CURRENT POWER GENERATION AND ALTERNATIVE TRENDS IN PAKISTAN (A CASE STUDY)

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ABSTRACT: *The global electricity demand is on a rise each next day including Pakistan, which faces an intensive shortage to fulfill high rate of this emerging consumer demand. This necessity forced global players to come up with the development of innovative and alternative ways as well as proper utilization of available infrastructure to acquire power generation. Our study focuses especially the power crisis, current situation of available power generation projects, a situation comparison of an emerging neighboring economy (i.e. China) and an outlook of the favorable locations/conditions for renewable energy acquisition projects in Pakistan. Apart from the detailed information of current power energy related situation in Pakistan, an accumulated electricity demand/supply and power generation technologies to fulfill the electricity needs of Pakistan are discussed with statistics referred from different renowned sources. The study also incampases, a viewpoint of the same matter in a neighboring country, which either went through same degree of the power outage or are partially going through it. With multi dimensional considerations i.e. power generation to meet current as well as the future demands and environmental friendly power generation alternatives are provided for Pakistan, by specifying Pakistan's natural territorial advantages and short time required to overcome the dead-end situation of power outage in Pakistan. We believe, this accumulated study can play as "a one stop guideline" for other researchers to understand the current situation with comparison of neighboring countries and the possible alternate ways to fulfill the power demand of entire country.*

Keywords: Renewable energy, environment friendly, power generation, environmental hazards.

1 INTRODUCTION

Pakistan from a decade is undergoing a massive electricity shortfall. According to reliable sources the gap between electricity demand and its supply is 4500-5500 MWs [1]. Many researches' have been conducted with the reference to country's current power sector situation and need of alternative trends for power generation which are widely adopted by the world largest power consumer countries like China. In these researches' Pakistan capability to generate power through renewable sources are mainly discussed [2]. These researches' came up with effective suggestion and strategies to related authorities in order to meet the extended power need of country [1-7.10.].

China with an average increase of 10% GDP every year as of 2010 has its strong concern for power generation with environmental friendly technologies [8]. Currently, China relies 71% of its total generation on fossil fuels, which are extremely affecting environment, but with effective ongoing plans, China is transforming its existing power generation sources to environment friendly sources [8-11]

This is a comparative study in which Pakistan is compared with world's largest economy as well as largest power consuming country i.e. China. The country has somehow gone through the same circumstances as Pakistan, in the past. Now the country is facing intense environmental hazards due to heavy consumption of fossil fuels, but it is planning to transform its existing power generation sources to renewable sources which are environmental friendly.

Purpose of this study is to accumulate the information from authentic sources to give an exact picture of Pakistan's existing situation of power sector. And to find out the feasible (in terms of clean and sustainable) alternative technologies for Pakistan, which can fulfill ever growing demand of electricity with environmental friendly sources that are widely adopted by its neighboring country (i.e. China).

The organization of the paper is as follows: Second part provides a brief overview of the current power sector situation of Pakistan. Third part presents accumulated electricity demand/supply & power generation technologies, where the comprehensive scenario of demand/supply and power generation of Pakistan is discussed according to reliable sources. Fourth part is a case study where a bird eye overview of China's current power generation trends and its adoption toward clean energy generation trends are discussed. Fifth part presents alternative options to meet extended power demands of Pakistan. Sixth part concludes the study.

2 Background Information

Pakistan geographically located in South Asia with population of around 190 million, the electricity generation in Pakistan comprises of four major entities, i.e. Water and Power Development Authority (WAPDA), Karachi Electric Supply Corporation (KESC), Independent Power Producers (IPPs) and Pakistan Atomic Energy Commission (PAEC). Two vertically integrated public entities, i.e. WAPDA, which serves entire country except economical capital – Karachi and KESC that solely facilitates Karachi as well as its surroundings. Due to unrealistic power tariff, irrational subsidies and higher degree of inefficiency; these entities were unable to fill the gap between the ever increasing demand of power and its proficient supply. To cover up the enormous inefficient practices and to step up the performance of power sector, a regulatory law named "The Regulation of Generation, Transmission and Distribution of Electric Power Act" was introduced in 1997, with an outcome of the formation of a new institutional setup.

