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PETROLEUM ENGINEERING

CHE 574 (ALTERNATIVE ENERGY SOURCES)

ASSIGNMENTS

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1. QUALITATIVE DEFINITION OF ENERGY

Most dictionaries define energy as "the capacity to do work." This implies that energy is a more abstract concept than work. The definition is correct, of course, but it is incomplete. Work is certainly an important 'manifestation' of energy; indeed, the Industrial Revolution went into full swing in late eighteenth century when breakthroughs were achieved in converting other forms of energy into work. But work is not the only 'palpable' form of energy. Heat is another important energy form; a lot of effort and expense is made by society to remove heat from our homes and offices in the summer and to bring it to them in the winter. And radiation too, for better or for worse, is energy that we can sense. Hence, a more complete definition(Times, 1996) is the following:

Energy is a property of matter that can be converted into work, heat or radiation.

1.1. Forms of energy

- *Gravitational (Potential) Energy*

All matter on our planet is subject to the force of gravity, which pulls objects toward the earth's center. Overcoming the force of gravity requires expending energy. Therefore, the farther (or higher) an object is from the earth's surface, the greater its gravitational, or potential, energy will be. The change in the gravitational energy of the object is thus proportional to the change in its vertical position. Times also said that the larger the mass of an object is, the greater its potential energy will be. Finally, the third factor that defines potential energy is the acceleration due to gravity. This is a relatively constant number on our planet; it represents an increase in speed of about 10 meters per second for every second of free fall.

Thus, the gravitational potential energy is defined as follows:

$$PE = m * g * h \quad (1.1)$$

PE=Potential Energy; m=Mass,kg; g=Acceleration (due to gravity); h= Height,m

Also, hydroelectric power plants take advantage of the high potential energy of some of the world's rivers and convert water's gravitational energy into huge quantities of electricity.

- *Kinetic Energy*

The energy in motion is known as Kinetic Energy. For example a moving ball, flowing water, etc.

$$KE = \frac{1}{2} m * v^2 \quad (1.2)$$

Where,

m = Mass of the object; v = Velocity of the object

- *Mechanical Energy*

It is the sum of potential energy and kinetic energy that is the energy associated with the motion & position of an object is known as Mechanical energy. Thus, we can derive the formula of mechanical energy as

Mechanical Energy(ME) = Kinetic Energy(KE) + Potential Energy(PE)

$$ME = \frac{1}{2} m * v^2 + m * g * h \quad (1.3)$$

- *Solar Energy.*

Practically all forms of energy available to us on earth – except gravitational and nuclear – come from the sun. Part of this energy reaches our planet. It travels in waves that possess a characteristic wavelength. The number of wave crests that pass by a given point in space in a second is called the frequency of the wave. The shorter the wavelength of radiation is, the higher its frequency and the more intense the radiation will be.The following fundamental relationship between frequency and wavelength of electromagnetic waves defines the speed of light:

Speed of light = [Wavelength] [Frequency] (1.4)

- *Wind Energy*

It is one of the various forms of energy. The energy present in the flow of wind, used by wind turbines is called wind energy. This energy is a major cheap source to produce electricity. In this phenomena, the kinetic energy of the wind is converted into mechanical power.

- *Nuclear Energy*

The energy present in the nucleus of an atom is known as nuclear energy. The particles of an atom are tiny and need the energy to hold themselves. Nuclear energy is that enormous energy in the bonds of an atom which helps to hold the atom together. Nuclear energy can be used to make electricity.

The splitting of atom's nucleus is called fission. The nuclei of identical or different atoms can also join together. This process is called fusion. In both these processes, part of the atomic mass is converted to energy, according to the famous Einstein equation:

$$\text{Energy} = [\text{Mass}]\,[(\text{Speed of light})^2] \tag{1.5}$$

- *Geothermal Energy*

The energy or heat present inside the Earth is known as geothermal energy. It is a cheap & convenient heat and power resource and use of this energy don't have a side effect like greenhouse gas emission etc.

- *Tidal Energy*

Tidal energy or tidal power is a form of hydropower (energy present in water), which converts the energy present in the tides to produce electricity.

- *Biomass Energy*

Biomass is organic matter obtained from living organisms. The energy produced from biomass is called biomass energy.

- *Electrical Energy*

The energy caused by moving electric charges is known as electrical energy. Electric energy is a type of kinetic energy as the electrical charges moves.

- *Thermal Energy*

As the name suggests, thermal energy is the energy obtained from heat. It is a microscopic, disordered equivalent of mechanical energy.

There may be instances where an object possess more than one type of energy. For example, boiling water, possess both kinetic and potential energy along with heat energy.

