AKOMOLAFE DAVID OLUSEGUN

15/ENG01/003

CHEMICAL ENGINEERING

QUESTION A

1. (a) With adequate mathematical relations, explain the various forms of energy

(b) distinguish between the sustainable energy and resources and non-sustainable energy and resources

2. With the aid of appropriate pie chart or bar chart briefly discuss the typical energy resource mix for sustainable energy development and provide your own view the case for the Nigerian environment.

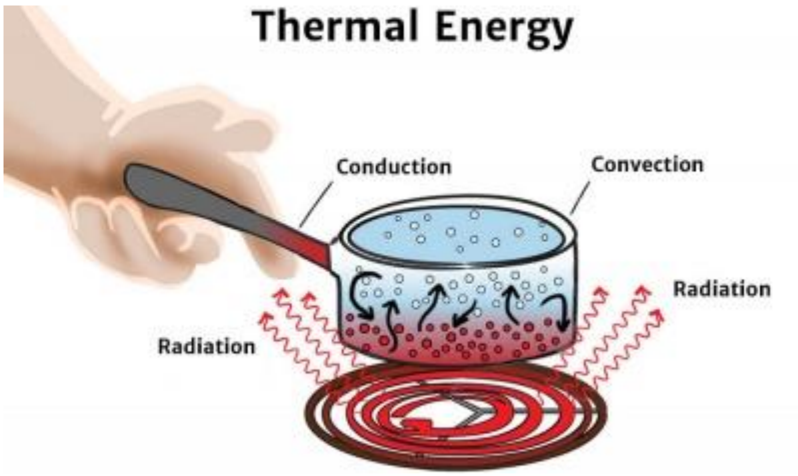
1) Energy exists in many different forms. Examples of these are: light energy, heat energy, mechanical energy, gravitational energy, electrical energy, sound energy, chemical energy, nuclear or atomic energy and so on. Each form can be converted or changed into the other forms.

Although there are many specific types of energy, the two major forms are Kinetic Energy and Potential Energy.

- Kinetic energy is the energy in moving objects or mass. Examples include mechanical energy, electrical energy etc.
- Potential energy is any form of energy that has stored potential that can be put to future use. Examples include nuclear energy, chemical energy, etc.

- **Heat or thermal energy**

Thermal energy (also called heat energy) is produced when a rise in temperature causes atoms and molecules to move faster and collide with each other. The energy that comes from the temperature of the heated substance is called thermal energy. The molecules and atoms that make up matter are moving all the time. When a substance heats up, the rise in temperature makes these particles move faster and bump into each other. Thermal energy is the energy that comes from the heated-up substance. The hotter the substance, the more its particles move, and the higher its thermal energy.



The thermal energy is usually expressed by Q. It is directly proportional to the mass of the substance, temperature difference and the specific heat.

The SI unit of thermal energy is Joules(J).

The thermal energy formula is given by

$$Q = mc\Delta T$$

Where

Q = thermal energy,

m = mass of the given substance,

c = specific heat, and

ΔT = temperature difference.

- **Chemical energy**

Chemical energy is energy stored in the bonds of chemical compounds, like atoms and molecules. This energy is released when a chemical reaction takes place.

Usually, once chemical energy has been released from a substance, that substance is transformed into a completely new substance.

Chemical energy is stored in the bonds that connect atoms with other atoms and molecules with other molecules. Because chemical energy is stored, it is a form of potential energy.

When a chemical reaction takes place, the stored chemical energy is released.