Under this new setup, National Electric Power Regulatory Authority (NEPRA) was formed; with a challenging charter to operate as an independent regulator and to devise a transparent, economically dynamic, competitive power sector in Pakistan. The Power Wing of WAPDA is further transformed into four sub tier entities i.e. GENCOs (Generation Companies), DISCOs (eleven Distribution Companies), one NTDC (National Transmission and Dispatch Company) and KESC (renamed currently as

K-Electric after its privatization). For the planning and develop ment of another power generation aspect i.e. nuclear power, is taken care by PAEC (Pakistan Atomic Energy Commission), which also owns a major potential resource named NPPs (Nuclear Power Plants). To magnetize the private investment into this ever expanding sector, PPIB (Private Power and Infrastructure Board) was established with an important task to facilitate private investment groups. For exploring and promoting the environment friendly renewable energy resources, AEDB (Alternative Energy Development Board) was also established in recent past.

Even with these changes, the condition of power sector remained at a standstill and for more than a decade, Pakistan unintentionally is facing the darker outcome due to the silly negligence. The list of this negligence as well as mismanagement activities are based on the fundamental/common reasons, i.e. unrealistic power tariff, higher degree of inefficiency, reduced payment recovery, outdated government policies, immature practices in entire power sector. Because of huge amount of negligence, despite an accumulative nationwide electric power demand of 16000+ MWs - Pakistan is currently going through an enormous amount of (4500-5500) MWs shortfall of electricity. This unbearable 33% of shortfall, not only contributed to the social disorder, but also took with it adverse effects of economical backlash [1, 2].

Due to this massive shortfall, people in Pakistan are forced to experience from 10 to 12 hours power outage in urban areas, whereas this situation is even worst in rural areas (14 to 18 hours power outage). Industrial sector stretching nationwide, is victimized severely by this power outage each day, which ultimately decreased domestic as well as volume of exported goods and have increased the unemployment rate. As a state of the art power sector is directly proportional to the country's economy so the Pakistan economy is the biggest victim due to those above mentioned power crisis.

Along with the power cuts and unstable economic conditions, the entire nation is also bearing higher tariff that is unaffordable for the majority of population. Higher tariffs are introduced due to the poor infrastructure of electricity supply, which results in higher degree of line loss, an enormous increase of deliberate theft and an unforgettable factor of inefficient power generation technologies.

3 Accumulated electricity demand/supply & Power generation technologies of Pakistan

According to Pakistan Electric Power Company (PEPCO), the current demand of electricity is 16,814 MWs, while the total supply in country is 10,800 MWs with the total installed power generation capacity of 21,375 MWs [1].

Pakistan power generation is based on three technologies i.e. hydroelectric, thermal and nuclear.

Figure1 shows Pakistan's power generation in context to acquisition sources. It is clearly shown that 65% of electricity is generated by thermal power, which includes natural gas, oil and coal. Whereas remaining 35% of power generation is comprised of approximately 30% and 5% on hydroelectric and nuclear energy, respectively.

Table 1. Energy constants used in the simulation [1]

By using this linear energy consumption model, we evaluated the MANET on-demand routing protocols. The energy consumption is further explained in following equations:

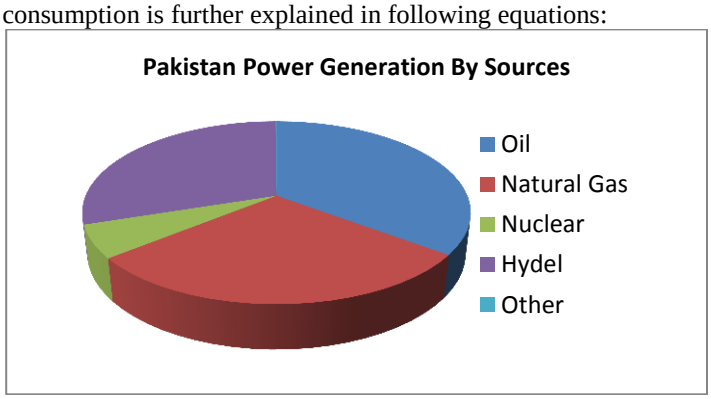

Figure 1: Pakistan's Power Generation by Sources [2].

