produced in the country accounts at 40MW which is about 0.21% of total installed generation capacity of all sorts. America, Canada and China have invested large sums of money into research and development in order to obtain maximum energy from wind. Wind power is now the fastest-growing energy source worldwide. Total worldwide production of electrical energy from wind is around 30000MW. Germany, with over 12,000 megawatts of wind power at the end of

2002, leads the world in generating capacity. Spain and the United States, at 4,800 and 4,700 megawatts, are second and third. Many predict that, with the development of more efficient wind turbines, wind energy will provide an increasingly large proportion of electrical production in the U.S. Tiny Denmark is fourth with 2,900 megawatts, and India is fifth with 1,700 megawatts. Although a score of countries now generate electricity from wind, a second wave of major players is coming onto the field, including the United Kingdom, France, Italy, Brazil, and China. However, land clearing for vast "wind farms" may cause concern to environmentalists. The investment in renewable, 50 MW wind energy project has been deployed in the Sindh region to date - that, too, with limited success (Daily Times, PM Inaugurates Pakistan's First Wind Power Project 2009).

The potential for renewable energy technologies to bridge the gap between energy supply and demand in Pakistan is significant. Renewable energy projects have the potential to improve energy security, provide socioeconomic benefits, reduce local pollution and mitigate climate change. Further, due to the decentralized nature of renewable energy projects, they have the potential to provide electricity to remote and rural areas, thereby helping to alleviate poverty and reducing the need to collect and burn biomass fuel [17].

Solar, wind, biomass and hydro energy resources are widespread and abundant in Pakistan. The potential for each of these energy resources to help meet energy needs will be discussed below.

4.1 Solar Energy

Pakistan lies about 15.5x1014 kWh of in a region of high solar irradiance; as such, it is ideally suited for solar energy projects. Pakistan receives solar irradiance each year with most regions receiving approximately 8 to 10 sunlight hours per day. The installed capacity of solar photovoltaic power is estimated to be 1600 GW per year, providing approximately 3.5 PWh of electricity (a figure approximately 41 times that of current power generation in the country[15].

4.2 Wind Energy

Pakistan has high potential of renewable energy sources. A very large part of the rural population does not have the facility of electricity because they are either too remote or it is found too expensive to connect their villages to the national grid station. Pakistan being in the sunny belt is ideally located to take advantage of solar energy. This energy sources is widely distributed and abundantly available in the country. During last 15 years Pakistan has shown quite encouraging progress in the use of photovoltaic cells. Currently electrical power derived from solar energy is being used is being used in some public parks. These include Khalid bin Waleed Park in Peshawar and the Race Course Park in Rawalpindi. The Public Health department has installed solar water pump for drinking purposes in some parts of the country. Both public and private sector are playing their role in up grading of photovoltaic system in the country. If this technology is used in large scale commercial production of electricity the problem of energy shortage can be substantially reduce. Wind energy has also been shown to have strong technical potential in Pakistan, particularly in the southern regions of Sindh and Balochistan. Pakistan has approximately 1000 km of coastline with steady average

wind speeds ranging between 5-7 m/s. The projected installed capacity for wind energy projects is estimated at 122.6 GW per year, providing about 212 TW of electricity

4.3 Biomass Energy

The availability of biomass in Pakistan is also widespread. Approximately 50 000 tonnes of solid waste, 225 000 tonnes of crop residue and over 1 million tonnes of animal manure are produced 3 daily. It is estimated that the potential production of biogas from livestock residue is 8.8 to 17.2 billion cubic meters of gas per year (equivalent to 55 to 106 TWh of energy). Additionally, the annual electricity production from bagasse (the fibrous residue remaining after sugarcane or sorghum processing) is estimated at 5700 GWh; this figure is about 6.6% of Pakistan's current power generation level[15]

Undoubtedly, renewable energy resources in Pakistan are widespread and present significant technical potential to meet energy needs. This begs the question then, if the potential for renewable energy resources in Pakistan is so great, why has there been such little development in this field? The technical potential and availability of renewable energy resources alone provides little indication about the success of renewable energy project development in a country. For instance, Pakistan has a greater technical potential for wind energy projects compared to its neighbor, India, yet India has the fourth largest installed capacity of wind power in the world[7-13]. Indeed, no matter how much technical potential exists, it is of little use unless an effective policy bolsters development. To this end, Pakistan instituted its first renewable energy policy in 2006. However, this policy has stimulated limited growth since its implementation. The slow uptake of renewable energy technologies can be attributed to numerous factors, ranging from a lack of infrastructure to poor competition with conventional power generation. In order to pave the way forward for a sustainable energy future in Pakistan, the challenges which energy policies face must be systematically identified and addressed. This paper intends to discuss policy strengths and challenges and to provide insight into how Pakistan can move forward towards a sustainable energy future.

