A Review Paper on Nuclear Power Plant and Its Importance in Indian Economy

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Abstract- *Nuclear power plants are the fourth largest source of electricity in India. The IAEA reports that there are 437 nuclear power reactors in operation, and 69 nuclear power reactors under construction in 31 countries around the world. Electricity was generated by a nuclear reactor for the first time ever on September 3, 1948 at the X-10 Graphite Reactor in Oak Ridge, Tennessee in the United States, and was the first nuclear power plant to power a light bulb. In India Nuclear Power Plants contribute to about 2% of its total power generation. There are & nuclear power plants in India with a sum total of 21 fully functional nuclear reactors. They produce a total of 30,292.91 GWh of electricity.*

Keywords: *Nuclear power, Nuclear Reactors, Electricity, Nuclear power Plants.*

I. INTRODUCTION

Nuclear power plant is a thermal station in which the heat source is a nuclear reactor. The heat source is used to generate steam which dives a steam turbine collected to an electric generator which produces electricity.

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II. NUCLEAR POWER PLANT

The conversion to electrical energy takes place indirectly, as in conventional thermal power stations. The fission in a nuclear reactor heats the reactor coolant.

The coolant used may be water even liquid metal depending on the type of reactor. The reactor coolant then goes to a steam generator and heats water to produce steam. The pressurized steam is then usually fed to a multi-stage steam turbine. After the steam turbine has expanded and partially condensed the steam, the remaining vapor is condensed in a condenser.

The condenser is a heat exchanger which is connected to a secondary side such as a river or a cooling tower. The water is then pumped back into the steam generator and the cycle begins again. The water-steam cycle corresponds to the Rankine cycle.

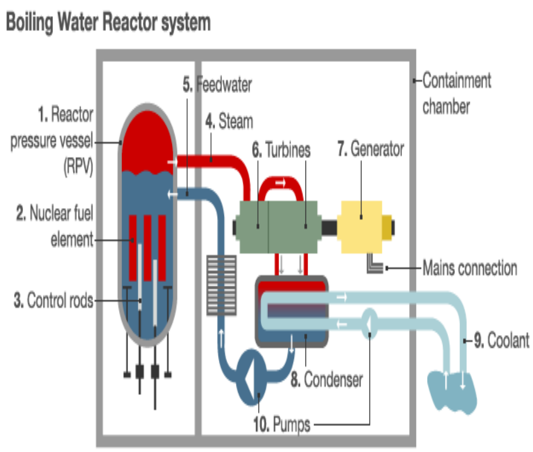

Fig.1 Boiling Water Reactor System

III. PARTS OF A NUCLEAR POWER PLANT

A. Fuel

The fissionable material used in the reactor is called as fuel. The commonly used fuels are Uranium, Plutonium and Thorium. It can be U-235, U-238, Pu-236 or Th-232.

Uranium is mostly preferred as it has high melting point.

B. Moderator

Moderators are used to reduce speed of the neutrons by absorbing energy. Neutrons having a certain speed will be used for the controlled chain reaction.

Commonly used moderators include regular (light) water (75% of reactors), solid graphite (20% of reactors) and heavy (5% of reactors).

Beryllium has also been used in some experimental types, and hydrocarbons have been suggested as another possibility.

C. Shielding

Nuclear radiations are hazardous to human health. Hence the nuclear reactors are protected using shielding which prevents radiations from harming human tissues.

Shielding prevents radiations to reach outside the reactor.

Lead blocks and concrete enclosure that is strong enough of several meters thickness are used for shielding.

D. Coolant

The coolant is substance in a pipe to the steam generator where water is boiled. This is where heat-exchange process occurs. Heat is absorbed by the coolant that is produced in the reactor.

Typical coolants are water, carbon dioxide gas or liquid sodium.

E. Control Rods

These rods absorb neutrons and stop the chain reaction to proceed further. These are made up of steel containing a high percentage of material like cadmium or boron which can absorb neutrons. When control rods are completely inserted into the moderator block then all the neutrons is absorbed and reaction comes to halt.

F. Turbines

Steam produced in the boiler is now passes to a turbine. The force of the steam jet causes the turbine to rotate. Heat energy (steam) is converted to mechanical energy (moving turbine).

G. Generator

The generator converts kinetic energy supplied by the turbine into electrical energy. Low-pole AC synchronous generators of high rated power are used.

The generator consists of coils that change the mechanical energy into electric energy. The turbine moves and the change in magnetic flux cause electricity. This is transmitted to substations for generation of electric power.

