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15/ENG07/016

CHE 574: ALTERNATIVE ENERGY SOURCES

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

1b. 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 on the case for the Nigerian environment.

1. Forms of Energy and their Mathematical Relations

The two basic forms of energy are: kinetic energy and potential energy (both mechanical energy).

Kinetic Energy is the form of energy that exists in particles or substances in motion. It appears in the form of an object's motion, and is also known as working energy. Mathematically, Kinetic Energy, **KE** = $\frac{1}{2}mv^2$

Where m is the mass of the object, and v is its velocity.

Potential Energy is the energy occurring in an object by virtue of its position or state in space. It is also known as stored energy. Mathematically, Potential Energy, **PE = mgh**

Where g is the acceleration due to gravity, h is the vertical height of the body, and m is the mass.

It is observable that the mathematical expression for the potential energy hints at gravitational energy. This is because gravitational energy is a type of potential energy. Other types are chemical energy, elastic energy, magnetic energy, elastic energy.

Some types of kinetic energy are sound energy, light energy and electrical energy.

Some forms of energy and their mathematical relations include:

Energy	Description	Mathematical Relation
Mechanical Energy	Also known as motion energy, this is the sum of the potential and kinetic energy that is used to do work.	ME = $m((v^2/2) + gh)$
Electrical Energy	This energy results from the moving electric charges known as electrons. This form of energy could be generated by various means such as solar, wind, nuclear and hydropower plants.	It is governed by the Ohms Law: V = IR.
Nuclear Energy	Nuclear energy comes from the nucleus of atoms. There are two ways by which this energy is released: by fission (splitting) or by fusion (fusing together).	$E = mc^2$ Where; E = Energy, m = mass, c = velocity of light
Wind Energy	This is the energy provided by harnessing the kinetic energy of the wind; by its rotating of a turbine (wind turbine).	The Rotational Energy in the turbine, $P = \frac{1}{2}\rho A v^3 C_p$ (MW) Where; ρ = air density (kg/m^3), A = radius of the swept area, πr^2 (m^2) v = wind speed (m/sec) C_p = Power Coefficient

Hydropower	This is the energy harnessed from falling water by rotating blades known as turbines. The maximum hydropower output is entirely dependent on the head and flow available at the site.	$P = m \times g \times H_{net} \times \eta$ Where; P is the power in Watts, m is the mass flow rate in kg/s g is the gravitational constant ($9.81 ms^{-2}$) Hnet is the net head. This is the gross head measured at the site less any head losses. Assuming lossees of 10%, Hnet = Hgross x 0.9
Solar Energy	Solar energy is the energy obtained by the capture and conversion of the radiant energy of the sun with the aid of photovoltaic cells assembled on panels (solar panels).	Solar panel output (daily watt-hours) = Solar panel watts x Average hours of sunlight x 75% The 75% accounts for variables which influence the wattage.

Sustainable and Non-Sustainable Energy Sources

The sustainable or renewable energy sources are those sources which are constantly replenished and as such cannot be completely depleted. They are the forms of energy that meet the present demand of energy without putting them in danger of getting expired or depleted and can be used over and over again.

The non-sustainable energy sources are the non-renewables, which upon depletion cannot be replenished. All fossil fuels are non-sustainable. They are formed over millions of years from biomass by geological forces.

Sustainable Energy Sources	Solar energy, Wind energy, Hydropower, Biofuels, Geothermal energy, Ocean energy
Non-Sustainable Energy Sources	Fossil fuels (coal, oil, natural gas), Burning of biomass

Author's Note

Nuclear plants generate electricity through the use of a radioactive element known as Uranium.

Radiant Energy is a form of electromagnetic energy which can take the form of visible waves (light) or invisible waves (such as x-rays or radio waves).