1.2. Differences between Renewable and Non-renewable energy resources

The concept of resources is a human centered concept. In other for something to be considered a resource, it must be perceived to have value by humans. Energy is fundamental to all human activities. Below are some differences between those renewable and those that are not

Table 1: Differences between Renewable and Non-renewable energy resources

S/NO	RENEWABLES	NON RENEWABLES
1	Can be reused throughout its life	Will be exhausted eventually
2	Low carbon emission	High carbon emission
3	Environmentally friendly	Not environmentally friendly
4	Presented in unlimited quantities	Presented in limited quantities; will vanish one day
5	Life of resource is infinite	Life of resource is finite
6	Has high maintenance cost	Low maintenance cost compared to its counterpart
7	Large land area is required for the installation of its power plant	Less land space is required
8	Solar, wind, hydro are examples	Coal, petroleum, natural gases are examples.
9	Despite been commercial commodities, they do not affect the GDP compared to that of its counterparts.	Are Commercial commodities that increase the GDP of an economy
10	Few policies on its exploration and	Restricted to many policies and legal rights

2. ENERGY MIX FOR A SUSTAINABLE ENERGY DEVELOPMENT

No single energy resource can sustainably meet the energy demands of any country. Integrating all exploitable energy sources is a viable way of achieving stability in any economy(Pedraza and Consulting, 2014). There should be a resource energy mix that effectively works for the provision of both energy for industrial, commercial and residential purposes to drive production for the realization of revenues and most importantly, lesser footprint effect on the environment.

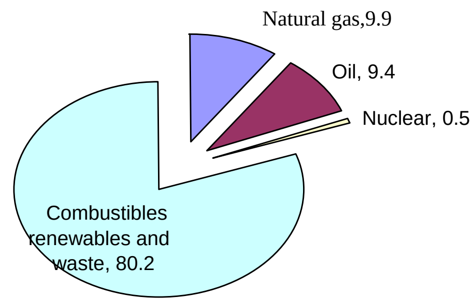

Figure 1: Chart representation of a typical sustainable energy mix

The figure above can serve as a sustainable energy mix to drive sustainability in an economy with the major energy source been renewables (hydro, wind, solar), combustible (firewood) and biomass waste. Oil and gas still providing energy ensuring gradual and smooth shift from non-renewable to renewable while still growing and developing the nuclear resource

2.1. Case Study; Nigeria

The role of energy mix in sustainable development of Nigeria is vital as energy availability, economic growth and sustainable development are grossly inseparable(D and Ezugwu, 2011). Generating adequate power has been a major challenge for successive Nigerian government. Below is the what the resource mix looks like

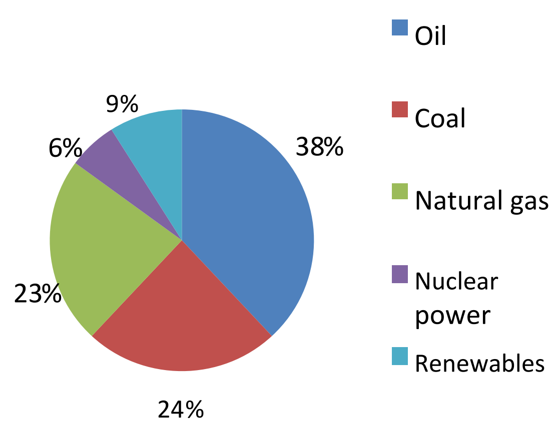

Figure 2: Pie chart representation of Nigeria energy mix

2.2 Looking forward

First, that energy sources should be diversified. Since power failure is a regular occurrence in Nigeria with attendant negative impact on the quality of living and business productivity, a new approach to electricity generation in which a mix of several energy sources including renewable sources is optimally utilized should be vigorously pursued and adopted.

Second, the utilization of renewable energy technologies especially solar energy to provide off-grid electricity to remote communities should be intensified.

Third, it is imperative to intensify research and development in the energy sector, especially renewable energy to increase energy sources and improve energy management systems that will promote sustainable development.

Last, there should be increased funding in energy sector, which is capital intensive and requires huge amount of investment. The public and private sector could form a partnership to tackle this investment problem. Government should also increase the budgetary allocation to the energy sector and release these funds duly.

3. ESTIMATION OF AVERAGE DAILY THERMAL ENERGY

An analysis was carried out to estimate the daily average thermal energy reaching Afe Babalola University, Ado-Ekiti(ABUAD). For this analysis, the ambient temperature was recorded over a five day time period as follows;

Table 2: Data collected

	AMBIENT TEMP,°c	
DAY	High	Low
17-Feb-20	35	25
18-Feb-20	36	25
19-Feb-20	35	25
20-Feb-20	36	25
21-Feb-20	37	25

Thermal energy can be estimated using the heat transfer equation written below

$$Q = mC\Delta T \quad (3.1)$$

Recall;

$$\rho_A = \frac{m}{A}. \quad (3.2)$$

Therefore,

$$m = \rho_A * A \quad (3.2a)$$

Where,

Q= thermal Energy,Joules; m=mass,kg; ΔT=change in temperature; C=Specific heat, J/Kg °C ;
ρ_A= Area density; A= Area of land,m^2