Conclusion

Pakistan has struggled to resolve its energy shortage problems for decades. As the country is now facing an unprecedented energy crisis the drive to find effective long-term energysolutions is stronger now than ever before. Renewable energy resources such as wind and solar energy are abundant in Pakistan and show significant technical potential to meet energy needs; however, the development of renewable energy power projects is hindered by social, economic, technical, institutional and informational barriers. The 2006 renewable energy policy makes important steps towards encouraging RET deployment, but several policy challenges remain to be addressed. The answer to strengthening the presence of renewable energy technologies in Pakistan does not lie in any one solution to these challenges; rather, a holistic approach must be employed. A number of approaches have been discussed to address the roadblocks which RETs face. The government of Pakistan must take bold steps towards restructuring energy policy in order to increase energy security and

move towards a sustainable energy future. Primarily, policies should focus on bridging the competitive gap between RETs and fossil fuels through measures such as subsidy transfers, feed-in tariffs and accounting for negative and positive externalities. Of course, increasing the competitiveness of RETs alone is not sufficient; issues such as poor infrastructure, financing and technology access must also be addressed. However, the biggest challenge lies in initially stimulating growth in renewable energy. Upon addressing the most significant challenges facing RETs, market penetration will naturally develop and the support for addressing further RET challenges will ensue. The passage way towards a sustainable energy future in Pakistan is by no means simple, but a solution certainly exists. Although a number of approaches have been presented to encourage the growth of renewable energy in Pakistan, all of these solutions will undoubtedly require significant effort and dedication on behalf of the government. Pakistan must consider the long-term social, economic and environmental benefits of renewable energy power generation for its people. Investing in 20 sustainable energy technologies today will pave the road towards a secure energy future for tomorrow.

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Table 1. Total capacity of electric power generation of Pakistan in 2009.

PUBLIC SECTOR	MW	%age
WAPDA	6444	33
GENCOs	4834	25
PAEC	462	2
Sub-total	11740	60
PRIVATE SECTOR		
IPPs	6185	31
KESC	1756	9
Sub-Total	7941	40
G.Total	**19681**	**100**

Table 2 Historical Peak Demand 2002-2007

Year	WAPDA MW G.Rate	KESC MW G.Rate	Country MW G.Rate
2001-02	10109 40.02%	1885 1.34%	11875 3.59%
2002-03	10481 3.68%	1973 4.67%	12330 3.11%
2003-04	11078 5.70%	2073 5.07%	13021 6.35%
2004-05	12035 8.46%	2197 5.98%	14091 8.22%
2005-06	13212 9.78%	2223 1.18%	15282 8.45%
2006-07	15138 14.6%	2349 5.67%	17314 13.33%
2007-08	16484 8.9%	2673 13.85%	18983 9.7%

Table 3 Forecast of Demand form 2009-2030 (as April 2011)

Fiscal Years		2009	2010	2015	2016	2020	2025	2030
Net Dependable Capability	MW	17008	19477	33028	36560	52909	76200	106565
	Growth Rate	9%	15%	9%	11%	10%	8%	8%
Peak Demand	MW	20594	24474	36217	40555	54359	80566	113695
	Growth Rate	7%	9%	8%	8%	9%	8%	7%
Surplus/ Deficits		-3586	-2876	324	1147	4066	4031	5087

Table 4 Pakistan's Total Power Potential

Station/Projects	**Capacity (MW)**
Hydro-electric Power Station in Operation	6596
Under Implements	1965
Chasnupp-2	300
Feasibility Study Completed (i) Run Of River (ii) Multipurpose	 1780 8840
Feasibility Studies in Hand	10331
Projects Feasibility Studies are to b Carried out	25000
Total	**54711**

