The warmest global year on record’s 1998.

Indirect observations also support the fact that the earth is warming. For instance glaciers are retreating more than at any time on record. Snow lines are creeping higher up the mountains and sea levels are rising. The rising temperature causes ice to melt and the sea levels rise because water from the melting ice is dumped into the seas and the oceans. Consequently, the waters expand and flood the low –land areas. All these lead to a sad situation in which the environment suffers terribly.

ELECTRICAL ENERGY FROM NUCLEAR REACTORS

The nucleons in the nucleus of each atom evolve are held together by very powerful nuclear forces. An enormous amount of energy is required to tear the nucleons apart.

Nuclear energy may be released through the process of nuclear fusion or through the process of nuclear fission. Nuclear fusion is involves the coming together of two or more light nuclei (like hydrogen nuclei) to form a more massive nucleus. Nuclear fission involves the splitting of a massive nucleus (like uranium or plutonium nucleus) to form small nuclei. In both cases, huge amounts of nuclear energy are released.

The nuclear fusion process has two major difficulties: the difficulty encountered in generating the extremely high temperatures needed to initiate the thermonuclear reaction. The second is the problem of containment. Thus, all present day nuclear power plants make use of the fission process to generate energy. A nuclear power plant may therefore, be regarded as a steam engine that makes use of uranium as its fuel.

There is also a third method of nuclear energy generation called fission process and in addition convert the natural uranium isotope ^{238}U to a fossile isotope of plutonium ^{239}Pu. A few large-scare experimental breeder reactors have beem built.

A large number of designs of nuclear reactors have been proposed, all of them have the same basic features as follows:

1. **The nuclear fuel**: in a fission reactor, the nuclei of uranium or thorium are broken up into two approximately equal parts by neutron bombardment. One typical reaction sequence is
   $^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + 175Mev$
   Large amount of energy is released, more neutrons are gotten back than are consumed – this gives rise to the possibility of a chain reaction and the unavoidable production of radioactive isotopes. The neutrons produced by

this reaction are called prompt neutrons. The immediate fission products also release neutrons through a beta-decay process on a time scale of seconds to minutes, this neutron is called decayed neutrons. It is this fact that makes a nuclear reactor controllable. A chain reaction that relies on the prompt neutrons alone is a nuclear explosion. If maintaining the reaction relies on the existence of delayed neutrons, the process is controllable.

2. **The moderator**: this is something that is required to absorb enough of the neutrons produced. In a thermal reactor, this is done by slowing the neutrons down so that they are more likely to be absorbed by a nucleus (^{238}U or ^{235}U) rather than breaking it up. Neutrons are slowed down by allowing them to hit the atoms of a moderator (light nuclei that take away the initial kinetic energy of the neutrons). Two moderators have been used; graphite and water.
3. A method of getting the heat from the reactor core. This is fairly a conventional chemical engineering involving heat transfer circuits and boilers.
4. There are a two basic problems with this method of energy generations:
   i. The possibility of a major release of radioactivity; the Chernobyl explosion is the clearest example
   ii. The problem of disposal of radioactive waste. Radioactive waste is divided into three types namely;
      a. Low level, which includes the waste produced by therapy in hospitals.
      b. Medium level. An example would be the fabric particularly the metals of a reactor.
      c. High level. Medium and long-lived decay products of the nuclear reaction including actinides produced by neutron capture rather than nuclear fission. Most attention has been devoted to high level; where the methods of under consideration include incorporating the decay products in glass or artificial mineral and then burning them in deep repositories. However, the much larger volumes of low-level and medium level waste are also a significant problem.

Under normal conditions, a nuclear power plant produces practically no air pollution. It does not release any carbon-dioxide (CO_2) into the environment. Thus, neither the fusion process nor the fission process contributes to the greenhouse effect. However, nuclear accidents can deal a devastating blow to man and the environment. For instance, the 1979 nuclear accident at Three Mile Island, the 1986 nuclear disaster at Chernobyl readily come to mind. More recently, the 2011 catastrophic melt down of some of the Japanese reactors at Fukushima is still fresh in mind. In all three reactors experienced total melt down in Japan. Today, the Japanese authorithies are still struggling to gain control of that nuclear crisis including retirees that are over 60 years of age volunteering to clear up the nuclear waste and accident site.

The uranium that is used in reactors is often enriched by increasing the proportion of 235U above the natural value of 0.7%, typically to 3% or so, by isotope-seperation processing. During nuclear fission the total mass of the component products is less than the mass of the original nucleus, the difference in mass is a measure of the nuclear energy released and is given by the following Albert Einstein energy equation

$$E = \Delta mc^2$$

Where E is the energy released, c is the velocity of light and Δm is the mass difference between the original nucleus and the component products.

The fission energy appears as kinetic energy of the fission fragments and it's immediate result is to increase the internal energy which is transferred as heat to generate steam to drive turbines which spin the electrical generators. A typical nuclear plant has an electric-generating capacity of 1000MW (or 10^9W). The turbines are heat engine and are subject to the efficiency limitation imposed by the second law of thermodynamics. In modern nuclear plants, the overall efficiency is about 33.3%. Thus 3000MW of thermal power from the fusion reaction is needed to generate 1000MW.

Example

[useful constants: 1MeV = $1.6\text{x}10^{-13}$J, U = $1.66\text{x}10^{-27}$kg]

Given that the fission of ^{235}U librates 200MeV per atom, what mass of ^{235}U must undergo fission each day to provide 3000MW of thermal power.

<u>Solution</u>

3000MW = 3000MJ/s

Each second we need 3000×10^{6}J but each fission provides 200MeV.

For each fission $200 \times 1.6\times10^{-13} = 3.2\times10^{-11}$J is produced.

To generate 300×10^{6}J/s

$$\frac{3000\times10^{6}\text{J/s}}{3.2\times10^{-11}\text{J/fission}}$$

$=9.4\times10^{19}$ fissions/second are needed

The mass of ^{235}U atom is $(235U)\times(1.66\times10^{-27}\text{kg/u})$

$=3.9\times10^{-25}$kg

$\therefore$ mass of 235U that undergoes fission each second is

= (number of fission per second) x (mass of ^{235}U atom)

$= (9.4\times10^{19}) \times (3.9\times10^{-25}\text{kg})$

$= 3.7\times10^{-5}$kg

One day = 24hrs x 60mins x 60 secs

=86,400s

$\therefore$ mass of ^{235}U consumed per day

$= 3.7\times10^{-5} \times 86400$

=3.2kg