A case has to be made for biofuels as a sustainable energy source. Although it is also formed from biomass, just like fossil fuels, it is considered sustainable because it is fairly cleaner, and takes way lesser time for formation. In the opinion of the author however, as regards the environment, biofuels are still chief emitters of greenhouse gases, CO_2 and CH_4. For instance, landfill gas (which is a biofuel) is basically methane (CH_4) escaping from landfill.

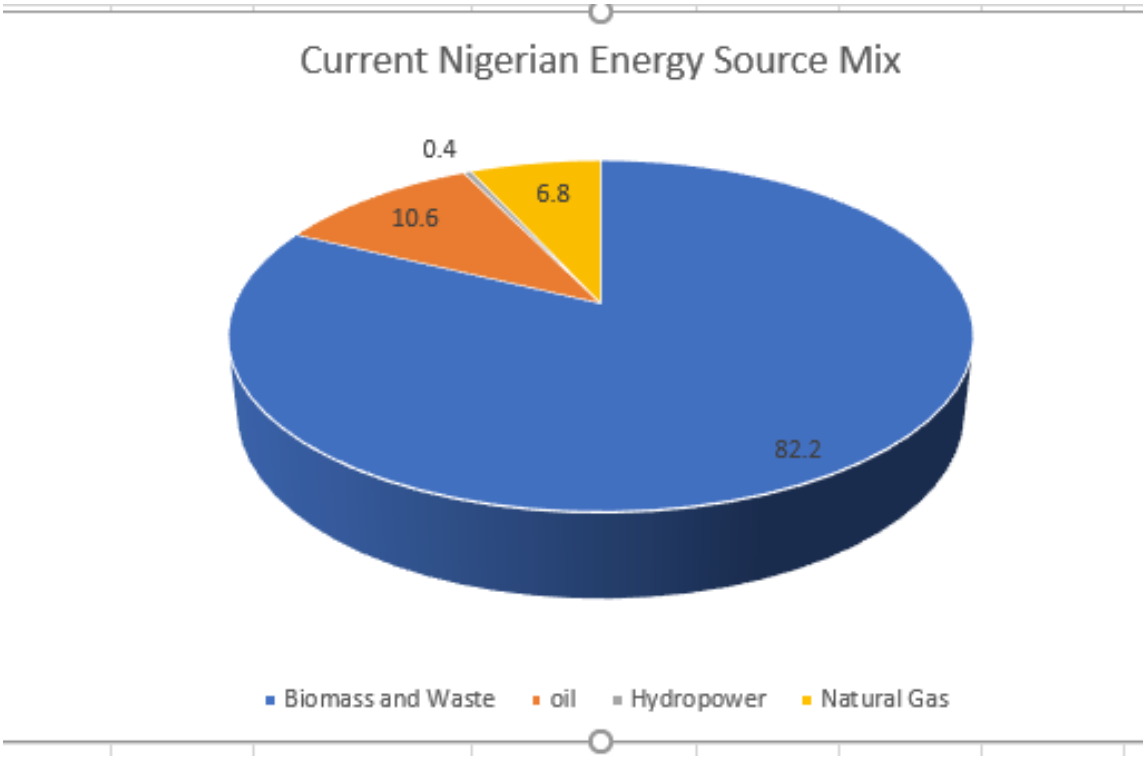
2. Energy source mix for sustainable energy in Nigeria

In designing an energy (source) mix, and constructing policies, it is worthy of note that there is no single perfect source of energy. Thus, we can only find the ideal source mix by finding the balance between reliability, affordability, security of supply, competitiveness, sustainability and the environment. It is on this premise that the following source mix has been designed for Nigeria by the author of this paper, drawing insights from statistics, and the author's viewpoint.

