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Comparison of Nuclear Energy of Bangladesh with India & Pakistan.

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Abstract: *Nuclear power is a unique source of energy for power production. Uninterrupted electric supply is essentially required for the smooth running of the modern society. Bangladesh is not alone in finding difficulties to fulfill its domestic energy demand; many countries around the world are facing similar problems. South Asian countries face on average a shortage of 15% to 30% of electricity with respect to peak load demand. South Asia has huge untapped hydropower potential. Only Pakistan, Bhutan and Nepal have techno-economically feasible hydropower potentials. There is a general neglect of electricity generation from renewable sources in South Asia, although huge potential exist for wind power, especially in coastal areas of India and Pakistan. However, India is taking the lead in developing renewable energy in the region. In this paper, Nuclear energy of Bangladesh is compared with other developing countries of South Asia like India and Pakistan.*

Keywords: *Nuclear power, generation, Asia, MW*

I. INTRODUCTION

South Asia is an under-developed and energy resources deficient region that housed 1.5 billion people at present, which makes one-fourth of the world population. The region contains the highest number of people without access to electricity (612 Million)[1]. Per capita energy consumption in South Asia has been less than 3% of the per capita energy consumption in the United States. Key statistics of overall energy Availability and consumption in the countries of the region is given at Table-I.

Table-I Comparison of Key Energy Indicators over time Across South Asian Countries

	Population (Million)		Energy Production (Million Tons of Oil Equivalent)		Energy Use (Million Tons of Oil Equi.)		Fossil Fuels Percent of Total Use (%)		GDP per unit of Energy Use 2005 PPP$/Kg of oil Equi		Net Energy Imports of Energy Use (%)		Energy Intensity BTU per Year 2005 US$	
Country	1990	2008	1990	2008	1990	2008	1990	2008	1990	2008	1990	2008	1990	2008
India	858.2	1140.6	291.8	468.3	318.9	621.0	55.7	71.1	3.3	5.1	8	25	22,337	18,825
Pakistan	118.8	178.5	34.3	63.3	43.0	82.8	52.8	61.8	4.2	4.7	20	24	20,230	19,852
Bangladesh	112.2	151.3	10.8	23.4	12.7	27.9	45.5	68.4	6.2	7.1	16	16	9,155	12,577
Nepal	18.9	28.2	5.5	8.7	5.8	9.8	5.1	10.9	2.3	3	5	11	4,164	8,157
Sri Lanka	17.4	21.1	4.2	5.1	5.5	8.9	24.1	43.4	6.3	9.5	24	43	8,730	7,241

Source: World Development Indicators 2010.

Nuclear power is desirable in Bangladesh, due to its underdeveloped and mismanaged energy infrastructure that has inhibited Bangladeshi growth (See: Electricity sector in Bangladesh). With a derated capacity of around 5500 Megawatt (MW) on an installed rating of over 6000 MW, only around 4000 is actually available. With a maximum generation of 4500 MW in mid-2010 to 4700 MW in late 2010, the peak is anywhere from 5700 MW to 6000 MW and only about 40% to 48% of the total population have access to electricity. The per capita consumption of 218-230 kWh and the availability is the lower among any developing country in the world.

As of 2012, **nuclear power in Pakistan** is provided by 3 licensed-commercial nuclear power plants. Pakistan is the first Muslim country in the world to construct and operate civil nuclear power plants.[2] The Pakistan Atomic Energy Commission (PAEC), the scientific and nuclear governmental agency, is solely responsible for operating these power plants. As of 2012, the electricity generated by commercial nuclear power plants constitutes roughly ~3.6% of electricity generated in Pakistan, compared to ~62% from fossil fuel, ~33% from hydroelectric power and ~0.3% from Coal electricity.[3] Pakistan is one of the four nuclear armed states (along with India, Israel, and North Korea) that is not a party to the Nuclear Non-Proliferation Treaty but is a member in good standing of the International Atomic Energy Agency.[4]

In **India**, there are presently 19 nuclear power reactors in operation with a capacity of 4560 MW. The 20th reactor, Kaiga-4 (220-MW), currently under the process of fuel loading, is expected to go in operation by December 2010, thus raising the nuclear power installed capacity to 4780 MW. Kaiga-4 brings yet another distinction to the country, elevating it to 6th rank in the world after US, France, Japan, Russian federation and Republic of Korea to have 20 or more nuclear power reactors in operation currently. In addition, three nuclear

power reactors with a capacity of 2500 MW are at an advanced stage of construction and four reactors each of 700 MW, two each at Kakrapar in Gujrat and Rawatbhata in Rajasthan, respectively, have also been launched for construction during this year. With the completion of the reactors under construction, the nuclear power capacity in the country will reach 7280 MW by 2012 and 10080 MW by 2017.[5]