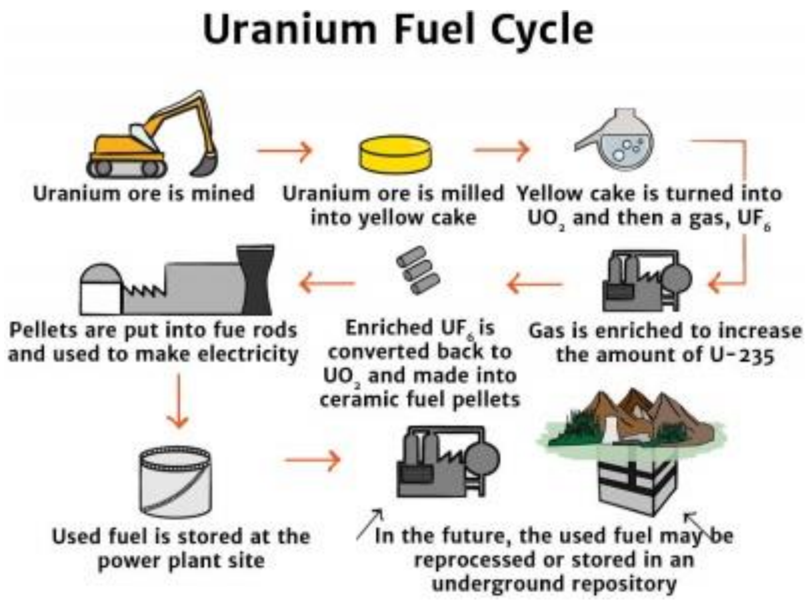
Heat is often produced as a by-product of a chemical reaction – this is called an exothermic reaction.

- **Nuclear Energy**

Nuclear energy comes from the nucleus of atoms. The energy is released by nuclear fusion (nuclei are fused together) or nuclear fission (nuclei are split apart). Nuclear plants use nuclear fission of a radioactive element called uranium to generate electricity.

Nuclear energy is released from an atom through either:

- Nuclear fusion- when nuclei of atoms are combined or fused together. This is how the Sun produces energy.
- Nuclear fission- when nuclei of atoms are split apart. This is the method used by nuclear plants to generate electricity.



- **Electrical energy**

Electrical energy is caused by moving electric charges called electrons. The faster the charges move, the more electrical energy they carry. As the charges that cause the energy are moving, electrical energy is a form of energy. Lightning, batteries and even electric eels are examples of electrical energy in action. Electrical energy is a type of kinetic energy caused by moving electric charges. The amount of energy depends on the speed of the charges – the faster they move, the more electrical energy they carry. Let's imagine an electric charge is represented by a ball being thrown against a window. If you don't throw the ball very fast, it won't have enough energy to break the window. But if you throw the ball faster, it will have more energy and will be able to smash through the window. The faster you throw the ball, the more energy it will have to break the window.

Current, $I = V / R$

Where;

I= current (amps)

V=voltage (volts)

R=resistance (ohms)

- **Light energy**

Light energy is a form of electromagnetic radiation. Light consists of photons, which are produced when an object's atoms heat up. Light travels in waves and is the only form of energy visible to the human eye. Light energy travels in the form of waves. Light energy is very fast – in fact, nothing travels faster. Light is made up of photons, which are like tiny packets of energy. When an object's atoms heat up, photon are produced from the movement of atoms. The hotter the object, the more photons are produced.

- **Gravitational energy**

As you may have guessed, gravitational energy is energy associated with gravity. It is the potential energy stored by an object because of its higher position compared to a lower position. (e.g. if it's further away or closer to the ground). Gravity is a force which tries to pull two objects toward each other. Earth's gravity is what keeps you on the ground and what causes objects to fall. The Earth has gravity. Gravity holds everything close to this planet. Trees, water, animals, buildings, and the air we breathe are all held here by gravity. The planets, their moons, and the stars in the universe have gravity. Even our own bodies have gravity. The Earth's gravity is far stronger than our own so we don't notice the gravity our bodies have. The Earth's tides are caused by the moon's gravitational pull on the oceans. Tides are the rise and fall of the ocean level as related to the shoreline. Systems can increase gravitational energy as mass moves away from the centre of the Earth or other objects that are large enough to produce significant amounts of gravity (like our Sun, the planets and stars).

$$\mathrm{U} = \frac{\mathrm{GMm}}{r}$$

Where;
U=gravitational potential energy
G=universal gravitational constant
M=mass of the earth

m=mass of the body

r=distance of the body from the centre of the earth

- Sound energy

sound energy is the form of energy that can be heard by man.

$$I = \frac{P}{A}$$

Where

I=sound intensity (W/m^2)

P=power (W)

A=Area (m^2)

Area is given as a distance of $4\pi r^2$ (surface area of a sphere)

2) **Sustainable energy** refers to the use of energy in a way that meets the needs of the present and will still be available for the future generations to use. Sustainable energy is often used interchangeably with the term renewable energy. Sustainable energy contributes to reducing the dependence on the use of fossil fuel resources, thus providing the opportunity to reduce greenhouse gases. Some of the resources which are considered as sustainable energy are solar, wind and hydro electrical energy.

