POWER SCENARIO IN INDIA AND THE NEED OF NUCLEAR POWER GENERATION

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Abstract-*Energy and powered devices are an integral part of society and today there is a lot of demand for energy. There are many sources of energy. Wind, solar, power, oil, natural gas, coal, petroleum etc. all provide electricity and energy for the world. Wind, Tidal and Solar power system are renewable but less efficient and unreliable energy system. The fast depletion of coal and petroleum leads to seek alternative sources of energy. Abundant power can be generated with cheap cost by breaking the atoms. But there are actually two ways of obtaining energy with atoms. One is called "fusion" and one is called "fission." But Nuclear power has the lowest levels of fatalities per unit of energy generated compared with another sources. The atom is considered as limitless source of power and hence the nuclear power is the large amount of energy which can be released from a small mass of active material. This paper presents the current status of energy generation in India and role of nuclear power industry in India and comparison with nuclear power systems to another power system.*

Keywords: Energy generation, Uranium, nuclear power plant, radiation, Nuclear Chain Reaction, India.

1. INTRODUCTION

A nuclear power plant reactor produces and controls the release of energy from splitting the radioactive atoms, of certain elements. In a nuclear power reactor, the splitting or nuclear fission of materials like uranium (U), Plutonium (Pu) has opened up a new source of power of great importance [1, 2]. The heat produced due to fission of uranium or plutonium is used to heat water to generate steam which is used for running turbo generators and energy has been generated.

1.1. NUCLEAR CHAIN REACTIONS

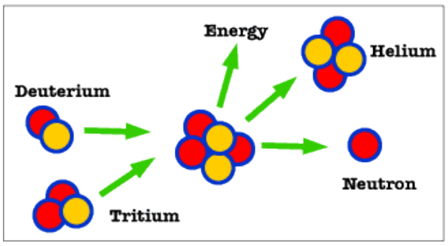

Fig.1. Nuclear Chain Reaction

Fission is the process in which heavy nucleus is split when it is bombarded by certain particles, as already stated. When the nucleus of a U-235 atom bombarded by a neutron it splits in two (fissions) and releases enormous amount of energy, also two or three additional neutrons are thrown off which creates a "Chain Reaction" [3]. Fig.1. shows the Chain Reaction of U^{235}. This fission of the nucleus produces two or rarely three, fragments moving at high speeds, two or three neutrons and considerable radiant energy. The energy resulting from the fission of an uranium 235 atom is about 200 MeV and is distributed among the various products of fission as follows:

Kinetic energy of the fission fragments	...	165(84%)
Kinetic energy of the fission neutrons	...	5(2.5%)
Radioactive decay energy	...	21(10.5%)
Gamma rays from fission products	...	6(3%)

The kinetic energy of the fission fragments and the radiant energy is ultimately converted into heat in the surrounding material. It is this heat which is finally used to produce steam for the operation of turbine generators.

If just one of the two or three neutrons produced in the fission of an atom can be made to fission another atom, and one of the neutrons from this second 'fission' can be made to cause a third fission and so on a self perpetuating chain reaction will result. Uranium exists as isotopes of U^{235}, U^{238}, and U^{234}. The U^{235} isotope is unstable and its spontaneous fissions give off neutrons, protons and electrons as well as energy rays. The mass difference is accounted for the release of energy according to the equation $E = \Delta mc^2$(Einstein Equation).

When a neutron is captured by a nucleus of an atom of $U^{235,}$ the U^{236} isotope is formed. This isotopic, highly unstable type of uranium exists for perhaps one millionth of a second. It splits roughly into two equal parts and has a total energy release of 200 million electron volts (MeV). The products formed include the fission fragments, neutrons and electromagnetic radiation or gamma rays. The fission products absorb most of the energy released by the fission as kinetic energy, which is converted into heat as the fragments collide. The particles decay mainly by beta and gamma radiation with some neutron particle emission and in rare causes alpha radiation. Most of the energy released as heat close to the site of fission and is released into surroundings. On the average two or three neutrons are released with each fission. When a neutron causes fission of U ^{235} a typical reaction produces barium, krypton, two or three neutrons and release of energy due to loss of mass.

2. NUCLEAR REACTOR WORKING PRINCIPLES

Nuclear reactor is used to produce heat and this heat is used to convert water into steam. The main components of a nuclear power plant are: Reactor, Heat Exchanger, Steam turbine, Condenser and Electric generator. The pressurized steam is first feed in a high pressure turbine. The steam turbine is turn to run an electric generator or alternator which is coupled to steam turbine and thereby producing electric energy (4). The steam that leaves the turbines is cooled in a condenser which is connected to the cooling tower. The cold water from the cooling tower takes the heat from the condensed water of the condenser. The hot water in cooling tower is sprayed in air thus cooling it down, to be again pumped back to the condenser. This is the working principle of Nuclear power plant. Some important reactors are as follows:

(i) Pressurized water reactor (PWR)

(ii) Boiling water reactor (BWR)

(iii) Gas-cooled reactor

(iv) Liquid metal-cooled reactor

(v) Breeder reactor.