II. Background And History

For **Bangladesh**, which is a historically agrarian country, the agricultural sector has shrunk from over 30% in the 1980s to under 20% a decade into the millennium. On the other hand, industry is growing from under 20% in the 1980s to over 30% currently. With highly industry national economy, the generation of electricity will be linearly related to the national GDP. With lesser agriculture and more industry, not only more emissions will be given off to the atmosphere but lack of trees and plants will hinder any chance of carbon sequestration. [3]

Pakistan, first commercial nuclear power reactor, [6] Known as Karachi Nuclear Power Plant (KANUPP) a small 137 MWe CANDU reactor, was developed. Then In 1969, France contracted with PAEC to provide plutonium and nuclear reprocessing plants in Pakistan. The work on projects did not start until 1972. In 1974, PARR-II Reactor was commissioned. In 1989, People's Republic of China signed an agreement with Pakistan to provide 300 MWe CHASNUPP-I power plant under the IAEA safeguards. In 1990, both France and Soviet Union considered the Pakistan's request to provide the commercial nuclear power plants under the IAEA safeguards. [7] By the 2000, China had expanded its contract with PAEC and is currently assisting in construction of III, and IV power plants. According to PAEC, the goal is to produce 8800 MW electricity by the 2030. The PAEC are currently planning to lead the construction of KANUPP-II nuclear power plant — a 1000 MWe power plant — and the KANUPP-III — 1000 MWe. While the commercial plants will be indigenously built, the preliminary work is put on hold as of 2009. In 2010, the Nuclear Power Fuel Complex (PNPFC) — a nuclear reprocessing power plant — was commissioned. PAEC led the construction, designing, and maintenance of the facility, while China and IAEA provided funds to the facility. [8]

India's first research nuclear reactor and its first nuclear power plant were built with assistance from Canada. The 40 MW research reactor agreements were signed in 1956, and CIRUS achieved first criticality in 1960. This reactor was supplied to India on the assurance that it would not be used for military purposes, but without effective safeguards against such use. [9] The agreement for India's first nuclear power plant at Rajasthan, RAPP-1, was signed in 1963, and followed by RAPP-2 in 1966. These reactors contained rigid safeguards to ensure they would not be used for a military programme. The 200 MWe RAPP-1 reactors were based on the CANDU reactor at Douglas Point and began operation in 1972. Due to technical problems the reactor had to be downrated from 200 MW to 100 MW. The technical and design information were given free of charge by AECL to India. The United States and Canada terminated their assistance after the detonation of India's first nuclear explosion in 1974; RAPP-2 was not completed.

III. Generation Capacity and Load Shedding

South Asian countries face on average a shortage of 15% to 30% of electricity with respect to peak load demand (Table 2). South Asia has huge untapped hydropower potential. Only Pakistan, Bhutan and Nepal have techno-economically feasible hydropower potentials of 50 GW, 23.7 GW and 42 GW respectively. Bangladesh and Sri Lanka have exhausted their hydropower source to a large extent. Electricity demand due to rapid economic growth and depletion of domestic gas reservoirs is the key to energy crisis in Bangladesh. Pakistan has enormous hydel generation potential and can export surplus electricity to these countries by tapping its huge potential Regional electricity trade may be an option to mitigate the shortfalls in South Asia. Trade of electricity on small scale is already taking place in the region. For example, India is importing around 1,200 MW of electricity from Bhutan. Pakistan is importing electricity from Iran.