With the capacity of power generation greater than the demand, due to an unfortunate lack of financial resources, the Pakistan government has failed to operate the existing power generation plants at its full capacity. The major contributors in Pakistan, for electricity generation are IPPs but these IPPs entirely adopted the thermal technology to produce electricity. As previously mentioned the 35% of national electricity is generated by thermal technology using furnace oil, the IPPs are the main actor that primarily use furnace oil and it is a fact that the furnace oil is without any doubt an infeasible (in terms of cost) option to carry out such an extensive generation.

These IPPs were first introduced in Pakistan in early 90s when country experienced its first power shortage. Constructing a number of the thermal plants were more feasible and a faster solution as compared to hydroelectric power plants and also country's economic condition was far better than today in terms of importing oil, which was a way cheaper than these days. But now, as the economical condition adversely declined so it acts as a huge budget overhead to continue persistent amount of oil imports to run these giant thermal power plants [4].

The other major share of around 30% electricity is also generated by thermal technology using natural gas as an input. Natural gas is accounted for 49% of Pakistan's primary energy supply in 2012 and it's worth noting that the country faced a natural gas shortfall of 912 Bcf (Billion Cubic Feet) in 2013, which proves an exponential decline of national gas reserves each next day. Recently (in July 2014), the Government of Pakistan approved the construction of three LNG (Liquid Natural Gas) terminals. The construction of these three terminals will enable Pakistan to import, store, and regasify up to 620 Bcf of LNG by 2018. The first LNG terminal is scheduled to be completed in December 2014 [7].

Another major share of 30% electricity is generated by hydroelectric technology, which is contributed by the water irrigation dams in Pakistan.

Country has potential to produce more than 70% of its entire power need by constructing more water irrigation dams. But these huge hydroelectric projects have some barriers that are very hard to breach in current condition of Pakistan. The biggest problem that exists is lack of funds to construct such huge water irrigation dams.

The remaining 5% of electricity is contributed by Nuclear energy, which is generated by three NPPs that are operated under the supervision of PAEC. In 1971, the first NPP named KANUPP (Karachi Nuclear Power Plant) was commercialized in Karachi - with an output capacity of 135 MWs. KANUPP was constructed by Canadian General Electric (CGE) under a turnkey contract, including entire operation by CGE until 1976 when PAEC took over the operations of NPP and its still in operation under PAEC.

In year 1993, after two decades of unfavorable international environment with lack of technological and industrial capabilities (to carry out innovative work), Pakistan started to construct its 2nd 325 MWs capacity NPP C-1 (Chashma Nuclear Power Plant) with the help of "China National Nuclear Corporation (CNNC)". This NPP started serving effectively to national grid in the year 2000.

Table.1: Construction status of ongoing Nuclear Power Plants. [11]

NPPs	Status	Capacity	Operat
CHASNUPP-1	Operational	300	PAEC
CHASNUPP-2	Operational l	300	PAEC
CHASNUPP-3	Under Construction	315	TBD
CHASNUPP-4	Under Construction	315	TBD
KANUPP-1	Operational	90	PAEC 1972 2019
KANUPP-2	Under Construction	1,100	TBD
KANUPP-3	Under Construction	1,100	TBD

Third NPP C-2 (Chashma Nuclear Power Plant), with capacity of 330 MWs started its commercial operation in May 2011.

Fourth and fifth NPP C-3 (Chashma Nuclear Power Plant) and C-4 (Chashma Nuclear Power Plant) are under construction progress. Both these plants are being supplied with cooperation of China and each of these magnificent power plants would offer the capacity of 340 MWs.

Another $9.59 billion project named "Karachi Coastal Power Project" with a significant capacity of 2,200 MWs is on its way with the cooperation of China and its groundbreaking ceremony was held in November 2013. This project is a proud moment in the power history of Pakistan and it is expected to be completed in the next six years.

Table1 shows the current status and performance of NPPs in Pakistan.

These three on-demand routing protocols are evaluated both in terms of performance and energy consumption.

4 Case Study;

Power generation trends adopted by China

If we take a look around Pakistan we find emerging economy bordering it i.e. China. China ranks second biggest global economy and first largest power consumer of the world.

