NUCLEAR ENERGY: THE DEPENDABLE OPTION

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Abstract:

The purpose of this paper is to address the current issue of Energy requirement and an alternative solution for it. The principle focus will be on concept of nuclear energy its need and threats. Today's world is undoubtedly facing a danger posed by continuously depletion of non-renewable sources of energy, which may possibly get finished within few years. Such utilization is depleting the sources like coalmines, natural oil reserves; which are responsible for global warming due to increased rate of carbon dioxide and several other environmental problems related to air environment. And on other hand renewable energy sources like solar, wind, geothermal energy are very dilute sources of energy and requires more land and money for setup of energy plant or sectors. Nuclear energy is fairly cheap and can be produced required amount of energy to fulfill the requirement .

In this paper nuclear power plant situated in Gujarat at Bhavnagar is taken as case study, which is a 3 stages nuclear power plant based on advancement of Nuclear power reactor.

Keywords: Non-renewable sources, Nuclear energy, Global warming, nuclear power plant.

1. Introduction

Energy is the fundamental requirement of every element present on the Earth to sustain its existence. As well it leads an important role in development of mankind. After a civilization by 18th century there is continuous increasing demand of energy due to vast industrialization. Current demand of energy is possible to get doubled in coming few years. It is estimated that over few years it will result into several pollution problems unless the pattern changes. Because current requirement of energy is fulfilled by the run of turbines with hot steam obtained after burning coal and natural oil. Generally energy is obtained by burning of fossil fuels majorly Coal

Which produces energy but releases harmful gases like carbon monoxide, nitrogen dioxide, and sulfur dioxide, which are responsible for greenhouse effects, global warming and degradation of air quality. But as compared to Nuclear energy; it can become a good alternative for energy demand because it is cheap to produce and it is a clean energy source.

2. Current world scenario of energy sources and utilization

Energy is obtained from different sources; each has its different characteristics. Based on it these sources are classified on two major categories as,

1) Conventional

2) Non-Conventional energy sources

Conventional energy sources are Fossil fuel that are coal, natural oil natural gas which on the way to running out due to rapid increase in energy consumption.

And other non convectional sources of energy that are solar, wind geothermal biomass and wave energy which are clean energy sources but are very dilute because of lack of technology to get its full benefits. Following figure shows the current requirement of sources in the world.

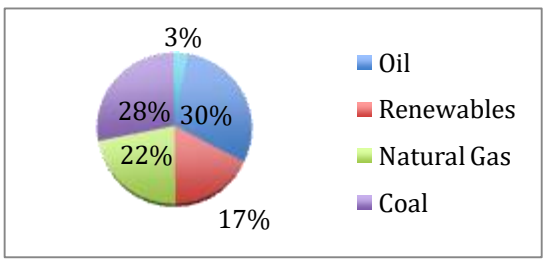

Fig No1. : Current requirement of sources in the world.

According to above figure it is clear that more than 70% energy is generated by non-renewable energy sources and remaining is generated either by remaining sources.

Energy consumption in India

India has more than 1.2 billion population and India is worldsfourth highest energy consumer after USA, China and Russia and India is 5th biggest GHG emitter in the world. In India energy is obtained by nonrenewable sources like Fossil fuels and renewable sources like solar, wind power, geothermal and biomass energy. But currently in India energy is generated either by using coal, natural oil and natural gas. In India plenty of coal is available (84,396 million tons) which can last up for 240 years only. Crude Oil consumption account more than 36% of the energy and together coal, natural gas and oil makes 70% of energy generation. While renewable energy sources requires costly infrastructure, land and money. Following char shows energy installments in India

Table No. 1:Energy installments in India.

Energy Type	Installment
Thermal Energy	64.6%
Hydroelectric	24,7%
Nuclear Energy	7.7%
Renewable Energy	2.9%

But still there is crisis in energy supply. Hence there is need of cleaner and concentrated energy source to meet the demand, and the good alternative can be'**Nuclear Energy**'

3. Why nuclear energy should be preferred?

- Clean source
- Sustainable source of energy
- Less air pollution problems
- Decreases dependency on fossil fuel
- Saving of land use
- Higher efficiency

Comparison between Nuclear fuel and fossil fuel.