Table-II Comparison of Electricity profiles of South Asian Countries (1990 to 2008)

Country	Electricity Installed Capacity (GW)		Electricity Generation (000, GWh)		Distribution Losses (Percent)		Per capita Consumption (KWh)	
	1990	2008	1990	2008	1990	2008	1990	2008
India	74.69	177.38	275.49	785.53	20.52	24.66	276	566
Pakistan	7.74	19.77	36.34	87.74	21.48	21.87	277	436
Bangladesh	2.52	5.45	7.62	32.93	34.08	13.17	44	149
Nepal	0.27	0.72	0.90	3.05	18.40	19.56	35	89
Sri Lanka	1.29	2.64	3.12	8.89	16.86	11.33	149	414

There is a general neglect of electricity generation from renewable sources in South Asia, although huge potential exist for wind power, especially in coastal areas of India and Pakistan. However, India is taking the lead in developing renewable energy in the region. The installed capacity of wind power in India of 2 GW (out of 43 GW gross potential) is the 5th largest wind power installed capacity in the world. Renewable capacity

is generally add to the off-grid systems based on small hydro power or solar /wind/biomass power plants in few countries.

IV. Nuclear Power Generation

Nuclear power have high capital cost for building the plant and relatively low fuel cost. Currently, two South Asian economies viz. India and Pakistan are generating nuclear electric power while Bangladesh and Sri Lanka may join the group in future. Bangladesh Atomic Energy Commission (BAEC) for instance, has set a target of raising the share of nuclear electricity in total generation up to 10% by 2021. The historical nuclear electricity generation in India and Pakistan is shown in Figure 1.

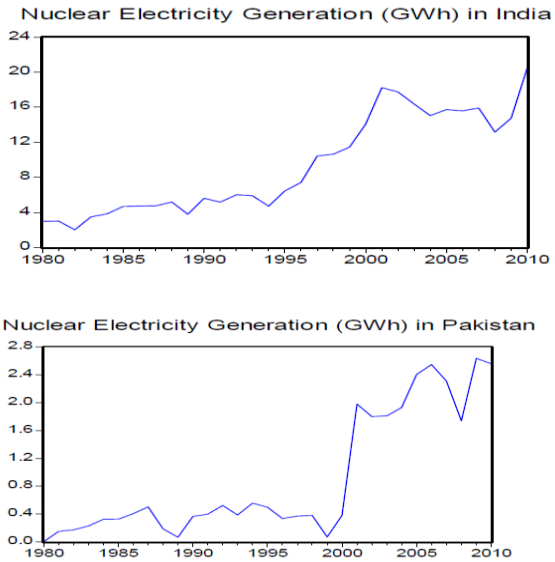

Fig.1 Nuclear Electricity Generation in India and Pakistan During the period 1980-2010 Where in **Bangladesh,[**10], Nucl;ear Energy statistics are is nil.

IV. Current Plans Up To 2020 / Perspective Energy Plan of Present Government

Bangladesh first considered building a nuclear power plant in 1961. Since then, several feasibility studies have been carried out, affirming the feasibility of the project. In 1963 the Ruppur site was selected. More recently, in 2001 Bangladesh adopted a national Nuclear Power Action Plan. On 24 June 2007, Bangladesh's government announced plans to build a nuclear power plant to meet electricity shortages. In May 2010, Bangladesh signed a civilian nuclear agreement with the Russian Federation. Bangladesh also has framework agreement for peaceful nuclear energy applications with the US, France and China. Although the Ministry of Science and ICT, the Ministry of Energy and Mineral Resources and Bangladesh Power Development Board (BPDB) are working on the electric grid system integration, the demographics and circumstances present do raise the question if indeed Bangladesh can produce energy from nuclear sources.[1]

In February 2011, Bangladesh reached an agreement with Russia to build the 2,000 megawatt (MW) Ruppur Nuclear Power Plant with two reactors, each of which will generate 1,200 MW of power. The nuclear power plant will be built at Ruppur, on the banks of the Padma River, in the Ishwardi subdistrict of Pabna, in the northwest of the country. The RNPP is estimated to cost up to US$2 billion, and start operating by 2021. [12] The inter-governmental agreement (IGA) was officially signed on 2 November 2011.[14]On 29th May, 2013 Bangladesh's prime minister declared that a second nuclear power plant will be constructed in an inland river island in southern region of the country. The Perspective Plan of the Planning Commission of the government of Bangladesh for the period 2010 - 2021 has recommended an energy mix to achieve the generation of 20,000 MW by 2021. Targets of electricity production by 2013 and 2015 are 7,000 MW and 8000 MW, respectively. According to the Perspective Plan, the energy mix for power generation is as follows.[11]

Table -III: Energy mix of the Perspective Plan 2010 - 2025 for power generation.