Assumptions

- Area(A) of land in ABUAD is 1300000m^2
- Area density is 1.67kg/m^2
- Specific Heat Capacity for air is 1020J/kg°C

3a. Results Obtained

Evaluation was done with the aid of Ms Excel spreadsheet and yielded results below;

Table 3 Results analysis

	AMBIENT TEMP(T),°c				
DAY	High	Low	ΔT,degC	Q(J)	Q(MJ)
17-Feb-20	35	25	10	22144200000	22144.20
18-Feb-20	36	25	11	24358620000	24358.62
19-Feb-20	35	25	10	22144200000	22144.20
20-Feb-20	36	25	11	24358620000	24358.62
21-Feb-20	37	25	12	26573040000	26573.04
			AVERAGE=	**23915736000**	**23915.74**

C=	1020
A=	1300000
ρA=	1.67
m=	2171000

3b. Discussion

From the result above, we can resolve that the estimated average daily thermal energy reaching Afe Babalola University(ABUAD) from 17th Feb to 21st Feb,2020 was approximately 23916 Mega Joules.

3.1 Anemometer

A 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 as shown in figure 3 below. 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.

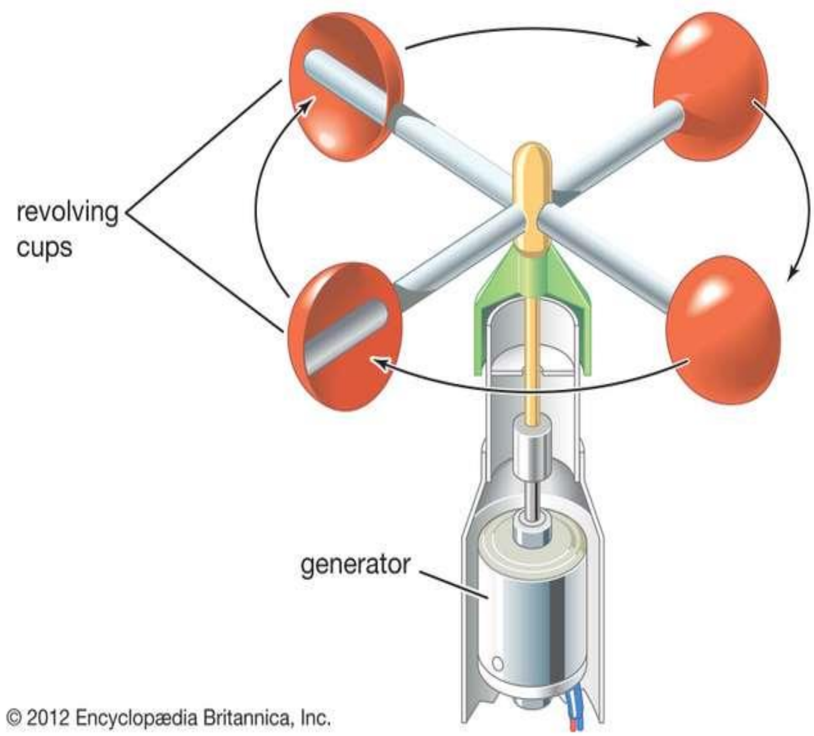

Figure 3: Revolving-Cup Anemometer

4. ENERGY SECTOR OVERVIEW

Nigeria is the largest economy in sub-Saharan Africa(Ijeoma and Briggs, 2018), but limitations in the power sector constrain growth. Nigeria is endowed with large oil, gas, hydro and solar resource, and it already has the potential to generate 12,522 megawatts (MW) of electric power from existing plants, but most days is only able to generate around 4,000 MW, which is insufficient(Sambo, 2008). Nigeria has privatized its distribution companies, so there is a wide range of tariffs.

GENERATION CAPACITY

Installed Capacity: 12,522 MW

Thermal: 10,142 MW

Hydro: 2,380 MW

4.1. Electric Power Stations And Their Installed Capacities

The various electric power stations installed capacity differs and so do they vary in terms of their outputs. The numbers of units in the different power station differs(Ijeoma and Briggs, 2018). These variations are illustrated in table 4 below.

Table 4:Power stations and their installed capacities

Power Station	**Installed Capacity(Mw)**	**Numbers Of Units**	**Plant Type**
Kanji	760	8	hydro
Shiroro	600	4	hydro
Jebba	578.4	6	hydro
Small scale stations	441.6	8	hydro
total installed capacity	**2380.0**	26	

Source: PHCN publications on Ughelli thermal power station, 4th November, 2013.

4.2. Discussion

From the ongoing, we can deduce clearly that the amount of energy produced by the fuel-type resources (crude etc.) is almost five times greater than that of hydroelectric dams. This sheds more light on the country’s dependence on non-renewable energy and non-involvement in developing its natural alternatives.

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