
Nuclear Energy; a Review of the Technology, Applications and Environmental Problems

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ABSTRACT

Nuclear energy is the energy in the nucleus or core of an atom. Atoms are made up of protons neutrons and electrons. When atoms are bombarded with a slow moving neutron, energy is released in the form of heat. The heat released is used to boil water in the core of a nuclear reactor, which can be used to generate electricity. Its use can also be applied in agriculture, medicine, industry and also as environmental tracers. Utilization of nuclear energy affects the health of living things and the environment at a horrific cost. The possibility of accidents such as the Chernobyl and Three Mile Island, the threat of nuclear terrorism, the potential for horizontal nuclear proliferation. The damaging effect from the entire nuclear cycle, from uranium mining to nuclear waste indicate that the risk of nuclear energy far outweigh the benefits.

KEYWORDS: *Nuclear energy, nuclear reactors, uranium, fission, nuclear application, isotopes, radioactivity, and environmental problems.*

1.0 Introduction

Nuclear energy is the energy in the nucleus or core of an atom. All matter is made up of atoms. Atoms are shaped just like a miniature solar system. At the centre of an atom is the nucleus, orbiting around the nucleus are the electrons. The nucleus is composed of protons and neutrons, very densely packed together. There is a huge amount of power in an atoms dense nucleus. In fact, the power holding the nucleus together is called the strong force. When large atomic nuclei are bombarded with a slow moving neutron, it can split apart a process known as fission. In nuclear fission atoms are split to release that binding energy in them. The larger unstable nucleus breaks into two smaller “daughter” nuclei and also releases more neutrons as well as alpha, beta and gamma particles. The neutrons must be slow moving to be absorbed by uranium or plutonium. The heavier resulting nucleus is unstable and breaks apart with the formation several smaller atoms, neutrons and lots of nuclear energy released, which mainly ends up as heat energy (Brown, 2000).

Hydrogen, the lightest known element has one proton, the heaviest naturally occurring element Uranium has 92 protons. Uranium atoms are so large; the atomic force binding them together is weak, making uranium suitable for fission.

Nuclear power plant is a series of machine that control nuclear fission. In power plants, neutrons collide with uranium atoms splitting them. This split releases neutrons from uranium called

fission product. These fission products cause other uranium atoms to split, starting a chain reaction. The two smaller atoms formed are themselves may be unstable and hence radioactive.

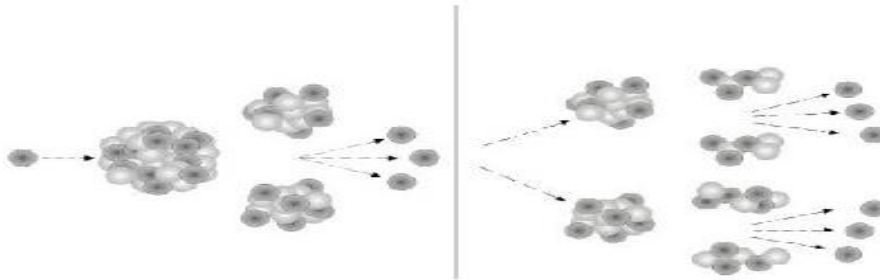
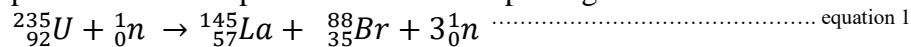
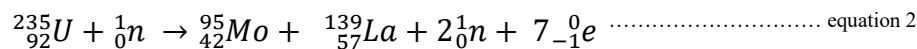


Fig 1: showing the splitting of large atomic nuclei

The nuclear equation below is a simplified form of the process. Lots of fission products are possible example uranium splitting to form Lanthanum and Bromine



Uranium splitting to Molybdenum and Lanthanum (Brown, 2000).



This chain reaction can be controlled with control rods that absorb neutrons.

In the core of nuclear reactors, the fission of uranium releases energy that heats water which is the cooling agent to about 271 degrees Celsius. This cooling agent (water) heated by nuclear fission produces steam. The steam turns turbine or Wheels turned by the flowing current. The turbine drives generators or engines that create electricity.