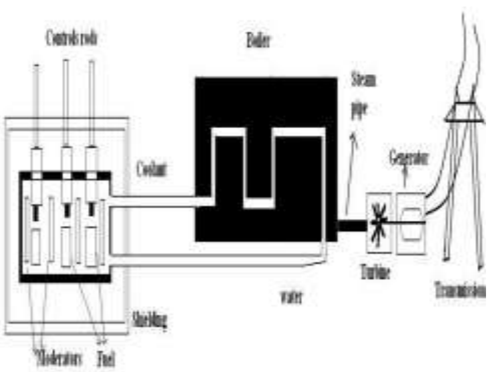

Fig.2 Parts Of Nuclear Plant

IV. NUCLEAR POWER IN INDIA

Nuclear power is the fourth-largest source, of electricity in India after hydroelectric, thermal and renewable sources of electricity. As per the latest reports, India has 21 Nuclear reactors in a total of 7 Nuclear Power Plants. The installed capacity of 5780 MW and producing a total of 30,292.91 GWh of electricity. A total of 6 more reactors are under construction and are expected to generate an additional 4,300 MW.

In October 2010, India drew up "an ambitious plan to reach a nuclear power capacity of 63,000 MW in 2032", but, after the 2011 Fukushima nuclear disaster in Japan, "populations around proposed Indian NPP sites have launched protests, raising questions about atomic energy as a clean and safe alternative to fossil fuels". There have been mass protests against the French-backed 9900 MW Jaitapur Nuclear Power Project in Maharashtra and the Russian-backed 2000 MW Kudankulam Nuclear Power Plant in Tamil Nadu. The state government of West Bengal state has also refused permission to a proposed 6000 MW facility near the town of Haripur that intended to host six Russian reactors. A Public Interest Litigation (PIL) has also been filed against the government's civil nuclear programme at the Supreme Court.

Despite this opposition, the capacity factor of Indian reactors was at 79% in the year 2011-12 compared to 71% in 2010-11. Nine out of twenty Indian reactors recorded an unprecedented 97% capacity factor during 2011-12. With the imported uranium from France, the 220 MW Kakrapar 2 PHWR reactors recorded 99% capacity factor during 2011-12.

The Availability factor for the year 2011-12 was at 89%.

India has been making advances in the field of thorium-based fuels, working to design and develop a prototype for an atomic reactor using thorium and low-enriched uranium, a key part of India's three stage nuclear power programme. The country has also recently re-initiated its involvement in the LENR research activities, in addition to supporting work done in the fusion power area through the ITER initiative.

Fig.3 Instilled Power Capacity

A. Fully Operational Plants

Currently, twenty-one nuclear power reactors have a total install capacity of 5,780 MW (3.5% of total installed base). The exact production of each plant is described in detail in the following table.

Power station	State	Type	Units	Total capacity (MW)
Kaiga	Karnataka	PHWR	220 x 4	880
Kakrapar	Gujarat	PHWR	220 x 2	440
Madras (Kalpakkam)	Tamil Nadu	PHWR	220 x 2	440
Narora	Uttar Pradesh	PHWR	220 x 2	440
Rajasthan	Kota Rajasthan	PHWR	100 x 1 200 x 1 220 x 4	1180
Tarapur	Maharashtra	BWR PHWR	160 x 2 540 x 2	1400
Kudankulam	Tamil Nadu	VVER-1000	1000 x 1	1000
		Total	21	5780

Fig.4 Functional Power Plants

B. Plants under Construction

The projects under construction in India will produce a total of 4300 MW of power once they are up and functional. The details are described below.

Power station	State	Type	Units	Total capacity (MW)	Expected Commercial Operation
Madras (Kalpakkam)	Tamil Nadu	PFBR	500 x 1	500	April 2016
Kakrapar Unit 3 and 4	Gujarat	PHWR	700 x 2	1400	Unit 3: Late 2016/Early 2017, Unit 4: 2017
Rajasthan Unit 7 and 8	Rajasthan	PHWR	700 x 2	1400	Unit 7: June 2016, Unit 8: December 2016
Kudankulam Unit 2	Tamil Nadu	VVER-1000	1000 x 1	1000	June 2016
		Total	4	4300	

Fig.5 Plants Under construction

C. Proposed Plants

The proposed plants in India will be place in different states. If these plants are sanctioned the total capacity of produced power will be 33564 MW. The details is as follows:

Power station	State	Type	Units	Total capacity (MW)
Gorakhpur	Haryana	PHWR	630 x 4	2,800
Chutka	Madhya Pradesh	PHWR	700 x 2	1400
Mahi Banswara	Rajasthan	PHWR	700 x 2	1400
Kaiga	Karnataka	PHWR	700 x 2	1400
Madras	Tamil Nadu	FBR	500 x 2	1000
Site to be decided		AHWR	300 x 1	300
Kudankulam	Tamil Nadu	VVER-1000	1000 x 2	2000
Jaitapur	Maharashtra	EPR	1650 x 6	9900
Kovvada	Andhra Pradesh	ESBWR	1594 x 6	9564
Mithi Virdi (Viradi)	Gujarat	AP1000	1100 x 6	6600
		Total	33	33564

Fig.6 Planned/Proposed Plants

VI. IMPORTANCE IN INDIAN ECONOMY

The consumption of electricity in India has seen an exponential growth in the past few years.