China, the world's most densely populated country took over USA as the world's largest power producer in 2011. Also in 2011, country's overall power generation was estimated at around 4,476 Terawatts-hour (TWh) with the increase rate of around 10% per year and in addition, its installed capacity was 1,145 GWs by 2012.

Figure2 illustrates, an accumulated power generation of China by using different natural resources. It can be obviously seen that 71% of electricity is generated by thermal technology, which uses natural gas, oil and coal as the main source, the other 22% of generation is based on hydroelectric technology that is acquired by state of the art water irrigation dams and the remaining 7% is roughly contributed with the use of Nuclear, Wind, Solar and Biomass/waste [8].

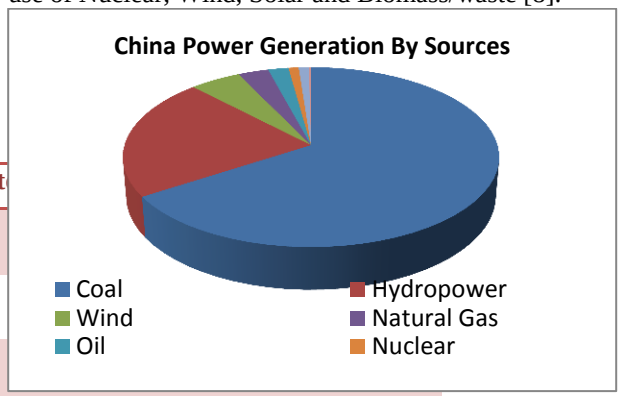

Figure 2: China's Power Generation by Sources [8.9.11].

4.1 Current Power Generation trends

With estimated installed electricity generation capacity of 1,145 GWs in 2012, China has doubled its electric power generation from 524 GWs in 2005. China heavily relies on fossil fuels like coal, due to two main reasons, i.e. China is world largest coal producer and it's a big importer of coal. Using these fossil fuels has led China to face environmental disorders, especially in major northern major cities like Beijing, Xingta, Tianjin and Jinan, which are also the heavily populated urban cities. In context with these environmental problems, China plans to rely on more electric generation from nuclear, other renewable resources and also the natural gas to especially replace environment unfriendly mineral i.e. coal. Each day, China willingly takes the forefront measures to reach the goals of reducing carbon emissions and the heavy air pollution in urban areas, till it fulfills the global standards of healthy environments [9, 11].

4.2 Plans of shifting towards clean energy

China is keep on encouraging the environmental friendly technologies for power generation like renewable energy, has set its goal to generate at least 15% of its electricity with renewable energy sources by 2020. In 2012 to follow up this goal, Chinese companies invested 20% more than the capital they invested in 2011 and they have planned to invest $473 billion on clean energy generation from year 2011 to 2015.

Nuclear power contributes 83 TWh that comprises approximately 2% of total electricity generation capability of China in year 2011. After Japan Fukushima Daiichi Nuclear Power Plant incident in 2011, the government of China right away postponed all the approvals for the new NPPs and after

reviewing all the projects in terms of safety, the process was later resumed in October 2012.

As the nuclear energy is clean, efficient and reliable source - China has planned to boost its nuclear projects to generate 58GWs by year 2020. Reference to an estimate, 31 nuclear reactors that are presently under construction, would be operational by year 2017. These nuclear reactors would add total capacity of 35 GWs in nationwide mainstream electric power and its worth mentioning that this capacity is considered equivalent to half of the current global nuclear power capacity [11].

4.3 Analysis

With reference to above case's fact and figures we have concluded that to meet the extended power consumption, China has set up its goals to shift its power generation from traditional trends (Thermal Technology) to more efficient trends i.e. RE.

The core objective for this shift of power generation is to avoid environmental hazards that currently China is facing.

This transformation will also reduce the current power generation cost because renewable sources require once investment with very less running cost than the other power generation technologies.

5 Alternative options to meet extended power demands of Pakistan

The world is moving so fast towards efficient, clean and affordable (in terms of natural resources) power generation technologies to meet ever increasing power needs. The traditional power generation technologies that falls under the category of thermal, are increasing environmental concerns as well as inr developing countries like Pakistan, it's no more feasible due to its exponential increasing cost each day.

Under current circumstances, the most favorable option right now for Pakistan is wider adoption of power generation using renewable energy (RE).