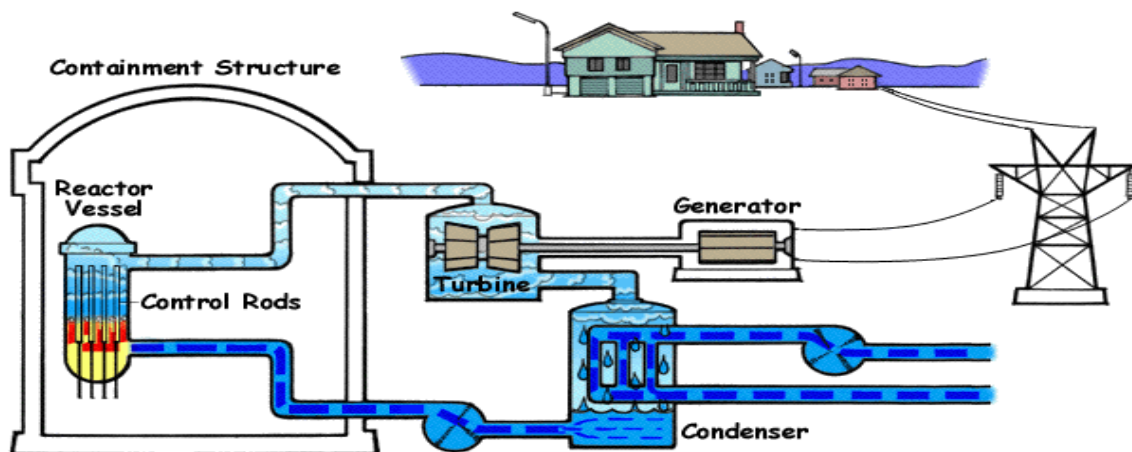


Fig 2: Showing electricity generation from a nuclear power plant. (Union of concerned Scientist)

Rods of materials can adjust how much electricity is produced. Nuclear poisons such as xenon, boron or graphite are used to absorb or adjust some of the nuclear products created by nuclear fission. The more the rods of nuclear poisons that are present during the chain reaction, the slower and more controlled the reaction will be and vice versa. About 15% of the world's electricity is generated by nuclear power plants. The United States has more than 100 reactors although creates most of its electricity from fossil fuel and hydroelectricity. Nations like Lithuania, France, and Slovakia creates almost all their electricity from nuclear power plants.

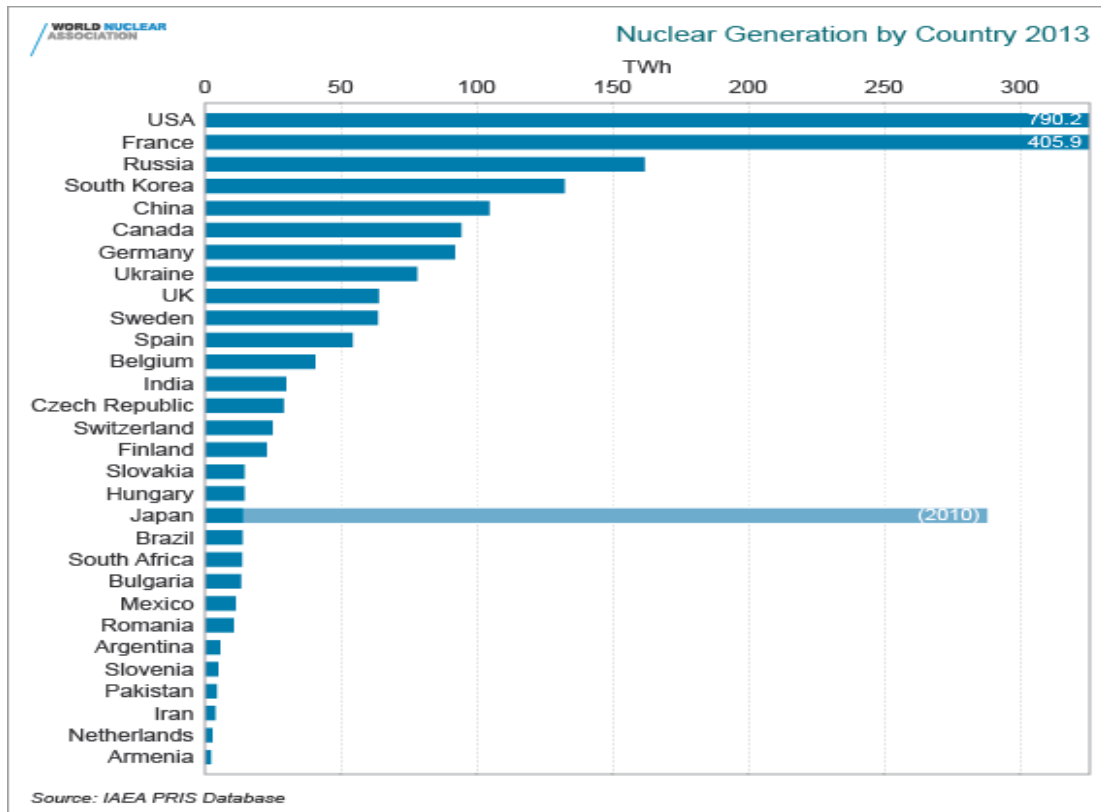


Fig 3: Nuclear generation by country.