Table No.2: Calorific value of fuel

Amount Of Fuel	Energy generation (KW/hr.)	Calorific value (KJ/Kg)
1kg Coal	8	17000-32500
1KL Oil	12	41200
1000 Cubic Feet of Natural Gas	127	43000

Table No.3: Calorific value of U_{235}

Fuel Uranium-235	Fuel Type	Calorific value
1Kg	Recycled	500GJ/Kg
1Kg	Natural	650GJ/Kg
1Kg	Enriched	3900GJ/Kg

Current utilization of energy in India

India holds 4th rank in utilization of nuclear fuel for energy generation. Presently in India there are total 21 nuclear reactors, which produces 5780MW energy. While 4 are under construction which will be able to produce 4300 MW energy and newly proposed reactors will be able to generate 28364MW energy by 2020. The plant installed in India is pressurized nuclear reactor, boiling nuclear reactor and free breeder nuclear reactor heavy water reactor, light water reactor. In which FBR reactor is based on generation of energy with the help of Plutonium formed during fission reaction. While remaining reactors utilizes Uranium-235. Hence combination of conventional reactor and FBR can able to produce more energy with less fuelling of rector.

Nuclear energy and working of rector

Initially nuclear reactor works on nuclear fuel, which emits thermal energy in from of different emission waves after bombarding of neutron on pellets containing nuclear fuel.

Working of nuclear reactor and handling of nuclear waste

A nuclear reactor is a system that contains and controls sustained chain reaction. In which 1st up all thermal power is generated by bombarding neutron on uranium, which undergoes nuclear

fission reaction and emits energy in a form of heat. During this reactor vessel holding chain reaction gets heated more enough to generated pressurized steam and vapors by using water to cool down vessel, which are able to rotate turbine attached to generator, which converts heat energy to kinetic energy. Engineered safety features added to rector for the emergency shutdown of control-rod-system which reactor operates vessel with cooling systems to avoid ant misshapen during reaction process.

Generally coolants used to control temperature of reactor vessel are water, CO_2, Graphite and heavy water. The coolant used serves to purposes it removes excess heat and provides intrinsic safety. And after a typical fuel cycle fuelling of reactor is done by replacing spent pellets by new pellets. The spent pallets are then removed and sent to handling and disposal unit.

Benefits and threats of nuclear energy

Benefits

- Relatively low cost
- Stable energy generation load
- Low air pollution only thermal
- Sustainable energy source
- Cleaner source
- High energy density
- Useful by product (plutonium, thorium)
- Medical health care instruments, UV radiations, security scanners.

Threats

Accidents may happen

- London Three Mile Island (March 28, 1979)**.** It was caused by partial meltdown of cooling system.
- Chernobyl Disaster (April 26, 1986)
  It took place due to failure of system during testing of nuclear vessel and turbine.
- Fukushima (March 11, 2011)
  It took place due tsunami occurred near to plant which had damaged the emergency cooling system of plant. Radioactivity
- Storage of nuclear fuel and waste
- Ecological Hazards like Mutation, Bio-accumulation, Bio-magnification, Bio-concentration, Alteration of nuclei.
- Social problems due to past evidences. Hence proper handling and storage of nuclear fuel is required to avoid any threat related to nuclear contamination.

Handling and disposal of nuclear waste

Handling of nuclear waste after spent is carried out by different methods;

In which methods like

1. Dilute and Disperse,
2. Delay and Decay and

3. Concentrate and Contain

Are used, based on concentration level of waste low, medium and high respectively.

After desired decrease in radioactivity and concentration waste containing anti-radioactive containers are disposed of either by gullwing metods

1. Incineration,
2. Compaction in soil,
3. Cementation
4. Verification.

- **Handling practice at Yucca Mountain**

  Yucca Mountain is located near Las Vegas in the desert of Nevada. It is 6 mile long 1,200 feet high and it is able to store more than 70,000 tons of radioactive material packed in container. In this waste handling of nuclear waste is carried out by storing spent pallets in carbon or stain steel- zirconium iron containers. Inside yucca mountain 3 tunnels are constructed which are parallel to main rail cart transportation lane which transports spent nuclear pallets packed in container to suitable tunnel depending upon type of waste low, medium and high level waste. And after storage has done entrance of Yucca Mountain in closed with the help of thick anti-radioactive door during this all system is operated with the help of automatic sensing system to avid any human contact with radioactive waste.