The Pressurized water reactors (PWRs) are used in the large majority of the world's nuclear power plants. Fig.2. shows Schematic Diagram of Pressurized-Water Reactor Nuclear Power Plant.

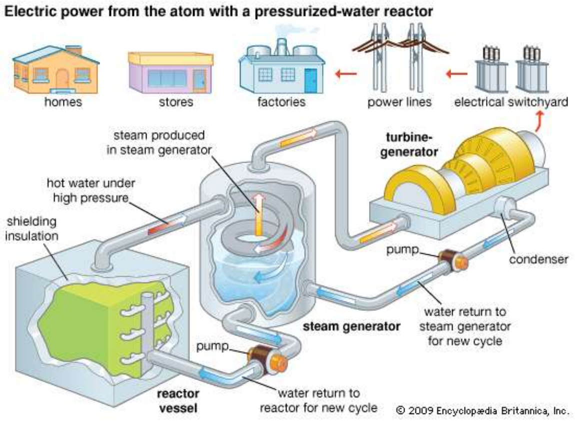

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Fig.2. Schematic Diagram of Pressurised-Water Reactor used in Nuclear Power Plant

3. NUCLEAR ENERGY STATUS IN INDIA

A country like France produces about 50% of its total energy by using nuclear plant whereas the country like India has sufficient uranium source but only to produce 6 x 10^6 kW, a mere of 1% of its current energy requirement by nuclear power plant.

At the time of independence the total installed capacity of electricity generation was 1,363 MWe (5). The installed capacity rose to 30,214 MWe in the year 1980-81. After 10 years i.e. 1990-91 the installed capacity was 66,086 MWe. In the year 2003 the capacity was 138,730 MWe. The average growth rate over the entire period, thus, has been an impressive 8.6%/yr. During the year 2000-01, there was an average electricity shortage of 7.8% and a peak power demand shortage of 13%. It has now increased to 10% and 15% respectively. **Table -1 shows the total installed power capacity by sector in India.** At present **in India a total of 360,456 MWe** power was generated by state, central and private put together (6).

It is estimated that India imports about 30% of its commercial energy. India is importing coal, hydrocarbons as well as enriched uranium (7). Nuclear fuel contains energy in a concentrated form thus requiring much less tonnage for fuel to be transported or stored.

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Sector	Thermal (MWe)					Nuclear (MWe)	Renewable (MWe)		Total (MWe)	%
	Coal	Lignite	Gas	Diesel	Sub-Total Thermal		Hydro	Other Renewable		
State	64,736	1,290	7,118	363	73,509	0.00	26,958	2,349	102,817	29
Central	56,340	3,140	7,237	0.00	66,717	6,780	15,046	1,632	90,176	25
Private	74,733	1,830	10,580	273	87,417	0.00	3,394	76,650	167,461	46
All India	195,80	6,260	24,937	637	227,644	6,780	45,399	80,632	360,456	100

Table -1: Total installed Power Capacity by Sector in India.

Source: Electricity Sector in India - Wikipedia

Technically nuclear energy is far more benign and much of the cost is already internalized in financial plans. **Table-2 shows the installed capacity of Nuclear Power Plant in India.**

India has considerable resources of nuclear fuel which would help development of nuclear power in the country. The indicated and inferred reserves of uranium at two locations; Jaduguda and Narwa Pahar and Bhattin (Bihar) total about 33,000 tonnes.

There are other important deposits in Singhbhum (Bihar) and minor deposits in MP, HP, UP, Rajasthan and are in the exploratory stage.

Power station	Operator	State	Type	Units	Total Capacity (MW)
Kaiga	NPCIL	Karnataka	PHWR	220 x 4	880
Kakrapar	NPCIL	Gujarat	PHWR	220 x 2	440
Kudankulam	NPCIL	Tamil Nadu	VVER-1000	1000 x 2	2,000
Madras (Kalpakkam)	NPCIL	Tamil Nadu	PHWR	220 x 2	440
Narora	NPCIL	Uttar Pradesh	PHWR	220 x 2	440
Rajasthan	NPCIL	Rajasthan	PHWR	100 x 1 200 x 1 220 x 4	1,180
Tarapur	NPCIL	Maharashtra	BWR PHWR	160 x 2 540 x 2	1,400
Total					**6,780**

Table -2: Installed Nuclear Power Plant In India

Source: Nuclear Power in India – Wikipedia.