2.0 Nuclear Energy Technology

2.1 Mining and processing of nuclear fuel

Uranium is the fuel most widely used to produce nuclear energy. This is because the large size uranium atoms split apart easily. It is also a very common element found in rocks all over the world. However the specific type of uranium used to produce nuclear energy is called uranium-235(U-235), is rare. Uranium 235 makes up less than 1% of the uranium in the world, but because of its radioactivity it is in plentiful supply for use as energy source. One pound of uranium has much energy as three million pounds of coal.

When radioactive elements decay, they lose their radioactivity. Losing half of its radioactivity is termed 'half life'. U-238 the most common form of uranium has a half life of about 4.5billion years. U-235, used for energy has a half life of about 713million years. As uranium decays in nature it turns into Lead.

Uranium is found on land as well as sea water. However to be mined as fuel, it must be sufficiently concentrated, making up at least one hundred parts per million (0.01%) of the rock it is in. The process of mining can be both open pit and underground mines. The environmental impact can be severe in that uranium tailings are radioactive.

2.2 Uranium in Nigeria and Africa.

Uranium has been found also to exist in six states of the country. The six states include Cross River, Adamawa, Taraba, Plateau, Bauchi and kano. The uranium discovered was by the Atomic energy division of the geological survey of Britain. The ministry of solid mineral in Nigeria has said the highly sort radioactive mineral could be the second largest revenue generation for the country when fully exploited. To further the process of uranium exploration the Federal government of Nigeria formed the Nigeria Uranium Mining Cooperation (NUMCO) in technical partnership with Total Compagnie Miniere (TCM) of France. Primarily to explore, develop, and mine uranium deposit in Nigeria.

The mineral which was mainly obtained from the ore Uranite, occurred in small bodies of granite containing pyrochlore, with 3.3 percent Uranium oxide, 3.3 Thorium oxide and 41.1 percent Niobium and Tantalum Oxide.

Africa has considerable mineral deposits, of which the highly valued uranium is among. Uranium production is an important part of African economy with Niger, Namibia and South Africa creating up to 18% of world's annual production. Exploration and mine development is ongoing in countries which has not supplied uranium in the past. Gabon has been a major supplier of uranium in the past (world nuclear association, 2016). Other African countries where uranium exists include Algeria, Botswana Central Africa Republic, Congo, Guinea, Malawi, Mali, Mauritania, and Morocco, Tanzania, Zimbabwe.



Fig 4: Typical uranium mining site in Namibia (Union of Concerned Scientist)

Uranium comes in two forms, U-235 and U-238. U-238 is 99% present, unfortunately U-235, used in power plants and is limited in supply, U-238 can be processed to plutonium, which is also fissionable.

Once mined, the uranium is sent to a processing plant to be concentrated into useful fuel. Most uranium concentrate is made by leaching the uranium from the ore with acids. When finished, the uranium is shaped into small pellets ready to be used in the core of the reactor.

As of 2012, over 80% of the uranium purchased by civilian nuclear reactors was imported to the U.S not mined domestically. The main suppliers include Russia, Canada, Australia, Kazakhstan and Namibia (Union of concerned scientist, 2014).

2.3 Nuclear reactors

There are currently 99 commercial nuclear reactors in operation in the United States. Most of the plants are light water, using normal water in the core of the reactor. Heavy water technologies are also being used in Canada. There two types of reactors the boiling water reactor (BWR) and the pressurized water reactor (PWR).

In boiling water reactors, shown below, the water is allowed to boil into steam, and is then sent through a turbine to produce electricity.