Non-sustainable energy refers to the energy which cannot be readily replaced by natural means at a quick pace to keep up with its consumption. Resources which are considered as non-sustainable energy are earth minerals and metal ores, fossil fuels, (coal, petroleum, natural gas) and ground water in certain aquifers. This non-sustainable energy is said to be not eco-friendly because when they are turned, they create pollution and carbon dioxide.

3) The most sustainable energy sources include all renewable energy sources such as hydro electrical, biomass, geothermal, wind, and wave, tidal and solar energies. The sustainable energy sources can be used to generate electricity, to heat and cool buildings and to power transportation systems and machines. The major resources for a sustainable energy mix include;

- Wind energy
- solar energy
- hydro energy
- Biomass energy

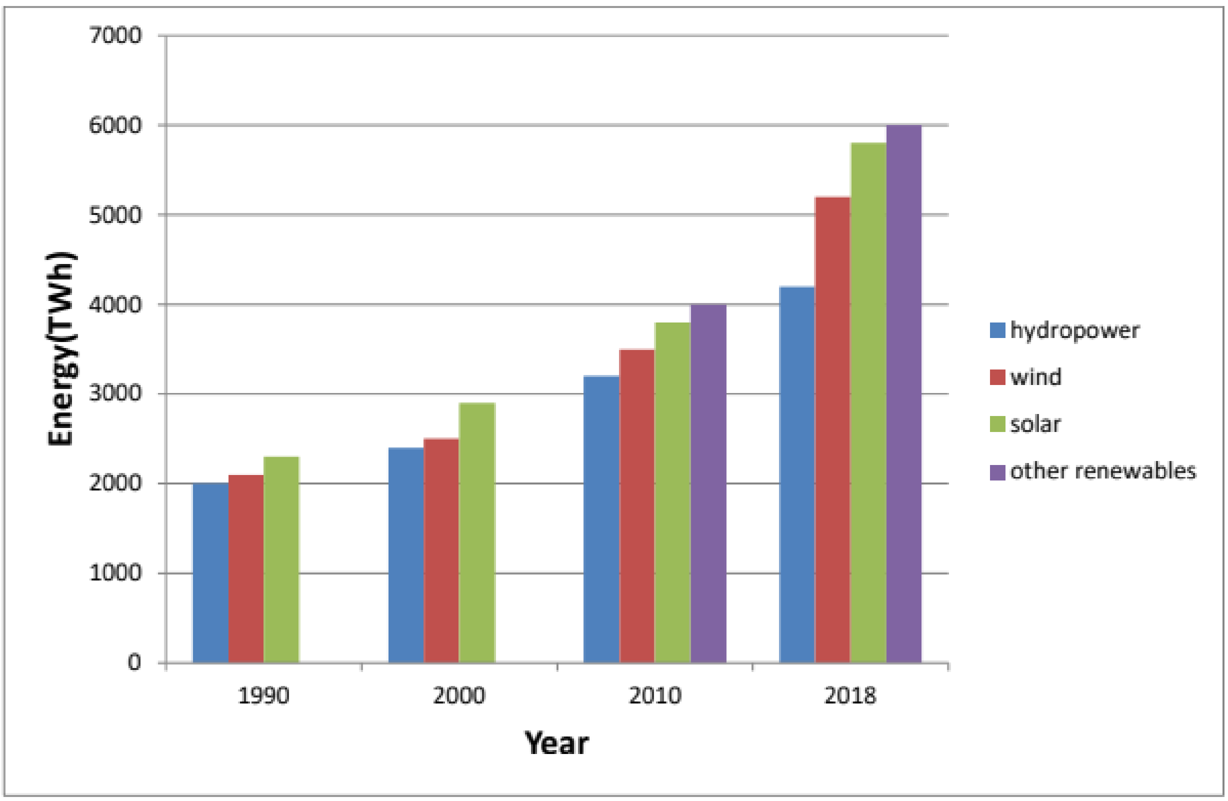


Figure 1:Renewable energy generation worldwide

Other renewables refer to geothermal, biomass waste, wave and tidal. From the graphical representation in Figure 1-1 above, it shows that between 1990- 2000 there was no form of solar energy. Slowly the energy being generated from the sun increased within the years and at 2010 it had risen to 3800 TWh. It gradually increased from 3800- 5700 TWh between 2010- 2018. The energy from other renewable sources was not being utilized over the years (1990-2010) but at 2018 it is seen that in the mix, other renewables have the most percentage energy generation in creating a sustainable energy source. Thus, it can be agreed that the use of biomass, geothermal wave and tidal sources are an important and effective way of generating energy. Also, over the years it is seen that hydropower are wind are equally major sources of energy development.

With Nigeria as a case study, this will be a suitable energy resource mix for sustainable energy at 2030. These estimations are made depending on the climatic factors and resources available in the country.