The per capita consumption in 2012-13 was 914.41 kWh.

It increased to 957 kWh in 2013-14, with a difference of nearly 44 kWh compared to the previous year.

The country's per capita electricity consumption has reached 1010 kilowatt-hour (kWh) in 2014-15, with a huge difference of more than 50 kWh.

With such increase in the power consumption, nuclear power plants contribute to about 2% of the produced electricity.

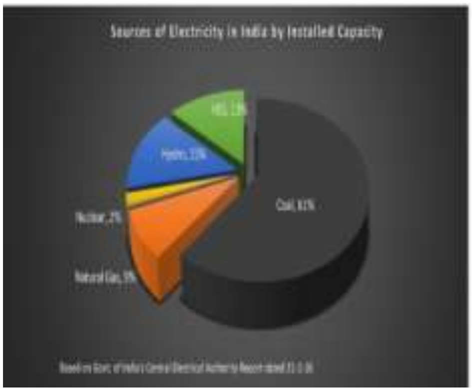

Fig.7 Electricity sources

As of 2013, India had 5.78 GW of installed electricity generation capacity using nuclear fuels. India's nuclear plants generated 32455 million units or 3.75% of total electricity produced in India.

India's nuclear power generation effort satisfies many safeguards and oversights, such as getting ISO-14001 accreditation for environment management system and peer review by World Association of Nuclear Operators including a pre-start up peer review.

Nuclear Power Corporation of India Limited admits, in its annual report for 2011 that its biggest challenge is to address the public and policy maker perceptions about the safety of nuclear power, particularly after the Fukushima incident in Japan.

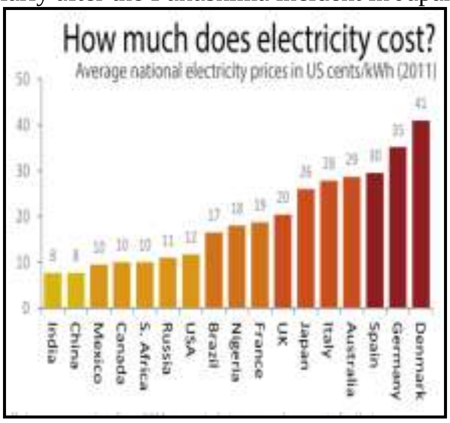

Fig.7 Cost of Electricity In Different Countries

In 2011, India had 18 pressurized heavy water reactors in operation, with another four projects of 2.8 GW capacity launched.

India is in the process of launching its first prototype fast breeder reactor of 500 MW capacity in Tamil Nadu.

India has nuclear power plants operating in the following states: Maharashtra, Gujarat, Rajasthan, Uttar Pradesh, Tamil Nadu and Karnataka. These reactors have an installed electricity generation capacity between 100 to 540 MW each.

India's share of nuclear power plant generation capacity is just 1.2% of worldwide nuclear power production capacity, making it the 15th largest nuclear power producer. Nuclear power provided 3% of the country's total electricity generation in 2011. India aims to supply 9% of it electricity needs with nuclear power by 2032.

The country currently gets under 2% of its electricity from nuclear power, with the rest coming from coal (60%), hydroelectricity (16%), other renewable sources (12%) and natural gas (9%). It expects to produce around 25% of its electricity from nuclear power.

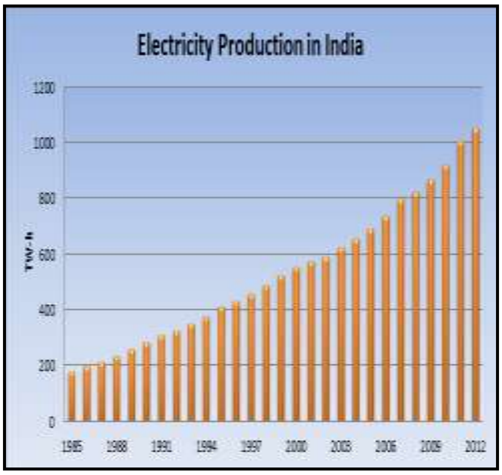

Fig.8 Production Of Electricity

VI. CONCLUSION

With an increasing appetite for the consumption of electricity in India, it is very important to implement Nuclear Power Plants for the generation of electricity.

All the other sources of generation of electricity are contributing in a huge percentage but nuclear power plants contribute a mere 2%.

Also India has to increase its contribution through Nuclear energy in the international level.

The total costs of the power production can be hugely affected with the implementation of Nuclear Power Plants.

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