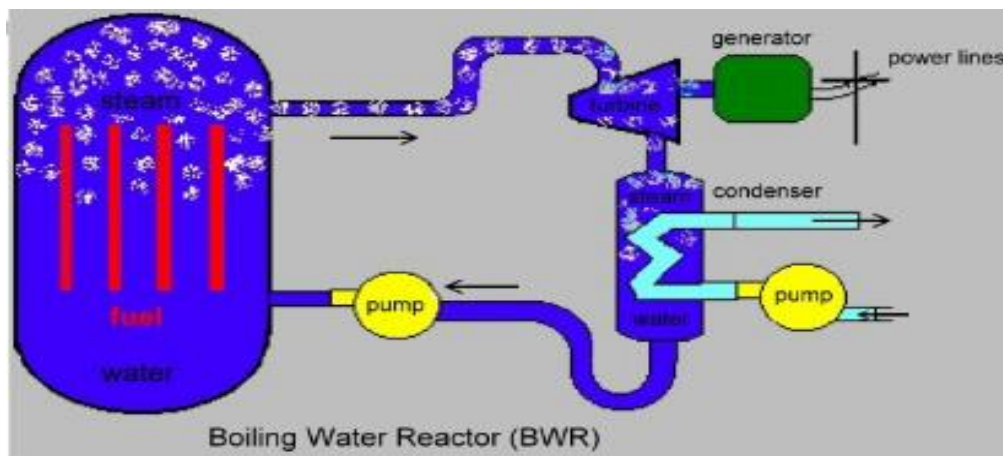


Fig 5: Simplified scheme of a boiling water reactor (BWR) based nuclear power plant (Paschoa 2004).

In pressurized water reactors, shown below, the core water is held under pressure and is not allowed to boil. The heat is transferred to water outside the core with heat exchanger, boiling the outside water, generating steam, and powering a turbine. In the pressurized water reactors the water that is boiled is separate from the fission process and so does not become radioactive.

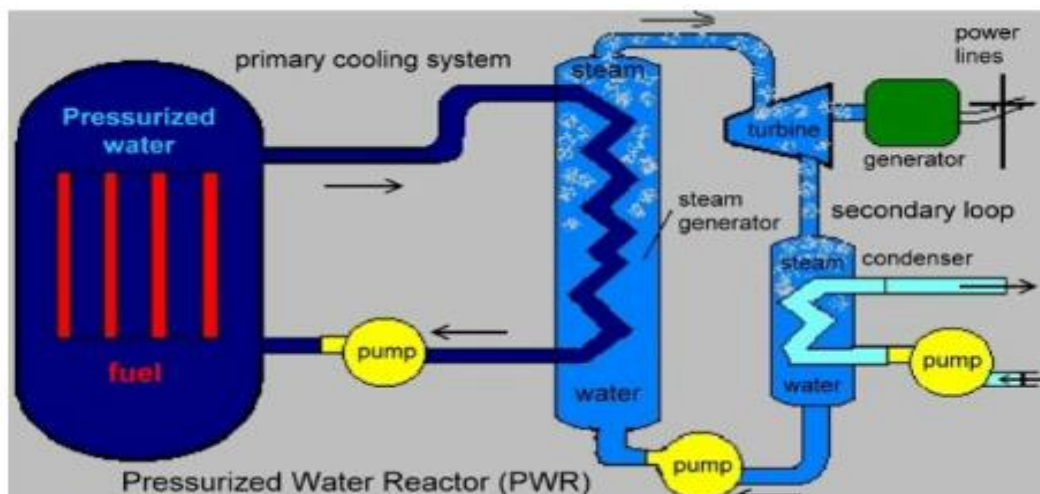


Fig 6: Simplified scheme of a pressurized water reactor (PWR) based nuclear power plant (Paschoa 2004).

After the steam is used to power the turbine, it is cooled off to make it condense back to water. Some plants use water from rivers, lakes and ocean to cool the steam, while others use tall cooling towers (Jaffer 2011). For every unit of electricity produced two units of heat are released to the environment. Some reactor designs use coolants other than water to carry the heat of fission away from the core. Canadian reactors use water loaded with deuterium (called heavy water) while others use helium gas as their coolant. A few plants use liquid metal or sodium as their coolant.

3.0 Case history of nuclear energy development/policy

The principles of nuclear power were formulated by the physicist of early 20th century. In 1939, the German scientists discovered the process of fission triggering a race with the American scientist to use the incredible power of fission to create bomb.

Through intense effort of the Manhattan project, the atomic bomb was created by 1945 and used to destroy Hiroshima and Nagasaki at the end of World War II.

After the war, atomic power was seen as potential source of energy. The government's Plowshare program thought atomic explosion would be a labor-saving way to dig canals and drinking water reservoir and to mine for gas and oil. As of late 1960's bombs were being set off above and below ground to test different ideas.