QUESTION B

1.Monitor the average ambient temperature between on Monday, 17th and Friday, 21st of February 2020 and estimate the average daily thermal energy from the sun reaching land 2. With the aid of a beautiful diagram ONLY, describe anemometer.

Table 1: Average ambient temperature observed

DAY	DATE	T1(^{0}C)	T2(^{0}C)	T(^{0}C)
Monday	17/02/2020	35	26	30.5
Tuesday	18/02/2020	36	26	31
Wednesday	19/02/2020	36	26	31
Thursday	20/02/2020	36	26	31
Friday	21/02/2020	37	28	32.5

T1= Temperature during the day

T2= Temperature during the night

T= Average ambient temperature

The Stefan-Boltzmann equation then gives the energy flux emitted at the sun's surface.

$$S_S = \sigma * T^4$$

$$\sigma = 5.67 * 10^{-8} Wm^{-2}K^{-4}$$

T=temperature in kelvin

The surface area of a sphere with a radius r is **$4\pi r^2$.** If **r_s** is the radius of the Sun, the total energy it emits is $\boldsymbol{S * 4\pi r_s{}^2}$.[1]

As the radiation is emitted from this spherical surface, it is spread over larger and larger spherical surfaces, so the energy per square meter decreases.

When the energy emitted by the sun reaches the orbit of a planet, the large spherical surface over which the energy is spread has a radius, **r_P,** equal to the distance from the sun to the planet. The energy flux at any place on this surface, **S_P**, is less than what it was at the Sun's surface. But the total energy spread over this large surface is the same as the total energy that left the sun, so we can equate them[1]:

$$S_S 4\pi \boldsymbol{r_s}^{\mathbf{2}} = S_P 4\pi d_P{}^{\mathbf{2}}$$

$$S_P = S_S \left(\frac{r_S}{d_P}\right)^2$$

Where

S_S=energy flux emitted by the sun's surface

S_P=energy flux at any point on the planet earth surface

r_S= radius of the sun (700,000km)

d_P=radius of planet earth(150,000,000km)[1]

Calculation

Using the equations above the thermal energy from the sun observed from Monday to Friday are calculated as follows