Fig. No. 2: **Yucca Mountain**

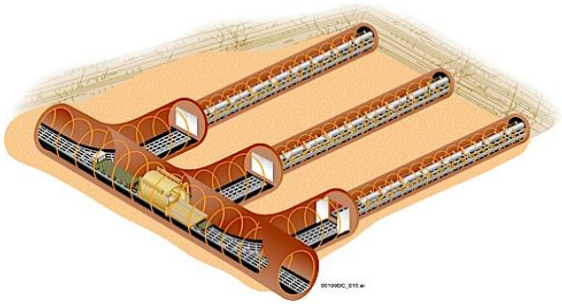

Fig. No. 3: **Tunnels of Yucca Mountain**

Fig. No. 4: **Tunnels of Anti-radio activedoor**

Case Study: Advancement in nuclear power plant (Ref.:EIA Report)

In India most commonly operated reactors are Pressurized Nuclear Reactors ad Boiling water Reactors Fast reactors. Moderation provided by these reactors use either natural

uranium or enriched uranium, which undergoes continuous chain reaction. Hence whenever nuclear fuel that is uranium-235 is used it keeps chain reaction continuous until splitting of uranium into plutonium and thorium occurs. When spiting of uranium takes place, then new pellets are replaced spent pallets. These spent pellets still contain nuclear energy potential hence it is termed as High-level nuclear waste. Due to lack of technology energy potential of uranium isotopes cannot be recovered because the design of reactor is based on only energy extradition from uranium. But on other hand if combination of Uranium reactor and thorium reactor is done then continuous energy extraction with least fuelling can be done. One good example of this option is Three-stage nuclear power plant which is under construction.

Three stage nuclear power plant

India is pursuing Three-stage nuclear power plant in Gujarat at Mithivirdi Bhavnagar; under execution of Government of India and Nuclear Power Corporation Of India Limited(NPCIL). In which total 6 reactors are designed having capacity of 1000MW per reactor. There are total 6 reactors in which 3 reactors are PHWR and 3 are FBR (Fast Breeder Reactor). The plant is consisting of 3 stages in which both uranium and its isotopes can be used for extraction of energy.

First Stage- In this step naturally occurring uranium is obtained and used as a fuel, after enrichment of fuel in ordinary pressurized water reactor.

Second stage- The second stage of program comprise of application of Fast Breeder Reactor using plutonium obtained from spent fuel of uranium pellets in 1_{st} PHWR reactor which forms plutonium and thorium isotopes are used to convert isotope Thorium into Uranium U-233 as a fissile material.

Third Stage- The third stage of the program involves the use of U-233 obtained from second stage of FBR and thorium as blanket there by producing continuousenergy generation with use and recovery of spent nuclear fuel.

Cooling system

For cooling purpose, water is extracted from Arabian Sea, which is dense in nature and used to generate steam after cooling down of nuclear vessel. After generation of energy steam is recovered as water by condensation and used as coolant for next cycle of energy generation.

Handling of nuclear waste

After nuclear potential is extracted from fuel the spent pellets are stored in thick stainless-steel container with obstruction of radioactivity through container. This waste contains low radioactivity due to extraction of fuel hence it causes less radioactivity and

nuclear contamination. After a drop of desired concentration nuclear waste is incinerated at site by using special furnace to follow onsite waste management, due to extracted energy potential waste disposal by incineration is safe from environmental point of view. The special furnace is used for incineration with required pollution control devices. These control devices are required to minimize the air pollution caused only by fuel containing pellets, which are manufactured to hold nuclear fuel.To avoid any misshapen coolant systems including anti nuclear materials are used like graphite, zirconium, $CO_2$and water.

Conclusion

Rapid economic growth has created a growing for supplies of energy. Current population in India is 1.21 billion, which is likely to touch 1.5 billion in 2030,and sparing of land for installment of other renewable energy sources by solar panels, wind farms and construction of hydroelectric energy generators will ultimately result in damage to original characteristics including biotic and abiotic components of land due to alteration caused in huge area required for installment. On other hand, India has vast nuclear fuel sources of Thorium and Uranium, which are capable of feeding of Nuclear Power Generation. Hence by utilizing both uranium and by converting thorium into uranium from spent uranium can act as dual purpose, one by utilizing energy potential and another by recovering uranium from spent fuel can lead to decrease in storage and handling of nuclear waste if proper care is taken. Hence India can become a capable to fulfill its requirement by utilizing nuclear fuel as its resource for energy, which will help to the Sustainable and Clean Development of India for long time.

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