Current Energy Resource Mix

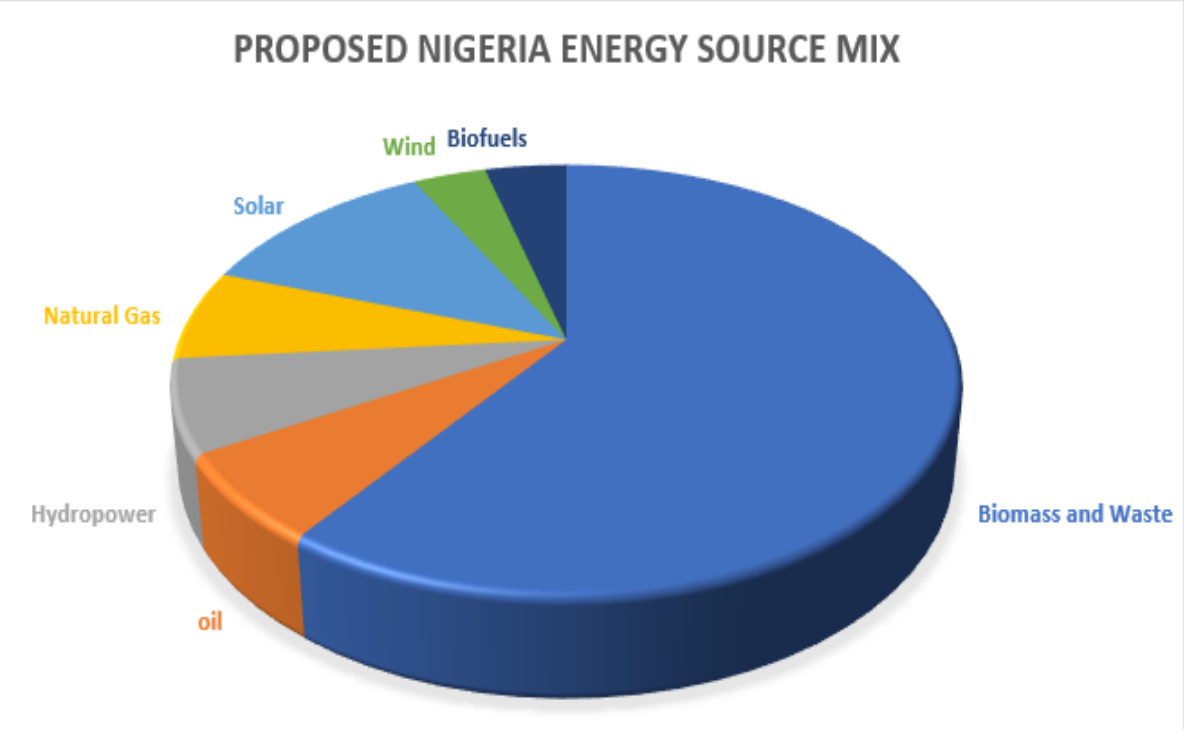
According to the IEA, total Nigerian primary energy supply was 118,325 kilotonne of oil equivalent (ktoe).

Energy Source	Biomass and Waste	Oil	Hydropower	Natural Gas
Percentage Supply (%)	82.2	10.6	0.4	6.8



Proposed Energy Resource Mix for a Sustainable Energy Development

Energy Source	Biomass and Waste	Oil	Hydropower	Natural Gas	Solar	Wind	Biofuels
Percentage Supply (%)	60	6.6	7	6.8	12	3.6	4



By increasing the renewables content in the energy mix, such as solar energy, wind energy, and improving the hydroelectric power contribution, there would be hope for sustainable energy production in Nigeria. It is not realistic to assume that there would be an automatic elimination of the biomass and waste, as energy and technologies takes time to integrate.

My view on the case for the Nigerian Environment

The Nigerian environment has long suffered from the effects of carefree exploitation of fossil fuels. However, Nigeria has resources for renewable energy such as solar, wind, biofuels, hydropower. The challenge is to optimize energy production from these resources while increasing their penetration into the energy mix which currently consists of fossil fuel-based energy (petrol and/or diesel generators, coal, and petroleum products) and hydroelectric power (HEP).

There is also the prospect of capturing and utilizing gas flares for energy, via tested technology. The Nigerian Gas Flares Commercialization Program (NGFCP) hopes that Niger Delta communities will benefit from reduced flaring, while eliminating about 20 million tons of CO_2 emitted into the environment and giving 6 million households access to clean energy through LPG. Thus, flare gas could be added to the energy mix for sustainable energy.