Uranium may be in a position to sustain about 5000 to 10,000 MW of nuclear power for its life time. In India, abundance of Thorium deposits are available from monazite sand on the west coast. Therefore, India's interests lie in the Thorium Breeder Reactors. There are following nuclear power plants in India at the moment. The 380 MW (2 x 190) Tarapore (Maharastra) nuclear power plant was commissioned in 1969, which uses enriched uranium as a fuel and boiling water reactors are employed. The second plant is at Rana Pratap sagar Kota (Raj), which has capacity 400 MW (2 x 200) which use, natural uranium as fuel and pressurized heavy water reactors are employed. The station at Kalpakkam (MAPP) a capacity of 470 MW (2 units of 235 MW). The reactors at these stations are similar to those at Rana Pratap Sagar. The nuclear power station at Kakrapar (Gujarat) is under construction.

Both units I and II of the Kakrapar Atomic Power Plant (KAPP) with a capacity of two units of 235 MW each are to attain critically by the year 1993. Both these projects are at the Pressurized Heavy Water Reactor (PHWR) types, which are now the standard.

For the Rajasthan Atomic Power Projects (RAPP) 3 and 4 (2 x 235 MW PHWRs) the target dates for attainment of critically are May and December 1995, while that of the Kaiga 1 and 2 in Karnataka (2 x 235 MW

PHWRs) are to attain critically by June 1995 and December 1995.

India would go ahead with its plans to have 10,000 MWe nuclear energy by the turn of the century. So far, the existing plants are providing about 2,000 MW of nuclear power.

Table -3 shows the details of Nuclear power plants and reactors under construction in India.

Power station	**Operator**	**State**	**Type**	**Units**	**Total capacity (MW)**	**Expected Operational year**
Madras (Kalpakkam)	Bhavini	Tamil Nadu	PFBR	500 x 1	500	2020
Kakrapar Unit 3 and 4	NPCIL	Gujarat	PHWR	700 x 2	1,400	2022
Gorakhpur	NPCIL	Haryana	PHWR	700 x 2	1,400	2025
Rajasthan Unit 7 and 8	NPCIL	Rajasthan	PHWR	700 x 2	1,400	2022
Kudankulam Unit 3 and 4	NPCIL	Tamil Nadu	VVER-1000	1000 x 2	2,000	2025-2026
Total					**6,700**	

Table-3: Nuclear power plants and reactors under construction in India.

Source: Nuclear Power in India – Wikipedia.

The report says that the environmental clearances for the sites from the state governments and the site clearance by Atomic Energy Regulatory Board (AEPB) were obtained for the Kaiga Project 3 to 6 (4 x 235 MW, PHWRs) and RAPP 5 to 8 (4 x 235 MW PHWRs).

India's GDP has been growing quite fast and it is forecast that it will continue. The GDP growth has to be accompanied by growth of energy generation. A number of organs of the Government of India (GOI) are engaged in energy generation and production and we felt it desirable to look at all the fuel resources.

In case of energy technologies, electrical energy in particular, lead times for developing new technologies are very long and, therefore, scenario building is desirable to identify problem areas and initiate R&D on relevant topics. **Table-4 shows the details of Cumulative Nuclear Power Installed Capacity up to 2052.**

	PHWR, AHWR and FBR based on Pu from PHWR			**LWR and FBR based on Pu from LWR**			**Sub Total**		**Grand Total**
Year	Thermal (GWe)	Fast (GWe)		Thermal (GWe)	Fast (GWe)		Oxide (GWe)	Metal (GWe)	(GWe)
	Oxide	Oxide	Metal	Oxide	Oxide	Metal			
2002	2.40	0.00	0.00	0.32	0.00	0.00	2.72	0.00	2.72
2022	9.96	2.50	6.00	8.00	0.00	3.00	20.46	9.00	29.46

2032	9.40	2.50	33.00	8.00	0.00	10.00	19.90	43.00	62.90
2042	7.86	2.50	87.00	8.00	0.00	26.00	18.36	113.00	131.36
2052	4.06	2.50	199.00	8.00	0.00	61.00	14.56	260.00	274.56

Table 4: Cumulative Nuclear Power Installed Capacity

4. CONCLUSION

India is the 7th largest country in the world with an estimated population of about 1.24 billion, is on a road to rapid growth in economy. Energy, particularly electricity, is a key input for accelerating India's economic growth. The consumption of electrical energy is more in India. The present electricity generation in India is having severe shortage for its impressive growth (8, 9). The developing country like India should think of sustainable development in social, economical and energy. India has to generate more and more power for its GDP growth. Therefore, the alternative energy for India is nuclear and it has to generate more power by using Nuclear power plant with **all the safety measures** in addition to the existing power generation by thermal, wind, hydro and turbine power plant.

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