A more successful use of atomic power was in nuclear reactors. Development of small reactors to power submarines, the USS Nautilus was launched in 1954. By late 1950's, nuclear power was being developed for commercial electric power first in England. Morris, Illinois, was the first site of the first U.S commercial reactor, the Dresden plant, starting in 1960. A plant at shippingport, Pennsylvania, went online in 1957, but was not commercially owned.

The nuclear power industry in the U.S grew rapidly in the 1960's, utility companies saw this new form of electricity production as economical environmental clean and safe. In the 1970's and 1980's however, the growth slowed. The demand for electricity decreased and concern grew

over nuclear issues such as reactor safety, waste disposal and other environmental considerations.

Still the U.S had twice as many operating nuclear power plants as any other country in 1991. This was more than one-fourth of the worlds operating plants. Nuclear energy supplied almost 22 percent of the electricity produced in the U.S.

At the end of 1991, 31 other countries also had nuclear power plants in commercial operations or under construction. That is an impressive worldwide commitment to nuclear power technology. The U.S has developed several major policy/goals for nuclear power which are

- ❖ To maintain exacting safety and design standards.
- ❖ To reduce economic risk.
- ❖ To reduce regulatory risk.
- ❖ To establish an effective high-level nuclear waste disposal program.

Several of these power goals were addressed in the energy policy act of 1992 which was signed into law in October of the same year (union of concerned citizens, 2014).

4.0 Applications of nuclear energy

Nuclear energy produces electricity that can be used to power homes, schools and hospitals. The first nuclear reactor to produce electricity was located near Arco Idaho in the United States. The experimental breeder began powering itself in 1951. The first nuclear power plant designed to provide energy to a community was established in Obninsk Russia, in 1954.

Building nuclear reactor involves a high level of technology and security, only the countries that have signed the nuclear non-Proliferation Treaty (NPT) can get the uranium or plutonium that is required. For these reasons most nuclear power plants are located in developed countries of the world.

Although nuclear energy is mainly used to produce electricity in nuclear power plants, this is not the only utility that can be derived from nuclear energy. This type of energy appears in many other aspect of our everyday life in science. If you work with different isotopes of same element, it is possible to use nuclear technology for other applications.

4.1 Radioisotope

Isotopes are different forms of an atom of the same chemical element. They have identical chemical properties but different atomic masses. While the numbers of protons are the same, the number of neutrons in the nucleus differs. Some isotopes are stable and unchanging, while others are unstable, changing over time from milliseconds to millennia, as they emit particles making them radioactive. It is the radioactive nature of these unstable atoms usually referred to as radioisotopes, which gives them so many applications in modern science and technology. Their radioactivity means that they can be used as a tag to follow some materials bearing them (World Nuclear Association 2014).

Radioisotopes have many applications in agriculture, medicine, industry and research. They greatly improve the day to day quality of our lives. Scientist continues to find new and beneficial

ways of using nuclear technology to improve our lives. In our daily life we need food, water and good health. Radioisotopes play an important part in technologies that provide us with these basic needs.

4.2 Nuclear technology and agriculture

The application of isotopes in agriculture has led to an increase in agricultural production in developed and developing nations of the world. Using fertilizers labelled with particular isotopes of Nitrogen-15 and phosphorus-32 provide means of finding out how much fertilizer is taken up by plants for better management and reduce the harmful effect on the environment. Gamma radiation is often used with other technique to produce new genetic line of root and tuber crops, cereals and oil seed crops. They are now more adaptable to harsh weather conditions. Even crop loss by insect in developing countries has been reduced with sterile insect technique (SIT) which tend to introduce sterile male, when the sterile male meet with the females no offspring is produced thereby reducing their population in the infested area. This method is better than chemical insecticide in that it doesn't leave any residue on the plants. There is also growing use of irradiation technology to reduce food loss by microbes and pest. Many countries have approved the irradiation of more than 60 kinds of food ranging from grains, spices, vegetables and meat. It can replace potentially harmful chemical fumigant to eliminate insects from dried agricultural products.

4.3 Water resources

Adequate water supply is essential to life, yet it is scarce and the quality poor in many parts of the world. Isotope hydrology technique enables accurate tracing and measurement of underground water resources. Such technique provide important analytical tool in management and conservation of existing supply of water and the identification of new renewable sources of water. They provide information about the origin, age, and distribution of groundwater, as well as the interconnection between ground and surface water and aquifer recharge systems.