Monday: 30.5^{0}C =303.5^{0}K

$$S_S = (5.67 * 10^{-8} Wm^{-2}K^{-4}) * (303.5)^4 K^4$$

$$S_S = 481.1\ Wm^{-2}$$

$$S_P = 481.8 \left(\frac{700{,}000}{150{,}000{,}000}\right)^2$$

$$S_P = 10.493 Wm^{-2}$$

Tuesday, Wednesday and Thursday: 31^{0}C =304^{0}K

$$S_S = (5.67 * 10^{-8} Wm^{-2}K^{-4}) * (304)^4 K^4$$

$$S_S = 484.259\ Wm^{-2}$$

$$S_P = 484.259\left(\frac{700,000}{150,000,000}\right)^2$$

$$S_P = 10.546 Wm^{-2}$$

Friday: 32.5^{0}C =305.5^{0}K

$$S_S = (5.67 * 10^{-8} Wm^{-2}K^{-4}) * (305.5)^4 K^4$$

$$S_S = 493.887\ Wm^{-2}$$

$$S_P = 493.887\left(\frac{700,000}{150,000,000}\right)^2$$

$$S_P = 10.756 Wm^{-2}$$

Table-2: Thermal energy received from the sun

Days	Monday	Tuesday	Wednesday	Thursday	Friday
Thermal Energy(Wm^{-2})	10.493	10.546	10.546	10.546	10.756

2) Anemometer, device for measuring the speed of airflow in the atmosphere, in wind tunnels, and in other gas-flow applications. Most widely used for wind-speed measurements is the revolving-cup electric anemometer, in which the revolving cups drive an electric generator. The output of the generator operates an electric meter that is calibrated in wind speed. The useful range of this device is approximately from 5 to 100 knots. A propeller may also be used to drive the electric generator, as in the propeller anemometer. In another type of wind-driven unit, revolving vanes operate a counter, the revolutions being timed by a stopwatch and converted to airspeed. This device is especially suited for the measurement of low airspeeds.

The cheapest and most widely used in ecological studies are cup or propeller anemometers, in which rotating cups or a propeller is driven by the wind. In the latter case, the device must either be held perpendicular to the direction of the wind or be mounted on a vane; for automated measurements such devices typically measure direction as well as speed. While mechanical anemometers are still in use in meteorological stations.[3]

More complex ultrasonic anemometers measure wind speed in three directions based on the time of flight of sonic pulses between pairs of transducers. While expensive, such sonic anemometers are suitable for measuring turbulent air flow with a very high temporal resolution and are typically used in conjunction with infrared or laser-based gas analysers to measure ecosystem fluxes using the eddy covariance method.[3]