The Nigerian environment will battle the effects of greenhouse gas emissions for a very long time. Running away from fossil fuels to bio fuels will not totally solve the problem, as biofuels still contribute to the greenhouse effect by the evolution of methane and carbon di oxide.

"Power Africa", a US government-led partnership, in its November 2018 energy sector review, stated that "Nigeria has the potential to generate 12,552 MW of electric power from the large oil, gas, hydro and solar resources at her disposal through existing plants, but ends up generating 4000MW"[1]. This speaks volumes about the current state of energy in the country.

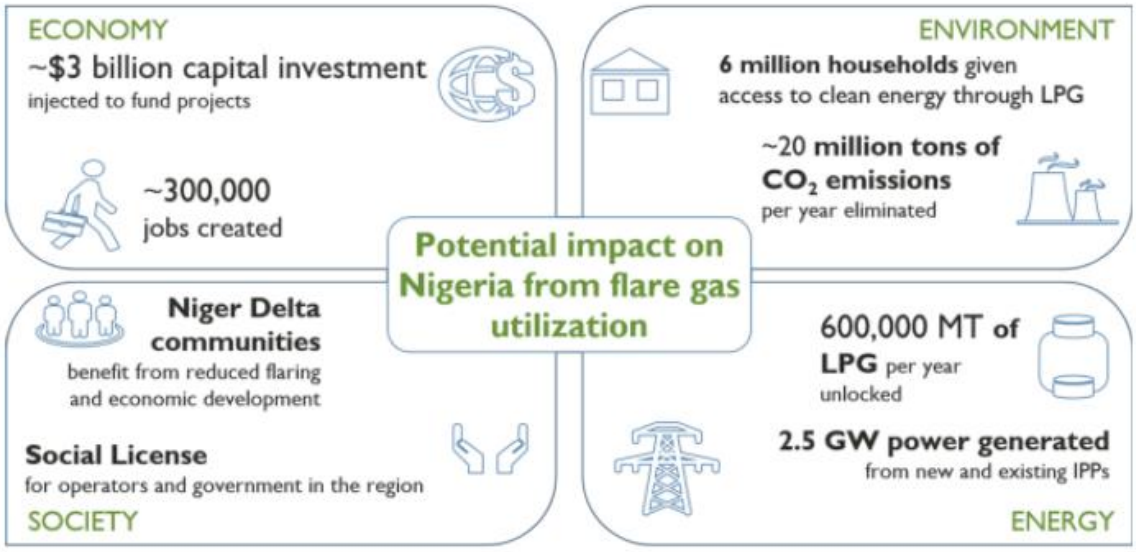


Figure 1: Potential Impact on Nigeria from Flare Gas Utilization

The role of technology often features amidst the dynamics of the energy transition, but much uncertainty remains about the widespread dissemination of low-carbon innovations. Cost, the speed of adoption and acceptance of technologies are basic parameters for carbon emission reduction, along with their impact on resources. By considering these effects, an adequate energy source transition for Nigeria from harmful fossil fuels to cleaner *sustainables* could be achieved.

References

[1] Power Africa, "Energy Sector Overview; Generation Capacity, Investment and Enabling Environment," *Nigeria - November 2018 Country Factsheet*, pp. 1–2, 2018.