For surface water they give information about leakages through dams and irrigation channels, the dynamics of lakes and reservoirs, flow rates, river discharges and sedimentation rate. Over 60 countries developed and developing have used isotope technology to investigate their water resources in collaboration with IAEA. Neutron probe can measure soil very accurately, enabling better management of land affected by salinity, particularly with respect to irrigation.

4.4 Medicine

Many people who visit hospitals in developed nation receive the benefit of nuclear medicine procedure, some without even knowing, particularly for diagnosis and therapy. Over 10,000 hospitals worldwide use radioisotopes in medicine. In the United States there are over 20million nuclear procedures per year among 315million people, and in Europe about 10million among 500million people. The use of radiopharmaceutical in diagnosis is growing at the rate of 10% per year.

In radiopharmaceutical for diagnosis, a radioactive dose is giving to a patient and the activity in the organ can be studied either as a 2-dimensional or, with a special technique called tomography, as a 3-dimensional picture.

The most widely used diagnostic radioisotope in medicine is technetium-99m, with a half life of six hours, which gives the patient a very low radiation dose. Such isotopes are ideal for tracing bodily processes with minimum discomfort to the patient. They are widely used to indicate tumors, and to study the heart, lungs, liver, kidney, blood circulation and volume and bone structure.

Many medical products are sterilized today by gamma rays from cobalt-60 source, a technique which is believed to be much cheaper and more effective than steam heat sterilization. The disposable syringe is an example of a product sterilized by gamma rays. The benefit of sterilization by radiation to humanity is tremendous, it is safer, cheaper, and can be done after item has been packaged. Apart from syringes medical products sterilized by radiation include cotton wool, burn dressing, surgical gloves, heart valve bandages, plastic and rubber sheet and surgical instrument (World Nuclear Association 2014).

4.5 Safety smoke detectors

One of the most common uses of nuclear technology in radioisotopes today is in house hold smoke detectors. These contain small amount of Americium-241 which is a decay product of Plutonium-241 originating in nuclear reactors. The Am-241 emit alpha particle which ionize the air and allow a current between two electrodes. If smoke enters the detector, it absorbs the alpha particle and interrupts the current flow, setting off the alarm.

4.6 Environmental tracers

Radioisotopes also play an important role in detecting and analyzing pollutants, since even very small amount of a radioisotope can easily be detected, and the decay of short-lived isotopes means that no residue remain in the environment. Nuclear technique has been applied in to a range of pollution problems including smog formation, Sulphur dioxide contamination of atmosphere, sewage dispersal from ocean out falls and oil spills.

4.7 Industrial tracers

The ability to measure radioactivity in minute amounts has given radioisotopes a wide range of application in industry as tracers. By adding small amount of radioactive substances to materials used in various processes it is possible to study the mixing and flow rates of a wide range of materials including liquids, powders, gases and to locate leaks.

Tracers added to lubricating oil can help measure the rate of wear of an engine, plants and equipments. Tracer technique has been used in plant operation to check the performance of equipment and improves its efficiency, resulting in savings in energy and better use of raw materials.

4.8 Dating of materials

Analyzing the relative abundance of particular naturally-occurring radioisotopes is of vital importance in determining the age of rocks and other materials that are of interest to geologist, anthropologist and archaeologist. It applies the properties of Carbon-14 fixation to bone, wood,

and organic waste, determining chronological age and it is applied in geophysics and geochemistry, which exploit the existence of naturally occurring radioactive material fixing dates of rocks and oil deposit.

4.9 Military application

Nuclear weapons are those weapons that use nuclear technology. Depending on the role that has the nuclear weapon technology, nuclear technology in military are of two types, those that use nuclear energy to explode as in the case of atomic bomb that was used in Hiroshima and Nagasaki and those using nuclear technology for propulsion. In this second category are included cruisers, aircraft carriers and submarines.

5.0 Problems of nuclear energy development and utilization

Even with so many applications and uses, nuclear technology comes with its negative impact to the environment; it is a nugget of mixed blessings. A nuclear power plant starts disturbing the environment during the plant construction stage. Normal process of plant construction as well as ancillary operation, not necessarily related to the nuclear nature of power plant fuel, do disturb the surrounding environment. New roads, increasing traffic flow, in existing roads, excavations, cutting trees and other plants, frightened animals, are some of the environmental impacts to be expected from the construction of a power plant.