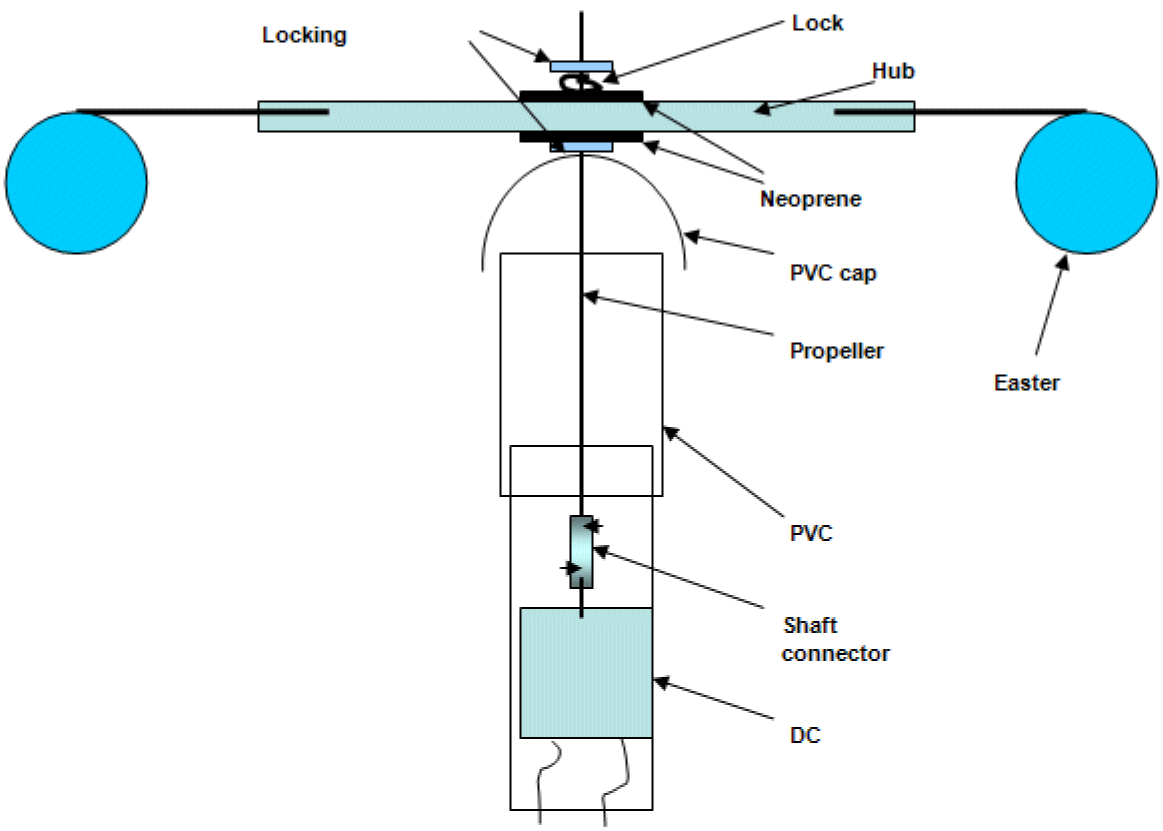


Figure 2:Components of Anemometer

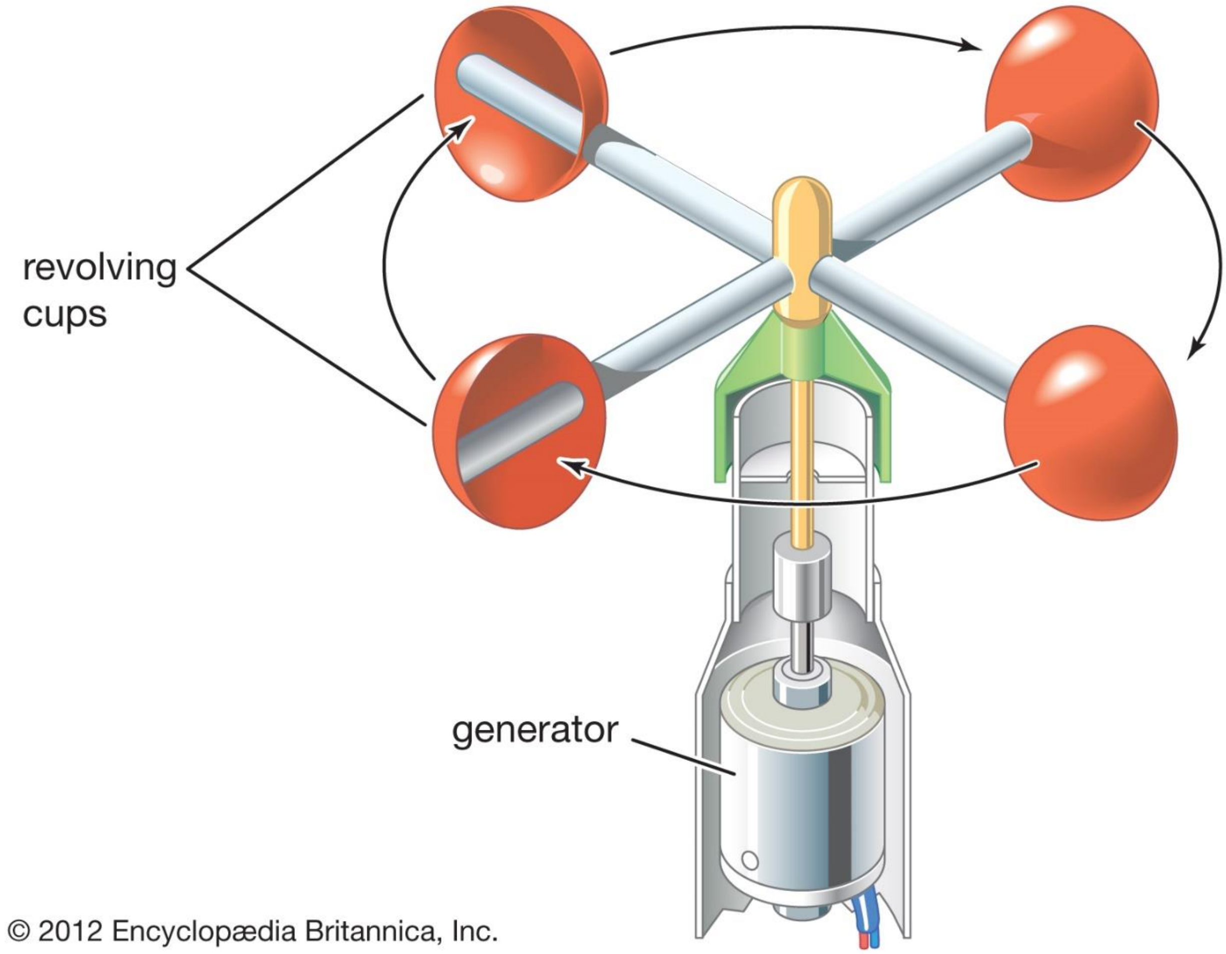


Figure 3: Anemometer

QUESTION C

How much energy is being produced from the dams in Nigeria? Compare with the energy produced from crude.

Answer

Electricity, bedrock of every nation development and can be transported instantaneously and pollution free at consumer end makes it attractive as compared to other forms of energy. Although it is a desirable source of energy, being pollution free it also has its drawbacks: The construction of electric hydrogenating stations are highly dependent on the inflow of water into their reservoirs and this construction of hydroplants involves displacement of people from their natural habitat and destruction of species of plants and animals. Therefore, the construction of power generating stations has substantial impact on its immediate environment; these consequences may be positive impacts that are useful to the environment and also negative effects that are hazardous to the environment. The effective management of these impacts of electric power generation in Nigeria, so as to ensure a conducive, balance and sustainable environment is highly desirable. [4]

However the intake level or quantity of water into the hydro power generation power stations differs. It varies with respect to the position of the hydro power stations and prevailing seasons experience at a particular point in time.

Nigeria is blessed with large rivers and natural falls. The three main sources of water flow for hydro power generation are the Kanji, Jebba and shiroro. The monthly hydrological water balance for energy generation on the kanji reservoir operation for 2015 was observed and estimated to be **1,621,534 MWH**; and the energy generated from the shiroro reservoir was estimated to be **1,440,601 MWH.**[4]