As we took an overview to China's existing and upcoming plans to generate power from clean and efficient technologies, China could be a better example for Pakistan to follow. The cooperation between China and Pakistan government in power sector could be the best way out for current power crises in Pakistan. China's expertise and experience in exploitation of renewable potential could be the greatest advantage of this cooperation. No doubt, the ongoing cooperation plans between both governments are very effective and progressing as planned.

Renewable energy is produce through natural energy like sunlight, wind, geothermal heat, which doesn't introduce even a tiny fraction of environmental hazard and is naturally reproduced for continues use.

According to a recent study, Pakistan has tremendous potential to produce sustainable renewable energy more than double of electricity than its current demand [3]. Its geographical location provides it prolonged day-time that is very useful to produce solar energy. Along with solar energy country is also blessed with wind corridors lying in southern part, which have no doubt tremendous exploitable potential for wind power.

5.1 Solar Potential

Country's ultimate geographical position with more sunny hours that provides an opportunity to produce significant amount of electric power, roughly up to 3 million MWs through only the solar energy. As almost entire country enjoys long sunny day, so it can also help in the electrification of remote areas, which right now are beyond the reach of this facility due to outdate and poor infrastructure. This renewable energy doesn't need any sort of fuel supply because its generating cycle requires only sunlight and it would extensively cut off the existing expenses of fuel that is used to operate thermal power plants. Such approach (if adopted) would need a onetime investment (mainly installation) and (provably) it doesn't pose even a smallest amount of environmental hazard.

5.2 Wind Potential

Beside solar energy, Pakistan also has an incredible wind power potential corridor in its south most part of coastal belt, stretching from Baluchistan (the biggest province) to Sindh (the trading hub). By utilizing this natural potential, the country can generate up to 50,000 MWs that no doubt is an insignificant amount of energy entirely from wind power [3]. Pakistan has around 1,100 km (Kilo Meter) coastlines, which mostly stays windy throughout the year and additionally there is a 60 km x 180 km wind corridor that is located in south of province Sindh - with tremendous exploitable potential for wind power. If the country decides to utilize the above mentioned renewable resources, Pakistan can be able to generate clean, cheap and sustainable energy in a matter of very short time.

5.3 Hydro Potential

Another possible renewable resource is the hydroelectric power and the country can generate up to 45,000 MWs from hydroelectric power [3]. Currently, Pakistan is merely generating a fraction of 29% from its total electricity pie using hydroelectric technique, but it can enhance its generation by constructing small water irrigation dams.

6 CONCLUSION

No doubt, with emerging needs of automation, requirement for industrialization to stay side by side with the world on the forefront of development and ease the human life; there exists an exponential demand of power generation/consumption. We focused Pakistan in this study, which is severely facing the electric power shortage and compared its neighbor the 1st largest populated and 2nd biggest economy i.e. China, in similar context. With reference to the latest statistics published by prominent/reliable sources in this field, an up to date overlook of previous, current and future power generation (in terms of power generation technologies usage) by Pakistan as well as China, is thoroughly discussed.

As the time passed, in the past China also predicted the power outage and acted timely in accordance to adopt right technology. Consider the similar experience of China, Pakistan can take it as an example to overcome intense power outage.

Plenty of projects with cooperation of China in power generation technologies namely, nuclear, hydro and many more are underway.

Pakistan could effectively take steps to address another important factor of choosing user friendly technologies instead of those technologies that caused a massive environmental problem in China.

Pakistan due to its geographically location, longer day light is suitable to use solar energy generation technology. Using the 1,100 km as well as 60 km more stretched costal line with heavy windy cooridor, Pa kistan can make use of the wind energy generation technology.

China earned an extended experience in above mentioned technologies and by establishing more cooperation than existing, Pakistan can overcome the power shortage with reduce risk to loss healthy environment.

All the facts are very well shown that the current shortage is also due to inefficient approach, mismanagement and following bad practices, otherwise Pakistan is quite capable of generating 10 times more energy it currently needs.

This paper is a quick reference overview of the in depth information that can be of great significance for the Pakistan authorities, power generation researchers and other stakeholders to chose a better approach that overcome this worrying situation, sometime soon in the future as well as seek the right partner i.e. China with its extended experience in this field.

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