Uranium is extracted from underground and open pit mines. For every ton of uranium oxide produced, thousands of tons of waste, or tailings, are left behind. Often the tailings are simply dumped on land near the mine and left to the effect of the elements. Wind carries radon gas and radioactive dust from these tailings for many miles. Contaminated rain water enters the soil, the watershed and, eventually the food chain, endangering the health of people, animals, and the plant.

Reprocessing is a chemical reaction that separates plutonium and uranium from fuel which has been irradiated in reactors. The plutonium is important for weapons production, thus the existence of reprocessing is what gives a country the ability to produce plutonium for nuclear weapon. This spread of plutonium through nuclear power has increased the number of potential nuclear weapon states, which is a threat to international security.

Thermal discharges of unused heat from fossil fuel or from fission in the nuclear fuel constitute another kind of environmental impact. Most nuclear plants use water bodies as coolant to the core of their reactors, these increases the temperature of the water body. Increase in temperature of such water bodies in temperate and Polar Regions causes melting of icecaps that would lead to increase in volume of the water body, these cause the water body to over flow it banks and cause flooding and submergence of coastal regions. Flooding destroys farmland and pollutes water bodies causing hardship for people around the flooded areas.

5.1 Gaseous and liquid emissions

The gaseous emission from nuclear power plants can be different forms and intensities. Nuclear power plants use diesel generators as a means of back-up electric power in case of emergencies. Most are also required to run and test these systems once every month to ensure their working.

As such release green house gases into the atmosphere. These gases primarily consist of carbon dioxide, carbon monoxide, nitrous oxides and sulphur dioxides (Jaffer, 2011).

Apart from the greenhouse gases, exhaust gases from buildings containing radioactive processes is radioactive in nature. In addition, in plants with boiling water reactors, the air ejector exhaust is radioactive as well. Such exhaust are passed through delay pipes, storage tanks and hydrogen recombines before release into the environment to ensure that radiation levels are in accordance to regulations. Radioactive exhaust from nuclear power is known to cause skin problems of many kinds.

However the byproduct of nuclear energy is a radioactive material. Radioactive materials are collection of unstable atomic nuclei. These nuclei lose their energy and can affect many materials around them, including organisms and environment. Radioactive materials can be extremely toxic, causing burns and increasing the risk of cancers, blood diseases and bone decay.

The iodine isotope ^{131}I is considered to be critical in the case of accident, so measures are taken for treatment at every stage. The Three Mile Island caused the release of H_2 and HT (tritiated hydrogen) although is now checkmated with its conversion into water to minimize the probability of hydrogen explosion. Estimated gaseous releases of isotopes of xenon and krypton are of the order of terabecquerels per year (TBq.Y^{-1}) based on 0.25% failed fuel. Xenon and krypton releases and to a lesser extent tritium, dominate the routine gaseous releases in nuclear power plants.

Tables 1,2,3 summarizes respectively the fission product, actinides and corrosion product content of spent nuclear fuel after a burn up to $33\text{GWd}(\text{metric ton})^{-1}$ and 150days cooling time. The knowledge of the content of spent nuclear fuel at any given time is important because of potential releases in the case of an accident during transportation (Paschoa, 2004).

Table 1: Fission product content in spent nuclear fuel

Fission product	Half -life (years)	TBq (Metric tons) $^{-1}$	g.(metric tons) $^{-1}$
^3H	12	32	0.08
^{85}Kr	11	420	27
^{99}TC	0.21million	0.6	880
^{103}RU	0.11	7,200	5.7
^{106}RU	1.0	33,000	240
$^{125\text{m}}\text{Te}$	0.16	260	0.36
$^{127\text{m}}\text{Te}$	0.30	1,000	2.7
$^{129\text{m}}\text{Te}$	0.09	530	0.42
^{129}I	17million	0.0016	250
^{131}I	0.02	0.08	<0.01
^{135}Cs	2.0	4,000	77
^{137}Cs	3million	0.048	1400
^{89}Sr	30	4200	1200
^{90}Sr	0.14	4000	3.5
^{91}Y	29	2,400	430
^{93}Zr	0.95million	0.08	490

⁹⁵ Zr	0.18	16,000	19
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Based on 33GWd(t). (metric ton)⁻¹ burn up and 150 days cooling time.