Nigeria has oil reserves of about 35 billion barrels ($3.5*10^9m^3$) and gas reserves of 5 trillion cubic meters. Crude oil which is a major source of energy production is used as to produce transportation fuels, such as gasoline, diesel and jet fuel.it is also used for heating and electricity generation. At 2015 Nigeria produced 1.9 million barrels/day of crude oil and the primary energy generated was estimated to be 1476 TWH which is **1,476,000,000MWH.** [5]

In comparison it can be seen that in 2015, the amount of energy produced in Nigeria from crude oil was **exponentially higher** than that produced from dams. And this is because the amount of reserves for the crude oil is significantly larger than that of the hydropower; **36.2 billion barrels for the former and 14,250MW for the latter.**[6]

REFERENCES

[1] https://en.wikipedia.org/wiki/Energy_mix

[2] "Energy balance calculation." [Online]. Available: www.acs.org /content/acs/en/climatescience/energybalance /energyfromsun.html.

[3] "Anenometer image." [Online]. Available: www.google .com/search?q=anemometer&tbm=isch&tbs =qdr:w&client=ms-android-samsung-gj-rev1& prmd=ivn&hl=en-GB&ved=2ahUKEwiRuo_fr4 _pAhWiAGMBHWXOBPUQ3Z8EegQIARAC& biw=360&bih=61.

[4] https://www.britannica.com/technology/anemometer

[5] https://www.usaid.gov/powerafrica/nigeria

[6] R. C. Ijeoma and I. Briggs, "Hydro Power Generation In Nigeria , Environmental Ramifications," vol. 13, no. 5, pp. 1–9, 2018, doi: 10.9790/1676-1305010109

[7] https://nerc.gov.ng/index.php/home/nesi/403-generation

[8] "crude oil production." [Online]. Available: www.google.com/amp/s/www.ceicdata.com/en/indicator/nigeria/crude-oil-production/amp.

[6] S. O. Oyedepo, "Energy and sustainable development in Nigeria : the way forward," pp. 1–17, 2012.