Table 5 Run of River Projects with their Feasibility Status

Name of Project	Capacity(MW)	Feasibility Status
Basho	28	Completed
Harpo	28	Completed
Phandar	80	Completed
Doyian	425	Completed
Naltr	32	Completed
Kohala	60	Completed
Gulpur	100	Completed
Kotli	100	Completed
Daral Khwar	35	Completed
Bunji	5400	In Hand
Dasu	3700	In Hand
Gabral	105	In Hand
Keyel Khwar	130	In Hand
Lawi	65	In Hand
Spat Gah Lower Scheme	545	In Hand
Chor Nullah Lower Scheme	386	In Hand
Total	**10331**	

Table 6 Installed Power Generation Capacity (as on June 30' 2008)

TYPE	MW	%
Hydel - WAPDA	6480	33.30
Thermal - WAPDA	4900	25.20
Thermal KESC	1,756	9.02
Thermal IPPs	5,822	29.91
Nuclear	462	2.37
Others (renewable)	-	0.20
Total	**19,420**	**100.00**

Table 7 Electric Power Generation from Nuclear Power Plants (June 30' 2011)

Break-up of nuclear generation capacity (MW) Power stations	Capacity (MW)
Karachi Nuclear Power Plant (KANUPP)	137
Chashma Nuclear Power Plant-I (CHASNUPP-I)	325
Chashma Nuclear Power Plant-II (CHASNUPP-II)	313
Total	**775**

Table 8 Renewable Energy Resources of Pakistan

Wind	0. 346 Million MW
Solar	2.9 Million MW
Bagasse Cogeneration	1,800 MW
Waste to Power	500 MW
Mini & Small Hydel	2,000 MW