Question:

1. Monitor the average ambient temperature between 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.

2. **Diagram of an anemometer**

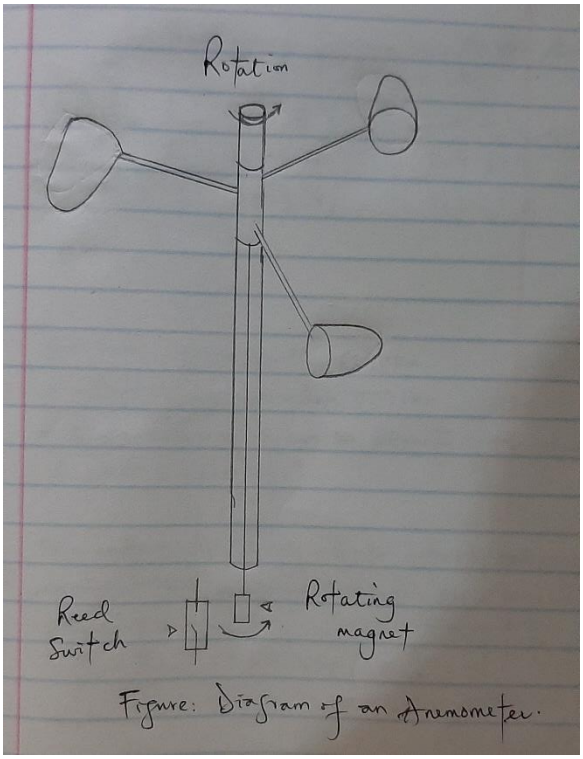


Figure: Labelled diagram of an anemometer.

1. Table 1: Average ambient temperature for a 3-day period between Monday and Friday (i.e. Tuesday, Wednesday and Thursday)

Day	Average Temperature (^oC)	Average Temperature (^oK)
Tuesday	31.25	304.4
Wednesday	30.5	303.65
Thursday	31.5	304.65

The total heat radiated from the earth is equal to the energy flux implied by its temperature.

Therefore, $Q_{out} = (4\pi R^2)\sigma\varepsilon T^4$

where σ = Boltzmann's constant = 0.567×10^{-11} W/cm^{2}K^4

ε = Emissivity = Absorptivity = 0.87

R = Earth's radius = 6370 km = 6.37×10^8 cm (since 1 km = 100000 cm)

for $T = 304.4°K$,

$Q_{out} = [4\pi \times (6.37 \times 10^8)^2] \times 0.567 \times 10^{-11} \times 0.87 \times 304.4^4$

$= 2.33 \times 10^{12}$ W

Thus, the average thermal energy reaching land on Tuesday was 2.33×10^{12} W.

For $T = 303.65°K$,

$Q_{out} = [4\pi \times (6.37 \times 10^8)^2] \times 0.567 \times 10^{-11} \times 0.87 \times 303.65^4$

$= 2.32 \times 10^{12}$ W.

Thus, the average thermal reaching land from the sun on Wednesday was: 2.32×10^{12} W.

For $T = 304.65°K$,

$Q_{out} = [4\pi \times (6.37 \times 10^8)^2] \times 0.567 \times 10^{-11} \times 0.87 \times 304.65^4$

$= 2.33 \times 10^{12}$ W.

Therefore, on Thursday, the average thermal energy from the sun reaching land was 2.33×10^{12} W.

Question:

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

Answer:

There are two (2) main types of power plants operating in Nigeria. They are; hydro-electric power (HEP) plants and fossil fuel power plants.

Table 2: Energy production in Nigeria from power plants

Plant	Energy Generation (MW)
HEP Plants	8457.6
Fossil fuel (crude oil) Plants	2062

Table 3: Hydro-Electric Power Generation in Nigeria by Dams

Dam	Power generation (MW)
Kainji Dam	760
Shiroro Dam	600
Jebba Dam	578
Tiga Dam	10
Zobe Dam	No quoted power generation figure

These are not the only dams in Nigeria. There are several dams in Nigeria in the North and Middle-Belt. However, most of them are not yet commissioned, or are for irrigation, flood control and farming purposes, and not power generation. The dams listed in Table 2 above are the ones responsible for power generation in Nigeria.

Other dams in Nigeria include: Zungeru hydropower dam, Mambilla HEP station, Oyan dam, Ikere gorge, etc.

References

1. International Hydropower Agency (IHA). https://www.iha.org/Nigeria
2. https://thedailysblog.com