Table 2: Actinide content in spent nuclear fuel

Actinide	Half -life	TBq (Metric tons) ⁻¹	g.(metric tons) ⁻¹
²³⁵ U	710million	<0.04	8000
²³⁶ U	24million	<0.04	4000
²³⁸ U	450million	<0.04	950,000
²³⁷ Np	2million	<0.04	600
²³⁸ Pu	86	160	230
²³⁹ Pu	24,000	20	8,100
²⁴⁰ Pu	6,600	26	2,900
²⁴¹ Pu	13	6000	1300
²⁴² Pu	0.38million	0.08	510
²⁴¹ Am	458	30	230
²⁴³ Am	7,800	0.08	100
²⁴² Am	0.45	1400	10

Based on 33GWd(t). (metric ton)⁻¹ burn ups, and 150 days cooling time.

Table 3: Corrosion product content in spent nuclear fuel

Corrosion product	Half -life	TBq (Metric tons) ⁻¹	g.(metric tons) ⁻¹
⁵⁴ Mn	0.86	1200	3.9
⁵⁵ Fe	2.7	800	8.3
⁵⁹ Fe	0.12	20	<0.01
⁵⁸ Co	0.20	1,200	1.0
⁶⁰ Co	5.3	80	1.8

Based on 33GWd(t). (metric ton)⁻¹ burn ups, and 150 days cooling time.

5.2 Social impact

Setting up a nuclear power plant in any region does not come without concerns and criticism from a wide range of people. People in such region fear the threat of being exposed to unusual level of radiation. The natural water sources in such places are also doubted to contain plant emissions especially if the plant uses the water body as a heat sink. In addition, during the post 9-11 era, there has been an increased concern over reactor safety and integrity. As such, a lot of effort has to go into convincing the people living around the plant that it is securely designed with several safety measures. Among other impacts that the plant can have on the region, plant commissioning in a region causes impairment of aesthetics, recreational and natural conservation values and also lowers significantly the value of property around the reactor (Jaffer, 2011).

5.3 Chernobyl accident

Critics, worry that the storage facilities for radioactive waste will leak, crack or erode. Soil, surface water and underground water around the facility could be contaminated by radioactive materials, leading to serious health problems for the people and organisms in the area.

In Chernobyl, Ukraine in 1986, explosion at one of the four power plant reactors caused the release highly radioactive plume, creating a cloud of radioactive particles that fell on the ground. The fallout spread over the Chernobyl facility, as well as the surrounding area. The fallout drifted with the wind and the particles entered the water cycle as rain. Radioactivity traced to Chernobyl fell as rain over Scotland, Ireland and most radioactive fall fell on Belarus.

The environmental impact of the Chernobyl disaster was immediate, for kilometers around the facility, the pine forest dried up and died. The red color of the dead pine earned the area a nickname, the 'Red forest'. Fish from the nearby Pripyat River had so many radioactivities that people could no longer eat them. Cattle and horses in the area died. More than 100,000 people were relocated after the disaster, but the number of human victim of Chernobyl was difficult to determine. The effects of radiation poisoning only appear after many years. Cancers and other diseases were very difficult to trace to a single source (National Geographic News 2011).

5.4 Three Mile Island

In 1979 at the Three Mile Island nuclear power plant in U.S.A a cooling malfunction caused part of the core to melt in the reactor number 2. The TMI-@ reactor was destroyed. Some radioactive gas was released a couple of days after the accident but not enough to cause any dose above background level to local residents. There were no injuries or adverse health effects from the Three Mile Island accident.

The Three Mile Island accident caused concerns about the possibility of radiation-induced health effects, principally cancer. Because of those concerns the Pennsylvania department of health for 18 years maintained a registry of more than 30,000 people who lived within five miles of Three Mile Island at the time of the accident. The state's registry was discontinued in mid 1997, without any evidence of unusual health trends in the area (world nuclear association 2001).

5.5 Fukushima

Fukushima was a station black out, caused by huge tsunami. The plants in the area totaling four lost cooling and the decay heat melted the core. Radiation was released and humans were evacuated to avoid the effect it will have on people residing in the area. These three accidents scare people and keep many people from being comfortable with nuclear power.

6.0 Conclusion

The health and the environmental cost of nuclear energy are horrific. The possibility of accidents, such as the Chernobyl or Three Mile Island, the threat of nuclear terrorism, the potential for horizontal nuclear proliferation, the damaging effects from the entire nuclear cycle, from uranium mining to nuclear waste all indicate that the risk of nuclear energy far outweighs the benefits.

Site selection for nuclear power plants and radioactive waste should be carefully made to avoid or minimize the extent of environmental degradation and in the case of an accident, the radiological and radio-ecological effects are supposed to be minimized.

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