Energy Sources	Target Period		
	Current	2021	2030
Nuclear	0%	10%	19%
Renewable	0%	3%	6%

As of today, In **Pakistan**, only 3 three commercial nuclear power plants are currently operating. The list provided the information about current and future commercial nuclear power plants.[11]In Table-IV, current and future commercial nuclear power plants of Pakistan is given.

Table-IV future commercial nuclear power plants of Pakistan

Nuclear power reactors	Type	Location	Net capacity	Gross capacity	Construction start	Connected to grid	Commercial operation
CHASNUPP-III	PWR	Chasma, Punjab Province	340 MWe	330 MWe	28 April 2009	2016	N/A
CHASNUPP-IV	PWR	Chasma, Punjab Province	340 MWe	330 MWe	2011	2017	N/A
CHASNUPP-V	PWR	Chasma, Punjab Province	1000 MWe	1000 MWe	2014	2020	N/A

In Table-V, Power reactors planned or firmly proposed for India, is given.

Table-V Power reactors planned or firmly proposed for India

Reactor	State	Type	MWe gross, each	Project control	Start construction	Start operation
Kudankulam 3	Tamil Nadu	PWR – AES 92	1050	NPCIL	2014	2019
Kudankulam 4	Tamil Nadu	PWR – AES 92	1050	NPCIL	2014	2020
Jaitapur 1&2	Ratnagiri, Maharashtra	PWR – EPR x 2	1700	NPCIL	2013	2018-19
Kudankulam 5&6	Tamil Nadu	PWR – AES 92 or AES-2006	1050-1200	NPCIL	2014	2019-21
Gorakhpur/ Kumbariya 1&2	Haryana (Fatehabad district)	PHWR x 2	700	NPCIL	by 2017	2018-19
Chutka 1&2	Madhya Pradesh	PHWR x 2	700	NPCIL	6 & 12/2015	2020, 21
Kalpakkam 2&3	Tamil Nadu	FBR x 2	500	Bhavini	2014	2019-20
Jaitapur 3&4	Ratnagiri, Maharashtra	PWR – EPR	1700	NPCIL	2016	2021-22
Mithi Virdi 1-2	Bhavnagar, Gujarat (Saurashtra region)	2 x AP1000	1250	NPCIL	2014?	2019-20
Mithi Virdi 3-4	Bhavnagar, Gujarat	2 x AP1000	1250	NPCIL	2015	2020-21
Kovvada 1-2	Srikakulam, Andhra Pradesh	2 x ESBWR	1350-1550 (1400?)	NPCIL	site works, 2014	2019-20
Haripur 1-2	West Bengal (but likely relocated, maybe to Orissa)	PWR x 4 VVER-1200	1200		2014	2019-21
Haripur 3-4	West Bengal	PWR x 4 VVER1200	1200		2017	2022-23
Mithi Virdi 5-6	Bhavnagar, Gujarat	AP1000 x 2	1250 x 2		2023-24	
Subtotal proposed		**approx 39**	**45,000 MWe approx**			

V. CONCLUSION

Asia is the main region in the world where electricity generating capacity and specifically nuclear power is growing significantly. In East and South Asia there are 119 operable nuclear power reactors, 49 under construction and firm plans to build a further 100. Many more are proposed. The study concludes the summary of the three countries in Table -VI &. Though among India, Pakistan and Bangladesh, India and Pakistan have already got some installed capacity but including Bangladesh both of them need more nuclear sectors in the region and increased of installation is required.

In Table VI no. of reactors and capacity, megawatts, is compared among the three countries.

Table:VI (Nuclear Power in Asia, and Involvement with the Nuclear Fuel Cycle)[13]

	Power Reactors operable or in Operation	Power Reactors Under Construction	Power Reactors Planned	Research Reactors	Other Stages of the Fuel Cycle
Bangladesh			2	1	
India	20	7	18	5	UM, FF, R, WM
Pakistan	3	2	0	1	UM, E, FF

Table: VII (no. of reactors and capacity, megawatts, MW) [14]

	Operator		**Construction**		**Planned**		**Proposed**		**Uranium Demand 2008(tonnes)**
	No	**MW**	**No**	**MW**	**No**	**MW**	**No**	**MW**	
Bangladesh							**2**	**2000**	
India	**17**	**8,857**	**5**	**4,540**	**30**	**32,000**	**86**	**68,000**	**1,396**
Pakistan	**2**	**400**	**1**	**300**	**2**	**600**	**2**	**2,000**	**65**

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