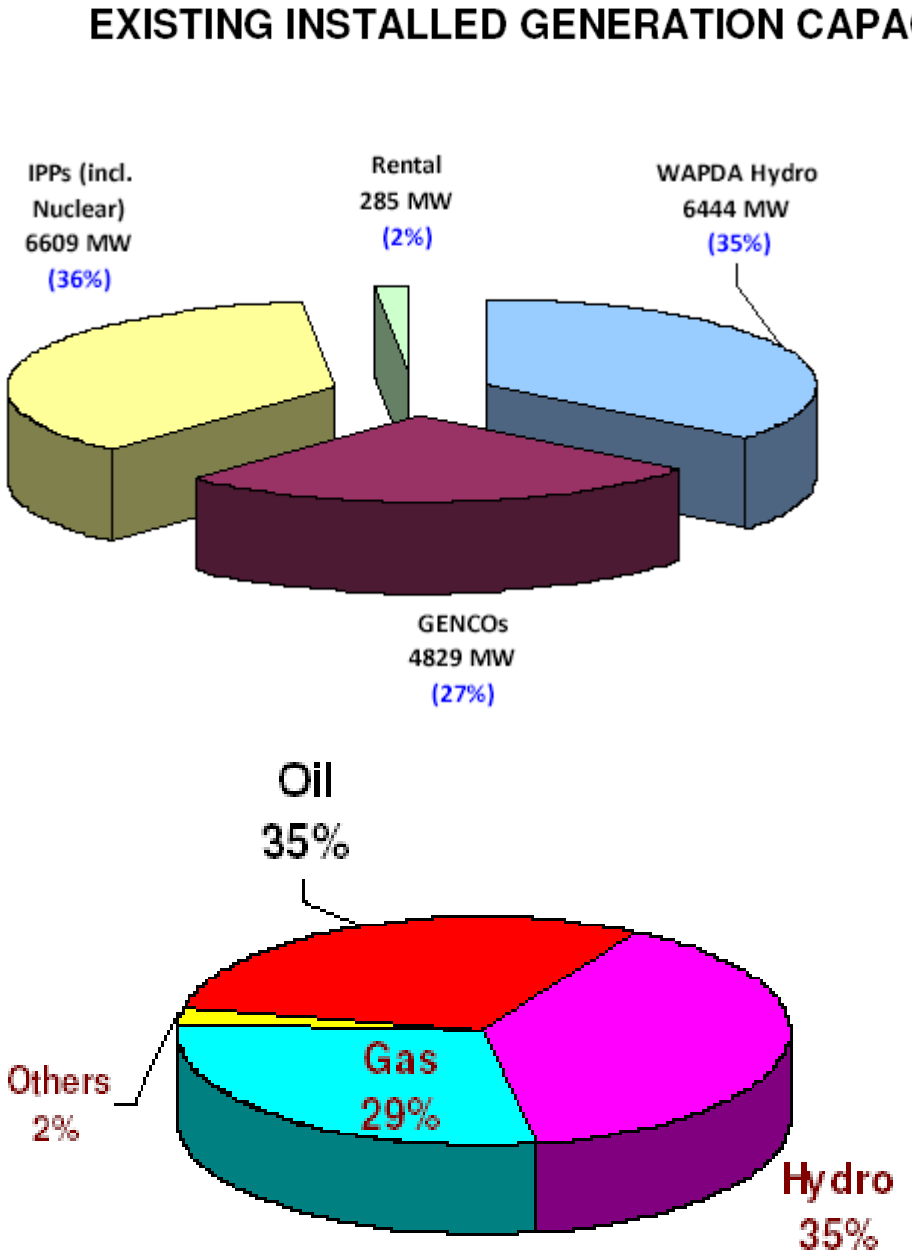
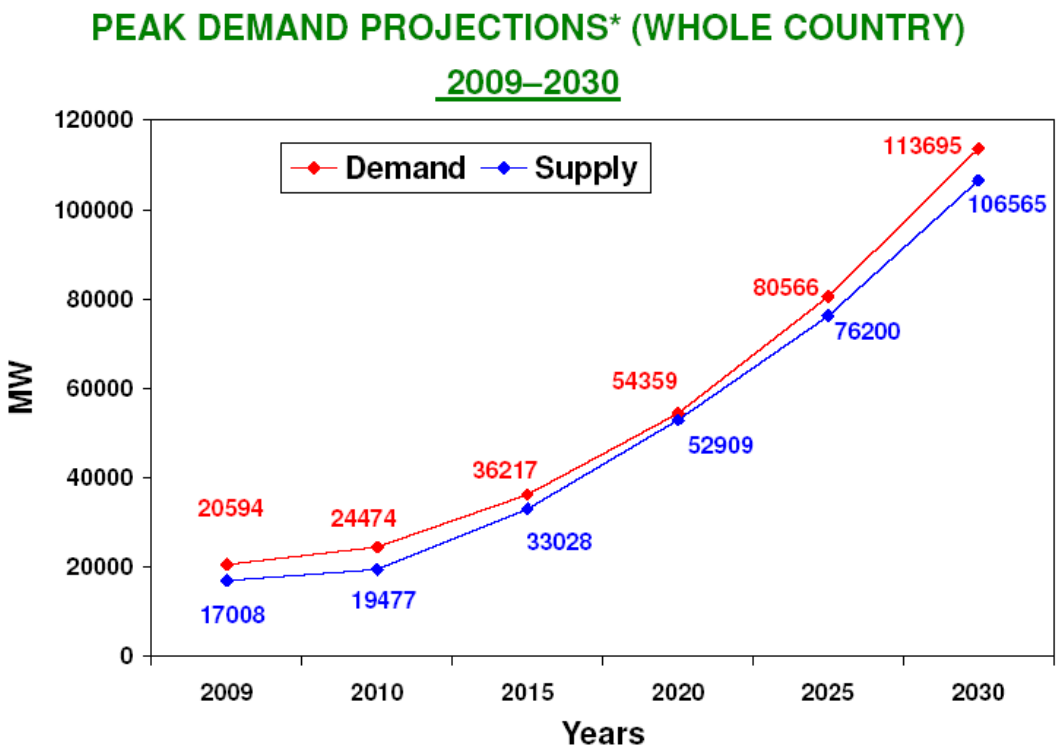

EXISTING INSTALLED GENERATION CAPACITY
IPPs (incl. Nuclear) 6609 MW (36%)
Rental 285 MW (2%)
WAPDA Hydro 6444 MW (35%)
GENCOs 4829 MW (27%)
Oil 35%
Others 2%
Gas 29%
Hydro 35%
ELECTRICITY GENERATION BY FUEL

Fig. 1



*Projected demand includes captive power also. Average growth rate is expected to be about 8%

Fig.2